Development of a Solid Waste Management Strategy for an Emerging Urban Centre, Samaru, Zaria, Kaduna State, Nigeria

Pearse, O. Femi , Ahanaiku, I. E

Abstract—Overburdened and ineffective solid waste management system is congruence with rapidly changing consumption patterns plague cities within the world, and Samaru town in Zaria-Kaduna state is not exempted from this menace. Samaru is considered as urban centre because of its sporadic increase in population every day. The area is constituted of more elite and working class people, which implies that most wastes generated are household wastes. The quantities and composition of solid waste generated from different sources in Samaru was determined by dividing the research area into three zones and 15 houses were considered from each zone. The houses were selected randomly base on the types of concentration of people in each zone. Two 25kg capacity woven sacks were distributed per selected houses for collection of wastes which was done twice per week at 3 days interval for 3 months. The average weight of wastes generated from each zone was found to be 262.10kg from zone A, 290.60kg from zone B and 426.27kg from zone C. The various composition of waste generated was sorted into six categories and their calorific values were found to range from 0.7 to 1.6. Two ways ANOVA was used for results analysis. At the end of the findings, Zero waste management strategy was recommended for Samaru town which include the Five R-plan. Reduce, Re-use, Recycle, Recover and Residue. This will go a long way in solving the problem of solid waste in Samaru and other urban cities.

Index Terms—Solid Waste, Generation, Characterization, Management, Urban Centre, Zero Strategy, Samaru

INTRODUCTION

Wastes are inevitable part of human activity, they are either a by-product of initial production process or they arise when objects or materials are discarded after they have been used. Waste is any item, material or substance derived from human or domesticated animal bodily functions which has outlived the purpose for which it was intended to and which does not appear to its or their chooses it by returning it to it natural medium or by releasing it to the responsibility of the community, municipal or waste collection entity (Scheinberg et al., 1996)

Solid waste management is a challenge for the cities' authorities in developing countries mainly due to the increasing generation of waste (Lilliana et al., 2012). Solid waste may be defined to include refuse from house, non hazardous waste from industrial, commercial and institutional establishment, market wastes. Solid wastes are those generated as solids or converted to solid form for disposal. They include common household wastes such as paper, plastics, glass, metals, appliances, kitchen and garden wastes as well as range of industrial and commercial wastes, such as construction and demolition waste, organic wastes from agriculture and food processing. The integrated waste management can be grouped into six categories, namely: (i) waste generation, (ii) waste handling, sorting and processing at the source, (iii) collection, (iv) separation and processing, (v) transfer station handling and waste transport, (vi) disposal. The functional groups are paramount, since they enable us to develop and define a framework for evaluating impacts of proposed changes in solid waste functions (Al-Jayyousi, 2001).

Urban government in many development countries are facing serious challenges with the management of solid waste. Quality is generally poor and cost is piralling , often with no effective mechanisms for improved cost recovery. Municipalities have failed to manage solid waste due to financial factors. The huge expenditure needed to provide the service , the absence of financial support, limited resources, the unwillingness of the users to pay for the service and lack of proper use of economic instruments have hampered the delivery of proper waste management services (Sujauddin et al., 2008). Heap of un-disposed municipal solid wastes are comm. Therefore, there is need to adopt appropriate solid waste management in order to have hygienic and suitable environment. Good understanding of the pattern of waste generation not only with respect to quantities but also complexities in the locality and the selection of an appropriate waste handling

Department of Agricultural and Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike,
P.M.B 7267, Umuahia, Abia State, Nigeria.Corresponding,
email:femovanpearse@yahoo.com.

and disposal technology. No solid waste management system would be effective or suitable unless the political, social-cultural, economic and environmental issues of solid waste management are first adapted to suit existing condition in a locality (Bertone, 1999)

Solid waste generated in urban areas may be derived from various sources such as household, commercial, institutional, street sweeping, construction and industrial depending on their source of origin, therefore, there are many types of solid wastes. They are industrial solid waste and commercial and domestic solid waste, many times domestic and commercial wastes are considered together as urban wastes (Maunsell, 1994). Solid wastes could also be classified under two broad categories which are degradable and non-degradable waste. Rapid urban growth, increasing per capital production of solid waste and non availability of land conveniently suitable for waste disposal are further aggravating the situation (Denis, 2002). In most cases less than half of the wastes generated in urban areas are collected by municipal authorities entrusted with the risk. In the absence of a good functional solid waste collection system, wastes are being dumped in open spaces, on access roads and along water ways. An emerging trend in Nigeria is the invasion of dumps by scavengers and animals that scatters the wastes, which serve as breeding grounds for diseases vectors, leachates from decomposing and putrefied garbage percolates into soil and nearby water sources. Storage, collection, transportation and disposal are the four principal element of any solid waste management system (Olumuyiwa, (2006). Compatibility between each of the first three stages is essential for efficient operation. An efficient and scientific management of solid waste is an important part of any attempt of upgrading environmental quality of an urban area.

