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Municipal Solid Waste Characterisation Survey in Owerri, Imo State, Nigeria

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ABSTRACT:Characterization of generated solid waste is a prerequisite in the development of a sustainable solid waste management system anywhere in the world. This study investigated the quantity and types of municipal solid waste, comprising of household and commercial waste in 11 locations in Owerri municipality. The ASTM direct sampling method was employed, where a total of 2,209.6kg of household waste and 295.1kg of commercial waste was sampled. The results were subjected to descriptive analysis using IBM SPSS Statistics software, moisture content and bulk density analysis. There were 50 different waste streams 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. Food waste had a percentage of 19.8%, while mixed rigid plastic, other plastic packaging and disposable nappies sat on the percentages of 11.3%, 6.7% and 9.0% respectively. The characterization survey showed homogeneousness in the waste streams across the sample locations, thus 90% one-type-fits-all waste management strategy can be implemented in the municipality.

KEYWORDS: Solid waste, Management, Owerri, Characterisation, Waste stream

I. INTRODUCTION

Solid waste management has remained a major problem globally. However, the case of developing countries in waste management has been even more challenging in the sense that over the years, there has not been much significant positive sustainable management of solid waste. To manage solid waste effectively, waste management personnel must understand the quantity, types, composition and variation of generated solid waste. This makes for better planning in terms of infrastructure, equipment and financial availability for solid waste management.

Several different approaches have been used to estimate waste stream composition. A commonly referenced method for conducting a waste composition study is the American Society for Testing and Materials (ASTM)'s Standard Test Method. (ASTM D5231). ASTM D5231 describes the procedures for measuring the composition of unprocessed municipal solid waste by employing manual sorting. It was developed in accordance with internationally recognized principles on standardization established in the decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) committee.

Municipal solid waste was also characterized in Owerri municipal to acquire knowledge for resource recovery potential and waste minimization by [1]. [2] was employed for sampling and proximate and ultimate analysis performed on the representative samples. SPSS version 20 was used for analysis of variance (ANOVA) to identify the mean difference. Results showed food waste (19.8%) as the most dominant waste component, followed by plastics bottles having a score of 16.69%. Metal cans had the least presence of 1.09%. This gives rise to the ability of the waste being recovered for energy, recycling and composting; which increases the possibility of a decrease in disposal at dumpsites. [3] conducted a waste characterization study in Owerri in an attempt at closing the knowledge gap on the current waste generation and streams in the municipal. They believe an integrated SWM program can be achieved if this data is known. Their survey involved using structured questionnaire, waste sample collection and observation. Results showed a 0.58kg/cap/day waste generation, giving a total of 319.67 tons of waste generated per day in the study area. They recommend composting of waste as a treatment method since over 60% of the waste generated were biodegradable. [4] researched on the estimation and characterization of municipal solid waste at the Nekede dumpsite in Owerri municipality in a bid to recommend the outcome for developing the right policies and strategies for an efficient solid waste management. Data was harnessed from literature and stakeholders from the public and private sectors. Results showed that between 19,650 – 30,000 tons of waste were disposed at the Nekede dumpsite on a monthly basis. They also discovered the per capita generation of solid waste in Owerri to be between 1.24kg – 1.90kg, with food waste having a mean occurrence of 58.4kg in the composition.

II. MATERIALS AND METHODS

Study Area

According to [5], "Owerri city (Figure 1) is located in the South Eastern zone of Nigeria, and lies between latitude 50°N to 60°30′N and Longitude 60°E to 70°34′E, sitting at the intersection of roads from Port Harcourt, Onitsha, Aba, Orlu, Okigwe and Umuahia. Figure 2.1 shows a map of Owerri municipal which has a total landmass of 24.88 square kilometers and a projected population of 632,781 (2019 estimates) based on 2012 estimates, and it is forecasted to be one of the biggest cities come the year 2025 due to its annual population growth rate of 3.2 percent. The weather and climatic conditions in Owerri encourages economic activities such as agriculture (palm products, corn [maize], yams, cassava, etc.), tourism, and small-scale industries. Owerri has an average temperature of about 27˚C (80˚F). Its vegetation is typically rain forest (although some parts consist of Guinea Savanna due to poor environmental management and pollution). Its inhabitants are mainly civil servants, traders and farmers who are predominantly native. Owerri West is a Local Government Area of Imo State, Nigeria. Its headquarters are in the town of Umuguma. A very large portion of the local government constitute the capital city of Imo State, Nigeria. It has an area of 295 km² and a population of 99,265 at the 2006 census. Owerri West comprises of the following communities: Umuguma, Avu, Okuku, Oforola, Obinze, Nekede, Ihiagwa, Eziobodo, Okolochi, Emeabiam, Irete, Orogwe, Amakohia, Ndegwu and Ohii".

