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MONTHLY ANALYSIS OF THE QUANTITY AND COMPOSITION OF SOLID WASTE GENERATION IN THE FOOD VENDOR STALLS OF THE MARKET AREA OF OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

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ABSTRACT: *The study investigated the monthly quantity and composition of solid waste generated in the food vendor stalls of the market area of Obafemi Awolowo University, Ile-Ife, Nigeria. The data for the study were obtained through measurement of solid waste generated over a period of a week in every twelve months of the year. Selection of shops was through systematic random sampling method of one out of every 20th food vendor. Data collected were analysed using descriptive statistical method. The study showed that the quantity of waste generated during the months that fall into raining season were higher than the productions in the months of the dry season. The highest daily average for the year and highest daily per capita (0.21kg) were produced in August. The least value of 0.09kg daily per capita was produced in March. Organic waste accounted for 76.5% of the total waste generated in the food vendor stalls while in-organic was 23.5%. The study concluded that the quantity of solid waste generated in the food vendor stall of OAU market varied with the variation in season of the year.*

KEYWORDS: solid waste generation, market, per capita, food vendors, stalls

INTRODUCTION

Solid waste generation and characterization is one of the major environmental challenges facing urban areas of developing nations. This was not of much concern in the early pre-industrial periods due to manageable population and low technology development. Disposal of waste was on ground where it would be compost to serve as fertilizers for soil improvement. Population

explosion and technology development of the modern time that increases volume of solid waste generation made solid waste a global concern and therefore called for the attention of the researchers (Lade, Agbede & Ilori, 2012). The increases was also considered to be the result of the high rate of turnover of goods produced, sold and purchased as a result of these development. This consequently brings about the waste products which constituted hazard in some of the major cities in the developing nations, including Nigeria. (Afon, 2005, Olukanni & Mnenga, 2015) posited that the factors responsible for such incremental change include: increase in population, change in standard of living and increasing use of disposable materials, excessive packaging of items and consumer practice.

Regardless of the social and economic status, humankind must inevitably generate solid waste on daily basis, no matter the geographical location of residence and nature of activity operating on land (Omoleke,2004., Ezigbo, 2012).. Thus with incessant progression in science and technology, there is significant increase in quantity and toxicity of solid waste generated (Ferronato & Torrenta, 2019). There is the need for investigation and understanding of the quantity and composition of solid waste if proper planning, effective projection and management is to be put in place.

Research on solid waste quantification and characterisation provide policy makers with a detailed understanding of a waste stream and enable management practices to be customized to local needs (Chang & Davila, 2008). Numerous studies focused the quantification and descriptions of waste generated at the market level have been conducted (Lade et al., 2012; Chooper, 2017; Fawole, 2012). For example, Fawole, (2012) quantified and characterised solid waste generated in selected markets of Ibadan, Nigeria into five components and determined quantity generated per person daily. Though, shops in the markets were disaggregated into fourteen categories based on the materials sold, the methodology adopted by the study could not capture waste generation pattern of each of the categories.

Others scholars such as Lade et al., (2012), Mondol et al., (2013) have also investigated solid waste composition in markets activity areas. Daily per capita of the entire market were determined. However, per person per quantity generated in different sections especially in food vendor stalls was not determined. Such study investigating solid waste generation across the months of the year in the food vendor shops in the market of academic institution especially in Nigeria is rare. Thus, it is difficult to ascertain the quantity, components and per capita waste generation in different months of the year among this category of space user.

This study investigated solid waste generation in the food vendor stalls of University market, using example of Obafemi Awolowo University, Ile-Ife, Nigeria and thereby determined the variations in the quantities generated in different months of the year. This activity area was selected for two main reasons. One, this section according to Adeniyi (2019) accounted for 20% of all the space users in the market. Secondly, the quantity of solid waste generated in this section was the highest in the area of the University, and thirdly, food waste accounted for the highest waste component generated in the University. Information about the quantity and components of waste generated in different sections of market if available could prevent environment related problems that are associated with poor waste management practices in public places especially, food vendor stalls in the market areas. Thus would also reduce the cost of managing the unavoidable ones.