The per capital waste generation for Nigeria is about 0.5kg per person per day (Kawai, 1992). This figure may seem small at the individual level but can become problem when accumulated especially in urban areas where overcrowding is being experienced. The quantity of refuse produced per head per day varies with regions of the world. The waste after generation are stored in different places using different types of storage facilities like refuse bins, receptacles, drums and other container. These containers are either provided by the house-holder or by the agencies responsible for the management of solid waste. The removal of solid waste from the storage point of generation is known as waste collection practice, It is an integral part of the urban management system. It is labour intensive and also affects the people when it ceases to function effectively, causing refuse to accumulate in an unwholesome fashion (Mara,1980). The conventional method of transporting refuse to disposal site is through vehicles. There are different types and model of refuse collection vehicles to choose from. In developing countries like Nigeria, the choice must reflect the existing level of technological and economic development appropriate to sustain and maintain the vehicle selected. Refuse disposal is the expression used to describe unit adopted to ensure that refuse cause nuisance in human environment according to Dobbs (1991). The important factors which need to be considered in selecting a disposal method are characteristic of wastes generated or collected, economic consideration, availability of disposal site and cost of labour as well as technical implications of the method

MATERIALS AND METHODS

The materials and equipment that were used during the execution of this research work are; 25kg capacity woven sack, 100kg capacity woven sack, weighing scale for weighing samples collected on site, waste bin, a gen lab drying oven, overall, pair of hand gloves, nose mask and boot. Field work exercise for collection of solid wastes sample for this research was done by dividing the research area (Samaru) into three zones and 15 houses were considered from each zone. The houses were selected randomly based on the types of concentration of people in each zone. Hundreds of interview guide were distributed and 25kg capacity woven sacks were distributed as collection material per each house that was considered. The sample collection is done twice per week that is 3 days interval. The manner in which Samaru town is being divided into three zones are listed below:

Zone A: - This consists of Danraka,Tinau street, Cheltech area along with Sokoto road.

Zone B:- This consists of Ahmadu road, Alkali road, Habibu road, Dandabo road, Basawa road, Yusuf road, cinema road, Galadima road

Department of Agricultural and Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike,
P.M.B 7267, Umuahia, Abia State, Nigeria.Corresponding,
email:femovanpearse@yahoo.com.

Zone C:- This consists of Main street, Samaru market, Alim basawa, saidu primary school and Habibu street along Sokoto road

Samaru metropolis is being divided as shown above with aid of area map and all samples were collected in accordance with method of sampling and analysis of solid waste suggested by "Swiss Federal Institute for water Supply'' sewerage purification and water pollution control EAWAG (1970). The weight and volume were determined on site by placing the generated weight per household on the weighing balance and reading is noted. The volume on the other hand was determined and the densities of the generated waste was being measured based on weight – volume-density relationship of Archimede's principle. The samples were then dried at 105^0c in a ventilated drying oven until the weight was constant. The dried samples was then left to cool for 4hr and weighed immediately afterwards

The Mc (%) was then computed as shown below

$$Mc\ (\%) = \frac{Nw-Nd}{Nw} \times 100$$

Various composition of wastes generated and collected was off loaded and in one of the disposal site and repackage in 100kg woven sack for different classification. All the components were sorted into six categories as follows. *Glass, Rubber, Plastic and Polythene, Metals, Tins and Can, Paper and Cardboard, Garbage and Grass and Others*. The composition were then computed in percentage

RESULTS AND DISCUSSION

Quantities of Wastes Generated from the Zones

Table 2 shows the weights, volumes and densities of wastes generated from Zone A in Samaru metropolis, Zaria. Wastes generated from this zone weigh between the range 224.88kg and 338.50kg with an average range of 262.10kg on the other hand the total corresponding volume and densities were shown on the same table with mean volume of volume and densities found to be 3.97 and 68.6 and range of the volume is between 2.60 to 5.86 and that of densities was found to be 50.61 has 88.60 respectively.

Department of Agricultural and Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike,
P.M.B 7267, Umuahia, Abia State, Nigeria.Corresponding,
email:femovanpearse@yahoo.com.

