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Characterization of Household Solid Waste Generated In Wuro Hausa Yola-South Local Area of Adamawa State in Northern Nigeria

Malgwi G.S.[1*], Abdulkadir S.A.[2]

[1,2]Dept. of Agricultural and Bioenvironmental Engineering Technology, Adamawa State Polytechnic, Yola Nigeria

Corresponding Author: salihuabd110@yahoo.com, Tel.: +2348036570793

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***Abstract*—** This paper presents a characterization study of the municipal solid waste generated in Wuro Hausa-Yola-South Local Government Area of Adamawa State in Northern Nigeria. The area was divided into three zones namely: Zone A-Lume, Zone B-Mallagiri, and Zone C-Bangel. Twenty households were randomly selected from each zone making 60 households that were studied. Household solid waste was collected daily within the period of within a period of (14) fourteen days with the help of (4) four trained waste collectors each fitted with a wheelbarrow and protective equipment. Solid waste features were determined based on components, mean mass (Kg) per household, solid waste, and bulk density. It was detected that 33.30% of the solid waste generated in the area is made up of food/putrescible matter and vegetable matter; 30.80% plastics and 36.40% metals. Per capita waste generated was 0.3kg/capita/day and the average bulk density of waste generated was 11.40kg/m3. It is recommended that formal composting and recycling facilities be established within the community, and private firms are involved in efficient and effective solid waste management in the area in the nearest future.

***Keywords*—**Characterization, Compositing, Household, Solid waste, Sorting, Sustainable, Recycling

I. INTRODUCTION

The municipal solid waste consists of domestic waste generated by urban residents (households) with the addition of commercial wastes but typically except for hazardous industrial waste and domestic sewage sludge [1], [2]. According to [3], hardwearing goods, containers, packaging, and food wastes, yard trimmings, and various inorganic solid waste. Hence, the municipal solid waste is a collection of refuses from households, market women, shop owners, traders, and various commercial activities carried out in the urban area, [4], [5]. The content and features of municipal solid waste are affected by several factors, that include the commercial, residential and other areas, economic level (variation amongst high and low-income areas), climate and weather (variation for the population throughout the year, tourist places) and the cultural activities of the doing business or living in the area. Areas associated with high-income earners produce more of inorganic waste materials like paper, plastics, and cardboard, while areas associated with low-income earners produce comparatively more of organic waste products, [6], [7]. Improper or uncontrolled solid waste dumpsite institute health hazards and damage the aesthetic beauty of many cities in Nigeria [8], [9]. It also encourages poor habits toward waste disposal.

The problem of municipal solid waste management in Nigeria cities has been attracting the attention of researchers [10], [6], and [11]. Most of the research findings point to the need for an efficient solution to solid waste menace in Nigerian cities. [12] Advocates an alternative to the conventional approach to municipal solid waste disposal. Uncontrolled or improperly sited open solid waste used by development agencies and international donor agencies in developing countries. According to them, the conventional approaches are bureaucratic and ignores the informal sector. The conventional approach concentrates on the use of advanced technology on collection and disposal. It is capital intensive nature can be a major reason why formal recycling or resource recovery programs are not common in Nigeria [12]. Importantly, it has been suggested that efficient recycling and compositing could save 18.6% in waste management costs and 57.7% in landfill cost [11], [13]. [11] Recommended that recycling should be accepted by Nigerians as a measure for an integrated solid waste management strategy. Recycling minimizes the number of solid waste materials needed to be collected, transported, and disposed of, thereby reducing cost. The initial stage of recycling is the collection and sorting of such waste into various categories suitable for reprocessing into new products. Compositing, on the other hand, involves a deliberate effort to convert organic waste into manure for agricultural purposes. According to [14], the practice of using compost from household waste and street sweepings ash as fertilizing materials by peri-urban farmers in Africa has gone on for centuries. Interestingly, compositing is not new in Yola. The state is known to have a tradition for compositing. However, improper collection and disposal discourage the extraction of organic components of municipal solid waste for compositing.

