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# Alternative Source of Cooking Gas – Conversion of Crop Waste to Energy

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***Abstract: -*** The research is aimed to reduce the total dependence on cooking gas refined from petroleum product for rural dwellers due to the difficult terrain and challenges of transportation system encountered. Study was carried out in Igbedi Community of Kolokuma/Opokuma Local Government Area in Bayelsa State, Nigeria; to procure an alternative source of cooking gas for indigenes.

The sample used for this research work is waste materials collected from arable crops predominantly cultivated by indigenes of this community. They are such as waste from cassava, sugar cane and grains (maize). Study unveils at the end of test duration that high performance rate recovered for average energy and moisture content, density, pressure and temperature for domestic cooking gas as obtained from cassava piles waste is 7.2391KJ/Kg, 45.56%, 842.4kgm-3, 6098Nm-2 and 3.37℃ respectively with the support of using Waste Transformation Techniques. Hence, waste from cassava piles satisfying the real properties of cooking gas from petroleum product as revealed in the review literature is the major source of alternative cooking gas from crop waste.

Therefore, to maintain sustainability this reliable and effective proven gas from crop wastes is aided with the provision of a larger waste disposal tank for waste collection at an affordable rate, design to recover at least a good quantity of cooking gas for every home. Thus, a consistent follow up with the lay down procedure to convert waste to energy will give rise to the availability of the gas.

***Keywords: -*** *Crop waste, cooking gas, moisture and Energy content, biogas.*

## I. INTRODUCTION

The usefulness of energy has led to its conversion from household domestic non-recyclable waste materials into useable biogas for cooking, electricity, heat supply, etc. This process is often called Waste – to – Energy (Marie, 2007). Such unwanted wastes are substances derived from human activities which are as follows; garbage, paper refuse, plastic/rubber and glass waste, textiles and leather waste, plant/food crop refuse, etc (Marie, 2007; Nolan, 2001). These heterogeneous mass of throwaways from residences and commercial activities is traceable to ancient time and has caused lots of epidemic of plagues in the world (Alaa et al., 2012).

Research reveals that biomass can be derived from the cultivation of dedicated energy crops such as Short Rotation Coppice (SRC), Perennial grasses and other plant residues; and biomass waste like organic industrial waste and organic domestic waste (Peter, 2001; Abdulkareem, 2005). Similar studies unveils Biomethanisation technology as an acceptable and proven technology for Bio-energy generation from domestic wastes which uses different types of anaerobic bacteria/microbes in a concealed chamber or digester to help treat degradable waste for easy conversion process and usage (Saji Das, 2011). Marie, 2007; Peter, 2001; Abdulkareem, 2005; reported that Waste – to – energy process is a source of reducing carbon/$No_x$ emissions by offsetting the need for energy from fossil sources and reduces methane generation from landfills. Meanwhile, a paper presented by (Saji Das, 2011) stated some advantageous facts that energy from waste is more suitable for eco-friendly waste disposal and also good source of energy generation. Hence, the merit of turning to this alternative source of energy are numerous, they are such as low cost in production and easy methodology, readily available, more economical, etc (Abdulkareem, 2005).

Therefore, the idea of providing an alternative source of cooking gas for rural dwellers and other future potential users has become very imperative. Thus, this paper presentation will help in reducing excessive spending for the importation of kerosene, and other cooking gas; however minimizing the risk of transporting the product through water means to local and interior communities.

## II. METHODOLOGY

The method employed for this research work is simply known as ***Waste Transformation Techniques.*** This technology is simple, users friendly and capable of generating energy such as cooking gas with the aid of simple waste disposal tank connected to an energy reservoir (gas cylinder). Large quantity of degradable waste materials from arable crops is deposited inside the tank for effective and sustainable recovery of energy (cooking gas) for the use of every rural dweller. However, dung from cow and other domestic animals are injected into the waste disposal tank for quick and easy decomposition. It also serves as a chemical catalyst which fastens the reactions. Thus, the recovered energy is a good substitute for the cooking gas from petroleum product.

