

Solid Waste Characterisation in Port-Harcourt Metropolis, Rivers State, Nigeria

Eunice Nnete Gam¹ and Cyprian N. Tom¹

¹*Department of Agricultural and Environmental Engineering
Rivers State University of Science and Technology, Port Harcourt, Nigeria*

Date of Submission: 20-03-2025

Date of Acceptance: 30-03-2025

ABSTRACT: A solid waste characterization study was conducted for Port-Harcourt municipality. This was prompted by the existent poor waste management services and the overwhelming presence of unmanaged municipal solid waste in the municipality despite various efforts and interventions to curb the menace. The purpose of this study is to determine the types and composition of wastes in the waste stream which can be utilized by waste management professionals to develop a sustainable waste management plan for the municipality and others with similar demographics. The determination of the composition of unprocessed municipal solid waste was conducted according to [1] Standard Test Method. This method involves the direct sampling of solid waste from specific sources, where manual sorting, classifying and weighing of all waste items from each sampling unit is done and detailed data recorded. Moisture content and bulk density analysis were conducted as well as descriptive analysis using IBM SPSS Statistics software, version 22.0. Waste characterization results showed that organics comprising of food and garden waste occupied the most space in the waste stream, having an average of 27%. Other predominant waste streams were mixed rigid plastics 11%, disposable nappies 11% and paper packaging 9%.

KEYWORDS: Solid waste, Management, Port-Harcourt, Characterisation, Waste stream.

I. INTRODUCTION

A lack of consistent information on waste quantity and composition makes it difficult to plan for sound waste management. Without reliable data, it is difficult to set realistic targets for waste reduction and to know when this has been achieved. By analyzing the actual waste stream on a systematic and repeatable manner, useful information can be collected [2]. This makes waste

characterization a must when aiming to manage solid waste sustainably.

Characterization of solid waste involves a systematic procedure to determine the waste stream amount and the respective proportions of the constituents or composition of the waste stream [3, 4], and to design an integrated and sustainable solid waste management system, waste characterization is key [5]. Municipal solid waste (MSW) composition data are used by state and local governments to improve and assess their waste management programs, with examples of assessment metrics including recycling and diversion rates. Operators of waste management facilities (e.g., materials recovery facilities, incinerators, landfills) use waste composition data to better understand material recovery potential, energy production opportunities, and land gas production behaviour. Several different approaches have been used to estimate waste stream composition. The US Environmental Protection Agency (EPA), for example, estimated that landfilled MSW in the United States included 24.1% food waste, 18.5% plastics, and 11.8% paper products in 2018 [6]. This estimate, conducted using a materials flow methodology, relied on national product sales data and reported waste flows for recycling and incineration [7, 8, 9]. While such estimates provide useful data for tracking waste stream trends over a broad geographic region, they are less helpful for state and local governments trying to assess waste composition for a specific area. The preferred approach involves conducting a location-specific waste composition study to capture a more refined picture of a target community's waste stream at a given time [7, 10, 11].

A typical waste composition study involves selecting different sources of waste from the target community (sample sources are usually garbage trucks or containers after completion of a

collection run), manually separating samples of each of these waste sources into desired material components, and weighing each of the material component categories to produce an estimate of waste composition for that sample [12, 13, 14].

A waste characterization study was conducted by [15] at fifteen dumpsites situated around markets, semi-industrial and residential areas in Port-Harcourt. Their research was prompted by the need for environmental safety in relation to the presence of heavy metals, with the intent to carry out an impact assessment, proffering mitigation measures. Scavengers were engaged for the sorting and weighing of the waste using on-the-spot method. The survey showed biodegradable items in the stream, as well as paper, plastics, metals, polyethylene, batteries, including chemicals. Polyethylene nylon had a mean value of 23.9%; closely followed by food waste with a mean occurrence of 20.1kg. This depicts the sure possibility of a future presence of heavy metals and Polycyclic Aromatic Hydrocarbons (PAH) at the end of the decomposition life of the more than 40,000 tons of food waste generated in the municipality daily.

[16] in a bid to assist the government in designing a better solid waste management plan, sought to determine the waste stream and contracts between four local government areas within the Port-Harcourt metropolis by conducting a municipal solid waste characterization study. The socio-demographic features of the study areas were obtained via a questionnaire survey, and the SPSS tool was employed for statistical analysis. Their result showed a high percentage of putrescible waste having an average of 56.3%, plastic films had a percentage of 9.5, while paper was 6.22%. Based on their results, they believe that the government should be more pragmatic in their management of solid waste in the area by leaning more towards recycling, energy recovery and composting.

In their paper on the characterization and composition analysis of municipal solid Waste in Port-Harcourt city, Nigeria, a prelude to methane emission estimation in the city's dumpsites, [17] investigated the composition of MSW at three dumpsites, namely, Elioizu, Igwuruta and Iwofe. Data was sourced from these three industrial area dumpsites and analyzed for recovery and MSW sustainability purposes. Solid waste having been collected from different collection points around the dumpsites, were weighed and proximate analysis conducted. Plastic waste was found to have the most occurrence in the waste stream, with a daily mean of 27.4kg, followed by food waste

having a 24.5kg mean value. Based on their findings, the authors opined that solid waste in the study area were ripe for recovery and recycling. However, they recommended that attention should be given by the government to the mass of the biodegradable waste stream present, since there were possibilities of harmful methane emission. They also pointed to the need for MSW equipment evaluation to achieve integration and sustainability.

A waste characterization study was conducted by [18] at a waterfront community in Port-Harcourt municipality with the aim of getting a better representation of the waste stream as against previous studies performed at solid waste dumps in the study area. They believe that previous studies done at the dumps were less represented because they had gone through tempering by scavengers on their way to the dumpsites. Over a period of 10 days, a representative sample of the 200 households were selected and given 5 litres bin bags to store their household waste. These were then weighed daily and recorded. At the end of 10 days, the waste was collected, sorted and weighed. The results showed plastics as being at the peak of the stream having a value of 42%. The waste generation per capita was recorded to be 0.22kg.

