Comparative Analysis of Fiber Reinforced Plastic (FRP) Biogas Plant with Existing Modified GGC-2047 Model Biogas Plant

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Abstract: This study was carried out to find out variation in production rate of biogas at GGC-2047 modified and FRP biogas plant of same capacity ($6m^3$). Later production analysis was done in liter/hr for both types of plant with its variability on ambient temperature, feed rate, pH etc. For the research study two different functional FRP ($6m^3$) and one function modified GGC-2047 biogas plants (6m3) were selected. Total 16 days of data was analyzed from Bhesipati, Lalitpur site FRP 6m3 model, 27 days of data form FRP 6m3 model Gaurigung Chitwan and 7 days of data was taken from GGC-2047 at RETS Khumaltar Lalitpur. The results shows that the biogas production by GGC-2047 model is greater than that of FRP model but while comparing the results of two FRP model, FRP of Chitwan which has greater ambient temperature produces more gas with low feed rate than that of same FRP model located at Bhaisepati, Lalitpur.

Keywords: FRP model; GGC-2047 model; Biogas

1. Introduction

The world today is facing acute problems of energy supply, shortage of cheap and efficient fuel, shortage of other many usable commodities and growing environmental pollution. Fast depletion of fossil fuels particularly oil, mass-scale deforestation leading to a fuel wood crisis, and the population explosion, all combine to emphasize the need for exploiting the non-conventional sources of energy particularly those which could meet the basic requirements of the world's growing demand. Even for the fast industrial growth of the developing countries and their overall socioeconomic progress, the need for efficient, decentralized and non-polluting energy sources is increasingly felt. Biological sciences and the uses of biological system for a variety of purposes have assumed tremendous significance, and the urgency of developing methods for obtaining energy from biomass resources cannot be underemphasized.

The present energy crisis has adversely affected the socio-economic development in the third world. The demand for energy is increasing day by day. The hike in the prices of petroleum products, fast depletion of fossil fuels, large –scale deforestation resulting on shortage of fuel wood and population growth have taken the attention of scientists, technologists, administrators, and planners all over the world has been focused on the development of unconventional, non- polluting, economical, socially acceptable and easily available, decentralized energy sources, The developing countries like Nepal need more and more energy as a primary factor of its development works.

The different sources of alternative energy include nuclear energy, hydropower, solar energy and energy from biomass and wind. In evaluating these alternatives,

Energy planners will have to take a number of factors into consideration, out of which the important factors are:

- Potentiality of energy resources in terms of their reserves.
- The cost and technical feasibility of the process for the production of energy.
- The relative impact of energy alternative on environmental issues.
- The convenience on the ways of consuming the energy.
- Cost of transportation.

Nepal is an agricultural country. Being as an agricultural country, 80% of the population of Nepal depends on agriculture. Most of the rural population has the tradition of raising cattle as an integral part of their farm. In addition to draft power and milk, cattle produce them necessary manure in the form of dung. People are dependent mainly on firewood for their energy requirements. Forest alone supply nearly 77% of the total energy requirements of the country. The forest consumption rate has been increasing to fulfill this demand. This will definitely create environmental problem: Global warming, flood, landslides, climate change etc. To overcome these problems we have to search for alternative sources of energy with longer availability and lower generation period to extract the energy. Biogas in this context is of special significance [1].

The main objective of this research was to do performance Analysis of fiber reinforced plastic (FRP) biogas plant and modified GGC model biogas plant of same capacity (6m3). And the Specific objectives of the study were to do production analysis of selected biogas plants and analyze parameters like pH, ambient temperature, feedstock's with respect to biogas production and financial analysis of both biogas plant on the basis of simple payback period.

