https://lafiascijournals.org.ng/index.php/iacproceedings
p-ISBN: 978-978-774-670-7

PERFORMANCE EVALUATION OF ANAEROBIC CO- DIGESTION OF COW DUNG AND BAGASSE FOR BIOGAS PRODUCTION

Umar Wabi, Abubakar*, Saidu Mohammed and Daniel N. Kolo

Department of Civil Engineering, Federal University of Technology, Minna, Niger state, Nigeria.
**Corresponding Author:* wabiumar@gmail.com

https://doi.org/10.62050/faic2024.bop24.014

ABSTRACT

Energy plays very important roles on the national security of any country; it has become a basic need for modern society to strive. In recent times, the cost of energy has increased significantly, due to a growing global demand for energy and the decreasing availability of fossil fuel sources. Many countries are adopting environmental policies promoting the production and consumption of alternative, sustainable and renewable energy sources. This thesis analyzed the biogas production from anaerobic co-digestion of Cow Dung and Sugarcane Bagasse; the experiment was conducted under a batch process at thirty (30) days retention time. Eight (8) number of 10 litres digesters are fed with Cow dung, Bagasse and inoculum of Rumen fluid at various mixtures for Digester 1: 0%SG:100% CD+ Inoculum. For Digester 2: 30%SG: 70%CD +Inoculum. For Digester 3: 70%SG:30%CD + Inoculum and Digester 4 100%SG:0% CD. Digester 5:0%CD:100% SG, Digester 6: 30%CD: 70%SG, Digester 7:70%CD:30%SG and Digester 8:0%SG:100% CD. The digestion process took place at room temperature for thirty (30) days under mesophilic (28 and 45oC) conditions. The proximate composition of the substrates before anaerobic digestion revealed D 1 had the highest Moisture content and Ash content (83.83), (12.83), D4 had highest Total Solid (51.22), D5 had highest Volatile Solid, Carbon content, and BOD of (10.83), (4.32), (2.40) respectively, D7 had the highest Nitrogen (2.93). After the anaerobic digestion D7 had the highest moisture content (89.42), D4 had the highest Total solid (31.8), D2 had the highest Volatile solid and Ash content of (9.63), (11.63) respectively. D5 had the highest Carbon content, Nitrogen, and BOD of (4.21), (3.11) and (200). From the analysis of the result after fermentation, anaerobic co- digestion of the Reactor 2 or Digester with the combination of 30%SG: 70%CD +Inoculum produces more volume of biogas. These values were either reduced or increased as a result of the breakdown of molecules during fermentation the substrate where subjected to ignition and where volatilized as when compared to before the broken down by microorganisms because the digestion is a microbial enhanced process.

Key Words: Abattoir wastewater, *Moringa oleifera*, Physio-chemical parameters.

1.0 Introduction

Energy is a fundamental requirement for man's comfort and basic needs of everyday life. A vast majority of countries especially developing countries have energy crises with over reliance on fossil fuels (Mohammed *et al*. 2021). The national energy drivers of all countries globally are energy security, environmental protection, and economic growth. It is predicted that fossil fuel sources like coal, gas, and oil are headed for depletion within the next 10 decades, hence the need for alternative sources of energy (Gürsan and Gooyert, 2021). Biogas has proved to have significant potential as a renewable energy source for industrial as well as domestic applications and an efficient solution to the global energy crisis (Kumar *et al*. 2018).

Co-digestion has been defined as the anaerobic treatment of a mixture at least two different substrates with the aim of improving the efficiency of the anaerobic digestion process (Neczaj *et al*. 2012). The composition of biogas largely depends on the type of substrate used for its formation. Biogas is about 20 percent lighter than air. It burns without smoke and is non-toxic. It is also an odorless and colorless gas that burns with clear blue flame similar to liquefied petroleum gas (LPG) (Karki *et al*. 2005). Additionally, international treaties like Agenda 21 and Kyoto Protocol advocate for a transition to renewable and low carbon sources of energy due to high greenhouse gas emissions associated with fossil fuels and the related climate change caused (Sahota *et al*. 2022). The increasing use of fossil fuels and environmental concerns over greenhouse gas emissions and climate change has generated interest in biogas as an alternative renewable energy resource (Pasternak, 2021).

