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Synergetic Effect of Proximate and Ultimate Analysis on the Heating Value of Municipal Solid Waste of Ado – Ekiti, Metropolis, Southwest Nigeria

O. L. Rominiyi[1*], T. K. Olaniyi [1], T. M. Azeez[1], J. F. Eiche[2] and S. A. Akinola[3]

[1]Department of Mechanical and Mechatronics Engineering, Afe Babalola University Ado-Ekiti (ABUAD), P.M.B. 5454, Ado-Ekiti, Nigeria.
[2]Department of Mechanical Engineering, Federal University of Technology Akure (FUTA), P.M.B. 703, Ondo State, Nigeria.
[3]Department of Electrical and Electronics, Ekiti State University (EKSU), Ado-Ekiti, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author OLR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TKO, TMA, JFE and author SAA managed the analyses of the study. Author SAA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The municipal solid waste which is a threat to the environment can be effectively utilized to boost the economic prosperity of where this waste is being generated. One of the way by which it can be utilized is energy production. The results generated in the proximate and ultimate analysis of the waste sample can be used to determine the specific energy content of the solid waste in the absence of bomb calorimeter. The samples of the Municipal Solid Waste (MSW) were sorted, sundried, pulverized and sieved. These analyses were carried out on the combustible components of MSW in Ado-Ekiti to determine the percentage Moisture Content (MC), Fixed Carbon (FC), Volatile Matter (VM) Ash Content (AC), Nitrogen Content (N), Sulphur Content (S) and Total

**Corresponding author: E-mail: rominiyiol@abuad.edu.ng;*

Carbon (C) by monitoring the weight change at different desired temperatures according to the standards of the American Society for Testing and Materials (ASTM) carried out on the combustible components of MSW in Ado–Ekiti showed that the moisture content of the components varied from 0.82% in polythene products waste to 12.79% in leaves and vegetables, volatile matter ranged from 6.70% in textiles to 67.12% in bones, the fixed carbon varied from 13.89% in rubber and leather to 81.62% in textiles, ash content ranged from 4.78% in coconut and palm kernel ton 76.48% in charcoal, the total carbon varied from 57.85% in paper and cardboards to 88.37% in textiles. The nitrogen content ranged from 0.36% in polythene products to 5.88% in fruits. Sulphur content also varied from 0.03% in coconut and palm kernel to 0.26% in leaves and vegetable. The lower the moisture content, volatile matter, ash content and nitrogen content the higher the specific energy content of the MSW while the higher the, sulphur content, total carbon and fixed carbon the higher the specific energy content of the MSW .The heating value of waste can be determined by the analytical method using the data obtained in the proximate and ultimate analysis of the solid waste sample.

Keywords: Municipal solid waste (MSW); proximate analysis; ultimate analysis; specific energy content.

1. INTRODUCTION

A wide range of biogenic and non-biogenic municipal solid waste which are causing environmental pollution can be utilized as fuels, among these are: food waste, paper and cardboards waste, charcoal waste, wood waste (branches, roots, bark, saw dust) as well as agricultural residues- maize cobs, coconut shells, cereal straws, rice husks),fruits waste, bones, textiles waste, leaves and vegetables, animal dungs and excreta, polythene products waste, rubber and leather. They are all useful feedstock in energy recovery systems [1].

1.1 Ultimate and Proximate Analysis of Solid Waste Components

These analysis are used for obtaining the elemental compositions (the nitrogen content, oxygen content, hydrogen content, total carbon, sulphur content and as well as the moisture content, volatile matter, ash content , fixed carbon, present in the municipal solid waste. These parameters are very important when considering a feedstock to be used for the Energy Recovery Systems (ERS) [1].

1.1.1 Moisture content

Theoretically, almost all kinds of biomass with moisture content of 5-30% can be gasified; however, not every biomass fuel lead to the successful gasification [2]. Most of the development work is carried out with common fuels such as coal, charcoal and wood. The Key to a successful design of gasifier and any other bioreactor is to understand properties and thermal behaviour of fuel as fed to the thermal plants. The properties of fuel which influence the design of gasifier and other energy recovery systems are: The moisture content of the feedstock, the percentage volatile matter, the ash content, the fixed carbon present, the sulphur content present, Nitrogen content, the total carbon content. The moisture content of the most biomass fuel depends on the type of fuel, it´s origin and treatment before it is used for pyrolysis, incineration, gasification and biosynthesis in fuel production.. Moisture content of the fuel is usually referred to inherent moisture plus surface moisture. The moisture content below 15% by weight is desirable for trouble free and economical operation of the energy production plants. Higher moisture contents reduce the thermal efficiency of these systems and results in low gas heating values. Igniting the fuel with higher moisture content becomes increasingly difficult, and the gas quality and the yield are also poor [3].

1.1.2 Volatile matter content of fuel

Volatile matter and inherently bound water in the fuel are given up in pyrolyis zone at the temperatures of 100-150°C forming a vapour consisting of water, tar, oils and gases. Fuel with high volatile matter content produces more tar, causing problems to internal combustion engine. Volatile matters in the fuel determine the design of gasifier for removal of tar. Compared to other biomass materials (crop residue: 63-80%, Wood: 72-78%, Peat: 70%, Coal: up to 40%), charcoal contains least percentage of volatile matter (3-30%) [3].