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 [6]. Waste samples were collected from 50 individual households [7] 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 220kg 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" [5].

"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" [5].

"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, Camry100kg 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)" [5].

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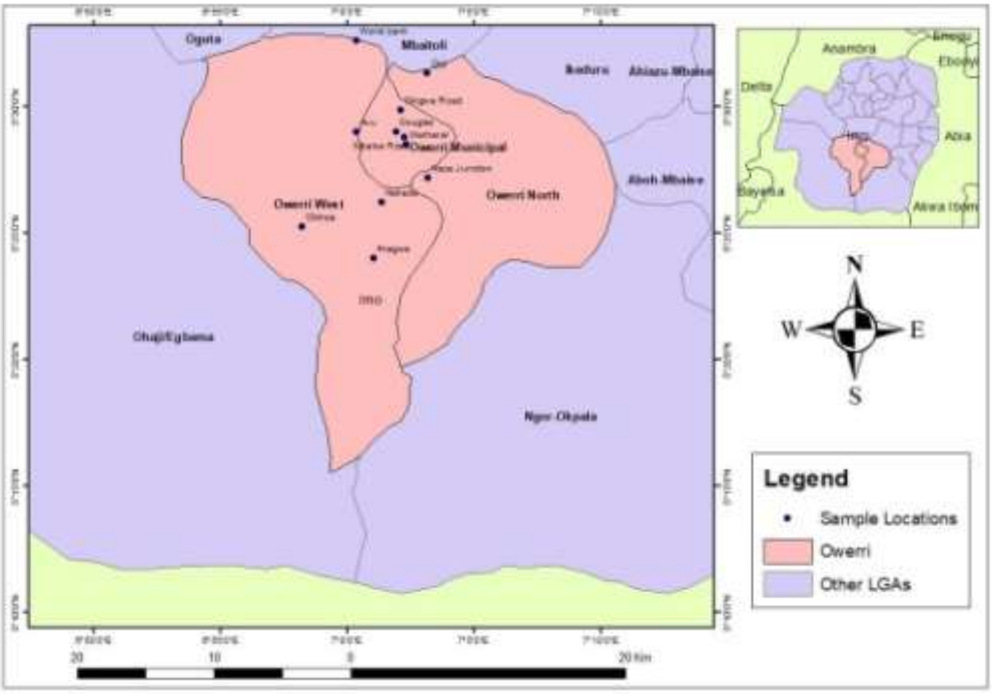

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Figure 1. Map of Owerri (Macpepple et al. 2024)

III. RESULTS AND DISCUSSION

Eleven sample locations were surveyed and 50 different waste streams identified, out of which 8 were more prominent in mass. These streams were food waste, garden waste, paper packaging, disposable nappies, mixed rigid plastics, supermarket bags, other plastic packaging, and styrofoam. Table 3.1 shows the identified waste streams and their mass solid waste composition in kilograms, while Tables 3.2 shows the 8 most prominent waste streams in percentages. Figures 3.1 to 3.11 shows the waste streams for the 11 sample locations with their various constituents' weights and percentages.

A total of 2,209.6kg of household waste and 295.1kg of commercial waste was characterized. Food waste stream had the highest mean occurrence at 43.7kg. Wetheral and World bank recorded the most weight having 51.8kg and 51.5kg respectively. In the commercial areas, the weight occurrence of food waste is 19.5kg. In percentages, food waste is 19.8%, mixed rigid plastic, other plastic packaging and disposable nappies sat on the percentages of 11.3%, 6.7% and 9.0% respectively. The standard error of the mean did not exceed 2 which is good, while the skewness and kurtosis is satisfactory for the data gotten.

