IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⋇ Vol. 9, Issue 5, May 2022

DOI: 10.17148/IARJSET.2022.9501

EFFECT OF TALINUM TRIANGULARE (WATER LEAF) ON BIOGAS FROM COW DUNG

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Abstract: The over-dependence on fossil fuels as primary energy source has led to myriads of problems such as global climatic change, environmental degradation and various health problems. Moreover, the recent rise in prices of oil and natural gas alongside its demand has necessitated the continuous search for alternative energy sources. Cow dung as a renewable source of energy supply has been proven to be very efficient. This study investigated and evaluates the effect of TalinumTriangulare (water leaf) on the biogas from cow dung. Two suitable digesters were constructed for its anaerobic digestion, fermentation and the production of the biogas. The experiment was conducted within a period of thirty five days in plastic bio-digesters of 20 litres each. The first digester labelled digester1 was for the production of biogas using only cow dung as substrate and the second digester labelled digester 2 for the production of biogas for the co-digestion of water leaf and cow dung. The PH values of the substrates were taken before and after digestion for both digesters. The result of the experiment showed that water leaf has catalytic effect on the anaerobic digestion of cow dung in the production of biogas.

Keywords: Biomass, Water leaf, Energy, Biogas, Cow dunk, Proximate, Digester

INTRODUCTION

The demand for energy (particularly cooking fuel) in Nigeria has led to deforestation and excessive exploitation of crude oil that are not environmental friendly (Balogunet al.,2019). There is need for the adoption of technologies that promote renewable energy and the conversion of organic wastes to biogas as a reliable option in this regard (Ben-Iwo et al.,2016). The biogas technology is one of such systems which has been found to be cost effective and environmentally friendly (Brown, 2003). Biomass has been predicted to be an attractive and reliable renewable energy source which has been confirmed to be readily available is various places on earth (Akinmusere, et al, 2017). From previous and present researches, energy can easily be harness from biomass in numerous forms (gas, liquid, solid) which has been deemed safer for the earth and the inhabitants

Also, biogas is a potential fuel which can be produced through anaerobic digestion of organic material, such as biomass, municipal waste and sewage (Authayanun et al., 2013). Biogas mainly consists of methane and carbon dioxide together with trace amounts of other gases such as hydrogen, nitrogen and hydrogen sulphide (Makaruk et al., 2010). The main constituent of biogas is methane; other combustible hydrocarbons of biogas do not contribute much to the calorific value of the gas (Cordova and Flouzino, 2022). Biogas is an odourless and colourless gas that burns with blue flame similar to Liquified petroleum gas which possess no serious hazardous threat to the environment (Osueke et al., 2018). Ogunwande et. al.,(2015) evaluated biogas yield from water leaf plant (talinum triangulare) and water hycienth (Eichhomiacrassipes) alone. Ebunilo, et. al . (2015); evaluated cow dung and talinum triangulare as a seeding agent for the production agent for the production of biogas from domestic wastes. Yaru, et. al.,(2013), compared biogas production of cattle dung with plantain peels and reported that the mixtures produces more biogas than the cattle dung alone.

MATERIALS AND METHODS

The materials used for this work includes; cow dunk, water leaf, thermometers, gas detector, plastic drums, weighing balance and pressure gauges. For this research, 5 kg of cow dung was mixed with 10 kg of water (1:2) for the digester 1 and 2.5 kg of cow dung was added to 2.5 kg of water leaf and was mixed thoroughly with 10kg of water (1:1:4) for the digester 2.The mixtures in each of the digesters were thoroughly stirred for 10 minutes to ensure even mixing. The pH

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Impact Factor 7.105 ∺ Vol. 9, Issue 5, May 2022

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(the quantitative measures of the acidity or basicity of the aqueous or other liquid solutions) of the slurry in each of the digesters was taken with a digital pH meter.
In other to ensure a gas tight environment, each of the digesters was properly covered with its lids.

