iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** III **Month of publication:** March 2024

DOI: https://doi.org/10.22214/ijraset.2024.59546

A Study on Utilization of Co-Digested *Citronella* Oilmeal Cake, Cow Dung and Poultry Dropping for Enhancement of Biogas Yield

Shilpa Bhajani[1], Dr Sanjay L Pal[2]
[1]*Research Scholar Sevadal Mahila Mahavidyalaya, Nagpur*
[2]*Assistant Professor Sevadal Mahila Mahavidyalaya, Nagpur*

Abstract: Power plays a pivotal role in the industrial, economic and infrastructural development of the country's growth. India is on the exponential growth paradigm and is playing a leadership role in the implementation of renewable energy projects for achieving the INDC's committed in the Paris agreement and meeting the net carbon zero economy by 2070. The present research work attempts to utilize the co-digested agriwaste and livestock to enhance the biogas productivity. The experimental study considered a co-digested feedstock of cow dung (CD), poultry dropping (PD) and Citronella grass oilmeal cake (CG) using different ratios of each in five different digesters. Amongst all five digesters R1, R2, R3, R4 and R5; R4 having a co-digested feedstock of CD: PD: CG in the ratio of 20% : 55% : 25% respectively. The cumulative biogas yield for an experimental period was observed to 41.26 litres whereas the methane percentage in the biogas was 74%. The feedstock quantity required for 1 m^3 biogas production was found to be 18.9 kg which was observed to be lower than the cowdung based monodigester which is 25 kg. Thus, co-digestion of the Citronella grass oilmeal cake along with poultry dropping using cow dung as substrate showed promising results which can be scaled up to commercial level biogas plants in villages where these feedstocks are easily available.
Keywords: Anaerobic Digestion, Agriwaste, Poultry waste, Biogas, co-digestion

I. INTRODUCTION

India being an agrarian economy generates huge quantity of agricultural and livestock waste are available in the rural areas. The disposal of these waste poses a problem to the municipal councils. One of the innovative solutions of converting the waste to wealth can be converting this waste to energy (biogas). India has proactively set a target of renewable energy from different alternative energy sources. Thus, we can optimize the bioenergy to the benefit of society by installing biogas plant creating employment and entrepreneurship opportunities in the rural areas. India's energy sector contributes 68.7% of greenhouse gases of the total country's greenhouse gas emissions (Nehra and Jain 2023). In India the biogas potential is estimated to 12.3 million, whereas, biogas plants installed are found to be 50.28 lakh family/small size biogas plants till 2018–19. 87990 m^3 biogas plant has generated an off-grid power of 895.15 kW (Kaur, et al. 2022)

Anaerobic treatment of the waste to generate biogas has been practiced since the ancient days. The anaerobic treatment of organic waste involves the degradation of organic matter in absence of oxygen. The organic matter is treated by different microorganisms at each step of anaerobic digestion and hence they slurry requires different digester conditions as the anaerobic process of hydrolysis, acidogenesis, acetogenesis and methanogenesis (Jingura and Kamusoko 2017). The initial stages of anaerobic treatment requires acidic conditions whereas the methanogenesis requires neutral to near neutral conditions. The bacteriological activity of the micro-organisms decomposes the organic matter into simpler molecules forming the intermediates and in the process release methane as a by-product. The anaerobic treatment in the biodigester undergoes through 4 vital steps of breakdown of complex organic matter which are hydrolysis, acidogenesis, acetogenesis and methanogenesis.

The pH of the slurry differs at every stage of treatment. The pH in the hydrolysis stage is around 6.8 and gradually the pH of the slurry increases till it reached the methanogenesis. The pH of the slurry also affects the biogas microbe's activity. The hydrolytic bacteria prefer slightly acidic to neutral pH while methanogenic bacteria prefer alkaline pH. Similarly, other parameters like the alkalinity, COD, volatile fatty acids, etc. needs to be monitored on the daily basis for maintaining the digester at optimum conditions to increase the biogas productivity.

