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CHARACTERIZATION AND MANAGEMENT OF SOLID WASTE IN FEDERAL UNIVERSITY OF TECHNOLOGY AKURE COMMUNITY, NIGERIA.

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Abstract:

This study focuses on the characterization and management of solid waste in Federal University of Technology Akure (FUTA) community and it identify strategies to improve the present situation. The data for the study was collected through measurement, direct observation and by well-structured prepared questionnaires. The results show that the moisture content and bulk density were 5.17 % and 251.8 kg/m^3. The composition of the waste generated within FUTA community is dominated by Plastics/Rubber (37.04%), Fabrics/Textiles (15.77%), Paper (11.91%) and Nylons (7.56%) wastes characterized as 'Combustible' (72.28%) followed by Ceramics/Glasses (13.10%) and Metals (12.92%) characterized as 'Incombustible' (26.02%). The remaining waste, including food and others accounted for 1.69% and 0.02%.The analysis in terms of management indicated that solid waste management in the community is on the average and therefore needs to be improved on, therefore, a sustainable waste management technique was proposed.

Keywords **—Solid waste, Characterization, Waste, Management, Community**

1.0 INTRODUCTION

Solid waste quantity is increasing at an alarming rate in developing countries like Nigeria due to rapidurbanization and modernization of most communities. Therefore, waste management is a major concern in most cities in developing countries (Zhen-Shan *et al.,* 2009). According to Tanaka (2006), the generation of solid waste isexpected to increase steadily along with economic growth if a lifestyle of mass production, consumption anddisposal is continued. Recently, there have been growing concerns about the environmental effects associatedwith solid waste management, as well as the increasing costs that solid waste management entails. How toaddress these increases has become an important issue. Inappropriate solid waste management causes air, soil,and water pollution. The solid waste materials block drainage systems, causing overflows during rainy seasonsespecially in urban regions. Furthermore, the arbitrary dumping of waste pollutes ground and surface areas (Foul *et al.,* 2009). The most visible implication of rapidly urbanizing is the increasing generation of solid waste which

has generated severe problems and these problems has been neglected and has caused severe health and environmental problems. Therefore, solid waste management (SWM) has a vital role to play in achieving the Sustainable Development Goals (SDGs) in health and environmentalsustainability (Singhal and Pandey, 2001).

A reduction in the quantity of generated waste materials minimizes their impacts on the environment.Solid waste matter must either be recycled or reused. When these alternatives are unsuitable, waste must beincinerated with energy recovery and only as a last option, should landfills be employed (Messineo and Panno, 2008). According to Khatib and Al-Khateeb (2009), segregating and composting organic waste, incinerating, andsegregating and recycling certain wastes should be considered as management options depending on theefficiency of the proposed collection and landfill measures. In order to determine the practicability of suchalternatives, studies on the quantity and composition of solid waste are considered essential. Idris*et al.* (2004) indicated that information regarding the composition of solid waste provides critical data for the formulation ofnew waste management plans. Waste minimization cannot be carried out effectively without reliable wastecomposition data. Sufficient waste composition data are required to evaluate the impacts of certain types ofwaste and to estimate a landfill's life.

2.0 Description of the Study Area

The Federal University of Technology, Akure (FUTA) is situated in Akure the urban township capital of OndoState, Nigeria. FUTA lies on latitude 7°28′North of the Equator and on longitude 5°13′East of the Greenwich Meridian. It stands on the altitude of about 295 metres above the sea level and has a present population of about 25,000 which include both staff and students. The study area covers the area of the FUTA dumpsite. Figures 1 and 2 show the topography map and the sectional view of the study area dumpsite respectively.

