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Comparison of Biogas Production Using Pine Needles as Substrate under Varying Ambient Temperature Conditions

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Abstract—*This paper describes the result of biogas production using pine needles (agricultural waste) as substrate under varying ambient temperature conditions. There is various kind of macrobiotic waste for biogas production but pine needle has not been utilize so much yet. This is floating type biogas digester. This study was batch operated so daily biogas production was measured. The temperature plays a vital role in the biogas production. In this study both the ambient temperature and digester temperature was measured daily. In the winter season the ambient temperature was less than as compare to starting of summer season. In the winter season ambient temperature range measured within the testing was 15^0 to 23^0C and the summer season temperature rang was 17^0 to 30^0C. The ratio of substrate and water was 1:15 in both digesters. The both digesters have same quantity of slurry. In this work different type of parameters was measured like volatile solid (VS) total solid (TS), chemical oxygen demand (COD) and biochemical oxygen demand (BOD) before and after digestion. The temperature and pH was measured daily basis. The biogas production was more in starting of summer season as compare to the winter season. The cumulative biogas production in winter season and summer season was measured 5.3l and 7.7l. The temperature plays a vital role in the biogas production. This means more the temperature more the biogas production. The main purpose of this study was to reduce the waste disposal problem and use as renewable energy source.*

Keywords*: Agricultural waste (pine needles), ambient temperature, biogas production, batch digester and digestion.*

1. INTRODUCTION

In the present circumstance there is a challenge to meet our energy demand and thus there is need to look at the new sources of energy which are renewable as well as eco friendly. The energy demand is mounting day by day due to the boost in population. On the environmental point of view the population increased the waste generation is also increased and waste disposal is the one of the major problem. So use the waste as renewable energy source. Biogas is one of the clean and renewable energy sources. Different types of substrates used for biogas production such as food waste, cow dung and agricultural waste etc. so in this study agricultural waste was used as alternative energy source.

Himachal Pradesh is a northern hilly state in India with latitude 31.007 and longitude 77.088. The 67% of geological area is covered by forests [1]. These study pine needles was used for biogas production. The Himalayan subtropical pine forests are a huge forest on covering portions of India, Nepal and Bhutan. The Indian Himalayan region is extending across Himachal Pradesh, Jammu & Kashmir, Sikkim and Manipur. The most distinctive fact about pine trees is their perennial nature of biomass [2]. The pine needles fall mostly during pre monsoon period and with the hottest months of the year there are chances of forest fires [3]. So use pine needles as alternative energy sources. In the H.P two temperature ranges exist in the summer season mesophilic (20-45^{0}C) and the winter season (< 20^{0}C) pyschrophilic microorganism exit [4]. The temperature plays a vital role in the biogas production. In the winter season temperature was low as compare to the summer season. In the winter season biogas production was low due to low temperature and sometime biogas production may be stopped. But in the summer season biogas production was more due to temperature. The temperature in the winter season are below 20^{0}C maximum and 2^{0}C minimum but in the summer season ambient temperature range is 20-35^{0}C in hilly areas [5]. There are many methods to increase the biogas in winter season such as use hot water for mixing slurry and insulation etc. The temperature plays a vital role in the biogas production.

2. EXPERIMENTAL SETUP

The experimental study was conducted in department of Civil Engineering at Jaypee University of information technology Waknaghat Solan (H.P) India. One of the main objectives of this study was to done the comparison of biogas production in varying ambient temperature condition. Two plastic made buckets was used in this study one for fermentation bucket and

second for gas holder. The capacity of fermentation bucket was 45*l* and diameter of fermentation bucket was 0.37 *m* at the top and 0.30 m at the bottom. The capacity of gas holder was 30 *l* and diameter was 0.30 *m*. The GI fitting plays vital role in the assembly of batch digester. This fitting contains ½ inch tank connection nipple, ½ inch valve and ½ gas cork. The digester used in winter season [17 Nov-26 Jan] was used as *DIGEESTER1* and the digester used in summer season [8 Feb-17 April] was named as *DIGESTER2*. The pictorial view of *DIGEESTER* 1 and *DIGEESTER* 2 was shown in figure 1 below:

