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Proximate and Ultimate Analysis of Municipal Solid Waste for Energy Generation

Oluwasina Lawan ROMINIYI[1] and Bernard Akindade ADARAMOLA[2]

[1,2]*Department of Mechanical and Mechatronics Engineering, Afe Babalola University, Ado-Ekiti, Nigeria*
rominiyiol@abuad.edu.ng / adaramolaba@abuad.edu.ng

Corresponding Author: adaramolaba@abuad.edu.ng

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***Abstract**: Municipal Solid Waste (MSW) has become a burden globally. Solid wastes, if not properly managed is an eyesore, contaminate the environment and lead to outbreak of diseases. This work focuses on the determination of MSW composition in Ado-Ekiti metropolis. A laboratory procedure known as proximate and ultimate analyses was used to determine the composition. The samples of the MSW used in this research were sorted, sundried, pulverized and sieved. The average waste generated per day in Ado-Ekiti is 300 tonnes as shown in table 5.* With 2015 as the base year, the per capita waste generation was computed using equation (1) as 0.67 kg/day within the metropolis. *The energy content of the combustible MSW was evaluated using Cal 2k-Eco Calorimeter (electronic bomb calorimeter). The energy content generated from MSW ranges from 47,272.87 MJ/day to 1,361,407.74 MJ/day in table 6, while the total energy content is 4,449,426.14 MJ/day. The mean specific energy content is 17.57 MJ/kg. Polythene products waste can be used to generate 15.76 MW of electricity while the combustible components of the MSW can be used to produce steam to generate 51.5 MW of electricity in Ado-Ekiti.*

***Keywords:** Ado-Ekiti, Biogenic, Composition, Energy Content, Municipal Solid Waste (MSW)*

1. INTRODUCTION

Waste generation is an unavoidable aspect of human existence. Municipal Solid Waste (MSW) generated within the urban metropolis often resulted into environmental pollution. It has become a burden to communities. China faces the problem of municipal solid waste (MSW) disposal and the pressing need for development of alternative energy. [3] Considers waste-to-energy (WTE) as recovering of energy from discarded MSW to produce electricity and/or steam for heating. Waste can be converted to a more useful form of energy and to create wealth. Among the common methods used for handling MSW is waste incineration with inherent emission of harmful gases. More environmental friendly technology is thus required for hygienic waste reduction. The determination of the energy content in the MSW components is useful for the efficient planning, economic analysis, design and subsequent management and operations of a disposal system or material energy resources recovery facilities [9].

The authors focused on a practicable and appropriate means of managing the waste generated within Ado-Ekiti metropolis. This work explain the procedures used for proximate and ultimate analysis of the MSW samples; measurement of energy content of MSW samples; ; alternative sources of energy in place of the convectional fossil fuel through waste-to-energy conversion; and means of abating environmental pollution resulting from MSW incineration [12].

El-Fadela *et al.* [8] evaluates economic considerations of landfills as an attractive disposal means of municipal solid waste (MSW). The composition of solid waste varies substantially with socio-economic conditions, location, season, waste collection and disposal methods, sampling and sorting procedures. MSW composed of refuse generated commercially, residentially and institutionally mixed up with other waste composites from hospitals, industries and municipal services such as construction and demolition wastes. The authors discussed the concept of MSW and their categorization; their sources; methods of conversion (harvesting, sorting, and preparation for energy recovery potential) MSW generated in Ado-Ekiti metropolis, Ekiti State.

