STATUS OF SOLID WASTE COMPOSITION AND QUANTITY AMONG VARYING HOUSEHOLDS IN IBADAN METROPOLIS, NIGERIA

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Abstract

Household solid wastes have varied quantity and composition in many urban centres. A waste audit was conducted among 250 volunteer households, in low, medium, and high residential densities at 50 households per Local Government Area in the Ibadan metropolis. Community sensitization was undertaken, followed by collection, weighing, and sorting of solid waste into over 40 categories. Analysis revealed the classes of waste to be organics 41.5%; plastics 21.4%; other waste 19.3%; Paper and paper board 8.4%; textile 3.4%; metal 2.7%; glass 1.9%; special care waste 0.7%, and construction and demolition waste; 0.7%. Waste generation rates were 0.17, 0.07 and 0.04kg/capita/day for low-, medium- and high-density areas respectively. About 41.8% of the waste was compostable, 37.9% recyclable, while 20.3% could be disposed of appropriately. Analysis revealed that a significant relationship exists between some socio-economic characteristics and percentage composition of waste, while religion and ethnicity of the respondents were not significant. It is recommended that households sort their waste from source to reduce the unusable quantity that would be disposed of at dumpsites.

Keywords: Household solid waste, Waste audit, Waste composition, Organics, Plastics, per capita waste, Ibadan metropolis, Nigeria.

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1 Introduction

The rising quantity and changing composition of solid wastes are posing an ever-increasing problem in many cities of the world. Ibadan, the capital of Oyo State, is a city that is daily grappling with the problems of mounting solid waste and poor disposal, which have portrayed the city as one of the dirtiest in Nigeria (Agbola and Mabawanku, 1996). This is also a major contributor to blocked drains and flooding (Oyo State Government, 2018). The exact quantities of waste generated in Ibadan are very difficult to determine probably due to diverse methods of calculation. However, many studies have given different estimates. Mclaren International Ltd. (1970) found the average per capita quantity of solid waste generated to be 0.37-0.5kg/day for the core area of the city. Oluwande (1983) estimated the average solid waste generated and its mean production rates per head for three density areas of Ibadan as 0.420kg/day in Government Reserved Areas; 0.377kg/day in out-laying areas and 0.35kg/day in the core area. Egunjobi (1986), estimated 0.32kg/day, which implies that 38 million kg solid waste was generated in 1986, using 1.6 million population estimates for the period as a yardstick. Studies conducted by Haskoning and Konsadem Associate (1994) revealed 0.6kg/day of wastes, with a density of 300kg/m3. In terms of waste composition, most of the substances found in the municipal waste stream in Ibadan and among many other cities in Nigeria, are mainly from paper, leaves, bones, ash dust, vegetable matters, plastics, metals, textiles, stones, rubber, and glass. Leaves and vegetable matter constitutes the bulk of the waste because raw food materials are brought to the city unprocessed. Sridhar (2016) buttresses this by indicating that organic matter constitutes about 60 to 80% of the total waste stream, while plastics/nylon and scrap metals are major recyclable constituents. There is, however, an increase in plastic/nylon and some recyclables which were not very conspicuous in the past due to lifestyle changes among urban dwellers (Wahab and Sridhar, 2014). Other factors include the fact that Ibadan is located in the heart of a rich agricultural land that has a lot of old and unplanned sections coupled with the change in the consumption pattern of the residents, which has led to the increase in leaves, tins, metals, papers, bones, ash dust, and stones as major solid waste items found in the city (Mudasiru, 2014). Despite these changes and differing methods in solid waste characterisation, many studies such as Omole and Alakinde (2013) and Mudasiru (2014) made use of past estimates in their work. Waste audit, also known as compositional analysis, is an analysis of 3 particular waste streams, which can

identify the types of waste and recyclable materials a household generates and how much of each category is recovered for recycling or adequate disposal. A comprehensive and up to date audit is essential for waste managers, investors as well as the planners alike. This study focuses attention on the composition and quantity of solid waste generated by varying households in Ibadan and how socio-economic characteristics affect them as well as resulting policy implication.