Meanwhile, for the purpose of this research a sample experimental bed is set as shown in figure 1. Waste materials from crop such as cassava pile, grain chaffs and sugar cane waste were disposed into three separate waste collection bins respectively with equal and corresponding dung added to the bins which is connected to an energy tank. In order to estimate the amount of energy in either of the waste reservoir; the other two will be shut with the help of the stop cork arrangement which regulate the flow of fluid from the waste reservoir to the energy tank. This is preceded with an analytical manipulation to determine the corresponding energy content and other parameters to obtain the properties of the gas in question.
However, the experiment is conducted in the presence of direct sun light of temperature variation of 25℃ - 31℃ for a period of 23 – days to serve as means of drier [a replacement of oven drying method (Alaa, 2001; Peter, 2001)] to enable determine the moisture content of the waste materials.


Figure 1:- Pictorial illustration of waste collection bins and energy collection tank

The importance and function of the sun light with respect to the temperature and the period of the experiment is to facilitate complete dehydration of the waste products; and limiting the vaporization of volatile materials.

## *III.* MOISTURE CONTENT

Moisture content is a depended variable to the mass composition of the waste which determines the quality of waste products. It is presented mathematically in equation 1 (Alaa et al., 2012) as:

$$\text{Moisture Content (\%)} = \frac{Mi - Md}{Mi} \times 100\% \qquad 1$$

Where $M_i$ = Initial mass of the sample
$M_d$ = Dry mass of the sample after 23 – days.
A tabulation of samples of waste materials collected with respect to their wet and dry mass and moisture content in percentage in the test duration is presented in table 1.

Table - 1 Sample of Waste Materials

| Test Duration (days) | Cassava Piles | | | Grain Chaffs | | | Sugar Cane Waste | | |
|---|---|---|---|---|---|---|---|---|---|
| | Wet Mass (Kg) | Dry Mass (Kg) | Moisture Content (%) | Wet Mass (Kg) | Dry Mass (Kg) | Moisture Content (%) | Wet Mass (Kg) | Dry Mass (Kg) | Moisture Content (%) |
| 1 | 3.8 | 3.8 | 0 | 1.2 | 1.2 | 0 | 1.4 | 1.4 | 0 |
| 2 | 3.8 | 3.8 | 0 | 1.2 | 1.2 | 0 | 1.4 | 1.4 | 0 |
| 3 | 3.8 | 3.799 | 0.026315789 | 1.2 | 1.2 | 0 | 1.4 | 1.4 | 0 |
| 4 | 3.799 | 3.79 | 0.236904449 | 1.2 | 1.2 | 0 | 1.4 | 1.4 | 0 |
| 5 | 3.79 | 3.75 | 1.055408971 | 1.2 | 1.2 | 0 | 1.4 | 1.399 | 0.07142857 |
| 6 | 3.75 | 3.7 | 1.333333333 | 1.2 | 1.2 | 0 | 1.399 | 1.3976 | 0.10007148 |
| 7 | 3.7 | 3.64 | 1.621621622 | 1.2 | 1.198 | 0.16666667 | 1.3976 | 1.396 | 0.11448197 |
| 8 | 3.64 | 3.56 | 2.197802198 | 1.198 | 1.1958 | 0.1836394 | 1.396 | 1.3942 | 0.12893983 |
| 9 | 3.56 | 3.47 | 2.528089888 | 1.1958 | 1.1935 | 0.19233986 | 1.3942 | 1.3902 | 0.28690288 |
| 10 | 3.47 | 3.37 | 2.88184438 | 1.1935 | 1.1911 | 0.20108923 | 1.3902 | 1.3802 | 0.71932096 |
| 11 | 3.37 | 3.27 | 2.96735905 | 1.1911 | 1.1871 | 0.33582403 | 1.3802 | 1.3602 | 1.44906535 |
| 12 | 3.27 | 3.17 | 3.058103976 | 1.1871 | 1.1791 | 0.67391121 | 1.3602 | 1.3352 | 1.83796501 |
| 13 | 3.17 | 3.07 | 3.154574132 | 1.1791 | 1.1631 | 1.35696718 | 1.3352 | 1.3052 | 2.2468544 |
| 14 | 3.07 | 2.97 | 3.25732899 | 1.1631 | 1.1381 | 2.14942825 | 1.3052 | 1.2742 | 2.37511492 |
| 15 | 2.97 | 2.87 | 3.367003367 | 1.1381 | 1.1131 | 2.19664353 | 1.2742 | 1.2422 | 2.51137969 |
| 16 | 2.87 | 2.77 | 3.484320557 | 1.1131 | 1.0881 | 2.2459797 | 1.2422 | 1.2092 | 2.65657704 |
| 17 | 2.77 | 2.67 | 3.610108303 | 1.0881 | 1.0621 | 2.38948626 | 1.2092 | 1.1752 | 2.81177638 |
| 18 | 2.67 | 2.57 | 3.745318352 | 1.0621 | 1.0361 | 2.44798042 | 1.1752 | 1.1412 | 2.89312457 |
| 19 | 2.57 | 2.47 | 3.891050584 | 1.0361 | 1.0101 | 2.50941029 | 1.1412 | 1.1062 | 3.06694707 |
| 20 | 2.47 | 2.37 | 4.048582996 | 1.0101 | 0.9831 | 2.67300267 | 1.1062 | 1.0702 | 3.25438438 |
| 21 | 2.37 | 2.27 | 4.219409283 | 0.9831 | 0.9561 | 2.7464144 | 1.0702 | 1.0342 | 3.36385722 |
| 22 | 2.27 | 2.17 | 4.405286344 | 0.9561 | 0.9291 | 2.82397239 | 1.0342 | 0.9972 | 3.57764456 |
| 23 | 2.17 | 2.07 | 4.608294931 | 0.9291 | 0.9021 | 2.9060381 | 0.9972 | 0.9572 | 4.01123145 |