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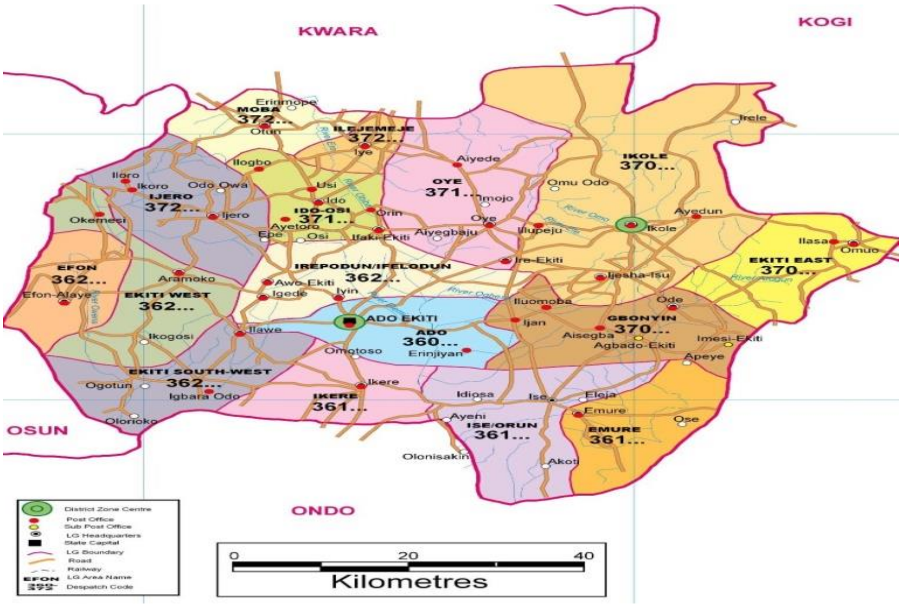

Figure 1: Ekiti State of Nigeria Map Showing Ado-Ekiti Geographical Location, Source [10]

1.1 Solid Waste Pyramid

The concept of waste management involves total inventory of all waste streams. Categorization reduces safety risks during waste treatment, recycling or disposal of wastes. The Pyramid depicting the solid waste management hierarchy is shown in figure 2. Source reduction is at the peak of the pyramid, followed by recycling composting, re-use, incineration and then land filling [1]. The hierarchy of solid waste management ranks gives the most profitable method to address solid waste. Re-use, is the best approach to waste prevention and source reduction. This is because the best approach to manage solid waste in the first instance is to avoid waste generation (i.e. the amount of trash discarded is reduced and the containers and products are re-used instead of throwing them away).

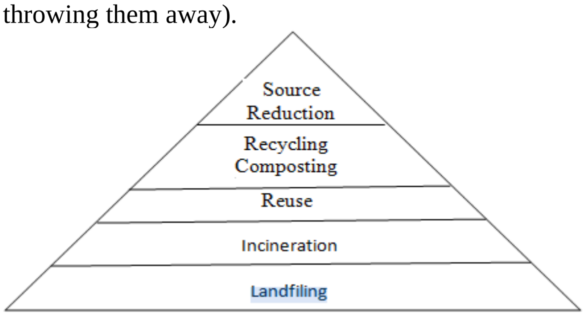

Figure 2: Waste Management Hierarchy Source [11]

Recycling wastes once created by composting is one of the most effective systems of reducing the quantity of materials in the waste streams. The U.S. Environmental Protection Agency (EPA) characterizes the generation and management of municipal solid waste (MSW). [5] considers MSW combustion with energy recovery for the purpose of calculating recycling rates for waste charging, and promotes source reduction, reuse, recycling and composting over materials management for energy recovery. However, incineration and sanitary land filling is the preferred method of treatment if waste cannot be recycled [6, 11].

1.2 Biogenic, Non- Biogenic Municipal Solid Waste and Biomass

Biogenic MSW is the components of the waste stream samples that are biodegradable while those that are non-biodegradable are called non-biogenic components. Examples of biogenic (organic) wastes are: food waste, charcoal, bones, coconut and palm kernel waste, animal dungs and excreta. Typical examples of non-biogenic MSW are: polythene products waste, textiles waste, rubber and leather, metals and cans, glass and ceramics. Biomass is generally considered as plant or animal material combustion for heat or electricity generation. This biomass combustion releases CO_2 which is absorbed by plants through photosynthesis [14].

The ratio of Biogenic and Non – Biogenic combustibles to Non-combustibles is given by the equation;

$$R = \frac{C}{N} \qquad (1)$$

Where, C is the quantity of Biogenic and Non-Biogenic combustible MSW generated per day; N is the Quantity of Non-Biogenic and Non-combustible MSW generated per day; and R is the Ratio of Biogenic and Non Biogenic combustible to Non Biogenic and Non-combustible MSW generated per day.