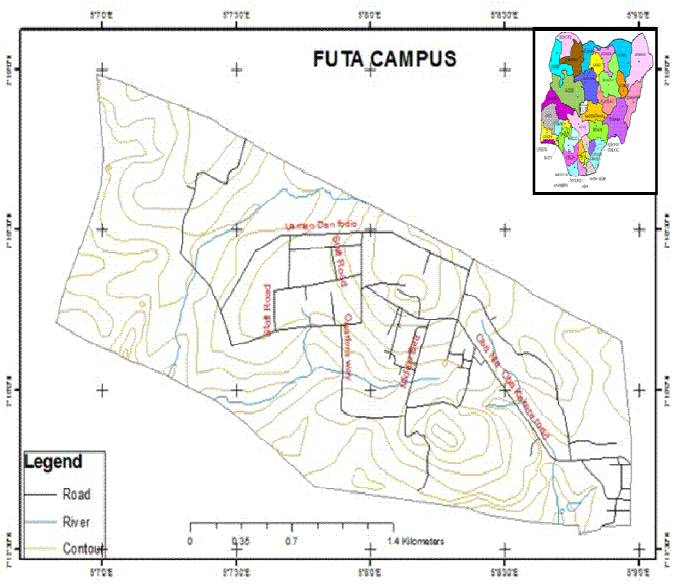

Figure 1: Topograhical Map of FUTA Community, the Study Area in Akure South

Figure 2: A Sectional View of FUTA Community Dumpsite

3.0 MATERIALS AND METHODS

The research gathered data from two main sources namely: primary and secondary sources. For the primary source of data generation, sampling was done while for the secondary source, questionnaire survey method was used.

Firstly, a reconnaissance visit was made to the dumpsite. The dumpsite is located in the interior part of the school, about 2000 m away from the school agricultural farm. The Dumpsite is an open expanse of land of about 30 m to the length and 55 m to the breadth. The site consists of various categories of waste ranging from organic to inorganic materials. Different categories of samples were gathered randomly and collected into big sacks. Samples were taken from predetermined points in the load (i.e. each corner and middle of each side) and then transported to the laboratory for further work. Samples were collected in triplicate and a total of 90 kg of waste was collected.After transporting the sample to the laboratory, the samples were then segregated manually into different physical components such as, paper, plastics, rubber, wood, glass, metals, textiles etc. The sorting was done in three categories namely Stream 1, Stream 2, and Stream 3. The remaining materials include uniform mixture of soil, mud, sand and other inert materials were not manually separable but weigh together as a single component. After the sorting and weighing was carried out, further analysis was carried out on the waste.

3.1 Laboratory Analysis of Waste

For the analysis of waste, the moisture content, the bulk density, the combustible, the incombustible and the recyclables materials were considered.

(a) Moisture Content

Different categories of waste (mainly organic) were collected in polythene bags, weighed and thereafter kept inside oven. The percentage moisture content was estimated by using the equations given by Peavy (2009).

$$\text{Moisture content } (\%) = \frac{(Initial\ Mass - Final\ Mass)}{Initial\ Mass} \times 100$$

(b) Bulk Density

Bulk density (kg/m^3) of solid waste is defined as the weight of waste per unit volume of uncompacted waste. Density is a significant criterion for the evaluation of storage, collection, transportation, and landfilling of waste (Yousuf and Rahman, 2007).For determination of bulk density of the solid waste, a rubber container of capacity V= 0.05m^3 was used and its weight was determined as W_1. Waste collected was poured into the container until

it was overflowing. The contents of the container were settled by dropping it three times from a height of 10 cm; and again more waste was added to fill it (EPA, 1996). The procedure was repeated until the container was completely full. No pressure was applied to the waste in the container to avoid altering the bulk density. The filled container and its contents were weighed to obtain a weight W_2. The bulk density (kg/m^3) was calculated as follows:

$$\text{Bulk density (kg/m}^3\text{)} = \frac{W_2 - W_1}{V_1} \quad (2)$$

Weight of measuring container used (W_1) = 0.545kg

Weight of the measuring container and its contents (W_2) = 1.804kg

Capacity of the rubber container used (V) = 0.005m^3

(c) Combustible and incombustible materials

Some of the solid wastes collected from the dumpsite are categorize as combustible and some incombustible. Combustible in the sense that they can easily be burnt when subjected to heat and incombustible in that they cannot be burnt easily when subjected to heat.The weight percentages of combustible and incombustible materials are calculated using equation 3 and 4.

$$\text{Combustible Materials}(\%) = Plastic(\%) + Paper(\%) + Textile\ (\%) \quad (3)$$

$$\text{Incombustible Materials}\ (\%) = Metal\ (\%) + Glass\ (\%) \quad (4)$$

(d) Recyclable materials

Plastics, papers, metals, and glasses are considered as recyclable materials due to their valuable and potential for recycling and their total percentages were then determined using equation 5.

$$\text{Recyclable Materials}\ (\%) = Plastics(\%) + Papers(\%) + Metals\ (\%) + Glasses(\%) \quad (5)$$

3.2 Questionnaires Survey and Data Measurement

A well- designed structured questionnaire was designed for the sole purpose of waste management and Microsoft Excel software package was used to analyze and rank the data information collected from the respondents. The questionnaire has a total of twenty-five questions grouped into four sections of similar concepts: Introduction, Concerns about solid waste management, Willingness to participate and Solid Waste Management Attitude Scale. They were distributed to selected respondents (i.e. students staying both in hostel and off campus and staff including both teaching and non-teaching) across FUTA community. Variables were measured on the basis of three point likert scales with responses ranging from 1- 3 representing 1 – No Option, Don't know and No opinion, 2 - Not Concerned, No and Disagree, 3- Concerned, Yes and Agree.

