Solid Waste Generation and Disposal in Owerri Municipality, Imo State, Nigeria

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Abstract— *Solid waste management remains one of the major problems in urban areas in Nigeria. This study focused on solid waste generation and disposal in Owerri Municipality. The cross-sectional study was carried out in the three major districts, selected through a systematic random sampling from nine districts of the town. A total of 300 copies of a structured questionnaire containing questions on study variables was distributed among subjects and only 210 correctly filled copies were used for the study. Data on the quantity of wastes generated was collected for a period of seven days; each subject was given a plastic bag into which all waste generated each day was put, collected and measured. Samples of the waste generated were sorted out, categorized and weighed. The techniques of waste disposal were obtained through observation, interviews and responses from the questionnaire. Results obtained show the population characteristics of respondents. The average quantity of solid waste generated in the town was 0.58kg per capita per day; 71% of waste generated were made up of biodegradables, plastics (11.9%), paper (11.3%), bottles (3.3%), metals (2.3%) and miscellaneous (2.0%). The methods of waste disposal include open dumping (70.4%), open burning (10.8%) dumping at river banks (5.5%) and others (2.8%). The study recommended that due to high percentage of putrescible materials contained in the waste generated, the reactor system of composting should be adopted for their treatment due to its flexibility, adaptability, modularity, cost-effectiveness and eco-friendliness.*

I. INTRODUCTION

Solid waste management has become one of the major environmental issues in recent times. The desire to protect the environment and natural resources is increasingly becoming a great concern to many countries through environmentally sustainable waste management programmes (Kumar, Balaram and Binod, 2017; Ugwu, Echiegu and Okonkwo, 2018). Many urban communities worldwide are experiencing increasing volumes of waste, resulting mainly from high population growth, industrialization, increased consumption of manufactured goods and agricultural produce (Pan, Yu and Yang, 2019). Nigeria is one of the Sub-Saharan countries battling with the management of wastes. Despite different policy interventions in the past three decades, most towns in the country experience poor waste management. All the towns, without exception, are saddled with the proliferation of waste dumps on open lands, farmlands, river banks, major roads and streets, which provide breeding grounds to disease vectors and vermin, but also contaminate surface and groundwater (Ike, Ezeibe, Anijiofor and David, 2018). A major concern is that current estimates on the quantity and typology of waste generated and disposed of are grossly lacking. This gap in knowledge constitutes a cog in the wheel of effective planning and management of waste in the country. An interesting case is Owerri, the hub of tourism industry in the South-Eastern zone of Nigeria, where the sector is presently under threat as a result of poor waste management. Efforts to implement an integrated solid waste management programme are hampered by lack of current estimates on the quantity of waste generated and disposed of in the area. It is to address this issue that this study was designed.