1.1.3 Ash content of fuel

Mineral contents of fuel which remains in oxidized form after combustion of fuel is called ash. In practice, ash also contain some unburned fuel. Ash content and ash composition have impact on smooth running of gasifier. Melting and agglormeration of ashes in reactor causes slagging and clinker formation [4]. If no measures are taken, slagging or clinker formation lead to excessive tar formation or complete blocking of reactor. In general, no slagging occurs with fuel having ash content below 5%. Ash content varies from fuel to fuel. Wood chips has contains 0.1% ash, while rice hust contains high amount of ash (16-23%) [3].

Because of the concern over the emission of chlorinated compounds during combustion, the determination of halogens is often included in an ultimate analysis. The results of the ultimate analysis are used to characterize the chemical composition of the organic matter in MSW. They are also used to define the proper mix of waste materials to achieve suitable C/N ratios for biological conversion process. The prediction of the heating value can be calculated as already established based on Dulong equation [5] stated in equation (1) and [6] (2) and (3) respectively.

$$HV\left(\frac{kJ}{kg}\right) = 33801(C) + 14415\{(H) - 0.125(O)\} + 9413(S) \quad (1)$$

$$CV\left(\frac{kCal}{drykg^{-1}}\right) = 244.7(979) + 70.4(11.9)(C) - 64.2(63.7)(N) + 572.2(798.6)(S) + 298.1(46.6)(H) - 46.7(9.63)(O) + 8.07(13.3)(OM) \quad (2)$$

$$CV\left(\frac{kCal}{drykg^{-1}}\right) = 99.5(C) - 136.2(H) + 61.9(O) + 143.1(N) - 1392.6(S) \quad (3)$$

Where HV is a Heating Value whereas C, H, O,N, OM and S are carbon, hydrogen, oxygen, nitrogen, organic matter or volatile matter and sulphur content on the dry basis. A number of multiple regression modeling studies were available in the literature for predicting heating value from the physical content, proximate and ultimate analysis of the municipal solid waste [7] and [8]. An empirical model was developed for the estimation of energy content of the municipal solid waste using their contents of water, carbon, hydrogen, nitrogen, oxygen and sulphur obtained from the ultimate and proximate analysis of the waste samples as in the equation 4.

$$y = \left(1 - \frac{x_1}{100}\right)(0.327x_2 + 1.241x_3 - 0.089x4 - 0.26x5 + 0.074x6 \quad (4)$$

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 model equation gave a high correlation when compared with that of the calorimeter [9]. Higher heating value (HHV) and composition of solid fuels are important properties which define the quantitative energy content and determine the clean and efficient use of these fuels. The net calorific value was determined by using the relationship in equation 5:

NCV = 18.7 (1.0 − AC − MC) − (2.5MC) (MJ/kg) [3] (5)

Where:

NCV is net (lower) calorific value (MJ/kg)
AC is ash content
MC is moisture content

Energy from waste, which is the major source of renewable energy, not only reduces the dependency on the traditional fossils fuels but also reduces the total greenhouse gas emissions [10]. Malaysia is obliged to adopt the resolutions of the Kyoto convention on Global Warming by cutting down the releases of greenhouse gas into the environment in the near future. Power generation from renewable energy sources such as municipal solid waste (MSW) could have a significant contribution to achieve this goal [10].

1.1.4 Aim and objectives of the research

The aim of this project is to determine the proximate and ultimate analysis of the municipal solid waste in Ado-Ekiti, Ekiti State

The specific objectives of the research are to:

(i) Determine the proximate analysis of the municipal solid waste samples .
(ii) Determine the ultimate analysis of the municipal solid waste samples.
(iii) Find out the synergetic effect of the result obtained from the proximate and ultimate analysis on the specific energy content of the municipal solid waste.

Plate 1. An indiscriminate dumping of refuse at the King's Market Ado-Ekiti, Ekiti State

2. RESEARCH METHODOLOGY

2.1 Sample Preparation

The samples are randomly collected from different dump site in the city of Ado-Ekiti and sorted It was sundried and grinded and sieved with 500μ mesh size sieve so that the analysis can be carried out on it.

2.1.1 Determination of proximate analysis of solid waste sample

Proximate analysis involves the determination of moisture content, volatile matter, ash content and fixed carbon of the waste sample. All these properties are very important if solid waste samples are to be used as fuel.

2.1.2 Determination of the percentage moisture content of the municipal waste samples

The weight of silica crucible was measured using the digital weighing balance and recorded w_1(g), the spatula was used to fetch 1.00 g of pulverized solid waste samples inside the crucible. The content kept inside the silica crucible and the crucible was measured and recorded as w_2(g). It was then heated in a muffle furnace at a temperature of 105°C for 1 hours. The crucible is taken out, cooled in a dessicator and weighed. The process of heating, cooling and weighing is repeated until a constant weight of the Municipal solid waste sample (anhydrous) was obtained w_3(g). The equation .6 was used to determine the percentage moisture content of the combustible components of the municipal solid waste using [11].

$$\%\,M.C = \frac{w_2 - w_3}{w_2 - w_1} \times 100 \tag{6}$$

Where: $w_2 - w_3$ is the loss in weight of the solid waste sample.

