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Assessment of Household Solid Waste Generation and Disposal in Mubi Metropolis, Adamawa State, Nigeria

Sunu J. B.[1], Okoro B. C.[2], Osuagwu J. C.[3]
[1,2,3]Department of Civil Engineering, Federal University of Technology, Owerri
([1]judesunu@gmail.com)

Abstract-This study, "Assessment of Household Solid Waste Generation and Disposal in Mubi metropolis, Adamawa State" was carried out to determine the solid waste generation per capita per day, types and composition of the waste generated and assessing the existing solid waste management process in the study area. Questionnaire was administered with respect to socio-economic characteristics and waste management data in the seven wards of the metropolis and household sampling survey approach was used to determine the rate of solid waste generation through sorting and weighing. Data gathered through interview were complemented through observations. Data analysis was by statistical method of regression aided by Microsoft Excel. The frequency of refuse collection was determined based on predetermined time interval. The estimated household solid waste generation rate in the metropolis was 8.522kg/day on the average. While the per capita waste generation rate estimated was 0.2134kg/day. The per capita waste generation rate in the high income group in the metropolis household was the same range of the per capita waste generation rate for low income group based on 1975 industrial directory published by the Federal Government of Nigeria. Manual separation of the waste collected revealed that the various components of the solid waste can be categorized into biodegradable, non – biodegradable and inert waste. It was observed that the study area produced about 68.87% (5.869kg) of biodegradable materials among which kitchen waste dominated with about 32.80% (2.795kg), while non – biodegradable waste contributed about 25.96% (2.212kg) and inert wastes contributed about 5.169% (0.441kg) daily. The study identified plastic waste containers as the most widely used household solid waste storage facility and the dwellers have no access to waste collection services by any agencies. Scavengers play vital role in salvaging the recyclable materials. The model developed is expressed in the form with haul time directly proportional to the round trip distance with correlation coefficient of 0.976. Effective management of solid waste generated will require disposal techniques like composting, properly designed landfill, a reliable waste collection service, reduction of waste generation at source and awareness among the masses. Finally, the study recommends further studies on the local factors affecting household solid waste generation and disposal in the metropolis, estimation of energy content of the household solid waste as well as recycling potential of the solid waste generated. The biodegradable and combustible wastes which formed about 83.66% of the total solid waste generated should be effectively used in composting manure to boost agriculture.

Keywords- *Solid Waste, Waste Generation, Waste Disposal, Waste Management*

I. INTRODUCTION

The history of solid waste generation dates back to ancient times. Human began to produce solid waste when they first settled down into smaller non-nomadic communities at around 10,000 BC (Worrel and Vesilind, 2012).The smaller communities managed to buried solid waste generated just outside their settlements or disposed them in nearby rivers and water bodies (Marshall and Farahbksh, 2013).

Solid waste is often referred to as the third pollution after water and air pollution.

Solid waste has been defined by Tchobanoglous et al. (1993) as any material that arises from human and animal activities that are normally regarded as useless or unwanted. Wastes can be regarded as a human concept as there appears to be no such thing as waste in nature. For example, items that are considered waste in developed countries find their way in developing countries where they are reused.

Solid waste may be biodegradable, non-biodegradable, combustible, non-combustible, recyclable and non-recyclable. The combustible materials that may be found in the waste stream are plastics, paper, yard debris, textiles, wood, food waste and other organics and non-combustible materials include metals, glass, leather, aluminum etc. It was reported that household solid waste is one of the most difficult sources of solid waste to manage because of its diverse composite nature (Huntly, 2010).

Basically, Household Solid Waste (HSW) refers to waste materials usually generated in residential environment. The waste production is based on day to day operations of household (Pakpour et al., 2014). Household solid waste is mainly classified into two groups; organic and inorganic waste. Organic waste comprises of food and vegetable waste and other kitchen waste. On the other hand, inorganic comprises of plastic, paper, glass, metal etc. Solid waste is temporarily stored before it is collected and disposed. According to

Ojedabenitez et al. (2003), by analyzing the HSW, the waste generation rate and any potential use for recyclable waste can be identified. The storage is of primary importance because of public and environmental health issues as well as aesthetic consideration.

