

Development of a Simple to use Regression Model for Estimating the Energy Value of Municipal Solid Waste

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Abstract
In Nigeria and many other African countries, the volume of solid waste generated continues to increase coupled with lack of infrastructure for adequate waste treatment. Nigeria with a population growth rate of about 2.8% per annum and an urban growth rate of about 5.5 % per annum generates about 0.58 kg solid waste per person per day. The focus of this study is to develop a simple regression model for estimating the energy value of municipal solid waste components.The study took a comprehensive evaluation of the solid waste composition in seven major communities in Benin City; Edo State Nigeria. The communities include; Evbuotubu, Ekenwan, Ikpoba-Hill, Ogbebuya, New Benin Oko-Central and Ugbowo. Solid waste survey/ collection using the stratified random sampling approach was done on a daily bases for a period of eight (8) weeks in order to generate enough data for specific analysis. In addition to the stratified random sampling approach 400 survey questionnaires were administered to 400 households (400) per community in order to acquire information about residents' attitudes towards waste, socio-economic characterization including waste management behaviour etc. To determine the economic value of the waste, analytical method for energy value estimation was employed while the least square regression approach was used to develop the mathematical model for predicting the energy value of solid waste. To validate the reliability of the regression model, selected goodness of fit statistics, namely; coefficient of determination (R^2), correlation coefficient (r), Adjusted Coefficient of Determination (Adj. R^2) and error sum of square (SSE) were employed.From the energy value estimation, it was observed that 99,693.86KJ/kg of energy was obtain for waste collected from Evbuotubu, 65,599.30 KJ/kg for waste collected from Ekenwan, 68,638.31 KJ/kg for waste collected from Ikpoba Hill, 110,904.98 KJ/kg for waste collected from New Benin, 90,301.96 KJ/kg for waste collected from Ogbebuya, 89,513.86 KJ/kg for waste collected from Oko Central and 79,861.51 KJ/kg for waste collected from Ugbowo. With a coefficient of determination (R^2) value of 0.992832 and Adjusted R-Squared value of 0.990784, it was concluded that the regression model developed for predicting the energy value is valid.
Keywords: Waste characterization, Energy value, Least square regression, Dependent variables, Independent variables and Sustainable Waste Management
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1.0 Introduction

At present, municipal solid waste (MSW) generated in Nigerian cities are dumped into borough pits while some are disposed along road sides causing threat to health of the citizens. This is simply because the waste management system has not attained acceptable standards. Efforts have been made by researchers to develop techniques to manage municipal solid waste in Nigeria and other developing countries with a view to reducing health hazards associated with poor management of solid wastes (Ujile, 2008). The estimation of solid waste energy value and its subsequent conversion to heat and electricity remain one of the foremost ways to manage municipal solid waste (Tchobanoglous, 2009). Solid waste which is regarded as discarded, unwanted material which evolves from human activities of various kinds has increased globally in quantity due to the introduction of new products with new packaging materials; change in income; change in living standards; and life style (Kaushal *et al*., 2012). Ineffective solid waste management is a problem plaguing the environments of urban dwellings in Nigeria including Benin City. This is intrinsic to high volume of waste generated, lack of management funding and lack of expertise on the part of management personnel (Atikpo and Erameh, 2019). The menace of solid wastes managements is a common challenge faced in urban communities in the globe (Oyinloye, 2013). The current management level is considered ineffective in numerous African communities - rural and urban (World Health Organization - WHO, 1997; Atikpo and Erameh, 2019). Lack of good solid waste management system results in numerous problems - among which are health challenges, damage to environmental aesthetics, air quality degradation, flooding of highways and useful land mass, water contamination, and release of objectionable gases rendering ecosystems disharmonious and sickly (Iro *et al*., 2012; Remigios and Wiseman, 2012). Some diseases associated with poor solid waste management are cholera, typhoid fever, malaria and laser fever (Sincero and Sincero, 2016). The above enumerated problems associated with poor solid waste management are also the occurrences in all communities in Benin City. In the light of these, sustainable solid waste management system is a solution which is the engineering approach (Atikpo and

Erameh, 2019). The Engineering approach to this problem is a good solid waste survey to reveal the compositions of solid waste and their generation rates in some major communities in Benin City in order to form a bench mark data for wholesome solid waste management in the metropolis (Peavy *et al*., 2008; Sincero and Sincero, 2016). It is important to note that the absence of adequate information on solid waste compositions and their generation rates can results in inadequate computation of data needed for the design of disposal systems thereby resulting to acute underperformances of the management systems (Sincero and Sincero, 2016; Intharathirat *et al*., 2015).

An overview of the entire literatures reviewed in this study has shown that most researchers in the areas of solid waste management tend to lay emphasis on the issues of solid waste generation, composition, storage and disposal. It is often said and believed that the most important aspect of sustainable solid waste management practice is collection hence, the need for researchers to lay much emphasis on the collection process of solid waste management systems. In this study therefore, an attempt was made to study the present solid waste management systems of seven communities in Benin City with the hope of Re-Engineering the present practice in order to achieve a more sustainable result.

2.0 Research Methodology

2.1 Study Area Description

The study area includes selected communities in Benin City, namely; Ekenwan, Evbuotubu, Ogbebuya and Ugbowo. Others are; Ikpoba-Hill, New Benin and Oko-Central. The study area map is presented in Figure 2.1

Benin City lies between Latitude 6°20′17″ N and Longitude 5°37′32″ E with an elevation of 88 m above sea level. The city is influenced by two seasons, which are wet season (March to October) and dry season (October to March). Benin City has a borderline tropical savanna climate bordering upon a tropical monsoon climate. The weather is uncomfortably hot and humid year-round, and generally very dull, especially between July and September. It is one of the largest cities in Nigeria, located in southern part of the country, about 40 miles from the Gulf of Guinea. It is an important industrial and cultural center. Benin City is the fourth-largest city in Nigeria after Lagos, Kano and Ibadan, with a total population of 1,782,000 as of 2021 (Encyclopedia Britannica, 2020), with most of them taking their ethnic roots from local Edo culture. It is situated approximately 40 kilometers north of the Benin River and 320 kilometers by road east of Lagos. Benin City is the center of Nigeria's rubber industry, and oil production is also a significant industry (International Rubber Study Group – Nigeria, 2020). The Benin Region is underlain by sedimentary formation of the South Sedimentary Basin. The geology is generally marked by top reddish earth, composed of ferruginized or literalized clay sand.

The City has been experiencing rapid rural-urban migration and influx of displaced citizens from Northern Nigeria as a result of insurgency in recent times. Balogun and Onokerhoraye (2017) reported that population and spatial growth of Benin City are faster than the pace of infrastructure provision and that the lag between the growth of Benin City and infrastructure provision is impacting negatively on the quality of lives of the residents and threatens the sustainability of urban environment. Such a rapid growth leads to rapid increase in solid waste generation. With the exception of a few major streets swept daily within the urban agglomeration during week days, most neighborhoods in Benin City streets remain littered with solid wastes thus rendering the landscape insightful (Ogboi and Okosun, 2003).