2.0 Materials and Methods

The agricultural waste materials used for this study were, fresh cow dung collected from Minna abattoirs and the Rumen fluid (Inoculum), Sugar cane bagasse which was sourced from golden sugar Estate located in Sunti, a village in Mokwa Local Government Area of Niger State, Nigeria. Bagasse was sack bag and transported to the laboratory for processing. The Cow dung and inoculum where collected in a polythene bag, the bagasse was sorted out to remove unwanted materials which was sun dried for about five days in order to reduce the moisture content, bagasse was further crushed mechanically to smaller sizes using pestle and mortar.

2.1 Characterization of Substrates

The raw material characteristics are important factors that affect the start-up of Anaerobic digestion (AD), process stability, and methane production (Gaballa *et al*.2020). Tests for Total solids (TS), volatile solids (VS), Biological Oxygen Demand (BOD) Moisture content (MC), Carbon content, Total nitrogen and Ash content, were carried out using the standard methods (APHA, 2005).

2.2 Digester Composition

Digester 1: Cow dung + inoculum (100%)

Digester 2: Cow dung + bagasse + inoculum (30% and 70%)

Digester 3: Cow dung + bagasse + inoculum (70% and 30%)

Digester 4: Bagasse + inoculum (100%)

Digester 5: Bagasse (100%)

Digester 6: Cow dung + bagasse (70% and 30%)

Digester 7: Cow dung + bagasse (30% and 70%) and Digester 8: Cow dung (100%)

Anaerobic digestion batch tests were conducted to assess the effect of the Sugar cane Bagasse and cow dung in a semi solid state co- digestion process in a batch system using jerry cans of 10 litres sealed fully airtight with effective working volumes as shown in the composition of substrates in reactors.

2.3 Apparatus and Equipment

The following equipment's were used in the study.

p-ISBN: 978-978-774-670-7

I. Eight 10L digester Jerry cans.1000ml, 500ml and 200ml measuring cylinders.

II. Digital weighing balance: to determine the weight of the samples.

III. pH meter: to measure the pH of the digested materials before and after retention period.

IV. Mixing tank: a big plastic container for mixing the substrate.

V. Thermometer: for measuring the temperature.

VI. Mortar and pestle: for size reduction.

VII. Funnel: for feeding the slurry into the digester so as to minimize spillage.

VIII. Shovels: for ensuring proper mixing and packing of the substrates.

IX. Nose mask: for prevention of inhalation of particulate and odor.

X. Protective gloves: worn to protect the hands from contamination

XI. Autoclave for steam explosion.

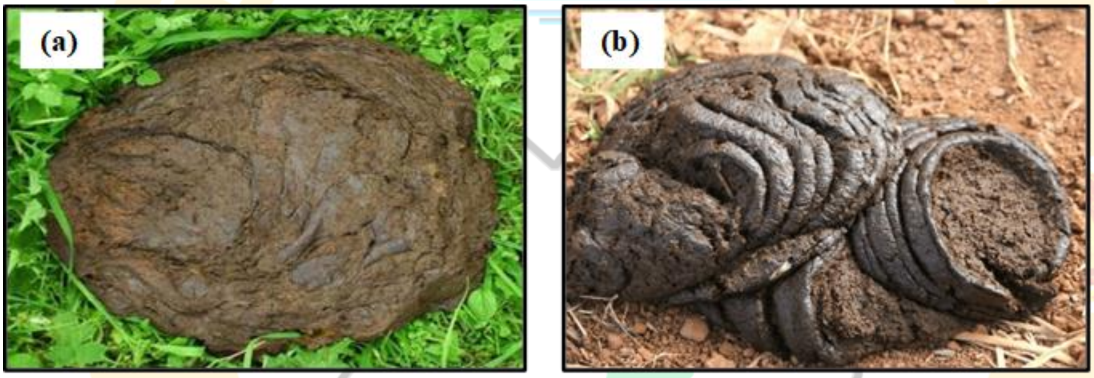

Plate 1 (a) and (b): Cow dung used as substrate

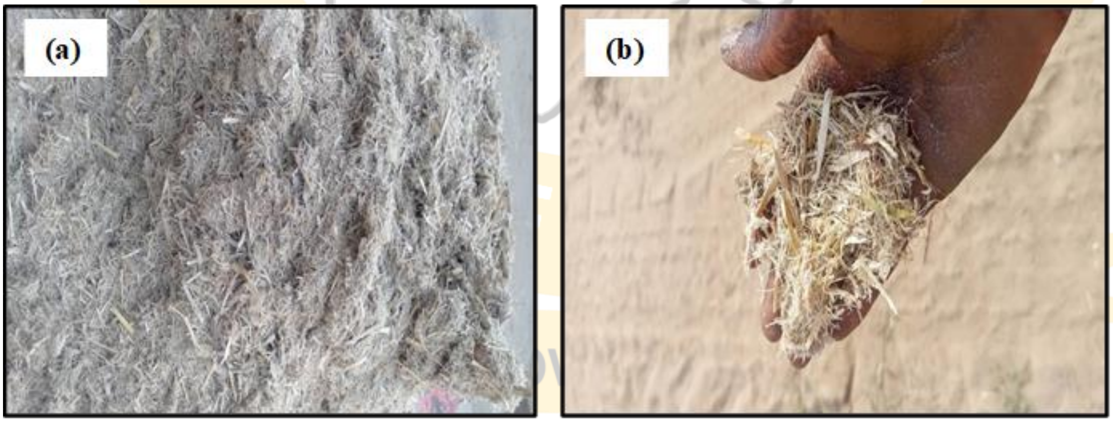

Plate 2 (a) and (b): Sugarcane bagasse used as substrate

https://lafiascijournals.org.ng/index.php/iacproceedings
p-ISBN: 978-978-774-670-7

3.0 Results and Discussion

Table 1 shows the physiochemical parameters of bagasse and cow dung before fermentation. After fermentation, the moisture content of D1 had the superior value of (83.41%) and varies significantly p<0.05 when compared with rest treatments. While for total solid, there was a significant difference between D4 when compared with the remaining treatments. However for the volatile solid, Ash and Carbon, a different pattern was observed with D 5 showing a significant difference p<0.05 when compared with the rest treatment before fermentation. The nitrogen on the other hand shows D7 to be significantly different <0.05 when compared to the remaining treatments and has retained the least value of (0.91% and 1.06%) respectively. Biological oxygen demand of the treatments before fermentation shows D5 to be significantly P<0.05 different when compared with the rest treatments. This result is in line with Latinwo and Agarry (2014), Muzenda (2014) and Yavini et al (2014) The results of the physical parameters of bagasse and cow dung that went through digestion process before and after is express as; there is an increase in the moisture content of the digested substrate this increase could be as a result of fermentation and breakdown of fibers and. Reversal was observed for total solid due to increase in the moisture content as the digestion process continue to the last stage after digestion. Volatile solid decreases in concentration of the digested bagasse and cow dung, these could also attributed to breakdown of the molecules their by increases the surface area which was subjected to ignition since the process went through a lot where substrates were volatilized as compared to when it was not yet breakdown or digested by microorganism because the process is microbial enhance process. There were decrease in carbon content of the substrate after digestion have taken place because of the minerals that was presents in the substrates that was use before since carbon and ash have similarities in respect to utilization. Nitrogen content increases in the digestion time because the fermentation that took place, during fermentation a lot of microbial metabolite where produce which cause breakdown hence there was increase of nitrogen. Most microbial metabolites are protein in nature.

Table 1: Proximate analysis of the Substrate before the Anaerobic Co-digestion

S/NO	Digester	Moisture %	Total solid %	Volatile solid %	ASH %	Carbon content %	Nitrogen %	BOD
1	D1	83.83	16.17	0.84	2.84	4.21	0.92	209
2	D2	68.75	31.25	10.64	12.63	1.68	1.94	129
3	D3	71.27	28.73	1.00	3.00	2.62	2.72	106
4	D4	48.73	51.22	0.74	2.74	1.04	1.96	62
5	D5	78.55	21.45	10.83	12.83	4.32	2.93	240
6	D6	79.48	20.52	9.84	11.84	3.28	2.00	214
7	D7	78.22	21.78	4.88	6.88	2.11	2.98	189
8	D8	57.16	42.84	2.37	4.37	1.63	1.06	109