2 Materials and Methods

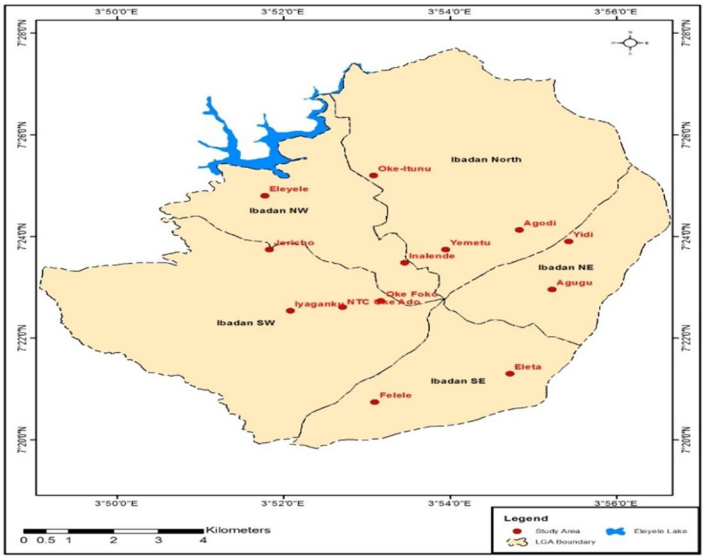
2.1 Study Area

Ibadan is located approximately on longitude 3°55' East of the Greenwich Meridian and latitude 7°23' North of the Equator. Situated within the tropical forest zone, Ibadan is, however, closer to the boundary between the forest and the Savannah. It has a rough topography with steep slopes thus creating a dense network of streams and wide valley plains. The city ranges in elevation from 160m in the valley area to 275m above sea level on the major north-south ridge, which crosses the.

Fig 1 Map of the five urban local government areas and the selected study communities
Source: Department of Geography, University of Ibadan, 2019

central part of the city (Ayeni, 1994). Ibadan is also surrounded by ridges, such as Mapo Hill, Mokola Hill, and Aremo Hill, which allow visitors to view the whole city (Mabogunje, 1969)

A recent estimate puts her population at 6 million (Oyo State Government, 2018) making it the third-largest



city in Nigeria after Lagos and Kano as well as the most populous city in the State. There are eleven (11)

Local Government Areas (LGAs), which make up the Ibadan Metropolis, five of which are urban LGAs, while the remaining six are either predominantly peri-urban or rural LGAs. Ibadan covers a total land area of about 314,596 ha, of which 54,000ha (17.4%) is urbanised, 16,478 ha (5.2%) is built development lying within the villages and the peripheral areas of the city, while the remaining 243,500 ha (77.4%) makes up the undeveloped area, that is the agricultural land, forests and open spaces (Oyo State Government, 2018).

2.2 Sample Collection and Data Collection

A total of 250 households were purposively selected from a stratified sample of 1990 households within the 5 urban LGAs, at 50 per LGA across 13 residential communities representing low, medium, and high densities. However, Ibadan North-East and Ibadan South East LGAs were without low-density areas (Table 1).

Table 1 Residential Population Density Distribution and Sampled Households

S/N	LGA	No. of households in the selected residential area	Sample Size	Waste audit sample 50–250 (EPA, 1996)
1	Ibadan North	High: Yemetu = 1066	191	24
		Medium: Oke Itunu = 681	119	15
		Low: Agodi GRA = 492*	88	11
		Sub Total 2239	**398**	**50**
2	Ibadan North East	High: Agugu = 954	259	32
		Medium: Yidi = 520	139	18
		Low: ----	---	---
		Sub Total 1474	**398**	**50**
3	Ibadan North West	High: Inalende = 1063	226	28
		Medium: Eleyele = 555	119	15
		Low: Jericho = 237*	51	7
		Sub Total 1855	**396**	**50**
4	Ibadan South East	High: Eleta = 715	144	18
		Medium: Felele = 1270	256	32
		Low: ---	---	---
		Sub Total 1985	**400**	**50**
5	Ibadan South West	High: Oke Foko 1990*	211	26
		Medium: NTC-Oke Ado 864*	92	11
		Low: Iyaganku 873**	95	13
		Sub Total 3727	**398**	**50**
		Grand Total 11,280	**1990**	**250**

Source: National Population Commission (NPC), 1991; *NPC, 1996; **Ministry of Local Government and Chieftaincy Matters, 2001.

The combination of 1991, 1996, and 2001 population estimates showed that little data on household census was available and the justification for using these figures is because the core local government areas selected for the study, as stated in the Final Report of the Ibadan City Master Plan (Oyo State Government, 2018), were already very densely populated as at 1991 and thus had very limited capacity to accommodate new population growth. Also, the difference in the proportion of samples for each LGA was as a result of the number of households per LGA.

After proper community sensitization, the collection and manual sorting of waste samples generated by each of the selected households was done for 7 days from Saturday, 7th April to Friday, 13th April 2018. Each household was provided with 2 free colour-coded bin liners. The black nylon was used for collecting 'wet' waste that is biodegradable, while the blue bin liner was used in collecting the 'dry' wastes, which were non-biodegradable.