Table 1: MSW Categorization

Biogenic	**Non-Biogenic**
Newspaper	Plastics
Paper	PET (Polyethylene Terephthalene)
Containers	HDPE (High Density Polyethylene)
Packaging	PVC (Polyvinyl Chloride)
Textiles	LDPE (Low Density Polyethylene)
Yard trimmings	PP (Polypropylene)
Food wastes	PS (Polystyrene)
Wood	Other plastics
Leather	Rubber
Other biogenic	Other Non-Biogenic

1.3 Sample Harvesting, Sorting and Preparation

Waste samples were collected randomly at the local dumpsites and dustbins located at some strategic locations in Ekiti state capital (Ado – Ekiti). Spot sampling method was adopted, which involves random withdrawal of small portion of waste from dumpsite. About 19.00 kg of MSW was collected twice a week for a period of 12 weeks. The samples collected were manually sorted into their different components. The cellophane bags, hand gloves and sacks were used to obtain waste from the dumpsite. Nose protector, jungle boot and overall were used throughout the period of samples picking and the sorting processes. [2] asserted that, Hand Sorting; Mechanical Sorting, Magnetic Separation; Electrostatic Separation; Screening; Gravity Separation; Floatation; Drying method; and Inertia separation techniques can be used for sorting of MSW constituents.

1.4 Demographic Status

Population data is required for planning at the state and local government level. Information on Demographic Status of Ado– Ekiti from the Department of Population Activities, Research and Statistics (DPARS), Ministry of Budget and Economic Planning Ekiti State projected population for all towns and villages in Ekiti State between 2012 and 2015. The projection of the population of the communities was based on the medium variance growth rate of 3.1 % per annum. It was only in Ado-Ekiti local government that a high variance growth rate model of 3.85 % was utilised. This is because Ado-Ekiti is the state capital with various opportunities attracting people to the area [4, 5].
The exponential growth rate method adopted from 2015 to 2035 in the study is as shown in equation 2,

$$P_{t+n} = P_t\ (1 + r)^n \tag{2}$$

Where, P_{t+n} *is* the projected population for a specified year;
P_t is the population of the base year which is 2015 in the present situation; t is the base year in consideration; r is the rate of growth used for the projection; and n, is the time interval of 5 years between the base (2015) and 2035. Using equation 2, the computation is presented in table 1.

Table 2: Population projection of Ado-Ekiti

S/N	**Year**	**Population of Ado-Ekiti**
1	2006	313,690
2	2012	430,811
3	2015	447,599
4	2020	540,657
5	2025	653,062
6	2030	788,836
7	2035	952,838

The population figure of Ado - Ekiti which was 447,599 in 2015 would increase to 540,657 in 2020 and would further reach 952,838 in 2035. The implication of this is that, if the rate of 3.85 % continues the current population will double in not less than 20 years [4]. The increase in population in the state *capital* leads to a rise in volume of waste generated on daily basis. In table 5 the average volume of waste collected in Ado-Ekiti was estimated at 300 tonnes. Using the base year 2015 and equation 1, the per capita waste generation was computed as 0.67 kg/day within the metropolis.

2. MATERIALS AND METHOD

2.1 *Instrumentation and Experimental Apparatus*

The equipment used for the tests consist of Bomb calorimeter, Hydrometer; Oven; Muffle Furnace; Gas Desiccator; Digital Weighing Balance; Cal 2k-Eco Calorimeter Assembly.; Pulveriser with Shaker; and Atomic Absorption Spectrometer (AAS).