II. MATERIALS AND METHODS:

A. Feedstock

The Citronella grass oilmeal cake (CG) was collected from the agricultural field in Kalmeshwar, Nagpur and poultry droppings were collected from Poultry Research & Training Centre, Telangkhedi, Nagpur, whereas cow dung was procured from the villagers in Besa involved in livestock business. The agricultural waste, cow dung and poultry droppings after procurement were sundried and then subjected to crushing and shredding in a shredding machine. The feedstocks were characterized before and after digestion in the reactors. Crop residues offer a promising potential for using as feedstock for the biogas plants. Bruan et al., 2009 have studied the forage crops which can be easily degraded and produce high biogas yield (Braun, Weiland and Wellinger 2009). Non-food crops also have shown good potential to generate biogas. Jatropha *curcas* presscake have been found to increase a biogas yield upto 60% as compared to cowdung based digester. The methane content in *Jatropha* based digster was observed to be 60% (Singh, *et al.* 2008). Hence we have considered a co-digested feedstock to study the enhancement of biogas quantitatively and qualitatively.

B. Experimental set-up

Laboratory scale digesters of 12 litres were set-up. There were 5 such digesters each subjected to anaerobic digestion with varying proportions of feedstock. The working volume of the digesters was 10 litres. The digestion process was carried out under mesophilic conditions and the total solids were maintained at 8%. The inlet pH of the digester were maintained between 6.0 – 7.5. The five reactors (R1, R2, R3, R4 and R5) were having the different ratios of Cow Dung (CD) : Poultry Droppings (PD) : Citronella Grass oilmeal cake (CG). The ratios in these reactors with co-digested CD : PD : CG were as follows: R1 (50% : 40% : 10%); R2 (40% : 45% : 15%); R3 (30% : 50% : 20%); R4(20% : 55% : 25%) and R5 (10% : 60% : 30%) respectively. The biogas digesters were initially fed with the feedstock and kept undisturbed for digestion for a period of 10 days. After the initial digestion, the digesters were daily fed with 300 ml of the freshly prepared slurry of required ratio and 300 ml of the digester slurry was removed from the digester. The digester inlet and outlet slurry was analysed on a daily basis to record the digester parameters like pH, COD, VFA, total alkalinity, etc. the pH of the digester was maintained between 6.5 – 7.6. The biogas productivity was measured with the help of water displacement method and the percent methane gas was measured using methane analyzer. The experimental setup was run for a period of 31 days. The average ambient temperature was recorded to be 33.5°C.

C. Analytical Methods

The characteristics of co-digested feedstock cow dung, poultry droppings and citronella grass oilmeal cake were done before the digestion process. The characteristics of the co-digested feedstocks are mentioned in Table no. 1. The standard methods from APHA manual were followed for determination of pH, alkalinity, moisture content, total solids, volatile solids, ash content, total carbon, volatile fatty acids (VFA's), Total Kjeldahl nitrogen (TKN), Total Phosphorus, Total Potassium, Crude Protein and C/N ratio (APHA 2016).

Table No. 1 Characteristics of co-digested feedstock cow dung (CD), poultry droppings (PD) and Citronella Grass oilmeal cake (CG)

Parameters	Cow Dung (CD): Poultry Droppings (PD): *Citronella* Grass (CG)				
	50%: 40%: 10%	40%: 45%: 15%	30%: 50%: 20%	20%: 55%: 25%	10%: 60%: 30%
pH	7.2	7.6	7.4	6.8	6.6
Alkalinity (mg/l)	1025	742	779	750	700
Moisture Content (%)	7.9	7.5	7.8	7.6	7.4
Total Solids (%)	25.7	20.8	18.4	16.2	14.56
Volatile Solids (%)	89.21	86.24	85.12	84.91	79.25
Ash Content (%)	4.5	4.04	4.03	4.02	4
Total carbon (%)	41.21	42.74	43.2	44.15	44.7

Parameters	Cow Dung (CD): Poultry Droppings (PD): *Citronella* Grass (CG)				
	50%: 40%: 10%	40%: 45%: 15%	30%: 50%: 20%	20%: 55%: 25%	10%: 60%: 30%
VFA (mg/l)	1285	1365	1250	1200	1350
Total Kjeldahl Nitrogen (TKN) (%)	2.23	2.25	2.22	2.29	2.28
Total Phosphorous (%)	1.61	0.51	1.00	0.93	1.21
Total Potassium (%)	1.92	0.60	1.72	1.69	2.33
Crude Protein	13.94	14.06	13.88	14.31	14.25
C/N ratio	18.48	19.00	19.46	19.28	19.61