At the point of collection, the waste bag with its contents was weighed with a weighing scale (a digital Camry hand-held scale) and the weight of the sample bag deducted before the resulting figure was recorded on a data sheet as the weight of the waste collected. Also, details regarding the number of inhabitants within each participating household were recorded. Sorting and weighing of the waste were conducted daily and hand-sorted into 9 major waste categories by a team of 8 research assistants who were trained before the exercise. The nine major categories were further broken down to make a total of 43 sub-categories. The sub-categories used for the waste audit were adopted from UNEP/International Environmental Technology Centre (IETC)'s 2009 document and Lenkiewicz and Webster (2017).

2.3 Sorting and Weighing of Waste

The waste produced by the 250 households were collected daily and weighed at the household premises before transporting to the area designated for the waste audit exercise. Large tarps were spread on a level ground where the wastes were hand-sorted by the survey team wearing protective hand gloves and nose masks. In line with the waste minimisation strategy, the bin liners (that were used to collect the waste) were reused to sort the waste first into the major categories and later into the subcategories with proper labels. After sorting into different categories, each was weighted and recorded and then evacuated by a private waste collector appointed for the exercise. Other data on

the waste included percentage composition as well as per capita generation, using Khan and Ahsan (2003) formulae.

Following data collection, statistical analysis was carried out using frequency distribution. The stated hypothesis, there is no significant relationship between socio-economic characteristics of households, and the percentage composition of waste in selected communities was further tested using Pearson Correlation.

2.5 Health and Safety Issues

The audit team (8 field assistants and 2 supervisors) were properly equipped with personal protective equipment (PPE) which consisted of leather gloves, face masks, over-all and safety boots in addition to the appropriate training received before the commencement of the exercise. There was also the provision of a fully stocked first aid box, portable wash water facilities with soap, sanitizers, and disposable paper towels as well as other materials for the waste audit. The team members were briefed on the dangers involved in conducting the study and with strict adherence to safety issues. No injuries were recorded before, during, and after the 7-day exercise.

3 Results and Discussion

3.1 Socio-demographic Characteristics of Households

The study revealed that close to 62% of the respondents were females (Table 2). On a community level, when compared with medium and high-density communities, the low-density areas of Agodi GRA, Jericho, and Iyaganku had a higher number of male volunteers than females (Table 3). This may be explained by a high sense of insecurity felt in the low-density areas as a result of the high crime rate during the period of study.

A greater percentage of respondents close to 50% were between the age cohort of 18 – 36 years, while the least (3.2%) were 73 years and above (Table 2). In terms of educational achievements, 44.8% had a secondary education to their credit, those with tertiary education at 34% and the least (2.8%) had vocational training. Most of the respondents were Christians accounting for 53.6%, while the remaining 46.4% belonged to the Islamic faith. Being a Yoruba city, 90.8% of respondents were Yorubas, while the remaining 8.2% were either Igbos, Hausas, or other ethnic groupings. Marital status was such that a greater proportion of respondents were married (73.2%), followed by widows and divorcees at 7.6% and 1.2% respectively.

Table 2 Socio-economic characteristics of households

Variables		**Frequency**	**Percentage**
Gender	Male	96	38.4
	Female	154	61.6
	Total	250	100.0
Marital status	Single	45	18.0
	Married	183	73.2
	Divorced	3	1.2
	Widowed	19	7.6
	Total	250	100.0
Educational level	Primary	28	11.2
	Secondary	112	44.8
	Tertiary	85	34.0
	Vocational	7	2.8
	No formal education	18	7.2
	Total	250	100.0
Religion	Christianity	134	53.6
	Islam	116	46.4
	Total	250	100.0
Age	18-36 years	107	42.8
	37-54 years	83	33.2
	55-72 years	52	20.8
	73 years and above	8	3.2
	Total	250	100.0
Occupation	Farming	1	0.4
	Public/civil service	19	7.6
	Private company salary job	36	14.4
	Trading/Artisan	135	54.0
	Unemployed	22	8.8

	Others	37	14.8
	Total	250	100.0
Monthly income	No income	34	13.6
	Less than ₦20,000	72	28.8
	₦21,000-₦40,000	65	26.0
	₦41,000-₦60,000	26	10.4
	₦61,000-₦80,000	14	5.6
	₦81,000-₦100,000	10	4.0
	Above ₦100,000	29	11.6
	Total	250	100.0
Total Household	1-3	40	16.0
	4-6	99	39.6
	7-9	39	15.6
	10-12	28	11.2
	Above 12	44	17.6
	Total	250	100.0
Ethnicity	Yoruba	227	90.8
	Ibo	9	3.6
	Hausa	4	1.6
	Others	10	4.0
	Total	250	100.0

In terms of occupation, over 50% of respondents were involved in trading/artisan, those working with private companies accounted for close to 15%, unemployed 8.8%, while the least at less than 1% were involved in farming activities. Less than ₦20,000 (i.e. $55.55) was earned as monthly income by the largest number of respondents who accounted for 28.8% of the total. This was closely followed by the monthly income of between ₦21,000 – ₦40,000 ($58.33 - $111.11) by 26% of respondents. Those without income, made up 13.6%, while 11.6% of respondents earned well over ₦100,000 closely followed by 10.4%, who earned between ₦41,000 – ₦60,000. Household size for a greater majority of the respondents was between 4 and 6 at 39.6%, followed by those

claiming a household size of above12 at 17.6% and this was very common in the medium density community of Oke-Ado (Table 4). The reason for such a high figure of household size, when compared to high-density communities under study, the communal lifestyle observed in the community, especially those habiting buildings made up of multiple households.