4.0 RESULTS AND DISCUSSION

4.1Waste Characterization

The results of the solid waste collected from the dumpsite which was weighed to determine the mass of each constituent waste quantity and its respective percentage are presented in Tables 1, 2 and 3. The

wastes were collected and grouped into three categories for easy sorting and weighing.

Table 1: Mass and Percentages of wastes collected for Stream A

S/N	WASTES TYPE	MASS(Kg)	PERCENTAGE (%)
1	Fabrics/Textiles	0.630	2.10
2	Papers	7.584	25.28
3	Glass/Ceramics	0.330	1.10
4	Plastics	17.010	56.70
5	Nylons	4.440	14.80
6	Others e.g Dust	0.006	0.02
	TOTAL	**30**	**100**

(Source: Author's Field survey, 2016)

Table 2: Mass and Percentages of wastes collected for Stream B

S/N	WASTES TYPE	MASS(Kg)	PERCENTAGE (%)
1	Fabrics/Textiles	6.840	22.80
2	Papers	3.138	10.46
3	Glass/Ceramics	11.460	38.20
4	Plastics	6.972	23.24
5	Metals	1.218	4.06
6	Nylons	0.372	1.24
	TOTAL	**30**	**100**

(Source: Author's Field survey, 2016)

Table 3: Mass and Percentages of wastes collected for Stream C

S/N	WASTES TYPE	MASS(Kg)	PERCENTAGE (%)
1	Rubbers	2.817	9.39
2	Food	1.518	5.06
3	Fabrics/Textiles	6.720	22.40
4	Plastics	6.540	21.80
5	Metals	10.410	34.70
6	Nylons	1.995	6.65
	TOTAL	**30**	**100**

(Source: Author's Field survey, 2016)

Tables 1, 2 and 3 shows the percentages of waste collected for Stream A, B and C respectively. The overall average percentage of all the three sampling point is 16.67%.It was observed from the combination of the three streams that the solid waste consisted predominantly of plastics by weight followed by fabrics, papers, metals and foods having the lowest percentage. The high percentage gotten for both plastics and fabrics was as a result of the population of students and staff living both in hostels and staff quarters respectively as lot of them make use of plastic and fabricmaterials for doing their house chores daily. Also, the percentage of paper waste was high based on the various administrative works carried out in various offices and from unused papers swept off from student lecture theatres. For proper waste composition and management, the result is summarized by grouping them according to their importance for recycling, reusing or incineration (Table 4).

Table 4: Characterization of the solid waste composition according to their importance

S/N	Characterization	Solid Waste Type	Total percentage (%)
1	Recyclable and Decomposable	Foods, Papers and Plastics	50.64
2	Combustible	Plastics, Papers and Fabrics	64.72
3	Incombustible Materials	Metals and Glasses	26.02

4.2 Waste Management

The waste management aspect of the research was conducted via the use of well-structured questionnaires and a proposed sustainable waste management technique. The questionnaire was prepared based on the current state of solid waste management in FUTA.Fifty (50) questionnaires were distributed to selected respondents (School hostel dwellers, Off campus hostel dwellers, Staff quarter dwellers and Others like shop owners, hawkers etc.). This number was selected based on the current status of waste management carried out in FUTA which can be rate to be on the average. However, this aspect of the work was carried out to improve waste managementtechniques in FUTA. Out of which 45 were returned which is 90% of the total respondent rate while one (1) of the forty five (45) was ignored for its inconsistency in entry, so total number of forty four (44) questionnaires were computed and analyzed.

(a) Characteristics of the Respondent

Respondent were divided into four groups; School hostel dwellers, Off campus hostel dwellers, Staff quarter dwellers and Others (Shop owners, hawkers etc.) with the number of questionnaires distributed to them with their response rate as shown in Table 5.

Table 5: Questionnaire's Distribution and Responses

Place of Residence	School hostel dwellers	Off campus hostel dwellers	Staff quarter dwellers	Others (Shop owners, hawkers etc.)	Total
Number Distributed	15	15	15	5	50
Number of Responses	14	13	14	3	44
Percentage of Total Responses (%)	31.81	29.55	31.81	6.82	100

(Source: Field survey, 2016)

Table 5 shows the percentage of respondents place of resident i.e. respondents living within the study area; 32% are school hostel dwellers, 32% are staff quarter dwellers, 29% are off campus hostel dwellers, 7% are other dwellers. It is therefore observed that more school hostel dwellers and staff quarter dwellers partook in this survey, which is good for analysis, as this category of dwellers are the main dominant of the study area.

(b) Analysis of respondent's rating, computed (R.I.I)'s and ranking

The respondents were asked to rank, based on their level of knowledge on solid waste management on the topics 'concern on solid waste management', 'willingness to participate' and 'solid waste management attitude scale'. Tables 6 to 8shows the respondent's ratings and the relative importance indexes (R.I.I) computed for each.

Table 6: Analysis of the Results ofConcerns of Solid Waste Management in FUTA Community.

Concerns about solid waste management in FUTA	**n_1**	**n_2**	**n_3**	**Total**	**RII**	**Rank**
How concerned are you about health risks related to **burning** refuse in FUTA?	3	7	34	44	0.902	4
How concerned are you about **illegal dumps** blocking drainage channel, polluting wells and groundwater in FUTA?	5	6	33	44	0.879	5
How concerned are you about **diseases** that are related to improper storage and disposal methods, like leptospirosis and malaria?	2	4	38	44	0.939	3
How concerned are you about **flooding of road** during rainfalldue to refuse blocking drains?	1	3	40	44	0.962	1
How concerned are you about the **service** provided by the waste truck in FUTA?	6	10	28	44	0.833	6
How concerned are you about **illegal dumping** in FUTA?	2	3	39	44	0.947	2

(Source: Field survey, 2016)

Table 7: Analysis of the Results of Willingness to Participate in Solid Waste Management in FUTA

Willingness to participate in solid waste management in FUTA	**n_1**	**n_2**	**n_3**	**Total**	**RII**	**Rank**
Have you ever heard about **composting***?	0	2	42	44	0.985	2
Have you ever heard about **recycling***?	0	1	43	44	0.992	1
If a recycling program was set up, that collected materials like plastic, paper, metals, etc, would yoube **willing to join FUTA community dweller to separate** these into separate bags for collection purposes	3	5	36	44	0.917	6
Would you be **willing to participate** in a program to compost food and yard waste?	3	3	38	44	0.932	5
If you were paid for every plastic bottle that you returned to the grocery store, would you participatein a program to **return** the plastic bottles?	1	1	42	44	0.977	3
Would you like **more information** about how and what types of refuse you can compost, reuse,and recycle in order to reduce the amount of refuse that you need to get rid of?	2	2	40	44	0.955	4

Table 8: Analysis of the Results ofSolid Waste Management Attitude Scale

Solid waste management attitude scale	n_1	n_2	n_3	Total	RII	Rank
I play an important role in the management of refuse in FUTA community	1	5	38	44	0.947	3
Environmental education should be taught in schools.	3	10	31	44	0.879	5
I **don't** care that burning refuse can be bad for my health and the health of others.	6	10	28	44	0.833	6
People throw refuse on the floors and in the drains and gullies because they have no other means of disposing off their refuse in FUTA.	0	39	5	44	0.705	7
Other personal issues (like crime, unemployment, and cost of living) are more important to people than a refuse-free community.	3	4	37	44	0.924	4
Regular collection of refuse is the only solution to the refuse problem.	2	6	36	44	0.924	4
Public education about proper refuse management is **one way** to fix the refuse problem.	0	3	41	44	0.977	2
It is **very** important that the FUTA community put recycling laws and programs in place.	1	2	42	44	0.992	1

(Source: Field survey, 2016)

In Table 6, the relative importance index (R.I.I) values range from 0.833 – 0.939. This result shows the concern on the flooding of roadduring rainfalldue to refuse and sand blocking some drains with the highest RII value of 0.939 serve as the frontline concern while the concern on the serviceprovided by the waste truck in FUTA with the least RII values 0.833 serves as the least concern on solid waste management in FUTA. Therefore more attention should be given to addressing the flooding of the roads during heavy rainfall caused by improper disposal of refuse into the flood drains.

