# Experimental Study on Biogas Production in Pre-fabricated FRP Floating Drum Digester in the month of February

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**ABSTRACT**

***Biogas is a value-added product of anaerobic digestion of organic compounds. Production of biogas depends on different factors including: pH, temperature, substrate, loading rate, hydraulic retention time (HRT), C/N ratio, and mixing. Small scale waste digesters are cheap, easy to handle and reduce the amount of waste. Biogas got after anaerobic digestion inside biogas digester could be used for cooking, lighting and electricity. Slurry of cow dung was used for initiating the process. After that 2.0 kg kitchen waste was fed every alternative day. Experiments were conducted in the month of February. Ambient temperature, global radiation and slurry temperature are recorded every hour for different climatic conditions. Based on these data pressure and volume of the biogas are calculated. Experimental investigation was done for bio gas production in prefabricated FRP made floating drum biogas digester. It has been found that ambient parameters such as solar radiation and ambient temperature affect significantly the biogas production.***

***Keywords: Global radiation, ambient temperature, slurry temperature, pressure, volume.***

## 1. INTRODUCTION

Due to the increasing prices of fossil fuels and taxes on energy sources compelled to find alternative, clean and economical sources of energy. It has now a day's become a major apprehension for nations' economies. In addition, economic prosperity and quality of life, which are linked in most countries to per-capita energy consumption, is a great determinant and indicator of economical development. The demand for energy is a major reason for extensive climate change, resource use and also restricts the living standards of humans. By the time fuel and fertilizer reaches rural areas, the end price is relatively expensive due to high carrying costs, leaving people to find alternative resources other than oil. Wood is used as the conventional source of fuel to produce energy for the household requirements of 4.3 billion people of Asia [1].

Several traditional methods have been used to utilize energy capacity embedded in carbon neutral biomass sources and anaerobic digestion is one of them. Anaerobic digestion (AD) is a natural process whereby bacteria existing in oxygen-free environments decompose organic matter. In anaerobic digestion, organic material is stabilized and gaseous byproducts, primarily methane ($CH_4$) and carbon dioxide ($CO_2$) are released. Anaerobic digesters are designed to run in either the mesophilic (20-45°C) or thermophilic (45-60°C) temperature. However, methanogenesis is also probable under low temperature (< 20°C) [2]. Biogas typically refers to a gas produced by the breakdown of organic matter in the absence of oxygen. It is a renewable energy source. Furthermore, biogas can be produced from regionally available raw materials such as recycled waste and is environmentally friendly [3]. A biogas digester, also known as a methane digester, is a piece of equipment which can turn organic waste into usable fuel. In addition to providing a source of renewable fuel, biogas digesters also provide low-cost fuel to people in poverty, and they help to dispose of waste materials which would otherwise be discarded.

The biogas digester relies on bacterial decomposition of biomass, waste material which is biological in origin, ranging from kitchen scraps to cow dung [4]. The main part of a biogas system is a large tank, or digester. Inside this tank, bacteria convert organic waste into methane gas through the process of anaerobic digestion. Each day, the operator of a biogas system feeds the digester with household by-products such as market waste, kitchen waste, and manure from livestock. The methane gas produced inside biogas system may be used for cooking, lighting, and other energy needs. Waste that has been fully digested exits the biogas system in the form of organic fertilizer [5]. New technologies in the field of biogas digesters include bag-type biogas digester plants, Vacvina biogas digester and plastic-drum type biogas digesters. The waste generation rate is increasing in India by 1.33 times per year as per calculated by recent studies. Up to 2047 India will produce around 260 million tones of solid waste and for the disposal of this waste the total land area around 1400 hectare km square is required.

The rate of generation of waste is really impossible to reduce and to supply such a big land area for its disposal. In India for solid waste management approx. Rs.1500 Crore is issued for its overall management [6]. In the present communication, efforts are made toward present status of biogas digester, government policy and market growth in India. Indian government has started a scheme "Biogas based Distributed / Grid Power Generation Programme" from 2005-06 (4th January 2006) with a vision to promote biogas based power generation, particularly in the small capacity range, based on the accessibility of large amount of animal wastes and wastes from forestry, rural based industries (agro / food processing), kitchen wastes, etc.


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## 2. MATERIALS AND METHODS

### *2.1 Experimental setup*

In this experiment a polymer biogas digester has been used which is made up of FRP and HDPE. The biogas digester is of Single Stage Floating Drum Type. Its volume is 1 cubic meter. It was fitted with a feedstock inlet and a gas outlet. The gas outlet was connected to a U-tube manometer via a Y-shaped nozzle. K-type thermocouple was used for the measurement of the interior temperature of the gas holder and the slurry. Various chemicals were used for fixing the U-tube manometer and the K-type thermocouple to the digester. These chemicals were resin, hardener, M-seal, Flex-quick, Araldite and FRP cloth. Initial seeding was done with cow dung. The feedstock provided was mainly kitchen waste. Fig.1 shows the biogas digester drum and Fig.2 shows the Thermocouple setting.

**Fig.1: Picture of the biogas digester drums**

**Fig.2: Thermocouple setting**

Fig.3 shows experimental setup biogas digester and Fig.4 shows pressure measurement of biogas digester.


**Fig.3: Experimental setup biogas digester**


**Fig.4: Pressure measurement of biogas digester**


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### *2.2 Materials to be used*

FRP and HDPE drum, cow dung, kitchen waste, hardener, resin, FRP cloth, PVC pipe, U-tube manometer , Y-shaped nozzle, K-type thermocouple, M-seal, Flex-quick, Araldite.

### *2.3 Instrument used*

Solar radiation intensity has been measure by a solar power meter at the tilted surface of the biogas digester. Surface temperature of gas holder and digester measurements have been done with the help of infrared thermometer and temperature indicator. Ambient temperature and humidity has been measure by a thermo-hygro meter. Water column has been measure by a U-tube manometer. K-type thermocouple has been used to measure the inside slurry temperature and gas holder temperature. Spring type weighing machine has been used to measure the weight (like as kitchen waste, cow dung etc.).

### *2.4 Methodology*

For the first time, feedstock provided was 230 kg cow dung and equal amount of hot water. The water temperature was between 44$^{o}$C. The hot water was used for properly mixing the cow dung. 15 liter of waste water was mixed with 2 kg of kitchen waste. The mixture was left for anaerobic digestion for 15-20 days. After the anaerobic digestion was over the various parameters were measured. The governing parameters such as global radiation, ambient temperature, humidity, inside temperature of gas holder, surface temperature of gas holder, slurry temperature, outside temperature of digester, pressure and volume of the gas chamber was measured from morning to evening. The gas generated could be used for kitchen purposes.

## 3. RESULTS AND DISCUSSION

This graph shows to the various parameters like, global radiation, ambient temperature, slurry temperature of biogas digester, pressure inside the biogas digester and volume of the biogas digester in the month of February.

Fig.5 shows the variation of ambient temperature, global radiation with respect to time of the day. The ambient temperature depends on the weather of the day. In a clear day, during afternoon the ambient temperature was maximum but during morning and evening ambient temperature was lower. The global radiation was maximum during afternoon. During morning and evening the global radiation was lower. The global radiations depend on the weather of the day. The maximum and minimum ambient temperature and global radiation were found to be 29.7 &17.0$^{o}$C and 824.48 & 24.22W/m$^{2}$ respectively.


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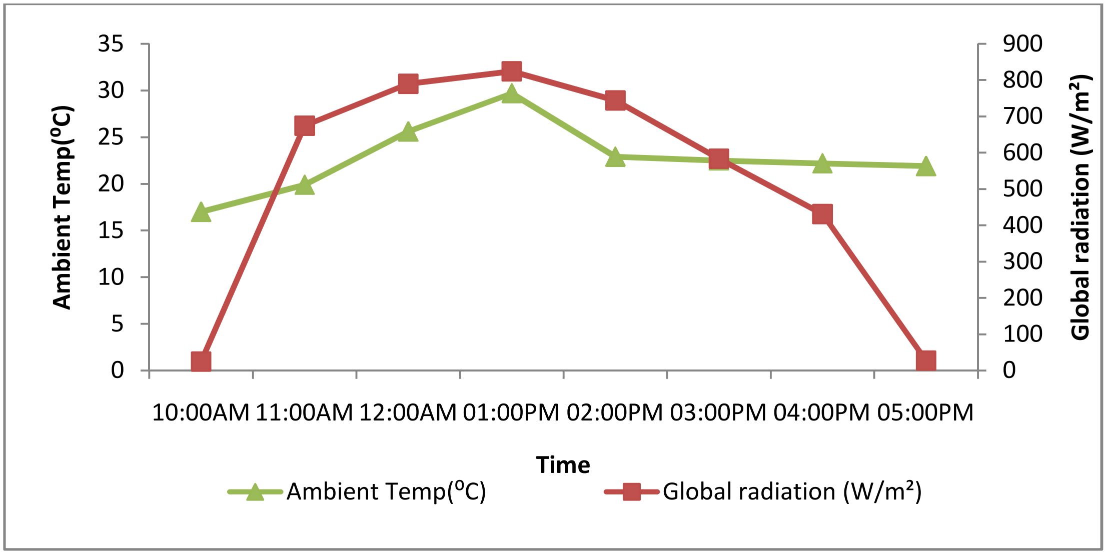


**Fig.5: Variation of ambient temperature, global radiation with respect to time**

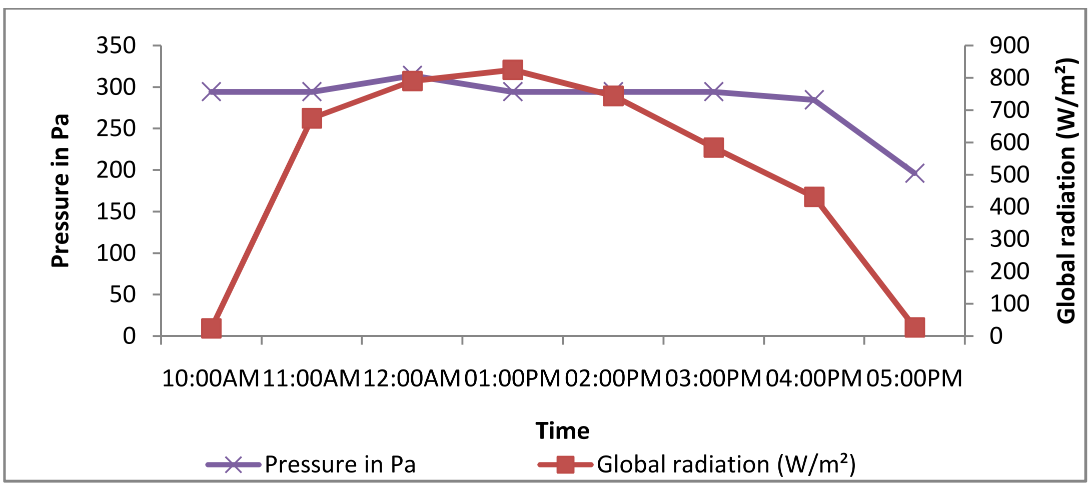


**Fig.6: Variation of Pressure, global radiation with respect to time**

Fig.6 shows the variation of Pressure, global radiation with respect to time of the day. The pressure of the biogas digester depends on the global radiation on that day and various parameters inside the biogas digester. When global radiation was maximum then the pressure of the biogas digester was also maximum. The global radiation was maximum during afternoon. During morning and evening the global radiation was lower. The global radiations depend on the weather of the day. The


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maximum and minimum pressure and global radiation were found to be 313.92 &196.20 in Pa and 824.48 & 24.22 W/m$^2$ respectively.