$w_2 - w_1$ is the initial weight of the solid waste sample.

The procedures to determine the moisture content of the combustible components of municipal solid waste were replicated three times and the average values were presented in the composite Table 1.

2.1.3 Experimental determination of the percentage volatile matter of the municipal solid waste samples

A unit weight of moisture free pulverized solid waste sample in the silica crucible was weighed on the digital weighing balance as w_3(g). The sample was further heated in a crucible fitted with cover in a muffle furnace at a temperature of 950°C for 7 minutes ISO 562/1974. It was cooled in the dessicator and weighed on the digital weighing balance as w_4(g). The percentage volatile matter in the combustible components of the municipal solid waste was determined using equation 7

$$\%\,V.M = \frac{w_3 - w_4}{w_3 - w_1} \times 100 \tag{7}$$

Where: $w_3 - w_4$ is the loss in weight of moisture free waste.

$w_3 - w_1$ is the initial weight of the moisture free solid waste.

The procedures to determine the volatile matter of the combustible components of municipal solid waste were replicated three times and the average values of the volatile matter of each of the components obtained were presented in the composite Table 1.

2.1.4 Experimental determination of the percentage ash content of the municipal solid waste samples

The crucible was weighed on the digital weighing balance and recorded as w_1(g) Spatula was used to fetch 1.00 g of solid waste sample into the silica crucible. It was then measured and recorded as w_6(g). The sample in the open crucible was thereafter burnt (in the presence of air) at a temperature of 750°C in a muffle furnace till a constant weight is achieved. The residue ash was measured and recorded as w_7(g).The procedure was repeated three times for each of the combustible components of the municipal solid waste samples ASTM D 2017 [2]. The equation 8 was used to determine the percentage of ash content in the combustible components of the municipal solid waste.

$$\%\,Ash\ Content\ in\ the\ solid\ waste = \frac{w_7 - w_1}{w_6 - w_1} \quad (8)$$

Where: $w_7 - w_1$ is the weight of residual ash formed.
$w_6 - w_1$ is the weight of solid waste initially taken.

This procedure was replicated three times and the average values of % ash in the solid waste of each of the components obtained were presented in the composite Table 1.

2.1.5 Determination of the percentage of the fixed carbon of the municipal solid waste samples

The percentage fixed carbon was determined directly by deducting the sum total of moisture, volatile matter and ash percentage from 100.

$$\%\,Fixed\ Carbon = 100 - (\%\,moisture\ content + \%\,volatile\ matter + \%\,ash) \quad (9)$$

2.1.6 Ultimate analysis of the waste samples

Ultimate analysis was also carried out to determine the percentage total carbon (C), percentage nitrogen (N),percentage sulphur (S),percentage hydrogen and oxygen (H_2 and O_2) present in the combustible components of the municipal solid waste generated in Ado-Ekiti, Nigeria.

2.1.7 Determination of the total carbon in the municipal solid waste samples

The percentage total carbon of the waste sample was determined directly by adding the volatile matter and the fixed carbon together as in the equation 10

$$\%\,Total\ Carbon = Volatile\ Matter + Fixed\ Carbon \quad (10)$$

The percentage total carbon of each of the components obtained were also presented in the composite Table 2.

2.1.8 Experimental procedure to determine the percentage of nitrogen in the municipal solid waste samples

The nitrogen estimation in the solid waste sample was done by Kjeldahal's method.1.00g of the prepared solid waste sample was measured and recorded as w_8(g). The solid waste sample was heated with concentrated H_2SO_4 (tetraoxosulphate (vi) acid) in the presence of K_2SO_4 (Potassium tetraoxosulphate (vi) salt) and $CuSO_4$ (Copper (ii) tetraoxosulphate (vi) salt) in a long necked flask called Kjeldahal's flask thereby converting the nitrogen in the solid waste sample into ammonium sulphate. When a clear solution is obtained that is when all the nitrogen present is converted to ammonium sulphate, the solution was treated with 50% NaOH (Sodium hydroxide) solution.The ammonia formed was distilled over and absorbed in a known quantity of standard H_2SO_4 solution. The volume of an un-used acid was then determined by titration against a standard solution of NaOH. The amount of acid neutralized by liberated NH_3 from the solid waste sample was then evaluated, the equations 11 and 12 were then used to determine the titre value and the percentage of nitrogen in the solid waste sample respectively [4].

$$(TitreValue)\ V\,t = V_1 - V_2\ (cm^3) \quad (11)$$

where: V_1 is the volume of H_2SO_4 neutralized (cm^3)
V_2 is the volume of H_2SO_4 neutralized in determination (cm^3)
W_8 = mass of the solid waste sample (g)

% Nitrogen in the solid waste sample =

$$\frac{V_{t} \times Normality \times 1.4}{W_8} \times \frac{100}{1} \quad [12] \quad (12)$$

The above procedure was replicated two times and the average values of the % nitrogen content of each of the components obtained were computed and presented in the composite Table 2.