The two metropolitan local governments of Adamawa State (Yola South and Yola North) have a combined population of 1.8 million people (NBS, 2006) and they currently generate a moderate amount of municipal solid waste than can be effectively disposed of by the authorities. [15] Put the municipal solid waste generated daily in Jimeta metropolis at 200 tonnes, out of which only 50 tonnes could be evacuated. The situation is yet to improve. [16] Also observed that in Jimeta metropolis; solid waste is disposed of "in a more or less uncontrolled manner". In some cases, dumpsites develop all of a sudden at any space, including metropolitan roads (Jemeta, Mubi-Numan bye-pass)

According to [10], the management of municipal solid waste should involve a detailed study of the characteristics of waste. When various classes of solid waste are disregarded during the collection and disposal, the aim of effective solid waste management will be difficult [17]. This study aims to characterize the household waste generated in the Wuro Hausa area of Yola South in Northern Nigeria to prescribe the most effective and efficient method of its management.

II. RELATED WORK

Urbanization has been a major factor affecting waste management; it has contributed to the high level of waste generation in developed and developing countries. Nevertheless, a high level of waste generated is not properly managed; this has constituted the large outcome of managing collection, disposal, and evacuation of waste products [18], [19]. Solid waste management services include waste collection from households or territory collection centers to point of evacuation and disposal. Yet, the inadequate financial and human resources, the capacity of those with such responsibility cannot meet up with such requirements and this entails that in most events they only provide limited services [20]. Lack of solid waste management developing countries contributed to problems human and animal health hazards and consequently lead to biological and economic, and environmental problems [21], [22], [23].

Solid waste generation amount largely depends on certain factors such as food consumption, populace per capita income, and standard of living, population influx due to urbanization-improved lifestyles, increase in the level of commercial activities.

Certain social and economic variables may constitute an impact on the amount of generated solid waste base on daily family consumption. These factors include demographic features like family size; household employment status, age group, level of education; land ownership status, and period of the stay [21], [24], [25].
Availability of data on quantity variation and generation are important in planning for waste collection and disposal program. Modern waste is also generated due to an attempt to control or solve environmental problems like industrial production, air, and water pollution. The main part of the increase in solid waste generation has given rise to novel problems, which include sewage blockage and large residues to industrial production activities [26]. [27] Discovered that detail selective information on both amount and composition of the solid waste generated is important for the efficient preparation of household waste handling basic facilities.. [28] in their study Characterize household solid waste and its current status of municipal contribution and recommended that sensitization, recycling of wastes, 100% door to door collection, rag pickers, and recycling industries.

III. METHODOLOGY

For this study, the aim is to characterize the household waste in Yola-south L.G.A of Adamawa State the residential area of Wuro Hausa was divided into three zones namely: Zone A-Lumel, Zone B-Mallagiri, and Zone C-Bangel. Random selection method was used to select (20) Twenty households from each zone to make a total of (60) Sixty households that were studied. For the purpose of human waste generated, Average of (5) five persons were considered per household. The solid waste collection was done on a daily from each of the households for a period of (14) fourteen days using (4) four of the trained collectors with wheelbarrows, with protective equipment each. t. The leaders of the selected household were consulted before the commencement of the study and they voluntarily agreed to give their household solid waste to only the approved collectors during the period of the study. To discourage withholding of refuse, the collectors were not allowed to collect money from households. For each Zone, the solid waste collected daily was sorted into different categories, quantified and their bulk density determined.