II. MATERIALS AND METHODS

- *Study Area*

Owerri, the capital of Imo State, is located in the South Eastern zone of Nigeria, between Latitude 5^0N to $6^0$30'N and Longitude 6^0E to $7^0$34'E. With a total landmass of 24.88 square kilometers, a projected population of 632,781 (2019 estimates) based on 2012 estimates. With an annual population growth rate of 3.2 percent, the town is expected to be one of the biggest towns in Nigeria by the year 2025 (Ezeah and Roberts, 2012). The town is sited on a flat, low-lying topography that has contributed to rapid physical development. The suitable weather and climatic conditions have also led to the development of economic activities, especially the tourism industry with the proliferation of exquisite hotel services and booming retail and informal activities as well as light industries. The upsurge in the number of these activities in recent times have contributed immensely in the generation of large quantities of waste. The town also counts a number of educational and health facilities that generate a lot of waste. As a nodal centre with a large zone of influence, most farmers from surrounding rural communities bring their produce for sale in its three large markets. However, poor storage facilities and high temperature cause high spoilage of most of the perishable agricultural produce (melon, fruits, vegetables, etc). Consequently, large quantities of waste is generated by households and traders due to high spoilage rate of these produce.
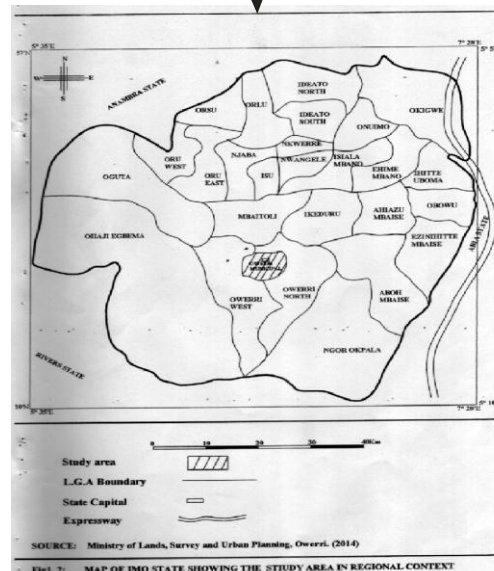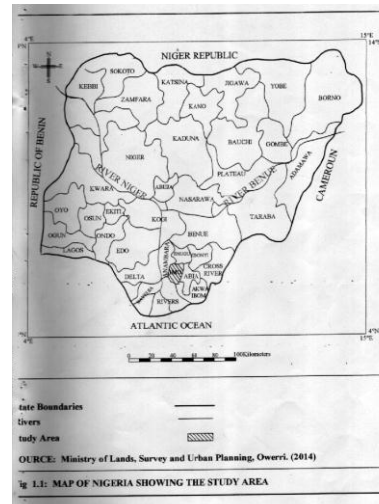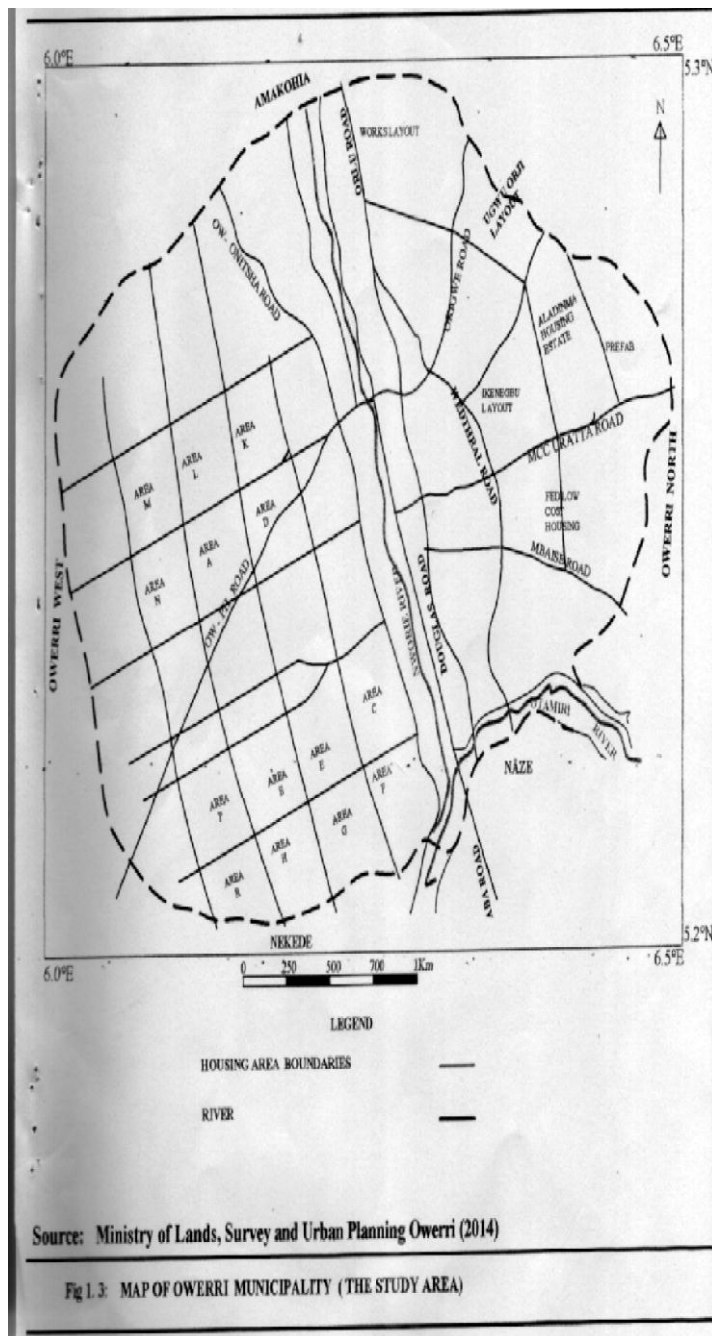
Fig. 1. Map of Study Area