Table 3 Gender of the Respondents within communities

Gender	Agodi	Iyaganku	Jericho	Eleyele	Felele	Oke Ado	Oke Itunu	Yidi	Agugu	Eleta	Foko	Inalende	Yemetu	Total
Male	7	7	7	5	12	5	3	5	12	6	12	4	11	96
% within Gender	7.3	7.3	7.3	5.2	12.5	5.2	3.1	5.2	12.5	6.25	12.5	4.2	11.5	100.0
% within location	63.6	58.3	87.5	33.3	38.7	45.5	20.0	27.8	37.5	33.3	46.2	13.8	45.8	38.4
Female	4	5	1	10	19	6	12	13	20	12	14	25	13	154
% within Gender	2.6	3.2	0.6	6.5	12.3	3.9	7.8	8.4	13.0	7.8	9.1	16.2	8.4	100.0
% within location	36.4	41.7	12.5	66.7	61.3	54.5	80.0	72.2	62.5	66.7	53.8	86.2	54.2	61.6
Total	11	12	8	15	31	11	15	18	32	18	26	29	24	250
% within Gender	4.4	4.8	3.2	6.0	12.4	4.4	6.0	7.2	12.8	7.2	10.4	11.6	9.6	100.0

Table 4 Household size of the Respondents

Household size	Agodi	Iyaganku	Jericho	Eleyele	Felele	Oke-Ado	Oke Itunu	Yidi	Agugu	Eleta	Foko	Inalende	Yemetu	Total
1-3	1	5	0	2	4	2	1	3	3	5	4	7	3	40
% within Household	2.5	12.5	0.0	5.0	10.0	5.0	2.5	7.5	7.5	12.5	10.0	17.5	7.5	100.0
% within location	9.1	41.7	0.0	13.3	12.9	18.2	6.7	16.7	9.4	27.8	15.4	24.1	12.5	16.0
4-6	6	7	6	7	18	0	8	7	9	6	10	5	10	99
% within Household	6.1	7.0	6.1	7.0	18.2	0.0	8.1	7.0	9.1	6.1	10.1	5.1	10.1	100.0
% within location	54.5	41.7	75	46.7	58.1	0.0	53.3	38.9	28.1	33.3	38.5	17.2	41.7	39.6
7-9	3	0.0	2	2	3	2	3	1	4	2	3	10	4	39
% within Household	7.7	0.0	5.1	5.1	7.7	5.1	7.7	2.6	10.3	5.1	7.7	25.6	10.3	100.0
% within location	27.3	0.0	25	13.3	9.7	18.2	20.0	5.6	12.5	11.1	11.5	34.5	16.7	15.6
10-12	0	0	0	2	4	2	0	3	5	3	4	3	2	28
% within Household	0.0	0.0	0.0	7.1	14.3	7.1	0.0	10.7	17.9	10.7	14.3	10.7	7.1	100
% within location	0.0	0.0	0.0	13.3	12.9	18.2	0.0	16.7	15.6	16.7	15.4	10.3	8.3	11.2
Above 12	1	0	0	2	2	5	3	4	11	2	5	4	5	44
% within Household	2.3	0	0.0	4.5	4.5	11.4	6.8	9.1	25.0	4.5	11.4	9.1	11.4	100.0
% within location	9.1	0.0	0.0	13.3	6.5	45.5	20	22.2	34.4	11.1	19.2	13.8	20.8	17.6
Total	11	12	8	15	31	11	15	18	32	18	26	29	24	250
% within Household	4.4	4.8	3.2	6.0	12.4	4.4	6.0	7.2	12.8	7.2	10.4	11.6	9.6	100.0