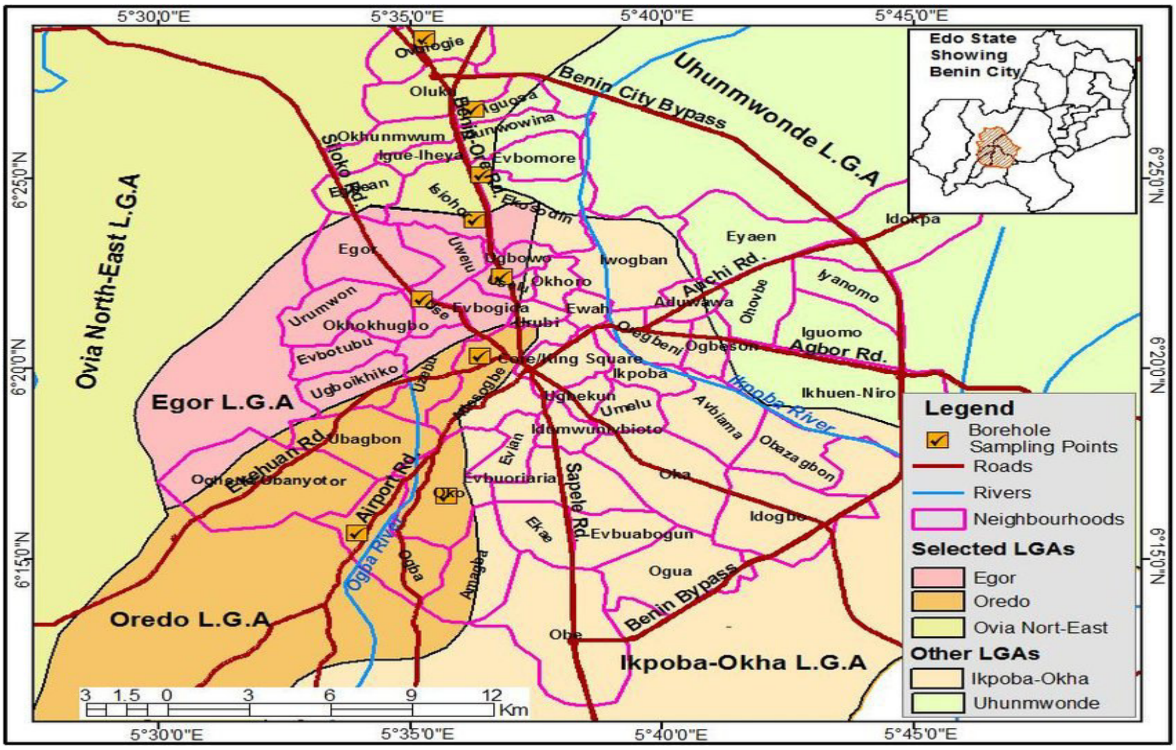

Figure 2.1: Map of study area

2.2. Materials/Equipment

2.2.1 Equipment for Data Collection

These include weighing scale, waste buckets, drums, dustbins, wheel barrows, bags, pencils, biros, notebooks, screening equipment, and a pick-up vehicle, hand gloves, face masks, hand trowels, hand forks, shovels, safety boots, helmets.

2.2.2 Household Survey

A survey questionnaire (400) per community was administered to 400 households in seven communities (Evbotubu, Oko central, New Benin, Ugbowo, Ikpoba-hill, Ogbebuya and Ekenwan) in Benin City. The questionnaire was aimed at acquiring information about residents' attitudes towards waste, socio-economic characterization, waste management behaviour (disposal and waste separation), problem faced with current management system, and how much they are willing to pay for waste management services, and whether they are aware of the possibility of converting waste to wealth.

The survey started from the first house in each street. Afterward, the alternate house was surveyed. The absence of respondent in a particular house made the next household to fall in line for survey. The door-to door questionnaire survey was conducted in one month (June, 2020), and respondents are targeted to be heads of households or their spouses. The oldest child or relative of over 16 years was targeted on the absent of the father or mother of any household. Microsoft Excel, 2016 version was applied to analyze the raw data from the questionnaire survey. The qualitative and the quantitative approach were applied for the questionnaire data analyses.

2.2.3 Descriptive Analysis of Solid Waste Data

Descriptive statistics of solid waste data which includes; mean ($\bar{X}$), standard deviation (S), and skewness coefficient (G) were computed using the following equations

$$\text{Mean } (\bar{X}), = \frac{1}{n}\sum_{i=1}^{n} X_i \tag{2.1}$$

$$\text{Standard Deviation (S)} = \left[\frac{1}{(n=1)}\sum\left(X_i - \bar{X}\right)^2\right]^{0.5} \tag{2.2}$$

Coefficient of Skewness (G) = $\frac{n\sum\left(X_i - \bar{X}\right)^3}{(n-1)(n-2)S^3}$ (2.3)

Where;
X_i is observed daily rainfall data
n is the no of observations
μ is the mean and
S is the standard deviation

2.2.4 Energy Value Estimation
The step by step methodology used to estimate the energy value of the solid waste is presented as follows;

(1).The wet weight of each solid waste component was estimated using

Wet weight (kg) = $\frac{percent \text{ by mass}}{100} \times 100kg$ (2.4)

Where; 100kg is the assumed weight of solid waste upon which the computation was done

(2).The dry weight of each solid waste component was estimated using

Dry weight (kg) = $x - (\frac{y}{100} * x)$ (2.5)

Where; x is the computed wet weight and y is the moisture content of the waste component

(3).The overall moisture content of the solid waste stream was computed using
Moisture content (%) = (Wet weight – Dry weight) (2.6)

(4). Using the computed dry weight of the organic component of the solid waste and the corresponding percent by mass of elemental composition, the chemical composition of each component of the waste was computed as follows;

Chemical composition = $\frac{percent \text{ by mass of element}}{100} \times Dry \text{ weight of the waste comp.}$
(2.7)

(5).The overall moisture content of the waste stream was then converted to hydrogen and oxygen and the values was added to the initial mass of hydrogen and oxygen in order to obtain the summary table of each elemental composition present in the solid waste stream.

(6).Finally, the energy value of the solid waste stream was estimated using the mass balance equation presented as follows;

KJ (kg) = $337C + 1428(H - \frac{O}{8}) + 9S$ (2.8)

Where;
C is the percent by mass of carbon;
H is the percent by mass of hydrogen and
S is the percent by mass of sulphur.

