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Experimental Investigation on Performance Improvement of Biogas Plant

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ABSTRACT

Biogas is a sustainable fuel that stands out from other biofuels because of the major environmental and socio-economic benefits that can be achieved. This opens up enormous potential for sustainable economic growth and will also improve our energy security.

An attempt has been made to find the different ways to improve the overall performance of biogas plant. The present work comprise of improving the biogas yield in terms of quality and quantity. Since it is a well known fact that temperature improves the performance of biogas plant, experimentation is carried out to modify the existing mild steel dome based biogas plant by transparent type fibre dome to capture the green house effect.

Modifications are carried out in one of the plant and the second plant is kept as a reference. So far these two biogas plants were studied for composition, yield, temperature effect; pH value of the end digestate.

***Keywords:* Energy Security, Transparent Fibre Dome, Mild Steel Dome, Temperature, pH.**

I. INTRODUCTION

Energy is the basis of human life. We need energy to do work. Over the past few decades, energy has been the subject of much debate. Energy is the backbone of technology and economic development. Our energy requirements have spiraled over the years following the industrial revolution. This rapid increase in our use of energy has created problems of demand and supply. The impending crisis the world over due to overuse of non-renewable energy sources for sustenance shall soon lead to a situation for all concerned to take a prudent decision to start depending on renewable energy sources for their daily needs in order to conserve our finite natural resources for generations to come.

After reading many studies and reports about available technologies for treating wastes mainly technologies treat organic wastes which usually available for rural families especially animals' dung, crops residues and domestic wastes with centering on technologies that could be constructed, operated and repaired by rural family itself. It was found that many methods and technologies could be applied to treat organic wastes such as direct combustion, fermentation, gasification, pyrolysis and anaerobic digestion. Direct combustion means burning organic wastes to get energy. It is a simple, easy and of low cost process, but it generates smoke and ash which means that this process associated with many pollutant gases, polyaromatic hydrocarbons and total suspended particles that cause chronic diseases as asthma and lung cancer.

There is an increasing interest in producing biogas from anaerobic digestion as a renewable source of energy and as means of reducing our dependence on fossil fuels. Anaerobic digestion can also be useful in achieving several environmental benefits and political objectives, such as more sustainable strategies for waste management and agricultural practices. The diversity is also reflected in the varying effects (e.g. environmental impact) and potential obstacles to the successful implementation of biogas systems. A broad systems perspective is therefore useful in order to explore the benefits and drawbacks of different biogas systems. So far, most of the research in this field has focused on specific biogas systems or parts of systems, for example, enhancing the digestion technology or use of the biogas. There are few comparative studies of biogas production that include several alternatives for anaerobic digestion, or studies that synthesize the current knowledge. The overall objective of the work described in this thesis was to assess biogas production from a systems analytical perspective in order to enhance the performance of a gobar gas based biogas plant. In this case, “biogas production” should be interpreted as the physical aspects of entire biogas systems, from the raw materials digested to the final use of the biogas and digestate produced. The systems analytical approach considers primarily the environmental impact of biogas production from a life-cycle perspective, including energy performance and emissions from the biogas production systems. The first aim was to assess when and under what conditions biogas and anaerobic digestion are good alternatives from an environmental point of view. The systems analytical approach was then broadened in order to identify factors of importance for the successful

implementation of biogas production. . The second aim was therefore to analyze the prospects for successful performance of biogas plants.
Biogas technology has, therefore, the potential to alleviate poverty providing substitutes for expensive fuels and commercial fertilizers, improving agric/aqua-cultural yields, reducing local deforestation, creating jobs and income as well as strengthening the indigenous technological knowledge.

The report described here is motivated by the need for better information concerning biogas production from a broad systems perspective. The principal audience envisaged is firstly those who are interested in, or engaged in, biogas related issues, including policy makers, decision makers, researchers, consultants, farmers, and operators of biogas plants, who require more information on the environmental implications of biogas production. Secondly, this Paper is directed towards those who carry out life cycle assessment, and similar analyses, of waste management, energy production, agricultural practices, etc., and who require information on the characteristics of biogas production from a systems analytical perspective.

II. Experimental work:

2.1 Materials Used:

The materials used are

1. pH meter
2. Dry test gas meter
3. Digital thermometer
4. Stirrer.

The study was carried out on floating type mild steel dome digester plant and a transparent dome type plant with sizes of 2 m^3 capacity at Vyara which is located 60 km away from Surat on operational parameters such as temperature , pH and composition of methane yield for both the plants.

2.2 Performance Monitoring of Test item and Reference item

The two biogas digester types were fed with 25kg cow-dung equal volumes of water and thereafter a comparative study of the temperature regimes inside them was undertaken for a period of one month. And in assessing their performance, the two biogas plants were used to kept for a retention time of 10 days and during this time the fermentation of the slurry takes place through undergoing normal anaerobic digestion process where thermopholic reactions takes place. During this exercise, the biogas production and temperature were monitored daily using a dry-test gas meter and a digital thermometer respectively.