2.2 *Experimental Methods*

American Standard Testing Methods (ASTM) D 3173-75 were used for Proximate Analysis of MSW samples. Proximate analysis involves the determination of moisture content, waste particle size, waste density, temperature, and fusion point of ash. Ultimate Analysis follows classical method of using (ASTM: D5868-10a) for determination of Carbon and Hydrogen, Oxygen, Nitrogen, and Sulphur (CHONS), Heating Value, and Energy Content of MSW

i. Moisture Content of Solid Waste (ASTM D-3173)

Determination of moisture content in waste sample involves loss in weight of waste caused by heating of weighed quantity of the sample for one hour, cooled and weighed. The process of heating, cooling and weighing is repeated a number of times till the constant weight of anhydrous waste sample is achieved using the oven.

The percentage of moisture content is given as

$$Moisture\ content = \frac{Loss\ in\ weight}{Weight\ of\ waste\ sample} \times \frac{100}{1}\ \% \qquad (3)$$

The volatile matter is obtained by using Muffle Furnace and equation 3 is used for its computation

ii. Ash Content in Solid Waste (ASTM D-3174)

This is the weight of the residue obtained after burning a weighed quantity of solid waste in an open crucible using Oven and Muffle Furnace.

$$Ash\ Content = \frac{Weight\ of\ residual\ ash\ formed}{Weight\ of\ waste\ sample} \times \frac{100}{1}\ \% \qquad (4)$$

iii. Fixed Carbon in Solid Waste (ASTM D-3175)

The fixed carbon present in a waste sample can be determined by using oven and muffle furnace.

$$\%\ \text{Fixed Carbon} = 100 - (\%\ \text{Moisture Content} + \text{Volatile Matter} + \%\ \text{Ash}) \qquad (5)$$

iv. Fusion Point of Ash (ASTM D-5868-10c)

On heating the biomass sample, it first softens and then finally fuses and melts. This temperature is called the fusion point of ash. The composition of ash affects the fusion temperature. The higher the fusion point of ash the better is the quality of the biomass. Fusion point of ash is increased by the increase in its alumina and silica content. However, the presence of Na_2O, K_2O, lime, magnesia, ferric oxide, ferrous oxide, FeS_2, $FeCO_3$, $CaCO_3$ decrease the fusion point of ash. If ash of the biomass has low fusion point, then it fuses when burnt on grates. On fusion of this ash, clinker is formed. Biomass having high calorific value and high fixed carbon content are more conducive to clinker formation.

v. Determination of Carbon and Hydrogen in Solid Waste (ASTM D:5868-10a)

Solid waste is burnt in a current of dry oxygen thereby converting the carbon and hydrogen into carbon (iv) oxide (CO_2) and water (H_2O) respectively. The products of this combustion are passed over weighed tubes of anhydrous calcium chloride ($CaCl_2$) and potassium hydroxide (KOH) which absorb H_2O and CO_2 respectively. The increase in weight of $CaCl_2$ tube represents the weight of water (H_2O) formed while the increase in the weight of KOH in the tube represents the weight of carbon(iv)oxide (CO_2) formed. % of Hydrogen (H) and Carbon (C) in the solid waste is calculated in equation 12 and 13 respectively.

$$Carbon\%\ in\ waste = \frac{12Z}{44X} \times 100\ \% \qquad (7)$$

Y = increase in the weight of $CaCl_2$ tube.
Z = increase in the weight of KOH tube

$$\text{Hydrogen content} = \frac{2Y}{18X} \times 100\ \% \qquad (8)$$

vi. Determination of Nitrogen in Waste Sample (ASTM D-5868-10d)

Nitrogen content is estimated using Kjeldahal's method. A known weight of the powdered sample is heated with concentrated tetraoxosulphate (vi) acid (H_2SO_4) in the presence of potassium tetraoxosulphate (vi) salt solution $K_2SO_4$and copper(ii) tetraoxosulphate (vi) salt solution $CuSO_4$in a long neck flask (called Kjeldahal's flask) thereby converting nitrogen of the waste to ammonium sulphate. A clear solution obtained when the whole nitrogen is converted into ammonium sulphate is then treated with 50% NaOH solution. The ammonia thus formed is distilled over and absorbed in a known quantity of standard H_2SO_4 solution. The volume of unused H_2SO_4 acid is then determined by titrating against standard NaOH solution. Thus the amount of acid neutralized by liberated ammonia in the waste sample is determined [9].