2.1.9 Experimental procedure to determine the percentage of sulphur in the municipal solid waste samples

25 ml of the weighed samples were dissolved in water and pipette into 50 ml standard flasks followed by 20 ml gelatine $BaCl_2$ solution and made up to 50 ml mark. The solutions were allowed to stand for 30 minutes. The absorbance of the standard solution (Na_2SO_4) and the samples were read from the spectrophotometer at 420 nm. The graphs of absorbance against concentration of standards were plotted and sample concentration evaluated from the graph. The equation 13 was used to calculate % sulphur in the solid waste samples. The above procedures were repeated two times for each of the samples and the mean values obtained were presented in the composite Table 2.

% of sulphur in the solid waste =

$$\frac{R \times V \times Df}{mass\ of\ \ sample\ used} \quad [13] \qquad (13)$$

where

R is the Graph reading
V is the Total Volume = 25 ml
Df is the Dilution factor

2.2 Determination of % of Hydrogen and Oxygen in the Waste Sample

The percentage of hydrogen and oxygen in the waste sample was obtained analytically by the difference between the sum of percentage total carbon, nitrogen, sulphur, and 100. The results was presented in the composite Table 2.

$$\%\ \text{Hydrogen} + \%\ \text{Oxygen} = 100 - (\%\ \text{of}\ C + N + S) \qquad (14)$$

The results obtained in the proximate analysis was used to determine the Net Calorific Value (NCV) of the combustible components of Municipal Solid Waste (MSW) which consist of Biogenic and Non Biogenic Combustible Components by using the equation 5 [2].

3. RESULTS AND DISCUSSION

This study was designed to determine the quality as well as the synergetic effect of the proximate and ultimate analysis on the specific energy content of the municipal solid waste of Ado-Ekiti, Ekiti State obtained by Rominiyi, [1]. The results of the sorting processes, percentage composition, classification, proximate and ultimate analysis, the energy content of the municipal solid waste and the graphical illustrations of the combined effect of proximate and ultimate analysis were also presented.

The composite Table 1 shows that the percentage moisture content of the components of the Municipal Solid Waste varies from 0.82% in polythene products waste to 12.79% in leaves and vegetables, volatile matter ranges from 6.70% in textiles waste to 67.27% in bones waste, the ash content ranges from 4.78% in coconut and palm kernel waste to 67.48% in bones waste while the fixed carbon ranges 6.43% in bones and leather to 81.62% in textiles waste. The total carbon ranges from 57.85% in paper and cardboards to 88.32% in textiles waste.

Themean % moisture content (MC) of the components of Municipal Solid Waste (MSW) is 6.68% and ranges from 0.82% in polythene products waste to 12.79% in leaves and vegetables, the mean % volatile matter (VM) of MSW is 22.40% and it ranges from 6.70% in textiles waste to 67.12% in bones. 55.09% is the mean fixed carbon (FC), it ranges from 6.43% in bones to 81.62 % in textiles waste. The mean ash content (AC) of the waste sample is and it varies from to 19.01% which varies from 4.78% in coconut and palm kernel waste to 64.27% in bones.

The Table 2 shows that the total carbon content varies from 57.85% in paper and cardboards to 88.32% in textiles waste, nitrogen content ranges from 0.36% to 5.88% in polythene product waste and fruit waste respectively .0.03% to 0.26% is the sulphur content ranges in coconut and palm kernel waste, leaves and vegetable while hydrogen and oxygen content varies from 10.45% in textiles waste to 41.57% paper and cardboards.

Table 1. Proximate analysis of municipal solid waste in Ado –Ekiti, Ekiti State

S/N	Components	% moisture content	% volatile matter	% fixed carbon	% ash	Total
1	Bones	3.58	67.12	6.43	64.27	100
2	Food waste	5.90	9.49	76.95	7.66	100
3	Rubber and Leather	0.86	53.05	13.89	32.20	100
4	Polythene products waste	0.82	9.18	78.23	11.77	100
5	Paper and Cardboards	5.57	36.88	20.97	36.58	100
6	Textiles waste	1.80	6.70	81.62	9.88	100
7	Leaves and Vegetables	12.79	24.87	43.07	19.27	100
8	Animals' dungs and Excreta	11.33	24.00	46.00	18.67	100
9	Wood waste	9.40	12.24	69.64	8.72	100
10	Charcoal	6.73	11.50	70.21	11.56	100
11	Fruit waste	9.55	20.60	55.38	14.47	100
12	Coconut and palm kernel waste	8.91	7.94	78.37	4.78	100
13	Tuberous peels waste	9.55	7.65	75.40	7.40	100

Table 2. Ultimate analysis of municipal solid waste in Ado– Ekiti, Ekiti State

S/N	Components	% C	% N_2	% S	% H_2+ O_2	Total
1	Bones	73.55	ND	0.08	26.37	100
2	Food waste	86.44	1.40	0.06	12.10	100
3	Rubber and Leather	66.94	2.69	0.19	30.18	100
4	Polythene products waste	87.41	0.36	0.16	12.07	100
5	Paper and Cardboards	57.85	0.45	0.13	41.57	100
6	Textiles waste	88.32	1.16	0.07	10.45	100
7	Leaves and Vegetables	67.94	1.43	0.26	30.37	100
8	Animals' dungs and Excreta	70.00	1.61	0.19	28.20	100
9	Wood waste	81.88	0.71	0.06	17.35	100
10	Charcoal	81.71.	1.15	0.05	17.09	100
11	Fruit waste	75.98	5.88	0.14	18.00	100
12	Coconut and Palm kernel waste	86.31	0.89	0.03	12.77	100
13	Tuberous peels waste	83.05	1.42	0.07	15.46	100