3.2 Waste Generation Rates across Local Government Areas

The results shown in Table 5 revealed that the bulk of waste collected for the week was from Agugu with a total of 138.64kg, Felele ranked second, weighing 105.52kg of the total amount of waste for the week. This is followed by Yemetu 103.07kg; Yidi 102.42kg; Inalende 98.62kg; Agodi GRA 89.88kg; Foko 75.88kg; Eleta 68.05kg; Iyaganku 65.73kg; Eleyele 60.01kg, while Oke-Ado, Oke-Itunu and Jericho recorded 65,73kg, 46.44kg and 42.14kg respectively and all amounted to a total of 1,045.56kg. Initially, the sample size seemed a key determinant in the total amount of waste generated for the week when we consider communities like Agugu and Felele, while the totals from low residential communities like Agodi, Iyaganku revealed that sample size was not the only determinant as these are areas where there exist sufficient purchasing power. Waste generation varied with the day of the week. The highest amount of waste was generated on Saturday with a total of 193.48kg, followed by Tuesday with a total of 170.39kg across the study area, while on Monday 114.25kg of waste, which is the least amount, was generated for the week. On Saturday, most of the waste generated also came from the high-density area of Yemetu with a total of 20.87kg, followed by Agodi GRA with 18.01kg of waste and the least amount was from the medium density area of Oke-Itunu with 6.02kg. In the case of Ibadan North East, Yidi, a medium-density area, recorded the highest amount of 20.04kg, while Agugu recorded 19.2kg which was just a little below Yidi's. For the selected communities in Ibadan North West, Inalende a high-density area recorded the largest amount of waste at 17.12kg, followed by Eleyele at 11.23kg and the least was Jericho with a total of 7.78kg of household waste. Ibadan South East had Felele recording 27.21kg of waste which was the overall highest so far, while Eleta recorded 13.13kg.

On Tuesday, Agugu under Ibadan North East local government recorded the highest amount of waste (28.39kg) and Yidi, in the same local government, accounted for the second-largest weight of 19.95kg. Unlike the situation on Saturday where there was no clear variation among the different household types under study, here lots of waste were generated amongst mostly the high and medium density areas. However, Agodi GRA, a low-density area, generated 14.47kg of waste, while other low-density communities of Iyaganku and Jericho generated 8.69kg and 7.6kg respectively.

Monday recorded the least amount of total waste generated amongst households totaling 114.25kg. The bulk of the waste generated that day was mainly within the low and medium density areas. Agodi GRA, a low-density community, however, recorded 14.47kg of waste, with similar figures to that of the medium and low-density communities, while Eleta, a high-density community on the other hand recorded 8.4kg in weight, which was also similar to the total weight obtained at Iyaganku (8.69kg), while Jericho had the least weight of 7.6kg.

Table 5 Daily generation of total waste in the communities investigated (kg)

Day of the Week	Agodi n = 88 (11)	Oketunu n 119 (15)	Yemetu n 191 (24)	Yidi n 139 (18)	Agugu n 259 (32)	Jericho n 51 (7)	Eleyele n 119 (15)	Inalende n 226 (28)	Felele n 256 (32)	Eleta n 144 (18)	Iyagunku n 95 (13)	Oke-Ado n 92 (11)	Foko n 211 (26)
Saturday	18.01	6.02	20.87	20.04	19.2	7.78	11.23	17.12	27.21	13.13	12.2	7.55	13.12
Sunday	19.43	8.36	26.28	13.64	14.53	6.41	6.07	14.79	19.59	12.48	10.22	6.07	7.74
Monday	10.32	5.02	10.37	11.69	15.12	3.58	4.5	13.05	10.59	9.91	7.09	4.78	8.23
Tuesday	14.47	9.08	13.42	19.95	28.39	7.6	9.86	10.95	16.45	8.4	8.69	12.14	10.99
Wednesday	7.87	7.22	7.16	13.95	24.41	6.93	10.15	14.6	11.75	9.37	8.25	7.76	12.93
Thursday	7.18	3.93	13.67	10.04	19.32	5.38	7.8	12.28	8.86	8.39	10.44	6.32	12.44
Friday	12.6	6.81	11.3	13.11	17.7	4.46	10.4	15.83	11.07	6.37	8.84	5.51	10.43
Week Total	89.88	46.44	103.07	102.42	138.67	42.14	60.01	98.62	105.52	68.05	65.73	50.13	75.88

3.3 Per Capita Waste Generation Rate

When viewed from the perceptive of population density, the low-density communities of Iyaganku, Agodi, and Jericho, recorded the highest amounts at 0.20, 0.18, and 0.13kg/person/day respectively, with a mean value of 0.17kg/person/day. For the medium density communities, the highest per capita waste generated was at Yidi (0.11Kg/person/day) followed by Eleyele (0.08Kg/person/day), Felele (0.07Kg/person/day) and Oke-Itunu (0.06Kg/person/day) while the least amount was recorded at Oke-Ado at 0.05kg/person/day. In other words, the mean per capita waste generation rate was 0.07kg/person/day. High-density communities compared to other communities recorded the least per capita figures. Eleta and Eleyele recorded 0.08kg/person/day. Inalende and Yemetu accounted for 0.7kg/person/day each, while Agugu accounted for a per capita waste generation rate of 0.06kg/day, and the least amount came from Foko with 0.04kg/person/day with a mean of 0.04kg/person/day (Table 6). The overall mean generation rate recorded was 0.09kg/person/day. With a population of 6 million according to the 2018 estimate, the projected total waste generation is 540,000kg/day and 6,480 tonnes/annum. Although differences occurred between the low, medium, and high-density communities, the waste generation rates between the medium and high-density communities were slight, this being an indication of a fast-disappearing middle class. The low per capita waste generation rate across board is also a reflection of lifestyle as most households had at least a meal or two outside their homes. Another reason could be the strict adherence by volunteers to the researcher's instruction of supplying only the daily waste and not the past accumulated waste they gave to the research assistants during the pilot survey.