Organics had the most presence in the waste streams. The characterization also 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 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 municipalities' citizens. This therefore justifies one of the intended outcomes of this research, namely, job creation.

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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**
Healthcare 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 bottles		0.6		1	1.8	0.8	1.5	0.4	0.3			2.8	**1.2**
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**
Supermarket 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	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**

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plastic waste (Styrofoam)													
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 waste	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**
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**

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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**
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

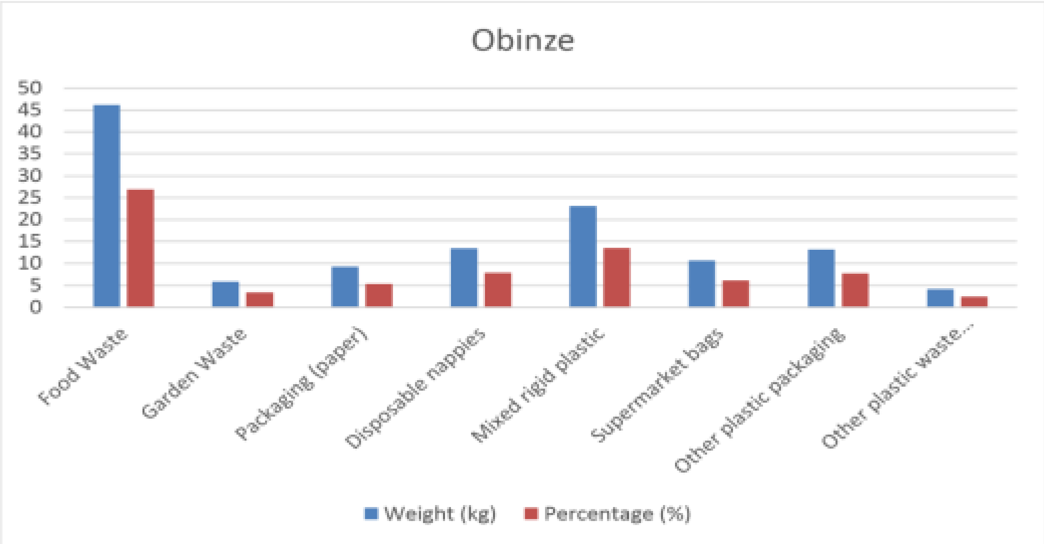

Figure 1. Waste Streams for Obinna

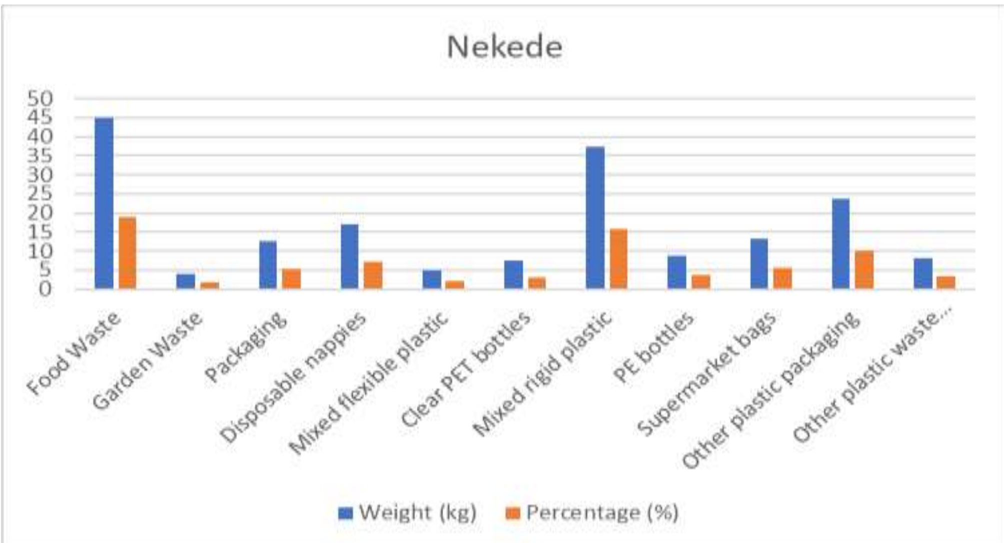

Figure 2. Waste Streams for Nekede

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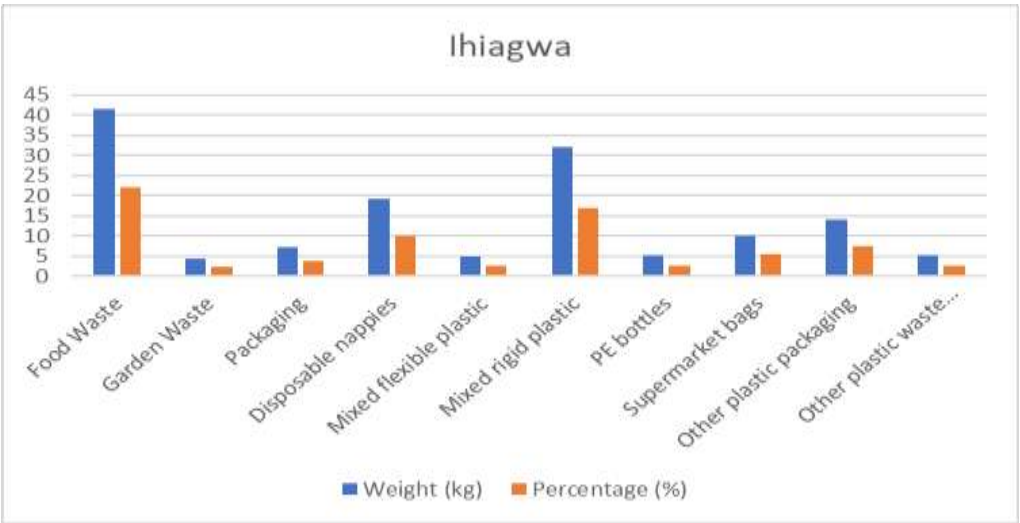