Classification of Waste and Determination of Quantity of Component

For the classification of waste, ten waste components were considered. These were food/putrescible, vegetables, paper, plastic, glass/ceramic, fabrics, wood, metal, electronic waste, and "others". Others represent solid waste that is not identified or do not fall into the first nine categories. Sorting and weighing of collected waste were done at the dumpsite. The weight measurements were done using portable electronic scales. An EQB 50/100 Torrey scale (with the capacity of 50kg, readability of 10kg and plate dimension of 15" x 19") and EK 9150.5kg/111b x 1g Digital Kitchen Scale (with a capacity of 5kg, readability 1g and plate dimensions of 5" x 7.5").

Determination of Bulk Density

For determination of bulk density of the un-compacted waste, a wooden container of capacity V1 = 0.1m3 was used and its weight was determined as W1. Waste collected from the household 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 10cm; and again more waste was added to fill it (EPA, Ireland 1996). The procedure was repeated until the container was full. When the waste was not enough to fill the container, the volume V2 was calculated. No pressure was applied to the waste in the container to avoid altering the bulk density. The field container and its contents were weighed to obtain a weight w2. The bulk density (kg/m^3) was calculated as follows:

$$\text{Bulk density (kg/m}^3\text{)} = (W2 - W1)/V1$$

$$\text{Bulk density (kg/m}^3\text{)} = (W2 - W1)/V1$$

Determination of the per Capital Generation

The per capita waste in the communities was calculated by dividing the weight (WT) of the waste collected from each zone per day by the number of residents in the zone. This was computed on a daily basis. Analysis of variance ANOVA was used to test for a significant difference between mean figures of data from the three zones.

IV. RESULTS AND DISCUSSION

Table 3. Bulk density of Household solid waste in Wuro Hausa, Yola South.

Days	ZONE A Density (kg)/m^3	ZONE B Density (kg)/m^3	ZONE C Density (kg)/m^3
1	12.2	7.0	9.60
2	13.5	8.6	10.00
3	11.90	9.6	9.70
4	12.00	10.2	8.50
5	14.00	5.5	10.20
6	13.11	8.6	7.50
7	14.50	7.5	8.40
8	12.80	10.4	9.60
9	11.50	9.6	10.40
10	13.60	8.5	11.50
11	14.40	10.00	10.40
12	13.50	11.20	9.60
13	12.60	10.50	8.50
14	14.40	9.40	10.50

Table 4. Results of the Analysis of Variance (ANOVA) of per capita solid waste generation

Source	DF	Adj SS	Adj MS	F-Value	P-Value
ZONE	2	0.001202	0.000601	0.19	0.830
Error	39	0.124903	0.003203		
Total	41	0.126104			

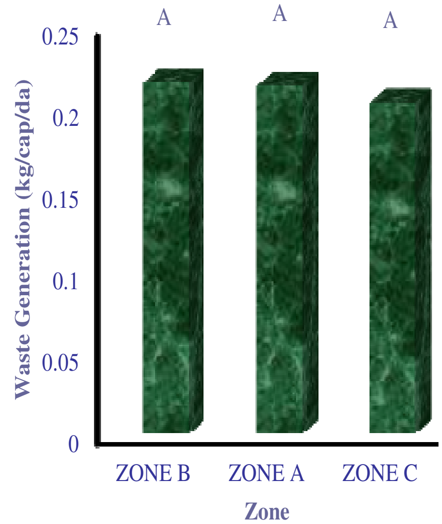

Figure 1. Per Capital Household Waste Generation in Wuro Hausa.

Table 5. Results of the Analysis of Variance (ANOVA) of the bulk density of solid waste.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
ZONE	2	138.52	69.261	45.81	0.000
Error	39	58.97	1.512		
Total	41	197.49			

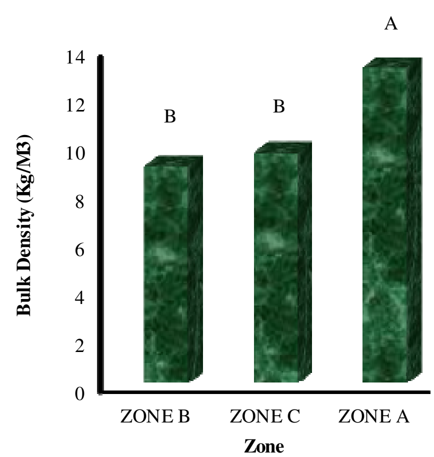

Figure 2. Bulk density for Waste Generation in Wuro Hausa

Discussion.