2.2.5 Development of Model for Energy Value Prediction
The model developed is a linear regression model. To develop the regression model, the input data were grouped into three viz; wet weight, moisture content and dry weight resulting to one dependent variable and twelve independent variables. The selected dependent and independent variables are presented in Table 2.1

Table 2.1: Selected dependent and independent variables

S/No	Variables	Variable Type	Symbol
1	Energy value (KJ/kg)	Dependent	Energy_Value
2	Wet weight of miscellaneous organic waste;	Independent	WW_{mo}
3	Wet weight of paper and cardboard waste	Independent	WW_{pc}
4	Wet weight of plastic waste	Independent	WW_p
5	Wet weight of textile waste	Independent	WW_T
6	Moisture content of miscellaneous organic waste	Independent	MC_{mo}
7	Moisture content of paper and cardboard waste	Independent	MC_{pc}
8	Moisture content of plastic waste	Independent	MC_p
9	Moisture content of textile waste	Independent	MC_T
10	Dry weight of miscellaneous organic waste	Independent	DW_{mo}
11	Dry weight of paper and cardboard waste	Independent	DW_{pc}
12	Dry weight of plastic waste	Independent	DW_p
13	Dry weight of textile waste	Independent	DW_T

To ascertain the dependence of the selected independent variables, on the dependent variable multiple linear regression models was applied to generate a regression equation of the form:

$$\hat{y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ---------- \beta_n x_n + \varepsilon \quad (2.9)$$

Where;

X_1, X_2 ---------- X_n are the selected independent variables; Y is the dependent variable, β_0 , β_1 are the regression constant while ξ is the deviation.

To diagnose the statistical properties of the regression model, Variance Inflation Factor (VIF) was employed

2.2.6 Validation of Regression Model

To validate the regression model, selected goodness of fit statistics, namely; coefficient of determination (R^2), correlation coefficient (r), Adjusted Coefficient of Determination (Adj. R^2) and error sum of square (SSE) were employed. The mathematical definition of the selected goodness of fit statistics is presented as follows;

$$\textit{Coefficient} \text{ of Determination } (R^2) = \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y}_i)^2} \quad (2.10)$$

$$\textit{Adjusted} \text{ Coefficient of Determination } (R^{-2}) = \frac{\sum (y_i - \hat{y})/(n-k)}{\sum (y_i - \bar{y})/(n-1)} \quad (2.11)$$

$$\text{Coefficient of Correlation } (r) = \frac{\left[(\sum x_3 y_1) - (n \bar{x}_3 \bar{y}_1\right]}{\sqrt{(\sum x_3^2 - n \bar{x}_3^2)(\sum y_1^2 - n \bar{y}_1^2)}} \quad (2.12)$$

$$\textit{Error} \text{ Sum of Squqre (SSE)} = \frac{1}{n-2}\left(\sum y_1^2 - n \bar{y}_1^2\right) - b\left(\sum x_3 y_1 - n \bar{x}_3 \bar{y}_1\right) \quad (2.13)$$

3.0 Results and Discussion

Result of solid waste characterization which was conducted in seven (7) different communities for a time frame of eight (8) weeks are presented in Tables 3.1 to 3.7

Table 3.1: Percent variation of total waste collected from Evbuotubu

S/N	Waste Components	Percentage of Waste Collected (%)							
		Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
1	Miscellaneous Organics	18.57	16.71	24.66	37.90	42.55	42.58	46.58	42.65
2	Paper & Cardboard	15.81	16.10	17.77	11.52	12.23	11.13	11.81	16.24
3	Plastics	22.08	22.07	13.19	8.79	7.88	8.63	6.72	8.80
4	Textile	7.76	7.84	4.46	5.68	5.51	1.41	2.63	2.36
5	Metals	20.24	19.00	11.90	3.95	4.06	10.61	8.59	5.55
6	Glass	3.68	5.37	3.11	0.95	0.58	2.17	0.70	0.77
7	Tin Cans	11.85	12.91	24.91	31.22	27.19	23.47	22.97	23.63
8	Total	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0

Table 3.2: Percent variation of total waste collected from Ekenwan

S/N	Waste Components	Percentage of Waste Collected (%)							
		Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
1	Miscellaneous Organics	61.53	64.71	65.48	62.38	62.77	80.19	61.23	49.91
2	Paper & Cardboard	10.13	7.31	3.70	6.19	4.90	2.59	7.53	11.76
3	Plastics	6.43	2.81	2.94	6.50	4.64	2.72	5.51	7.92
4	Textile	3.02	2.56	3.13	3.31	4.59	1.54	0.71	0.49
5	Metals	3.81	4.50	8.77	4.96	8.03	1.11	3.26	7.86
6	Glass	1.31	1.87	1.69	1.35	1.88	0.31	0.53	0.67
7	Tin Cans	13.77	16.24	14.29	15.32	13.19	11.54	21.22	21.39
8	Total	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0

Table 3.3: Percent variation of total waste collected from Ikpoba Hill

S/N	Waste Components	Percentage of Waste Collected (%)							
		Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
1	Miscellaneous Organics	68.47	74.10	69.79	65.97	58.08	64.03	55.03	52.26
2	Paper & Cardboard	9.45	9.31	8.29	5.59	6.42	6.02	8.43	9.78
3	Plastics	5.05	4.39	6.55	3.99	5.88	6.19	8.90	6.89
4	Textile	3.38	1.77	2.51	5.01	4.30	2.54	1.11	1.06
5	Metals	2.52	2.19	3.48	2.88	4.30	2.10	6.90	6.28
6	Glass	2.42	1.77	1.84	5.70	3.05	1.82	1.00	0.96
7	Tin Cans	8.70	6.47	7.53	10.86	17.96	17.29	18.64	22.76
8	Total	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0

Table 3.4: Percent variation of total waste collected from New Benin

S/N	Waste Components	Percentage of Waste Collected (%)							
		Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
1	Miscellaneous Organics	33.98	29.49	28.68	20.07	36.29	37.10	36.70	33.97
2	Paper & Cardboard	17.11	17.58	13.85	15.06	18.24	17.71	17.88	17.99
3	Plastics	18.14	13.09	12.53	17.47	14.81	14.63	14.74	12.64
4	Textile	14.47	18.28	15.52	14.53	2.52	3.93	4.03	8.07
5	Metals	13.67	16.76	18.31	22.09	18.33	13.97	15.74	21.22
6	Glass	2.26	4.71	9.40	6.59	1.00	1.96	2.34	3.29
7	Tin Cans	0.38	0.10	1.71	4.19	8.81	10.70	8.57	2.83
8	Total	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0

Table 3.5: Percent variation of total waste collected from Ogbebuya

S/N	Waste Components	Percentage of Waste Collected (%)							
		Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
1	Miscellaneous Organics	58.93	61.13	44.07	37.31	37.46	33.22	43.53	42.02
2	Paper & Cardboard	9.07	6.10	5.45	10.98	7.07	11.94	11.45	12.12
3	Plastics	7.90	7.10	14.97	17.44	24.47	14.39	9.63	16.55
4	Textile	2.95	0.87	1.78	2.22	1.77	2.86	1.30	1.24
5	Metals	4.67	5.70	10.97	7.54	4.96	9.96	9.82	5.99
6	Glass	4.12	5.63	7.36	7.41	8.02	9.07	1.50	1.24
7	Tin Cans	12.36	13.47	15.41	17.10	16.25	18.55	22.77	20.85
8	Total	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0