Table 3. The specific energy content (kJ/kg) of the combustible components of the municipal solid waste generated in Ado-Ekiti, Ekiti State

S/N	Components	Specific energy content (kJ/kg)
1	Bones	6,994.39
2	Food waste	14,176.14
3	Rubber and Leather	20,946.52
4	Polythene products waste	**35,959.00**
5	Paper and Cardboards	11,210.00
6	Textiles waste	17,800.48
7	Leaves and vegetables	14,069.37
8	Animals' dungs and Excreta	13,848.16
9	Wood waste	16,795.96
10	Charcoal	18,711.70
11	Fruit waste	14,328.96
12	Coconut and palm kernel waste	13,944.80
13	Tuberous peels waste	14,574.95

Source: Rominiyi, (2015)

The Table 4 shows the analytical estimation of the Lower Heating Value (LHV) of the Municipal Solid Waste (kJ/kg) using the results obtained in proximate analysis.

Formulae for calculating the Lower or Net Heating Value of the fuel sample is given as in equation 5

NCV = 18.7 (1.0 − AC − MC) − (2.5MC) (MJ/kg) [2] (5)

It can be inferred from the result of proximate analysis in the Fig. 1 that the lower the moisture content of the municipal solid waste above, the higher the specific energy content. Polythene products waste have the least moisture content of 0.82% hence the higher calorific value of 35,959.00 kJ/kg, rubber and leatherhas a moisture content of 0.86% with the corresponding specific energy content of 20,946.52 kJ/kg. The leaves and vegetable waste have the moisture content of 12.79% and specific energy content of 14,069.37 kJ/kg.

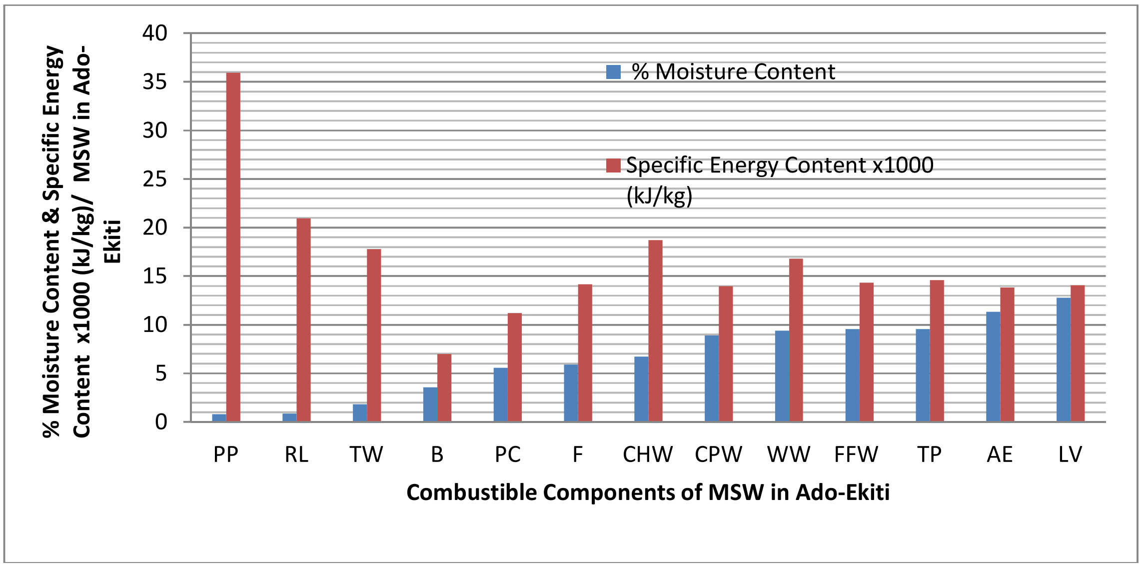

Fig. 1. Variation of % moisture content with specific energy content (kJ/kg) of combustible components of MSW