Table 1 shows the categories of solid waste collected from the three zones (A, B, and C). For the 20 households in each zone, there are 60 residents in Zone A, 56 residents in Zone B, and 70 residents in Zone C. this makes a total of 186 residents in the 60 households studied. Table 2 shows the per capita waste generated. Table 3 shows the bulk density (mass per unit volume) of the waste generated. Tables 4. and 5. Show a summary of Analysis of variance (ANOVA) used to determine if there exists a significant difference in the means of per capita generation and bulk density among the zones.

The Analysis of solid waste composition shown in Table 1 indicates that 33.30% of the solid waste is made up of food/putrescible and vegetable materials. This is slightly below the values of the result of a similar study done for the whole of Kano Municipal by [10], obtaining a total biodegradable waste of 66%. Wuro Hausa is not highly urbanized; this could probably be the reason. This indicates that the compositing/biodegradation component can be used as fertilizer thereby reducing the cost of disposal of this 33.30% of the total waste generated in the area.

Plastic materials are much as 30.80% of the solid waste being generated in Wuro Hausa. The plastic materials are mostly made of drinks-related packaging materials (cellophane bags, sachet water bags, etc.). This is a pointer to the fact that the traditional packing materials for food and drink items that used to be of biodegradable material such as green leaves have been replaced by plastic materials that are not easily biodegradable. Paper materials, glass/ceramics, and metals were 23.70%, 27.50%, and 36.40% respectively. Recycling has been a very useful method for managing these types of waste. Electronic wastes were negligible quantitatively small, though it could have a significant negative environmental impact considering its potential toxic character.

Table 2 indicates that the average per capita waste being generated in the area is 0.20kg/capita/day. [7] Obtained 0.25Kg/capita/day for Maiduguri, [29] found 0.56kg/capita/day for Munshin, Lagos, and [30], quoted 0.49Kg/capita/day for average Nigerian communities with household in commercial centers. With the average number of individuals per household being five, this shows that a household in the area generates an average of 1.4kg of solid waste per day. The result presented in Table 3 shows that solid waste being generated at Wuro Hausa of Yola South L.G.A metropolis has an average bulk density of 11.43kg/m3. This bulk density of 11.43Kg/m3 is lower than the national average obtained by [30]. This is also because Wuro Hausa is not highly urbanized. Bulk density is important for the selection of waste collection equipment. For example, compactor trucks are most effective if the waste has a low bulk density [3]. The summary of analyses of variance (ANOVA) in tables 4 and 5 ($p<0.05$) shows that there is no significant difference in the means of per capita waste generation among the three-zone in which Wuro Hausa was divided. The same goes for the bulk density of waste.

V. CONCLUSION AND FUTURE SCOPE

The characteristics of household solid waste generated by Wuro Hausa residents in the Yola South L.G.A area have been determined. The solid waste being generated is made of nine major components (food/petruscible, vegetables, paper, plastic, glass/ceramic, fabrics, wood, and electronic waste). During the study period, 33.30% of the total solid waste being generated in Wuro Hausa was made of biodegradable matter and 30.80 plastics. The per capita waste generation in the area was 0.20kg.capita/day and the average bulk density of waste generated was 11.40Kg/m3. There is a need to establish formal compositing (for 33.30% of the waste) and recycling facilities (for almost 25% of the waste) within the Wuro Hausa area shortly using the result of this characterization study as a guide. The participation of private firms in the collection, processing, and disposal of municipal solid waste is also recommended. This has been found to work well in Singapore [6]. The plastics (30.80%), glass/ceramics (27.5%), and metals (36.40%) are recyclable and this should be encouraged.