III. RESULT AND DISCUSSION

A. *Characteristics of the Substrates Used*

The characteristics of the co-digested substrates for the cow dung, poultry droppings and *citronella* grass oilmeal shows that the pH of the setup range from 6.6 – 7.6 which is within the favourable range for the hydrolysis process of anaerobic digestion. The alkalinity of the digester is observed to decreasing with the increase in the lignocellulosic content (i.e. *Citronella* grass oilmeal cake) The total solids were found to be in the range of 14.56 – 25.7%. The volatile solids in the different ratios were observed to be between 79.25% - 89.21% suggesting a considerable amount of organic matter in the feedstocks. The volatile fatty acids (VFA's) is observed to be increasing with the increase in the *citronella* grass oilmeal cake concentration. The nitrogen, phosphorus and potassium content was observed to be higher in the Citronella grass oilmeal cake rich slurry as these elements are required by the green plants for the growth. The crude protein was also found to higher in digester having higher percentage of *Citronella* grass oilmeal cake. The C/N ratio is observed to have increased in the co-digested feedstock which is necessary for the digester operation at optimum level.

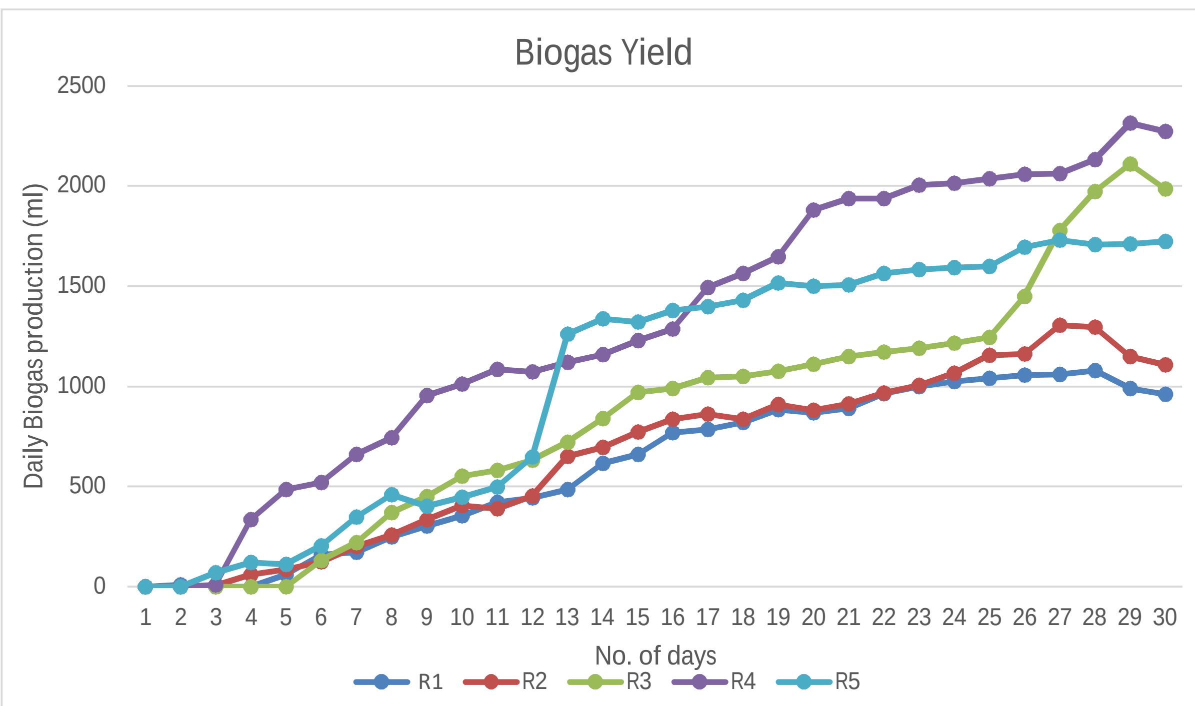


Figure.1 Daily biogas production from the co-digested feedstock of cow dung (CD), poultry dropping (PD) and *Citronella* oilmeal cake (CG) in different digesters having different ratios