Design Considerations

The following assumptions were made in the design of the digesters:

i. The biogas composition comprised principally methane (CH_4) and carbon dioxide (CO_2) as other constituents are negligible.

ii. The percentage volume of methane and carbon dioxide were 60% and 40% respectively

The maximum temperature (T) of digester did not exceed 40˚C (313k).
The volume of digester is calculated using the relation,
$V_T = \pi r^2 h$
(The volume of the substrate occupied two third of the total volume of the digester ($2/3V_T$).

Design Parameters

These were the various dimensions of the materials, other variables, constant and the formulae considered during the design of the digester
Height of the digester (h) = 0.36m
Radius of the digester (r) = 0.145m
The total volume V_T,
$V_T = 3.142 \times 0.145^2 \times 0.36 = 0.024m^3$
Maximum temperature of the digester (T) = 40˚C = 313K
From Ideal Gas Equation

$$P_T V_T = nRT \quad (1)$$

Where, $P_T =$ Total pressure of the biogas inside the digester (kpa)
V_T = volume of digester (m^3)
T = maximum temperature of the digester (K)
R = Universal gas constant = 8.314KJ/kgK
n = Number of moles

but $n = \frac{m}{M}$

and m = mass of substrates or reacting mass
M = molecular mass of the gas (kg)
Therefore, equation (1) becomes

$$P_T V_T = \frac{mRT}{M} \quad (2)$$

And the volume of substrates is $2/3V_T$ and putting this into the equation it becomes

$$P_T = \frac{3mRT}{2V_T M} \quad (3)$$

The expected pressure for both methane (CH_4) and carbon dioxide (CO_2) was calculated using the equation (3) above.

$$P_{CH_4} = \frac{3x5x8.314x0.6x0.037}{2x16x0.024}$$

= 1128.33kPa

$$P_{CO_2} = \frac{3x5x8.314x313x0.4x0.037}{2x44x0.024}$$

=273.54kg

Using Dalton's law of partial pressure

$$p_T = p_{CH_4} + P_{CO_2} \quad (4)$$

$P_{CH_{4\$}}$ =Partial pressure of methane

P_{CO_2} =Partial pressure of carbon dioxide

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Expected Pressure inside the Digester

Partial pressure of methane (CH_4) and Partial pressure of carbon dioxide (CO_2) were obtained using Equation 3above

$P_{CH_{4\$}}$ = 1128.3 kPa

M_{CO_2} = 44 kg

P_{CO_2} = 273.54 kPa

Hence, the total pressure in the digester $P_{T\,=}$ 1128.33 + 273.54= 1401.87Kpa

From the relationship between factor of safety (n) and allowable stress (σ) is represented by Equation 5

$$n = \frac{\sigma_y}{\sigma} \qquad (5)$$

σ_y = yield stress for plastic = 320Mpa, n = 0.73, t = 0.73mm = 0.00073m

Therefore allowable or working stress, σ = 438.36 MPa

Using the value above and the values for the diameter of the digesters and substituting into the equation below

Therefore, the expected maximum pressure P, in the digester is obtained using Equation 6 below

$$P = \frac{2\sigma t}{D} \qquad (6)$$

P = 2210 kPa

plate 4 below shows the stages in the biomass preparation in order to obtain the biogas.

Plate 1:**Fresh Sliced Water Leaf**

Plate 2: Cow Dung Preparations

Plate 3: Mixed Cow Dung – Water Leaf

Plate 4: Finished Biomass

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Plate 5: The Loaded Digesters.

The table below shows the ratio of the biomass preparation

Table 1: Mixing Ratio of wastes in each digesters

Digester	Cow dung (Kg)	TalinumTriangulare (Kg)	Water (Kg)
1	5	-	10
2	2.5	2.5	10

RESULTS AND DISCUSSIONS

From the prepared biomass, the pH meter recorded a value of 5.17 for the cow dung and 8.14 for the mixture of cow dung and waterleaf before digestion and 6.48 for cow dung and 6.18 for the mixture of cow dung and water leaf after digestion. The pH readings are presented in Fig. 1 below, while Fig 2 – 3 shows the proximate analysis for varying conditions. Table 2- 5 below presents the proximate analysis.

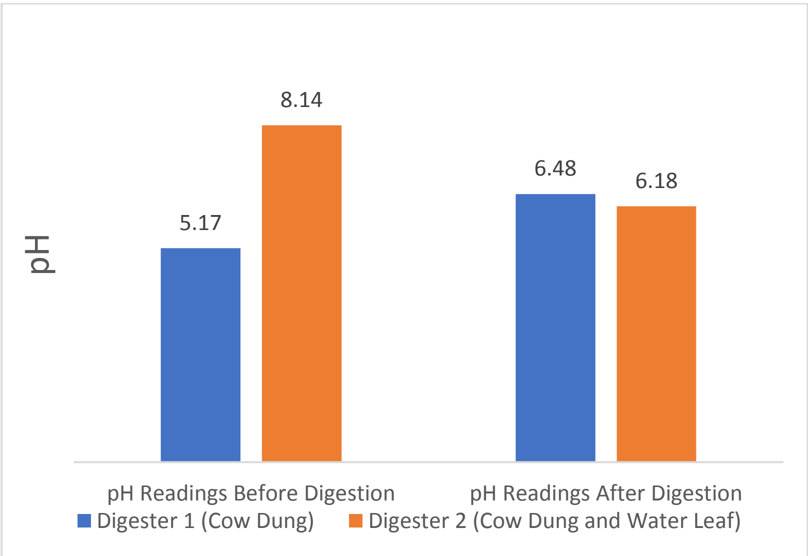

Fig.1: The pH of substrate in each of the digesters before and after digestion.

TABLE 2: Proximate Analysis of Sample 1 (Cow Dung) Before Digestion

Moisture Content (%) (DRY WT)	Crude Protein (%)	ASH (%)	FAT (%)	Crude Fiber (%)	CHO (%)
20.4786	6.9824	9.8611	5.1649	37.4546	19.9314

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TABLE 3: Proximate Analysis of Sample 1 (Cow Dung) After Digestion

Moisture Content (%) (DRY WT)	Crude Protein (%)	ASH (%)	FAT (%)	Crude Fiber (%)	CHO (%)
78.1713	11.8113	13.1508	4.3714	26.1404	22.6975

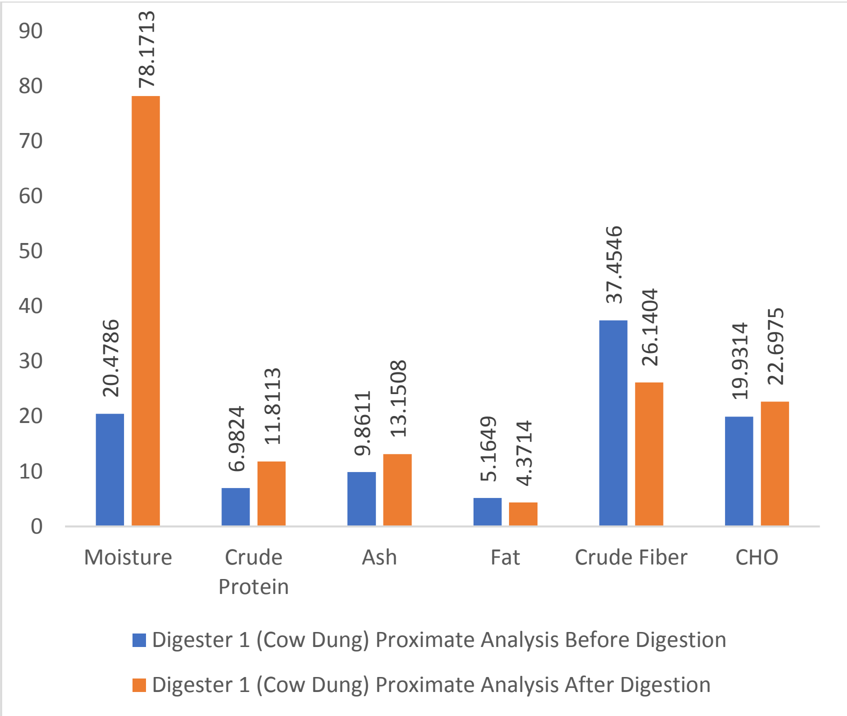

Fig.2: The Proximate Analysis for Digester 1 (Cow Dung) Before and After Digestion.

