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Comparison of Biogas Production in Ambient Temperature Condition and under Green House Canopy

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Abstract—*The current study focuses on the production of biogas from pine needles. The experimental study was conducted at Himachal Pradesh, India where temperature hardly exceeds 35^{0}C. There are various type of organic waste used for biogas production such as food waste, cow dung and agricultural waste but the use of pine needles has not been used so much for biogas production. The batch study was done in a plastic made floating type biogas digester. In the biogas digesters, one fermentation bucket and 2nd gas holder was used. The capacity of fermentation bucket and gas holder was 45 l and 20 l respectively. The feed materials were collected from the local sources. The study was batch operated and daily gas production from the digesters was measured. In this study comparison of biogas production under green house canopy and the ambient temperature condition has been made. The ambient temperature range measured within the testing period was 15^{0}C-28^{0}C and green house canopy temperature inside the digester range was between 18^{0}C-32^{0}C. The both digesters have same capacity of slurry. In both the digesters inoculum was prepared from the cow dung. The ratio of substrate and water is (1:15) in both the digesters. The retention period of both digesters was 70 days. The different parameter like Total solid (TS), Volatile solid (VS), Biochemical oxygen demand (BOD), and Chemical oxygen demand (COD) before and after digestion was measured. The pH and temperature was measured on daily basis because temperature plays vital role in the biogas production. The cumulative biogas production in ambient temperature condition and green house canopy was recorded 7.7l and 10.9l respectively. The biogas production under the green house canopy was noticed more as compare to without green house canopy digester.*

Keywords*: Agricultural waste (pine needles), ambient temperature, batch study, biogas, and green house canopy.*

1. INTRODUCTION

The energy demand is rising day by day due to raise in population and higher living standard. The available conventional sources of energy are limited and its prices are rising so there is need to explore more alternative source of energy. In this context biogas is one of the clean, cost effective and renewable source of energy.

Biogas is the natural process where microorganisms degrade organic material in the absence of oxygen. The biogas is produced by anaerobic digestion of different raw materials such as manure, food waste, agricultural waste (plant waste, pine needles, rice husk and crop waste etc). A little study has been done so for on utilization of pine needles for biogas production and a little study has been conducted so far on the comparison of biogas production under green house canopy and without canopy. The temperature play vital role for the biogas production. But in the low temperature the biogas production is also low and sometime may stop. The ambient temperature in summer season is lies in the range of 20- 35^{0}C but in the winter season temperature are below 20^{0}C maximum and 2^0 C minimum in hilly areas [1]. There are many methods to increase the slurry temperature inside the digester such as insulation, use hot water for making a slurry and green house canopy etc. In this study green house canopy is utilized to increase the temperature inside the biogas digester.

Himachal Pradesh is a northern mountainous state in India with latitude 31.007 & longitude 77.088. According to census of 2011 the population of Himachal Pradesh is 6864602 and area of Himachal Pradesh is 55670 km^2. The 67% of geological area is covered by forests [2].

Pine needles are available in abundance in Himachal Pradesh region and the main advantage about the pine trees is that it is perennial nature of biomass. Pine trees grow at a height of 650 m to 1500 m above the mean sea level [3]. During the autumn season the pine needles fall from the trees and cover the large forest surface area. In the summer season there are chances of pine needles to catch the fire which ultimately pollute the environment, destroy the upper fertile layer of the soil and reduce the growth of favorable agricultural microbes [4]. The purging of pine needles from the forest surface area is required to reduce these hazards, disposal problem and used for alternative source of energy.

So the present study focuses on the use of pine needles as substrate for biogas production. In this study comparison of biogas production in digesters kept under green house canopy and without green house canopy has been made.

2. EXPERIMENTAL SETUP AND INSTRUMENTATION

In the present study two batch digesters were used. The first digester was used for biogas production from pine needles in ambient temperature condition and in the second digester pine needles was used as substrate under green house canopy. Each batch digester consists of two plastic made buckets; one for fermentation bucket and second for gas holder. The capacity of fermentation buckets and gas holder was 45*l* and 20*l* respectively. The internal diameters of fermentation bucket was 0.30 m at the bottom and 0.37 m at the top and the height of fermentation bucket is 0.45 m. The diameter of gas holders is 0.30 m and height of gas holders was 0.35 m. The GI fittings play vital role in the structure of batch digester. The fitting contain ½ inch nipple, ½ inch tank connection nipple, ½ inch valve and gas cork. The green house canopy stand was made of iron pipe. The length and height of green house canopy stand was 90 *cm* and 142 *cm* respectively. The digesters were placed near the Fluvial Hydraulics Laboratory at the Department of Civil Engineering in the Jaypee University of Information Technology (JUIT) Waknaghat, Solan (H.P). The pictorial views of two digesters are shown in fig. 1.