$$\%\ Nitrogen = \frac{Volume\ of\ acid\ used \times Normality}{Weight\ of\ sample\ taken} \times 1.4 \qquad (9)$$

vii. Determination of Sulphur in the Waste Sample (ASTM D-5868-10a)

A known quantity of the waste sample will be heated with Eschka mixture (which consists of 2 parts of Magnesium oxide (MgO) and 1 part of anhydrous Sodium trioxocarbonate (iv) (Na_2CO_3) at 800^{0}C. The sulphate formed is precipitated as Barium tetraoxosulphate (vi) salt ($BaSO_4$) by treating with $BaCl_{2)}$ and it is weighed.

$$\text{Sulfur content} = \frac{32W}{233X} \times 100\ \% \qquad (10)$$

Where X= weight of waste sample taken.
W= weight of $BaSO_4$ precipitate formed

viii. Determination of Heating Value

The heating value was experimentally determined using a bomb calorimeter. An empirical model was developed for the estimation of energy content, which is represented by higher heating value (HHV) of MSW using their contents of water, carbon, hydrogen, nitrogen, oxygen and sulphur obtained from the results of the ultimate and proximate analysis of the waste samples.

$$y = \left(\frac{1-x_1}{100}\right)(0.327x_2 + 1.241x_3 - 0.089x_4 - 0.26x_5 + 0.074x_6) \qquad (11)$$

Where x_1, x_2, x_3, x_4, x_5 and x_6 are the water, carbon, hydrogen, oxygen, nitrogen, sulphur content in the analysis and y (MJ/kg) the higher heating value predicted. The experimental higher heating values (MJ/kg) are taken into account as output (target variable) in the empirical model developed.

$$\frac{y = (1-x_1)(ax_2 + bx_3 + cx_4 + dx_5 + ex_6)}{100} \qquad (12)$$

where x_1, x_2, x_3, x_4, x_5 and x_6 represent water (H_2O), Carbon (C), Hydrogen (H), Nitrogen (N), Oxygen(O), and Sulphur (S) respectively.

$$H_V\ (\text{kJ/kg}) = 33801(C) + 144158[(H) - 0.125(O)] + 9413(S) \qquad (13)$$

$$C_V\ (\text{kCal/dry kg}^{-1}) = 99.5\ (C) - 136.2(H) + 61.9(O) + 143.1(N) - 392.6(S) \qquad (14)$$

ix. Evaluation of the Energy Content of MSW

Using Bomb Calorimeter (Cal 2k-Eco Calorimeter), the energy content was determined in Afe Babalola University, Ado-Ekiti (ABUAD) Laboratory. The weight of a clean crucible was fixed at zero on the digital weighing balance. 0.5g of already dried pulverized waste sample will be measured. The sample identification and the corresponding mass were entered using the calorimeter PC keyboard prior to the determination of the energy content. The pre-cut of firing cotton was looped over the firing wire, and the weighed crucible containing the sample in a crucible holder was inserted to ensure that the firing cotton touches the samples. With filling station uprightly positioned and filled with oxygen to 3000kPa, the vessel was inserted into the measuring chamber and then the lid was closed. The temperature stabilization phase was carried out for the duration of 10 minutes at a voltage of 220 V until the vessel fires automatically and the calorific value displayed on the screen of the system.

3. RESULTS AND DISCUSSION

The results of the sorting processes for MSW is presented in tables 3, percentage composition in table 4, and percentage by weight in table 5 while figure 5 show the graphical illustration of the percentage composition of MSW in Ado Ekiti, Nigeria.

The average waste generated per day in Ado-Ekiti is 300 tonnes while the average waste compositions per day varies from 3,390 kg in coconut and palm kernel waste to 37,860 kg in polythene products waste. The Per Capita Waste Generation in the metropolis is 0.67 kg/day. The average percentage moisture content of the components of the solid waste samples vary from 0.82 % in polythene products waste to 12.79 % in leaves and vegetables, volatile matter range from 6.70 % in textiles waste to 67.12 % in bones. The average proportion of the fixed carbon varies from 13.89 % in rubber and leather to 81.62 % in textiles waste, ash content range from 4.78 % in coconut and palm kernel waste to 76.48 % in charcoal, the total carbon ranges from 57.85 % in paper and cardboards to 88.37% in textiles waste. The nitrogen content ranges from 0.36 % in polythene products waste to 5.88 % in fruits waste. Sulphur content also varies from 0.03% in coconut and palm kernel waste to 0.26% in leaves and vegetable.

