International Journal of Current Research and Modern Education (IJCRME)
Impact Factor: 6.925, ISSN (Online): 2455 - 5428
(www.rdmodernresearch.com) Volume 8, Issue 2, 2023

DESIGN AND COMPARATIVE STUDY OF BIOGAS PRODUCTION FROM A FLOATING DOME BIOGAS PLANT USING ORGANIC WASTES

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Cite This Article: D. Madesh, A. Mohamed Hamdan, R. Rajesh Kumar & K. Arun Prasath, "Design and Comparative Study of Biogas Production from a Floating Dome Biogas Plant Using Organic Wastes", International Journal of Current Research and Modern Education, Volume 8, Issue 2, July - December, Page Number 71-75, 2023.

Abstract:

Biogas technology provides an alternative source of energy mainly from organic wastes. Using local resources like cattle waste, kitchen waste and other organic wastes, energy and manure are derived. It is produced when bacteria degrade organic matter in the absence of air. Here an attempt to design and test the performance of plastic made portable floating type biogas plant of volume capacity 0.5 m^3 for outdoor climatic conditions. In this work, cow dung, vegetable wastes, food waste, agriculture waste such organic wastes were using for biogas production of 50 kg slurry capacity in batch system. In this work the temperature have to measure; in addition, the constituent of biogas, pH, volume and rate of biogas production were analyzing at different level of temperature observation on daily basis. Physical and chemical analysis of biogas and slurry have also been carrying out along with the comparison of other fuel sources like LPG, Kerosene

Key Words: Winglet, Induced Drag, Split Tip, Computational Fluid Dynamics (CFD), Split Angle.

Introduction:

In accordance with the fast growing population, the demand for energy and the discharge of waste are increasing day by day. To overcome the energy crisis, alternative energy sources are the only remedy. Generation of energy from waste is beneficial in many ways. It is most suitable for eco-friendly waste disposal and also for energy generation.

Organic wastes are a serious environmental and economic concern all around the world. The fast and highly decomposable nature of this waste demands efficient management for it to become a sustainable operation. Since these wastes are generated in large quantities in highly populated and urban areas, the space available for it to be handled is very limited. It has become a global threat to the environment and health due to its inappropriate disposal developing countries, while in developed countries a majority of them is still ending up in landfills.

In order to minimize the risk to the environment and human health, economically feasible solutions are sought for the treatment of solid waste particularly in urban areas. A plan to turn solid organic waste into energy through different technology has been possible; however, maximum energy recovery, and less discharge are possible through anaerobic digestion that seems viable economic option for the country like India. Biogas is produced from organic wastes by concerned action of various group of anaerobic bacteria through anaerobic decomposition.

Globally, the reduction of greenhouse gas emissions particularly of CO2 has become more important. Currently much of the carbon dioxide emitted to the atmosphere the result of anthropogenic activities from the use of the fossil fuel in the transportation and energy sectors. Significant emission reductions may be achieved in the energy sector by improving efficiency through the use of alternative fuels. Through the use of biogas plant, the CO2 emission can be reduced in the atmosphere.

In many places vegetable waste are taken away by farmers as animal feed, however mixed vegetable and food waste is still a problem to manage. Alternate methods to land filling these wastes include composting and anaerobic digestion. Composting process has several practical difficulties in utilizing food waste. Anaerobic digestion has proved to be an efficient process to handle animal and human waste and has received attention as a renewable energy production method while treating wastes simultaneously. However the technology is not yet developed for small scale application in urban areas especially to deal with organic wastes.