Fig. 1: Pictorial view of DIGESTER1 and DIGETSER2

Fig. 2: Pictorial view of pine needles before and after grinder

3. MATERIALS AND METHODS

The digester having pine needles as substrate without green house canopy was named as DIGESTER1. The digester having pine needles as substrate inside green house canopy was named as DIGESTER2. The pine needles were collected from nearby area of JUIT campus. The pine needles were dried for 3 hour at 70^{0}C in oven and then converted to small particles size using electrical grinder. The pine needles are shown before and after grinder in fig. 2.

Pine needles and water was mixed in the ratio of 1:15 by weight in this study. Hence 1.5 kg pine needles was mixed with 22.5 kg of water and 4.5 litre inoculum were used in both digesters. All the lumps of were broken and then mixture was filled in the fermentation bucket. The gas holder was placed in reversed position over the fermentation bucket with opened gas cork. When gas holder sunk to the bottom of the fermentation bucket then gas cork was closed. DIGESTER1 was kept into the ambient temperature condition while DIGESTER2 under the green house canopy. The various parameters such as pH, Total solid, Volatile solid, BOD and COD were measured before and after digestion. The pH, temperature and biogas production measured on daily basis. The temperature measured three times in a day (Morning, Afternoon and Evening) with the help of thermometer. The gas production was also calculated on daily basis on the basis of daily rise in height of gas holder. The raise height was multiplied by $\pi/4d^2$. Where d is the diameter of gas holder. This study was started on 8 Feb 2016 and ended on 17 April 2016. Thus retention period for this study was 70 days.

4. RESULTS AND DISCUSSION

The result of the study are discussed and summarized on the basis of performance of DIGESTER1 and DIGESTER2. The performance of digesters was investigated on the basis of experimental observation for: Total solid reduction, volatile solid reduction, pH, temperature, BOD reduction, COD reduction, and biogas production.

4.1 Total solid and volatile solid reduction

Total solid content in the start time was observed more but after the degradation total solid content decrease with the time, because microorganism use these total solid content as a food. In the batch system no new food coming so the starting food quantity was high as compare to end of time because food was utilized by bacteria so solid content was less in spent slurry. Fig. 3 shows the total solid reduction in both digesters. The total solid percentage reduction in both digesters was observed as 69.4% and 80.7% respectively.

In DIGESTER1 total solid reduction was observed less as compare to DIGESTER2 because the DIGESTER2 was kept under the green house canopy and DIGESTER1 was kept in the ambient temperature condition so the temperature was more under the green house canopy as compare to ambient temperature condition. Similar observation were noticed by [5] with substrate as kitchen waste. Similarly more total solid percentage reduction was noticed in the DIGESTER2 when compared to DIGESTER1 that means more biogas production in DIGESTER2.

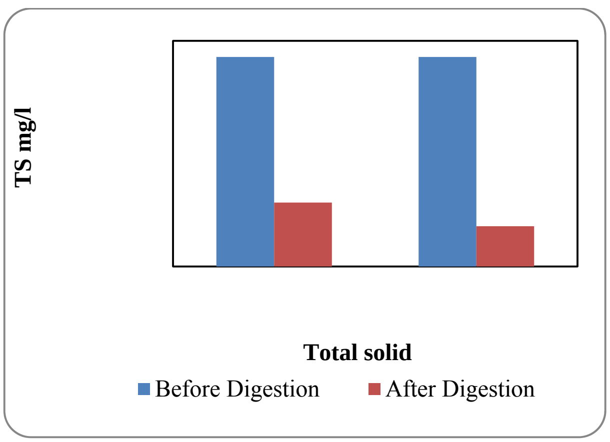

Fig. 3: Total solid reduction

Fig. 4 shows the volatile solid decline in DIGESTER1 and DIGESTER2. The volatile solid reduction in both digesters was observed 76% and 87% respectively. In DIGESTER1 volatile solid reduction was less as compare to DIGESTER2 because the DIGESTER2 was kept under the green house canopy so the temperature was high as compare to ambient temperature condition. More volatile solid reduction more will be the biogas production [6].