Table 3: Composition of MSW by Weight in Ado-Ekiti, Nigeria

S/N	Components	Keys	% Compositions (kg)
1	Polythene Products waste	PP	12.62
2	Fruit waste	FW	12.53
3	Food waste	F	9.76
4	Glass and Ceramics	GC	9.71
5	Leaves and Vegetables	LV	8.39
6	Paper and Cardboards	PC	8.14
7	Tuberous Peels waste	TP	7.66
8	Animal dungs and Excreta	AE	5.83
9	Wood waste	WW	5.20
10	Textiles waste	TW	4.36
11	Metals and Cans	MC	3.90
12	Bones	B	3.73
13	Rubber and Leather	RL	3.71
14	Miscellaneous/Unclassified waste (dirt, sand, stones, egg shells and ashes)	MW	1.98
		Total	**100**

Polythene products waste has the highest weighted average while coconut and palm kernel waste have the least composition as presented in Table 3. Also the highest in abundance is polythene products waste which accounted for 12.62%, next to this was fruit waste of 12.53 %, food waste was 9.76 %, glass and ceramics was of 9.71 % in abundance, leaves and vegetable accounted for 8.39 %, paper and cardboards was found to account for 8.14 %, tuberous peels composed of 7.66 %. Animals' dung and excreta, wood waste, textiles waste, metals and cans, bones waste, rubber and leather were of 5.83 %, 5.20 %, 4.36 %, 3.90 %, 3.73 % and 3.71 % respectively. Miscellaneous and charcoal wastes were of 1.98% and 1.35% respectively, while coconut and palm kernel waste accounted for the least abundance of 1.13% per capita waste generation. Table 4 shows the weighted average of MSW in Ado Ekiti.

The proximate and ultimate analyses carried out in relation to the specific energy content of the MSW show that the average percentage moisture content of the components of the waste samples vary from 0.82 % in polythene products waste to 12.79 % in leaves and vegetables, while volatile matter range from 6.70 % in textiles waste to 67.12 % in bones. The average proportion of fixed carbon varies from 13.89 % in rubber and leather to 81.62 % in textiles waste.

Ash content ranges from 4.78 % in coconut and palm kernel waste to 76.48 % in charcoal. The total carbon ranges from 57.85 % in paper and cardboards to 88.37% in textiles waste. The nitrogen content ranges from 0.36 % in polythene products waste to 5.88 % in fruits waste. Sulphur content also varies from 0.03% in coconut and palm kernel waste to 0.26% in leaves and vegetable.

The composition of Biogenic and Non-Biogenic combustibles in the waste stream is 84.41 %; putrescible is 64.35 % while Non–combustible components constitute 15.59 % of the MSW in Ado-Ekiti. This implies that 84.41% of the MSW stream has potential for the production of steam to generate electricity in Ado-Ekiti. 64.35 % of the waste stream can be used to produce organic manure to improve agricultural production, biofuel (biogas) for cooking and the generation of electricity.15.59 % of the MSW can be re-used, recycled while the rest portion of the waste stream can be used for land reclamation (land filling).