Table 3.6: Percent variation of total waste collected from Oko Central

S/N	Waste Components	Percentage of Waste Collected (%)							
		Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
1	Miscellaneous Organics	37.00	35.87	35.92	37.58	37.00	35.10	42.05	43.31
2	Paper & Cardboard	8.12	6.41	6.73	6.09	4.93	4.50	12.82	10.71
3	Plastics	6.43	12.19	13.88	6.86	12.47	14.55	7.24	7.30
4	Textile	7.95	4.51	4.15	6.72	3.38	4.25	3.01	0.80
5	Metals	5.49	6.29	9.80	10.05	9.94	7.43	8.27	8.63
6	Glass	3.04	2.86	3.47	4.03	6.27	9.06	0.58	0.60
7	Tin Cans	31.97	31.87	26.05	28.66	26.00	25.11	26.03	28.65
8	Total	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0

Table 3.7: Percent variation of total waste collected from Ugbowo

S/N	Waste Components	Percentage of Waste Collected (%)							
		Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8
1	Miscellaneous Organics	59.64	53.74	61.18	40.94	43.96	45.79	47.84	44.12
2	Paper & Cardboard	15.17	22.79	9.78	9.36	13.40	9.67	10.22	13.74
3	Plastics	7.46	9.85	6.60	9.02	7.80	7.56	7.15	9.64
4	Textile	2.56	1.75	4.85	4.14	1.98	3.25	1.72	1.07
5	Metals	4.27	2.02	4.17	3.41	6.44	3.37	2.00	6.32
6	Glass	2.11	1.84	3.73	2.29	0.75	2.07	1.88	1.22
7	Tin Cans	8.79	8.02	9.69	30.85	25.66	28.28	29.19	23.89
8	Total	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0

It was observed from the results of tables 3.1 to 3.7 that the solid waste around the study area composed mainly of organics, paper and cardboard, plastics, textile, metals, glass and tin cans with organics (comprising of agricultural produce and food waste constituting the main components of the waste). The descriptive statistics of the waste composition which was done in order to estimate the mean±std is presented in Table 3.8

Table 3.8: Mean±std of solid waste composition

Solid Waste Composition	Computed mean±std.						
	Evbuotubu	Ekenwan	Ikpoba Hill	New Benin	Ogbebuya	Oko Central	Ugbowo
Miscellaneous Organics	57.55±20.61	106.69±14.11	119.55±14.13	66.15±12.23	67.14±14.94	58.09±5.57	119.49±21.02
Paper & Cardboard	23.78±4.39	11.39±5.25	14.96±3.70	34.95±3.44	13.91±4.11	11.59±4.63	31.24±10.42
Plastics	20.74±10.77	8.34±3.39	11.30±3.09	30.53±4.91	21.11±8.55	15.44±5.29	19.54±2.98
Textile	8.03±4.22	4.14±2.62	5.08±2.65	21.02±13.00	2.80±1.08	6.73±3.66	6.34±2.94
Metals	17.63±10.73	8.95±4.70	7.28±3.65	36.06±5.87	11.25±3.96	12.46±1.93	9.64±4.16
Glass	3.63±2.92	2.04±1.10	4.35±2.85	8.11±5.78	8.29±4.44	5.71±4.40	4.75±1.94
Tin Cans	37.73±11.95	26.61±5.91	26.00±11.78	9.66±8.74	25.74±5.66	43.03±6.19	49.51±24.16

Result of Table 3.8 shows the level of variability that exists between the compositions of the solid waste from location to location. The mean±std. of plastic waste from Evbuotubu was 20.74±10.77. For plastic waste collected from Ekenwan, the mean±std was 8.34±3.39. For plastic waste collected from Ikpoba Hill, the mean±std was 11.30±3.09. For plastic waste collected from New Benin, the mean±std was 30.53±4.91. For plastic waste collected from Ogbebuya, the mean±std was 21.11±8.55. For plastic waste collected from Oko

Central, the mean±std was 15.44±5.29 while for plastic waste collected from Ugbowo, the mean±std was 19.54±2.98.

Estimation of the energy value of solid waste is one out of the numerous techniques employed to determine the economic value of solid waste. The conversion of MSW into energy for power generation has so far not been successful in Nigeria. However, with the persistent power problem affecting all sectors of the economy, there are urgent needs for complimentary energy sources and one of them is energy generation from municipal solid waste materials (MSW). The estimated energy value of the solid waste from the seven communities in week 1 is presented in Tables 3.9, 3.10, 3.11, 3.12, 3.13, 3.14 and 3.15 respectively while the computed energy value for the different community on weekly bases is presented in Table 3.16.

Table 3.9: Computed Energy Value for Evbuotubu (Week 1)

Composition	Wet Weight (Kg)	Dry Weight (Kg)	Elemental Composition					
			Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash
Miscellaneous Organics	18.57	5.571	2.701935	0.362115	2.089125	0.122562	0.016713	0.27855
Paper & Cardboard	15.81	14.8614	6.464709	0.891684	6.539016	0.0445842	0.0297228	0.891684
Plastics	22.08	21.6384	12.98304	1.5579648	4.9335552	0	0	2.16384
Textile	7.76	7.6048	4.18264	0.5019168	2.3726976	0.3498208	0.0114072	0.19012
Metals	20.24	19.8352						
Glass	3.68	3.6064						
Tin Cans	11.85	11.4945						
Elemental Sum without Moisture			26.332324	3.3136806	15.9343938	0.516967	0.057843	3.524194
Elemental Sum with Moisture			26.332324	5.0223806	29.6039938	0.516967	0.057843	3.524194
Percentage Composition of Each Elements			40.475337	7.71988622	45.5042104	0.79462843	0.0889103	5.41702807
Computed Energy Value (KJ/Kg) = 16,542.48								

Table 3.10: Computed Energy Value for Ekenwan (Week 1)

Composition	Wet Weight (Kg)	Dry Weight (Kg)	Elemental Composition					
			Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash
Miscellaneous Organics	61.53	18.459	8.952615	1.199835	6.922125	0.406098	0.055377	0.92295
Paper & Cardboard	10.13	9.5222	4.142157	0.571332	4.189768	0.0285666	0.0190444	0.571332
Plastics	6.43	6.3014	3.78084	0.4537008	1.4367192	0	0	0.63014
Textile	3.02	2.9596	1.62778	0.1953336	0.9233952	0.1361416	0.0044394	0.07399
Metals	3.81	3.7338						
Glass	1.31	1.2838						
Tin Cans	13.77	13.3569						
Elemental Sum without Moisture			18.503392	2.4202014	13.4720074	0.5708062	0.0788608	2.198412
Elemental Sum with Moisture			18.503392	7.35167918	52.9238296	0.5708062	0.0788608	2.198412
Percentage Composition of Each Elements			22.668231	9.00643292	64.8361972	0.69928619	0.09661119	2.69324187
Computed Energy Value (KJ/Kg) = 8,927.988								

Table 3.11: Computed Energy Value for Ikpoba Hill (Week 1)