TABLE 4: Proximate Analysis of Sample 2 (Cow Dung and Waterleaf) Before Digestion

Moisture Content (%) (DRY WT)	Crude Protein (%)	ASH (%)	FAT (%)	Crude Fiber (%)	CHO (%)
21.5354	7.0966	12.1117	7.2428	36.8899	14.1618

TABLE 5: Proximate Analysis of Sample 2 (Cow Dung and Waterleaf) After Digestion

Moisture Content (%) (DRY WT)	Crude Protein (%)	ASH (%)	FAT (%)	Crude Fiber (%)	CHO (%)
71.1321	13.1724	15.1722	5.3674	24.1719	13.2482

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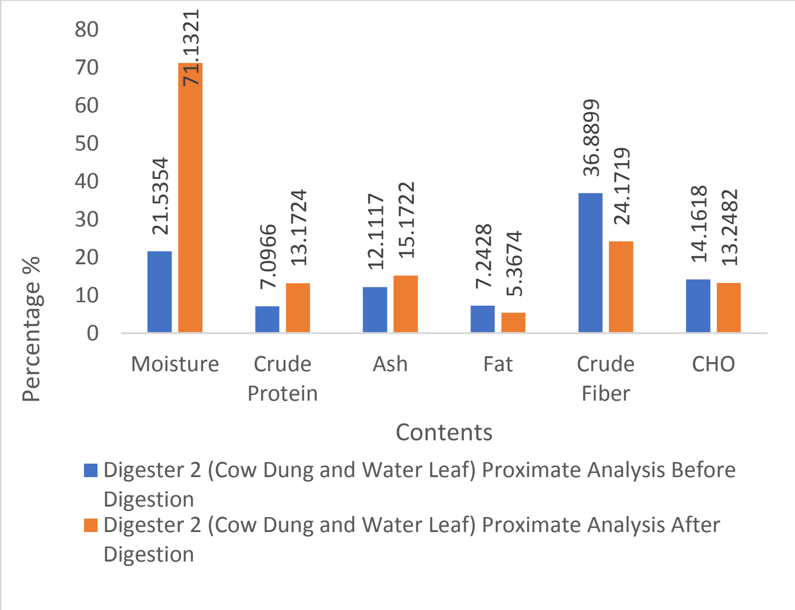

Fig. 3: The Proximate Analysis for Digester 2 (Cow Dung and Water Leaf) Before and After Digestion.

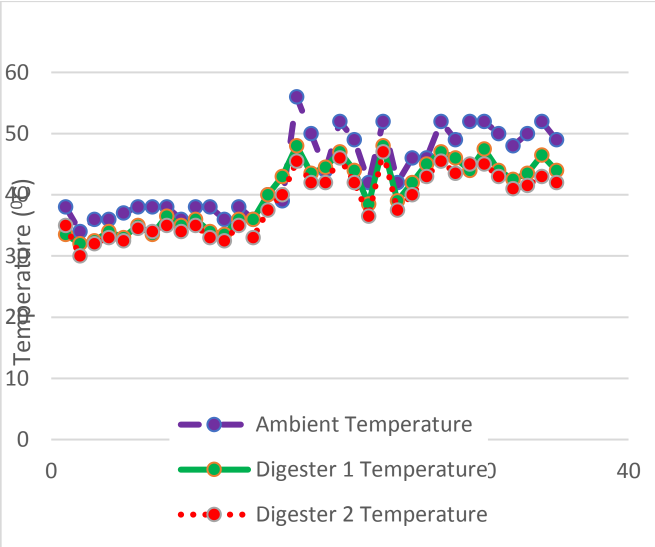

Fig. 4: Plots of ambient and digester's temperatures against time (days) for digester 1 (5 kg of cow dung) and digester 2 (2.5kg of cow dung and 2.5kg of waterleaf).