Figure 3. Waste Streams for Ihiagwa

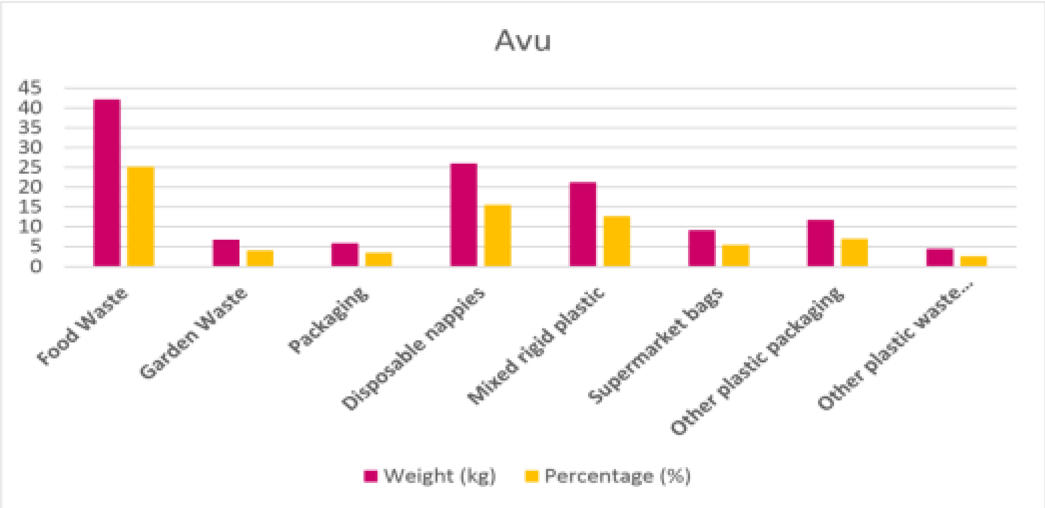

Figure 4. Waste Streams for Avu

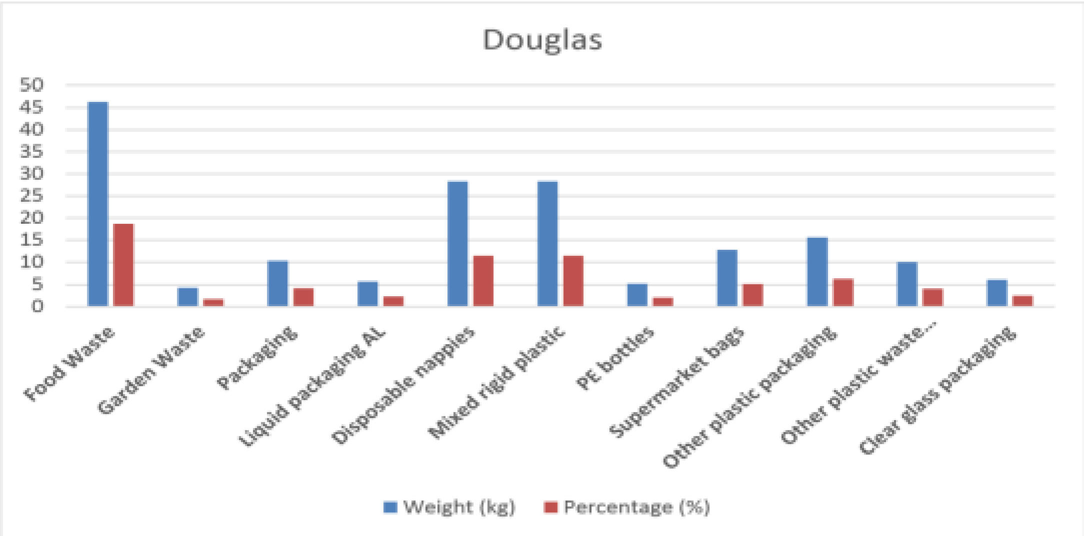

Figure 5. Waste Streams for Douglas