Composition	Wet Weight (Kg)	Dry Weight (Kg)	Elemental Composition					
			Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash
Miscellaneous Organics	68.47	20.541	9.962385	1.335165	7.702875	0.451902	0.061623	1.02705
Paper & Cardboard	9.45	8.883	3.864105	0.53298	3.90852	0.026649	0.017766	0.53298
Plastics	5.05	4.949	2.9694	0.356328	1.128372	0	0	0.4949
Textile	3.38	3.3124	1.82182	0.2186184	1.0334688	0.1523704	0.0049686	0.08281
Metals	2.52	2.4696						
Glass	2.42	2.3716						
Tin Cans	8.70	8.439						
Elemental Sum without Moisture			18.61771	2.4430914	13.7732358	0.6309214	0.0843576	2.13774
Elemental Sum with Moisture			18.61771	7.89024696	57.3504802	0.6309214	0.0843576	2.13774
Percentage Composition of Each Elements			21.470877	9.09942850	66.1394500	0.7276102	0.09728541	2.46534898
Computed Energy Value (KJ/Kg) = 8,424.653								

Table 3.12: Computed Energy Value for New Benin (Week 1)

Composition	Wet Weight (Kg)	Dry Weight (Kg)	Elemental Composition					
			Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash
Miscellaneous Organics	33.98	10.194	4.94409	0.66261	3.82275	0.224268	0.030582	0.5097
Paper & Cardboard	17.11	16.0834	6.996279	0.965004	7.076696	0.0482502	0.0321668	0.965004
Plastics	18.14	17.7772	10.66632	1.2799584	4.0532016	0	0	1.77772
Textile	14.47	14.1806	7.79933	0.9359196	4.4243472	0.6523076	0.0212709	0.354515
Metals	13.67	13.3966						
Glass	2.26	2.2148						
Tin Cans	0.38	0.3686						
Elemental Sum without Moisture			30.406019	3.843492	19.3769948	0.9248258	0.0840197	3.606939
Elemental Sum with Moisture			30.406019	6.70958089	42.3057059	0.9248258	0.0840197	3.606939
Percentage Composition of Each Elements			36.181666	7.98407092	50.3417071	1.10049717	0.09997931	4.29207983
Computed Energy Value (KJ/Kg) = 14,609.38								

Table 3.13: Computed Energy Value for Ogbebuya (Week 1)

Composition	Wet Weight (Kg)	Dry Weight (Kg)	Elemental Composition					
			Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash
Miscellaneous Organics	58.93	17.679	8.574315	1.149135	6.629625	0.388938	0.053037	0.88395
Paper & Cardboard	9.07	8.5258	3.708723	0.511548	3.751352	0.0255774	0.0170516	0.511548
Plastics	7.90	7.742	4.6452	0.557424	1.765176	0	0	0.7742
Textile	2.95	2.891	1.59005	0.190806	0.901992	0.132986	0.0043365	0.072275
Metals	4.67	4.5766						
Glass	4.12	4.0376						
Tin Cans	12.36	11.9892						
Elemental Sum without Moisture			18.518288	2.408913	13.048145	0.5475014	0.0744251	2.241973
Elemental Sum with Moisture			18.518288	7.13766856	50.8781894	0.5475014	0.0744251	2.241973
Percentage Composition of Each Elements			23.323355	8.98972829	64.0799016	0.68956534	0.09373669	2.82371309
Computed Energy Value (KJ/Kg) = 9,259.884								

Table 3.14: Computed Energy Value for Oko Central (Week 1)

Composition	Wet Weight (Kg)	Dry Weight (Kg)	Elemental Composition					
			Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash
Miscellaneous Organics	37.00	11.1	5.3835	0.7215	4.1625	0.2442	0.0333	0.555
Paper & Cardboard	8.12	7.6328	3.320268	0.457968	3.358432	0.0228984	0.0152656	0.457968
Plastics	6.43	6.3014	3.78084	0.4537008	1.4367192	0	0	0.63014
Textile	7.95	7.791	4.28505	0.514206	2.430792	0.358386	0.0116865	0.194775
Metals	5.49	5.3802						
Glass	3.04	2.9792						
Tin Cans	31.97	31.0109						
Elemental Sum without Moisture			16.769658	2.1473748	11.3884432	0.6254844	0.0602521	1.837883
Elemental Sum with Moisture			16.769658	5.23676369	36.1035543	0.6254844	0.0602521	1.837883
Percentage Composition of Each Elements			27.657370	8.63673620	59.5438123	1.03158058	0.09937082	3.03112983
Computed Energy Value (KJ/Kg) = 11,026.12								

Table 3.15: Computed Energy Value for Ugbowo (Week 1)

Composition	Wet Weight (Kg)	Dry Weight (Kg)	Elemental Composition					
			Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash
Miscellaneous Organics	59.64	17.892	8.67762	1.16298	6.7095	0.393624	0.053676	0.8946
Paper & Cardboard	15.17	14.2598	6.203013	0.855588	6.274312	0.0427794	0.0285196	0.855588
Plastics	7.46	7.3108	4.38648	0.5263776	1.6668624	0	0	0.73108
Textile	2.56	2.5088	1.37984	0.1655808	0.7827456	0.1154048	0.0037632	0.06272
Metals	4.27	4.1846						
Glass	2.11	2.0678						
Tin Cans	8.79	8.5263						
Elemental Sum without Moisture			20.646953	2.7105264	15.43342	0.5518082	0.0859588	2.543988
Elemental Sum with Moisture			20.646953	7.51607084	53.8777756	0.5518082	0.0859588	2.543988
Percentage Composition of Each Elements			24.227099	8.81934471	63.2200900	0.64749080	0.10086391	2.98511118
Computed Energy Value (KJ/Kg) = 9,474.678								

Table 3.16: Computed Weekly Energy Value (KJ/Kg)

Study Areas	Energy Value (KJ/Kg)								Total Energy Value per Study Area (KJ/Kg)
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	
Evbuotubu	16542.5	16845.3	13683.10	11306.84	10762.7	10156.4	9721.81	10675.22	**99,693.86**
Ekenwan	8927.99	7720.04	7514.67	8672.26	8365.66	6831.91	8124.44	9442.33	**65,599.30**
Ikpoba Hill	8424.65	7880.83	8471.25	8251.14	8881.61	8400.47	9291.81	9036.55	**68,638.31**
New Benin	14609.4	14728.6	14442.84	16260.37	12531.6	12591.5	12669.1	13071.59	**110,904.98**
Ogbebuya	9259.88	8419.01	11265.97	12668.18	13810.1	12577.8	10337.3	11963.79	**90,301.96**
Oko Central	11026.1	11828.3	12180.99	10731.38	11524.3	12349.0	10256.5	9617.207	**89,513.86**
Ugbowo	9474.68	10494.3	9247.76	10733.67	10122.5	9921.66	9463.48	10403.49	**79,861.51**
Weekly Total Energy Value (KJ/Kg)	**78,265.2**	**77,916.4**	**76,806.58**	**78,623.84**	**75,998.4**	**72,828.7**	**69,864.5**	**74,210.18**	

On the community with the highest waste energy value, Figure 3.1 revealed that the solid waste from New Benin has the highest.