Figure 1 Pictorial view of DIGESTER1 and DIGESTER2

3. MATERIAL & METHOD

This study was done in the Jaypee University Waknaghat Solan (H.P). The pine needle was collected from nearby area of JUIT Campus. The pine needles were dried for 3 hours in oven at 70^0C temperature. After this pine needles were converted to small size with the help of electrical grinder. The pine needles are shown before and after grinding in figure 2 below:

Figure 2 Pictorial view of pine needle before and after grinding

The total quantity of substrate was same. Pine needle and water was mixed thoroughly in the ratio of 1:15 by weight hence 1.5 kg pine needle, 22.5 *l* water and 4.5 *l* inoculum. The gas holder was placed in reverse position over the fermentation bucket with opened gas cork. When gas holder was sunk bottom of the fermentation bucket then gas cork was closed and digester was put in the ambient temperature condition. The various parameters such as pH, BOD, COD, VS and TS were measured before and after digestion. The pH and biogas generation was measured on daily basis. The temperature was measured on three times in a day (morning, afternoon and evening) with the help of thermometer. Temperature plays a vital role in the biogas production more the temperature more the biogas production.

4. RESULTS AND DISCUSSION

The result of the study was discussed or summarized on the basis of experimental study of DIGESTER 1 and DIGESTER 2. The performance of digesters was investigated on the basis of experimental examination for: pH, Temperature, BOD reduction, COD reduction, Total solid reduction, Volatile solid reduction and biogas production.

4.1 pH

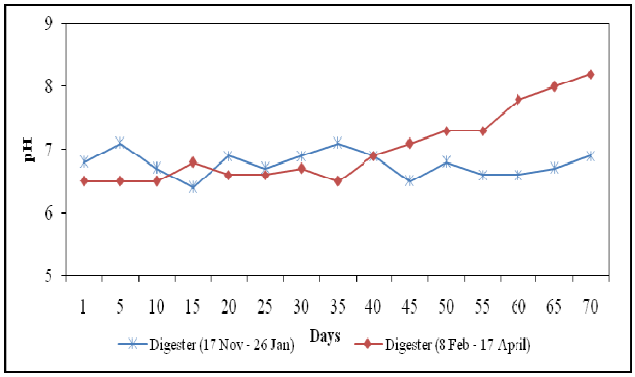

Figure 3 Variation of pH with Time

In the DIGESTER1 pH varies from 6.4-7.3 and in DIGESTER2 pH lies in the range of 6.4-8.2. The pH in this study was unregulated means no acid or bases add to make the pH in neutral condition. In the ending days the pH in DIGESTER1 increased and DIGESTER2 pH lies in 6.4 to 7.3 till 55^{th} day after that day pH was increased due to the digestion of volatile fatty acid and nitrogen compound through methanogenesis bacteria[6].The pH was important due to the fact that Methanogenic microbes are sensitive in acidic condition. In DIGESTER1 pH varies from 6.4- 7.3 and DIGESTER2 pH varies from 6.4-8.2. In this result observed that in the starting pH was low and the ending pH was increased because in starting decreased due to the acid formation in the hydrolysis phase and the ending increased due to the formation of volatile fatty acid and ammonia[6].