[19] in their work on solid waste composition analysis for the development of a suitable waste disposal system in Port-Harcourt, selected five sample locations, namely, Diobu, Elekahia, Woji, GRA/Aba road and Trans Amadi for characterization. The study followed the [1] standard test method, which employed direct sampling of raw solid waste. The resulting data was further analyzed for mean, standard deviation, and standard error. Organic waste was found as having the highest volume sitting at 64.6%, followed by paper, nylon, plastic, metal and glass; having percentages of 12.8%, 12.2%, 3.5%, 1.9% and 1.2% respectively. They recommended that energy can be harnessed from the organic content, while others can undergo various waste recovery and recycling processes. 1.16 kg/cap.day was found to be the waste generated by individuals in the study area. Other recommendation was for the government to treat waste management independently of each location since they observed a heterogenous waste occurrence at the different locations.

[20] covered three distinct local government areas (Emuoha, Obio-Akpor and Port-Harcourt) in Rivers State in their waste characterization survey. Standard test method applied was the ASTM D5231-92 (2008). Their result showed organic waste stream as the most prevalent in the waste composition. Per capita

waste generation was analyzed to be 0.45kg, 0.98kg and 1.16kg for Emuohia, Obio-Akpor and Port-Harcourt respectively. They attribute the poor waste management of the areas to the absence of comprehensive data on waste characteristics.

II. MATERIALS AND METHODS

Study Area

“Port-Harcourt is the capital of and largest city in Rivers State, Nigeria. The municipality lies between longitude 6°55’ and 7°10’ east of Greenwich meridian and latitude of 4°47’ north of the equator housing, and is bounded by an area of about 2600km with a population of 1,850,020. It also lies along the Bonny River and is located in the Niger-Delta region. As of 2016, the Port Harcourt urban area had an estimated population of 1,865,000 inhabitants, up from 1,382,592 as of 2006” [21] It is bounded on the east by Otamiri/Imo River and on the west by the New Calabar River, North by Imo/Abia States, and south by Degema/Bonny LGAs. Port Harcourt is densely populated within the neighbourhood of Diobu. Port Harcourt region comprises the city itself and parts of Obio/Akpor local government areas and is highly congested and also generate a greater part of the waste in the region.

Sampling and Data Collection

The waste characterization study was carried out according to ASTM standards test method for determination of the composition of unprocessed municipal solid waste. To get a representative sample of the waste, the social class grouping method was employed, where waste was collected directly from selected households, of different classes; 26% from upper-income class, 48% middle-income class and 26% low income class [22] Waste samples were collected from 50 individual households [4] in each area, and 10 commercial areas (business complexes and markets) within the study location. For low income

houses, waste was gathered from the general dumpsite close to them. About 6kg waste were collected in bin bags from each household at each study location, bringing the total waste to about 300kg at each location. A flat surface was identified close to the dumpsite/receptacle, and a clear large nylon spread on the floor before commencement of the sorting process. The sample was placed on the floor and thoroughly mixed by shovels, then placed in a uniform pile of 0.8m high. The pile was then divided into four quarters using straight lines perpendicular to each other. Afterwards, either pair of opposite corners was removed to leave half the original sample. This process was repeated until the desired sample size of 200kg was obtained. The surplus ‘two quarters’ from the last size reduction was retained for analysis of moisture content and bulk density. The final opposite pair of refuse was sorted into different categories, where the larger items were first picked out. Each category was weighed using Camry 100kg digital weighing scale, model DF104-2W. The percentage composition determined was filled out in a tabular form. The remaining material was then passed through a 20mm mesh sieve and classified as components with particle sizes smaller than 20mm diameter.

Materials employed for the waste characterization study included a covered shed, plastic containers to store segregated waste, bin bags, a vehicle with large boot space, shovels, Camry 100kg digital weighing scale, model DF104-2W, box sieve with a 20 mm round mesh, a tray for fines recovery, brooms, disinfectant, coveralls, gloves, masks, magnets (for distinguishing between ferrous and non-ferrous metals), first aid kit, oven (for moisture content), and a 300 litres plastic graduated container for bulk density analysis. IBM SPSS Statistics software, version 22.0, was employed for statistical analysis. Results were expressed in percentages, frequencies, tables, and charts (Descriptive Statistics).

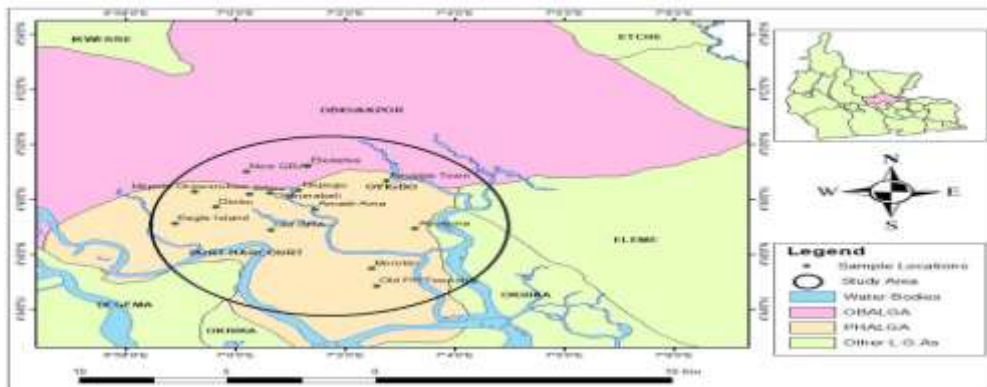


Figure 1. Map of Port-Harcourt Metropolis [21]

III. RESULTS AND CONCLUSION

In the study, a total of 14 sample locations were researched, namely, Azuabie Town, Abuloma, Amadi Ama, Borokiri, D-line, Diobu, Eagle Island, Elekahia, New GRA, Nkpogu, Nkpolu Oroworukwo, Ogbunabali, Old GRA, Old Port Harcourt Township. 50 different waste streams were identified, out of which 8 were more prominent in mass, namely food waste, garden waste, paper packaging, disposable nappies, mixed rigid plastics, supermarket bags, other plastic packaging, and styrofoam. Tables 3.1 shows the statistical analysis of the characterization study. The descriptive analysis covered the mean, minimum, maximum and standard deviation, kurtosis and skewness. Table 3.2 shows the 8 most prominent waste streams in kilograms and their averages, while the comparative percentage waste streams result for the study locations is shown in Table 3.3. Figures 3.1 to 3.14 shows the waste streams for the 14 sample locations with their various constituents' weights and percentages.