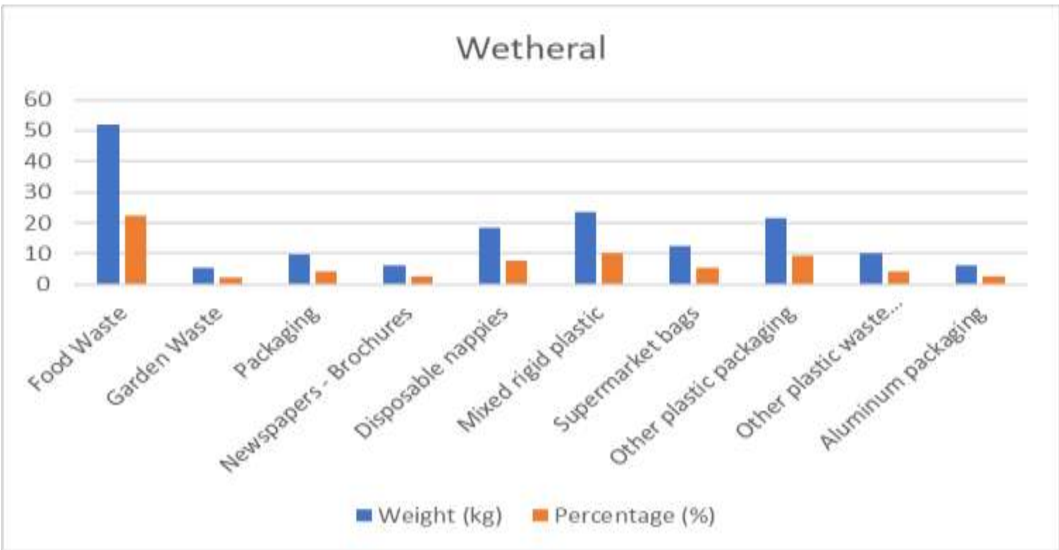

Figure 6. Waste Streams for Wetheral

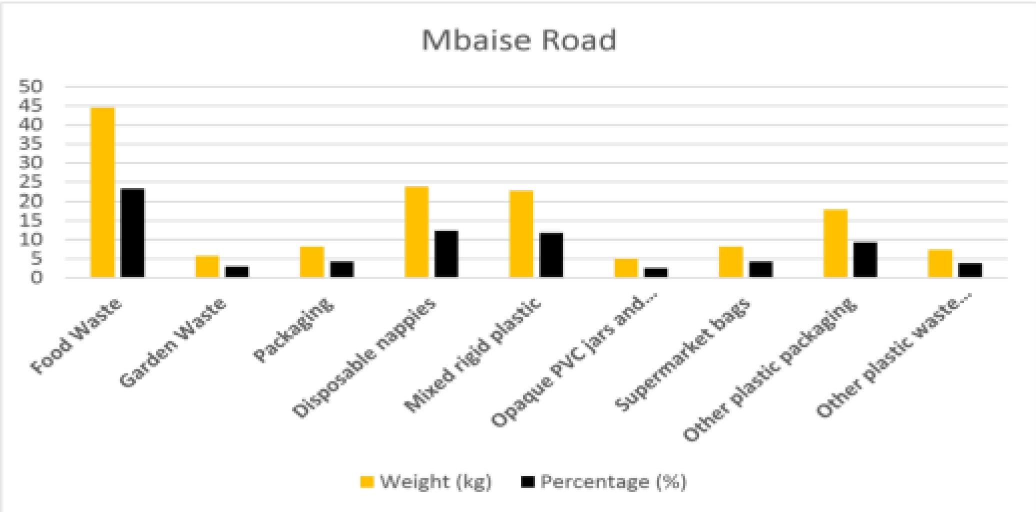

Figure 7. Waste Streams for Mbaise road