The physiochemical parameters of bagasse and cow dung after fermentation is shown in Table 2. The moisture content of the fermenting substrates material shows no significant difference p>0.05 between D1 and D7 but the vary significantly p<0.05 when compared with the rest treatment. The total solid of the treatments also shows D4 to have a superior value (31.13%) and varies significantly p<0.05 when compare with remaining treatment after fermentation. While for the volatile solids and ash content of the treatments shows a significant difference p<0.05 between D2 when compared with the remaining treatments. While for the Carbon, Nitrogen and Biological oxygen demand shows D5 to vary significantly p<0.05 when compared to the rest treatment after fermentation period having a higher value (4.17, 3.344 and 240) respectively.

Table 2: Proximate analysis of the Substrate after the Anaerobic Co-digestion

S/NO	Digester	Moisture %	Total solid %	Volatile solid %	ASH %	Carbon content %	Nitrogen %	BOD
1	D1	89.41	10.59	0.92	2.92	3.24	1.04	190
2	D2	73.88	26.12	9.63	11.63	1.08	2.34	115
3	D3	83.41	16.59	0.18	2.18	1.84	2.98	90
4	D4	68.92	31.08	1.00	3.00	0.98	1.98	50
5	D5	88.44	11.56	9.21	11.21	4.21	3.11	200
6	D6	88.31	11.69	7.48	9.48	3.06	2.72	192
7	D7	89.42	10.58	2.72	4.72	2.00	3.04	186
8	D8	74.16	25.84	2.32	4.32	1.14	1.11	70

he highest methane generation crests that appeared in the eight experimental series are on the twenty second day 22. The Means were significantly different (p<0.05). The methane content was tested every day, as shown in Figure 4. At day 1 to day two 2, no gas was produced across all the treatments., while days 3, 4, 5, 6, 7, 8, 9, 10, 11 up to day 30 demonstrated a similar trend in methane content, where it increased rapidly to a stable level and then gradually decreased as the substrate degraded. Overall, D2 was observed to vary significant when compared with the rest treatment throughout the fermentation periods and produces highest methane content.

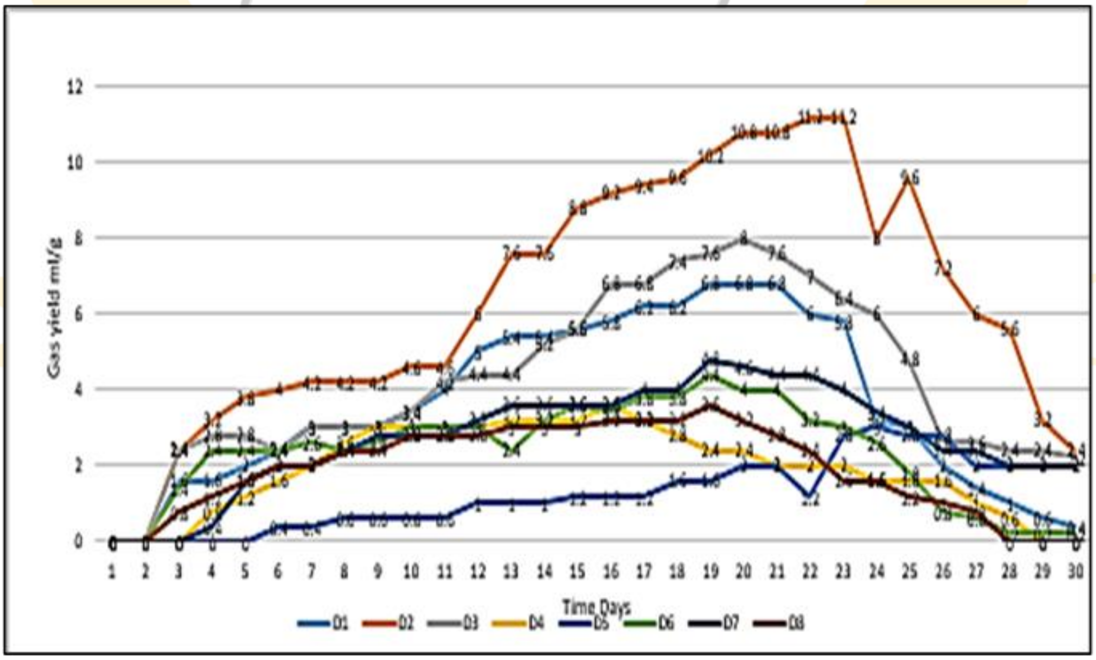

Figure 1: Gas Yield ml/g treatments.

