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Quality Biogas and Energy Production in the Anaerobic Digestion of Napier Grass

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Abstract -- **India is a large consumer of CNG and major need is fulfilled by import, nearly 50% natural gas is imported. It also constitutes around 6.5% of our total energy basket. Biogas produced from cow dunk/ animal waste/ garbage/ kitchen waste can be an alternate for cooking. It contains methane up to 48%, comparatively it does not results to clean burning like natural gas. Also biomasses selected are solution to waste not solution for energy demand.**

If biomass selected is hydrocarbon rich and economical and optimum catalytic for anaerobic digestion is used then the chances of good quality methane rich biogas production are more.

The objective of present work is to produce biogas from Napier grass through anaerobic digestion using a combination of catalysts and compression on basis of methane percentage in it. After successful construction of biogas setup it is tested that around 78% methane content biogas is produced by anaerobic digestion of Napier grass as prime biomass.

Keyword-- Biogas; Methane content; Flame temperature; Biogas pressure; Napier grass

I. INTRODUCTION (*HEADING 1*)

1.1 Anaerobic digestion it is a process through which bacteria break down organic matter—such as animal manure, wastewater biosolids, and food wastes—in the absence of oxygen. Anaerobic digestion for biogas production takes place in a sealed vessel called a reactor, which is designed and constructed in various shapes and sizes specific to the site and feedstock conditions. These reactors contain complex microbial communities that break down (or digest) the waste and produce resultant biogas and digester which is discharged from the digester.

Multiple organic materials can be combined in one digester, a practice called co-digestion. Co-digested materials include manure; food waste (i.e., processing, distribution and consumer generated materials); energy crops; crop residues; and fats, oils, and greases (FOG) from restaurant grease traps, and many other sources. Co-digestion can increase biogas production from low-yielding or difficult-to-digest organic waste

1.1.1 Choosing a biomass

The choice of a biomass depends on several evaluation factors; The most important are:

Bromato logical and physical characteristics and its methane potential;

Type and availability in terms of quantity and continuity of supply;Economic value of the substrate and costs derived from its use. The amount of biogas that can be produced is closely related:

- Composition (amount and type of carbohydrates, lipids and proteins in the substrates);
- The presence or absence of lingo cellulosic structures that are not readily degradable;
- Particle size;

Therefore, before introducing biomass into the feed plan of a digester, the following parameters must be evaluated:

- dry matter or total solids (SS or ST);
- organic matter or volatile solids (SO or SV);
- fibrous component (cellulose, hemicellulose, lignin);
- total nitrogen and organic carbon;
- potential biogas production and its methane percentage.

1.1.2 Types of substrate

Silage biomass

It is preferable to include silage crops in the feeding plan, for the considerable advantage of being able to preserve them and thus guarantee a product with constant characteristics for long periods of time. The main energy crops used as silage can be divided into spring-summer crops such as maize, sorghum, chard and sunflower and autumn-winter crops such as barley, triticale, rye, ryegrass.

Good biogas yields are obtained with maize silage which is 25% higher than in pre-silage. This difference in production is probably due to the presence of acetic, lactic and formic acids that are formed during the silage process. They are in fact important precursors for the formation of methane (Madigan et al., 2000). Another reason is the pre-decomposition of the crude fiber that occurs during silage and that improves the availability of nutrients for methane metabolism (Castelli and Blacks, 2011).

1.2 PROCESS CONTROL PARAMETERS (ANAEROBIC DIGESTION)

Anaerobic digestion processes of agro-zootechnical substrates can be classified according to the following parameters: process temperature regime, solids content, number of phases (one or two) provided for by the plant design. In digesters with a single-stage process, the biological phases of digestion take place in the same reactor and at the same time, while in digesters with a two-stage process there are two distinct reactors, in series with each other, one dedicated mainly to the hydrolysis, acidogenesis and acetogenesis phases, the other to the methanegen phase. In agricultural biomass systems, the most common digesters are fully mixed single-stage, operating with a concentration of total solids or dry matter not exceeding 10% (wet process). The management of the anaerobic fermentation plant aims to maximize biogas production and the stability of this production over time. The goal is achieved with the homeostasis of the fermentation environment, keeping the level of biogas production constant (Castelli and Blacks, 2011). If the % of CH4 in the gas is not constant, this may indicate that an accumulation of acids has occurred and the process is therefore not proceeding in a balanced manner. In this case, the composition of the organic matter of the substrates must be evaluated. The maintenance of tight anaerobic conditions and constant temperature depends on the smooth functioning of all fermenter facilities, while the "operation of the fermenter" "biology" depends on the correct balance between the activity of the different microbial consortia, in particular, as mentioned above, on the efficiency of methanogenic bacteria. Some chemical-physical parameters are indicators of the stability of the process or the occurrence of malfunctions. The multiplicity of factors involved in the anaerobic digestion process determines a high risk of instability (Schoen and Sperl, 2009). For this reason, particular attention must be paid to the parameters that govern it:

- Quantity and quality of biogas
- Microbial composition
- temperature
- pH & Buffer System
- ammoniaca (NH3)
- Volatile Fatty Acids (VFA)
- Volatile Fatty Acid/Alkalinity Ratio
- C:N ratio
- water
- Macronutrients
- Micronutrients
- toxicity of the growing environment.

Each anaerobic digester is characterized by a unique microbial ecosystem, which depends, for example, on the design of the reactor, the composition and the quantity of substrates introduced. For this reason it is important to build, for each reactor/digester, a history of the values of the process parameters to identify the reference values of the plant and optimize its management (Castelli and Blacks, 2011).

1.3 The yield in biogas, biomethane and digestate from organic substrates

From the values of the average biogas and methane yields of DA of different types of organic substrates (Al Seadi et al., 2008; CTI, 2007) there is some variability between the various feedstocks: the highest average biogas production yield (202 $^{m3\ t-1}$) is obtained from maize silage, while the lowest (10 $^{m3\ t-1}$) comes from slurry. The average methane yield of all types of organic waste is above 50%, and in 2 cases above 60%, i.e. for pig slurry (65%) and distilled wheat (61%) (Comparetti et al., 2013a). From a quantity of 28,500 tons/year of biomass input to an anaerobic digestion plant, it is possible to obtain 1,100 tons of solid digestate at 0% moisture (or 1,500 tons at 25% moisture) plus 9,000 tons of solid digestate at 75% moisture and 10,000 tons of liquid digestate (Agroenergia Naro S.R.L., 2013).

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II. LITERATURE REVIEW

Mohamed Abdel-Hadi has done an experimental investigation of the flame temperature and voltage of biogas burner as a method to determine methane content in biogas. An experimental prototype has been developed to find the quality of biogas, which produced from mixture of cattle dung and chicken manure 50:50 %, total solid (7.8 % TS) by bench-scale continues anaerobic digester (horizontal type) with 17 liters digestion volume and 25 days hydraulic retention time (HRT). The hydraulic retention time was replicated two times under 38 °C mesophilic region in order to reach the steady state biogas product.

The obtained results showed that, the minimum flame temperature and voltage were 460 °C and 38 mV, respectively at 54.5 % methane. Meanwhile, the maximum flame temperature and voltage were 631 °C and 42.6 mV, respectively at 68.1 % methane. The average velocity of biogas passing through the port of burner (3 mm diameter) was 2.1 m/s and the average biogas pressure in gasholder was 996 mbar. The biogas flow rate through the port of burner was 0.9 liter/min and laminar, flow type.
The variation of flame temperature and voltage of the sample of biogas collected from a bench-scale anaerobic digester every day was also studied to find the change in quality throughout the second replicate hydraulic retention time. The obtained data indicated that, there was a proportional relationship between flame temperature, voltage and methane percentage in the biogas.
Pavan M et,al - have experimentally investigated that Bio-CNG is a purified form of biogas, in which all unwanted gases (> 95%) of pure methane gas are removed. Bio-CNG is exactly the same as the natural gas. In India, we have inadequacy in fuel sources, so we depend on oil-rich countries. Today there is a burning need for alternative fuels because fossil fuels are getting vanished. It is therefore necessary to find another source of energy .A replacement to those exhausting resources can be made by using Bio CNG. Bio-CNG is a good automotive fuel and has lower emissions and makes it more

environmentally friendly than biogas and other fuels.. Bio-CNG is much cheaper than other competitive fuels. The biogas produced from anaerobic digestion are further processed and hydrogen sulphide and carbon dioxide are removed so that the final product contains 90% - 95% methane to be used as Bio-CNG. f the Government of India focuses on Bio CNG, then there will be a reduction in imports of petroleum products, thus saving a significant amount of foreign exchange every year.

III. OBJECTIVE

Natural gas is renewable energy source. It is a petroleum product and extricated like any other fossil fuel also extent in availability. When it is compressed it becomes CNG or LPG, having applications in automobile, industrial heating, house hold cooking, etc. having methane content up to 99% by volume.

India is a large consumer of CNG and major need is fulfilled by import, nearly 50% natural gas is imported. It also constitutes around 6.5% of our total energy basket.

Biogas produced from cow dunk/ animal waste/ garbage/ kitchen waste can be an alternate for cooking. It contains methane up to 48%, comparatively it does not results to clean burning like natural gas. Also biomasses selected are solution to waste not solution for energy demand.

If biomass selected is hydrocarbon rich and economical and optimum catalytic for anaerobic digestion is used then the chances of good quality methane rich biogas production are more.

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IV CONSTRACTION OF BIOGAS MODEL

4.1. Material required.

1. curser- for cutting the biomass into fine size.
2. Digester tank- 250 Lt.
3. Pipe fittings
4. Pressure gage (auto clave 30 Bar)
5. Compressor-to fill biogas in pressure vessel.
6. Pressure vessel - to collect produced gas.

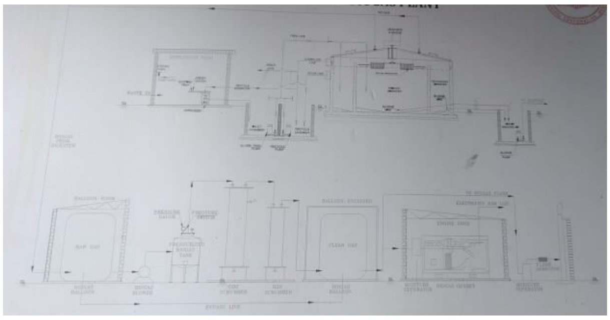

Fig.1 line diagram CBG plant.

After assembly of all above materials the experimental setup is shown in figure bellow

Fig 2 experimental setup

The experiment was conducted at Vidhyapeeth institute of science and technology Bhopal MP. Were biogas generation is done by Napier grass as biomass and following constituents for anaerobic digestion

Table 1 material used as biomass

S.NO	**material**	**Quantity**	**remarks**
1.	Napier grass	100KG	Grinded (paste)
2.	Cow dunk extract	5(Lt.)	For fast digestion
3.	yeast	200(Grams)	For fast fermentation
4.	water	40Lt.	For processing

As shown in figure 2 the experimental setup is arranged were material in table 1 are kept in digester tank, a pressure gauge, an outlet valve is connected on it to read pressure readings. The outlet is connected with a reciprocating compressor further to storage tank.

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V EXPERIMENTATION, OBSERVASION AND DISCUSSION

5.1 Pressure readings

The setup is kept in observation, gas generated inside rises the pressure of tank and can be read by pressure gauge shown bellow.

Fig 3 Digester tank during Digestion

The tank in figure 3 can be seen swelled due to pressure

Fig.**4 DAY 10 PRESSURE**

Fig.**5 DAY 20 PRESSURE**

FIG.**6 DAY 35 PRESSURE OBSERVATION**

Table 2 pressure readings

S. No.	Date Of Pressure Ridding	pressure rising (Ib/in^2)	difference previous pressure
1.	20 Nov. 2022	1.7 (Ib/in^2)	1.7 (Ib/in^2)
2.	5 Dec.2022	5.6 (Ib/in^2)	3.9 (Ib/in^2)
3.	12 Dec. 2022	12 (Ib/in^2)	6.4 (Ib/in^2)
4.	29 Dec. 2022	15.9 (Ib/in^2)	2.9 (Ib/in^2)

After 16 bar the pressure found constant in duration of 56 days this is similar to the biogas tank pressure used for gobar gas. This also implies that biogas is generated inside.[5]*(Alemayehu Teressa Negawo et.al)*

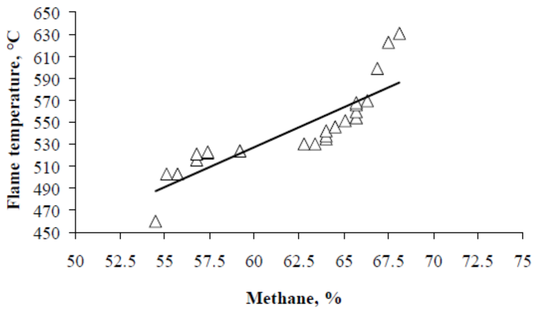
5.2 FLAME INSPECTION

A domestic burner is connected to outlet on 56 th day the flame color found is light blue, no yellow flame is obtained, which again implies the methane percentage if above 80% [2] *(Timothy C. Williams et.al)*

Fig.**7 flame color**

5.3 RADIATION TEST

As suggested in literature [1] (*Abdel-Hadi, M. A. et al)*in fuel gas temperature generated on heating metal piece, it follows following graph and methane percentage can be determined



Relationship between the flame temperature and the methane content of biogas.

Since the test was conducted in open burner system though the temperature readings are found to be 570 C which indicates the methane percentage is more than 70%.

VI CONCLUSION

Producing biogas from waste can be a solution to waste but not to fuel. In the present study benefits of suggesting Napier grass as biomass are discussed also in all four tests conducted the composition of methane are assumed considering literature. It is found that the composition of methane from the process suggested is around 78% which is a great finding. The gas produced can be used directly as CBG in industries for using it as a fuel in IC engine; the methane can be separated by PSA technology. It can be then considered as BIO CNG.

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