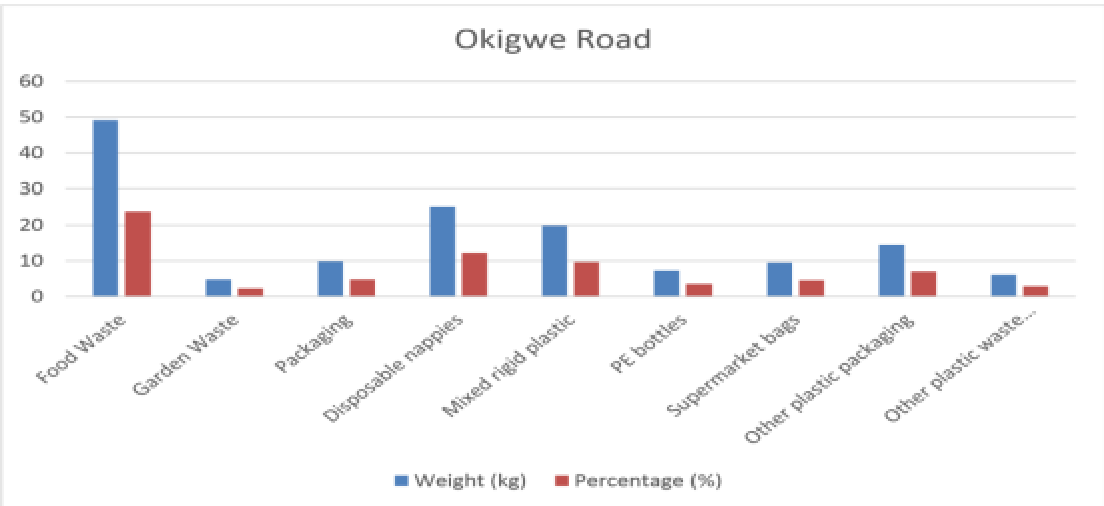

Figure 8. Waste Streams for Okigwe road

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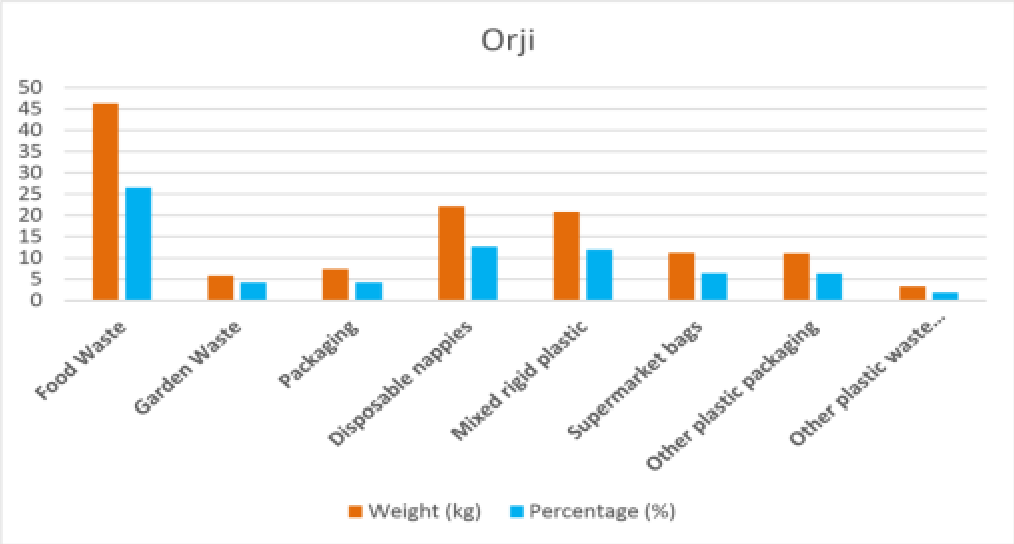