Figure 1: Determination of gas volume through dry gas meter

The results are noted daily for a period of 10 days and the readings are tabulated. The readings are noted daily through digital dry gas meter to determine the biogas production rate.

Table 1: Daily Biogas production rates at different slurry temperatures

MILD STEEL DOME DIGESTSER TYPE			TRANSPARENT DOME TYPE DIGESTER	
Duration (days)	Biogas produced (cm^3/day)	slurry temperature (°C)	Biogas produced (cm^3/day)	slurry temperature (°C)
1	2.78	30.0	11.00	33.0
2	10.00	29.0	25.00	33.0
3	36.36	27.4	38.60	29.8
4	68.75	28.5	58.33	29.6
5	84.62	28.5	111.54	30.3
6	92.86	27.7	133.35	29.9
7	100.00	29.1	152.22	32.1
8	106.25	29.3	169.5	31.4
9	113.24	30.6	176.47	33.2
10	125.00	30.8	188.89	34.8

Table shows the daily biogas yields from cow dung on a daily basis under the various modes of operation in both the digesters. The rates were calculated as ratio of the amount of biogas produced daily to the volume of the digester. The average slurry temperatures for test item and reference item are recorded as 31.71°c and 29.09°c respectively. It is evident from the table that the temperatures in the transparent type of digester plants are having higher ratios than that of mild steel dome type plant which shows a rise of 8.26 % for the given specific period of time. This is because of the fact that transparent dome type digested plants can have higher absorption of heat from the sun light .As a result of this the temperature regimes inside the plant are higher .

From the rate of gas production shown in the table, it is shown that as the concentration of slurry increases during the days, the rate of production also increase. The variation of rate of gas production against time is clearly observed from the graph.

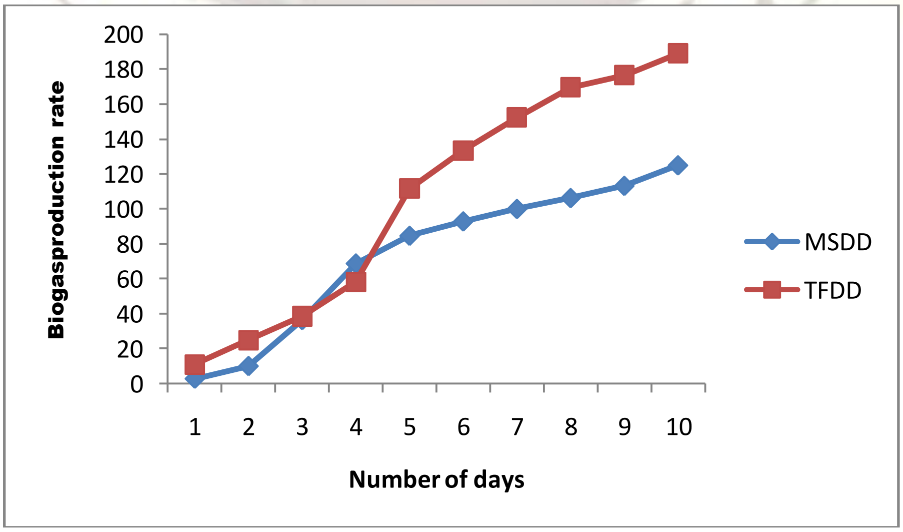

Figure 2: Daily biogas production rate (cm3/day)

From the graph it clearly shows that the biogas production has increased enormously in the transparent dome type as it is captures the solar effect in which temperature regimes inside the plant have been increased of better anaerobic digestion process. Fluctuations in the temperatures reduce the methane formation, because of inhibition in growth of methanogens. In case of better gas production the temperature regimes should be maintained in the range between 30°c and 40°c. From the results it concludes that transparent type of dome is having greater advantage compared to that of mild steel dome type plant. In mild steel dome type plant the temperatures are moderately maintained throughout the day whereas is in transparent dome type digester the temperatures are very much during the sunlight as it captures much solar effect during the day time .so finally the results reviewed that, the digester temperatures in the transparent dome type plant are higher than that of mild steel dome type plant. The graph is plotted for the variation of temperature during the number of days.

2.3 Determination of pH

The pH is measured daily with the help of digital pH meter (BVM scientific). The pH meter is used to determine the value of pH in the digested slurry

The digesters of both the plants are monitored using a digital pH meter and the pH values of both the digesters are documented in order to analyze the effect of pH with the temperature for a period of ten days.

Table 2: Variation of pH with Temperature

MILD STEEL DOME DIGESTSER TYPE			TRANSPARENT DOME TYPE DIGESTER	
Duration (days)	pH	slurry temperature (°C)	pH	slurry temperature (°C)
1	6.5	30.0	6.2	33.0
2	6.9	29.0	6.6	33.0
3	6.4	27.4	6.5	29.8
4	7.2	28.5	6.8	29.6
5	6.9	28.5	6.8	30.3
6	7.2	27.7	6.9	29.9
7	7.2	29.1	7.0	32.1
8	6.8	29.3	6.8	31.4
9	7.3	30.6	6.9	33.2
10	7.0	30.8	6.8	34.8

From the table it clearly shows that, due to rise in temperature of the digester the pH values are lower as the anaerobic digestion process takes place inside the digester for better formation of methanogens. From the results it shows that the pH values are maintained between 6.5 and 7.5 which holds good for the digestion process and the pH values of test item are slightly lower to that of reference item. The temperature rise in digester yields better digestion process for the process of fermentation to take place as a result of which pH is stabilized. The methane producing bacteria live best under neutral to slightly alkaline conditions. Once the process of fermentation has stabilized under anaerobic conditions, the pH will normally take a value of 6.5 to 7.5.As anaerobic digestion will occur best within in a pH range of 6.5 to 8.