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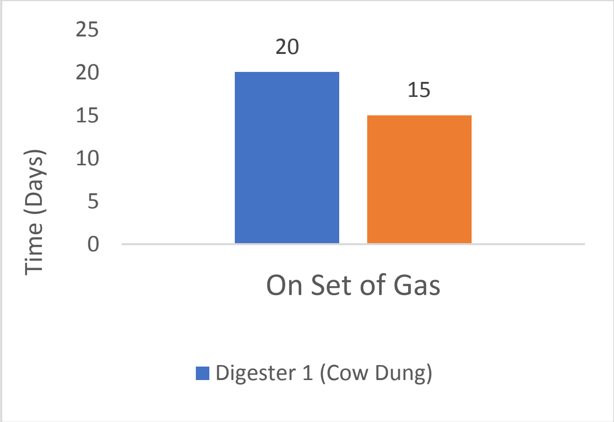

Fig. 5: On set of gas for digester1 and 2 were 20th and 15th day respectively.

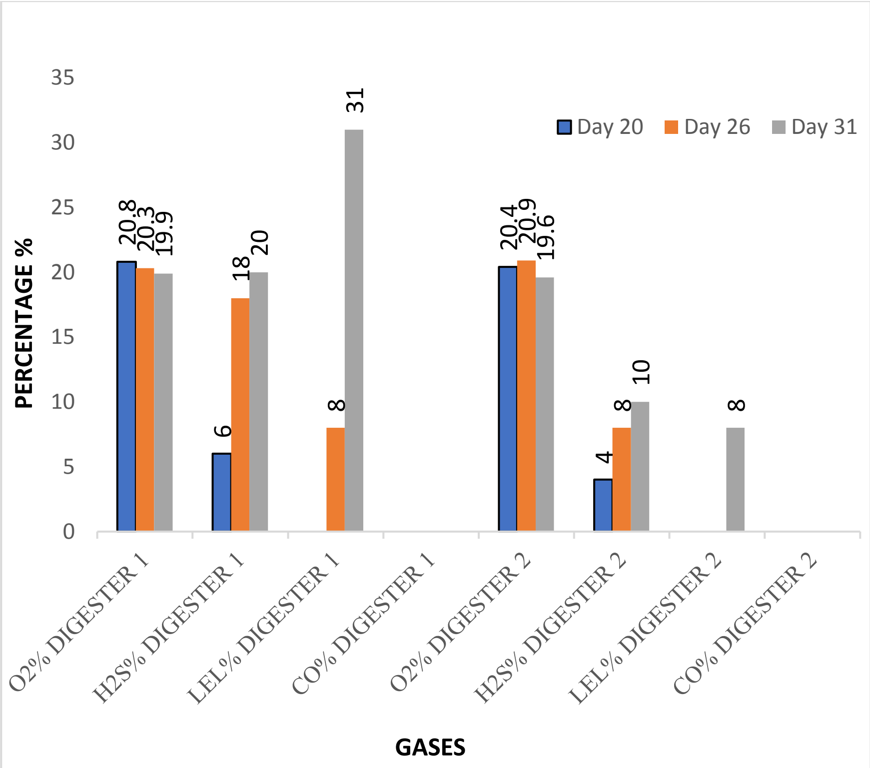

Fig 6: Percentage of gas detected in both Digesters

Fig. 1 shows that the digester 1 with 5kg of cow dung had the lowest value of pH (5.17) before digestion, which implies an acidic condition. This acidic content in the cow dung was due to the presence of bicarbonates and organic acids in it. It was also observed that the digester 2 with 2.5 kg of cow dung and 2.5 kg of water leaf has the highest value of pH (8.14), which implies alkalinity condition resulting from the alkaline content in water leaf. After digestion the pH for digester 1 increased to6.48 which is acidic and digester 2 decreased to 6.18 which is also acidic.
Table 2 and 3, shows the results of the proximate analysis test of the cow dung in digester 1 before and after digestion respectively.