The performance of a greenhouse integrated biogas plant was analyzed with their basic aim to reduce thermal loss to ambient in harsh cold climates (Usmani JA et al 1996). Due to the lower temperature, biogas production decreases drastically and may stop. Thus, to enhance biogas production, a higher digester temperature than ambient temperature is required. The green house concept should be integrated for larger capacity biogas plant (Lau AK et al 1987). It has been suggested that the rate of biogas production and the period to achieve the optimum temperature are function of the temperature of the slurry. Also, for a required production rate of biogas, the period to achieve the optimum temperature should be reduced (Tiwari GN et al 1988; Tiwari GN et al 1986). A heat exchanger connected to a flat plate collector has been suggested for heating of the slurry (Tiwari GN et al 1992). Installation of PVC greenhouse type structure over a biogas plant allow solar heating of the substrate from 18 °C to about 37 °C (Gupta RA et al 1988; Sodha MS et al 1987; Sodha MS et al 1989 and Tiwari GN et al 1997). Solar greenhouse assisted biogas plant in hilly region recommended and it has come to conclusion that biogas-green house hybrid system may be successful in hilly regions where average temperature remains below 37°C throughout the year (Vinoth KK et al 2008). It can also evaluate the carbon credits earned by energy security in India and also analyze the return on capital for biogas plants with and without embodied energy (Prabhakant et al 2009). It is considered a kind of efficient and renewable energy after cleaning sulphur through physical, chemical and biological methods such as absorption and bioreactor, which can be used to cook, heat, light and generate power and can thus reduce the dependency on fossil fuels and curtail greenhouse gas (GHG) emissions (Lastella G et al 2002). The slurry and residues from the biogas process can be used as an organic fertilizer to replace the use of chemical fertilizer on the farm (Hu GQ 2008; Zhou CX et al 2004; Liu Y et al 2008 and Chen RJ 2007). Anaerobic digestion process produces a higher biogas yield when running on a mixture of animal manure and vegetable/crop waste rather than animal manure alone, and biogas production is considered the most suitable bioenergy technology in China (Wu CZ et al 2009) . In this paper, an attempt has been made to study the rate of biogas production in plastic made portable biogas plant. Here I analyze various ratio of organic waste under biogas production and their composition under the effect of various temperature throughout the retention period. The few data of biogas production and its composition (CH_4 fraction) with the operating temperature of slurry is available in the literature. Through this paper, I have tried to evaluate the maximum rate of biogas production. I also compare rate of biogas production from organic waste with the other energy sources which we use for cooking purposes like LPG, Kerosene.

Experimental Setup and Instrumentation:

A plastic made biogas chamber, of 50kg slurry capacity has been used under the outdoor simulation above the ground, so that the digester and dome both can direct receive the solar radiation. The diameter and height of digester have been taken as 0.5 m respectively. Similarly the same diameter, depth and weight of both the dome have been taken respectively.

Figure 1: Photograph of Plastic Made Floating Dome Biogas Plant

Plastic is more efficient to increase the sufficient temperature inside the digester which increases the production rate of biogas. A calibrated thermocouples has been used to measure slurry temperature inside the plastic made biogas plant by using digital temperature indicator of resolution 0.1 °C. This field study has been done at Cochin, Kerala under the different climatic condition of 2014 -2015. This observation has been taken during day time due to presence of sunlight at 9:00 am, 1:00 pm and 5:00 pm every day. Ambient temperature, slurry temperature have been measured during this experiment. Gas production have been recorded on daily basis by the observation of upliftment height of dome. This upliftment height is multiplied by $2\pi r$ and the volume of biogas production is measured every day. This biogas sample has been taken out with the help of toddler bags, which is safe to carry biogas without any leakage and entry of atmospheric air, which has been tested through gas chromatography.

Methodology and Experimental Observation:

Different parameters like ambient temperature, slurry temperature are measured on daily basis. These data have been taken at the interval of 4:00 hours between 9:00 am to 5:00 pm due to presence of solar radiation. Three readings have been taken in every day at 9:00 am, 1:00 pm and 5:00 pm. Here we use various ratio of organic waste with water composition. Under the analysis I have calculated the average ambient temperature and average slurry temperature at these three different times in a day until the biogas production inside the biogas chamber stop. The production rate and methane fraction have also been observed under the influence of various temperature ranges during the experimental work in Kerala, India.

Result and Discussion:

In this observation, all the research analysis has been done under batch system. In the batch system, the slurry has been added once to the digester for whole duration of the process. It has been observed that the Production of biogas is dependent upon the temperature and the solar intensity of the atmosphere in plastic made biogas plant. In these all the data I got various analysis through various comparison.

Table 1: Comparison among Various Ratio of Organic Waste under Biogas

Characters	Case 1	Case 2	Case 3	Case 4
Amount of Organic Waste	10 Kg	10 Kg	10 Kg	10 Kg
Water	30 Litre	20 Litre	14 Litre	10 Litre
Ratio of Organic Waste And Water	01:03	01:02	01:01.4	01:01
Ph	7.3	7.4	7.7	7.9
Total Biogas Production (M3)	0.2308	0.2581	0.12785	0.12168
Maximum Methane Fraction	52%	58%	54%	No
Duration of Methane Fraction Production in Days	03-Nov	Mar-15	18-22	No
Number of Days Methane Fraction Present	10	15	5	No

