SOLID WASTE GENERATION AND CHARACTERIZATION IN KADUNA METROPOLIS, NIGERIA.

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ABSTRACT
This study examined and characterized solid waste generated from forty-eight selected households in Kaduna metropolis. Four (4) households were randomly selected from low, medium and high-density areas of Kaduna North and South LGAs while, four (4) houses were also selected randomly from medium and high-density areas of Chikun and Igabi LGAs within the metropolis. The results show that the percentages of waste generated are 63.75% (Garbage), 5.28% (metals), 5.44% (Glass), 5.71%(rubber and Plastic), 5.55% (Paper/Cardboard), 2.19% (Textile) and 12.08% (Miscellaneous), while the mean per capita waste generation is 0.30 kg/day with a mean volume and mean density of 0.0029m^3/day and 6.37kg/m^3 respectively.

KEY WORDS: Waste, Composition, Generation and Kaduna metropolis

INTRODUCTION

Solid waste consists of materials, which can be classified according to their physical and chemical properties as garbage, rubbish, trash, junks and ashes (Hagerty *et al*, 1973). In Kaduna metropolis, the increase in population and industrial activities has given rise to generation of large amount of solid waste, which has been difficult to manage. Consequently, this has led to unprecedented hills of refuse at strategic and important locations within the metropolis. Some streets, drains/gutters, and streams are even blocked by heaps of refuse, affecting not the scenery, soil and water resources but also constituting a potential health hazard to plants, animals and people within the environment. The central metropolis of Kaduna consists of about 250,000 houses and the per capita production of solid waste is estimated at 175.2 kg/yr (Agboola, 1993). Ojukannaiye, (1998) estimated about 86.24% of the total solid waste is from residential sources while 10.14%, 2.90% and 0.72% are from the commercial, industrial and mixed sources respectively. He also estimated that about 62.41% of the solid wastes in the Kaduna metropolis are disposed at unorganized public dumpsites. (i.e. street corners, uncompleted buildings, undeveloped plots of land, borrow pits and incidental open spaces on the outskirts of urban areas) 13.48% on organized public facilities, while 16.31% and 7.80% are disposed on unorganized and organized privately owned facilities respectively.

Waste characterization can be used to determine the average rate of waste generated, the means of disposal including recycling strategy and could also assist in the development of appropriate waste disposal facilities. This study seeks to quantify and characterized solid waste generated in Kaduna metropolis.

STUDY AREA

The study area lies between latitudes $10^0$25'28" and $10^0$35'53"North of the equator and longitudes $7^0$21'49" and $7^0$30'00" East of the Greenwich Meridian. The area covers about 268.359 Km^2, with built-up areas covering 200,000 hectares. Presently, Kaduna metropolis is comprised of four local government areas (LGA) namely; Kaduna North, Kaduna South, Igabi and Chikun local government areas. The wet season in Kaduna starts from April and ends in October, while the dry season begins in November and lasts till March. The average rainfall is about 1397mm (Olugboye 1974) while; the minimum and the maximum temperatures are 12.8^0 C and 35^0C respectively (Russ, 1975, Olugboye 1974).

MATERIALS AND METHODS

Solid wastes from forty-eight selected households in Kaduna metropolis were classified and analyzed. Four (4) households were randomly selected from low, medium and high-density areas of Kaduna North and South LGAs while, four (4) houses were also selected randomly from medium and high-density areas of Chikun and Igabi LGAs within the metropolis.

Each household was provided with refuse bags for storage and identified with the sample location and family size. These bags were collected and replaced with new ones every other day. The wastes were weighed and sorted out manually at the point of collection. The sorted out materials were further weighed and the process was repeated for five days. Some of the sorted wastes were well mixed and poured into airtight polythene bags for laboratory analyses.

CHARACTERIZATION OF WASTE

The collected wastes were characterized at the point of collection as follows: (i). Glass, (ii) Rubber, plastic and polythene materials (iii) Metals, tins, cans, foil wrappings and associated materials, (iv) Paper cardboard and other related materials (v) Garbage and (vi) Grass cuttings, leather, textile etc. (Tables 8&9)

WEIGHT, VOLUME, DETERMINATIONS

The weights and volumes were determined on site. Weights were determined by emptying the contents of waste containers into a pre-weighed fiber-woven sack and hung on to a spring balance. The volume was determined by inserting a steel rod into the waste containers to determine the average depth of the wastes and then multiplied by the pre-determined cross-sectional area of the containers. The densities of the measured wastes were computed using the mass volume relationship of Archimedes's principles.

MOISTURE CONTENT DETERMINATION

Moisture contents were determined in accordance with methods suggested by Eawag (1970). The entire crude sample was weighed and thinly spread on pre-weighed ceramic or steel plates. It was dried at 105^0C in a ventilated drying oven until the weight was constant. The dried sample was then weighed immediately afterwards. The moisture contents (%) were then computed using the formula.

$$W(\%) = \frac{N_w - N_d}{Nw} x100$$

Where W (%)= Moisture content of crude sample in weight percent

N_w = net weight (wet)

N_d = net weight (dry)

RESULTS AND DISCUSSIONS

The measured weights, volumes, and densities of the solid waste generated from the selected households from the four LGA in Kaduna metropolis are shown in Tables 1- 5.

TABLE 1: Mean Weights, Volumes and Densities of Waste generated by 208 persons in Kaduna South L.G.A.

Population Type	**No. Persons**	**Household Number**	**Weight** Kg/day	**Volume.** m^3/day	**Density** Kg/ m^3
High Density	**35**	1	11.61	0.117	99.23
	28	2	8.06	0.062	130.00
	42	3	13.30	0.112	118.75
	40	4	12.66	0.078	162.30
Medium Density	**8**	1	2.47	0.019	130.00
	10	2	3.11	0.023	135.17
	13	3	3.55	0.033	107.57
	9	4	2.69	0.041	65.61
Low Density	**6**	1	1.98	0.019	104.21
	4	2	1.36	0.012	113.33
	8	3	2.84	0.028	101.43
	5	4	1.80	0.017	105.88
Mean/capita	17		0.31	0.003	6.60

Measured mean /Capita waste generation for Kaduna South L.G.A. :
Weight=0.31 Kg/capita/day
Volume =0.003 m^3/day
Density =6.60Kg/m^3

TABLE 2: Mean Weights, Volumes and Densities of Waste Generated by 209 Persons in Kaduna North L.G.A.

Population Type	Household Number	No. Persons	Weight Kg/day	Volume. m^3/day	Density Kg/ m^3
High Density	1	34	10.61	0.115	92.26
	2	29	8.82	0.077	114.55
	3	31	10.11	0.091	111.09
	4	36	9.46	0.070	135.14
Medium Density	1	9	2.65	0.022	120.45
	2	13	3.64	0.045	80.88
	3	7	2.16	0.043	50.23
	4	11	3.17	0.020	158.50
Low Density	1	10	2.93	0.037	79.19
	2	12	3.41	0.033	103.33
	3	11	3.10	0.027	114.81
	4	6	2.09	0.021	99.52
Mean/capita			0.30	0.0029	6.03

Measured mean/ Capita waste generation for Kaduna North LGA :
Weight=0.30 Kg/capita/day
Volume =0.0029 M^3/day
Density =6.03 Kg/M^3

TABLE 3: Mean Weights, Volumes and Densities of Waste Generated by 139 Persons in Chikun L.G.A.

Population Type	Household Number	No. Persons	Weight Kg/day	Volume. m^3/day	Density Kg/m^3
High Density	1	31	9.73	0.136	71.54
	2	23	6.76	0.070	96.57
	3	28	8.12	0.074	109.72
	4	17	5.07	0.039	130.00
Medium Density	1	11	3.19	0.033	96.67
	2	13	3.75	0.062	60.48
	3	9	2.68	0.041	65.36
	4	7	2.13	0.022	96.82
Mean/capita			0.30	0.0034	5.23

Measured mean/ Capita waste generation for Chikun L.G.A. :
Weight=0.30 Kg/capita/day
Volume =0.0034 M^3/day
Density =5.23 Kg/M^3

TABLE 4: Mean Weights, Volumes and Densities of Waste Generated by 143 Persons in Igabi L.G.A.

Population Type	Household Number	No. Persons	Weight Kg/day	Volume. m^3/day	Density Kg/m^3
High Density	1	24	6.91	0.039	177.18
	2	32	9.41	0.060	156.83
	3	27	7.61	0.061	124.75
	4	19	5.25	0.034	170.76
Medium Density	1	11	3.23	0.026	154.41
	2	9	2.39	0.028	85.36
	3	12	2.82	0.028	100.71
	4	9	2.39	0.020	119.50
Mean/capita			0.280	0.0021	7.62

Measured mean/ Capita waste generation for Igabi L.G.A. :
Weight=0.28 Kg/cspita/ day
Volume =0.0021 M^3/day
Density =7.62 Kg/M^3

TABLE 5: Mean Weight, Volume and Density Quantities for Kaduna Metropolis

S/No	LGAs	Mean Residents per Household	Mean Wt/capita/day (Kg)	Mean Volume Person/day (M^3)	Mean Density/Person/day (Kg/M^3)
1.	Kaduna South	17	0.31	0.003	6.60
2.	Kaduna North	17	0.30	0.0029	6.03
3.		18	0.30	0.0034	5.23
4.	Chikun	18	0.28	0.0021	7.62
	Igabi				
Mean/capita			0.30	0.0029	6.37

Measured mean /Capita waste generation for Kaduna Metropolis:

Weight=0.30 Kg/capita/day
Volume =0.0029 M^3/day
Density =6.37 Kg/M^3
Number of residents per household in Kaduna Metropolis is 18.

Table 1; shows the weights, volumes and densities of waste generated by selected households in Kaduna South Local Government Area. Wastes from these selected households have weights ranging from 1.36 – 13.3 kg. The weight/ capita waste generation for Kaduna South Local Government Area is estimated as 0.31 kg/day. Corresponding volumes of wastes generated by these selected households in Kaduna South Local Government Area range from 0.012 – 0.117 m^3 with an average of 0.003 m^3per capita. Densities of the wastes from these selected households' range from 65 – 130.00 kg/ m^3 with an average of 6.60 kg/ m^3.

Table 2; shows the weights, volumes and densities of waste generated by selected households in Kaduna North Local Government Area. The wastes from these selected households have weights ranging from 2.09-10.61 kg. The mean weight/ capita waste generation for Kaduna North Local Government Area is estimated as 0.30 kg/day.

Corresponding Volumes of the Wastes generated by selected households in Kaduna North Local Government Area range from 0.020 – 0.115 m^3 with an average of 0.00029 m^3. Densities of the wastes from these selected households' range from 92.26 – 158.50 kg/ m^3 with an average of 6.03kg/ m^3.

Table 3 shows the weights, volumes and densities of waste generated by selected households in Chikun L.G.A.

Wastes from these selected households have weights ranging from 2.13 – 9.73 kg. The Mean weight/capita waste generation for Chikun L.G.A. is estimated as 0.30 kg/day. Corresponding volumes of wastes generated by these selected households in Chikun L.G.A. range from 0.0022 - 0.136 m^3. Densities of the wastes from these selected households' range from 60.48 – 130.00 kg/ m^3 with an average of 5.23 kg/ m^3.

Table 4 shows the weights, volumes and densities of waste generated by selected households in Igabi L.G.A. The wastes from these selected households have weights ranging from 2.39 – 9.41 kg. The mean weight/ capita waste generation for Igabi L.G.A. is estimated as 0.28 kg/day. Corresponding volumes of wastes generated by selected households in Igabi L.G.A. range from 0.20-0.061 m^3 and with an average of 0.0021 $m^{3.}$ Densities of the wastes from these selected households' range from 85.39 – 177.18kg/ m^3 with an average of 7.62 kg/ m^3.

Table 5 shows the weights, volumes and densities of measured mean /capita waste generation for Kaduna metropolis. The mean weight/ capita generation for Kaduna metropolis is estimated as 0.30 kg/day. The corresponding mean volume is estimated as 0.0029m^3/day while that of density is 6.37kg/m^3.

The results above conformed to a study carried out by Parkman (2002), in some selected Nigerian cities, which estimated per-capita waste generation rate as 0.3 – 0.6kg per day. The value of 0.30kg per day can be said to be within the lowest range of the values reported by Parkman, (2002). (Table 6)

The present value of 0.30 kg per capita day falls within the value quoted for Lagos and Abuja but higher than the value quoted for Ilorin as shown in Table 6

Table 6: Per capita waste generation by some selected Nigerian cities.

S/N	Source	Selected City	Year of Study	Kilograms per day
1	Lavalin	Lagos	1991	0.21
2	UDBN	Lagos	1997	0.48
3	LAGA	Abuja	2001	0.28
4	CIWAT	Ilorin	2001	0.11

Source: Parkman Nigeria Limited (2002).

Table 7 shows the moisture contents of 1kg of wastes from the selected households from Kaduna metropolis. The values obtained ranged from 38.2% to 52.8% moisture.

The computed moisture contents of selected samples are shown in Table 7.

TABLE 7: Moisture Content of Some Solid Waste Generated in kaduna Metropolis

LGAs in Kaduna Metropolis	Population Type	Sample No.	Sample Weight (g)		Moisture (%)
			Wet	**Dry**	
Kaduna South	High	1	1000	539	46.1
	Medium	2	1000	515	48.5
	Low	3	1000	568	43.2
Kaduna North	High	4	1000	472	52.8
	Medium	5	1000	591	40.9
	Low	6	1000	565	43.5
Chikun	High	7	1000	618	38.2
	Medium	8	1000	579	42.1
Igabi	High	9	1000	550	45.0
	Medium	10	1000	597	40.3
Mean				559.4	44.06
Range				472-618	38.2 –52.8

Tables 8 and 9 show the waste composition in Kaduna metropolis, with Garbage ranging from (62- 65)%, Metals, Tins and Cans (2 7)%,Glass and Bottles (4.5-6.2)%, Rubber, Plastic and Polythene (4.3- 7)%, Paper and Card-board(4.5-6)%, Textile(1.3-3.1)% and Others(10-15)%.

TABLE 8: Composition of Waste Generated by Weight for 5 days in Selected Areas of Four (4) LGAs in Kaduna Metropolis

Local Govt. Area	Area	Population Type (Density)	Total Weight (Kg)	Garbage (Kg)	Metals, Tins & Cans (Kg)	Glass & Bottles (Kg)	Rubber, Plastic & Polythene (Kg)	Paper & Card -board (Kg)	Textile (Kg)	Miscellaneous Other (Kg)
Kaduna South	**1**	High	228.20	144.91	13.69	11.41	15.97	12.55	4.56	25.10
	2	Medium	59.11	39.01	2.36	3.55	3.25	3.55	1.48	5.91
	3	Low	29.98	18.59	2.04	1.56	1.80	1.80	0.60	3.60
Kaduna North	**4**	High	194.93	124.76	13.64	8.77	12.67	11.70	3.51	19.88
	5	Medium	58.05	37.73	3.49	2.90	2.50	3.19	1.80	6.46
	6	Low	57.66	35.75	2.88	3.46	2.88	3.46	1.38	7.84
Chikun	**7**	High	148.41	92.01	10.39	8.90	8.90	6.69	4.01	17.51
	8	Medium	58.79	38.80	1.18	3.23	3.23	2.94	1.23	8.17
Igabi	**9**	High	145.92	93.39	7.30	9.05	9.19	7.30	1.90	17.80
	10	Medium	54.22	34.16	2.17	2.71	2.71	3.25	1.08	8.13
Mean			103.53	65.91	5.91	5.55	6.31	5.64	2.16	12.04
Range			29.98 - 228.20	18.59 - 144.91	1.18 - 13.69	1.56 - 11.41	1.80 - 15.97	1.80 - 12.55	0.60 - 4.56	3.60 - 25.10

TABLE 9 : Percentage composition of Waste Generated by Weight in Selected Areas of Four(4) LGAs in Kaduna Metropolis for 5 days

Local Govt. Area	Area	Population Type (Density)	Total Weight (%)	Garbage (%)	Metals, Tins & Cans (%)	Glass & Bottles (%)	Rubber, Plastic & Polythene (%)	Paper & Card - board (%)	Textile (%)	Miscellaneous Other (%)
Kaduna South	**1**	High	100	63.5	6.0	5.0	7.0	5.5	2.0	11.0
	2	Medium	100	66.0	4.0	6.0	5.5	6.0	2.5	10.0
	3	Low	100	62.0	6.8	5.2	6.0	6.0	2,0	12.0
Kaduna North	**4**	High	100	64.0	7.0	4.5	6.5	6.0	1.8	10.2
	5	Medium	100	65.0	6.0	5.0	4.3	5.5	3.1	11.1
	6	Low	100	62.0	5.0	6.0	5.0	6.0	2.4	13.6
Chikun	**7**	High	100	62.0	7.0	6.0	6.0	4.5	2.7	11.8
	8	Medium	100	66.0	2.0	5.5	5.5	5.0	2.1	13.9
Igabi	**9**	High	100	64.0	5.0	6.2	6.3	5.0	1.3	12.2
	10	Medium	100	63.0	4.0	5.0	5.0	6.0	2.0	15.0
Mean			100	63.75	5.28	5.44	5.71	5.55	2.19	12.08
Range				62.0 - 65.0	2.0 - 7.0	4.5 - 6.2	4.3 - 7.0	4.5 - 6.0	1.3 - 3.1	10.0 - 15.0

CONCLUSIONS AND RECOMMEDATIONS

The mean per capita solid waste generated in Kaduna metropolis is estimated at 0.30 kg/head/day. This is within the range of values reported by Parkman (2002) for some selected Nigerian cities.

It is observed that 63.75% of the solid waste is organic matter (Table 9). The decomposable organic matter can be used to improve the nutrient and physical qualities of agricultural soils. Other components (metals, glass, plastics, paper etc) constituting 36.25% of the solid waste generated in Kaduna metropolis have a high recycle potential and can be sorted out and sold to the prospective buyers.

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