A total of 2,840.9kg of household waste and 323.7kg of commercial waste in the Port-Harcourt municipality were characterized into 50 different waste streams. Out of the 50 different waste streams identified in all the sample locations in the municipality, 8 had the most presence and heavier in weight. These were organics food and garden waste, paper packaging, disposable nappies, mixed rigid plastics, supermarket bags, other plastic packaging, and Styrofoam. In comparing the waste characteristics among the 14 different sample locations in Port-Harcourt, food waste had the highest percentage score, being between 21% and 27%, with Azuabie having the highest percent within its stream and New and Old GRA recording the lowest. However, when compared with the commercial waste characterization, garden waste had the highest occurrence at the commercial areas of the city, having a total weight of 43.2kg as opposed to food waste which had a 39kg weight (Table 3.2). Garden waste was highest in Old GRA, an area known for more horticultural activities. New GRA had the highest presence of disposable nappies, being a choice residential area. The proliferation of paper was found at the industrial sections of the city, namely, Diobu, Old PH township, Amadi-Ama and Abuloma. Bar charts showing the percentages of the prominent waste streams in the different locations in Port-Harcourt is given in Figures 3.1 to 3.14. The mean statistics of the food waste with a standard error of 1.5 is 47.5kg. This fall within the 95% confidence level of consistency and accuracy. The minimum value of the food waste data set is 36.8kg which was

recorded at New GRA, while Diobu had the highest waste stream of 56kg. The standard error of skewness and kurtosis fell between 0.1 and 1.1 showing validity of data. Mixed rigid plastics had a mean of 23.5kg. The minimum value is at New GRA with a total weight of 18.2kg, while the commercial areas recorded the highest stream of 30.5kg. The standard error for the set of mixed rigid plastics is less than 1 with a comfortable skewness and Kurtosis, showing well distributed outliers, which is satisfactory. Disposable nappies stream had a mean value of 22.4kg, and a minimum value of 9.7kg at the commercial areas; it recorded a 29.1kg weight at the New GRA section of the municipality. The data showed a good range of normality at 0.8 and 0.03 skewness and kurtosis values. Other plastics packaging includes all other plastics used in wrapping products aside from carry bags from supermarkets. The standard error of the mean for this set were between 0.2 and 1.4. The minimum weights for other plastics, supermarket bags, garden waste, styrofoam, paper packaging, clear PVC bottles and paints and resins are 5.4kg, 6.2kg, 3.2kg, 3.7kg, 3kg, 0.2kg and 0.1kg respectively; while their corresponding maximum values are 23.9kg, 16.4kg, 43.2kg, 12.6kg, 11.2kg, 4.3kg and 4.7kg respectively. The household and commercial waste was seen to hold more moisture content at 41.8% and 32.5% respectively. This level can be attributed to the high occurrence of organic waste in the waste stream. The more moisture, the more leachate production and microbial activities. The bulk density of the commercial and household waste was 0.5kg/l and 0.6kg/l. The study conducted by [23, 24 & 25] all agree with the results where food and garden waste occupy the highest percentage in the waste stream in Port-Harcourt. They also concur that paper and plastics are not far behind the biodegradables in the study areas.

The characterization showed homogeneousness in the waste streams across the sample locations, except in some special waste types which were location-specific, such as medical waste, metals and electronics. This means that 90% one-type-fits-all waste management (WM) strategies can be implemented in the municipality. About 27% of the waste stream were discovered to be organics, showing that composting must be one of the top strategies for disposal. Other waste streams like papers, plastic packaging and rigid plastics occupied about 43% stream space, signifying that reuse and recycling is necessary to reduce the total percentage waste tonnage entering the final disposal sites. These methods of WM will provide job employment for a good number of the municipality's citizens.

REFERENCES

- [1] ASTM D5231-92 (2008). <https://cdn.standards.iteh.ai/samples/65549/94c20f86b4d54608bae2625503a28ddb/ASTM-D5231-92-2008>. Assessed 25th August 2021.
- [2] Lenihan, Terra "Waste Reduction." *Pollution A to Z*. Retrieved November 20, 2019 from Encyclopedia.com:<https://www.encyclopedia.com/environment/educationalmagazines/waste-reduction>
- [3] Okereke, C. D. & Onyeche, T. I. (2020). Environmental Pollution Control: 52-78. Lambert Academic Publishing, Schaltungsdienst Lange o.H.G., Berlin (2nd Edition).
- [4] EPA 1996. <https://archive.epa.gov/epawaste/nonhaz/municipal/web/pdf/msw97rpt.pdf>. Assessed 28th June 2021.
- [5] Owojori, O., Edokpayi, J. N., Mulaudzi, R., & Odiyo, J. O. (2020). Characterisation, Recovery and Recycling Potential of Solid Waste in a University of a Developing Economy. *Sustainability*, 12(12): 5111.
- [6] EPA 2020. <https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management>. Assessed 6th July 2021.
- [7] Martin, J. H., Collins, A. R., & Diener, R. G. (1995). A Sampling Protocol for Composting, Recycling, and Re-use of Municipal Solid Waste. *Journal of the Air & Waste Management Association*, 45(11): 864-870.
- [8] Tonjes, D. J., & Greene, K. L. (2012). A review of national municipal solid waste generation assessments in the USA. *Waste Management & Research*, 30(8), 758-771.
- [9] EPA 2014. https://www.epa.gov/sites/default/files/2016-11/documents/2014_smmfactsheet_508.pdf. Assessed 2nd July 2021.
- [10] Aphale, O., Thyberg, K. L., & Tonjes, D. J. (2015). Differences in Waste Generation, Waste Composition, And Source Separation Across Three Waste Districts in a New York Suburb. *Resources, Conservation and Recycling*, 99: 19-28.
- [11] Ozcan, H. K., Guvenc, S. Y., Guvenc, L., & Demir, G. (2016). Municipal Solid Waste Characterization According to Different Income Levels: A Case Study. *Sustainability*, 8(10): 1044.
- [12] Smyth, D. P., Fredeen, A. L., & Booth, A. L. (2010). Reducing Solid Waste in Higher Education: The first Step Towards 'Greening' a University Campus. *Resources, Conservation and Recycling*, 54(11): 1007-1016.
- [13] Edjabou, M. E., Jensen, M. B., Götze, R., Pivnenko, K., Petersen, C., Scheutz, C., & Astrup, T. F. (2015). Municipal Solid Waste Composition: Sampling Methodology, Statistical Analyses, and Case Study Evaluation. *Waste Management*, 36: 12-23.
- [14] ASTM D5231-92 (2008). <https://cdn.standards.iteh.ai/samples/65549/94c20f86b4d54608bae2625503a28ddb/ASTM-D5231-92-2008>. Assessed 25th August 2021.
- [15] Loremikan A. G. (2020). Solid Waste Characterization at Classified Solid Waste Dumpsites in Port Harcourt, Nigeria. *International Journal of Research and Scientific Innovation (IJRSI)*, 7 (10): 266-271.
- [16] Emine, A. J., Ugochukwu, N. H., & Adiamologi, N. C. (2022). Facilitating Solid Waste Handling System in Port Harcourt Cosmopolis. *Turkish Journal of Agriculture-Food Science and Technology*, 10(10): 2016-2020.
- [17] Onuegbu, I. V. & Gunorubon, A. J. (2018). Characteristics and Composition Analysis of Municipal Solid Waste in Port Harcourt City, Nigeria – A Prelude to Methane Emission Estimation in the City's Dump Sites. *International Journal of Scientific & Engineering Research* 9(2): 2004-2009.
- [18] Nwankwo, C., Amah, V. and Onwukwe, Q. (2016). Solid Waste Management Plan at Ibiminapolo Community, Port Harcourt Nigeria. *Uniport Journal of Engineering and Scientific Research (UJESR)*, 1(1): 31-36.
- [19] Audu, H. A. P., Aigwi, I. E., & Enaboifo, M. A. (2015). Solid Waste Composition Analysis for the Development of a Suitable Waste Disposal System in Port Harcourt LGA of Rivers State, Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences*, 6(2): 113-119.
- [20] Babatunde, B. B., Vincent-Akpu, I. F., Woke, G. N., Atarhinyo, E., Aharanwa, U. C., Green, A. F., & Isaac-Joe, O. (2013). Comparative Analysis of Municipal Solid Waste (MSW) Composition in Three Local Government Areas in Rivers State, Nigeria. *African journal of Environmental Science and Technology*, 7(9): 874-881.