Table 6 Per capita waste generation rate among households

Density	Community	Per capita waste (kg/person/day)
Low	Iyaganku GRA	0.20
	Agodi GRA	0.18
	Jericho	0.13
	Mean value	**0.17**
Medium	Yidi	0.11
	Eleyele	0.08
	Felele	0.07
	Oke-Itunu	0.06
	Oke-Ado	0.05
	Mean Value	**0.07**
High	Eleta	0.08
	Inalende	0.07
	Yemetu	0.07
	Agugu	0.06
	Foko	0.04
	Mean value	**0.04**
	Grand mean value	**0.09**

3.4 Composition of Solid Waste among Households in Ibadan Metropolis

The findings revealed that organic waste represented the single largest component of household waste, accounting for 41.5% by weight, followed by plastics at (21.4%), other waste 19.3%, paper and paper board 8.4%, textile 3.4%, metal 2.7%, glass 1.9%, special-care waste and construction, and demolition materials were 0.7% respectively (Table 7). The figures obtained from the waste audit exercise for items such as organic waste, other waste, and textiles were similar to those reported by Ogungbuyi (2013) for Ibadan. The organic waste figure of 41.5% also compared well with the UNEP's/International Environmental Technology Centre's (IETC) (2009) average figures for Ibadan, Dakar, Accra, Abidjan, and Lusaka. However, plastics (21.4%) increased considerably when compared to Urban Development Bank of Nigeria's 1997 field survey figure of 9.25% as cited by Oyelola and Babatunde, (2008), UNEP/IETC's (2009) figure of less than 10%, and Ogungbuyi's (2013) figure of 9%. These variations may partly be explained by Ibadan's rapid demographic expansion in the last decade as well as lifestyle changes among the residents. Today, plastics are provided in large quantities and have replaced paper cartons and cardboards, glass, and metal in the packaging of consumables. The organic (biodegradable) materials such as leaves which the local people in Ibadan use extensively to

wrap *moin-moin*, *akara* (bean cakes), *eko-tutu* (cold pap), *iyan* (pounded yam), *iru* (locust beans), *fufu*, and similar food items have been widely replaced with cellophane, nylon, foil sheets, etc. Drinking water and minerals now come in plastic (sachets and bottles), while local drinks are no longer sold and consumed in calabashes, gourds and similar biodegradable containers/items. The indigenous packaging and household/domestic materials, including raffia baskets for waste storage and disposal, are discarded for plastic bags, bowls, buckets, dishes, cups, utensils and kegs.

Table 7 Waste Materials by Weight and Percentage

Main Material Groups	**kg**	**%**
Organics	434.94	41.5
Plastics	223.99	21.4
Other waste	201.69	19.3
Paper & paper board	88.04	8.4
Textile	35.56	3.4
Metal	28.65	2.7
Glass	20.27	1.9
Special care waste	7.64	0.7
Construction and demolition material	6.78	0.7
Total	1046.56	100.0

Table 8 gives a clear indication of the sub-categories of wastes that contributes the most as well as the least to the main waste categorisation and how they vary amongst the communities sampled. Food wastes contributed the most to the organic waste fraction. The low, medium, and high-density communities recorded 50.9, 41.1, and 33.2 mean percentages respectively. For plastic waste, film plastic contributed most and varied among the low, medium, and high-density areas.