Table 2.1: Shows the weights, volumes and densities of waste generated from zone A in Samaru Metropolis Zaria.

House No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
05/08/13	7.80	7.82	13.60	7.25	8.45	13.40	8.80	7.92	6.65	14.10	7.25	9.90	10.20	9.25	10.20
09/08/13	8.50	9.12	12.50	8.00	9.40	14.40	9.80	8.90	8.20	15.00	8.70	10.00	12.50	10.30	8.90
12/08/13	7.22	8.15	13.15	8.42	10.25	12.50	8.10	9.10	9.85	14.60	8.50	10.20	10.10	8.40	10.25
16/08/13	7.60	7.50	10.60	9.22	10.30	10.20	10.50	10.22	7.65	13.60	9.50	12.60	9.20	10.80	9.15
19/08/13	7.90	9.45	11.40	7.25	8.20	13.80	12.00	8.50	8.50	12.50	8.40	9.20	10.50	10.60	10.30
23/08/13	7.75	8.20	13.40	7.50	7.45	12.10	9.60	7.80	7.50	13.65	13.10	9.50	9.30	9.25	9.85
26/08/13	8.20	10.10	9.10	10.15	8.30	12.60	7.45	8.20	8.60	12.30	10.02	8.14	10.20	10.60	10.80
30/08/13	7.10	9.50	12.35	13.10	8.90	10.15	8.50	9.10	6.90	10.00	13.20	7.85	10.35	11.00	12.30
02/09/13	10.50	6.60	14.50	8.42	7.50	10.60	9.60	7.20	10.22	15.70	10.00	6.40	12.80	9.80	10.20
06/09/13	9.12	13.40	12.40	9.50	10.90	12.50	10.00	10.50	10.00	16.80	7.50	10.50	13.70	12.50	9.80
09/09/13	9.50	14.40	9.12	7.24	10.20	10.90	9.10	10.80	9.55	10.80	8.42	12.80	13.50	11.50	9.45
13/09/13	10.20	8.15	10.40	7.80	8.15	11.40	7.60	9.80	8.60	12.80	6.55	10.20	10.50	12.80	10.50
16/09/13	9.15	9.13	13.80	10.00	9.30	12.40	8.22	9.50	8.70	13.50	7.80	10.80	8.90	9.50	10.20
20/09/06	7.73	8.70	16.00	6.00	10.50	13.20	6.80	7.60	7.70	12.20	8.20	9.30	10.60	8.20	9.30
23/09/13	7.90	9.20	14.10	7.65	10.80	10.90	7.60	7.00	6.50	10.00	9.40	8.15	9.25	9.50	7.82
27/09/13	10.10	12.15	10.20	8.24	7.90	12.10	7.35	8.15	8.00	13.40	9.80	8.10	9.30	8.90	8.60
30/09/13	9.80	8.55	13.60	7.50	7.30	9.20	8.60	7.60	7.45	10.80	7.80	7.50	8.70	10.60	9.35
04/10/13	12.50	10.12	12.70	8.40	7.30	12.30	9.70	10.20	10.20	16.00	10.00	10.80	13.60	11.30	10.50
07/10/13	11.45	10.05	10.80	9.45	9.60	14.42	9.60	10.00	11.50	16.80	12.00	10.60	12.80	10.60	11.80
11/10/13	10.40	8.35	13.60	10.00	9.75	8.90	10.20	9.12	10.60	13.30	10.80	12.00	13.50	8.40	11.60
14/10/13	8.40	9.55	18.00	7.24	8.25	12.50	8.60	8.50	7.35	8.20	9.60	9.20	7.90	7.80	10.60
18/10/13	7.75	10.25	14.45	7.80	9.80	13.60	7.45	10.20	9.40	10.50	7.50	8.40	10.00	7.80	9.50
21/10/13	8.15	10.12	10.00	9.20	10.20	12.30	8.14	10.75	10.10	16.15	9.60	10.80	12.60	7.60	8.75
25/10/13	8.30	9.85	14.50	10.15	10.15	13.20	9.20	9.25	9.50	10.80	8.42	10.82	11.80	8.65	9.30
28/10/13	7.12	10.12	12.05	10.50	8.60	14.00	8.40	8.22	8.20	11.80	8.60	12.00	12.30	9.95	10.20
31/10/13	10.20	7.32	13.20	8.90	9.30	12.30	9.50	9.50	9.30	13.80	9.30	9.60	11.70	8.60	
T WLT (KG)	230.36	265.72	329.62	224.88	236.95	315.61	228.61	233.66	226.72	338.50	239.96	255.36	285.80	256.40	
T Volume	2.60	3.28	3.28	2.98	3.09	5.79	4.02	3.06	4.48	5.88	4.11	3.25	4.52	3.26	
Density	88.60	80.95	80.95	75.46	76.68	54.55	56.87	56.87	50.61	57.50	58.38	78.57	63.23	78.65	

Source: Field Work, 2014

Department of Agricultural and Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike,
P.M.B 7267, Umuahia, Abia State, Nigeria.Corresponding,
email:femovanpearse@yahoo.com.