Improper solid waste management often results in very serious health consequences. Many factors are responsible for the poor solid waste management. These include over population, insufficient information regarding waste generation rate and composition of waste generated, lack of waste collection points and disposal points, poor environmental education and culture of citizens, inadequate technology and facilities for waste management practice and lack of interest in sorting the waste into various constituents at source. Solid waste in Mubi metropolis is progressively becoming more and more difficult to manage as a result of increasing solid waste generation due to rapid increase in population. Similarly, this leads to littering of different kinds of solid waste materials in the area thereby making it to look untidy and loose its aesthetic value. In order to adequately address this problem, the rate of solid waste generation of the town is necessary.

The collection of waste at its generation source and sort it out directly into different types of materials is justify since it is one of the most accurate approaches for characterizing waste composition (Brunner and Ernest, 1986). This can helps to increase the rate of capture of recyclable materials, produce compost lower in heavy metals and increase the percentage of organic. This will now lead to accurate assessment of solid waste management system and assist in achieving the proper solid waste management and utilization of reusable resources in the area. In most cases, the solid wastes are putrescible and therefore the properties of this kind of solid waste are affected during storage, collection and transportation processes. Thus, characterization of this kind of waste at transfer stations would not give actual values. Solid waste generation rate could be effectively investigated when the solid waste quantities and composition are conducted at source of generation. Assessment of the entire element involved in solid waste management is necessary to ascertain the deficiencies that exist currently in the management strategies in the area and enable a change in the waste management system.

The paper presents information on the daily solid waste generation rate, the type and composition of the solid waste generated at the source of generation (houses), the current methods of household solid waste collection process and disposal, a model relating haul time and round trip distance of solid wastes disposal and the solid waste management approach for improvement in waste management. And suggest appropriate methods for effective solid waste management in the metropolis.

The study focused on household solid waste collection and disposal systems and was limited primarily within the boundaries of the seven wards in the area for primary data collection.

II. METHODOLOGY

The methods adopted for the study were the used of questionnaire administered with respect to socio-economic characteristics and waste management data in the seven wards of the town, secondary data were applied and household survey approach was used to determine the rate of solid waste generation through sorting and weighing. Similarly, through observation which complemented the reality of the data gathered through interview.

A. Sampling Technique

The study involved stratifying the metropolis (stratified random sampling) into zones based on suburbs in the metropolis because of the homogeneous nature of buildings within the study area. In the sample size allocation, sampling was done in 56 houses stratified according to the number of houses per zone whereby every 5^{th} building was sampled.

B. Survey of the Study Area

A survey on the selected houses were carried out in order to identify the solid waste retain, the number of household members and also to seek their permission for the exercise. The households were briefed during the process of surveying on the procedure of solid waste collection from their houses. Each house that accepted the request for the participation in the survey was labeled with a reminder notes on not to discard their solid wastes out of the house.

C. Solid Waste Characterization and Measurement

The study was carried out to estimate quantitative and qualitative composition of the household solid waste in the study area. The houses selected for a particular week that is eight houses (8) were attendant to daily for sample collection throughout the week and was repeated same for seven weeks.

The selected households were provided with labeled polythene bags for easy identification. At each house, two polythene bags were given; one for putrescible and other bag for other forms of solid wastes. The polythene bags were collected every morning and gathered at the point where they were emptied for segregation and weighed. Solid wastes generated were sorted into different categories and weighed separately using weighing scale; digital weighing balance and other balance that enables the determination of the quantities of the various components. The sorting process was done manually and it was daily. The solid wastes collected were segregated accordingly into the various components, viz; kitchen waste, food waste, paper waste, textile waste, plastic rigid waste, plastic film waste, metal waste, glass waste, dust waste, and hair, wax waste etc. The components have been selected because they were consistent with component categories reported in literature, were readily identifiable and were adequate for the characterization of solid wastes for most application. These constituents were grouped into three major components, viz; biodegradable wastes, non-biodegradable wastes and inert materials. During the process, personal protective equipment (PPE) were used such as hand gloves, nose mask and proper foot wear to avoid any unwanted incident and hygiene purpose.