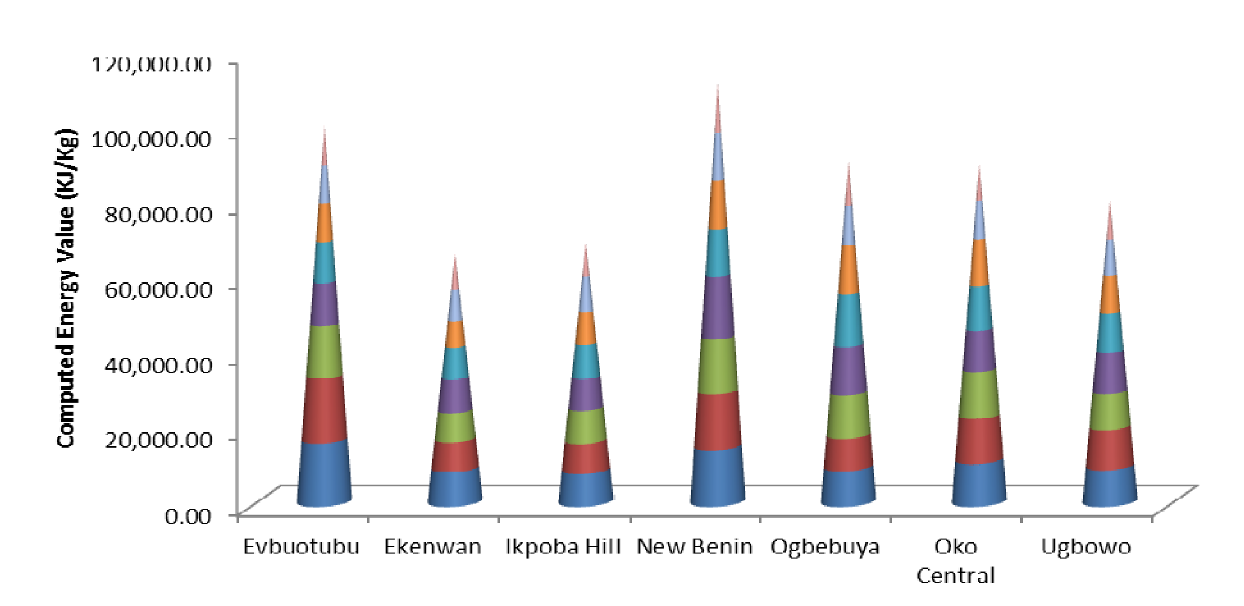

Figure 3.1: Computed energy value of solid waste per communities

It was observed from the plot of Figure 3.1 that there is a high degree of untapped energy that is constantly being wasted owing to inadequate management of municipal solid waste especially in Nigeria. It will suffix to say that; at present, municipal solid waste (MSW) generated in Nigerian cities are dumped into borough pits while some are disposed along road sides, causing threat to health of the citizens. This is simply because of the fact that the waste management system has not attained acceptable standards. Efforts have been made by researchers to develop techniques to manage municipal solid waste in Nigeria and other developing countries with a view to reducing health hazards associated with poor management of solid wastes. The estimation of solid waste energy value and its subsequent conversion to heat and electricity remain one of the foremost ways to manage municipal solid waste. During the process of incineration, waste material is converted to gases, particles and heat which are later used for the generation of electricity (Ujile, 2008; Troschinetz and Mihelcic 2009; Eze, 2010). In the recent time municipal solid waste (MSW) has also been given a good attention as to the gasification and combustion of same in a fluidized bed in order to eliminate the environmental menace and gainfully generate energy in the form of process heat and power generation (Choi et al., 2008). In developed countries, MSW has been established as one of the sources of energy generation. In United States of America for example, the use of wheelabrator has helped in the conversion of over 100 million tons of MSW to energy. In Nigeria over 250 million tons of solid waste is generated annually and more than 70% of the waste ends in one dumpsite or the other. Therefore, knowledge of the amount of energy hidden in municipal solid waste materials can serve as motivation to government and other concern authorities in order to formulate adequate policies that can drive the need for alternative source of energy which is cheap, clean and environmentally friendly.

Several mathematical models are available in the literature for the prediction of energy values of municipal solid waste materials. Most often, the model to be selected usually depends on the nature of data at ones disposal since most of the predictive models for energy value are data driven model. In this study, the input data required were grouped into three viz; wet weight, moisture content and dry weight. Tables 3.17, 3.18 and 3.19 shows the input and target variables employed for model development.

Table 3.17: Input data for energy value prediction

Communities used for Waste Survey	Duration (week)	Wet Weight (kg)				Moisture Content (%)				Dry Weight (kg)				Energy Value (KJ/Kg)
		WW_{mo}	WW_{pc}	WW_p	WW_T	MC_{mo}	MC_{pc}	MC_p	MC_T	DW_{mo}	DW_{pc}	DW_p	DW_T	
	1	18.57	15.81	22.08	7.76	70.2	6.5	2.6	2.5	5.571	14.86	21.6	7.60	16542.5
	2	16.71	16.10	22.07	7.84	70.1	6.2	2.2	2.2	5.013	15.13	21.6	7.68	16845.3
	3	24.66	17.77	13.19	4.46	70.3	6.3	2.1	2.2	7.398	16.70	12.9	4.37	13683.1
Evbuotubu	4	37.9	11.52	8.79	5.68	70.4	6.1	2.2	2.1	11.37	10.83	8.61	5.57	11306.84
	5	42.55	12.23	7.88	5.51	70.1	6.4	2.3	2.5	12.77	11.50	7.72	5.40	10762.7
	6	42.58	11.13	8.63	1.41	70.2	6.5	2.4	2.3	12.77	10.46	8.46	1.38	10156.4
	7	46.58	11.81	6.72	2.63	70.1	6.1	2.2	2.4	13.97	11.10	6.59	2.58	9721.81
	8	42.65	16.24	8.8	2.36	70.3	6.2	2.1	2.3	12.80	15.27	8.62	2.31	10675.22
Ekenwan	1	61.53	10.13	6.43	3.02	70.1	6.4	2.3	2.5	18.46	9.522	6.30	2.96	8927.99
	2	64.71	7.31	2.81	2.56	70.2	6.5	2.4	2.3	19.41	6.871	2.75	2.51	7720.04
	3	65.48	3.7	2.94	3.13	70.1	6.1	2.2	2.4	19.64	3.478	2.88	3.07	7514.67
	4	62.38	6.19	6.5	3.31	70.3	6.2	2.1	2.3	18.71	5.819	6.37	3.24	8672.26
	5	62.77	4.9	4.64	4.59	70.1	6.4	2.3	2.5	18.83	4.606	4.55	4.50	8365.66
	6	80.19	2.59	2.72	1.54	70.2	6.5	2.4	2.3	24.06	2.435	2.67	1.51	6831.91
	7	61.23	7.53	5.51	0.71	70.1	6.1	2.2	2.4	18.37	7.078	5.40	0.70	8124.44
	8	49.91	11.76	7.92	0.49	70.3	6..1	2.4	2.2	14.97	11.05	7.76	0.48	9442.33
	1	68.47	9.45	5.05	3.38	70.2	6.5	2.4	2.3	20.54	8.883	4.95	3.31	8424.65
	2	74.1	9.31	4.39	1.77	70.1	6.1	2.2	2.4	22.23	8.751	4.30	1.74	7880.83
	3	69.79	8.29	6.55	2.51	70.2	6.5	2.6	2.5	20.94	7.793	6.42	2.46	8471.25
Ikpoba Hill	4	65.97	5.59	3.99	5.01	70.1	6.2	2.2	2.2	19.79	5.255	3.91	4.91	8251.14
	5	58.08	6.42	5.88	4.3	70.3	6.3	2.1	2.2	17.42	6.035	5.76	4.21	8881.61
	6	64.03	6.02	6.19	2.54	70.4	6.1	2.2	2.1	19.21	5.659	6.07	2.49	8400.47
	7	55.03	8.43	8.9	1.11	70.1	6.4	2.3	2.5	16.51	7.924	8.72	1.09	9291.81
	8	52.26	9.78	6.89	1.06	70.2	6.5	2.4	2.3	15.68	9.193	6.75	1.04	9036.55