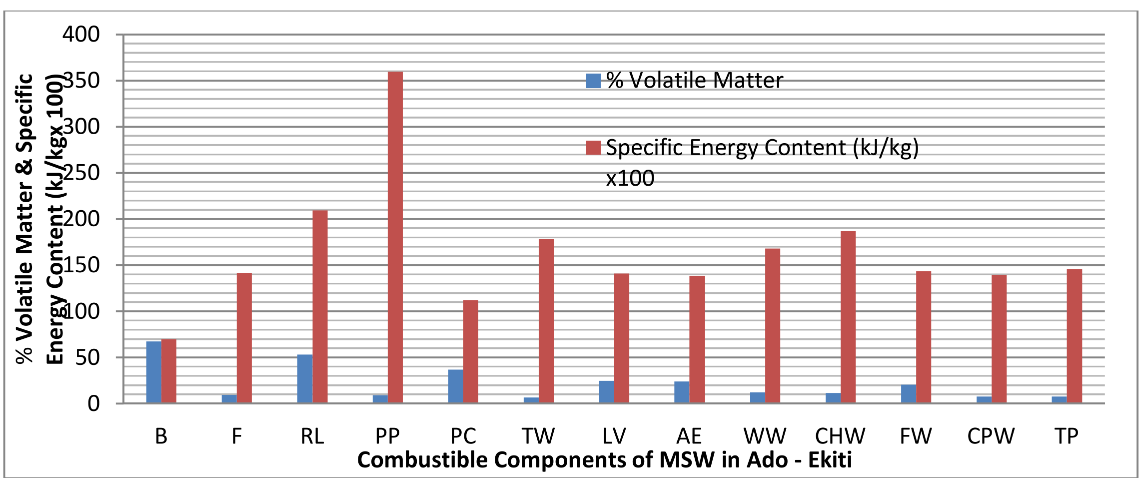

Fig. 2. A Multiple bar chart of variation % volatile matter with specific energy content (kj/kg) of combustible components of MSW

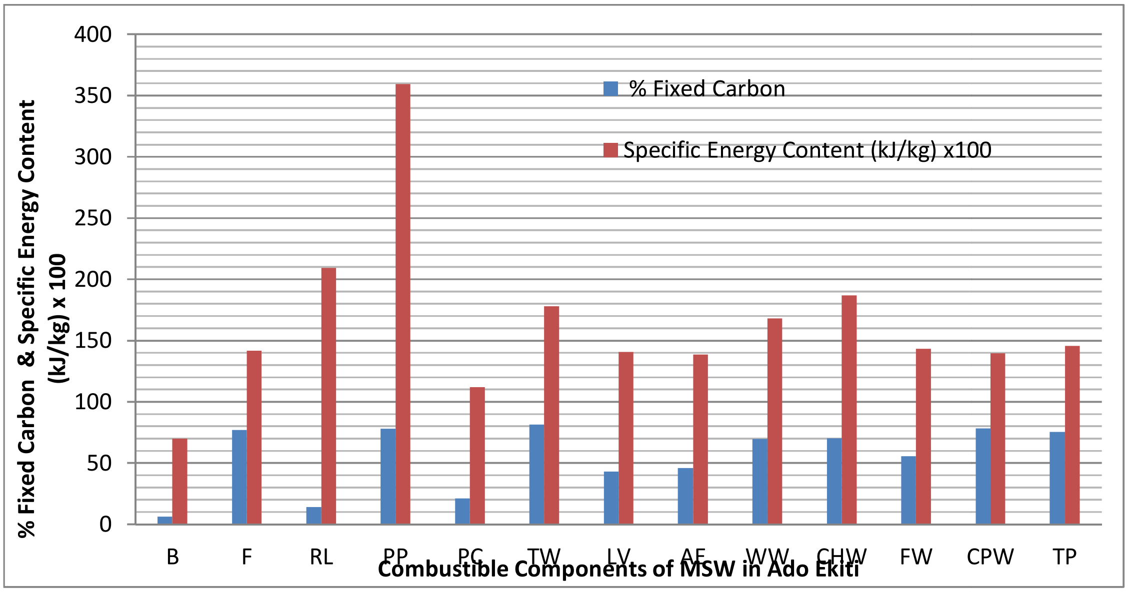

Fig. 3. Variation of % fixed carbon with specific energy content (kJ/kg) of the MSW

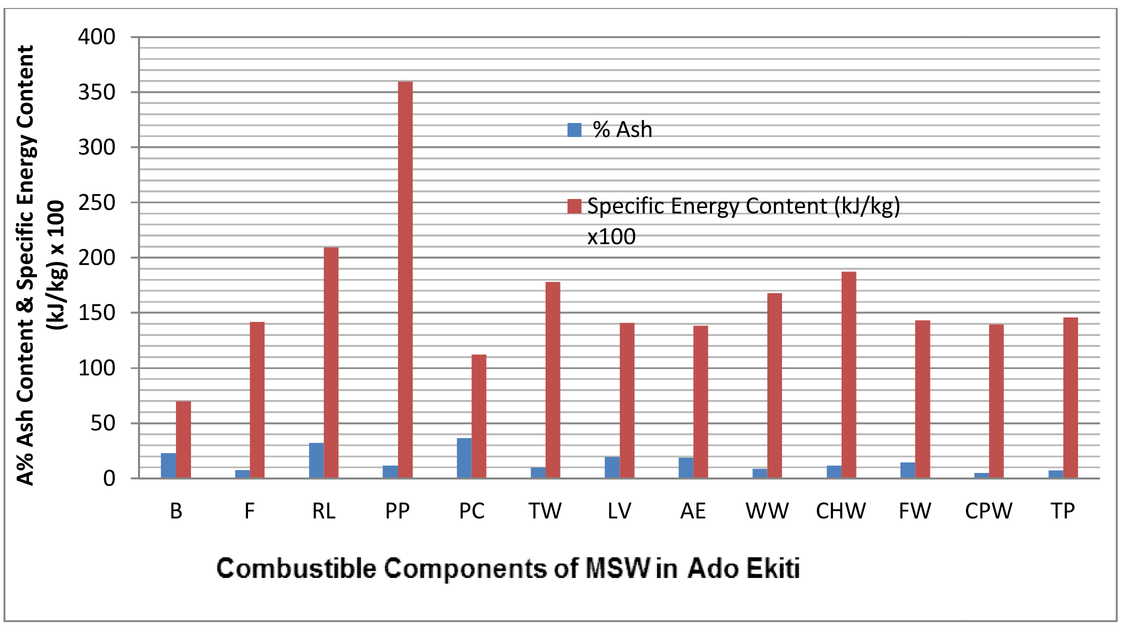

Fig. 4. Variation of % ash content against the specific energy content (kJ/kg) of MSW