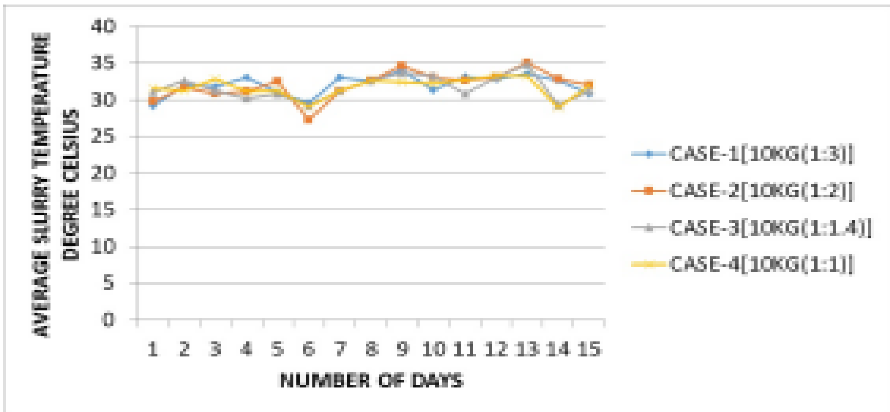

Figure 2: Variation of Average Slurry Temperature Daily Basis under Various Ratio of Organic Waste

Solar radiation is responsible for increasing the slurry temperature inside the digester, which influences the rate of biogas production. Average slurry temperature, biogas production (volume) and methane fraction are measured on daily basis in different ratio of organic waste (Figure 2, 3 and 4). By daily observation got the best result in case-2 of organic waste and water, where we have used 10kg organic waste, 20 liter water under biogas production. In case - 1 and case - 2 obtained the good result but in the case of case - 3 and case - 4 the biogas production was not present. Even in the case of case- 3 the production of biogas started from 18th days. Because earlier the pH value was comparatively higher, which was not better for the growth and activity of anaerobic bacteria but after 17 days it became favorable due to some microbial activity. In the case of case- 4 the pH value was very high at which the bacterial activity was arrested so there was no production of biogas in this ratio.

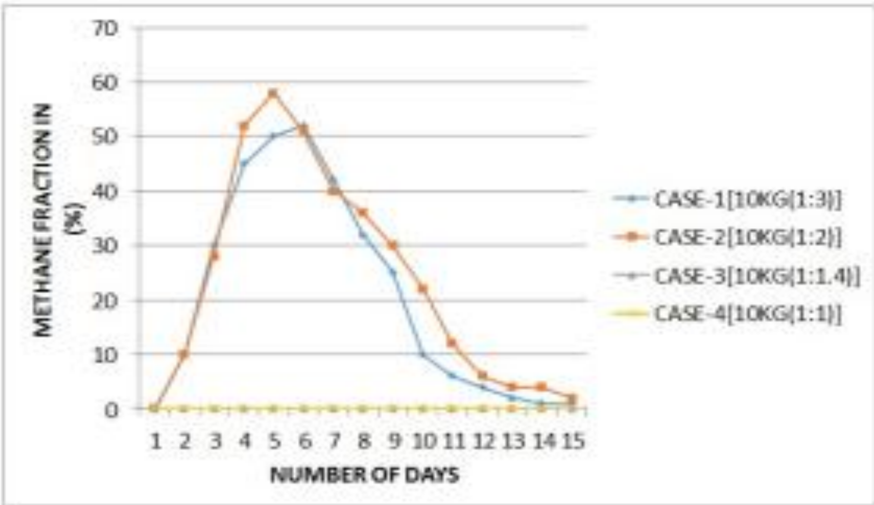

Figure 3: Volume of Biogas Production in Respect of Number of Days under Various Ratio of Organic Waste

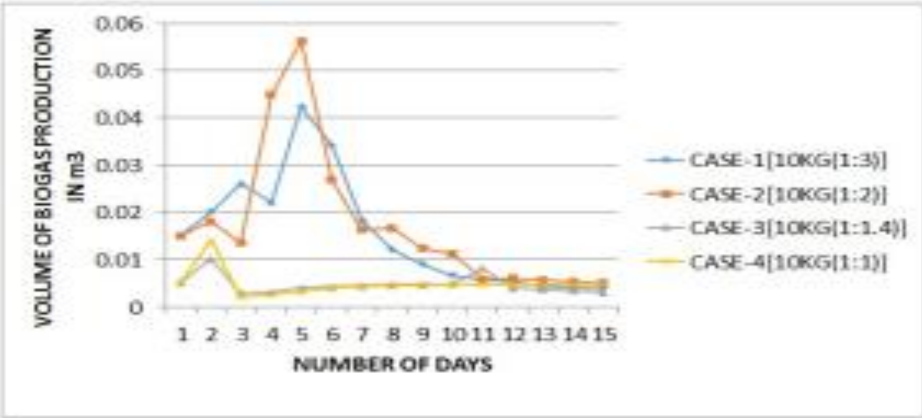

Figure 4: Measurement of Methane Fraction on Daily Basis under Various Ratio of Organic Waste