Table 2.2: Shows the quantities, volumes and densities of waste generated from zone B.

House No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
05/08/13	8.90	10.00	7.75	13.25	9.60	12.80	14.00	7.75	11.65	10.80	10.00	8.90	9.80	12.80	13.00
09/08/13	10.40	11.30	8.90	10.20	8.65	13.60	9.25	10.30	12.30	12.60	9.30	10.20	12.80	14.00	10.90
12/08/13	9.10	12.50	7.90	11.80	10.50	10.10	12.05	10.40	13.40	12.80	10.70	11.50	12.40	13.50	14.20
16/08/13	7.50	13.60	10.50	9.25	11.30	9.75	11.80	9.80	12.75	9.50	8.75	9.30	11.30	10.30	18.00
19/08/13	10.00	9.40	10.90	9.60	9.60	10.80	11.65	10.70	13.60	10.50	9.40	7.30	13.50	10.60	9.00
23/08/13	10.50	12.30	10.15	10.60	8.75	13.60	13.60	10.80	12.60	13.65	8.30	13.50	9.25	14.50	8.75
26/08/13	7.90	8.90	18.00	12.80	10.20	13.80	10.70	8.75	9.80	9.30	10.50	11.75	12.80	14.30	9.80
30/08/13	12.15	10.10	9.50	14.00	11.90	12.60	9.50	9.80	7.90	8.70	10.90	10.60	10.90	13.60	9.30
02/09/13	11.50	13.90	10.30	9.90	8.25	9.80	9.80	10.20	10.12	13.40	8.10	10.80	13.60	13.00	16.00
06/09/13	12.40	10.10	11.60	13.60	9.80	10.75	13.90	10.30	18.00	12.50	12.60	9.35	16.40	16.75	13.60
09/09/13	8.50	9.80	9.25	13.80	10.25	10.30	12.25	9.75	16.30	12.60	12.80	8.30	10.75	14.50	13.45
13/09/13	9.40	7.60	9.20	14.15	18.02	9.10	13.60	10.30	10.20	13.50	10.30	9.25	10.60	16.90	12.80
16/09/13	10.40	10.50	9.85	10.40	10.15	11.10	13.75	11.60	10.30	10.00	9.40	9.40	11.30	17.00	11.50
20/09/13	12.20	13.25	10.20	10.90	12.00	14.50	9.30	10.10	10.40	10.30	8.60	8.70	9.25	15.50	11.90
23/09/13	13.40	14.25	8.70	12.30	12.65	10.40	10.40	9.80	10.50	13.60	10.40	13.20	9.75	10.60	18.10
27/09/13	9.20	9.60	7.65	13.40	9.30	9.25	12.30	8.70	9.80	9.30	12.50	12.60	13.60	10.30	11.75
30/09/13	10.40	10.70	10.30	15.50	10.25	15.00	14.70	7.60	9.85	13.60	12.80	10.80	16.30	12.80	9.30
04/10/13	12.60	9.75	10.90	14.70	9.85	10.60	8.30	10.75	10.90	10.30	13.90	13.40	10.20	11.40	10.90
07/10/13	14.20	10.90	8.70	9.90	10.75	9.75	13.10	10.00	9.70	8.60	10.90	10.60	10.80	12.50	12.50
11/10/13	10.00	13.40	12.30	14.30	12.50	10.35	10.70	11.50	12.20	10.30	12.60	9.45	10.90	9.80	13.40
14/10/13	13.40	9.80	10.20	12.60	9.25	10.70	12.30	7.80	11.80	9.80	11.50	7.60	11.60	13.50	19.50
18/10/13	10.10	10.75	11.70	13.75	13.30	12.00	14.50	7.70	11.40	10.30	10.90	7.85	10.25	10.90	10.40
21/10/13	9.80	9.60	9.40	10.40	10.35	14.40	13.85	10.30	9.80	9.75	8.70	10.90	10.40	7.80	11.20
25/10/13	10.70	7.80	8.40	11.50	11.30	12.70	12.20	10.40	10.80	9.80	10.20	10.00	9.00	9.20	11.30
28/10/13	12.20	10.75	10.60	12.50	12.35	9.80	13.60	9.75	9.65	10.60	10.70	9.30	9.90	10.60	10.60
31/10/13	9.80	12.50	9.75	12.90	10.80	13.40	12.80	9.90	10.70	10.50	9.90	8.90	10.80	8.90	9.50
T WLT (KG)	276.65	283.15	261.30	318.00	281.17	301.55	313.90	254.75	297.12	286.60	274.65	263.45	298.15	327.55	321.15
T Volume	4.44	5.50	3.30	4.82	3.48	5.66	4.76	3.25	4.62	3.53	4.42	3.32	5.63	4.89	3.83
Density	62.30	51.48	79.18	66.25	80.79	53.28	65.95	78.38	64.31	64.84	62.14	59.60	52.96	66.98	83.85

The means of the data collected were found to be 290.6kg for weights, 4.36m for volume and 66.15 for densities respectively. The ranges of the waste generated per collection were found to be 254.73 to 327.55 kg.

Source: Field Work, 2014

Department of Agricultural and Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike,
P.M.B 7267, Umuahia, Abia State, Nigeria.Corresponding,
email:femovanpearse@yahoo.com.

Table 2.3: Shows the weight and volume of waste generated from zone C, the densities were also calculated as well.

House No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
05/08/13	13.50	12.00	14.95	20.25	14.20	10.30	11.40	25.60	14.60	11.90	28.00	12.30	19.00	10.30	28.80
09/08/13	10.60	13.60	13.65	18.30	10.40	11.90	13.40	28.70	13.60	13.30	30.00	10.60	20.30	13.40	32.40
12/08/13	13.10	10.90	14.80	19.25	9.30	8.90	9.25	19.90	12.50	18.00	27.50	9.30	21.60	11.25	34.60
16/08/13	11.30	10.80	13.20	17.80	13.60	12.60	12.60	26.50	13.40	15.10	26.30	10.30	20.50	10.80	30.50
19/08/13	14.20	11.85	13.65	18.30	12.30	10.60	13.80	29.30	10.10	13.75	30.80	12.80	18.70	11.50	31.20
23/08/13	12.60	13.80	14.80	19.20	12.15	12.70	12.40	29.10	12.40	12.80	31.60	9.25	19.10	11.80	29.60
26/08/13	18.00	12.70	14.75	20.80	13.20	10.30	14.80	27.40	12.20	13.90	28.40	10.80	15.40	9.30	29.80
30/08/13	13.30	12.80	10.80	16.35	10.60	11.40	9.25	26.50	11.00	11.70	27.40	13.60	10.80	10.40	35.30
02/09/13	13.60	13.50	15.00	22.10	11.65	8.40	10.30	28.30	13.60	12.30	20.40	9.80	19.30	13.40	19.25
06/09/13	14.90	11.90	12.80	18.90	12.80	9.60	11.60	29.35	14.20	13.40	30.60	10.40	18.70	12.40	28.75
09/09/13	15.00	10.80	13.75	18.25	13.90	10.60	10.20	20.00	13.60	14.25	19.25	10.30	16.75	11.40	30.30
13/09/13	10.90	11.25	12.90	25.75	10.75	12.40	12.25	24.60	13.80	13.60	28.75	12.60	17.40	11.75	34.25
16/09/13	13.70	10.25	12.25	23.70	10.30	10.60	13.10	27.50	12.30	11.90	28.00	10.30	18.60	10.70	36.80
20/09/13	12.00	13.25	13.85	18.90	11.20	10.80	11.60	28.60	12.30	18.60	19.30	13.00	19.30	10.30	30.00
23/09/13	12.20	12.90	18.00	19.75	13.30	9.80	11.80	29.40	10.10	16.20	30.60	9.30	20.50	12.40	29.70
27/09/13	12.85	13.95	13.60	20.20	12.35	10.70	10.30	30.50	10.75	13.40	30.80	8.50	16.30	13.80	32.30
30/09/13	10.90	10.30	14.90	25.30	10.70	8.80	9.30	20.80	10.60	12.50	25.70	10.60	15.70	10.70	31.40
04/10/13	13.90	14.60	13.75	24.60	10.80	12.60	10.40	21.60	13.60	13.40	26.40	10.75	20.30	11.80	33.90
07/10/13	12.85	14.75	13.80	21.80	14.20	13.40	10.75	22.10	18.50	13.80	25.90	9.30	21.30	9.20	19.90
11/10/13	10.30	12.30	16.20	26.90	15.00	10.60	11.30	23.40	11.40	12.30	29.80	10.40	18.40	8.70	29.40
14/10/13	12.30	12.85	10.90	19.90	13.00	13.30	10.70	25.30	12.50	11.60	34.40	9.25	19.20	7.50	29.50
18/10/13	12.80	13.90	14.25	19.60	9.20	8.20	9.90	20.50	10.80	10.75	29.30	10.00	20.00	13.00	20.40
21/10/13	9.10	10.00	14.60	20.00	12.60	10.40	10.25	28.75	11.75	12.80	22.20	12.30	14.50	9.30	30.25
25/10/13	12.80	11.75	14.80	25.50	13.50	9.25	10.80	29.60	14.60	13.60	30.40	10.80	13.90	10.40	32.90
28/10/13	11.90	13.70	13.90	22.60	12.40	10.30	11.25	26.60	13.30	12.70	19.90	13.40	18.60	13.30	33.60
31/10/13	16.30	12.80	15.30	19.90	14.30	10.50	12.00	21.80	12.80	14.20	29.70	10.80	20.30	12.10	28.80
T WLT (KG)	333.90	323.20	370.15	544.00	318.30	278.95	294.70	670.70	330.10	351.75	721.40	297.75	474.45	290.90	793.80
T Volume	4.95	3.85	5.27	6.80	4.81	3.46	4.60	8.92	4.39		7.87	4.63	6.12	4.57	9.00
Density	67.45	83.95	70.24	80.00	66.17	80.62	64.07	75.19	75.10	68.97	91.66	64.31	77.52	63.65	88.20

The average value of waste generated from this zone is 426.27kg and density is found to be 74.7kg/cm^3 as shown in the table above.

Source: Field Work, 2014

Department of Agricultural and Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike,
P.M.B 7267, Umuahia, Abia State, Nigeria.Corresponding,
email:femovanpearse@yahoo.com.

Waste Characterization

Right from the first day of collection, two sacks were distributed to each household. One was meant for dry collection and the other for wet collection of some solid wastes. Table 3 shows the detail of accumulation of both dry and wet solid wastes from each household within the three zones in Samaru town. The average range of dry waste generated from zone A was found to be 79.14kg and that of zone B was found to be 83.92kg and 114.96kg for zone C respectively.

SAMPLE WEIGHT A			SAMPLE WEIGHT B		SAMPLE WEIGHT C	
S/N	WET	DRY	WET	DRY	WET	DRY
1	150.60	79.74	178.66	97.99	243.10	90.80
2	196.00	69.72	211.20	711.97	221.32	101.88
3	227.73	101.89	177.91	83.39	254.95	115.20
4	164.42	60.46	249.71	60.29	328.87	85.70
5	145.86	91.09	196.82	84.35	232.60	85.70
6	231.11	84.76	193.09	108.65	185.27	93.41
7	165.03	63.58	219.73	94.17	211.29	83.41
8	171.56	62.09	183.22	71.43	469.49	201.21
9	153.70	73.02	217.98	79.14	239.07	91.03
10	234.95	103.55	208.62	77.98	234.22	117.53
11	162.97	76.99	194.42	80.39	484.98	236.42
12	185.75	69.61	199.42	64.04	193.43	104.33
13	200.06	85.74	198.70	99.45	302.11	172.34
14	185.48	70.92	246.28	81.27	217.63	73.27
15	169.15	93.92	224.80	96.35	505.66	288.14
TOTAL	**2744.39**	**1187.08**	**3100.30**	**1258.84**	**4219.61**	**2174.4**

Table 3: Accumulation of dry and wet solid wastes from all zones

Source: Fieldwork, 2013

Table 4 below shows the composition of waste in the three zones of Samaru metropolis. The garbage has the highest composition follow by paper and grass as shown in the table.

Table 4: Composition of wastes in the three zones

	Parameters	Amounts in %		
S/N	Composition	Zone A	Zone B	Zone C
1.	Glass	0.86	0.44	0.13
2.	Rubber Plastic and Polythene	2.02	1.13	0.39
3.	Metal, tins and cans	0.58	2.48	1.76
4.	Paper and Cardboard	2.47	2.15	0.85
5.	Garbage	90.62	89.55	93.73
6.	Grass and others	3.45	4.86	3.13
		100	100	100

Source: Fieldwork, 2013

Moisture Content, Volatile Solids and Calorific Value of Waste

Table 5 shows the range of moisture in zone A was found to be 49.6% to 75.5% with average value of 62.71% while the average range of 67.1% was found in zone B and 71.4% average in zone C respectively.

The waste generated had volatile solid ranging from 75.2% to 96.05 in zone A with mean value of 85.28% while volatility value of wastes in zone B were determined to range from 76.6% to 96.8% with average value of 88.5%. The volatility values of zone C wastes were discovered to range between 70.4% to 96.02% average. The calorific value for the three zones was found to range between 0.7 to 1.6 as shown in table below.

Table 5 below shows that the maximum weight and volume for zone A was found to be 33850 and 5.88 and zone B was found to be 327.55 and 4.89 while that of zone C was obtained to be 793.80 and 9.00 respectively.

Table 5: Accumulation of weight, volume and density from all zones

	Zone A			Zone B			Zone C			
No	WGT	VOL	DTY	WGT	VOL	DTY	WGT	VOL	DTY	TOTAL
1.	230.36	2.60	88.60	276.65	4.44	62.30	333.90	4.95	67.45	840.91
2.	265.72	3.28	80.95	283.15	5.50	51.48	323.20	3.85	83.95	872.07
3.	329.62	5.86	56.20	261.30	3.30	79.18	370.15	5.27	70.24	961.07
4.	224.88	2.98	75.46	318.00	4.80	66.25	344.00	6.80	80.00	1086.88
5.	236.95	3.09	76.68	281.17	3.48	80.79	318.30	4.81	66.17	836.42
6.	315.87	5.79	54.55	301.55	3.66	53.28	278.95	3.46	80.62	896.37
7.	228.61	4.02	56.87	313.90	4.76	65.95	294.70	4.60	64.07	837.21
8.	233.66	3.06	76.35	254.75	3.25	78.38	670.70	8.92	75.19	1159.11
9.	226.72	4.48	50.61	297.12	4.62	64.31	330.10	4.39	75.10	853.94
10.	338.50	5.88	57.50	286.60	3.53	64.84	351.75	5.10	68.97	976.85
11.	239.96	4.11	58.38	274.65	4.42	62.14	721.40	7.87	91.66	1236.01
12.	255.36	3.25	78.57	263.45	3.32	59.60	297.75	4.63	64.31	816.56
13.	285.80	4.52	63.23	298.15	5.63	52.96	474.45	6.12	77.52	1058.40
14.	256.40	3.26	78.65	327.55	4.89	66.98	290.90	4.57	63.65	874.85
15.	263.07	3.42	76.92	321.15	3.83	83.85	793.80	9.00	88.20	1378.02

Source: Field work, 2013

Application of Two –Ways ANOVA

Using the values in table 5, two ways ANOVA analysis was used for the quantities of wastes generated among households and zones in samara metropolis city. The results of the analysis are shown in the table 6 below.

Table 6.1: Two- way Anova table for quantity of waste generated among households and zones

Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, Umudike, P.M.B 7267, Umuahia, Abia State, Nigeria.Corresponding, email:femovanpearse@yahoo.com.

Sources of Variable	DT	SS	MS	F_{CAL}	$F_{Critical}$ (0.05)
Household	14	135539.0995	9681.3643	0.87^{NS}	2.12
Zones	2	230844.8068	115422.2534	10.32*	3.34
Error	28	313133.2034	11183.3287		
Total	44				

Interpretation: There is no significant difference (P>0.05) in the quantity of wastes generated among the households while there are significant differences in the waste generated among the zones.

Table 6.2: Average weight of waste generated per zone.

Zone	Average weight
A	262.10^{b}
B	290.61^{b}
C	426.27^{a}

Interpretation: Zone C has the has means of wastes generated while the average waste generated in A and B are not significant from each other

Using the values in table 5. Two –ways ANOVA analysis was used to analyze the volume of wastes generated among the zones and households in Samaru town. The result obtained is shown in table 6.3 below and interpreted as well.

Table 6.3: Two-way Anova analysis for volume generated in Samaru

Source of Variation	DF	SS	MS	F_{CAL}	$F_{Critical}$ (5%)	$F_{Critical}$ (1%)
Households	14	13.9919	0.9994	0.49	2.12	
Zones	2	22.3032	11.1516	5.49	3.34	5.45
Error	28	56.8334	2.0298			
Total	44	93.12848				

Interpreted: This shows that variation of volume among the household s is non significant while variation of volume among the zones are highly significant.

Table 6.4: The average volume of waste generated per zone in Samaru

Zone	Average volume generated
A	59.60^{c}
B	65.43^{b}
C	84.34^{a}

LSD 0.05= 2.38

This indicates that zone C has the highest means of volumes of wastes generated while the average volume of wastes generated in zone A and zone B are not significantly different from each other

Discussion and Proposed Strategy for Solid Waste Management in Samaru

Samaru is growing fast in terms of population in which if adequate measure is not taking base on the findings of this research, the situation might get out of control. The quantity of waste generated in any community is function of the population of the community. The total amount of wastes generated from Samaru were found to be 14684.67kg and based on the population figure, the per capital waste generated was found to be 0.78kg per day. Apart from garbage which constitutes 80 percent of waste generated in Samaru, polythene remains another composition which imposed threat to waste management in this city. However, it could be recycled if adequate management strategy is put in place.

The outcome of the findings shows that, there is significant different between the waste generated in zone C and the two other zone, that is zone A and B. this can be likened to the fact that zone C is commercial area of Samaru, which indicates that the level of wastes that is generated in this zone will be higher because of nearness to market.

Whereas in zone A and B, there is no significant different because the standard of living of the dwellers in these areas is almost the same. Both zones are more of residential that constitutes the elite and low income earners of the community.

From the result that was obtained through this research work, it shows that local government

Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, Umudike, P.M.B 7267, Umuahia, Abia State, Nigeria.Corresponding, email:femovanpearse@yahoo.com.

and other stake holders of the community should intensify effort in combating the menace of solid waste generation in Samaru metropolis. However, if strategy and recommendation that is suggested through this research work is adopted, it will go a long way in solving the problem of solid waste in Samaru and other emerging urban city in the country.

CONCLUSION

The primary objectives of this research is to evaluate the rate of solid waste generation in Samaru and to propose the adequate and effective strategy that is meant to curtail the environmental degradation and health hazards that are likely to follow indiscriminate disposal and poor management of solid waste. However, Zero waste management strategy is recommended for Samaru city.

Zero Waste Management Strategy in Samaru

Zero waste as a term work better than 100% recycling because the latter vision seems to imply that the community has to do everything. Zero waste requires the need for dual responsibility. First, the community has reuse, repair, recycling and composting and secondly industry has to redesign the objects the community cannot reuse, repair, recycle or compost. Industry and the community need to reduce wasteful practices like over-packaging and over-consumption, while plan has not been without problems, the concept was a good one and and can certainly make the dwellers and local government as well as other stake holders in Samaru to be much more conscious of their responsibilities.

In general Zero waste strategy describe practices that lead to waste minimization and may include the Five R plan. *Reduce, Re-use, Recycle and Recover and Residue.* This plan is the officially recognized waste management system that has been used effectively in most developed and developing countries of the world.

References

Al-Jayyousi, O., 2001. A methodology for evaluating environmental impact of solid waste disposal sites: case study from Jordan. Arabian Journal of Science and Engineering 26 (2C), 81–88

Bertone,C.R (1999) "Institutional and Management Approach to Solid Waste Disposed in Large Metropolitan Areas" In journal of Waste Management research (9)

Denis, O (2002) Towards Integrated Household Solid Waste Maintenance in Nigeria Global Press, Akure.

Dobbs, M. (1991) "Litter and Waste Management Disposal taxes Versus Changes" Canadian Journal of Economics. The World Bank 1818 Street, N.W. Washington DC 20427 U.S

Kawai Philip (1992). Solid Waste Management in Kaduna Metropolis, A case study of Kaduna Tudun wada

Lilliana A.G., Ger M and William H, (2012). Solid waste management challenges for cities in developing countries. Journal of Waste Management 33 (2013) 220–232. www.elsevier.com/locate/wasman

Mara, D. (1980) 'Appropriate Technology for Solid Waste Management and sanitation

Maunsell, E (1994) Monitoring of Performance against Waste Minimization and Recycling Targets. Maunsell pty Ltd, Camberra

Olumuyiwa Abidemi A. (2006) "Characterization of Solid Wastes at the Kaduna Polytchnic, Kaduna" Water Resources and Environmental Department Engineering A.B. U, Zaria

Scheinberg, A, Miller, M and Tasheva, J (1996) "Gender and Waste, UWEP Working Document (12)

Sujauddin, M., Huda, M.S., Rafiqul Hoque, A.T.M., 2008. Household solid waste characteristics and management in Chittagong,Bangladesh. Journal of Waste Management 28, 1688–1695

Department of Agricultural and Bioresources Engineering,
Michael Okpara University of Agriculture, Umudike,
P.M.B 7267, Umuahia, Abia State, Nigeria.Corresponding,
email:femovanpearse@yahoo.com.