An estimation of moisture content of the selected waste sample by percentage and amount of water loss in each case is analyzed as 45.56%, 37.56% and 28.20%; and 1.73, 0.44 and 0.3 for cassava piles, sugar cane waste and grain chaffs respectively for the period of the experiment.

### DENSITY

Previous studies disclose the relationship between moisture content and the density of the wet waste material (Kraszewski et al., 1998; Mohammad et al., 2010; Laurent et al., 2005). The density, ρ is a reliable tool in the determination of the properties of fluid which is presented mathematically in equation 2 (Rajput, 2004; John et al., 2011) is significant to the study as it is used to analyze the amount of temperature of the gas, as in equation 3;- a standard value of maximum density of water as bench mark for the most dense fluid which equals $1000 kgm^{-3}$ at 4°C; knowing that density of any fluid is temperature dependent (Rajput, 2004; John et al., 2011).

$$\rho = MV^{-1} \qquad 2$$

$$1000 kgm^{-3} = 4°C \qquad 3$$

### ENERGY CONTENT

The energy content of the waste products was established by the use of some simple dimensional analytical procedures in terms of M-L-T fundamental system. The energy extracted is a function of the pressure and volume of the gas with respect to its mass.

Thus, the governing equation for this expression is given in equation 4-5 as:

$$\text{Energy Content } E_{con} = \frac{\text{Pressure} \times \text{Volume}}{\text{Mass}} \qquad 4$$

Dimensionally;

$$E_{con} = \frac{ML^{-1}T^{-2} \times L^3}{M} \qquad 5$$

Where;

$ML^2 T^{-2}$ = Newton × Metre = Joule

So that $E_{con}$ is expressed in J/Kg or KJ/Kg.

Meanwhile, statistical data concerning density, energy content and other useful parameters to obtain the properties of the cooking gas is presented on table 2 based on equations stated above and other sensitive mathematical expressions.

Table - 2 Data Presentation for Sample Waste Materials

| Test Duration (days) | Empty Mass (ME) of Energy Container (Kg) | Empty Mass of Energy Container & Fluid (MEF) (Kg) | Mass of Fluid (MEF-ME) (Kg) | Density of the Fluid (KgM-3) | Temp. of Fluid (°C) | Weight of Fluid (MEF-ME)g N | Press. (Nm-2) | Energy Content (KJ/Kg) |
|---|---|---|---|---|---|---|---|---|
| **Cassava Piles** | | | | | | | | |
| 1 | 0.1 | 0.5 | 0.4 | 173.91304 | 0.6957 | 3.928 | 1259 | 7.2391 |
| 2 | 0.1 | 0.5 | 0.4 | 173.91304 | 0.6957 | 3.928 | 1259 | 7.2391 |
| 3 | 0.1 | 0.625 | 0.525 | 228.26087 | 0.913 | 5.1555 | 1652.4 | 7.2391 |
| 4 | 0.1 | 0.696 | 0.596 | 259.13043 | 1.0365 | 5.85272 | 1875.9 | 7.2391 |
| 5 | 0.1 | 0.802 | 0.702 | 305.21739 | 1.2209 | 6.89364 | 2209.5 | 7.2391 |
| 6 | 0.1 | 0.897 | 0.797 | 346.52174 | 1.3861 | 7.82654 | 2508.5 | 7.2391 |
| 7 | 0.1 | 0.995 | 0.895 | 389.13043 | 1.5565 | 8.7889 | 2817 | 7.2391 |
| 8 | 0.1 | 1.023 | 0.923 | 401.30435 | 1.6052 | 9.06386 | 2905.1 | 7.2391 |
| 9 | 0.1 | 1.195 | 1.095 | 476.08696 | 1.9043 | 10.7529 | 3446.4 | 7.2391 |
| 10 | 0.1 | 1.323 | 1.223 | 531.73913 | 2.127 | 12.00986 | 3849.3 | 7.2391 |
| 11 | 0.1 | 1.437 | 1.337 | 581.30435 | 2.3252 | 13.12934 | 4208.1 | 7.2391 |
| 12 | 0.1 | 1.568 | 1.468 | 638.26087 | 2.553 | 14.41576 | 4620.4 | 7.2391 |
| 13 | 0.1 | 1.667 | 1.567 | 681.30435 | 2.7252 | 15.38794 | 4932 | 7.2391 |
| 14 | 0.1 | 1.698 | 1.598 | 694.78261 | 2.7791 | 15.69236 | 5029.6 | 7.2391 |
| 15 | 0.1 | 1.856 | 1.756 | 763.47826 | 3.0539 | 17.24392 | 5526.9 | 7.2391 |
| 16 | 0.1 | 1.904 | 1.804 | 784.34783 | 3.1374 | 17.71528 | 5678 | 7.2391 |
| 17 | 0.1 | 1.999 | 1.899 | 825.65217 | 3.3026 | 18.64818 | 5977 | 7.2391 |
| 18 | 0.1 | 2.357 | 2.257 | 981.30435 | 3.9252 | 22.16374 | 7103.8 | 7.2391 |
| 19 | 0.1 | 2.675 | 2.575 | 1119.5652 | 4.4783 | 25.2865 | 8104.6 | 7.2391 |
| 20 | 0.1 | 2.892 | 2.792 | 1213.913 | 4.8557 | 27.41744 | 8787.6 | 7.2391 |
| 21 | 0.1 | 3.015 | 2.915 | 1267.3913 | 5.0696 | 28.6253 | 9174.8 | 7.2391 |
| 22 | 0.1 | 3.255 | 3.155 | 1371.7391 | 5.487 | 30.9821 | 9930.2 | 7.2391 |
| 23 | 0.1 | 3.575 | 3.475 | 1510.8696 | 6.0435 | 34.1245 | 10937 | 7.2391 |
| **Grain Chaffs** | | | | | | | | |
| 1 | 0.1 | 0.12 | 0.02 | 20.202 | 0.081 | 0.1964 | 20.67 | 1.023 |
| 2 | 0.1 | 0.12 | 0.02 | 20.202 | 0.081 | 0.1964 | 20.67 | 1.023 |
| 3 | 0.1 | 0.12 | 0.02 | 20.202 | 0.081 | 0.1964 | 20.67 | 1.023 |
| 4 | 0.1 | 0.12 | 0.02 | 20.202 | 0.081 | 0.1964 | 20.67 | 1.023 |
| 5 | 0.1 | 0.12 | 0.02 | 20.202 | 0.081 | 0.1964 | 20.67 | 1.023 |
| 6 | 0.1 | 0.12 | 0.02 | 20.202 | 0.081 | 0.1964 | 20.67 | 1.023 |
| 7 | 0.1 | 0.175 | 0.075 | 75.7576 | 0.303 | 0.7365 | 77.53 | 1.023 |
| 8 | 0.1 | 0.225 | 0.125 | 126.263 | 0.505 | 1.2275 | 129.2 | 1.023 |
| 9 | 0.1 | 0.232 | 0.132 | 133.333 | 0.533 | 1.29624 | 136.4 | 1.023 |
| 10 | 0.1 | 0.255 | 0.155 | 156.566 | 0.626 | 1.5221 | 160.2 | 1.023 |
| 11 | 0.1 | 0.275 | 0.175 | 176.768 | 0.707 | 1.7185 | 180.9 | 1.023 |
| 12 | 0.1 | 0.295 | 0.195 | 196.97 | 0.788 | 1.9149 | 201.6 | 1.023 |
| 13 | 0.1 | 0.315 | 0.215 | 217.172 | 0.869 | 2.1113 | 222.2 | 1.023 |
| 14 | 0.1 | 0.324 | 0.224 | 226.263 | 0.905 | 2.19968 | 231.5 | 1.023 |
| 15 | 0.1 | 0.345 | 0.245 | 247.475 | 0.99 | 2.4059 | 253.3 | 1.023 |
| 16 | 0.1 | 0.365 | 0.265 | 267.677 | 1.071 | 2.6023 | 273.9 | 1.023 |
| 17 | 0.1 | 0.385 | 0.285 | 287.879 | 1.152 | 2.7987 | 294.6 | 1.023 |
| 18 | 0.1 | 0.398 | 0.298 | 301.01 | 1.204 | 2.92636 | 308 | 1.023 |
| 19 | 0.1 | 0.42 | 0.32 | 323.232 | 1.293 | 3.1424 | 330.8 | 1.023 |
| 20 | 0.1 | 0.435 | 0.335 | 338.384 | 1.354 | 3.2897 | 346.3 | 1.023 |
| 21 | 0.1 | 0.445 | 0.345 | 348.485 | 1.394 | 3.3879 | 356.6 | 1.023 |
| 22 | 0.1 | 0.46 | 0.36 | 363.636 | 1.455 | 3.5352 | 372.1 | 1.023 |
| 23 | 0.1 | 0.485 | 0.385 | 388.889 | 1.556 | 3.7807 | 398 | 1.023 |

| Sugar Cane Waste | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1 | 0.325 | 0.225 | 40.9091 | 0.164 | 2.2095 | 232.6 | 5.685 |
| 2 | 0.1 | 0.325 | 0.225 | 40.9091 | 0.164 | 2.2095 | 232.6 | 5.685 |
| 3 | 0.1 | 0.325 | 0.225 | 40.9091 | 0.164 | 2.2095 | 232.6 | 5.685 |
| 4 | 0.1 | 0.325 | 0.225 | 40.9091 | 0.164 | 2.2095 | 232.6 | 5.685 |
| 5 | 0.1 | 0.352 | 0.252 | 45.8182 | 0.183 | 2.47464 | 260.5 | 5.685 |
| 6 | 0.1 | 0.385 | 0.285 | 51.8182 | 0.207 | 2.7987 | 294.6 | 5.685 |
| 7 | 0.1 | 0.395 | 0.295 | 53.6364 | 0.215 | 2.8969 | 304.9 | 5.685 |
| 8 | 0.1 | 0.405 | 0.305 | 55.4545 | 0.222 | 2.9951 | 315.3 | 5.685 |
| 9 | 0.1 | 0.445 | 0.345 | 62.7273 | 0.251 | 3.3879 | 356.6 | 5.685 |
| 10 | 0.1 | 0.565 | 0.465 | 84.5455 | 0.338 | 4.5663 | 480.7 | 5.685 |
| 11 | 0.1 | 0.675 | 0.575 | 104.545 | 0.418 | 5.6465 | 594.4 | 5.685 |
| 12 | 0.1 | 0.795 | 0.695 | 126.364 | 0.505 | 6.8249 | 718.4 | 5.685 |
| 13 | 0.1 | 0.985 | 0.885 | 160.909 | 0.644 | 8.6907 | 914.8 | 5.685 |
| 14 | 0.1 | 1.05 | 0.95 | 172.727 | 0.691 | 9.329 | 982 | 5.685 |
| 15 | 0.1 | 1.265 | 1.165 | 211.818 | 0.847 | 11.4403 | 1204 | 5.685 |
| 16 | 0.1 | 1.465 | 1.365 | 248.182 | 0.993 | 13.4043 | 1411 | 5.685 |
| 17 | 0.1 | 1.795 | 1.695 | 308.182 | 1.233 | 16.6449 | 1752 | 5.685 |
| 18 | 0.1 | 1.855 | 1.755 | 319.091 | 1.276 | 17.2341 | 1814 | 5.685 |
| 19 | 0.1 | 2.015 | 1.915 | 348.182 | 1.393 | 18.8053 | 1980 | 5.685 |
| 20 | 0.1 | 2.235 | 2.135 | 388.182 | 1.553 | 20.9657 | 2207 | 5.685 |
| 21 | 0.1 | 2.655 | 2.555 | 464.545 | 1.858 | 25.0901 | 2641 | 5.685 |
| 22 | 0.1 | 2.805 | 2.705 | 491.818 | 1.967 | 26.5631 | 2796 | 5.685 |
| 23 | 0.1 | 2.955 | 2.855 | 519.091 | 2.076 | 28.0361 | 2951 | 5.685 |