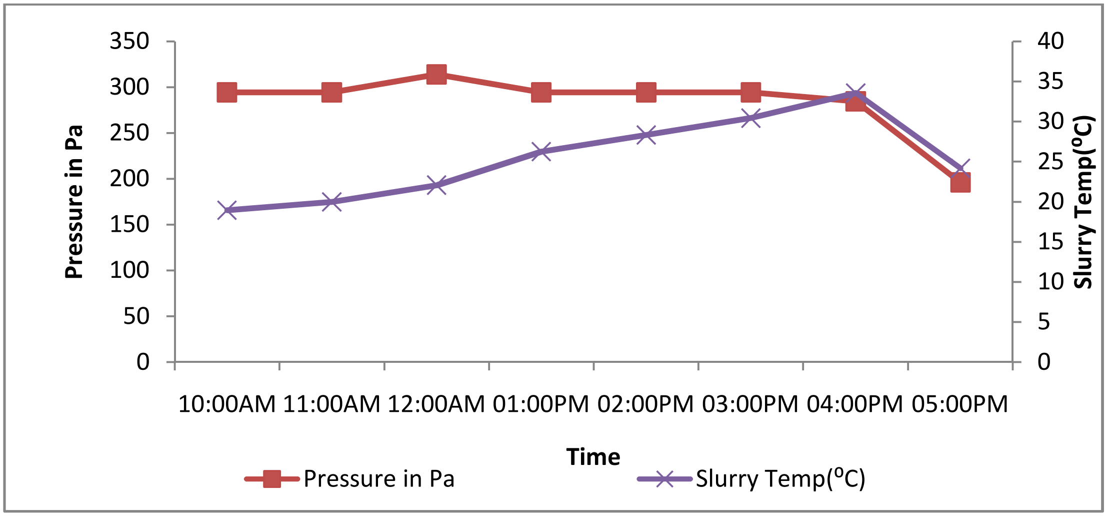


**Fig.7: Variation of Pressure, slurry temperature with respect to time**

Fig.7 shows the variation of Pressure, slurry temperature with respect to time of the day. The pressure of the biogas digester depends on the global radiation on that day and various parameters inside the biogas digester. When global radiation was maximum then the pressure of the biogas digester was also maximum. The slurry temperature of the biogas digester varies from month to month. During the winter month of February the slurry temperature was lower as compared to that of warmer month of April. During morning and evening the slurry temperature was low and during afternoon time the slurry temperature was high. The slurry temperatures depend on the global radiation of the day. The maximum and minimum pressure and slurry temperature were found to be 313.92 &196.20 in pa and 33.54 & 18.93$^o$C respectively.

Fig.8 shows the variation of volume, global radiation with respect to time of the day. The volume of the biogas also depends on the global radiation. The volume of the gas was maximum when the global radiation was maximum. Usually during morning, the volume of the gas of the biogas was lower and the volume of the biogas continuously increases till afternoon after which it again starts to decrease till evening. The global radiation was maximum during afternoon. During morning and evening the global radiation was lower. The global radiations depend on the weather of the day. The maximum and minimum volume and slurry global radiation were found to be 2512 &1570 in mm$^3$ and 824.48 & 24.22 W/m$^2$ respectively.