- [21] Macpeple, E. D., Okereke, C. D., Egwuonwu, C. C., & Tom, C. N. Solid Waste Management in Port-Harcourt Municipality. *International Journal of Advances in Engineering and Management (IJAEM)*, Volume 6, Issue 10 Oct. 2024, pp: 01-12
- [22] Okereke, C. D. (2006). *Environmental Pollution Control*: 52.
- [23] Ugorji, H. I., Onwujiariri, C. M., & Nkwocha, E. E. (2020). Solid Waste Generation and Disposal in Owerri Municipality, Imo State, Nigeria. *International Journal of Scientific Engineering and Science*, 4(7): 67-73.
- [24] Okere, K. J., Abu, G. O., & Ndukwu, B. (2018). Estimation and Characterization of Municipal Solid Waste in Nekede Landfill, Owerri Metropolis, Nigeria. *International Journal of Engineering and Applied Sciences (IJEAS)*, 5(3): 93-100.
- [25] Alao, J. O., Ayejoto, D. A., Fahad, A., Mohammed, M. A., Saqr, A. M., & Joy, A. O. (2024). Environmental Burden of Waste Generation and Management in Nigeria. In *Technical Landfills and Waste Management: Volume 2: Municipal Solid Waste Management* (pp. 27-56). Cham: Springer Nature Switzerland.

Table 1. Waste Streams at Sample Locations

WASTE STREAMS (kg)	SAMPLE LOCATIONS												AVERAGE
	Obinze	Nekede	Ihiagwa	Avo	Douglas	Wetheral	Mbaise Rd	Okigwe Rd	Orji	World Bank	Nazi	Commercial	
Food Waste	46.2	45.1	41.6	42.2	46.3	51.8	44.6	49.2	46.3	51.5	40.2	19.5	43.7
Garden Waste	5.9	4.1	4.5	6.7	4.3	5.2	5.8	4.8	5.8	7.4	5.1	13.7	6.1
Packaging	9.2	12.7	7.1	5.8	10.3	9.6	8.2	9.9	7.4	11.7	9.8	12	9.5
Newspapers - Brochures	3.6	2.2	2.8	2.3	3.9	6.2	4.1	5.1	4.1	4.5	3.6	13.4	4.7
Magazines and Glossy paper		0.9	1.6		0.1	1.5	1.8	2	0.3	3.2	2.8	10.2	2.4
Other papers	0.9	2.4	1.5	0.2	0.8	1.9	0.3	2.1	0.6	0.3	1.4	7.3	1.6
Flat packaging cardboard	0.2	1.7	2.1	0.2	3.1	1.6	0.4	0.7		0.1	0.3	8.7	1.7
Corrugated packaging board	0.1	0.4	1.1		2.1		1.8	0.2			2	2.2	1.2
Other cardboard												6	6.0

Cardboard composite packaging		0.8	1.2		2.3		1.4	0.7	0.3		1.3	4.1	1.5
Liquid packaging AL	2.7	3.1	2.4	1.1	5.7	4.2	2.1	3.9	1.2	4.2	3.7	1.8	3.0
Liquid packaging Non-AL	1.4	0.2	0.1	0.3	3.5	2.7	1.3	2.8	1.5	4.8	1.2	4.9	2.1
Disposable nappies	13.4	16.9	19.2	26	28.3	18.4	23.8	25.2	22.1	28	14.5	1.5	19.8
Other composite packaging	1.2	0.7	1.8	0.2	4.1	2.6	1.4	3.4	1.3	2.4	2	0.3	1.8
Packaging (textiles)	0.1	0.3	0.4	0.1	1.7	1	0.2	0.9	0.6	0.5	0.3	1.3	0.6
Other textiles			0.1	0.1	0.5	0.2	0.1	0.1	0.5	0.9	2	0.5	0.5
Health care textiles	0.2	0.1	1.3	0.1	0.6	1.9	1.4	1.8	0.3	0.2	1.2	15.7	2.1
Mixed flexible plastic	3.2	5.1	4.9	2.4	5.3	4.8	3.2	3.7	4.1	3.9	2.9	2.4	3.8
Clear PVC bottles	2.2	4.2	3.5	1	4.7	3.4	2.6	4.2	1.9	3.6	2.6	5.3	3.3
Clear PET bottles	1.8	7.5			2.1	1.7	3.7		3.3	6.1	1	7.9	3.9
Mixed rigid plastic	23.1	37.4	32	21.2	28.3	23.4	22.7	19.9	20.8	26	18.2	26.7	25.0
Opaque PVC jars and bottles	1.2	2.4	3.2	2.7	3.6	4.5	5	1.4	2.2	3.2	2.4	0.3	2.7
Green PET jars and		0.6		1	1.8	0.8	1.5	0.4	0.3			2.8	1.2