Table 3.18: Input data for energy value prediction

Communities used for Waste Survey	Duration (week)	Wet Weight (kg)				Moisture Content (%)				Dry Weight (kg)				Energy Value (KJ/Kg)
		WW_{mo}	WW_{pc}	WW_p	WW_T	MC_{mo}	MC_{pc}	MC_p	MC_T	DW_{mo}	DW_{pc}	DW_p	DW_T	
	1	33.98	17.11	18.14	14.47	70.2	6.5	2.4	2.3	10.194	16.08	17.8	14.18	14609.4
	2	29.49	17.58	13.09	18.28	70.1	6.1	2.2	2.4	8.847	16.53	12.8	17.91	14728.6
	3	28.68	13.85	12.53	15.52	70.2	6.5	2.6	2.5	8.604	13.02	12.3	15.21	14442.84
New Benin	4	20.07	15.06	17.47	14.53	70.1	6.2	2.2	2.2	6.021	14.16	17.1	14.24	16260.37
	5	36.29	18.24	14.81	2.52	70.1	6.1	2.2	2.4	10.887	17.15	14.5	2.470	12531.6
	6	37.1	17.71	14.63	3.93	70.2	6.5	2.6	2.5	11.13	16.65	14.3	3.851	12591.5
	7	36.7	17.88	14.74	4.03	70.2	6.5	2.4	2.3	11.01	16.81	14.4	3.949	12669.1
	8	33.97	17.99	12.64	8.07	70.1	6.1	2.2	2.4	10.191	16.91	12.4	7.909	13071.59
	1	58.93	9.07	7.9	2.95	70.1	6.1	2.2	2.4	17.679	8.526	7.74	2.891	9259.88
	2	61.13	6.10	7.10	0.87	70.3	6.2	2.1	2.3	18.339	5.734	6.96	0.853	8419.01
	3	44.07	5.45	14.97	1.78	70.1	6.4	2.3	2.5	13.221	5.123	14.7	1.744	11265.97
Ogbebuya	4	37.31	10.98	17.44	2.22	70.2	6.5	2.4	2.3	11.193	10.32	17.1	2.176	12668.18
	5	37.46	7.07	24.47	1.77	70.1	6.1	2.2	2.4	11.238	6.646	24.0	1.735	13810.1
	6	33.22	11.94	14.39	2.86	70.2	6.5	2.6	2.5	9.966	11.22	14.1	2.803	12577.8
	7	43.53	11.45	9.63	1.30	70.2	6.5	2.4	2.3	13.059	10.76	9.44	1.274	10337.3
	8	42.02	12.12	16.55	1.24	70.1	6.1	2.2	2.4	12.606	11.39	16.2	1.215	11963.79
	1	37.00	8.12	6.43	7.95	70.3	6.2	2.1	2.3	11.1	7.633	6.30	7.791	11026.1
	2	35.87	6.41	12.19	4.51	70.1	6.4	2.3	2.5	10.761	6.025	11.9	4.420	11828.3
	3	35.92	6.73	13.88	4.15	70.2	6.5	2.4	2.3	10.776	6.326	13.6	4.067	12180.99
Oko Central	4	37.58	6.09	6.86	6.72	70.4	6.3	2.6	2.1	11.274	5.725	6.72	6.586	10731.38
	5	37.00	4.93	12.47	3.38	70.2	6.5	2.4	2.3	11.1	4.634	12.2	3.312	11524.3
	6	35.1	4.50	14.55	4.25	70.1	6.1	2.2	2.4	10.53	4.23	14.3	4.165	12349
	7	42.05	12.82	7.24	3.01	70.2	6.5	2.4	2.3	12.615	12.05	7.10	2.950	10256.5
	8	43.31	10.71	7.30	0.80	70.4	6.3	2.6	2.1	12.993	10.07	7.15	0.784	9617.207

Table 3.19: Input data for energy value prediction

Communities used for Waste Survey	Duration (week)	Wet Weight (kg)				Moisture Content (%)				Dry Weight (kg)				Energy Value (KJ/Kg)
		WW_{mo}	WW_{pc}	WW_p	WW_T	MC_{mo}	MC_{pc}	MC_p	MC_T	DW_{mo}	DW_{pc}	DW_p	DW_T	
	1	59.64	15.17	7.46	2.56	70.2	6.5	2.6	2.5	17.892	14.26	7.311	2.51	9474.68
	2	53.74	22.79	9.85	1.75	70.1	6.2	2.2	2.2	16.122	21.42	9.653	1.72	10494.3
	3	61.18	9.78	6.6	4.85	70.3	6.3	2.1	2.2	18.354	9.193	6.468	4.75	9247.76
Ugbowo	4	40.94	9.36	9.02	4.14	70.4	6.1	2.2	2.1	12.282	8.799	8.840	4.06	10733.67
	5	43.96	13.4	7.8	1.98	70.1	6.4	2.3	2.5	13.188	12.60	7.644	1.94	10122.5
	6	45.79	9.67	7.56	3.25	70.2	6.5	2.4	2.3	13.737	9.090	7.409	3.19	9921.66
	7	47.84	10.22	7.15	1.72	70.1	6.1	2.2	2.4	14.352	9.607	7.007	1.69	9463.48
	8	44.12	13.74	9.64	1.07	70.3	6.2	2.1	2.3	13.236	12.92	9.447	1.05	10403.49

Variance inflation factor (VIF) measures the correlation of the dependent variable with the independent variables. Ideal VIF is 1; VIF greater than 10 is cause for alarm showing the variables are uncorrelated due to multicollinearity. Result of the calculated VIF for the selected variables is presented in Table 3.20