Data was collected through interviews, observations and field measurements. All data obtained from field measurements, observation or interview were analyzed using statistical methods of regression for data conversion in model calibration. Data obtained from the solid waste characterization were analyzed by simple mathematical applications for the estimation of average wastes and percentage contributions. Similarly, data obtained from the questionnaire were analyzed using statistical approach aided by Microsoft Office Excel.

D. Determination of Daily Solid Waste Generation Rate

The daily solid waste generation rate was determined by adopting household survey sampling approach which involved sorting and weighing. The total waste of the waste streams was determined by simple addition of all the household wastes generated in the study area. Average waste generation was then calculated for each component. The average waste per house per day (wph) was obtained by simple dividing the grand total waste by the total number of household's attend to throughout the study period. Lastly, the average capital waste generated per day (WGpc) was calculated by the relation;

The average capita waste generation per day:

$$(WGpc) = \frac{wph}{H} \quad (1)$$

H is the average number of persons per house.

E. Identification of the Type and Composition of Solid Waste Generated

The data obtained for the cumulative summary of quantification and qualitative compositions of household solid waste in the study area were used to identify the type and the composition of the solid waste generated.

The percentage contributions was obtained by dividing the total average waste generation (TAwg) of each major component by the grand total of the average waste generation (GTAwg) and multiply by 100.

Thus; %contribution=

$$\frac{Total\ of\ average\ waste\ generation}{Grand\ total\ of\ average\ waste\ generation} \times 100 \quad (2)$$

or % contribution of major component=

$$\frac{TAwg}{GTAwg} \times 100$$

Similarly, the percentages of household composition was obtained by dividing the average waste generation of individual waste constituents (Awg) by the grand total of average waste generation (GTAwg) and multiply by 100. Thus;

% composition=

$$\frac{Average\ waste\ generation\ of\ each\ constituents}{Grand\ total\ of\ averag\ waste\ generation} \times 100 \quad (3)$$

or, % composition of individual constituent=

$$\frac{Awg}{GTAwg} \times 100$$

F. Assessment of Current Methods of Household Solid Waste Collection and Disposal

The assessment of current methods of household solid waste collection and disposal processes were ascertained from the information gathered through questionnaire and interview/observation. The questionnaire was analyzed using simple percentage via bar charts by using Microsoft Office Excel. The data used provide information on solid waste disposal of different families, waste disposal locations, households that attempted to separate solid waste before disposal, how regular refuse were picked up if there were government designated refuse collection points near houses, what should determine the frequency for refuse collection, house – to – house collection of solid waste and those willing to pay for refuse collection etc.

G. Development of a Model relating Haul Time and Round Trip Distanceof Solid Waste Disposal/Determination of Average Waste Storage Container Size

The development of model relating haul time and round trip distance and determination of container size involved the use of data from field measurements or interview/observation and were analyzed using statistical method of linear regression.

This is to investigate the relationship between haul time, h and round trip distance, x. With the variables h and x and there were n pairs of measurements of (x_i, h_i) as shown in Table (1), the empirical constants as well as the product moment were determined. The calibrated model equivalent was also developed from the plot of h against x.

TABLE I. HAUL TIME, h AND THE ROUND TRIP HAUL DISTANCES, x OF SOME OPEN DUMP SITES IN THE METROPOLIS

Dump sites	h hr/trip	x km/trip
1	0.20	5.0
2	0.25	6.5
3	0.26	6.9
4	0.30	8.5
5	0.32	8.9
6	0.42	11.0

Other data gathered for the analysis i.e. for the determination of the average container size for the residential solid waste collection included;

i. Time spent at disposal site (Time spent waiting to load as well as off- load), S = 7mins.

ii. Round trip distance, x = 12km

iii. Time spent driving to the next waste dump, T_d = 4mins.

iv. Time spent to load collection vehicle at dump site, T_L = 5mins.

v. Off-route factor, W = 0.18

(Off route factor is the time spent on activities that were non-productive with the respect to actual collection e.g. time lost due to unavoidable congestion, time spent on checking in and out, time spent on equipment repairs and maintenance, others may include time spent for lunch, talking to friends etc.)

vi. Field utilization factor, f = 0.40

(Field utilization factor is the fraction of the field size occupied by the waste)

vii. Hours worked/day, H = 4hrs

viii. Number of days worked in a week = 1

Therefore, the average size of container to be used by the household was estimated as follows;

Collection time/trip, $T_{ct} = T_L + T_d = 5 + 4 = 9$mins.