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AUTHORS PROFILE

S. G Malgwi received B.Sc. and M.Sc. degrees in Agricultural Engineering from the University of Maiduguri, Maiduguri Nigeria, and the University of Ibadan, Ibadan Nigeria in 1982, 1989 respectively. He is a Chief Lecturer at Adamawa State Polytechnic, Yola Nigeria.

S. A. Abdulkadir received Bachelor, Master in 2004 and 2013 and presently a candidate for Doctor of Philosophy (Farm Power and Machinery option) in Agricultural and Environmental Engineering from the Modibbo Adama University of Technology, Yola, Nigeria. Currently, he is a Senior Lecturer in the Department of Agricultural and Bioenvironmental Engineering, Adamawa State Polytechnic Yola, Adamawa Nigeria.

Table 1: Household Waste Categories and Quantities in Wuro Hausa

Category	Zone A		Zone B		Zone C		Zone A+B+C	
	Weight (kg)	%	Weight (kg)	%	Weight (kg)	%	Weight (kg)	%
Food Putreable	1.2	9.84	0.8	11.43	0.9	12.0	2.9	33.30
Vegetables	1.2	9.84	0.7	10.0	0.5	6.670	2.4	26.60
Paper	0.7	5.74	0.7	10.0	0.6	8.00	2.0	23.70
Polyethene's	1.2	9,84	0.7	10.0	0.5	6.70	2.4	26.80
Glass/ceramic	1.0	8.20	0.7	10.0	0.7	9.33	2.4	27.50
Fabrics	0.5	4.55	0.2	2.86	0.5	6.67	1.2	14.20
Plastics	1.4	11.48	0.7	10.0	0.7	9.33	2.8	30.80
Wood	1.5	12.30	0.7	10.0	0.7	9.33	2.9	31.60
Metal	1.4	11.48	0.9	12.86	O.9	12.00	3.2	36.40
Electronic waste	-	-	-	-	-	-	-	-
Others	2.1	17.21	1.60	22.86	1.8	24.00	5.5	64.10
Total	12.2	100.0	7.00	100.0	7.5	100.0	27.7	100.0
Waste/household/day	1.39	-	1.44	-	1.56	-	-	-

Table 2: Per Capital Household Waste Generation in Wuro Hausa.

DAY	ZONE A Total Waste (kg/da)	No. of Residents	Waste Generation (kg/cap/day)	ZONE B Total Waste (kg/day)	No. of Residents	Waste Generation (kg/cap/da)	ZONE C Total Waste (kg/day)	No. of Residents	Waste Generation (kg/cap/da)
1	11.50	60	0.192	12.10	56	0.216	21.00	70	0.300
2	11.20	60	0.187	11.00	56	0.197	11.40	70	0.163
3	11.30	60	0.188	11.20	56	0.200	11.30	70	0.161
4	11.10	60	0.185	11.40	56	0.204	11.60	70	0.166
5	11.40	60	0.191	11.50	56	0.205	11.50	70	0.164
6	11.50	60	0.197	11.10	56	0.198	11.80	70	0.169
7	11.30	60	0.188	11.40	56	0.204	21.0	70	0.300
8	11.40	60	0.190	11.00	56	0.197	11.50	70	0.164
9	11.20	60	0.187	11.30	56	0.202	11.40	70	0.163
10	21.00	60	0.350	21.10	56	0.377	21.00	70	0.300
11	11.55	60	0.198	11.50	56	0.205	11.50	70	0.164
12	11.50	60	0.192	11.20	56	0.200	11.60	70	0.166
13	11.45	60	0.191	11.50	56	0.205	11.40	70	0.163
14	21.00	60	0.350	11.40	56	0.204	21.00	70	0.300
Total	178.70			168.60			199.00		
Mean	12.76	60	0.1993	12.04	56	0.215	14.21	70	0203