Table 8 Varying solid waste composition and quality among communities in Ibadan metropolis

S/N		Sample Area								
	Waste type	Low density			Medium-density			High density		
	Material type	Agodi	Jericho	Iyagunku	Oke-Ado	Eleyele	Felele	Yemetu	Inalende	Foko
A	**PAPER & PAPER BOARD**									
1	Newspaper	0.4	1.9	0.3	0.9	0.8	0.5	0.3	3.1	2.4
2	Cardboard/Carton	2.1	1.6	1.3	6.1	3.9	2.4	0.7	3.5	3.0
3	Magazine/catalogues	0.0	6.4	0.1	0.0	0.6	0.3	0.3	0.3	0.1
4	Office Paper	1.0	2.7	1.3	1.9	2.9	1.1	1.4	1.3	1.5
5	Other/miscellaneous paper	1.1	2.0	1.9	4.1	1.9	2.3	2.1	3.4	2.1
	Total A	4.6	14.6	4.9	13.0	10.1	6.6	4.8	11.6	9.1
B	**GLASS**									
6	Clear containers	1.5	0.5	1.1	0.3	0.6	1.0	0.6	0.4	0.1
7	Green containers	0.0	0.0	0.0	0.0	0.4	1.1	2.0	0.8	0.7
8	Amber containers	2.0	0.0	0.0	0.2	0.4	0.5	0.3	0.6	0.1
9	Remainder/composite glass	1.7	0.9	0.3	0.1	0.6	0.1	0.2	0.3	0.1
	Total B	5.2	1.4	1.4	0.6	2.0	2.7	3.2	2.1	1.0
C	**METAL**									
10	Tin/steel containers	1.8	3.0	3.4	1.3	2.4	1.7	0.9	0.8	0.5
11	Aluminium containers	0.1	0.6	0.6	0.5	0.5	0.2	0.3	0.3	0.2
12	Other ferrous metal	0.2	0.0	0.2	2.5	0.9	0.2	1.3	0.4	0.1
13	Other nonferrous metal	0.0	0/0	0.1	0.4	0.4	0.2	0.4	0.0	0.0
14	Major appliances	0.0	0.0	0.0	0.0	0.0	1.0	1.6	0.0	0.0
	Total C	2.1	3.6	4.3	4.7	4.2	3.3	4.5	1.5	0.8
D	**PLASTICS**									
15	Clear PET Bottles/containers	1.1	1.4	2.2	0.9	1.4	0.8	3.0	1.3	0.3
16	Green PET Bottles/containers	0.2	0.2	0.2	0.7	0.3	0.2	0.1	0.3	0.2
17	Amber PET Bottles/containers	0.0	0.1	0.2	0.3	0.5	0.2	0.5	0.3	0.1
18	HDPE containers	0.1	0.0	0.3	0.3	1.1	0.1	1.6	0.3	0.1
19	Film Plastics	16.3	22.4	18.2	21.6	22.0	17.8	16.0	16.4	21.7
20	Other Plastics	2.9	1.3	1.6	1.7	2.0	2.0	1.2	0.7	1.5
	Total D	20.6	25.4	22.7	25.5	27.3	21.1	22.3	19.5	23.9
E	**TEXTILE**									
21	Textile	0.0	0.4	0.5	2.6	3.1	3.3	2.1	3.7	4.2

F	**ORGANICS**									
22	Food waste	42.7	47.5	62.4	31.7	26.7	41.1	33.4	22.4	29.8
23	Garden waste	13.8	0.2	0.8	0.2	0.2	0.0	0.1	0.0	0.0
24	Agricultural waste	2.2	1.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0
25	Abattoir waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	Remainder/composite Organics	7.6	3.4	1.7	4.2	1.6	9.6	9.4	4.6	1.2
	Total F	66.3	52.2	65.0	36.2	28.6	50.7	42.9	27.1	31.0
G	**CON. & DEMOLITION MATERIAL**									
27	Concrete	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.5	0.0
28	Lumbar	0.1	0.0	0.0	0.0	0.0	0.1	1.5	0.0	0.0
29	Remainder/Composite C & D	0.0	0.0	0.2	0.9	0.0	0.5	0.0	0.0	0.0
	Total G	0.1	0.0	0.2	0.9	0.7	0.6	1.5	0.5	0.0
H	**SPECIAL CARE WASTE**									
30	Paint	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	Hazardous materials	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
32	Biomedical Waste	0.1	0.0	0.1	0.2	0.2	0.0	0.1	0.1	0.1
33	Batteries	0.1	0.0	0.2	0.4	0.3	0.1	2.6	0.2	0.1
34	Oil filters	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
35	Remainder/Composite S.C waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Total H	0.3	0.0	0.3	0.6	0.5	0.1	2.7	0.3	0.5
I	**OTHER WASTE**									
36	Waste Electrical and Electronic Equipment	0.0	0.0	0.2	1.3	0.5	0.1	0.2	0.2	0.6
37	Tyre	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	Furniture	0.0	0.0	0.2	0.3	0.2	0.1	0.0	0.2	0.6
39	Ceramics	0.0	0.0	0.0	0.9	0.2	0.6	0.2	0.1	0.5
40	Others	0.5	2.1	0.7	9.4	7.7	8.8	14.6	19.8	17.6
41	Soil/Sand/Ash	0.0	0.1	0.0	0.0	3.8	0.9	0.0	0.2	3.5
42	Feces	0.0	0	0.0	0.0	0.0	0.0	0.0	0.2	0
43	<6.5mm	0.5	0	0.0	3.9	10.7	0.7	0.9	13.2	6.9
	Total I	1.0	2.2	1.1	13.8	23.3	11.2	15.9	33.8	29.7
	GRAND TOTAL (%)	100	100	100	100	100	100	100	100	100