Round trip time,

$$T_{rt} = \frac{T_{ct} + S + h}{1 - W} \quad (4)$$

But the total haul time, h = 0.0141 + (0.3592 × 12) = 0.4451hrs. = 26.71mins. (From equation 3)

Therefore, $T_{rt} = \frac{9+7+26.71}{1-0.18} = 52.085$mins.

$$\text{No. of trip/day, } N_{td} = \frac{H}{T_{rt}} \quad (5)$$

H is worked hour /day = 4hrs

$N_{td} = \frac{4 \times 60}{52.085} = 4.608 \cong 5$trips

From equation 4, the average size of container, C is given as:

$$C = \frac{W_w}{N_w f} \quad (6)$$

N_w is the no. of trip/week = $N_{td} \times 1day = 5 \times 1 =$ 5trips/wk

W_w is the weight of waste/week = waste generation rate × no. of trip/day

Using the standard volume-to-weight conversion factors (US EPA Archive Document, 2006), the respective volumes (m^3) of the components were deduced as shown in Table (2).

TABLE II. CONVERTED WEIGHTS OF THE AVERAGE WASTE GENERATION OF THE VARIOUS CONSTITUENTS TO CUBIC METRE

Component	Weight (kg)	Volume (m^3)
Paper waste	0.308	0.0106
Textile waste	0.868	0.0065
Plastic rigid waste	0.799	0.0269
Plastic film waste	0.461	0.0345
Metal waste	0.504	0.00102
Glass waste	0.448	0.00035
Fine (Dust) waste	0.420	0.00262
Food and kitchen waste	4.693	0.00548
Wax, hair etc. waste	0.0205	0.00002116
Total	8.5215	0.08799116

Hence, the average volume of household solid waste generated in the metropolis was $0.08799m^3$/day.

Weight of waste/week ≡ Volume of waste/week

$= 0.08799 \times 5 = 0.43995m^3$

Therefore, $C = \frac{0.43995}{5 \times 0.4} = 0.21998m^3 \approx 0.220m^3$ (220 litres)

The average waste storage container size is approximately $0.220m^3$.

III. RESULTS AND DISCUSSIONS

A. *Waste Generation Rate*

Table (3) shows the results of the cumulative summary of all the weeks for the quantification and qualitative composition of household solid waste in the study area. Similarly, the quantification and qualitative composition of household solid waste for week one to seven were observed in Tables (4) – (10).

TABLE III. QUANTIFICATION AND QUALITATIVE COMPOSITION OF HOUSEHOLD SOLID WASTE IN THE STUDY AREA (CUMULATIVE SUMMARY OF ALL THE WEEKS)

	Biodegradable waste				Total	Non-biodegradable Waste				Total	Inert waste		Total	Grand total	Total SW/ House/day
	Kitchen waste	Food waste	Paper waste	Textile waste		Plastic rigid waste	Plastic Film Waste	Metal waste	Glass waste		Dust waste	Hair, Wax Waste etc.			
Total Waste (kg)	106.2	72.14	11.58	33.59	223.5	30.38	17.53	19.16	17.04	84.11	15.95	0.778	16.73	324.3	
Average Waste generation	2.795	1.898	0.308	0.868	5.869	0.799	0.461	0.504	0.448	2.212	0.420	0.0205	0.441	8.522	1.067
Percentage Contribution	32.80	22.27	3.614	10.19	68.87	9.376	5.410	5.914	5.257	25.96	4.928	0.241	5.169	100	

TABLE IV. QUANTIFICATION AND QUALITATIVE COMPOSITION OF HOUSEHOLD SOLID WASTE FOR WEEK 1

	Biodegradable waste				Total	Non-biodegradable Waste				Total	Inert waste		Total	Grand total	Total SW/ House/day
	Kitchen waste	Food waste	Paper waste	Textile waste		Plastic rigid waste	Plastic Film Waste	Metal waste	Glass waste		Dust waste	Hair, Wax Waste etc.			
Total Waste (kg)	19.76	13.35	2.013	8.044	43.17	6.360	3.632	3.987	3.366	17.35	2.575	0.139	2.714	63.23	1.129
Average Waste generation	2.823	1.907	.2876	1.149	6.167	0.9086	0.5189	.5696	.4809	2.478	.3679	.01986	.3878	9.034	
Percentage Contribution	31.25	21.11	3.184	12.72	68.26	10.06	5.745	6.306	5.324	27.44	4.073	0.2199	4.292	100	