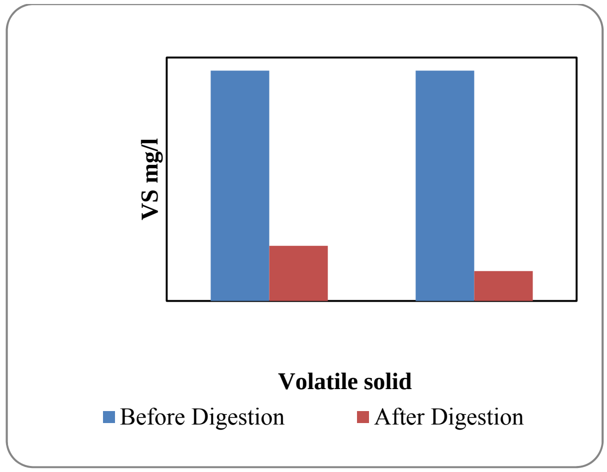

Fig. 4: Volatile solid reduction

4.2 BOD and COD Reduction

Fig. 5 shows the initial value of BOD in both digesters was 205 because in both the digesters same substrate was used and the final value of BOD in DIGESTER1 and DIGESTER2 was observed 199 and 196 respectively. Fig. 5 shows the comparison of BOD in both digesters. The BOD_5/COD ratio value before and after digestion varied from 0.01-0.02 that's means the some quantity of complex biodegradable organic material present in both digesters.

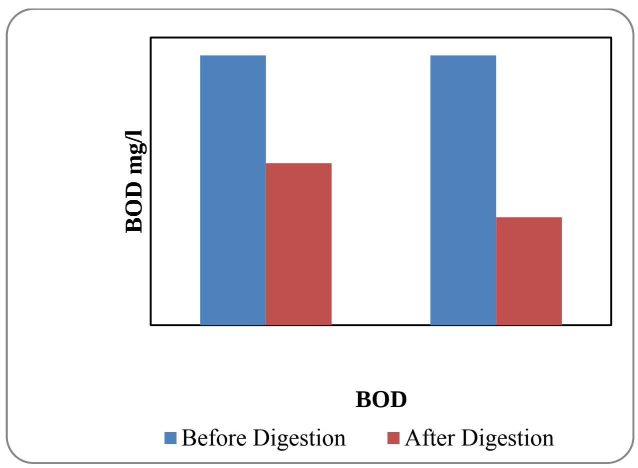

Fig. 5: BOD reduction

Fig. 6 shows the initial value of COD in both digesters was 11520 because in both the digesters same substrate was used. Final value of COD was observed as 4800 and 3840 in DIGESTER1 and DIGESTER2 respectively. Fig. 6 shows that COD reduction in DIGESTER1 and DIGESTER2 is 58.3 and 66.6% respectively. The COD reduction in DIGETER1 was observed less as compare to DIGESTER2. The COD is used to measure the quantity of organic matter in the waste and envisage the prospective for biogas production. The BOD and COD will be less during anaerobic digestion process in a biogas system. The BOD and COD will be decreased with time [7].

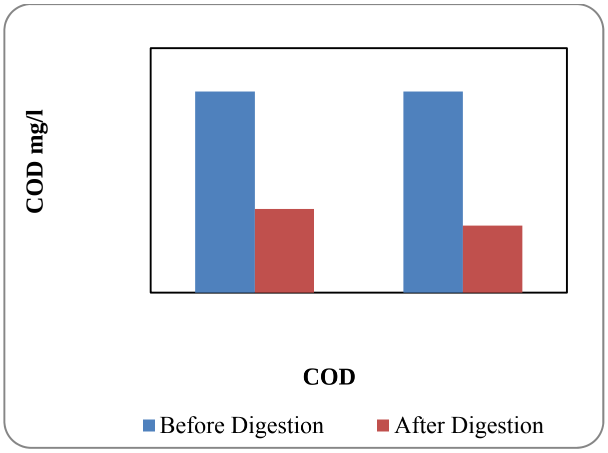

Fig. 6: COD reduction

4.3 Temperature

The ambient temperature and temperature inside the DIGESTER1 and DIGESTER2 is shown in figure7. The average ambient temperature range measured within the testing period was 15^0C – 28^0C and average slurry temperature inside the digester range varied from 16^0C – 29^0C in DIGESTER1. The ambient temperature for both digesters was same. In DIGESTER2 temperature observed during testing period was 18^0C – 29^0C and the slurry temperature inside the green house canopy digester was varied from 18^0C – 32^0C. In both the digesters temperature varied from 15^0C – 32^0C (Pyschrophilic < 20^0C and mesophilic 20^0C – 45^0C).