bottles													
Brown PET jars and bottles		1.2			0.8				0.1			1.7	0.7
PE bottles	4.6	8.9	5.1	4.3	5.2	3	2.9	7.3	3.5	3.9	4.2	11	5.3
Super market bags	10.6	13.1	10.2	9.1	12.8	12.3	8.2	9.5	11.2	8.9	6.2	6.2	9.9
Other plastic packaging	13.2	23.6	14.2	11.7	15.6	21.7	18	14.5	11.1	13.7	16.2	3.9	14.8
Other plastic waste (Styrofoam)	4.2	8.3	5.1	4.4	10	10.2	7.4	6.1	3.3	5.2	5.9	14.8	7.1
Green glass packaging	0.6	1.3	2.2	2	4.3	2.8	1.4	2	3.2			0.4	2.0
Clear glass packaging	4.3	4	2.6	1.4	6.1	4.5	1.3	1.8	3.3	2.7	2.2	1.5	3.0
Brown glass packaging		3.2	1.2	1.8	3.6	1.4		1.6		1.2	5	0.6	2.2
Packaging glass other colour	0.2	0.4	0.7	0.1	0.9	0.5	0.5	0.2	0.1	0.7	0.4	0.3	0.4
Other glass waste		1.3	0.1		0.2		0.2	0.3		0.5		0.1	0.4
Ferrous metal packaging	1.6	1.9	1.2	0.2	1.3	0.6		1.5	1.8	1.1	1.8	2.7	1.4
Other ferrous metal waste			1.4	1.7	2.1	1.3		0.6				2.4	1.4
Aluminum packaging	2.4	4.1	1.3	4.2	4.5	6.2	0.8	2.6	2.8	3.4	1.5	9	3.6
Other aluminum	0.1	0.3	0.1	0.6	0.1	1.7	0.8	1.4	0.6	1.5	2.4	3	1.1

um waste													
Other metal packaging	0.1	0.9	0.2	0.9	0.6	0.2	0.1	0.4	0.2		0.1	2.6	0.6
Other metal waste	1.7	1.4	3.1	2	1.9	0.5	0.2	1.6	1.1	0.3	1	4.7	1.6
Paints, ink, paste and resins	1.2	2.4	1.5	2,1	2,4	1.4	0.2	0.3	1.2	0.7	1.3	3.5	1.4
Batteries and accumulators		0.5	0.2		0.6	0.5	0.1	0.3	0.5		0.2	6.2	1.0
Fluorescent tubes and other mercury-containing wastes		0.1		0.2	0.4	0.3	0.1	0.3	0.2			8.4	1.3
Electronic equipment	1.1	0.8	0.6	1.1	2.1	4.2	4	3.3	0.2	2.3	1.4	15.7	3.1
Other special domestic wastes	3.2	3.6	2.9	3.2	3.5	4.2	3.3	2.1	1.7	2.9	1.3	5.3	3.1
Wood packaging	1.3	0.8	0.4	1.5	1.2	2.1	0.9	0.3	0.5	0.1	2.4	2.6	1.2
Other combustible packaging	2.2	2.2	1.4	1.2	2.7	3.2	2.3	3.2	1.2	0.4	1.9	4.8	2.2
Other unclassified combustibles	1.3	2.4	1.6	1.8	2.5	1.7	1.3	2.1	1.3	2.3	1.5	6.1	2.2
Unclassified incombustible packaging		0.1			0.2	0.1	0.3	0.4	0.1	0.4	0.3	3.7	0.6

ing													
Other unclassified incombustibles	0.1	0.2	0.2		0.4	0.1				0.2	0.1	5.2	0.2
Fine elements smaller than 20mm round mesh	0.8	0.9	0.5	0.9	1.1	0.7	0.4	0.3	0.4	0.3	0.9	0.2	0.6
TOTAL	171.4	236.7	188.6	167.9	247.3	232.8	192.1	206.4	174.5	215.2	176.7	295.1	220.2

Table 2. Comparative Percentage Results for 8 Predominant Waste Streams at the Sample Locations

Waste Stream (%)	Obinze	Nekede	Ihiagwa	Avo	Douglas	Wetheral	Mbaise Road	Okigwe Road	Orji	World Bank	Nazi	Commercial
Food waste	27	19	22	25	19	22	23	24	27	24	23	7
Garden waste	3	2	2	4	2	2	3	2	4	3	3	5
Packaging (paper)	5	5	4	3	4	4	4	5	4	5	6	4
Disposable nappies	8	7	10	15	11	8	12	12	13	13	8	1
Mixed rigid plastics	13	10	17	13	11	10	12	10	12	12	10	9
Supermarket bags	6	6	5	5	5	5	4	5	6	4	4	2
Other plastic packaging	8	10	8	7	6	9	9	7	6	6	9	1
Other plastic waste (styrofoam)	2	4	3	3	4	4	4	3	2	2	3	5