B. *Biogas Production*

The daily biogas production of co-digested feedstock of cow dung (CD), poultry droppings (PD) and Citronella oilmeal cake (CG) having different ratios in the reactors R1, R2, R3, R4 and R5 are is shown in the Figure. 1. The figure depicts that the daily maximum quantity of biogas production was observed to be highest in R4 reactor followed by R5, R3, R2 and R1. Thus, we found that the daily biogas and cumulative biogas yield was highest for the R4 reactor having a co-digested feedstock of cow dung (CD), poultry droppings (PD) and *Citronella* grass oilmeal cake in the ration of 10%: 60% : 30%. The productivity of biogas enhanced by using a co-digested feedstock.

C. *Performance of Biogas Reactors*

Table No. 2 Performance of five different ratios of co-digested cow dung, poultry droppings and citronella grass oilmeal cake in five laboratory scale digesters

Cow Dung (CD): Poultry Dropping (PD) : *Citronella* grass oilmeal cake (CG)

Digester ratios	Total feed required (gms)	Cumulative COD Reduction (%)	Biogas Yield (ml)	Methane Content (%)
R1 (50% : 40% : 10%)	784	24.84%	18120	53%
R2 (40% : 45% : 15%)	776	25.63%	19868	60%
R3 (30% : 50% : 20%)	832	37.95%	27992	67%
R4 (20% : 55% : 25%)	780	52.25%	41266	74%
R5 (10% : 60% : 30%)	776	39.06%	30852	61%

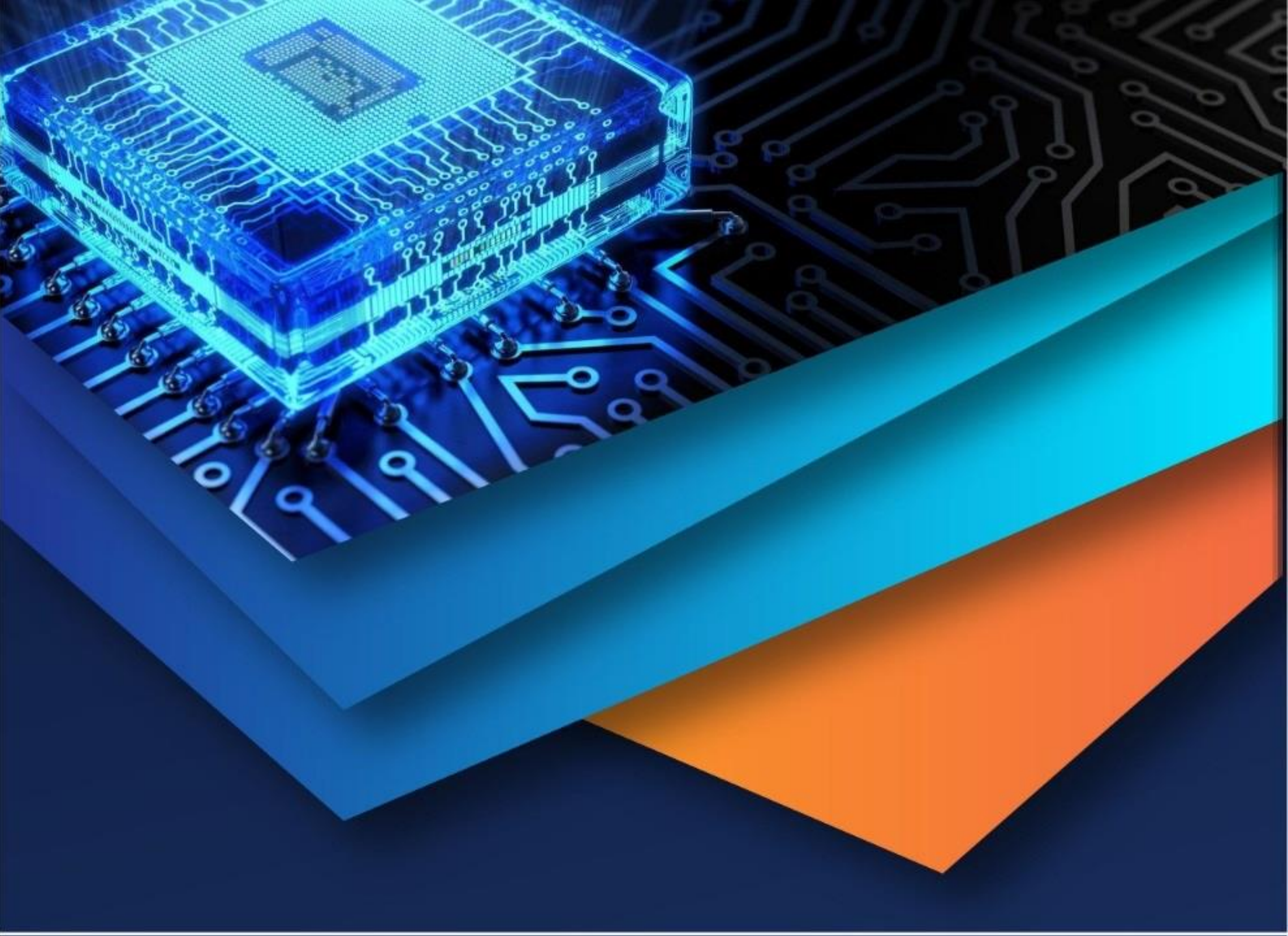
Table No. 2 depicts the overall performance of the set up of five digester containing various ratios given in the table. The digesters were named R1, R2, R3, R4 and R5. From the above table we can observe that the maximum cumulative COD reduction was found in R4 digester which is 52.25%. The biogas yield was also observed to be maximum i.e. 41266 ml having a methane content of 74%. The higher concentration of animal waste which already has undergone digestion in the animal stomach with an optimum concentration of the lignocellulosic *citronella* grass oilmeal cake aided the process of degradation resulting in increasing the biogas productivity. The percentage methane content was recorded with the help of methane analyzer. The calorific value rises in the proportion of the increase in the methane content in the biogas. The biogas generation for $1m^3$ of biogas for R1, R2, R3, R4 and R5 was found to be 43.27 kg, 39.06 kg, 29.72 kg, 18.9 kg and 25.15 kg respectively. Thus, we can interpret that the R4 digester is found to have the right combination of the feedstock which optimized the biogas yield with the least amount of feedstock. Thus, increasing the process efficiency of the anaerobic treatment showing promising results.