2. Materials and Methods

2.1 Study area

For the research study two different functional FRP (6m3) and one function modified GGC biogas plants (6m3) were selected . Two FRP biogas plants were located at Bhaisepati of Lalitpur and Gaurigung of Chitwan district. And modified GGC biogas plant is located at khumaltar, Lalitpur. The details of biogas plants are as follows

1) Plant Owner :- Nawaraj Khanal

Location:- Gaurigung, chitwan

Biogas type:- FRP 6m3

Installed on:- 2070 BS

No of animal :- 1 buffalo and 1 cow

No of family members:- 4 (2 adults and 2 children)

2) Plant Owner :- Pratima

Location:- Bhaisepati , Lalitpur

Biogas type:- FRP 6m3

Installed on:- 2070 BS

No of animal :- 1 adult cow and 1 calf

No of family members:- 3 (all adults)

3) Plant Owner :- Renewable Energy Test Station (RETS)

Location:- Khumaltar , Lalitpur, NAST Compound

Biogas type:- Modified GGC-2047 model(6m3)

Constructed on:- 2067 BS

Uses:- RETS canteen

Every day feeding:- 40 kg cow dung

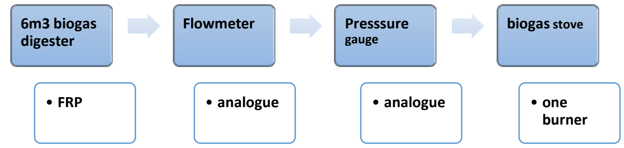

Figure 1: Setup of flow meter at FRP plant chitwan

Figure 2: Experimental Setup at RETS GGC-modified biogas plant

Figure 4: pH meter with buffer 7.0 solution for calibration

2.1 Methodologies

At Bhesipati, Lalitpur site the flow meter has been installed on Tuesday, June 17, 2014, at 10:35 AM, before installing the flow meter the gas has been completely extracted from the digester .The flow meter has been removed on Thursday, July 03,2014, before removing the flow meter all the gases has been completely extracted from the digester. So total production analysis was done for 16 days. At the experiments days every day 20 kg of cow dung and 40 liter of urine was feed into digester. Average PH of feedstock and slurry is found to be 7.1 and 7.3 respectively. The average ambient temperature is 27.16 °C.

At Gaurigung, Chitwan (6m3 FRP), the flow meter has been installed on the site two time firstly from Thursday, May 29, 2014 to Saturday, May 31, 2014 and secondly from 15 July 2014 to August 9, 2014, before installing and removing the flow meter the gas has been completely extracted from the digester . At first phase total production analysis was done only for 2 days . At the experiments days every day 20 kg of buffalo dung and 20 litre of urine was feed into digester. During first phase of data analysis average pH of feedstock is found to be 7, pH of urine is 9.2 and pH of slurry was found 7.2 .The average ambient temperature on first phase of production analysis was found to be 32°C.

Figure 3: Setup of flow meter at FRP plant, Chitwan

The second phase of data analysis has been done for 25 days. The average feeding rate was same as previous. The average temperature at that period was 33°C .The average pH of feedstock was 7.2 while average pH of slurry was 7.7. The average inlet and outlet temperature of digester was 29.4 °C and 29.6°C.

Figure 5: Measurement of inlet temperature of digester of FRP at Chitwan

At modified GGC model installed at RETS laboratory, Khumaltar, Lalitpur. The data analysis was done from Wednesday, July 9, 2014 to Wednesday July16, 2014 .

The digester is feed with 40 kg of cow dung per day. Before installing and removing the flow meter the gas has been completely extracted from the digester through water boiling. The average temperature 27.34°C .The average pH of feedstock and slurry was found 7.0 and 7.1 respectively.

3. Result and Discussion

3.1 Development trend of biogas in Nepal

Biogas technology is considered to be one of the most promising and sustainable sources of renewable energy in Nepal. The history of biogas promotion in Nepal goes back to 1955, when Father B.R Saubolle of St. Xavier's School demonstrated the first biogas plant in Godawari, Lalitpur .Then slowly the biogas energy concept was introduced to Nepali society and its promotion was started through different institutes, NGOs, INGOs and others. The global energy crises of 1973 compelled people to think about different energy options, this caused the formation of Biogas Development Committee (BDC) as a part of the Energy Research and Development Group (ERDG) under Tribhuvan University in 1975. On fiscal year 1975/76 with the announcement of 'Agriculture year' government provided subsidy to farmers for the biogas construction and Agricultural Development Bank (ADB) also provided interest free loan. This resulted in construction of 250 family size floating drum type biogas plants. (Karki, 2005)

After the establishment of Biogas Support Programme (BSP) in 1992, the rate of biogas construction accelerated considerably. Government assisted by different donor agencies provided financial subsidy to household plants and BSP/ Nepal, a well-structured executing agency, is still working for its development. BSP/Nepal has successfully implemented the 3 phases of biogas construction and currently the fourth phase running.