The graph is plotted for the variation of pH with the no. of days

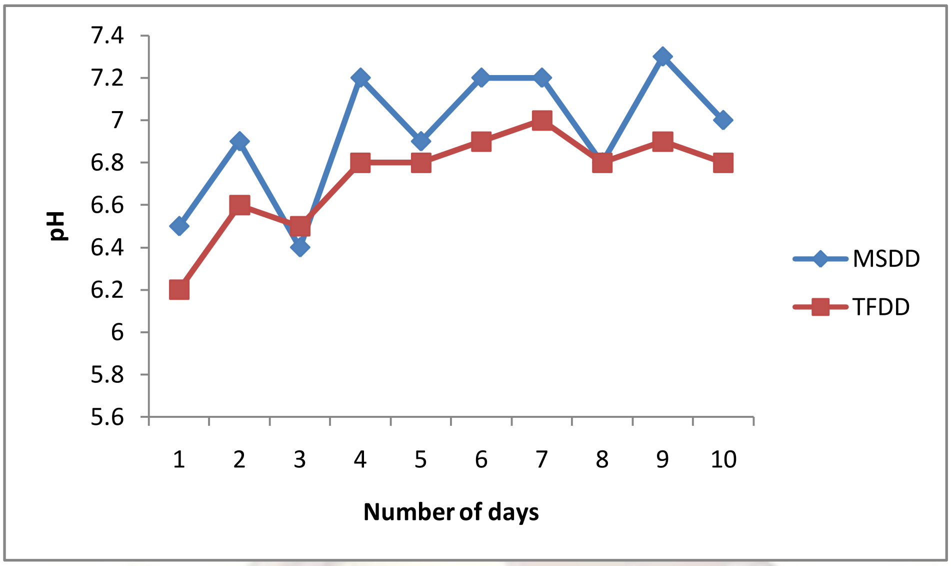

Figure 3: variation of pH with no. of days

From the graph, it clearly shows that the pH is lower than the transparent fibre dome digester compared to that of mild steel dome digester .This is because higher concentration of acids are produced during digestion process in transparent dome digesters because of more temperature regimes maintained inside the digester. The amount of acids may exceed the potential buffer capacity due to better formation of methanogens during the digestion process. So finally it suggested that the pH in the transparent dome digesters are comparatively lower than that of mild steel dome digester because of higher temperature regimes maintained inside the digester.

III. Conclusion

The experimental and the field results from this study and the experience gained from the operation of biogas production system lead to the following conclusions:

- The use of transparent fibre dome digester reduced the digester thermal losses and a positive rise in the temperature regimes inside the digester plant which leads for better anaerobic digestion for the formation of methanogens.
- The use of transparent fibre dome digester keeps the dome completely more airtight than the conventional plants with less compatibility and well structured which lead to better methane yields.
- An increased temperature facilitates faster reaction rates and hence faster gas yields. Operation at higher temperatures yields greater sterilization of the end digestate.

In the present study, the testing of transparent fibre dome as an alternate building material for biogas plant proves to be more effective than conventional biogas plant which is evident from the experimental results. The study mainly focuses on increase in temperature regimes of the biogas plant for the better anaerobic digestion process. The temperature plays a crucial role in fermentation of the slurry for the better formation of methanogens.An increased temperature in the digester tank facilitates faster reaction rates and hence faster gas yields are produced. The results reviewed that the temperature regimes are maintained moderately higher than that of mild steel dome digester which yields greater sterilization of the end digestate and faster gas yields.

Finally it concluded that the usage of transparent fibre dome type digester proves to be more effective than that of conventional mild steel dome digester in terms of performance and economical viability is considered.

REFERENCES

[1] Khapre UL. Studies on biogas utilization for domestic cooking. Paper presented at XXV annual convention of ISAE, held at CTAE, Udaipur; 1989.
[2] Janani Chakravarthi “Biogas and energy production from cattle waste” IEEE Energy Conversion Engineering Conference, IECEC-97 32nd Intersociety pp: 648 - 651 vol.1.1997.
[3] Karve of Pune A.D (2006). Compact biogas plant compact low-cost digester from Waste starch. www.bioenergylists.org.
[4] The University of Southampton and Greenfinch Ltd. - Biodigestion of kitchen waste a comparative evaluation of

mesophilic and thermophilic biodigestion for the Stabilization and sanitization of kitchen waste.
[5] http://www.renewableenergyworld.com
[6] www.fao.org

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