Also in the Fig. 2 it was observed that the higher the volatile matter, the higher the tendency the waste sample to catch fire easily by lowering the ignition temperature which invariably lower the heating value of the solid waste. Bones and textile waste have 67.12% and 6.70% volatile matter with corresponding 6,994.39 kJ/day and 17,800 kJ/day specific energy content respectively while polythene products waste of 9.18%, Charcoal waste 11.50% and Tuberous-peels waste 7.65% volatile matter have calorific values of 35,959.00 kJ/kg, 18,711.70 kJ/kg and 14,574.95 kJ/kg respectively.

The bar charts in Fig. 3 and Fig. 4 showed the percentage ash content and that % Fixed Carbon of the municipal solid waste It shows that the higher the fixed carbon the higher the specific energy content while the higher ash content results into lower specific energy content of the waste sample.

The Fig. 3 and Fig. 5 vindicated that the higher the fixed carbon and total carbon present in the solid waste samples, the higher its specific energy content. The polymeric materials, textiles waste, Coconut and palm kernel waste, Charcoal , food waste, fruit waste and others have very high percentage fixed carbon and total carbon, hence high specific energy content and so also the lower the percentage of fixed carbon and total carbon present in the municipal solid waste sample, the lower the heating value.

High percentage of sulphur favour a high heating value of the municipal solid waste except in some few cases of polythene products waste, textiles waste and tuberous peels waste whereas the higher percentage of nitrogen lower the heating value of the solid waste sample and vice-versa.

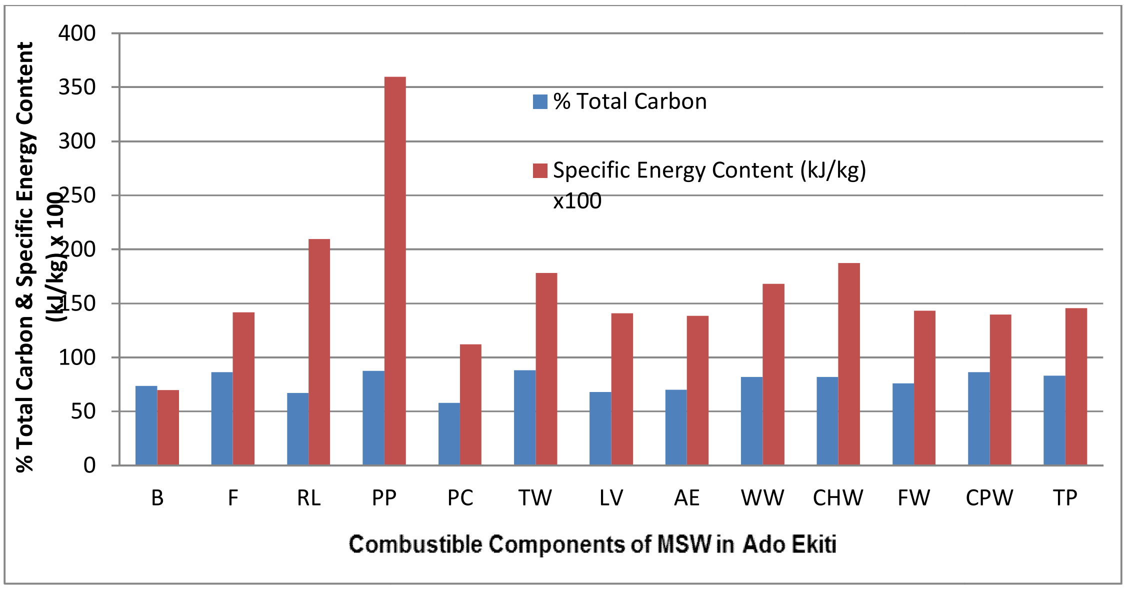

Fig. 5. Variation of % total carbon against specific energy content (kJ/kg) of the MSW

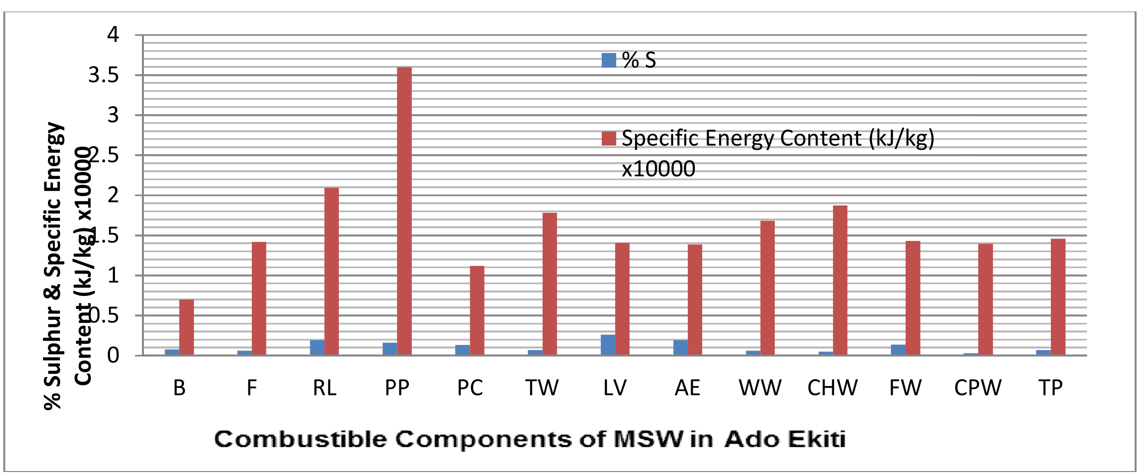

Fig. 6. Variation of % Sulphur content against the specific energy content (kJ/kg) of MSW

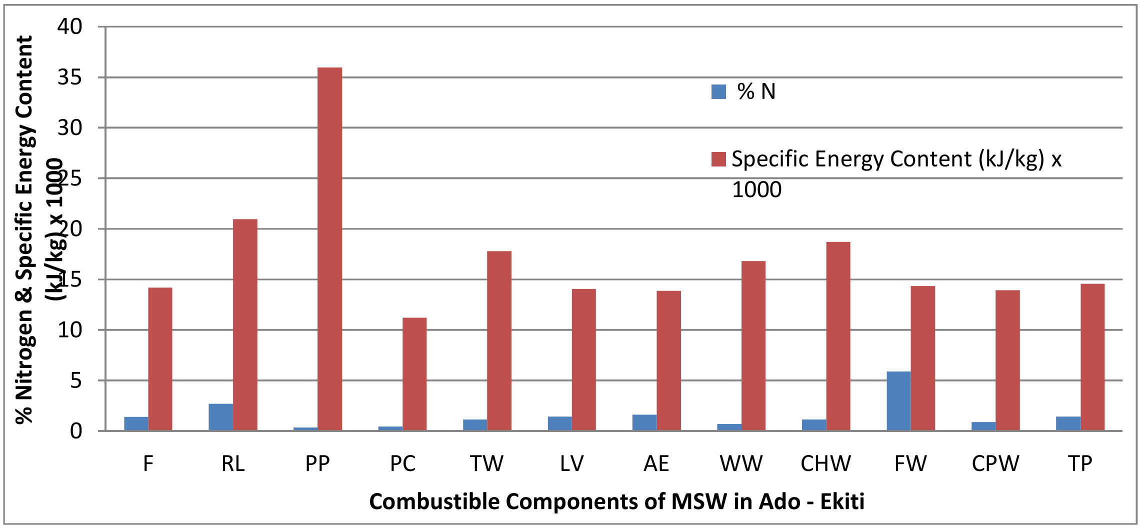

Fig. 7. Variation of % nitrogen content against the specific energy content (kJ/kg) of MSW

Table 4. The estimated lower heating values (LHV) (kJ/kg) of the Combustible Components of MSW in Ado – Ekiti, Ekiti State

S/N	Components	Estimated LHV (kJ/kg)
1	Bones	5,922.55
2	Food waste	16,016.78
3	Rubber and Leather	12,496.28
4	Polythene products waste	16,325.17
5	Paper and Cardboards	10,678.70
6	Textiles waste	16,470.84
7	Leaves and vegetables	12,385.03
8	Animals' dungs and Excreta	12,806.75
9	Wood waste	15,311.56
10	Charcoal	15,111.52
11	Fruit waste	13,968.51
12	Coconut and palm kernel waste	15,917.22
13	Tuberous peels waste	15,291.16

4. CONCLUSION

Energy demand, most especially in the developing nations can be augmented by the use of municipal solid waste, a renewable energy source which is available in abundance. Ineffective utilization of the biomass solid waste constitutes environmental hazard and pollution and also emits strong irritating smell due to microbial decomposition activities at dump sites. This calls for quantification, characterization and effective conversion of these readily available by-products for energy production. This study has shown that the calorific value of municipal solid waste can be improved by reducing its moisture content and this can be achieved by sun drying. The Lower Heating Value (LHV) (Net Heating Value) (NHV) of the biogenic and non-biogenic combustibles components of the waste sample in Ado - Ekiti metropolis ranges from 5.922 MJ/kg to 16.470 MJ/kg MJ/kg. The data generated in the proximate and ultimate analysis could be useful in the design of the processes and facilities that will utilize the waste. The results suggest that the disposed off could be developed as a source of energy for domestic and industrial purposes.

The specific energy content of the components of municipal solid waste sample varies with their elemental compositions. The higher the total carbon, fixed carbon, sulphur content, the higher the heating value and vice versa. The lower the moisture content, ash content and nitrogen content, the higher the heating value and vice versa.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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