
EFFECTIVE SOLID WASTE MANAGEMENT IN THE CIRCULAR ECONOMY: THE CASE STUDY OF LAGOS STATE, NIGERIA*

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Abstract

As urbanization intensifies and population increases in any country, consumption pattern of a range of resources changes. Applying the principle of sustainable development in Lagos State involves a new approach to solid waste using appropriate concept of circular economy taking into account the existing waste-to-wealth initiatives and zero waste objectives. The paper focuses on disposal which discourages waste generation and the role of government and other stake holders for the efficiency of waste management that supports the circular vision. A pilot study was carried out on the rate of generation, collection and composition of waste in four Local Government Areas of the State for a period of 24 months. The result showed that foods and packages wastes account for over 68% of what households throw away daily which constitutes a menace in the landfill, while a minute percentage collected is recovered in some forms mostly by the informal sector. The government and stake holders should ensure no food waste gets to landfill but employ different recycling methods according to individual waste streams.

Keywords: waste collection, waste generation, waste management

1. Introduction

Lagos is an international megacity in Nigeria with an ever-growing population and wide spread environmental impact. It is a major financial Center in Africa. Its economic growth and pace of urbanization is continually changing the pattern of a range of resources. Significant quantities of solid waste are produced which generation, collection and management threatens the prosperity and sustainable development of the city.

Lagos State Waste Management Authority (LAWMA) was mandated to collect and transport commercial and industrial waste to designated landfill sites as well as manages the landfills. In 1997, Private Sector Participation (PSP) scheme was introduced to complement the efforts of LAWMA. The participants were assigned the responsibility of door to door / bulk waste collection in all the Local Government Areas at fees to be paid by serviced clients. For better performance, mega waste management companies were integrated to collect waste from tenements, markets, parks, industries and commercial centers within their zones for disposal at designated landfill sites. Cart pushers were equally integrated into the program in an effort to cope with the enormity of the waste (Akinmuleya, 2006).

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The collection Agents in Lagos State are: Lagos State Waste Management Authority (LAWMA), Private Sector Participants (PSP), Highway Managers Limited (HWM) and Local Governments (L/GOVT). There are four types of solid waste collection systems in operation in Lagos State. These are: Door to door collection, Bin collection, Communal / bulk collection and Street collection (Figs. 1-3). Different scholars noticed that there has been no time in the past twenty years when the Waste Management Agencies in Lagos catered for more than 70% -90% of the waste generated (Akoni, 2014; Onibokun et al., 2000).

In the Vanguard Newspaper of 2nd April 2014, LAWMA confirmed that Lagos Metropolis generates large quantities of waste to the tune of 10,000 to 12,000 metric tons per day. This has resulted in blockage of drainages, flooding and poor air quality due to bad habit of throwing wastes from their cars and still dumping wastes in unauthorized areas (Akoni, 2014). Many compounds are hemmed in by solid waste; the highways are not left out, which contribute to traffic bottlenecks and environmental pollution.



Fig. 1. Uncollected household waste on a street



Fig. 2. Uncollected market waste



Fig. 3. Uncollected waste on the highway

Lagos State still embraces the open land fill disposal method and unfortunately none of the waste is sorted before disposal. The application of circular economy requires a rethink about the way we currently consume product and services, reuse material through their lifecycle, redesigning waste out of the industrial economy. In 2015, over 23 million inhabitants of Lagos produce large amount of waste in form of paper, cardboard, plastics, metal, food and other materials which can be recycled making many scavengers earn a difficult and potentially hazardous livelihood by searching the landfill site for the materials (Akoni, 2015).

To effectively manage waste in any environment, the first step is the proper characterization of the waste in terms of quantity, composition and the source of generation. This study aimed to characterize the composition of domestic waste at source of generation, the rate of generation and collection in four Local Government Areas of the State

2. Material and methods

2.1. Description of the study area

Domestic waste for this study is defined as the waste generated by the activities of families at their homes. The study area covers four (4) Local Government Areas (LGAs) of the State. These settlements are classified according to the category of the inhabitants and their population densities. The settlements are Lagos Island in Lagos Island LGA, Ojodu in Ikeja LGA, Baiga in Somolu LGA and Agric in Ikorodu LGA. The population census of Lagos State is 9113,605 (Population Statistics, 2006).

The study area was categorized according to Lagos State Ministry of Physical Planning & Urban Development (Handbook, 1999), as follows:

Planned Settlement: This was also subdivided into two, based on low and high density zones.

- i. *Low density zone:* Lagos Island LGA. This is the principal and central local government area in Lagos, population of 212,700.
- ii. *High density zone:* Ojodu (Ikeja LGA). Ikeja is the state capital of Lagos State with a population of 317,614

Unplanned Settlement: This was also subdivided into two based on low and high density zones.

- i. *Low density zone:* Bariga (Somolu LGA). Population of Somolu Local government area is 403,569.
- ii. *High density zone:* Agric (Ikorodu LGA). Ikorodu is a city located North East of the state along the Lagos Lagoon. It shares boundary with Ogun State and has a population census of 527,917.

2.2. Sample collection

Thirty waste samples were taken randomly from each Local Government Area according to the number of residents chosen for the study. Each of the samples was emptied into a polythene sheet (1 meter square) laid on the bare floor for sorting, weighed (wet weight) with Kwonnie balance (20 kilograms) model TN – 1741874 and sorted into categories, as recommended by the American Society for Testing and Materials (ASTM, 1998) test method D5231-92 (1998).

The total wet weight of each waste category was determined and expressed in gram. The whole process of sorting and weighing was carried out four times a week in every two months between January 2013 and December 2015. From the data collected, it was possible to determine the quantities of waste generated per day per person and also the percentage composition of each waste constituent.

2.3. Waste collection

Waste data was collected from the Olusosun dumpsite for a period of two years between January 2013 and December 2015. The dumpsite is the disposal point for the selected study area. The dumpsite is located at Ojota in Kosofe LGA of Lagos State. It covers about 42 acres of land with maximum depth of 15 meters. It is the largest of the three dumpsites in operation in Lagos State Lagos State Waste Management Authority, Landfill Gate Records (Handbook, 2004).

Quantities of waste in dump trucks were determined in-situ at the dumpsite with the use of Weight Bridge.

3. Results and discussion

3.1. Composition of waste

The composition of waste varies from one local government areas to another (Table 1). Agric in Ikorodu Local Government area has the highest food waste and the lowest glass because is of unplanned high

density area. While Lagos Island the planned low density area has the lowest food waste and the highest glass. The packages are more in planned areas than the unplanned because of process food (Figs. 4, 5). Nylon is higher in the unplanned areas due to lack of portable water that make the residents depend on sachet water.

Table 1. Mean composition (g) of domestic waste from Lagos Metropolis

<i>Waste Composition</i>	<i>Lagos Island</i>	<i>Ojodu</i>	<i>Bariga</i>	<i>Agric</i>	<i>Mean</i>
Food Waste	1323.32	1354.22	1540.63	1627.33	1461.38
Metal	59.31	93.88	68.64	42.86	66.18
Textile	118.23	114.14	99.54	72.60	101.13
Plastics	135.87	130.10	115.55	100.62	120.53
Glass	62.09	52.86	52.79	41.31	52.26
Paper	240.33	224.08	217.31	204.11	221.46
Nylon	152.56	164.34	209.68	223.3	187.47
Mean	298.82	304.80	329.16	330.30	315.77

* Mean of 840 components of domestic waste samples

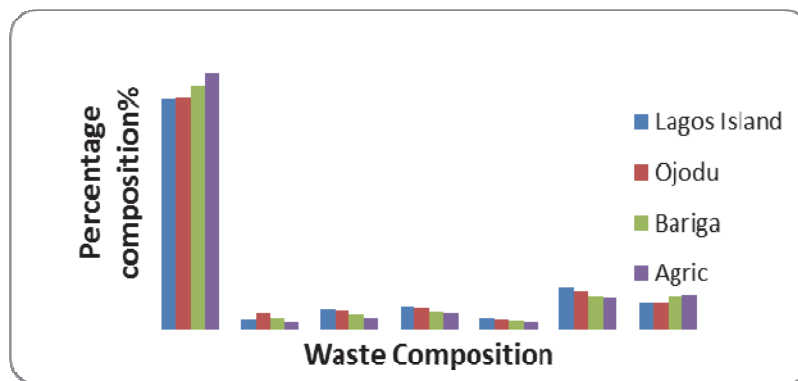


Fig. 4. Percentage composition of domestic waste in the four local government areas of Lagos State

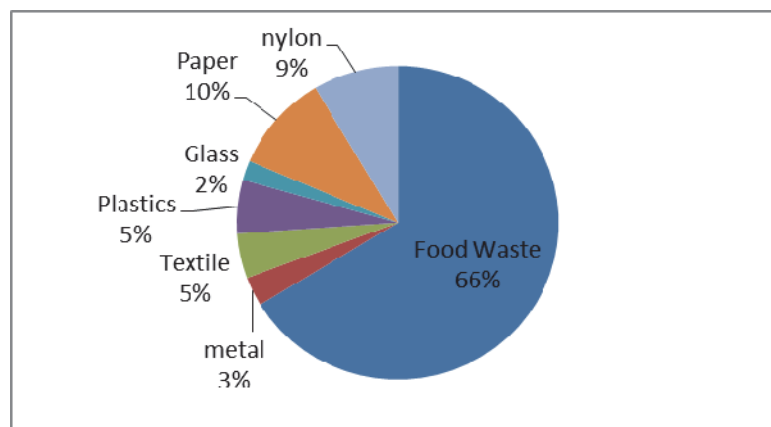


Fig. 5. Percentage composition of domestic waste in Lagos metropolis

The percentage composition for each of the Local Government Areas shows that Ikoyi has the lowest value of food waste. This can be explained according to Cointreau – Levine (1997) that higher income and economic growth have an impact on the composition of wastes. Wealthier individuals consume more packaged products, which result in a higher percentage of inorganic materials in the waste stream. In the case of planned areas (Lagos Island and Ojodu) most residents depend on processed food while those from unplanned areas (Bariga and Agric) rely more on unprocessed food for cooking at home, thus generating a significant amount of food waste. Bolaane and Ali (2004) reported that the packaging fractions of household waste have a direct relationship with household income. Likewise in this study, the packaging materials (paper, plastic, glass and metal) from Lagos Island, Ojodu, and Bariga are higher than those of Agric. The low value of packaging materials from Lagos Island, when compared with Ojodu and Bariga may be due partly to the accessibility of scavengers to waste bins that are usually placed outside the gates of buildings.

3.2. Waste generations per capita per day

Under the planned settlement category, Lagos Island has the highest generation rate which is attributable to the fact that the settlement is mainly inhabited by high income group compared to Ojodu which has more of middle income group (Table 2). For the unplanned category, Bariga has the highest rate of generation because it is averagely inhabited by the middle income group, unlike the low income group of Agric. Wealthier individuals consume more than lower income earners, which results in higher waste generation rate for the former (Cointreau-Levin, 1997).

Table 2. Average solid waste generated (g) / capita / day

Day	Local Government Area				Mean	Std. Dev.
	Lagos Island	Ojodu	Bariga	Agric		
1	576.21	567.11	496.44	471.78	527.89	38.71
2	578.32	568.48	499.75	471.87	529.61	30.44
3	582.12	561.49	481.93	474.32	524.97	24.22
4	577.33	562.93	496.77	472.44	527.37	39.20
5	573.81	567.44	493.21	472.31	526.69	34.02
6	583.11	564.67	489.45	471.69	527.23	34.03
7	575.44	562.92	486.96	473.27	524.65	43.30
8	576.41	564.88	499.21	470.88	527.85	183.49
9	573.29	564.37	494.37	475.82	526.96	29.66
10	575.56	568.34	484.55	472.73	525.30	31.10
11	578.69	567.28	497.88	474.37	529.56	20.66
12	574.62	564.66	494.37	475.55	527.30	32.89
13	577.84	565.45	489.78	473.29	526.59	22.50
14	574.93	564.72	490.74	475.20	526.40	39.57
15	576.98	566.30	487.94	472.94	526.04	16.96
16	575.93	567.05	497.66	472.06	528.18	20.20
17	574.65	564.81	495.56	474.45	527.37	27.64
18	578.44	567.03	497.78	476.54	529.95	37.26
19	576.46	565.31	497.53	478.65	529.49	39.44
20	577.08	567.55	497.55	473.67	528.96	11.25
21	574.87	564.97	496.74	477.44	528.51	26.03
22	576.82	562.88	489.47	473.05	525.56	23.33
23	578.54	567.03	497.54	478.11	530.31	23.33
24	575.84	568.11	487.76	474.63	526.59	30.77
25	578.44	563.94	493.85	472.65	527.22	33.25
26	577.81	562.73	494.47	472.43	526.86	21.42
27	581.12	565.52	496.33	478.44	530.35	15.15
28	578.43	563.22	496.50	474.88	528.26	38.00
29	576.90	562.45	497.44	478.90	528.92	37.81
30	578.23	563.87	495.30	474.33	527.93	18.18
Mean	579.40	565.25	493.83	474.29	528.19	42.20

3.3. Waste collection

The mean weight of waste collected from the four Local Government Areas by the four Agents responsible for the municipal solid waste collection and disposal in Lagos State indicated that Ikorodu has the highest generation rate because it is the most highly populated settlement. This shows that the rate of collection depends on the rate of generation of waste, which also depends on the population of a particular settlement (Odunaiya, 2002). The total mean waste collected in Ikorodu is the highest of all the settlements, due largely to the fact that it is the most densely populated settlement in the study area (Table 3).

Table 3. Average monthly weight (tons) of municipal solid waste collected from Lagos Island, Ikeja, Somolu and Korodu

Local Government Areas	LAWMA	L/GOVT	HWM	PSP	Mean	Std Error
Lagos Island	654.78	397.38	443.42	1945.96	860.39	245.02
Ikeja	644.59	452.32	398.47	2148.52	910.98	211.61
Somolu	1130.50	462.66	422.15	2642.22	1164.38	121.04
Ikorodu	5786.16	462.54	428.74	2145.33	2205.70	1108.40
Mean	2054.01	443.73	423.20	2245.57	1291.62	393.54

Between Local Govt, $F = 39.24^*$, Between Agents, $F = 36.38^*$, $^* =$ significant at 95%, LSD at 0.05 alpha level = 223.41

Municipal solid waste collected by Agents from Lagos Island, Ikeja, Somolu and Ikorodu showed that LAWMA had the highest collection of waste from Ikorodu only, while the PSP has the highest in Somolu. The reason is that the Lagos State Government introduced a pilot scheme, which gave a mandate to the PSPs to operate fully in some selected Local Government Areas which included the study areas. LAWMA operated fully in Ikorodu because of its large population and the problems of indiscriminate dumping of waste as well as the congested markets in the area.

4. Conclusions

Waste generated in Lagos State contains a large percentage of organic materials. The waste is also more dense and humid, due to the prevalent consumption of fresh fruits and vegetables, as well as unpackaged food which can be used for biogas and compost.

The remaining non-biodegradable materials can be reused or recycle. The most effective waste management method can be achieved by allowing the generator of waste to sort and package appropriately for collection instead of the current dumping of waste together for collection and final disposal at the dumpsite.

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