IV. CONCLUSION

The research work conducted showed promising results for the co-digested feedstock of cow dung, poultry droppings and *citronella* grass oilmeal cake. The study revealed that co-digestion helps in improving the productivity of biogas quantitatively as well as qualitatively. The innovative applicability of agricultural waste i.e. citronella grass oilmeal cake left over after the extraction of oil and the animal waste can provide a sustainable resource to generate energy from the waste. These biogas plants can serve as revenue-based model in villages where the feedstock is easily available.

REFERENCES

[1] APHA. 2016. Standard Methods for Examination of Water and Wastewater. 21st. Washington DC: American Public Health Association.
[2] Braun, R, P Weiland, and A Wellinger. 2009. “Biogas from energy crop digestion.” IEA Task 37 Brochure (International Energy Agency).
[3] Jingura, Raphael Muzondiwa, and Reckson Kamusoko. 2017. “Methods for determination of biomethane potential of feedstocks: a review.” Biofuel Research Journal 14: 573-586. doi:10.18331/BRJ2017.4.2.3.
[4] Kaur, Gagandeep, Naveen Kumar Sharma, Jaspreet Kaur, Mohit Bajaj, Hossam M Zawbaa, Raina A Turky, and Salah Kamel. 2022. “Prospects of biogas and evaluation of unseen livestock based resource potential as distributed generation in India.” Ain Shams Engineering Journal (Elsevier) 13.
[5] Nehra, Mayank, and Sheilza Jain. 2023. “Estimation of renewable biogas energy potential from livestock manure: A case study of India.” Bioresource Technology Reports (Elsevier) 22. doi:https://doi.org/10.1016/j.biteb.2023.101432.
[6] Singh, R N, D K Vyas, N S.L Srivastava, and M Narra. 2008. “SPERI experience on holistic approach to utilize all parts of Jatropha curcas fruit for energy.” Renewable Energy 33 (8): 1868-1873.



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY