OPTIMISATION OF BIOGAS PRODUCTION

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Introduction:

Biogas is a locally accessible and renewable energy source that can be generated from organic feedstocks under anaerobic conditions. With the accessibility and potential India possesses in this field of energy it is important to make the right developments to harness this power efficiently and effectively. With the current energy crisis it is important for each nation to make the transition to clean energy to help ensure the energy demand is being met in a sustainable way. It is estimated that the biogas potential ranges from 310-655 billion m3/year in the year 2040 depending upon 18 availability of different resources. With such a potential to aid the current energy demand in India, it is important to try and push development to ensure quicker implementation and better functionality.

The Indian economy and the never declining trend of energy consumption makes us find some alternative ways so to achieve sustainable energy needs. It is important that we also consider the environmental impact of the present energy extractions. The present energy extraction practices along with the drawbacks in the existing renewable or alternative sources will motivate to make changes in the design of the digesters from an engineering point of view. Biogas technology provides very attractive ways to exploit various categories of biomass for meeting partial energy needs. The biogas which works properly will give any kind of benefits to the users and for the society resulting in energy resource preservation and environmental protection. Our main agenda in this research work is to improve the biogas yield, thus the outcome of these experiments is to find out the ratio and additive that gives the best yield of biogas. The importance of the result is that the conventional method of biogas production can be improved and a minute change in the ratio of water to matter can bring a great difference in biogas production. This study is going to motivate the people to shift towards renewable energy and to save the earth from the crisis of energy sources. Increase the biogas production will lead to maximum usage of the same. This biogas energy is Green and safe energy. The pollution occurs by this biogas is very less, compared to the other sources of energy.

Objectives:

- To use various organic additives to improve biogas yield at 1:3 cow dung to water ratio
- To analyse the composition of the biogas yield obtained

Methodology:

The setup consists of 20 reactors with cow dung, water, and inoculum in various proportions. Each bottle was filled with cow dung, water, and inoculum of various proportions. Two reactors are in 1:1 ratio with 500 g of cow dung, 450 g of water and 50 g of inoculum without any additives. Two other reactors are in 1:3 ratio (250 gm cow dung, 700 ml water and 50 ml inoculum), without any additives. These digesters are control reactors. The remaining 14 reactors are in 1:3 ratio (250 gm cow dung, 700 ml water and 50 ml inoculum) along with various additives. Additives were added in appropriate proportions, and the reactors were numbered based on the combination of additives added. Leak tests of the bottle caps and tyre tubes were done to ensure that the process was completely anaerobic. M-seal was added at the top of the bottle caps, and teflon tape was used around the bottle mouth to facilitate the process without leakage. In the end, we covered each bottle with aluminium foil properly so that direct sunlight does not affect the temperature change abruptly. The volume of gas collected is proportional to the volume of water displaced based on the principle of water displacement.

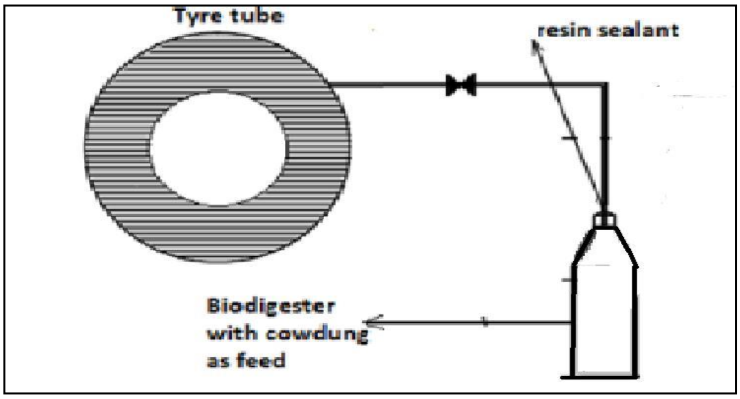


Figure 1: Schematic representation of the batch experimental setup

Table 1: List of materials used in the experiment

Sl No	Materials	Sl No	Materials
1	1.25-liter soda bottles	8	Bucket (Water)
2	M-seal/ Teflon sealant	9	Cow dung, inoculum
3	Flexible pipes/ Adapter	10	Organic/inorganic additives
4	Measuring Jar, Measuring Cylinder	11	Drilling machine/Power Supply
5	Funnel, Glass rod	12	Scissors/Knife/Scale
6	Weighing scale, Mixie Grinder	13	Tyre tubes
7	Aluminum foil	14	Dye

Table 2: Base feed and additive combinations in the reactors

Reactor Number	Cow Dung to Water Ratio	Base Feed Contains	Additives Combination
1	1:3	250g cow dung, 700ml water and 50ml inoculum	-
2	1:3	250g cow dung, 700ml water and 50ml inoculum	-
3	1:3	250g cow dung, 700ml water and 50ml inoculum	Cabbage waste
4	1:3	250g cow dung, 700ml water and 50ml inoculum	Cabbage waste
5	1:3	250g cow dung, 700ml water and 50ml inoculum	Bamboo biochar
6	1:3	250g cow dung, 700ml water and 50ml inoculum	Bamboo biochar
7	1:3	250g cow dung, 700ml water and 50ml inoculum	Bamboo biochar + Cabbage waste
8	1:3	250g cow dung, 700ml water and 50ml inoculum	Bamboo biochar + Cabbage waste
9	1:3	250g cow dung, 700ml water and 50ml inoculum	Fish waste
10	1:3	250g cow dung, 700ml water and 50ml inoculum	Fish waste
11	1:3	250g cow dung, 700ml water and 50ml inoculum	Fish waste + Bamboo biochar
12	1:3	250g cow dung, 700ml water and 50ml inoculum	Fish waste + Bamboo biochar
13	1:3	250g cow dung, 700ml water and 50ml inoculum	Fish waste + Bamboo biochar + $NaHCO_3$
14	1:3	250g cow dung, 700ml water and 50ml inoculum	Fish waste + Bamboo biochar + $NaHCO_3$
15	1:3	250g cow dung, 700ml water and 50ml inoculum	Bamboo biochar + $NaHCO_3$
16	1:3	250g cow dung, 700ml water and 50ml inoculum	Bamboo biochar + $NaHCO_3$
17	1:3	250g cow dung, 700ml water and 50ml inoculum	Cabbe biochar + $NaHCO_3$
18	1:3	250g cow dung, 700ml water and 50ml inoculum	Cabbe biochar + $NaHCO_3$
19	1:1	500g cow dung, 450ml water and 50ml inoculum	-
20	1:1	500g cow dung, 450ml water and 50ml inoculum	-

1. Total Solids (TS):

Total solids (TS) were determined by weighing the residue left after the water in the cow dung sample evaporated at 105°C for 5 hours.

Procedure to calculate total solids:

A novel process (dilution method) was devised for determining the total solids in a cow dung sample. In a petri dish, 2 grams of cow dung was diluted with a specified amount (5 ml) of water. The resulting slurry was thoroughly stirred to break any lumps and create a homogeneous slurry that is dilute in nature. The slurry was heated for 5 hours at 105 °C in a hot air oven. This approach eliminated uneven drying caused by the formation of crusts and lumps and produced reliable results in a short time.

Determination of total solids

% T.S = [(W2-W1)/(W3-W1)] *100
% T.S = Percentage of total solids
W1= Empty weight of petri dish
W2= Weight of petri dish + dried cow dung sample (after 5 hours)
W3= Weight of petri dish + sample of cow dung initially taken

2. Fixed Solids and Volatile Solids

The fixed solids were determined by burning (incineration) at 500°C in a muffle furnace for 2 hours and calculate the residue.

Procedure for calculating fixed and volatile solids

A specific weight of cow dung (about 2 grams) was taken in a silica crucible. This cow dung sample was burnt (incinerated) in a muffle furnace at 500°C for 2 hours. After 2 hours, the door was opened for 1 hour to allow it to cool, and then the silica crucible was taken out, and the contents were weighed.

Volatile solids = Total solids - Fixed solids

Volatile solids

The fraction of volatile solids in total solids is usually expressed in percentages. After the sample (cow dung) is incinerated at 500°C, the dry solid remains.

Determination of volatile solids

% V.S. = [[(W2-W1)- (W4-W5)]/(W2-W1)] *100
% V.S.= Percentage of Volatile Solids
W5 = Weight of empty silica crucible
W4 = Weight of silica crucible + Weight of dried residue after incineration
W6 = Weight of silica crucible + Weight of cow dung sample initially taken

Ash Production

Ash was generated by burning dry cow dung samples in a silica crucible at 500°C for a couple of hours in a muffle furnace.

% of Ash generated = (W4 -W5)/ (W6 -W5) *100

Conclusion:

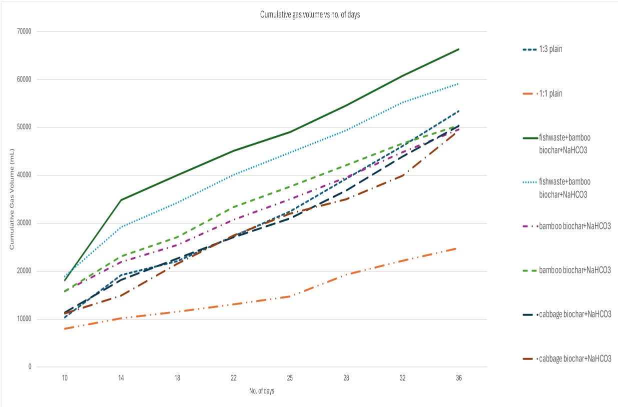
Table 3: Proximate Analysis of Cow Dung Feed

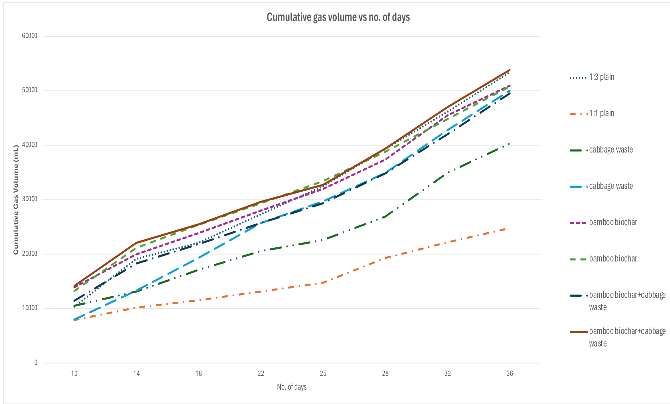
Total Solids	22%
Volatile Solids	85%
Ash (% of cow dung)	3%

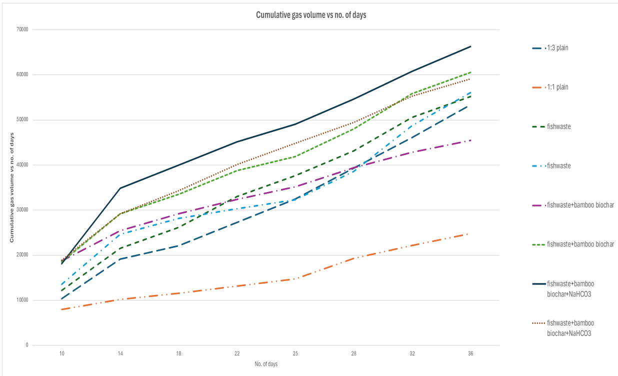
The cumulative yield results of each reactor were plotted graphically, and the effect of different additives was studied. The gas was collected every 3-4 days upto 36 days. The cumulative yield standardised per kg of cow dung was plotted along with the number of days of the experiment.

Table 4: Cumulative volume of biogas collected in each reactor

Bottle Number	Reading Date							
	04-Apr	08-Apr	12-Apr	16-Apr	19-Apr	22-Apr	26-Apr	30-Apr
1	10800	20320	26920	32920	38720	45480	52520	61120
2	10360	19160	22080	27320	32440	39320	46120	53400
3	10520	13120	17120	20560	22640	26920	34920	40320
4	8040	13280	19280	25720	29720	34920	42720	50040
5	13880	19960	23880	27960	32000	37360	45480	50920
6	13200	21200	25360	29360	33360	38760	44800	50800
7	11480	18320	21840	25760	29360	34800	42000	49480
8	14200	22120	25440	29560	32720	39360	47000	53800
9	12160	21520	26200	33040	37640	43160	50560	55200
10	13560	24640	28160	30320	32320	38600	48760	56080
11	18760	25480	29160	32400	35160	39400	42840	45480
12	18480	29200	33480	38800	41880	48000	55880	60520
13	18080	34880	40000	45120	49040	54640	60800	66320
14	18880	29200	34320	40120	44800	49440	55280	59160
15	15840	21920	25520	30720	35040	39600	44880	49600
16	15840	23120	27160	33440	37640	42160	46720	50400
17	11360	18160	22680	27080	31000	36840	43960	50360
18	11200	14880	21600	27440	32000	35040	39920	49320
19	6600	9080	10560	12780	14760	17940	22740	26740
20	7960	10200	11560	13140	14720	19320	22200	24800







The setups we have come with have the smaller capacity (1.25 liters) is best for carrying out experiments on the effect of additives, as it is added in small concentration and the time required for stabilization is also minimal when compared with larger digester.

In our work, so far, it can be observed that a combination of bamboo biochar, fishwaste and NaHCO3 has provided the greatest biogas yield - 24% more biogas than 1:3 plain reactor and 167% more biogas than 1:1 plain reactor. Fishwaste + bamboo biochar as additive proved to produce next highest biogas yield – 13% more biogas than 1:3 plain reactor and 144% more biogas than 1:1 plain reactor. All reactors have produced biogas in the range between 20,000 and 70,000 mL per kg cow dung cumulatively.

Scope for future work:

Future research can focus on optimizing the composition and concentration of organic additives, including biochar, to maximize biogas production. Additionally, scaling up these optimized conditions from laboratory to industrial-scale operations is crucial for practical implementation. Assessing the economic feasibility of implementing organic additives, such as biochar, in biogas production from cow dung is also important. Future research can focus on evaluating the cost-effectiveness of using these additives in terms of increased biogas yield, reduced input costs, and overall profitability.