p-ISBN: 978-978-774-670-7

Table 3: Gas production yield of Bagasse and Cow dung mixture during fermentation

HRT	Gas Production (grams) in the Gas Bag							
(Days)	D1	D2	D3	D4	D5	D6	D7	D8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	1.6	2.4	2.4	0.0	0.0	1.4	0.0	0.8
4	1.6	3.2	2.8	0.8	0.0	2.4	0.4	1.2
5	2.0	3.8	2.8	1.2	0.0	2.4	1.6	1.6
6	2.4	4.0	2.4	1.6	0.4	2.4	2.0	2.0
7	3.0	4.2	3.0	2.0	0.4	2.6	2.0	2.0
8	3.0	4.2	3.0	2.6	0.6	2.4	2.4	2.4
9	3.0	4.2	3.0	3.0	0.6	2.6	2.8	2.4
10	3.4	4.6	3.4	3.0	0.6	3.0	2.8	2.8
11	4.0	4.6	4.2	3.0	0.6	3.0	2.8	2.8
12	5.0	6.0	4.4	3.0	1.0	3.0	3.2	2.8
13	5.4	7.6	4.4	3.2	1.0	2.4	3.6	3.0
14	5.4	7.6	5.2	3.2	1.0	3.2	3.6	3.0
15	5.6	8.8	5.6	3.2	1.2	3.6	3.6	3.0
16	5.8	9.2	6.8	3.6	1.2	3.4	3.6	3.2
17	6.2	9.4	6.8	3.2	1.2	3.8	4.0	3.2
18	6.2	9.6	7.4	2.8	1.6	3.8	4.0	3.2
19	6.8	10.2	7.6	2.4	1.6	4.4	4.8	3.6
20	6.8	10.8	8.0	2.4	2.0	4.0	4.6	3.2
21	6.8	10.8	7.6	2.0	2.0	4.0	4.4	2.8
22	6.0	11.2	7.0	2.0	1.2	3.2	4.4	2.4
23	5.8	11.2	6.4	2.0	2.8	3.0	4.0	1.6
24	3.2	8.0	6.0	1.6	3.0	2.6	3.4	1.6
25	3.0	9.6	4.8	1.6	2.8	1.8	3.0	1.2
26	2.0	7.2	2.6	1.6	2.8	0.8	2.4	1.0
27	1.4	6.0	2.6	1.0	2.0	0.6	2.4	0.8
28	1.0	5.6	2.4	0.6	2.0	0.2	2.0	0.0
29	0.6	3.2	2.4	0.0	2.0	0.2	2.0	0.0
30	0.4	2.4	2.2	0.0	2.0	0.2	2.0	0.0

It was obvious that the peak time of methane production in anaerobic co-digestion digesters was obviously shorter than that in D1. This was possibly due to the anaerobic co-digestion stimulating the growth of methanogen microorganisms. As reported by Mu *et al* (2020), a higher methane content in biogas with the optimization of the anaerobic co-digestion using various types of organic solid wastes. This was possibly due to the Anaerobic co - digestion stimulating the growth of methanogenic microorganisms (Murto *et al*., 2004; Muzenda, 2014).

4.0 Conclusion

A laboratory batch anaerobic digester has been used to evaluate biogas yields Bagasse and Cow dung at different ratio in the mixtures using mesophilic temperature. At the different ratios of the yield, it was observed that there exit significant methane yields of the selected substrates. Both Bagasse and Cow dung have good proximate composition that support biogas production. Also, the results showed that co-digestion of Bagasse and Cow dung plus Inoculum have higher yields when compared with mono substrate. The study is in agreement with the previous similar studies of various researchers on the effect of co-digestion on biogas yields.