Figure 9. Waste Streams for New Orji

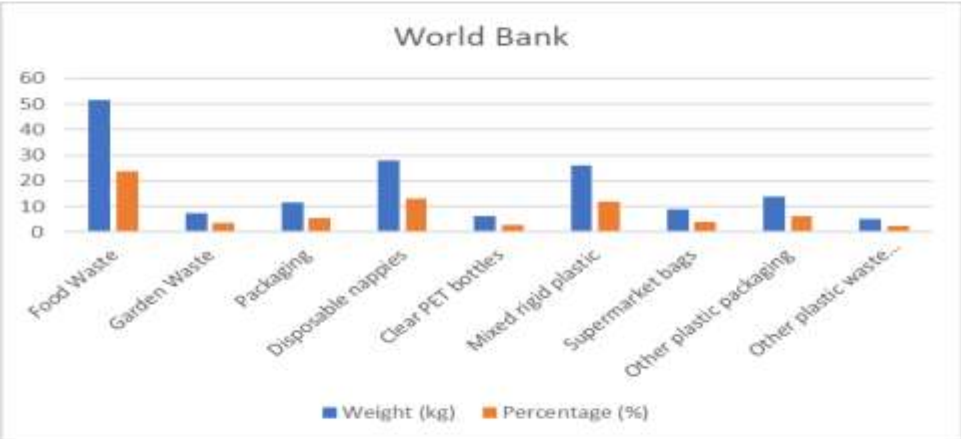

Figure 10. Waste Streams for World Bank

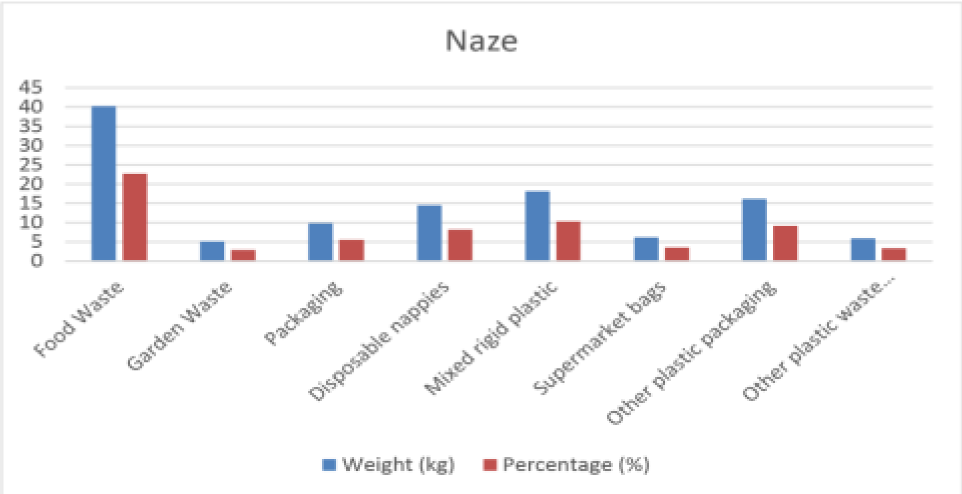

Figure 11. Waste Streams for Naze