TABLE V. QUANTIFICATION AND QUALITATIVE COMPOSITION OF HOUSEHOLD SOLID WASTE FOR WEEK 2

	Biodegradable waste				Total	Non-biodegradable Waste				Total	Inert waste		Total	Grand total	Total SW/ House/day
	Kitchen waste	Food waste	Paper waste	Textile waste		Plastic rigid waste	Plastic Film Waste	Metal waste	Glass waste		Dust waste	Hair, Wax Waste etc.			
Total Waste (kg)	19.64	14.79	2.301	7.918	44.65	6.376	3.825	3.581	2.653	16.44	4.248	0.171	4.419	65.51	1.170
Average Waste generation	2.806	2.113	.3287	1.131	6.379	0.9109	0.5464	.5116	0.379	2.348	.6069	.02443	.6313	9.358	
Percentage Contribution	29.99	22.58	3.513	12.09	68.17	9.734	5.839	5.467	4.050	25.09	6.485	0.2611	6.746	100	

TABLE VI. QUANTIFICATION AND QUALITATIVE COMPOSITION OF HOUSEHOLD SOLID WASTE FOR WEEK 3

	Biodegradable waste				Total	Non-biodegradable Waste				Total	Inert waste		Total	Grand total	Total SW/ House/day
	Kitchen waste	Food waste	Paper waste	Textile waste		Plastic rigid waste	Plastic Film Waste	Metal waste	Glass waste		Dust waste	Hair, Wax Waste etc.			
Total Waste (kg)	10.51	7.207	0.715	2.876	21.31	2.344	1.360	2.048	1.703	7.455	1.136	0.064	1.200	29.97	1.249
Average Waste generation	3.503	2.402	.2383	0.9587	7.102	0.7813	0.4533	.6827	.5677	2.485	.3787	.02133	0.400	9.987	
Percentage Contribution	35.08	24.05	2.386	9.599	71.12	7.823	4.539	6.836	5.684	24.88	3.792	0.2136	4.006	100	

TABLE VII. QUANTIFICATION AND QUALITATIVE COMPOSITION OF HOUSEHOLD SOLID WASTE FOR WEEK 4

	Biodegradable waste				Total	Non-biodegradable Waste				Total	Inert waste		Total	Grand total	Total SW/ House/day
	Kitchen waste	Food waste	Paper waste	Textile waste		Plastic rigid waste	Plastic Film Waste	Metal waste	Glass waste		Dust waste	Hair, Wax Waste etc.			
Total Waste (kg)	16.03	10.37	2.655	5.602	34.66	5.508	2.522	2.782	2.788	13.60	2.482	0.121	2.603	50.86	1.060
Average Waste generation	2.672	1.728	.4425	0.9337	5.776	0.918	0.4203	.4637	.4647	2.267	.4137	.02017	.4339	8.477	
Percentage Contribution	31.52	20.38	5.220	11.01	68.13	10.83	4.958	5.470	5.482	26.74	4.880	0.2380	5.118	100	

TABLE VIII. QUANTIFICATION AND QUALITATIVE COMPOSITION OF HOUSEHOLD SOLID WASTE FOR WEEK 5

	Biodegradable waste				Total	Non-biodegradable Waste				Total	Inert waste		Total	Grand total	Total SW/ House/day
	Kitchen waste	Food waste	Paper waste	Textile waste		Plastic rigid waste	Plastic Film Waste	Metal waste	Glass waste		Dust waste	Hair, Wax Waste etc.			
Total Waste (kg)	15.18	8.736	1.389	3.949	29.25	4.120	2.368	2.356	3.239	12.08	1.855	0.111	1.966	43.30	0.9021
Average Waste generation	2.530	1.456	.2315	0.6582	4.876	0.6867	0.3947	.3927	.5398	2.014	.3092	0.0185	.3277	7.218	
Percentage Contribution	35.05	20.17	3.207	9.119	67.55	9.514	5.468	5.441	7.479	27.90	4.284	0.2563	4.540		

TABLE IX. QUANTIFICATION AND QUALITATIVE COMPOSITION OF HOUSEHOLD SOLID WASTE FOR WEEK 6

	Biodegradable waste				Total	Non-biodegradable Waste				Total	Inert waste		Total	Grand total	Total SW/ House/day
	Kitchen waste	Food waste	Paper waste	Textile waste		Plastic rigid waste	Plastic Film Waste	Metal waste	Glass waste		Dust waste	Hair, Wax Waste etc.			
Total Waste (kg)	12.88	9.102	1.335	2.571	25.89	3.379	2.135	2.236	1.979	9.729	1.751	0.091	1.842	37.46	0.9365
Average Waste generation	2.576	1.820	0.267	0.5142	5.177	0.6758	0.4270	.4472	.3958	1.946	.3502	0.0182	.3684	7.492	
Percentage Contribution	34.38	24.29	3.564	6.863	69.10	9.020	5.699	5.969	5.283	25.97	4.674	0.2429	4.917	100	

TABLE X. QUANTIFICATION AND QUALITATIVE COMPOSITION OF HOUSEHOLD SOLID WASTE FOR WEEK 7

	Biodegradable waste				Total	Non-biodegradable Waste				Total	Inert waste		Total	Grand total	Total SW/ House/day
	Kitchen waste	Food waste	Paper waste	Textile waste		Plastic rigid waste	Plastic Film Waste	Metal waste	Glass waste		Dust waste	Hair, Wax Waste etc.			
Total Waste (kg)	12.21	8.580	1.171	2.631	24.59	2.297	1.692	2.169	1.316	7.474	1.898	0.081	1.979	34.04	1.064
Average Waste generation	3.053	2.145	0.293	0.658	6.149	0.574	0.423	0.542	0.329	1.868	0.475	0.0203	0.495	8.512	
Percentage Contribution	35.87	25.20	3.442	7.730	72.24	6.743	4.969	6.367	3.865	21.94	5.580	0.239	5.819	100	

Substituting the value of wph of Table (3),

Therefore, $WGpc = \frac{1.067}{5} = 0.2134kg/capita/day$

In the metropolis, the per capita waste generation rate estimated was 0.2134kg per day i.e. based on the average number of persons in the household which were five persons.

And also, looking at the Table (3), the total average household solid waste generated in the metropolis was 8.522kg/day and the waste generated per household per day was 1.067kg.

The high percentage of business people as compare to civil servants and their economic backgrounds might also have influenced their purchasing power and probably translated to the relatively low waste generation rate. It was observed that the socio- economic background of the town had influenced their generation rate. It implies that the residents in Mubi might have adopted inconvenient lifestyles that produced low amount of waste and it might have coupled with the displacement they had by the ''Boko Haram'' in 2014. Since then, up till date, some of the residents have not return to their respective homes because they are still living in fear. Similarly, the waste generation within the metropolis could be ascertained by other socio -economic factors such as household size, cultural patterns and personal attitudes.

B. *Model relating HaulsTime and Round Trip Distance/ Average Waste Storage Container Size*

The calibrated model equivalent deduced from the plot of haul time against round trip distance as shown in Fig. (1) is given below;

$$h = a + bx \quad (7)$$

where a and b are the parameters to be determined from the data (i.e. a and b are empirical constants in hrs/trip and hrs/ km respectively).

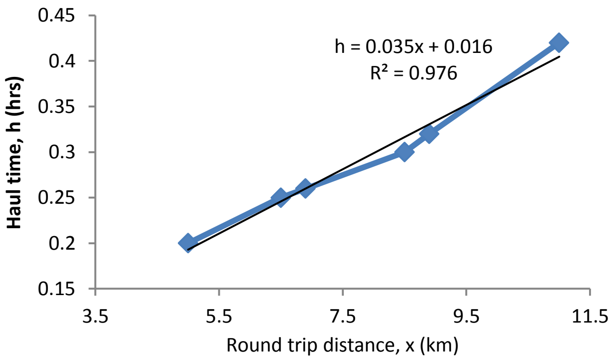


Figure 1. Haul time, h against round trip distance, x

From the regression line, the value of b is 0.035hrs/km (the slope) and the value of a is 0.016km/trip (the intercept) and the correlation coefficient, R^2 is 0.976 (97.6%) and the calibrated model as shown from the plot is;

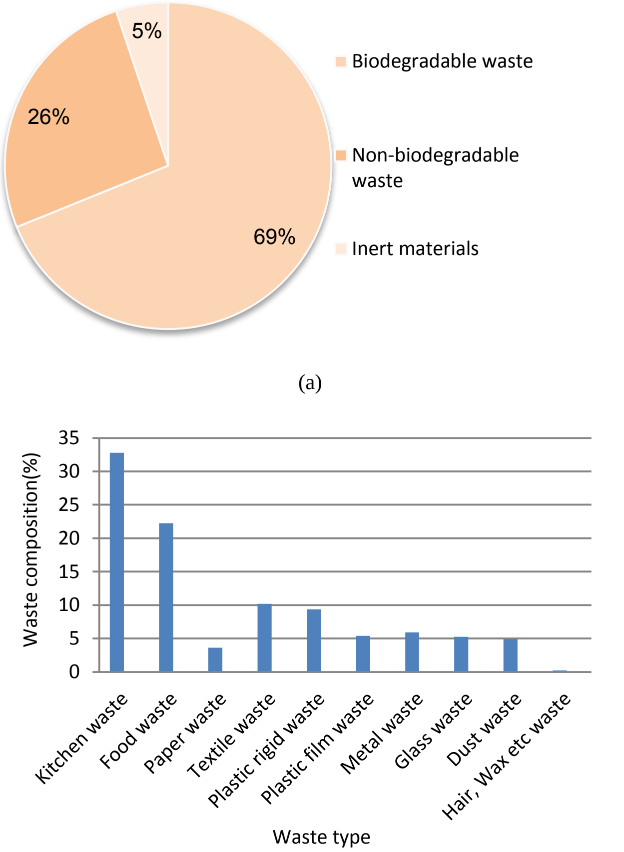
$$h = 0.035x + 0.0161.8$$

The linear correlation coefficient as shown in Figure (1) gives a high coefficient of correlation (product moment) which is significantly high relationship between haul time, h and round trip distance, x. The correlation is of direct (positive) dependence since large values of both variables tend to occur together, that is, h increases as x increases. In addition, the model was verified using the monitored value of round trip distance, x to predict the known value of the total haul time, h.

Similarly, the average size of waste container estimated was $0.220m^3$.This could be used as storage facility. The container should be placed in designated points within the neighborhood for daily households' waste collection to avoid indiscriminate dumping of the waste in the area. This container size might have been influenced by the low waste generation rate in the area. Thus, the type and capacity of container may depend on the characteristics of households waste to be collected and collection frequency.

C. Solid waste Composition

Figure 2 represents the percentage share of major components of household solid waste in the metropolis and the percentage of household solid waste composition in the metropolis respectively.



(a)

(b)

Figure 2. a) Percentage share of major components of household solid waste in the metropolis. b) Percentage of household solid waste composition in the metropolis

Manual separation of the waste collected revealed that the various components of the solid waste could be categorized into biodegradable, non-biodegradable and inert waste. Looking at the percentage share of major components (see Figure 2a), the study area produced about 69% of biodegradable waste which consisted of decomposable materials like kitchen, food, textiles wastes etc. while non-biodegradable waste contributed about 26% consisted of non-decomposable materials like plastics, metals wastes etc. And the inert wastes contributed about 5% which included dust, hairs wastes etc. that have no active chemical and other properties. Similarly, Figure 2b revealed that kitchen waste have the maximum with about 33%, it consisted of vegetable residue, egg shells, yam peels etc. And the least were hairs, wax wastes with about 0.2%.

D. Household Solid Waste collection and disposal Processes

Analysis of Questionnaire reveal that the largest proportion of the respondents dispose of their waste on daily bases and about 22% of the respondents have different situations.

Disposal by burning recorded highest percentage with about 46%. Burning generate smoke and contribute to air pollution.

Government designated refuse collection was the least disposal location; it implies that there was no suitable nearby common location provided by government to serve as a transfer station. And about 31% disposed theirs in other locations. Most of the residents near river Yadzaram sent their waste to the bank of the river where the wastes are burnt as shown in fig 3(a), open dump within the neighborhoods that could provide harborage for diseases causing organisms, insects and rodents and also causing foul odor as well as polluting of groundwater sources due to strong leachates produced as shown in fig 3(b) and dispose of into the gutters and drains that can cause clogging of the system, resulting in flooding and insanitary conditions as shown in fig 3(c).

(a) (b) (c)

Figure 3. a) Open dump near the bank of river Yadzaram. b) Indiscriminate dumping within the neighborhood. c) Indiscriminate dumping into gutters and drains

Only about 29% of the respondents attempted to separate waste before disposal and the rest did not attempt. It is important to note that scavengers to play a significant role in waste segregation.

About 72% supported house-to-house waste collection with about, but only few of the respondents with about 48% were willing to pay for the refuse collection as shown in Figure

The study identified the household solid waste storage facilities which were polythene bags, plastic containers (most widely used), baskets and carton. Waste in such storage facilities were later on disposed indiscriminately. In fact, in the metropolis presently, the dwellers had no access to waste collection service by either the government agencies, donor agencies or the informal operators, hence, the residents used to take responsibilities for the solid waste management.

IV. Conclusion

The study was carried out to determine the rate of solid waste generation and the composition of the solid waste generated. It was achieved by the used of the qualitative and quantitative data obtained from household. Primary data were also obtained using questionnaire. The questionnaire was subsequently analyzed using simple percentage and then combined with the information obtained from observations. The following conclusions were made from the results obtained;

The waste generation rate per capita was estimated as 0.2134kg/day.

Biodegradable waste showed the greatest with about 68.87% out of the three major components.

Plastic container was identified as the most widely used household storage facility.

The residents have no access to waste collection services by any agencies.

Substantial amount of solid wastes are reclaimed en route by rag pickers before reaching the disposal point.

The model is expressed in form with haul time directly proportional to the round trip distance, showing high coefficient of correlation of the variables.

220litres container size was estimated for daily operation of households to avoid indiscriminate dumping.

For improved solid waste management in Mubi metropolis, the following should be considered;

- Small dustbin for household solid waste storage.
- House-to-house solid waste collection service.

- Temporary waste collection point for waste sorting.
- Disposal techniques like composting and properly designed sanitary landfill.
- Reduction of waste generation at source and awareness among masses.

REFERENCES

[1] Brunner, P. H. and Ernest, W.R. (1986).Alternative method for the analysis of municipal solid waste. *Waste Management and Research*, *4* (1), 147 – 160.

[2] Huntly, S. (2010).Recycling household waste: Composition, collection and public participation. Retrieve on March 29, 2014 from http://www.lineone.net/ngooovemit/extra/winessay.htm

[3] Marshall, R. E., and Farahbakhsh, K. (2013). Systems approaches to integrated solid waste management in developing countries. *Waste Management*, *33*, 988 – 1003.

[4] Ojedabenitez, S., Armijodevega, C. and Ramirezbarreto, M. (2003).Characterization and quantification of household solid waste in Mexican city. Resources, Conservation and Recycling, *39*(3), 211 – 222.

[5] Pakpour, A. H., Zeidi, I. M., Emamjomeh, M. M., Asefzadeh, S. and Pearson, H. (2014). Household waste behaviors among a community sample in Iran: an application of the theory of planned behavior. *Waste Management* (New York, N. Y.), 34(6), 980 – 6.

[6] Tchobanoglous, G., Theisen, H. and Vigil, S. (1993). Integrated solid waste management: Engineering principles and management issues. McGraw – Hill, New York, pp. 17 – 52.

[7] United State Environmental Protection Agency Archive Document (2006). Standard volume-to-weight conversion factors.

[8] Worrel, W.A., and Vesilind, P.A. (2012).Solid waste engineering (2^{nd} Ed.).Cengage Learning, Stanford, CT.