LITERATURE REVIEW

Solid waste is the materials originated from human and animal activities that are usually throw away or regarded as of no use to the former user. In the same vein, Zhu, Asnani, Zurbrugg, Anapolsky & Mani (2008) defined solid waste as non-liquid material that is no longer precious to the possessor. In the work of Alabi, (2008), solid waste was categorised to include waste from households, hazardous waste from industrial and commercial establishments, market waste and refuse from institutions. It could take the forms of refuse and garbage (Yukantag,Clarke & Ross, 2017; Abalo et al., (2016).

It cannot be over emphasized that solid waste has been on the increase in quantity. The increase in solid waste generation could be attributed to several factors, namely: the proponent world population boom, rapid development, increase consumer buying power and plethora of other causes (Lade et al., 2012; Irwan, Basri & Watanabe, 2012). According to Schubeler, Wehrle & Christen (1996) and Adeniyi (2010), waste generation by a population is mainly a function of their socio-economic characteristics; consumption pattern, pattern of material use. People's attitude and belief also influenced the characteristics of solid waste generation by a given population (Srun & Kurish 2018., Appasamy, 1994). Afon (2007), in the study of residential area attributed factors of solid waste generation to standard of living of the city inhabitant, the land use structure, eating habit, educational level, household size, occupation, geographical location seasonal variation, cultural values (modes of living) and rate of population changes. In earlier study, Collins & Dawness (1977) posited that the higher income households are expected to produce more solid waste in quantity than low income household. This shows that quantity of solid waste generation is a function of population and socio-economic. No much effort was laid on the impact of landuse type on waste generation.

The quantity of municipal solid waste (MSW) generated in world as at 2016 was estimated at 2.01 billion tones amount to 0.74 kilogramme/person/day (World Bank, 2019). The quantity is expected to increase by 70% to 3.40 billion tones in 2050 resulted from rapid world population

growth and urbanization (World Bank, 2019). Also, Afon (2005) had earlier quantified per capita waste generation of some selected cities of Oyo State, Nigeria at 0.139 kg/day. In another study, Srinivas (2006) established that municipal solid waste represents about 14 - 20 percent of all waste generated. The study further adds that per capita waste generation varies from 5.3 kg/day for developed countries to less than 0.8 kg/day in developing countries. The study believes that ineffective policies, changing lifestyles, lack of awareness, among others will increase the rates over the next decade. Similar assertion was made by Mensah, & Larbi (2005) for Accra and Kumasi,

At a more widely geographical context, Cointreous (1992) earlier asserted that the daily per capita solid waste generation in lower income countries is lower than those of middle and higher income. The study discovered that while lower income countries generate on per capita basis per day of between 0.4 and 0.6 kg; middle income 0.5-0.9 kg; higher income countries generate between 0.7 and 0.8 kg. In a report carried out by UNEP (1992), it was observed that per capital waste generation in low and the high-income countries found to be 0.5 and 3.5 kg per day per person respectively. Likewise, in a research carried out by Afon (2005) on solid waste generation in Ogbomoso, Nigeria, the daily per capita waste generation for the core, transition and sub-urban zones was 0.154 kg, 0.121 kg and 0.109 kg respectively. The study concluded that the daily per capita waste generation decreased from the low income to high income people.

It has been established by UNEP (2009) that quantifying and characterising waste generated is the most fundamental step in solid waste management. However, data on waste generation and composition are largely unreliable and insufficient in developing countries (UN-Habitat, 2010; Wilson, Rodie, Scheinberg, Velis & Alabaster, 2012). Without proper data, it might be difficult to design sound strategies or to make wise budget decisions on waste management (Wilson et al., (2012). Having the necessary data on the amount of solid waste generated is an important precondition for efficient waste management. This is because without this data the design of justifying measures will be vulnerable in public places. Landuse activities in the market area of institutions of higher learning are not spared from this phenomenon. Hence, the interest this study.