The temperature inside the digester was observed higher than the temperature outside the both digesters. This proved the microbial degradation of the waste that raised the temperature of the waste slurry [8]. The inside temperature in DIGESTER1 was observed less as compare to DIGESTER2 because the DIGESTER1 was kept in the ambient temperature condition and DIGESTER2 was kept under the green house canopy so temperature under the green house canopy was more ascompare to ambient temperature condition [5]. The temperature is a vital parameter for biogas production and generally at higher temperature the biodegradation process are more and thus the biogas yield are also more.

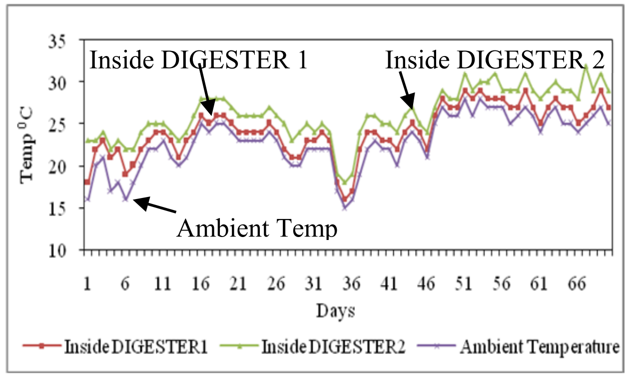

Fig. 7: Variation of temperature inside or outside in DIGESTER1 and DIGESTER2

4.4 pH

In DIGESTER1 pH was observed in the range of 6.4-8.2 and in the DIGESTER2 pH lies in the range of 6.5 to 8.4. The pH in this study was unregulated means no acid or bases were added to make the pH in neutral condition. The pH range in DIGESTER1 varied between 6.4 to 7.3 till 55^{th} day after that day pH increased and in the DIGESTER2 pH varied between 6.5 to 7.3 till 55^{th} day after that day pH value increased. In ending period the pH in DIGESTER1 and DIGESTER2 increased due to the digestion of volatile fatty acid and nitrogen compound through methanogenesis microorganism [9,12]. The pH is important due to the fact that Methanogenic microbes are sensitive in acidic condition. The encouraging range of biogas production in anaerobic digestion is 6.5-7.5. So when pH below 6.3 and above 7.8 biogas generation is less [10]. When pH was lies between 6.5 -7.2 the biogas production was more. This may be due to the increase in growth of methanogenesis bacteria, which are responsible for biogas generation [11]. In ending period biogas generation rate was less in both digesters.

4.5 Biogas production

Fig. 9 shows the comparison of cumulative biogas generation in DIGESTER1 and DIGESTER2. In the DIGESTER1 biogas generation started from the 7^{th} day but in the DIGESTER2 biogas production started from the 5^{th} day of the slurry feeding inside the fermentation bucket. The biogas generation rate in DIGESTER1 reached constant on 37^{th} day to 41^{st} day and in DIGESTER2 reached constant on 24^{th} day to 28^{th} day after this day the biogas generation rate decreased. This decrement may be attributed to low methanogenesis activity [13]. In the starting period biogas generation was low because microorganism was kept into new environment this was the lag phase of microorganism growth. The cumulative biogas generation in DIGESTER1 and DIGESTER2 was observed 7.7 and 10.9 *l* respectively. The biogas generation in DIGESTER2 was observed more as compare to DIGESTER1 because the DIGESTER2 was kept under the green house canopy and green house canopy raised the temperature and temperature plays vital role in the biogas generation.