3.5 Relationship between socio-economic characteristics of households and the percentage composition of waste

The relationship between the socio-economic characteristics of households and the percentage composition of waste generated is best explained with the use of Pearson Correlation. As indicated in Table 9, percentage composition of waste and gender have statistically significant linear relationship ($r = 0.138$; $p < 0.05$). The direction of the relationship is positive (i.e., % of waste and gender are positively correlated), meaning that these variables tend to move together (i.e., a greater percentage of the waste is associated with gender). This implies that both males and females generated a greater percentage of waste. Percentage composition of waste has a statistically significant linear relationship with marital status ($r = 0.245$; $p < 0.05$). This shows that the percentage composition of waste increased with differences in the respondent's marital status. Married people were expected to generate greater wastes than those who were single. Similarly, income is significantly correlated with percentage composition of waste ($r = 0.183$; $p < 0.05$). This shows that as income increased, the percentage of waste generated increased as well, and vice versa. The level of education was also found to be significantly related to the percentage of wastes composition ($r = 0.221$; $p < 0.05$). This reveals that percentage of waste composition increased as level of education increased. Occupation had a positive and significant relationship with percentage composition of wastes ($r = 0.083$; $p < 0.05$). This implies that some occupations generated more wastes than others. Household size had a direct significant relationship with percentage composition of waste ($r = 0.176$; $p < 0.05$). This result indicates that as household size increased, percentage composition of waste increased as well, and vice versa. However, age had a negative and significant relationship with percentage composition of waste ($r = -0.220$; $p < 0.05$). This shows that percentage composition of waste decreased with increasing age. Similarly, religion ($r = -0.038$; $p > 0.05$) and ethnicity ($r = -0.076$; $p > 0.05$) each had negative and an insignificant relationship with percentage composition of waste. This showed that percentage composition of waste was not significantly related to any religious affiliation or a particular ethnic group. The strength of the relationship for all the socio-economic characteristics of households is weak ($r < 0.5$). Therefore, the hypothesis which states that there is no positive significant relationship between socio-economic characteristics of households and percentage composition of waste is rejected for gender, marital status, educational level, income, and household size but accepted for religion, age and ethnicity. In other words, there is a

significant relationship between socio-economic characteristics of gender, marital status, educational level, income, and household size and percentage composition of waste. However, religion and ethnicity do not have a significant relationship with waste composition.

Table 9 Relationship between socio-economic characteristics of households and percentage composition of waste (N = 250)

Variables	Pearson Correlation	P-value	Level
Waste composition vs gender	0.138	0.030	Sig.
Waste compostion vs marital status	0.245*	0.000	Sig.
Waste compostion Vs educational level	0.221*	0.000	Sig.
Waste compostion vs religion	-0.038	0.553	Not Sig.
Waste compostion vs age	-0.220*	0.000	Sig.
Waste compostion vs occupation	0.184	0.013	Sig.
Waste compostion vs income	0.183*	0.005	Sig.
Waste compostion vs ethnicity	-0.076	0.233	Not Sig.
Waste compostion vs household size	0.176*	0.004	Sig.

4 Conclusion

The waste audit carried out in April 2018 amongst selected households in the five central local government areas of Ibadan North, Ibadan North East, Ibadan North West, Ibadan South East, and Ibadan South West before the onset of the rains of 2018, revealed that the waste contents were majorly compostable and recyclables which were comingled for disposal. If these wastes were separated for composting (41%) and recycling (37%), there would remain just 22% of household waste for disposal. The kind of waste items found in the communities depicted the socio-economic characteristics of the low, medium, and high-density areas. The solid waste found in the low-density areas depicted higher income of residents, recyclables were fairly-used and new, while the medium and high-density communities had lower income and generate waste items which had experienced more usage before disposal. Unlike past studies on waste composition, this study had more sub-categories to better appreciate the specific waste items

found among households. The study also revealed that the stench associated with household waste from low density and medium communities are majorly from food waste, while waste from the high-density communities contains feces due to inadequate toilet facilities. To reduce the amount of wastes that eventually end in the dumpsite, it is recommended that households separate their waste at source to compost as well as recycling. This will rid the environment of the pilling-up of waste and the accompanying health and environmental impacts. The separation of solid wastes for composting and promotion of recycling will create employment and resources for manufacturing without affecting nature's reserve. It is suggested that regular waste audit should be carried out in the metropolis to keep pace with the changing quantity and composition of solid waste.

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