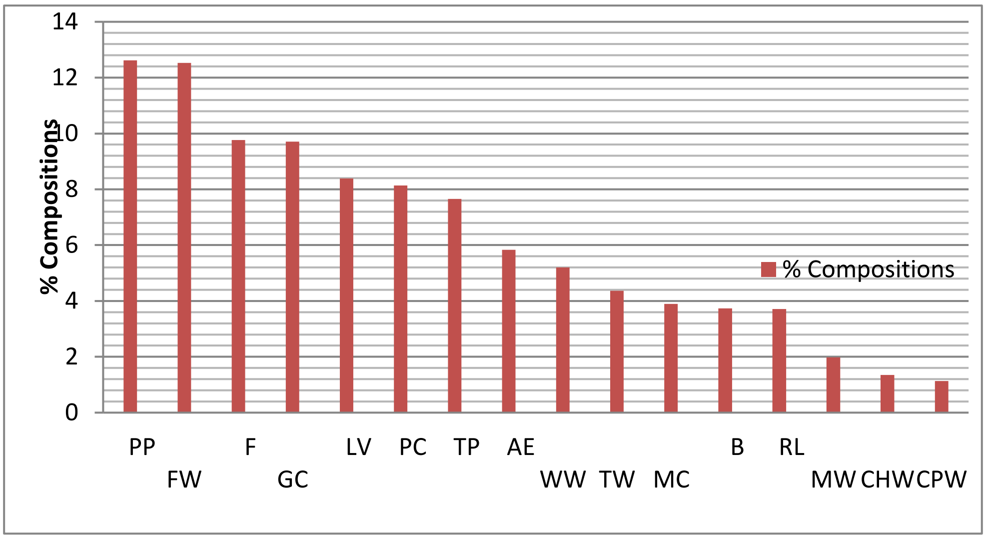

Figure 5: Percentage Composition of the MSW in Ado- Ekiti, Nigeria, 2018

From equation (1), the ratio of biogenic and non-biogenic combustible to non-biogenic and non-combustible MSW generated per day,

$$PCWG = \frac{Q}{P}\ kg/\text{day}$$

where PCWG is the Per Capita Waste Generation in Ado-Ekiti Metropolis (kg/day); Q is the Total Quantity of Waste' Generated per day; and P is the Total Population.

$$PCWG = \frac{300{,}000}{447{,}599} = 0.67\ \text{kg/day}.$$

Table 4: Composition of MSW of Ado-Ekiti

S/N	Compositions	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk 10	Wk 11	Wk 12	Total	Average Weight (kg)
1	Bones	1.07	-	0.47	0.67	0.85	0.79	0.38	0.76	0.73	1.10	0.92	0.96	8.70	0.725
2	Food waste	1.70	1.33	1.79	1.70	1.65	1.23	2.13	2.50	2.74	1.88	1.59	2.54	22.78	1.898
3	Rubber and leather	0.70	1.50	0.36	0.16	0.45	0.99	0.84	0.88	0.48	0.48	0.49	1.32	8.65	0.721
4	Polythene products waste	1.85	1.63	1.44	3.99	1.69	2.35	1.47	3.94	2.00	2.03	3.36	3.71	29.46	2.455
5	Paper and cardboards	1.20	1.03	0.63	2.84	1.62	1.82	2.02	1.44	1.29	1.28	2.23	1.59	18.99	1.583
6	Textiles waste	0.50	0.53	1.79	0.87	1.44	0.51	0.81	0.33	0.30	2.24	0.33	0.52	10.17	0.848
7	Metal and cans	0.28	0.52	0.48	0.99	1.05	0.75	0.61	0.62	0.49	0.60	1.19	1.55	9.13	0.761
8	Leaves and vegetables	0.74	0.85	0.87	1.56	1.94	1.77	2.27	1.38	3.92	0.80	0.86	2.62	19.58	1.632
9	Animals' dung and excreta	1.20	1.48	2.70	-	1.35	0.60	0.64	2.38	1.52	0.80	-	0.94	13.61	1.134
10	Glass and ceramics	2.90	0.45	0.76	2.39	2.20	2.92	3.15	0.75	0.93	1.48	1.90	2.84	22.67	1.889
11	Wood waste	0.47	-	3.45	1.50	1.60	1.02	0.08	0.70	0.60	0.90	0.96	0.85	12.13	1.011
12	Charcoal	0.60	-	0.96	-	-	0.54	-	-	0.08	-	0.98	-	3.16	0.263
13	Fruit waste	3.82	3.20	1.79	0.94	2.86	1.46	4.30	1.75	3.09	1.83	1.28	1.46	29.24	2.437
14	Coconut & palm kernel waste	-	0.06	0.38	0.24	0.08	-	-	0.76	-	0.74	-	0.28	2.54	0.220
15	Tuberous peels waste	0.40	1.43	1.28	0.41	1.12	0.59	0.71	1.84	2.52	2.47	4.46	0.66	17.89	1.491
16	Miscellaneous	0.62	0.14	0.40	0.81	0.43	0.27	0.04	0.60	0.47	-	0.47	0.38	4.63	0.386