## IV. RESULT PRESENTATION

Figures 2-7 illustrates the variation of energy and moisture contents of the sample waste materials for the research with a corresponding rate of density, temperature and mass of the fluid recovered with respect to the test duration. Meanwhile, the chart presentation were generated from tables 1 and 2 which shows the practical ways of obtaining domestic cooking gas for rural communities from waste products of arable crops. Result plots also describe and explain the relationship, behavior and properties of the cooking gas and its raw material. However, the trend of energy content, temperature and Pressure change of the gas for the waste sample such as cassava piles, grain chaffs and sugar cane waste is best demonstrated on a histogram in figures 5 – 7.

## V. DISCUSSION

Established results in the test duration of moisture content is obvious and clear that cassava piles is of the highest moisture content of 45.56%, followed by sugar cane waste with 37.56% and grain chaffs yielding 28.19%. This indicates a speedy decay of the reactions it undergoes in the experimental test duration. The reason for this might be the high level of sugar content in its waste product which is a component of carbohydrates. However, the analyzed result for energy content of the waste materials is 7.2391KJ/Kg, 1.023KJ/kg and 5.685KJ/Kg for cassava Piles, grain chaffs and sugar cane waste respectively. Other subsequent results obtained in the process for an overall average density, pressure and temperature of the gas in terms of Cassava piles, grain chaffs and sugar cane waste is 842.4kgm-$^{3}$, 6098Nm$^{-2}$, 3.37°C; 204.55kgm-$^{3}$, 209.34Nm$^{-2}$, 0.82°C and 280kgm-$^{3}$, 1591.8Nm$^{-2}$, 1.12°C respectively.