Acknowledgment

The authors are thankful for to the Department of Animal production Laboratory, Water and Fishery Technology (WAFT) Laboratory and Food Science and Technology Laboratory at F.U.T. Main Campus, Minna where the research was carried out..

Conflict of Interest

The authors declare that there is no conflict of interest of interests regarding the publication of this paper.

REFERENCES

1. Fidelis, O. A., Bashir, A., Kayode, H. L., Oluniyi, O. F., Temitope, F. A., Nathaniel, A. N., Ishaq, D. S., Adamu, Y. U., Hong, C. W., Aijie, W. (2021). In Ajay K., Vipin, K. S., Pardeep, S. and Virendra, K. M. (Eds.), *Environmental pollution and their socioeconomic impacts*. In: Microbe Mediated Remediation of Environmental Contaminants, Pp. 321-354, Woodhead Publishing Series in Food Science, Technology and Nutrition, Woodhead Publishing.
2. Singh, A. and Rashid, M. (2017). Impact of animal waste on environment, its managemental strategies and treatment protocols to reduce environmental contamination. *Veterinary Science Research*, 8(1 & 2): 1-12.
3. Adeniran, K. A., Akpenpuun, T. D., Akinyemi, B. A., & Wasiu, R. A. (2017). Effectiveness of Moringa oleifera seed as a coagulant in domestic wastewater treatment. *African Journal of Science, Technology, Innovation and Development*, 9(3), 323–328. https://doi.org/10.1080/20421338.2017.1327475
4. Tamilselvi, N. A., and Arumugam, T. (2019). Health Benefits, Therapeutic and Pharmacological Properties of Moringa- A Review. *Journal of Pharmaceutical Research International*, 25 (1):1-11.
5. Eman N.A., Tan C. S., Manaf A. M., Essam A. M., (2017). The use of *Moringa oleifera* seed as a natural coagulant for wastewater treatment and heavy metals removal, *Applied Water Science*, 7, 1369-1376.
6. Villasenor, D, Astudillo-Sanchez, PD and Bandala, ER (2018). Wastewater Treatment using *Moringa oleifera* Lam Seeds: A Review. *Journal of Water Process Engineering*, 23(1), 151-164.
7. Marzougui, N., Guasmi, F., Dhouioui, S., Bouhlel, M., Hachicha, M., Berndtsson, R., and Sleimi, N. (2021). Efficiency of Different *Moringa oleifera* (Lam.) Varieties as Natural Coagulants for Urban Wastewater Treatment. *Sustainability*, 13(23), 13500. https://doi.org/10.3390/su132313500.
8. Desta, W. M., Bote, M. E. (2021). Wastewater treatment using a natural coagulant (*Moringa oleifera* seeds): optimization through response surface methodology. *Heliyon*,7(11), e08451.
9. Vigneshwaran, S., Uthayakumar, M., and Arumugaprabu, V. (2020). Potential use of industrial waste-red mud in developing hybrid composites: A waste management approach. *Journal of Cleaner Production*, 276, 124278.
10. Megersa, M., Beyene, A., Ambelu, A., Asnake, D., Bekele, T., Firdissa, B., Alebachew, Z., and Triest, L. (2016). A preliminary evaluation of locally used plant coagulants for

household water treatment. *Water Conservation Science and Engineering*, 1(2), 95–102. https://doi.org/10.1007/s41101-016-0006-y.

11. Tunggolou, J. and Payus, C. (2017). Application of *Moringa oleifera* plant as water purifier for drinking water purposes. *Journal of Environmental Science and Technology*, 10(5): 268–275.
12. Yuliastri, I. R.,Rohaeti, E., Effendi H., and Darusman, L. K.(2016). The use of *Moringa oleifera* seed powder as coagulant to improve the quality of wastewater and ground water. *IOP Conference Series: Earth and Environmental Science,* 31 (1), 012033. DOI: 10.1088/1755-1315/31/1/012033.
13. Verma, R.K., Kumar, R., Sethi, M. (2020). Use of Distinct Parts of Moringa Oleifera in Domestic Wastewater Treatment (An Analogous Study). *2020 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions)*(*ICRITO*), Noida, India, 2020, pp. 463-467. Doi: 10.1109/ICRITO48877.2020.9197942.