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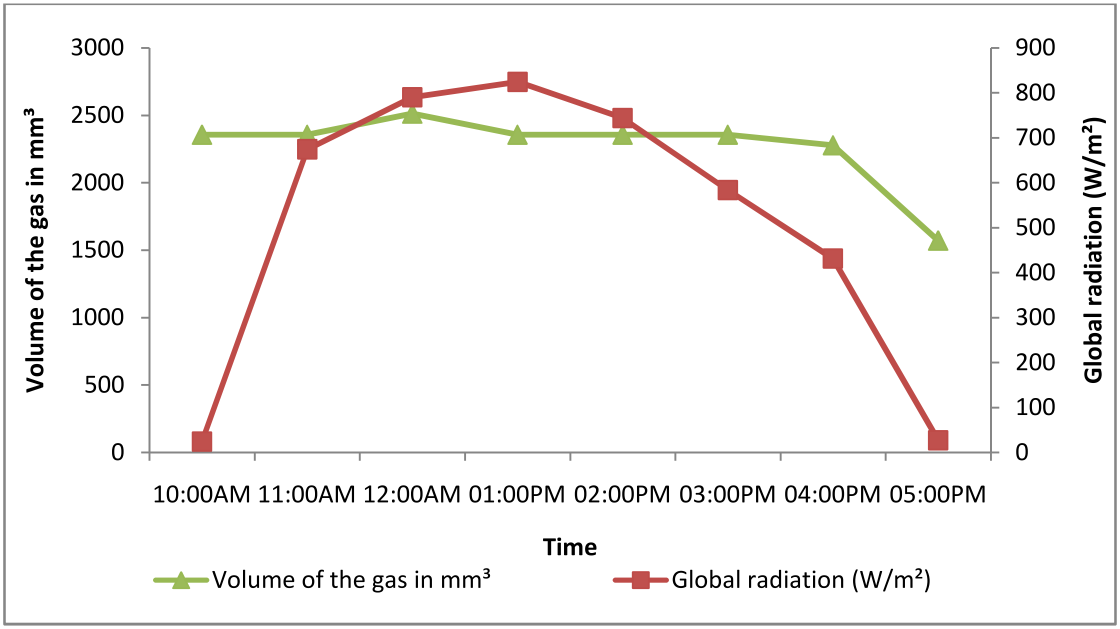


**Fig.8: Variation of volume, global radiation with respect to time**

## 4. CONCLUSIONS

The following conclusions were drawn on successful completion of the experimentation on biogas Production in Pre-fabricated FRP Floating Drum Digester:

The slurry temperature inside the digester is very important factor for proper production of biogas as mesophilic and thermophilic bacteria sustain in the range of 30-45°C and 45-52°C respectively. The slurry temperature inside the biogas digester varies from day to day. During morning and evening the slurry temperature were low where as it raised significantly from 10:00 am to 04:00 pm up to 34°C. The global radiation also varies from day to day. During morning and evening the global radiations were low where as it raised significantly from 10:00 am to 01:00 pm to about 824 $W/m^2$. The ambient temperature also varied from day to day. The ambient temperature increased from 10:00 am to a maximum value of 30°C. It was found that the production of biogas is dependent on the global radiation, slurry temperature, ambient temperature and various other parameters. In the month of February, the inside pressure of biogas digester was on an average 299.90pa at 12:00 noon to 01:00 pm and 199.00pa at 05:00 pm. In the month of February, the volume of the biogas was on an average 2399.85$mm^3$ at 12:00 noon to 01:00 pm and 1592.78$mm^3$ at 05:00pm. The pressure of the biogas and volume showed a direct proportionality with changes in the global radiation, slurry temperature and ambient temperature.

## REFERENCES

[1] Rajendran Karthik, Aslanzadeh Solmaz and Taherzadeh Mohammad J. Household biogas Digesters. *Energies 2012; 5*(8): 2911-2942.

[2] Vanegas Carlos, artlett John. Anaerobic Digestion of Laminaria digitata: The Effect of Temperature on Biogas Production and Composition. Springer 2012; 3: 305-310.

[3] Information on www.en.wikipedia.org/wiki/Biogas_digester

[4] Information on www.wisegeek.com/what-is-a-biogas-digester.htm

[5] Information on www.simgas.com/advantages-of-biogas/how-does-biogas-work/item46

[6] Bansal Ankur K., Kapoor Shivam, Agrawal Mayank, Kaushlendra. The road to zero waste: Anaerobic digestor. International Journal of Environmental Sciences 2013; 3(5):0976 – 4402.