Result comparison with estimated properties of a cooking gas from petroleum product of 7.379KJ/Kg and 46.54% energy content and moisture content respectively from review sources (Alaa et al., 2012, Propane, 2013) is used to validate the result obtained from this paper.

## VI. CONCLUSION

After critical evaluation of the properties of crop waste with that of cooking gas from petroleum product, energy derived from crop waste is considerably potential substitute for its counterpart.

Thus, it shows that waste product from carbohydrates class of food with animal dung is prompt to decay faster to produce energy capable of cooking.

For the purpose of validation of the established Waste Transformation Techniques used for this research, result comparison was a measure to establish a bench-mark for the sustained energy for the cooking gas.

In order to maintain sustainability of this derived energy from crop waste is the provision of a larger waste disposal tank at an affordable rate for every house hold in rural communities to help generate a larger quantity of the gas.
Therefore, massive production of animal dung will lead to rearing of animal for reliability and effectiveness of this alternative source of cooking gas for rural dwellers.

## VII. ACKNOWLEDGEMENT

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## REFERENCES

[1] Abdulkareem A. S. (2005). "Refining Biogas Produced from Biomass: An Alternative to Cooking Gas".
[2] Alaa Husaeen Wadie, Jawad Kadhim Abbood, Riyad Hassan Hadi (May, 2012). "Residential Solid Wastes Characteristics and Energy Content in Al-Mussaib City in the Middle of Iraq", *ICEBS*, PP. 38-43.
[3] John F. Douglas, Janusz M. Gasiorek, John A. Swaffield, Lynne B. Jack (2011). "Fluid Mechanics, (5th Ed)", Dorling Kindersley (India): PVt. Ltd., ISBN: 978-81-317-2140-7.
[4] Kraszewski A. W.,Trabelsi S., Nelson S. O. (1998). "Simple Grain Moisture Content Determination from Microwave Measurements", *Transactions of the ASAE*, Vol.4 (1), PP. 129-134.
*[5]* Laurent J. P., Olivier F., Goure J. P. (March, 2005). "Monitoring Moisture Content in Municipal Solid Waste: Results of a Preliminary test under Laboratory Conditions", *International Workshop "Hydro-Physico- Mechanics of Landfills.*
[6] Marie Lariviere (May, 2007). "Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy", EI-52, Washington, DC.20585.
[7] Mohammad Reza Seifi, Reza Alimardani (December, 2010). "The Moisture Content Effect on some Physical and Mechanical Properties of Corn (SE 704)", *Journal of Agricultural Science*, Vol. 2, No. 4, PP. 125-134. ISSN 1916-9752 E-ISSN1916-9760.
[8] Nolan Itu Pty Ltd., TBU Environmental Engineering Consultants (March, 2001). "Guideline for Determining the Renewable Components in Waste for Electricity Generation", Ref: 3082-01.
[9] Peter Mckendry (July, 2001). "Energy Production from Biomass (Part 2) Conversion Technologies", *Applied Environmental Research Centre Ltd, UK*.
[10] Propane (2013). Properties of Propane, available at http://en.wikipedia.org/wiki/propane, Accessed on the 20th August, 2013.
[11] Rajput R. K. (2004). "A Text Book of Fluid Mechanics and Hydraulic Machines, (Reprint-2nd Ed)", Ram Nagar, New-Delhi: S.Chand and Company Ltd., ISBN:81-219-1666-6.
[12] Saji Das A. (August, 2011). "Generation of Energy through Decentralized Waste Treatment", Biotech Renewable Energy PVt. Ltd., Thiruvananthapuram-14, Kerala.

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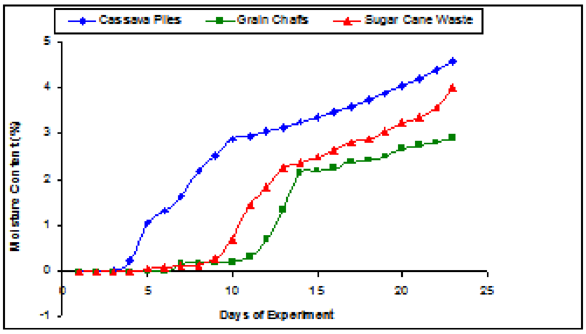


Figure 2:- Moisture Content Percentage Performance of Waste Materials

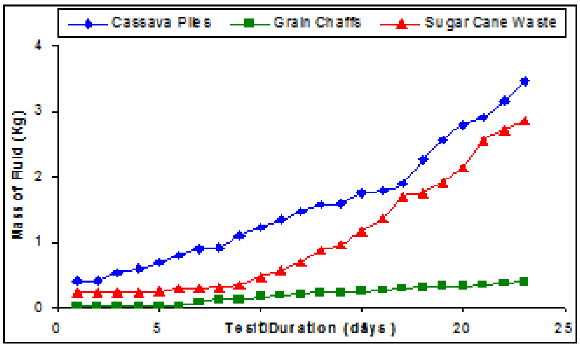


Figure 3:- Deviation of Mass of Fluid with Days of Experiment

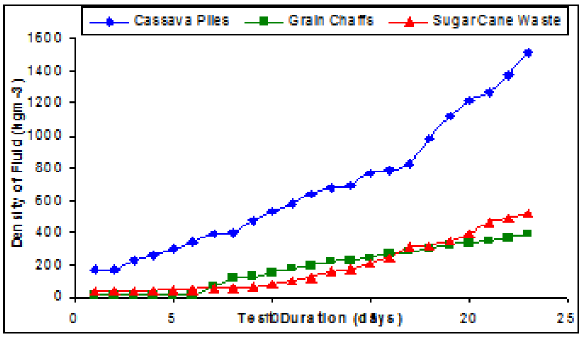


Figure 4:- Rate of Density Change with Time

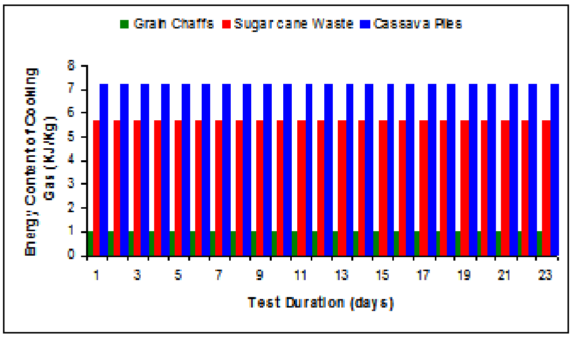


Figure 5:- Variation of Energy Content for Waste Materials

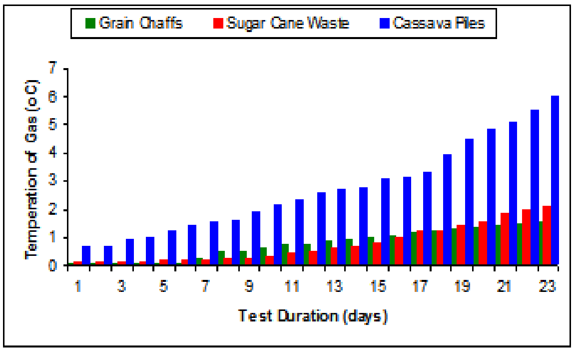


Figure 6:- Variation of Temperature with Time

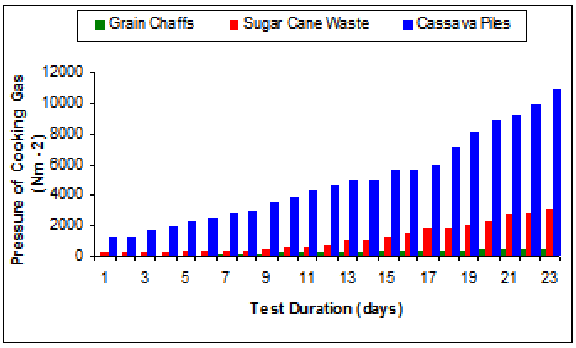


Figure 7:- Variation of Pressure with Test Duration