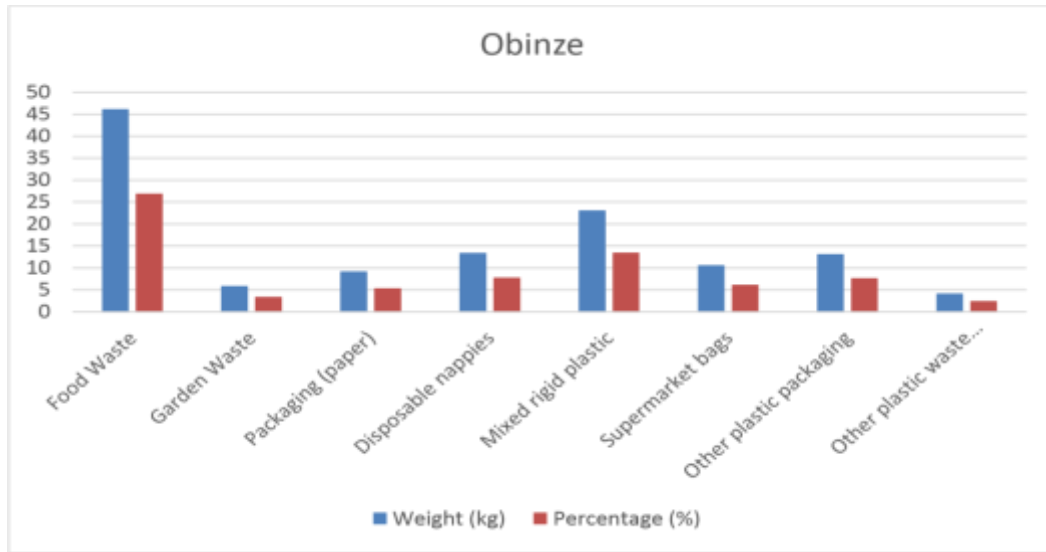


Figure 1. Waste Streams for Obinna

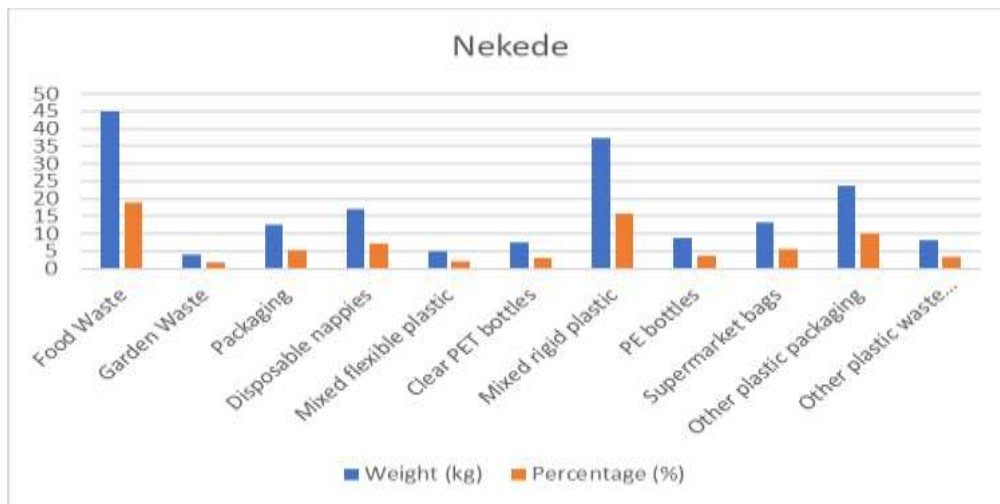


Figure 2. Waste Streams for Nekede

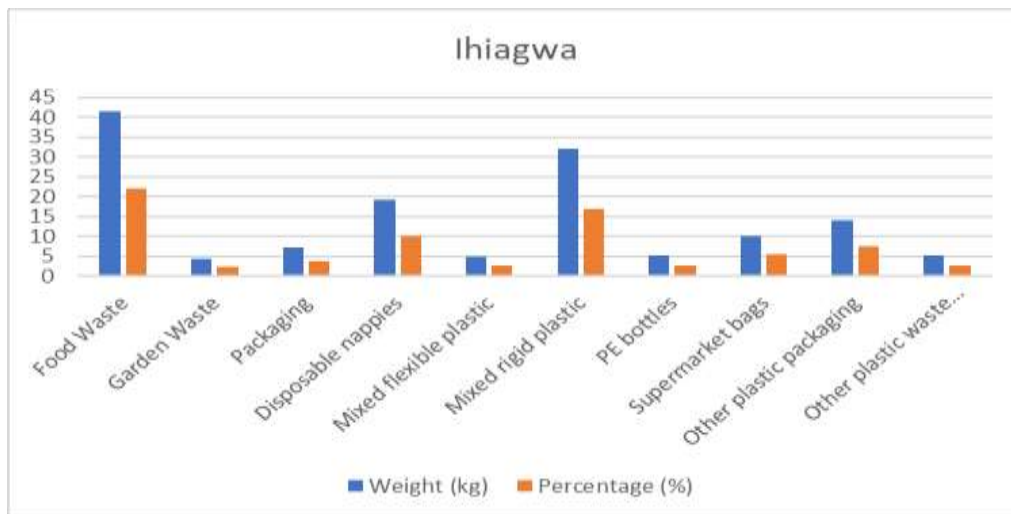


Figure 3. Waste Streams for Ihiagwa

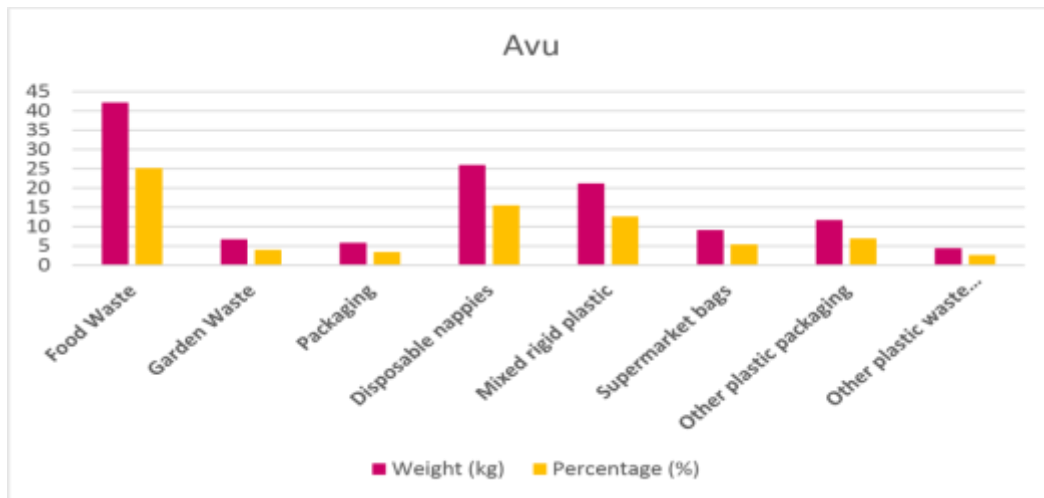


Figure 4. Waste Streams for Avu

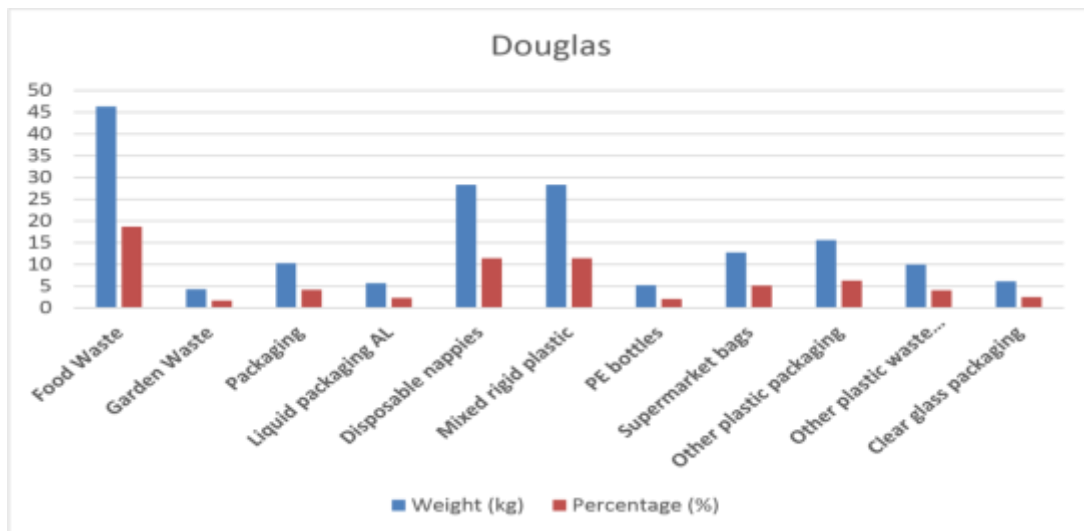


Figure 5. Waste Streams for Douglas

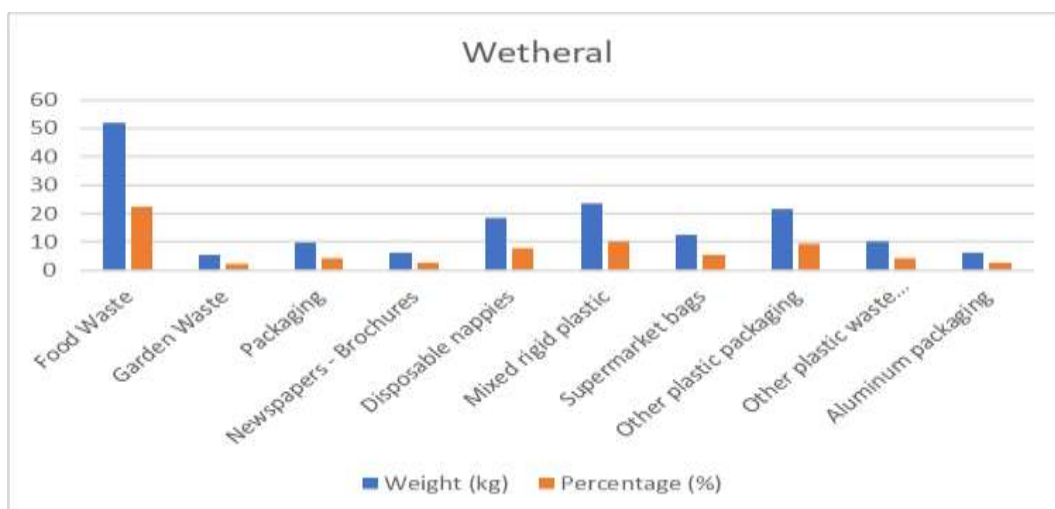


Figure 6. Waste Streams for Wetheral

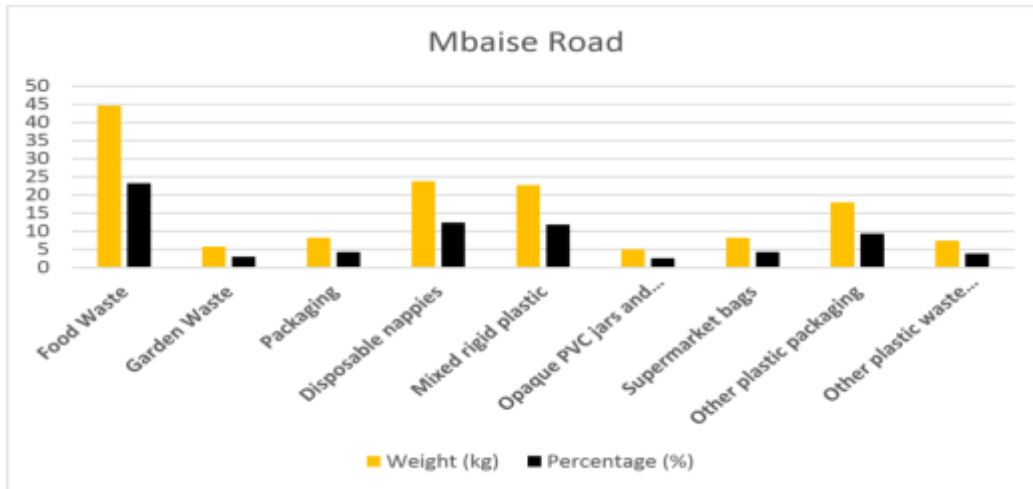


Figure 7. Waste Streams for Mbaise road

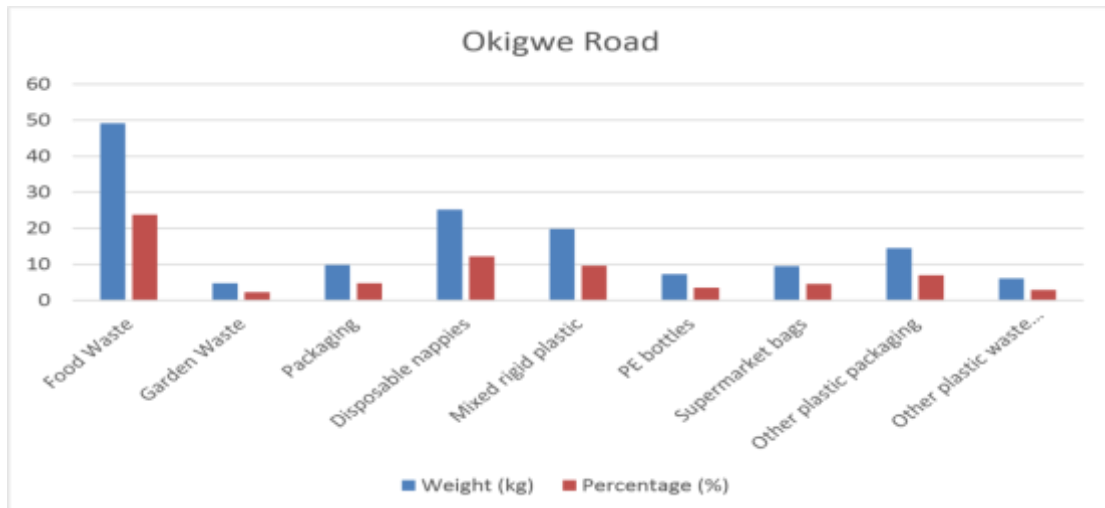


Figure 8. Waste Streams for Okigwe road

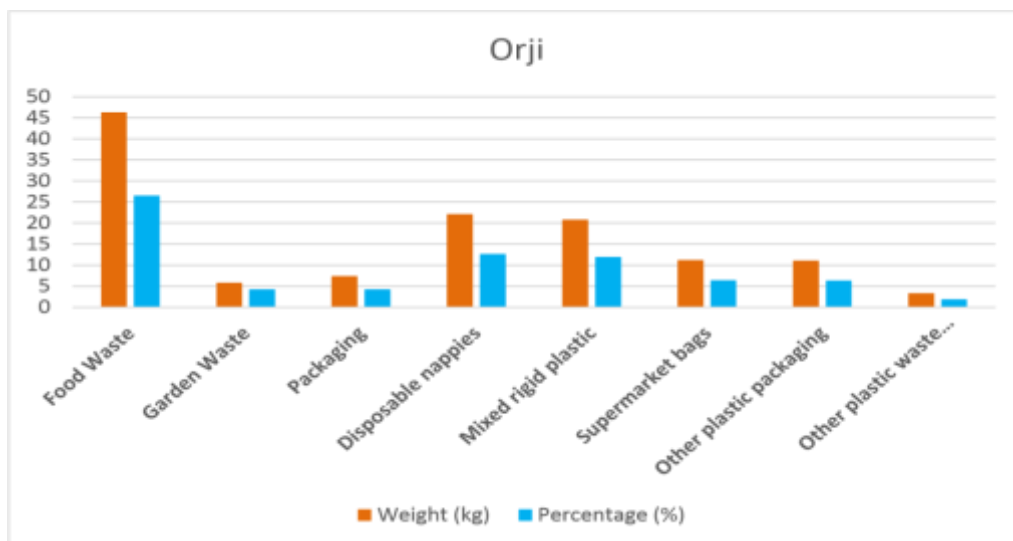


Figure 9. Waste Streams for New Orji

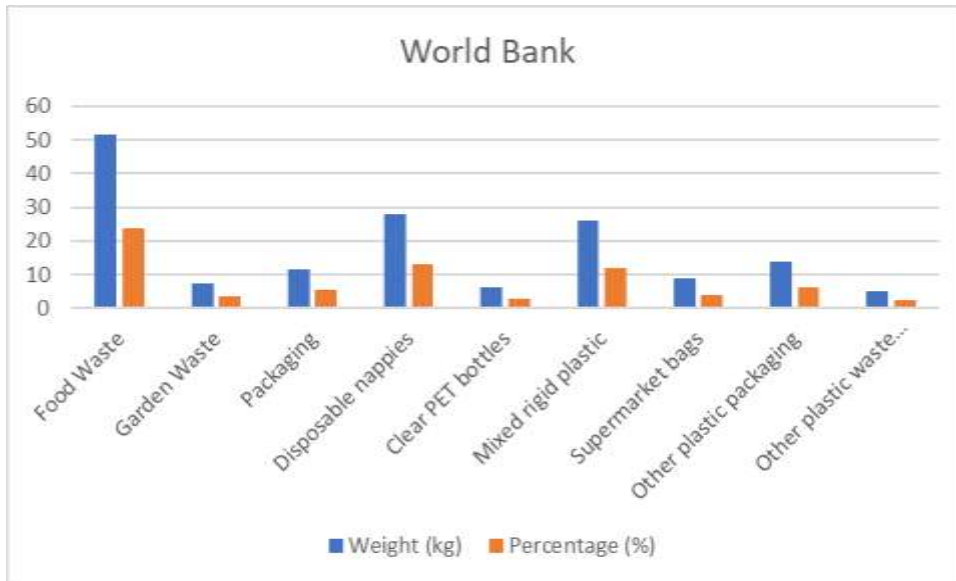


Figure 10. Waste Streams for World Bank

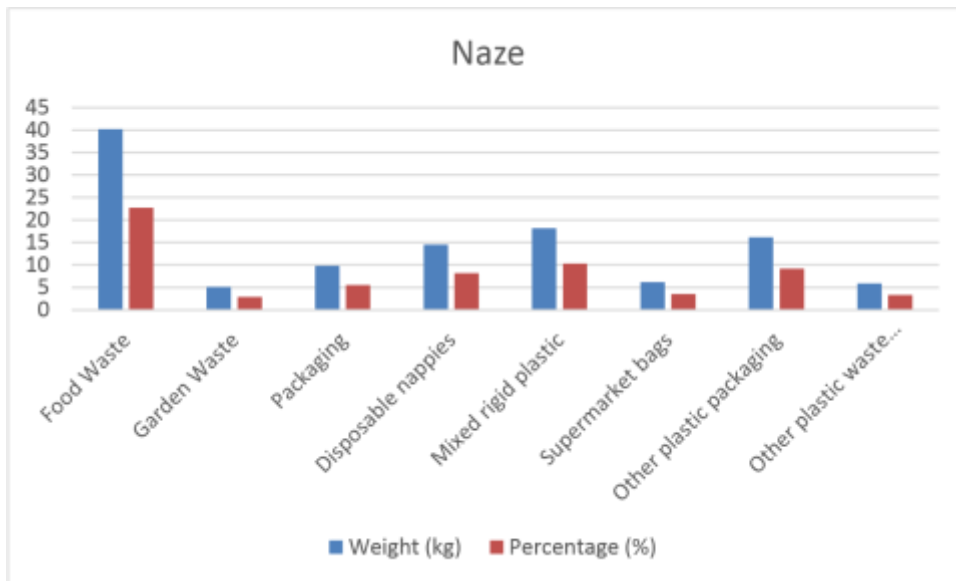


Figure 11. Waste Streams for Naze