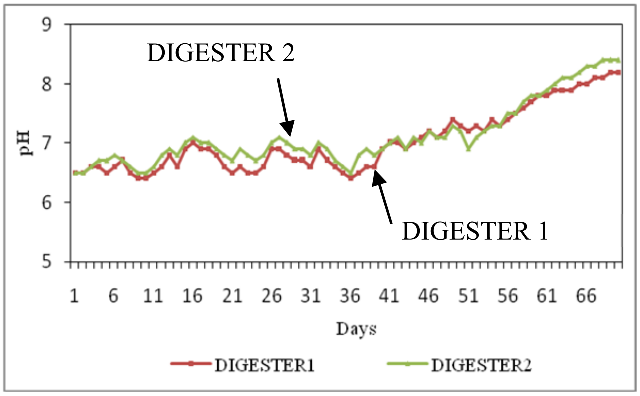

Fig. 8: Variation of pH with time

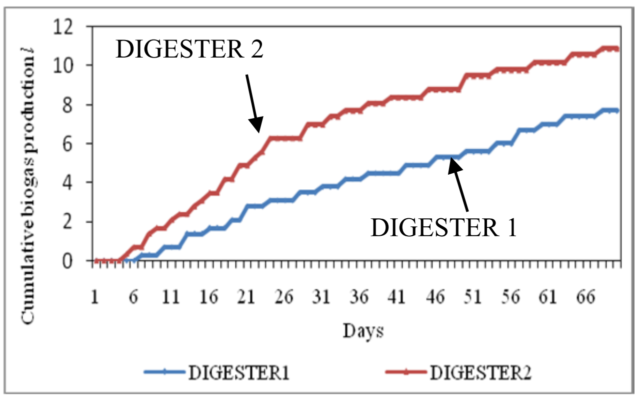

Fig. 9: Cumulative biogas productions

5. CONCLUSION

Pine needle has the potential of generation of biogas. Results shows that biogas production from agricultural waste (pine needles) under the ambient temperature condition was low when compared to the under the green house canopy conditions. The biogas production in DIGESTER1 and DIGESTER2 was 7.7*l* and 10.9*l* respectively. Green house canopy are good option to increase the biogas generation in the areas like Himachal Pradesh where temperature in summer season varies between 20-35^{0}C. The purpose of this study was to reduce the waste disposal problem due to use this agricultural waste for alternative energy source.

REFERENCES

[1] Kumar, K.V., and Bai, R.K., "Solar greenhouse assisted biogas plant in hilly region–A field study", *Solar Energy* 82, 10, 2008, pp. 911-917.

[2] Tripathi, A.K., Kumari, M., Kumar, A., and Kumar, S., "Generation of Biogas using pine needles as substrate in domestic biogas plant", *International Journal of Renewable Energy Research,* 5, 3, May 2015, pp.716- 721.

[3] Sharma, R.K., and Lekha, C., "Tapping of Pinus Roxburghii (Chir Pine) for Oleoresin in Himachal Pradesh, India", *Advances in Forestry Letters (AFL),* 2, 3, September 2013, pp.51-55.

[4] Chandran, M., Sinha, A.R., and Rawat, R.B.S., "Replacing controlled burning practice A.R. by Alternate methods of reducing fuel load in Himalayan Long leaf pine (Pinus roxburghii Sarg) Forests", *International Wildland fire conference, Sun City, South Africa,* May 2011, pp.9-13.

[5] Agrahari, R.P., "Utilization of Kitchen Waste inside Green House Chamber: A Community Level Biogas Programs", *World Academy of Science, Engineering and Technology International Journal of Environmental, Ecological, Geological and Geophysical Engineering,* 07, 12, 2013, pp. 627-631.

[6] Somashekar, R.K., and Verma, R., "Potential of Biogas Production from Food Waste in a Uniquely Designed Reactor under Lab Condition", *Department of Environmental Science Bangalore University, Janana Bharathi Campus, Bangalore, Karnataka, India,*2,2, April 2014, pp. 1-7.

[7] Shukla, P.N., Bhalerao, T.S., and Ingle, S.T., "Comparative study of Biogas Production from Different Food Wastes", *Journal of Environmental Research and Development,* 4, 4, June 2010, pp. 958-963.

[8] Voegeli, Y., and Zurbrugg, C., "Decentralized Anaerobic Digestion of Kitchen and Market Waste in Developing Countries- "State –of –The-Art" In South India", *Proceedings of second International Symposium on Energy from Biomass and Waste Venice, Italy,* November 2008, pp.17- 20.

[9] Christy, P.M., Gopinath, L.R., and Divya, D., "Microbial Dynamics during Anaerobic digester of Cow dung", *International Journal of Plant, Animal and Environmental Sciences,* 4, 4, Oct- Dec. 2014, pp. 86-94.

[10] Sagagi, B.S., Garba, B., and Usman, N.S., "Studies on Biogas Production from Fruits and Vegetable wastes", *Bayero Journal of Pure and Applied Sciences,* 2, 1, June 2009, pp.115-118.

[11] Ukpai, P.A., and Nnabuchi, M.N., "Comparative Study of Biogas Production from Cow Dung, Cow Pea, and Cassava Peeling using 45 Liters Biogas Digester", *Advanced in Applied Science Research,* 3, 3, 2012, pp.1864-1869.

[12] Christy, P.M., Gopinath, L.R., and Divya, D., "Microbial Dynamics during Anaerobic digester of Cow dung", *International Journal of Plant, Animal and Environmental Sciences,* 4, 4, Oct- Dec. 2014, pp. 86-94.

[13] Sibiya, N.T., Muzenda, E. and Tesfagiorgis, H.B., "Effect of temperature and pH on the anaerobic digestion of grass silage", *Int'l Conf. on Chemical Engineering & Advanced Computational Technologies,* 2014.