CONCLUSION

The construction of the suitable biogas digesters has been successfully completed and its objectives fully achieved. Under the same conditions, the biogas produced from digester 1 containing 5kg of cow dung burnt on 28th day, while digester 2 containing 2.5kg of cow dung and 2.5kg of talinum triangulare (water leaf) burnt on 30th day. Both small and

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large industries in Nigeria should tap from the enormous benefits of biogas as an alternative and renewable source of energy by converting both human and animal dung (waste) to wealth. Secondly, public and private partnership should be encouraged in establishing small, medium and large scale biogas production plants in various parts of the country. This will reduce the rate of unemployment and generate income for the country.

REFERENCES

1. Akinmusere, O.K., Babatola, J.O., Lafe, O. and Ajayi, O.E. (2017), Termite-Methan Production, Gut Microbes and Wastes: A Review Proceeding of the 2017 Annual Conference of the School of Engineering and Engineering Technology (SEET): Innovative and Adaptive Technology for National Development. 2nd International Conference held at Federal University of Technology, Akure, Nigeria, 11th – 13thJuly.Pp526– 531.
2. Authayanun S.,Aunsup P., Im-orb K., Arpornwichanop A., (2013), Systematic Analysis of Proton Electrolyte Membrane Fuel Cell Systems Integrated with Biogas Reforming process, Chemical Engineering Transactions, 35, 607-612DOI:10.3303/CET1335101.
3. Balogun K, Lasode M., Onokwai A., Ezugwu C., Olayanju T. and Osueke C., (2019), Elemental Analysis and Combustion Characteristics Evaluation of Nigerian Biomass Resources, International Journal of Mechanical Engineering and Technology, Vol.10(02), Pp.1522–1527
4. Brown, J. (2003), Wastewater Treatment: The Experiences of the Scientific Research Council In Jamaica (SRC). Hope Gerdons, Kingston 6. Pp. 7, 10, 16 – 20. Center for Energy Studies (CES) (2001): A Study Report on Efficiency Measurement of Biogas, Kerosene and LPG Stoves.
5. Ben-Iwo J., Manovic V. and Longhurst P. (2016), "Biomass Resources And Biofuels Potential for the Production of Transportation Fuels in Nigeria, Renewable and Sustainable Energy Reviews,:Vol. 63, Pp. 172-192.

a. Cordova, M. E. H. and Flouzina, B. K. (2022), Analysis of Viable biogas Production from Anaerobic Digestion of Swine Manure with Magnatate Powder. Environmental Technology and Innovation.Vol 25.

b. Ebunilo, P., Aliu, S. and Orhorhoro, K. (2015). Comparative Analysis of biogas Yield from Different Composition of Domestic Wastes from Benin City, Nigeria. Vol 04 Issues 05 Pp 169 – 177.

6. Makaruk A., Miltner M., Harasek M. (2010), Membrane Biogas Upgrading Processes for the Production of Natural Gas substitute, Separation and Purification Technology, Vol.74(1), 83-92.
7. Ogunwande, G.,Muritala, A. O. and Babalola, W. O. (2015). Evaluation of Biogas Yield from Water Leaf (Talinumtriangulare). Agricultural Engineering Innternational.The CIGR e-journal 17(1).Pp 110-117.Osueke, C. O., Olayanju T. M. A., Ezugwu, C. A., Onokwai, A. O., Ikpotokin, I., Uguru-Okorie, D. C., and Nnaji, F. C. (2018), Comparative Calorific Evaluation of Biomass Fuel andFossil Fuel.International Journal of Civil Engineering and Technology Vol. 9 (13) Pp.1576-1590
8. Yaru, S. S., Adewole, K. A. and Adegun, I. K. (2014).Comparative Study of Biogas from Cattle Dung and Mixture of Cattledung with Plantain Peels. NigerianJournal of Technological Research.Vol 8(44).