Table 5: Gravimetric Compositions of Biogenic and Non-Biogenic Combustibles of MSW Generated in Ado-Ekiti

S/N	Combustible Components	% Composition	Quantity of MSW generated (kg/day)
1	Bones	3.73	11,190
2	Food waste	9.76	29,280
3	Rubber and Leather	3.71	11,130
4	Polythene Products waste	12.62	37,860
5	Paper and Cardboards	8.14	24,420
6	Textiles waste	4.36	13,080
7	Leaves and Vegetables	8.39	25,170
8	Animal dungs and Excreta	5.83	17,490
9	Wood waste	5.20	15,600
10	Charcoal	1.35	4,050
11	Fruit waste	12.53	37,590
12	Coconut and Palm kernel waste	1.13	3,390
13	Tuberous peels waste	7.66	22,980
14	Miscellaneous	15.59	46,770
	Total	**100.00**	**300,000**

The results obtained directly from Cal 2k-Eco Calorimeter test are presented in Table 6.

Table 6: Combustibles Components of MSW Generated and The Energy Content

S/N	Combustible Components	% Composition	MSW generated (kg/day)	Specific Energy Content (kJ/kg)	Energy Content (kJ/day)	Electricity Generation Potential (MW)
1	Bones	3.73	11,190	6,994.39	78,267,224.10	0.91
2	Food waste	9.76	29,280	14,176.14	415,077,379.20	4.80
3	Rubber and Leather	3.71	11,130	20,946.52	233,134,767.60	2.70
4	Polythene Products waste	12.62	37,860	35,959.00	1,361,407,740.0	15.76
5	Paper and Cardboards	8.14	24,420	11,210.00	273,748,200.00	3.17
6	Textiles waste	4.36	13,080	17,800.48	232,830,278.40	2.69
7	Leaves and Vegetables	8.39	25,170	14,069.37	354,126,042.90	4.10
8	Animal dungs and Excreta	5.83	17,490	13,848.16	242,204,318.40	2.80
9	Wood waste	5.20	15,600	16,795.96	262,016,976. 00	3.03
10	Charcoal	1.35	4,050	18,711.70	75,782,385. 00	0.88
11	Fruit waste	12.53	37,590	14,328.96	538,625,606.40	6.23
12	Coconut and Palm kernel waste	1.13	3,390	13,944.80	47,272,872. 00	0.55
13	Tuberous peels waste	7.66	22,980	14,574.95	334,932,351 .00	3.88
Total		**84.41**	**253,230**	**213,360.43**	**4,449,426,141.00**	**51.50**

4. CONCLUSION

This research provides a clear understanding of solid waste characterisation, their sources, disposal methods, sorting, physiochemical composition, energy content, resource recovery potential and categorization of the MSW generated in the society. The Quantitative Analysis of MSW of Ado-Ekiti Metropolis, Southwest Nigeria was investigated extensively. From the analysis, results obtained and the foregoing discussions, the following conclusions were drawn. The quantitative analysis of the MSW in Ado–Ekiti shows that resource recovery is possible to a great economic advantage.

The quantity of the biogenic waste generated within the metropolis justifies its use as a means of revenue generation when effectively utilized through waste to energy recovery techniques. Ado-Ekiti municipal solid waste have the highest polythene products waste and the least in abundance in the components is coconut and palm kernel waste, so also the highest energy content was obtained in the polythene products and least in coconut and palm kernel waste. MSW in Ado-Ekiti metropolis can be used to better the lots of the inhabitants through conversion to source of energy.

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