Since the first biogas plant demonstrated in 1955 and from 1974/75 till the establishment of BSP/Nepal, it has been estimated; around 11000 biogas plants had been constructed in Nepal through different donor and other agencies and also by individual. But no authentic data are available to prove this figure. Since1992, when the government body regulated the financial subsidy policy and BSP/ Nepal worked as the main executing agency for the biogas development; it has constructed 189,698 plants till December 2008 (BSP-N). BSP/Nepal has reported that 65% of the plants are toilet attached. With the development of biogas energy, 1,080,000 personals have been directly benefited and 11,000 personals are employed through the programme till end of 2007. (BSP Year book 2008).

Biogas plants are installed in each of the 75 districts of Nepal with total 2,56,662 plants by July 2011 (AEPC 2011) [2].

3.2 Description of GGC modified Model and FRP Model biogas plant

Gobar Gas and Agricultural Equipment Development Company Pvt. Ltd. (GGC) established in 1977 with the mandate to promote Biogas technology has been providing services throughout the country. In context of Nepal since 1990 the continuous feeding type biogas digester, GGC 2047 model recognized as a standard biogas model has been commonly promoted. The GGC 2047 is a modified version of Chinese model –fixed dome bio-digester. The BSP also gave approval to the GGC 2047 as the only standard model for promotion in Nepal. GGC 2047 design is derived from the Chinese model fixed dome plant and has been modified over the years to adopt it to the local demands and conditions. With the numerous suggestions and requests from the stakeholders and users to reduce cost to disseminate the technology among the larger segment of farmers, BSP-Nepal came up with the design called Modified GGC-2047 model.

Although, many efforts in reducing cost without compromising on quality have been tried-out in the past, no significant reduction was achieved. Hence, BSP-Nepal came up with an aim to reduce cost by enhancing efficiency. Therefore, considering all these parameters, Research and Development Unit of BSP-Nepal has come up with the modified biogas design. The new design has the following advantages and benefits over the existing design GGC-2047 model [3]:

- Minimum sedimentation
- Increase in agitation effect to generate more biogas that that of the existing design
- Option for other soft organic matter such as kitchen waste
- Increased retention time for maximum digestion of feed materials
- Even with low feed quantity, enough gas is produced for consumption.

FRP biogas plant is a composite of a polymer (the resin) and a ceramic (the glass fibers). Over 5 million FRP biogas plants have been installed in 2010 in China [4].

It is the new technology in context of Nepal, AEPC/NRREP has installed FRP biogas plants as a pilot plants at 3 locations of Kathmandu, and each at Chitwan and Pokhara in year of 2014 [5].

There are some comparative advantages of FRP over Modified GGC model

- Less time required for installation and shortened period of construction
- Less demanding for skilled masons and labors and easier for quality control
- Less gas leakage and easier maintenance for gas tightness
- Better adaptable to long rainy seasons, high groundwater table, and soft foundation soil
- Good for mass prefabrication for large-scale installation
- Reduced land area for installation of the plant
- Fabrication technologies and facilities readily available

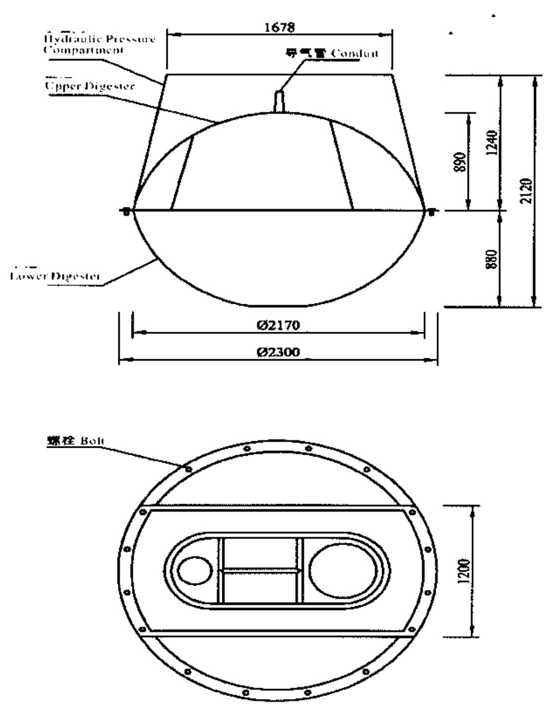

Figure 6:- FRP model biogas plant

3.3 Results and Discussion

For the research purpose total 16 days of data was taken from Bhesipati,, Lalitpur site FRP 6m3 model, 27 days of data form FRP 6m3 model Gaurigung Chitwan and 7 days of data was taken from GGC-2047 at RETS Khumaltar, Lalitpur. We have observed following results.

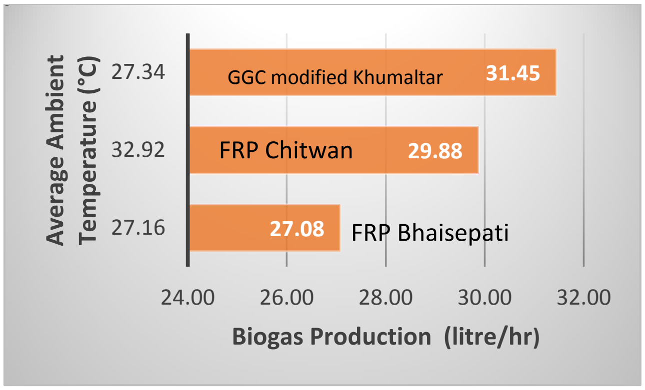

Figure 7: Effect of ambient temperature on biogas production

Here, the maximum average temperature was found in FRP model Chitwan and maximum average biogas production was found in GGC model, Khumaltar.

The above figure shows that average biogas production of GGC modified model at RETS, Khumaltar with average temperature of 28.34°C is greater than other FRP models. But while comparing data with FRP models biogas production rate is increased with increasing in ambient temperature.

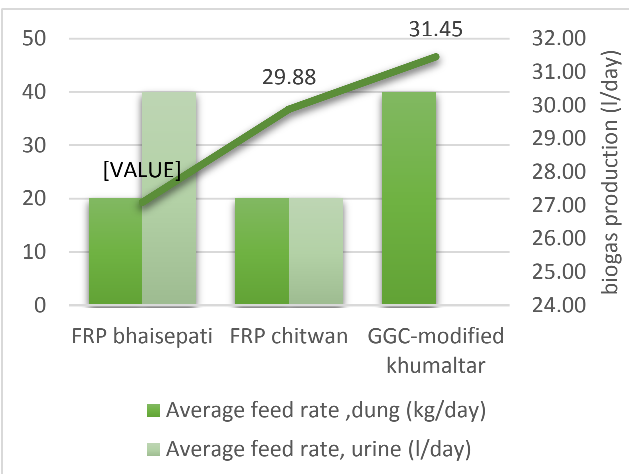

Figure 8: Effect of feedstock on biogas production

The maximum feed of solid cow dung (40 kg/day) without urine was feed in GGC modified model Khumaltar, Lalitpur. But in FRP model Chitwan equal amount of dung and urine was mixed. In FRP model Bhaisepati cow dung and urine was mixed in 1:2 ratio i.e 20 kg and 40 liter respectively per day.

The result shows maximum amount of gas is produced in GGC model but while comparing with two FRP models in Chitwan and Lalitpur, FRP Chitwan has produced more gas with low feed rate than FRP Lalitpur.

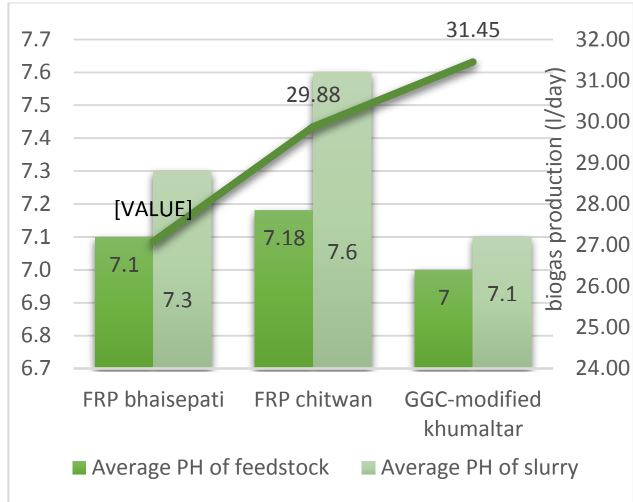

Figure 9: Effect of pH on biogas production

The above figure shows that maximum average PH of feedstock as well as of Slurry was found in FRP chitwan model. The maximum average PH of slurry was 7.6 found in chitwan.

3.4 Financial Analysis

Assumption for 4 members family

- Per day biogas consumption per family = 700 liter (2.5 hr per day)
- Yearly biogas consumption per family= 700 * 365 =255500 liter
- Average LPG gas consumption per family per month = 0.66 cylinder (Assuming 1 LPG for 1. 5 moths)
- Average Annual cost for LPG gas per family = 0.66 * 1470 * 12= Rs 11642.4
- Per liter of biogas cost (baseline on LPG cost)= Rs 0.0455

	GGC-Modified (6m3)	FRP (6m3)
First Investment (Rs)	55439	82810
Annual O & M cost (Rs)	1000	0
Life	25 years	25 years
Annual Gas production (Ktm valley)	275502	237220
Annual revenue from gasproduction(Rs) (baseline on LPG)	12553.83	10809
Annual net cash flow(Rs)	11553	10809
Simple Payback Period	*5.12*	*7.16*

Figure 9: Simple Payback period calculation for different biogas plants

4. Conclusion and Recommendation

4.1 Conclusion

Based on the results obtained it can be concluded as bellows:

- For FRP model at Bhaisepati site, Lalitpur average gas production rate was found to be 650 liter per day at average ambient temperature of 27.16°C with average per day feeding of 20 kg cow dung and 40 liter of urine, so per hour gas production rate is 27.08 liter at Bhaisepati site, Lalitpur .
- For FRP model at Chitwan average production rate was 754 litre/day at average ambient temp of 32.92°C with average per day feeding of 20 kg of buffalo dung and 20 litre of urine, so per hour gas production was 29.88 liter.
- At Khumaltar, on modified GGC-2047 model average production rate was 754.51 liter with average per day feeding of 40 kg of cow dung, so per hour gas production was 31.41.
- The study shows that FRP model is easy for installation, adequate gas production and few difficult for digested sludge removal than GGC –modified model.
- But from Economic View GGC has 2 years less payback period than that of FRP model.
- From the view of user satisfaction GGC model are liked by people.

4.2 Recommendation

- Outlet technology in FRP needs to be improved with due pipeline system to decompose slurry in pit.
- Feeding material other than cow dung (Slaughter house product, sewage, kitchen wastes) can be study for FRP in future.
- Comparative study would give reliable result with exact control in feed rate with two different models (FRP and GGC) of biogas plants at same ambient conditions.

Acknowledgement

Sincere gratitude goes to Mr. Suraj Regmi, programme officer of AEPC for providing flow meter and Mr. Hari Bahadur Darlami, Deupty Head of Mechanical Department, IOE, Pulchowk campus for providing other necessary equipment and suggestion during research period. Last but not the least, I would like to express my sincerest acknowledgement to biogas owners of Bhasepati Latiptur and Chitwan, for warmest cooperation during research period.

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