Studies also abound on variation in solid waste generation between seasons of the year (Afon & Okewole, 2007; Kamran,Chaudhry & Battool, 2015). For instance, Afon and Okewole, (2007) established that highest quantity of waste generation (9.8 %) was recorded in October and the lowest was in February (6.5 %) in the study carried out inresidential area of traditional City of Oyo, Nigeria. Likewise, (Kamran et al., 2015) in a similar research carried out in Labhore, Pakistan revealed that minimum waste was generated in the Winter season (November, December and January) compared to Spring (February, March, April), Summer (May, June and October) and Wet season (July, August and September) of the year. Measurement of quantity solid waste generation in the study area in every months of the year would provide information

on generation patterns and assist in planning management strategies for different months of the ecological periods of the year.

MATERIAL AND METHODS

Study area setting

Ile-Ife town lies between latitude 7° 28′ 43.5″ and 7°34′ 51.41″ north of the equator and longitude 4° 27′ 22.5″ and 4° 35′ 40.61″ East of the Greenwich. A midsized city, Ile- Ife is the home to both the Obafemi Awolowo University (OAU) and the National Museum of Nigeria (figure 1). Because of its proximity to the equator, it has a high relative humidity with a rainfall of between 1800 mm and 2000 mm annually (Sogbesan, 2013). The rainy season is between April and October while the dry season lasts from November to March. The University lies to the North of Ile – Ife. The campus has an eye attractive landscape built on about 5,000 acres (20km²) of a total of 13,850 acres (53km²) of the land acquired and allocated for its use.

The climatic situation is as found in the rain forest zone. However, this is modified by the topography of the land to a little extent. The University consists of many landuse activity areas one of which is the market area (figure 2). Market area comprises New Buka and New Markets. Survey indicated that there were thirty three (33) shops in the New Buka, and three hundred and seventy four (374) were in the New Market. While the users of the shops in the New Buka are mainly food vendors, shops users in the New Market sell variety of good that were categorized into seven. Of all the 407 shops available in the two markets, 83 were allotted to food vendors. Though, all activity in the market produce waste, the contribution of food vendor to waste generated in the market is of interest to this study.

Figure 1: Osun State in the Perspective of Nigeria
Source: Advanced Space Technology Laboratory Applications (ASTAL), OAU, Ile-Ife, 2019

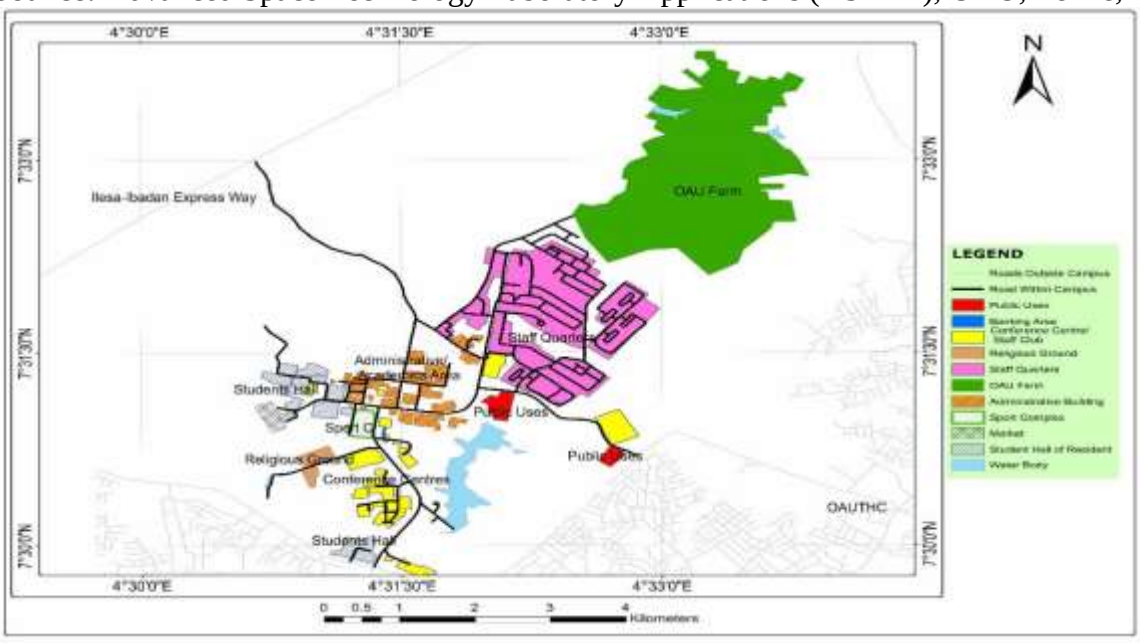

Figure 2: Obafemi Awolowo University Showing Different Activities Area
Source: Advanced Space Technology Laboratory Applications (ASTAL), OAU, Ile-Ife, 2019

Data source, collection procedure and analysis

The data for the study were obtained through measurement of actual solid waste generated in the food vendor stalls of the Obafemi Awolowo University markets. Measurement was carried out over a period of seven days of a week, in every month of the year. Solid waste generated was classified into different components disaggregated into nine major ones based on Afon (2005) and Rahaman, et al., (2013). These are paper, leaf, food waste, nylon and polythene, plastic materials, metal, old furniture, rag and broken bottle. For the period of survey, respondents were requested to sort the waste generated on daily basis into the receptacles that was provided by the researcher. The quantity of waste components generated was measured through the use of portable electronic scale. The figure of the waste generated and number of users in each of the shops where waste measurement take place were recorded on daily basis. Using systematic sampling technique, waste of the 10% of the available food vendors shops were considered for measurement. Therefore, solid waste was measured in 6 shops in the markets.

The above samples size far exceeded the acceptable minimum of 1% used by Afon (2005); Fawole, (2012) and Pfametter & Schertenleib (1996) for such exercise. The quantity of waste generation was measured for a period of one calendar year. This was done to show the effects of different ecological periods of the year. The method by (Afon, 2005), used in residential areas was employed. Each day's measurement was preceded with a familiarization visit. This visit on each occasion is to explain what the project is all about as well as request for respondents' cooperation. Similarly, waste receptacles for storage before actual measurement were distributed during the visit. Big sacks were provided for shops occupants at the market. This was necessary because of the quantity of waste that is generated in such activity centre.

Digital spring balance was used for the measurement. This is calibrated at interval of 0.1 kg and has the capacity to measure up to 40 kilogrammes (kg). This set is ideal for measuring most of household daily solid waste generation, including waste generated at the market.

Data collected was analyzed using descriptive statistical method. Analytical techniques used depended on the data collected. Frequency distribution, cross tabulation and measures of central tendency are the descriptive statistics employed. Cross tabulation was used in this study to show quantity and composition of waste and number of generator in all the activity areas. Measure of central tendency was used to determine the middle of distribution and helps to summarize the data. The tool was also used to determine average solid waste generation per day, per week, per month and per year in the area.

Data collected as a result of measurement carried out in these activity areas were summarized in table. For the purpose of arriving at waste multiplier through which future forecast on solid waste generation can be made, this study arrived at some useful information. These included multiplier

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on: daily per capital (kgper^{-} ^{1}day^{-} ^{1}) and daily average generator. The daily per capita (kgper^{-} ^{1}day^{-} ^{1}) was reached by the ratio of the daily waste generated and the daily number of generator.

In the same vein, daily average generator was obtained by dividing the number of generators by the number of days. The mathematical expression of the multiplier is presented as follows:

(i) kgper^{-1}day^{-1} = $\sum_{i=1}^{n} \frac{QG_i}{NGi_i}$ .....(1)

Where: kgper^{-} ^{1}day^{-} ^{1} Daily per capita

QG_i = quantity Generated per day i; and

NG_i = number of generator per day i

n = Number of days i

Other multipliers is

(ii) DAG = $\sum_{i=1}^{n} \frac{QG_i}{n}$ .....(2)

Where: DAG = Daily average generator
NG_i = number of generators per day i: and
n = Number of days

RESULTS AND DISCUSSION OF FINDINGS

Analysis of the solid waste generated in the twelve months of the year showed in Table 1. It could be established that the highest quantity was produced in the month of August. The quantity produced in the month was 179.9kg. The quantities generated in the month of September and October ranked second and third respectively. The months quantities produced were respectively 164.6kg and 160.6kg. The least quantity of waste generated for the year was in the month of January, when 89.6kg of solid waste was generated. It could be established that solid waste generated was on the increase between the months of April through August. It is also deducible that the quantity of waste produced was higher during the raining season (April –October) than the dry period of the year.

Similarly, finding on the daily per capita (kgper^{-} ^{1}day^{-}) of waste generation in the study area showed that the highest produced by individual was in the month of August when 0.21kg was generated. The month of September and October ranked second with the kgper^{-} ^{1}day^{-} ^{1} of 0.19kg and 0.18kg respectively. The least daily per capita was produced in the months of January and

February (0.10kg). It could be established that the month with the highest quantity of daily per capita according to investigation was the beginning of new semester in the University. It follows therefore that the students would be financially buoyant at the period to patronise the goods sold at the market. Through this, quantity of solid waste generated per person will also increase.

Information on the quantity of specific waste component produced in the area during the data collection period showed that food waste had the highest. The component accounted for 68.6% of the total waste generated in this area of the market. The components of nylon/polythene, plastic and leaf ranked second, third and fourth respectively. The corresponding percentages were 10.6, 8.1 and 6.3. The least quantity (2.6kg), representing 0.2% was recorded for paper. The high quantity of food waste could be attributed to the type of the material sold in the area. It was further established that organic waste components (food, paper; leaf and furniture) accounted for 76.5% of the total waste generated in the food vendor stalls. Monthly productions of these waste components is presented in Table 2

Shown also in the table was the $kgper^{-1}day^{-1}$ of the different waste components generated in the marked area. It could be deduced that the food waste had the highest $kgper^{-1}day^{-1}$. The component's $kgper^{-1}day^{-1}$ was 0.106kg. The $kgper^{-1}day^{-1}$ of 0.016 and 0.013 were ranked second and third respectively. The $kgper^{-1}day^{-1}$ were recorded respectively for nylon/polythene and plastic. The least $kgper^{-1}day^{-1}$(0.0003) was recorded for paper.

The study showed that a total of 1586.1kg of solid waste was produced in the area occupied by food vendors in the market area of the University. The quantity was generated by 10,277 people. The highest quantity and daily average of waste was produced in the month of August. January was the month of the year when the least quantity and the least daily average quantity of solid waste was generated.

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Table 2: Summary of the Quantity and Composition of Solid Waste Generated in the Food Vendors Stalls in the Market area of OAU on the Basis of the twelve months of the year

Waste component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%	Weekly average generator	Weekly average (kg)	kgper⁻ ¹day⁻ ¹
Paper	0.6	-	-	-	-	0.4	0.6	0.2	-	0.4	0.2	0.2	2.6	0.2	-	0.22	0.0003
Leaf	9.6	7.9	5.8	5.7	8.0	10.6	9.1	9.2	8.6	8.2	8.4	8.1	99.2	6.3	-	8.3	0.009
Food waste	49.5	59.7	53.8	91.8	88.9	100.2	108.2	126.8	122.9	107.8	91.7	87,3	1088.6	68.6	-	90.7	0.106
Nylon/polythene	13.5	10.9	8.9	15.9	17.8	16.3	12.6	20.1	11.9	18.8	7.6	14.4	168.7	10.6	-	14.1	0.016
Plastic material	11.2	7.9	4.8	13.7	13.7	10.3	10.3	13.7	11.0	10.4	11.8	9.8	128.6	8.1	-	10.7	0.013
Metal material	0.9	1.0	0.8	1.6	1.4	1.6	2.6	2.3	1.4	8.1	2.6	0.8	25.1.	1.6	-	2.1	0.002
Old furniture/wood	1.5	1.4	-	3.6	4.7	3.9	3.6	3.5	5.6	4.2	3.2	2.9	38.1	2.4	-	3.2	0.004
Rag/textile	0.9	0.84	0.43	3.5	2.0	1.7	1.1	2.3	1.6	0.7	1.8	1.6	18.5	1.2	-	1.5	0.002
Broken bottle/glass	1.9	0.8	-	2.2	1.6	2.3	1.1	1.3	1.3	2.0	1.2	0.9	16.6	1.1	-	1.4	0.0020.
Total	89.6	90.4	74.5	138.0	138.1	147.3	149.2	179.4	164.3	160.6	128.7	126.0	1586.1	-	-	132.1	0.154
%	5.6	5.7	4.7	8.7	8.7	9.3	9.4	11.3	10.4	10.1	8.1	7.9	-	100	-	-	-
No of generator	866	871	796	806	874	864	853	866	886	881	833	891	10277	-	856	-	-
%	8.4	8.5	7.8	7.8	8.5	8.4	8.3	8.4	8.6	8.6	8.1	8.7	-	100	-	-	-
Daily average generator	124	124	114	115	125	123	122	124	127	126	119	127	1470	-	123	-	-
Daily average (kg	12.8	12.9	10.6	19.7	19.7	21.0	21.3	25.6	23.5	22.9	18.4	18.0	56.2	-	-		-
kgper⁻ ¹week⁻ ¹	0.10	0.10	0.09	0.14	0.16	0.17	0.17	0.21	0.19	0.18	0.15	0.11	1.77	-	-	-	0.154

Source: Author's survey (2019

CONCLUSION AND RECOMMENDATIONS

The study had analysed the quantity and composition of solid waste generated on monthly basis in the food vendor section of the market area of Obafemi Awolowo University. This was done to determine monthly variations in the quantity, per capita waste generation and to understand the contributions of this category of market operator to waste production in the area. Food waste and nylon/polythene were the highest and second highest waste component produced in the area. The study concluded that the quantity of solid waste generated during the months that fall into raining season was higher than the waste generated in the dry season. This might be resulted from the fact that more farm produce especially fruits, vegetables and other putrecible materials are usually harvested during the raining season in the area.

High quantity of organic waste generated in the area is suggesting potential for composting which eventually could be used to boost farm produce in the area. This give way for many benefits, including the reducing the need for chemical fertilizer, water and pesticides, higher crop yield and revitalization of poor soils. It would also reduce the volume of solid waste to be disposed into the environment. The waste users should be educated on what constituted sustainable waste management practices such as sorting at the point of generation, type of waste receptacles to be used for specific waste component, storage material that is environment friendly and disposal practices that is sustainable. Adoption of this will address the problem of poor storage practice and the reducing the un-healthy odour perceived from waste receptacles located in different area in the study area which could be attributed to poor storage practice.

Solid waste management practices in the study area needs and operating master plan. Master plan is in form of manual that contain information and instructions about operation of how something is going to be done. The plan is to comprehensively map out strategies that would improve and sustain waste management practices. There is the need to develop a comprehensive solid waste management system. Plans must be formulated in area like preliminary fact findings on the environmental and physical condition, quantity and composition of solid waste generation and action on engineering issues. The plan will also cater for energy and cost recovery activity.

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