- *Methodology*

The study is a cross-sectional survey design in which subjects were selected through systematic random sampling, that were themselves selected from the nine residential areas that make up the town; using a lucky-dip random sampling (See Table 1). The study area was divided into three zones representing high income zone (low density area), middle income zone (medium density area) and low income zone (high density area). Each of these zones were represented by Ikenegbu Estate, World Bank Estate and Old Owerri district respectively.

Data collection was carried out in these representative areas with the use of a structured questionnaire, waste sample collection, interviews and observation.

- *Estimation of the Quantity of Waste generated*

A total of 300 copies of the questionnaire was distributed among subjects in the three selected districts, 290 copies were collected and only 210 were correctly filled and used as the sample population. The structured questionnaire contained close-ended questions on variables containing population characteristics (age, educational levels, occupation, income, etc.) sources of waste, methods of waste disposal and more (see Table 2).

TABLE 1: Neighbourhoods in the three zones of Owerri

S/N	Housing Areas	2006 population census (NPC 2006)	2019 Projected population from 2006	Selected Neighbourhood
1	Ikenegbu	11,840	16,389	
2	Aladinma	11,230	15,545	
3	Works layout	7,941	10,993	**Ikenegbu**
4	Prefab Housing Estate	6,505	9,004	
5	Federal Low Cost Housing Estate	5,594	7,743	
6	Ugwu Orji Layout	3,361	4,653	
	Total	**46,471**	**64,327**	**62**
	Group B			
7	Federal Housing Estate	11,120	15,393	
8	Umuguma World Bank Housing Estate	11,751	16,266	
9	Federal Housing Estate Egbeada	4,550	6,298	**World Bank Housing Estate**
10	Irete Residential Estate	2,739	3,792	
11	Concorde Estate	4,540	6,284	
	Total	**34,700**	**48,033**	**68**
	Group C			
12	Umuodu (Old Owerri)	9,882	13,679	
13	Umuoyima	8,061	11,158	
14	Amawom	11,323	15,674	**Old Owerri**
15	Umuororonjo	8,884	12,298	
16	Umuonyeche	7,892	10,924	
	Total	**46,042**	**63,733**	**80**
	Sum Total	**127,213**	**176,093**	**210**

TABLE 2: Questionnaire distribution

S/N	Zones	Total number of questionnaire distributed	Percentage of the questionnaire distribution	Total of questionnaire collected	Total number of questionnaire correctly filled	Percentage of the total number of correctly filled
1	Ikenegbu	92	30.7	70	62	29.5
2	World Bank	96	32	103	68	32.4
3	Old Owerri	112	37.3	117	80	38.1
	Total	**300**	**100.0**	**290**	**210**	**100.0**

In estimating the quantity of waste generated, each of the subjects in the sample population in the three districts was given a plastic bag into which the waste generated each day was kept. The generated waste was weighed on a scale every morning and replaced with a new bag. The weight of the waste (in kilograms) was divided by the number of each household to obtain the quantity of waste generated per capita per day. This activity was carried out for a period of seven days as recommended by Rushbrook and Pugh (2004). The total waste generate per capita per day in each of the three districts during the period was later added and divided by three to obtain the per capita waste generation in Owerri. The result was then multiplied by the estimated population of Owerri to obtain an estimate of the total quantity of waste generated per day as recommended by Sharma and Ganguly, (2018).