Table 3.20: Result of variance inflation factor

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	1.40E+09	1475998.	NA
WWMO	34967121	87030240	7.726858
WWPC	2.70E+08	38831940	5.862112
WWP	4430736.	591465.1	1.182783
WWT	3.12E+08	10383928	4.603260
MCMO	274729.7	1424467.	2.657108
MCPC	94186.73	3950.551	2.727599
MCP	102706.8	576.2739	2.671328
MCT	156724.2	904.2190	2.488516
DWMO	3.88E+08	87014857	7.725227
DWPC	3.06E+08	38831984	5.862338
DWP	4608102.	590312.5	1.17985
DWT	3.25E+08	10387088	4.603241

Since the computed variance inflation factors (centered VIF) for the selected independent variables is less than 10, it was concluded that the variables are well correlated with the dependent variable, hence absence of multicollinearity. Finally, the dependence of the dependent variable on the selected independent variables was evaluated using the coded least square regression equation presented as follows;

$$\text{Energy\_Value (KJ/kg)} = C\ WW_{mo}\ WW_{pc}\ WW_{p}\ WW_{T}\ MC_{mo}\ MC_{pc}\ MC_{p}\ MC_{T}\ DW_{mo}\ DW_{pc}\ DW_{p}\ DW_{T} \quad (3.1)$$

The coded regression equation was implemented using EVIEWS statistical software and results obtained is presented in Table 3.21

Table 3.21: Output of Regression Analysis

Dependent Variable: ENERGY_VALUE
Method: Least Squares
Date: 03/11/22 Time: 22:35
Sample: 1 56
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	40926.17	3.744991	1.092824	0.0020
WWMO	-10196.64	5.913300	-1.724356	0.0420
WWPC	32976.32	1.643594	2.006354	0.0513
WWP	5413.434	2.104931	2.571787	0.0137
WWT	17063.75	1.767513	0.965410	0.0399
MCMO	-417.4939	5.241467	-0.796521	0.0302
MCPC	-202.8531	3.068986	-0.660978	0.0122
MCP	179.3176	3.204790	0.559530	0.0788
MCT	-245.2410	3.958841	-0.619477	0.0389
DWMO	33793.84	1.970940	1.714606	0.0438
DWPC	-35038.68	1.748467	-2.003966	0.0516
DWP	-5296.278	2.146649	-2.467231	0.0178
DWT	-17248.30	1.803942	-0.956145	0.0445

R-squared	0.992832	Mean dependent var	10819.48
Adjusted R-squared	0.990784	S.D. dependent var	2381.328
S.E. of regression	2.286069	Akaike info criterion	13.90495
Sum squared resid	2.194966.	Schwarz criterion	14.37941
Log likelihood	-369.3861	Hannan-Quinn criter.	14.08843
F-statistic	484.7838	Durbin-Watson stat	1.207474
Prob(F-statistic)	0.000000		

From the result of Table 3.21, the following observations were made

i. With a regression (p-value) of 0.0020, coefficient of determination (R^2) value of 0.992832, Adjusted-R^2 value of 0.990784 and regression error sum of square value of 2.286069, it was concluded that the regression analysis was significant at 0.05 degree of freedom
ii. More than 95% of the independent variables were observed to be strongly correlated with the dependent variable.

Using the result of Table 3.21, the overall regression equation was thereafter generated and presented as follows;

Energy_Value (KJ/kg) = $40926.17C - 10196.64WW_{mo} + 32976.32WW_{pc} + 5413.434WW_p + 17063.75WW_T - 417.4939MC_{mo} - 202.8531MC_{pc} + 179.3176MC_p - 245.2410MC_T + 33793.84DW_{mo} - 35038.68DW_{pc} - 5296.278DW_p - 17248.30DW_T$
(3.2)

Where;
C is the constant of regression;
WW_{mo} is the wet weight of miscellaneous organic waste;
WW_{pc} is the wet weight of paper and cardboard waste;
WW_p is the wet weight of plastic waste;
WW_T is the wet weight of textile waste;
MC_{mo} is the moisture content of miscellaneous organic waste;
MC_{pc} is the moisture content of paper and cardboard waste;
MC_p is the moisture content of plastic waste;
MC_T is the moisture content of textile waste;
DW_{mo} is the dry weight of miscellaneous organic waste;
DW_{pc} is the dry weight of paper and cardboard waste;
DW_p is the dry weight of plastic waste; and
DW_T is the dry weight of textile waste;

When you develop regression equation, it is important that we conduct the hypothesis test of constant return to scale using the Wald Coefficient Restriction test. The test is normally employed to determine whether the difference between the coefficients estimates of all the independent variables is statistically significant. To test the hypothesis of constant return to scale, a restriction equation of twelve (12) independent variables was written as follows;

$C(2)+C(3)+C(4)+C(5)+C(6)+C(7)+C(8)+C(9)+C(10)+C(11)+C(12)+C(13) = 1$

The equation was implemented using Eviews statistical software and result obtained is presented as in Table 3.22

Table 3.22: Result of Wald Test:

Test Statistic	Value	Df	Probability
t-statistic	1.562707	42	0.1256
F-statistic	2.442054	(1, 42)	0.1256
Chi-square	2.442054	1	0.1281

Null Hypothesis: C(2)+C(3)+C(4)+C(5)+C(6)+C(7)+C(8)
+C(9)+C(10)+C(11)+C(12)+C(13) = 1
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-1 + C(2) + C(3) + C(4) + C(5) + C(6) + C(7) + C(8) + C(9) + C(10) + C(11) + C(12) + C(13)	20780.18	1.1329755

From the result of Table 3.22, it was observed that the restrictions are linear in coefficients. In addition, F-statistical value of 0.1256 and chi-square value of 0.1281 shows a strong similarity between both of them. In addition, standard error value of 1.1329755 and a p-value greater than 0.05 shows that we decisively accept the null hypothesis of constant return to scale and conclude that the restrictions are linear in coefficient. Hence, the regression equation is valid.

4.0 Conclusion

The outcome of the energy value computation and analysis revealed that there is a high degree of untapped energy that is constantly being wasted owing to inadequate management of municipal solid waste especially in Nigeria. It will suffix to say that; at present, municipal solid waste (MSW) generated in Nigerian cities are dumped into borough pits while some are disposed along road sides, causing threat to health of the citizens. This is simply because of the fact that the waste management system has not attained acceptable standards. In addition, the conversion of MSW into energy for power generation has so far not been successful in Nigeria. However, with the persistent power problem affecting all sectors of the economy, there are urgent needs for complimentary energy sources. This study has therefore considered municipal solid waste generation potentials as one of the best option for alternative source of energy. On the validity of the regression model developed for the prediction of the energy value of solid waste materials, it was observed based on the Wald test statistics that the F-statistical value of 0.1256 and chi-square value of 0.1281 shows a strong similarity between both the dependent variable (energy value) and independent variables (wet weight, moisture content and dry weight). In addition, standard error value of 1.1329755 and a p-value greater than 0.05 shows that we decisively accept the null hypothesis of constant return to scale and conclude that the restrictions are linear in coefficient thus given credence to the ability of linear regression to established a valid relationship between energy value and the other variables

5.0 References

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