4.2 BOD and COD Reduction

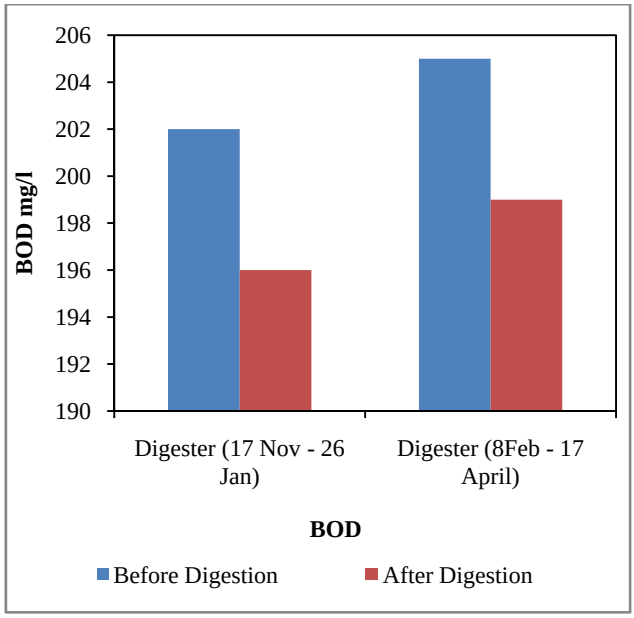

Figure 4 BOD Reduction

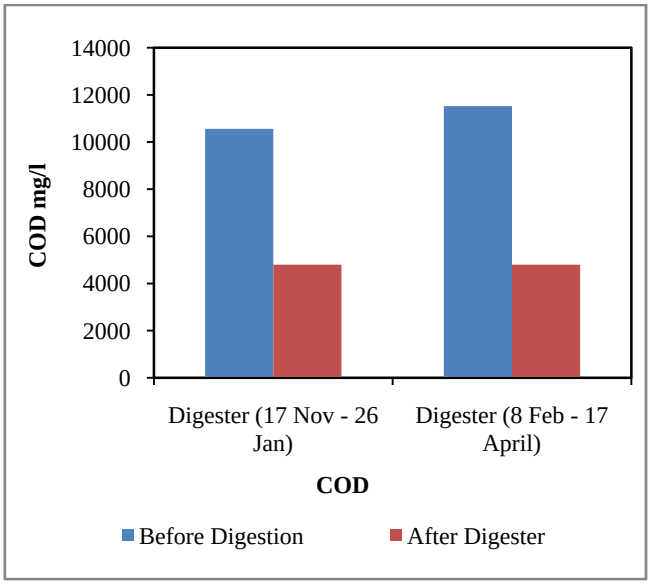

Figure 5 COD Reduction

In figure 4 the initial value of BOD was observed 202 and 205 respectively and the final value of BOD was observed 196 and 199 respectively. Figure 4 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.

Figure 5 shows the initial value of COD was observed 10560 and 11520 respectively and the final value of COD was observed 4800 in both digesters. Figure 5 shows the COD reduction in both digesters was 55% and 58.3% respectively. The COD reduction in DIGESTER1 was less as compare to DIGESTER2. The biogas production increased with increase in COD removal so in the DIGESTER1 has more COD removal as compare to the DIGESTER2. The BOD and COD will be decreased during anaerobic digestion process in a biogas system. The BOD and COD will be decreased with time [7].

4.3 Total solid and volatile solid Reduction

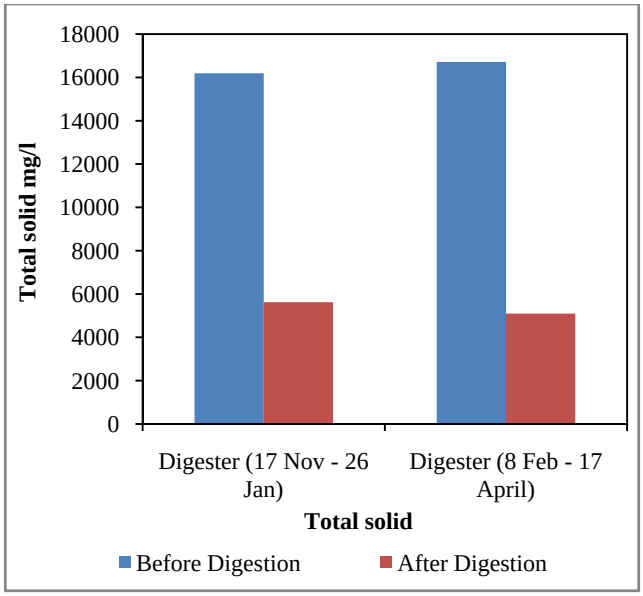

Figure 6 Total solid Reduction

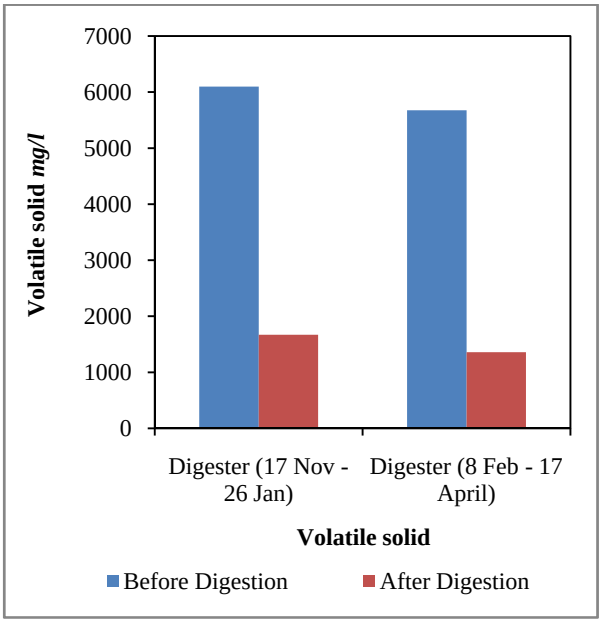

Figure 7 Volatile solid Reduction

Total solid content in the starting are more but when the degradation start the total solid are decrease, because the microbes utilize the total solid content as a food. In the batch system no new food coming in so starting food are more but after some time food are less and solid content was less in digested slurry. In the starting total solid content in both the digesters was more and after digestion the value of solid content was decreased in both the digesters.

Figure 6 shows the comparison of total solid in both digesters. The total solid reduction in both digesters was observed 65.2% and 69.4% respectively. In the DIGESTER1 total solid reduction was less as compare to DIGESTER2 because the DIGESTER1 work under winter season so the temperature was quit less than the DIGESTER2. The higher total solid reduction higher the biogas production. In DIGESTER2 more total solid reduction as compare to DIGESTER2 that means more biogas production in DIGESTER2.

Figure 7 shows the volatile solid reduction in both digesters. The volatile reduction in both digesters was observed 72.61% and 76.7% respectively. More volatile solid reduction more will be the biogas production [8].