The synthesis of gas has been started from the first day of the slurry feeding inside the biogas chamber under case - 1 and case - 2 but we obtained methane fraction from third day. Organic waste is rapidly disintegrated by microorganism so the production of biogas stops after 11th day and 12th days in the case of case- 1 and case - 2. The amount of biogas production is 0.230844 and 0.258198 m3 under

Case - 1 and case - 2. The retention period of biogas production is maximum 15 days in the case of organic waste. Production of Energy (Heat, Light, Electricity)

The calorific value of biogas is about 6 kWh/ m3. Which is equal to about half a liter of diesel oil. The net calorific value of fuel also depends on the efficiency of the burners or appliances. Methane is the main important component under the aspect of using biogas as a fuel. The use of biogas can replace various conventional fuel like kerosene or firewood and protect the environment. Biogas is the best substitute of firewood in rural households. The biogas generated from small and medium sized units (up to 6 m3) is generally used for cooking and lighting purposes. If we use a 10 kg (1:2 ratio) [case-2] organic waste for biogas production, we can save various fuel sources which can be used as alternatives. Total biogas production from 10 kg (1:2 ratio) organic waste of volume capacity 0.5 m3 biogas plant was 0.258198m3 during whole retention period. The amount of other fuel sources which we can save by the use of 10kg (1:2 ratio)[case-2] organic waste in respect of ICAR Women spend 2-4 hours per day in searching and carrying the firewood. Once a biogas is installed, they will have much extra time for herself and her children. This will help in improving their quality. They will get more time for education and interesting activities outside the home. Biogas plants also improve health conditions in the homes. The annual time saving for firewood collection and cooking average to almost 1000 hours in each household provided with a biogas plant.

Table 2: The Amount of Other Fuel Sources Which We Can Save By the Use of 10 Kg (1:2 Ratios) Organic Wastes in Respect of ICAR Data

No:	**1 m3 biogas (approximately 6 kWh/ m3) is equivalent to:**	**0.258198 m3 Biogas production will be equivalent to:**
1	Diesel, Kerosene (approx.12kWh/kg) 0.5 kg	Diesel, Kerosene (approx. 12kWh/kg) 0.13kg
2	Wood (approx. 4.5 kWh/kg) 1.3 kg	Wood (approx. 4.5 kWh/kg) 0.34 kg
3	Cow dung (approx. 5 kWh/kg dry matter) 1.2 kg	Cow dung (approx. 5 kWh/kg dry matter) 0.31 kg
4	Plant residues (approx. 4.5 kWh/kg dry matter) 1.3 kg	Plant residues (approx. 4.5 kWh/kg dry matter) 0.34 kg
5	Coal (approx. 8.5 kWh/kg) 0.7 kg	Coal (approx. 8.5 kWh/kg) 0.18 kg
6	City gas (approx. 5.3 kWh/m3) 0.24 m3	City gas (approx. 5.3 kWh/m3) 0.06 m3

Source: According to ICAR paper (report issued by Indian Council of Agricultural Research, New Delhi) http://www5.gtz.de/hate/ techinfo/biogas/framecond/environ.html, Winrock International, Nepal Biogas Support Program (BSP) Nepal

Conclusions and Recommendations:

In all these measurement if the different ratios of organic waste were compared under plastic made biogas plant. Plastic is having comparatively good sunlight absorbing capacity because it is coated with black paint in the dome. In overall observation, we got, the black color of the dome helps to absorb more sunlight to increase the temperature inside the digester of the biogas plant. Plastic made biogas plant is comparatively low cost and better life as compared to other metal made biogas plant. And it also have good biogas production and carbon credit. The plastic made biogas plant is having very low fabrication and maintenance cost as compared to the metal made biogas plants. The black color paint coating is very successful in absorbing more sunlight during the observation. In that way, black painted plastic made biogas plant will be the best alternative under a community level biogas production from organic waste. Here my research was just under a proto type biogas plant but if we will made this at a big level, it will generate more biogas production and increase their utilization under multiple role.

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