In Table 7, the relative importance index (R.I.I) values ranges from 0.917 – 0.992. This result shows that most of the respondents have the knowledge of the word recycling and this complement the level of knowledge of dwellers in the community on solid waste management. It has the highest RII value of 0.992 while the willingness of FUTA community dweller to separatewastes into separate bags during collection for recycling program purposeswith the least RII values 0.992 indicates some dwellers unwillingness to participate in the recycling programme.

In Table 8, the relative importance index (R.I.I) values ranges from 0.833 – 0.992. This result with the highest RII value of 0.992 shows the interest of dwellers in FUTA community about putting recycling laws and programs in place that will help in the management of solid waste in the area while the concern on whether burning of refuse can be

bad for one's health and the health of others with the least RII values 0.833 indicates that the dwellers are less concern about what burning of those waste can do to their health. Therefore more education is still needed for the dwellers concerning health risk when it comes to solid waste management programme.

(c) Existing Solid Waste Disposal and Management

Solid waste collection presently in FUTA community is being implemented by moving from one designated area to the other. These designated areas have been supplied with large waste dumping container from which the waste management staff of the university gets it disposed to the school main dumpsite using truck when filled. The type of solid waste collection is commingled that is the mixture of all the wastes generated. There is presently no existing solid waste recycling and reuse programme going on in FUTA community.

(d) Proposed Sustainable Waste Management Technique

A proper waste management technique must be sustainable and efficient in operation. Since there is currently nosolid waste reuse and recycling programme going on in FUTA community, a simple but efficient waste management technique was therefore proposed. This proposed technique is term 'the 3Rs Model' which means 'Reduce, Reuse and Recycle' Model.According to Al-Maaded*et al.* (2012), this '3Rs' model provides the basis for a comprehensive management strategy of solid waste especially for municipals.

'REDUCE' which is the first R, involves the prevention and reduction of waste which actually means to minimize the amount of waste generated. Waste reduction in FUTA community could be achieved through separation of waste at source where provision is made for isolating recyclables and compostables from the whole waste generated.This could be intensified by public awareness and education. For instance, student rallies and public meetings could be an opportunity to be used as campaign strategies to propagate waste segregation and reduction (Zhu *et al.,* 2008). 'REUSE' which connotes the second R, involves subsequent use of waste materials either in part or whole. Some waste disposed within FUTA community which include some office gadgets, second-hand clothes from hostels and so on, could be reused directly by other users. It is achieved through sorting done at source rather than disposal site (The Cadmus Group, 2009); andalso through detailed processes of checking, cleaning, refurbishing and repairing whole items or some parts. This management strategy depends largely on the dweller's habit. 'RECYCLE' is the third R and this involves transforming waste materials which cannot be reused directly but can be converted to new product or raw materials. For instance, considering the percentages of each waste generated in FUTA community, used papers

obtained from offices and lecture theatres can be recycled into tissue papers, cardboards, files, envelops and other paper products. Metal cans and broken plastics from Staff quarters and Hostels can be re-melted and made into containers useful fordomestic purposes while food wastes collected from Hostels can be composed to produce a fertilizer.In the process of recycling waste generated in FUTA community, energy is recovered through pyrolysis and anaerobic digestion and gasification.

5.0 Conclusion and Recommendations

5.1 Conclusion

From the research, the bulk density of the solid waste generated for FUTA community was found to be 251.8 kg/m^3. This bulk density of 251.8kg/m^3 agrees with the national average obtained by Diaz and Golueke (1985) and Ogwueleka (2009). The composition of the waste generated within FUTA community is dominated by Plastics/Rubber (37.04%), Fabrics/Textiles (15.77%),Paper (11.91%) and Nylons (7.56%) wastes characterized as 'Combustible'(72.28%) followed by Ceramics/Glasses (13.10%) and Metals (12.92%) characterized as 'Incombustible' (26.02%). The remaining waste, including food and others accounted for 1.69% and 0.02%. With this high portion of combustible and recyclable wastes, recyclingof the waste for reuse would be the best option for sustainable solid waste management in FUTA community instead of collecting wastes from the hostels bins, offices bins, staff quarters bins and road sweeping and transporting them to the open air dumpsite located at the outskirt of the school for burning.

5.2 Recommendation

From, this research, it is recommended that community based solid waste management techniques be established and recycling of the waste be given due consideration as this on the long run will reduce the quantity of waste burnt thereby preventing the release of dangerous gases which has negative effect on human health to the atmosphere. These wastes can be recycled into different usable items as discussed in the research. The overall turnout will be economical as the recycled products will eventually be reused or sold.Also, sustained environmental education through local information means, jingles, and public enlightenment programmes must be done to enhance community participation.

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