4.4 Temperature

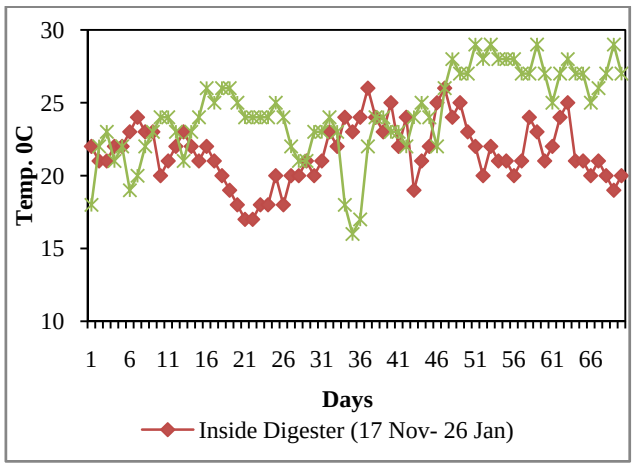

Figure 8 Variation of Temperature inside Digesters

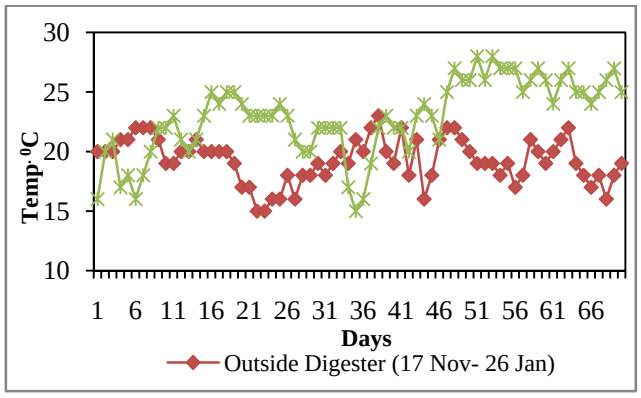

Figure 9 Variation of Temperature outside Digesters

Ambient temperature and the slurry temperature inside the both digesters were shown in figure 8-9. The inside temperature range in DIGESTER1 measured within the testing period were 15^0-25^0C and inside temperature range in DIGESTER2 was observed 16^0-31^0C. The inside temperature in the DIGESTER2 was observed more as compare to DIGESTER1 because the temperature from Nov. to Jan. was observed less as compare to Feb. to April. From figure 9 outside temperature in DIGESTER1 was observed range of 15^0-23^0 C and in the DIGESTER2 temperature range varies from 15^0-28^0C. The temperature plays vital role in the biogas production more the temperature more will be the biogas production. In the low temperature biogas generation was observed low as compare to the high temperature because in the winter season temperature was low so the biogas production was low.

4.5 Cumulative Biogas Production

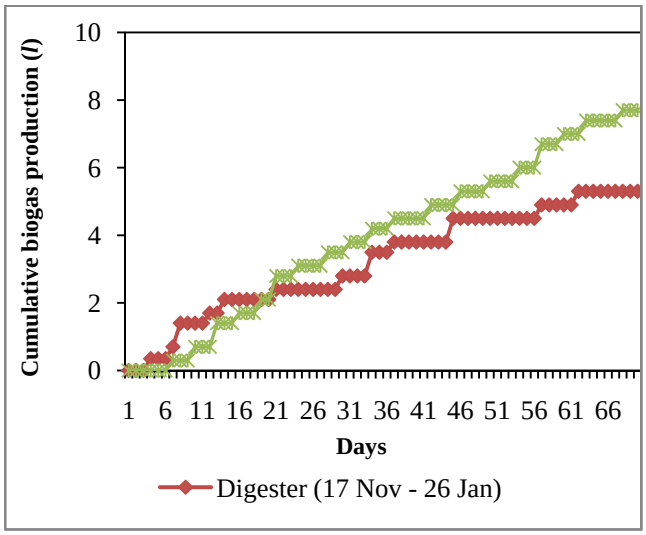

Figure 10 Cumulative Biogas Production

Figure 10 was shows the comparison of cumulative biogas production in DIGESTER1 and DIGESTER2. In the DIGESTER1 biogas was started from 3rd day but in the DIGESTER2 biogas production start from the 7th day of the slurry feeding inside the fermentation bucket. In the starting and ending biogas production was less because microbes put into the new atmosphere this is the lag phase of bacterial growth in the batch operation it predicts that the biogas production is directly equal to the growth of Methanogenic organism[9]. The cumulative biogas production in DIGESTER1 and DIGESTER2 was observed 5.3 and 7.7 l. The biogas production in DIGESTER2 was more as compare to the DIGESTER2 because in the DIGESTER2 was observed more temperature in the DIGESTER1 during the testing period so temperature plays a vital role in the biogas production thus more the temperature more the biogas production.

5. CONCLUSION

Pine needle has the admirable potential for biogas production. This experimental study shows the biogas production from agricultural waste (Pine needle) in the winter was low as compare to the starting of summer. The biogas production in DIGESTER1 was 5.3 *l* and the DIGESTER2 was 7.7 *l*. In Himachal Pradesh ambient temperature varies from 20-35^{0}C in the summer season and in the winter season ambient temperature varies from 2-17^{0}C. So temperature plays a vital role in the biogas production. This experimental study the ambient temperature in the winter season was observed 15-23^{0}C and in the starting of summer was observed 17-30^{0}C. So this study shows that more the temperature more will be the biogas production and the main purpose of this study was to use agriculture waste (Pine needle) for renewable energy source.

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