- *Characteristics of the Waste Generated*

Samples of waste generated by subjects were used to characterize the waste generated. The items contained in the waste were carefully sorted out and categorized into food waste/biogenics, bottles, papers, plastics, metals and miscellaneous materials during the seven-day study period. A comparison was made between the typology of waste generated in the three districts to know the differences and the predominant materials in each of the zones.

- *Waste Disposal Techniques*

Information on waste disposal techniques were obtained through observation, sidewalks and interviews on the subjects.

Efforts were made to locate the major waste dumpsites to ascertain their major characteristics (age, distance, size, disposal technique, etc.).

- *Data Analysis*

Data obtained from the field survey were analysed using descriptive and inferential statistics. Descriptive statistics used include the mean and standard deviation. Data were presented graphically in tables and charts. Analysis of variance (ANOVA) was used to analyse variations in waste generation in the study area.

Data analysis was carried out using the Statistical Package SPSS Version 15.0 (SPSS, Chicago, ILL, USA).

III. RESULTS

- *Characteristics of Respondents*

The age distribution of subjects shows representation of different age groups including youths, adults and the aged, with predominance of people between the ages of 20 and 40 years (56.7%); 41 and 65 years (35.2%) and 65 years and above (8.1%). In addition to the age structure, 52.9% of the subjects were males while 47.1% were females; 49% were married, 46.3% were single while 4.8% were widows (See Tables 3a and 3b).

Majority of respondents were literate as 63.3% attended tertiary institutions, 19.5% secondary and 17.2% only primary education. Despite the slight variations in the three districts as regards education and occupational structure, 22.8% of the

subjects were public servants, 56.2% in private sector, 6.2% as artisans while 14.8% were not gainfully employed despite their level of education. Majority of the respondents, made up of 71.4% are middle income earners with their monthly income averaging between ₦21,000 and ₦99,000; 9.5% are high income earners with an income above ₦100,000 while 15.7% earned below ₦20,000 monthly. These results show that our samples were highly representative having captured all segments of the urban population (See Tables 3c, 3d and 3e).

TABLE 3a: Gender of the respondents

S/N	Gender	Ikenegbu		World Bank		Old Owerri		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	Male	34	54.8	35	51.5	42	51.9	111	52.9
2	Female	28	45.2	33	48.5	38	48.1	99	47.1
	Total	**62**	**100**	**68**	**100**	**80**	**100**	**210**	**100**

TABLE 3b: Marital Status of the respondents

S/N	Marital status	Ikenegbu		World Bank		Old Owerri		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	Single	28	45.6	34	50.0	35	41.1	97	46.3
2	Married	31	50.1	32	47.0	40	50.1	103	49
3	Widow	3	4.3	2	3.0	3	3.8	8	4.8
	Total	**62**	**100**	**68**	**100**	**80**	**100**	**210**	**100**

TABLE 3c: Occupational structure of the respondents

S/N	Occupational Structure	Ikenegbu		World Bank		Old Owerri		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	Private sector	35	56.0	35	50.7	48	60.2	118	56.2
2	Not gainfully employed	8	13.5	12	16.6	11	14.0	31	14.8
3	Public/civil servants	17	27	15	22.0	16	20.0	48	22.8
4	Artisans etc	2	3.5	6	8.7	5	5.8	13	6.2
	Total	**62**	**100**	**68**	**100**	**80**	**100**	**210**	**100**

TABLE 3d: Educational level of the respondents

S/N	Educational level attained	Ikenegbu		World Bank		Old Owerri		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	None	00	00	00	00	00	00	00	00
2	Primary	11	17.5	14	20.0	11	14.4	36	17.2
3	Secondary	10	16.8	17	25.0	14	17.2	41	19.5
4	Tertiary	41	65.7	37	55.0	55	68.4	133	63.3
	Total	**62**	**100**	**68**	**100**	**80**	**100**	**210**	**100**

TABLE 3e: Income distribution level of respondents

S/N	Income level distribution (monthly) ₦	Ikenegbu		World Bank		Old Owerri		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	₦0 – ₦20,000	8	13.2	12	17.1	13	16.0	33	15.7
2	₦21,000 – ₦59,000	35	55.8	33	48.4	40	50.0	108	51.4
3	₦60,000 – ₦99,000	12	20.4	17	35.6	20	25.0	49	23.3
4	₦101,000 and above	7	10.6	6	8.9	7	9.0	20	9.5
	Total	**62**	**100**	**68**	**100**	**80**	**100**	**210**	**100**

- *Quantity of waste generated*

The quantity of waste generated in the area depended on a number of factors including dominant activities in each zone, income of subjects, population density and size, season of the year and local habits. While there were variations in the quantity of waste generated in the three zones, the average waste generated in the area was 0.58kg per capita per day. Waste generation varied on daily basis with lesser quantities generated on Mondays, Tuesdays and Wednesdays of the week. Large quantities of waste were generated on Fridays, Saturdays and Sundays, with averages exceeding 0.60kg per person per day (See Table 4a).

- *Characteristics of Waste Generated*

At household level, 71% of waste generated were biogenics made up of food wastes, sweepings and other biodegradables. The study also recorded high percentage of non-degradable materials such as plastics (11.9%) papers (11.3%), bottles (3.3%), metals (2.3%) and miscellaneous (2.0%). The practice of waste separation is not common among subjects, especially residents in Old Owerri district but poorly practiced at Ikenegbu and World Bank Estates (See Table 4b).

- *Methods of Waste Disposal*

The common methods of waste disposal in the area include open dumping (70.4%), open burning (10.8%), use as fertilizer (compost) in gardens/farms (10.8%) and recycling (2.8%) (see Table 5). However, while 72% of waste generated at Old Owerri, 69% at World Bank Estate and 70.2% at Ikenegbu Estate are disposed of at waste dumpsites; 11.6% of these wastes from Old Owerri, 9.1% from World Bank Estate and 11.9% from Ikenegbu Estate are disposed of by open burning. The other components such as bottles, papers, and metals are

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usually sold to scavengers who move from street to street looking for these items. Waste disposal in Owerri is handled by the Imo State Waste Management Agency and the State Ministry of Environment.

TABLE 4a: Quantity of solid waste generated

Quantity of waste generated kg/day	Days	Ikenegbu		World Bank		Old Owerri			
0kg – 10kg	Sunday	1	2.0	7	2.9	2	2.5	5	2.4
0.11kg – 0.20kg	Monday	5	8.0	4	5.9	3	3.8	12	5.7
0.21kg – 0.30kg	Tuesday	7	11.3	6	8.8	4	5	17	8.1
0.31kg – 0.40kg	Wednesday	5	8.0	3	4.4	5	6.3	13	6.2
0.41kg-0.51kg	Thursday	8	3	5	7.4	6	7.3	19	9.0
0.51kg – 0.60kg	Friday	6	9.7	8	1.8	9	11.3	23	11
0.61kg +	Saturday	30	48	40	58.9	51	63.8	121	57.6
	Total	**62**	**100**	**68**	**100**	**80**	**`100**	**210**	**100**

TABLE 4b: Characterization of waste generated in the study area

Types of solid waste generated in the study area	Ikenegbu	World Bank	Old Owerri	Total	%
Papers	7	6	11	24	11.4
Bottles	2	3	2	7	3.33
Metals	2	2	1	5	2.38
Polythene/waterproof	6	10	9	25	11.9
Domestic waste/ biodegradable waste	45	47	57	149	71
Total	**62**	**68**	**80**	**210**	**100.0**

TABLE 5: Methods of waste disposal in the study area

S/N	Methods of waste disposal in the study area	Ikenegbu		World Bank		Old Owerri		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	Burning	8	12.9	10	15.1	13	16.6	31	10.8
2	Open dumping	50	80.1	52	75.9	59	74.3	161	70.4
3	Composting	3	5.4	4	6.0	5	5.7	12	10.8
4	Recycling	1	1.6	2	3.0	3	3.4	6	2.8
	Total	**62**	**100**	**68**	**100**	**80**	**100**	**210**	**100**

- *Discussion*

This study revealed that the average quantity of solid waste generated in Owerri Municipality in 2019 was 0.58kg per capita per day bringing a total of 319,669kg per year. This result corroborates the one obtained by Nwoke (2018) in his study in Owerri which was 0.55kg per capita per day. Our result is also close to those obtained by Bello *et al* (2016) that put the average waste generated per capita per day in Nigeria at 0.56kg. However, when compared with results obtained from studies carried out in other Nigerian towns, things turned out to be quite different.

For example, the per capita waste generation rate was 0.71kg in Ado-Ekiti and 0.73kg at Ibadan (Wahab, 2015), 0.49kg at Mubi (Mshelia, 2015), 0.48kg at Yola (Limar and Ngar, 2015), 0.68kg at Abuja (Imam et al, 2007); and 0.53kg in Kano (Naberu and Mustapha, 2014). With these variations in the results obtained by various studies in different towns, it may appear an over-exaggeration to place the average per capita waste generation rate in Nigeria between 0.65 and 0.95kg as suggested by Ike, Ezeibe, Anijiofor and Nik-Dand (2018). The lower mean of this estimate does not even capture the per capita waste generation rate of most towns.

Also, when the results obtained in Owerri are compared with those obtained in other Sub-Saharan African cities, it may surprise that the former shows slightly higher records. For example, it was 0.45kg per capita per day in Freetown, Sierra Leone (Sanko, Yau and Tran, 2014), 0.48kg in Sekondi-Takoradi in Ghana (Nyankso, Fer-Baffor and Gorkay-Miah, 2015), but generally below the average of the European Union of 1.7kg per capita per day. (Halkos and Petrou, 2018).

These results generally show that variations in the average waste generation rates may be due to certain factors including total population, local habits, socioeconomic characteristics, consumption patterns, seasons of the year, recycling culture among others.

Generation rates vary even within urban districts. As in the case of Owerri, for example, Old Owerri district generates more waste due to its high population density, but these waste contain more of putrescibles (73%) higher than the other two districts. Ikenegbu Estate, occupied mainly by medium and high income earners generates more of papers, bottles, and cans but with less biogenic materials (66%) due to their high consumption of manufactured and packaged products.

The average waste generation rate at household level may also be attributed to high litter habits observed along the streets of Owerri. Observation shows that Old Owerri district that houses the Central Business District, with different commercial activities, warehouses and eateries, experience high level of street littering (Tetlow Road, Douglas Road, Wetheral Road, Rotibi, etc). As observed by Nkwocha and Okeoma (2009) 5 out of 10 objects littered in the town were "food related", while 8 out of 10 objects were "trade related". While the former are made up of banana peels, maize husks, orange peels, fruits, the latter are made up of polythene bags, sachet water waste, food packaging materials, etc. The fact that household members litter these waste and do not take some of their purchases home tend to affect the per capita waste generation rate at household level in all the districts of the town.

It may also interest to know that some households remove some of the items generated and keep them for future use. For example, it was observed that items such as old newspapers, and beer bottles were not usually included in the quantity of waste generated per day by many households in Ikenegbu and World Bank Estates. Such items are sorted out either for sale or mere accumulation. This estimate also excludes the quantity of waste generated from commercial activities, markets, litters and fly-tipping in the area. It is estimated that these wastes make up 20% of all wastes generated in the town.

The characteristics of waste generated are typical of those obtained in most Nigerian towns, although the percentage of biodegradables (71%) is slightly higher than the national average of 65%. Other components of the waste generated are similar to those obtained from other studies, even though the percentage of paper (11.3%) was also slightly higher than the national average of 8% (Bello *et al*, 2016).

As regards waste disposal, open dumping remains the most practiced method, as about 70.4% of all waste generated in the town are disposed at the two approved waste dumpsites at Avu and Obinze at the outskirts of the town. These two dumpsites are located in burrow pits, surrounded by farmlands and at a distance of 7km and 8km from the town respectively. Operational for the past 12years, these dumpsites receive commingled wastes such as biogenics, plastics, papers, bottles, sanitation waste and sometimes biomedical and miscellaneous objects. These objects are openly dumped on the site without any cover materials, as leachate seeps ceaselessly into the soil. The waste dumps produce highly offensive odour and form breeding grounds to different disease vectors (rats, flies, birds, etc). Sometimes, the waste dumps are deliberately put on fire, especially during dry season to reduce the volume of waste. Open burning is also practiced by households during dry and harmattan seasons, while others dump their waste at the bank of Otamiri and Nworie Rivers that flow across the town. Some households at World Bank and Ikenegbu Estates spread some of the biodegradable components in their gardens where they grow some vegetables (pumpkin, pepper, vegetables and fruits).

However, as waste treatment technologies are evolving worldwide to meet the increasing stringent requirements, landfilling is becoming less viable and environmentally unfriendly. Therefore, the current crude practice of *collect and dump* adopted in Owerri over the years should be replaced with the modern "Enhanced Waste Management Concept", which emphasizes prevention, reuse and recycling and considers landfills as a temporary storage facility awaiting further treatment instead of as a final solution. The waste in these secure landfills can be minded after a fixed period. As a greater percentage of waste generated in the town are biodegradables, the adoption of in-vessel composting (IVC) technology should be seriously considered as land in Owerri is becoming scarce and at a premium. Precisely, the Vertical Composting Unit (VCU), one of the most successful variants of the IVC is highly recommended. The system, which is modular and allows for addition of extra chambers, is capable of processing all organic wastes in a safe and cost-effective manner without emitting malodour or leachate, in such a way

that efficiencies of time, space, energy and labour are all achieved. Besides, the compost produced can be readily sold to farmers in the surrounding communities to replace the highly demanded chemical fertilisers for cultivation of crops. Other waste materials such as bottles, papers, plastics, etc, could also be sorted out and sold to the growing number of scavengers, who, through their well established networks buy and sell these materials to local industries. With the adoption of this modern concept, waste in Owerri can no longer be seen as useless and valueless material that should be collected and dumped in a burrowpit, but as a resource that is useful to the society.

IV. CONCLUSION

This study has tried to determine the quantity, characteristics and methods of disposal of waste generated by households in Owerri Municipality. The study found out that the average waste generation rate per capita per day was 0.58kg; giving the total estimate of waste generated per day as 319.67tons. Biogenic materials make up 71% of all waste generated while the quantity of plastics, and papers are relatively on the increase when compared with results from other Nigerian towns. Open dumping of waste is the main waste disposal method, which is not only a source of environmental pollution but has become less adaptable in a town where land is becoming scarce due to population increase and high demand for physical development. As the major component of waste generated are biogenics, it is recommended that the reactor system of composting (Vertical Composting Unit) should be adopted in the treatment of these wastes because of its flexibility, adaptability, modularity, cost-effectiveness and eco-friendliness. Farmers in rural communities around Owerri would greatly benefit from the cheap compost that may be produced from this system in the production of food crops in the area. The adoption of the modern concept in waste management will help, not only to improve the level of cleanliness in the town but will also help to optimize it potentials as a major tourist centre in the southeast region of the country.

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