International Journal of Scientific Engineering and Technology ISSN : 2277-1581
Volume No. 6, Special Issue 1, PP : 28-32 22-23 Dec. 2017

Microbial Pretreated Water Hyacinth as an Energy Source

Diksha Srivastava ,Yashwant Raj Verma, Dr. Nafisa Ali
Department of Renewable Energy Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur -313001, Rajasthan, India

Abstract: The present research work was undertaken to study the potential of water hyacinth in generation of biogas; after a microbial pre-treatment. Water hyacinth, an aquatic weed is often associated with uncontrolled growth and eutrophication. Culture of Phanerochaete chrysosporium, a lingocellulytic fungus was used for microbial pre-treatment. Performance evaluation, in terms of biogas production was checked in 2m^{3}Modified Deenbandhu biogas plant, which is fitted with a stirrer on its side to remove scum formation in digester.The biogas production from the water hyacinth was only 1.92% more than that of cattle dung but the methane content of the biogas from the water hyacinth was 10.71% higher than that of cattle dung. The average NPK content of the digested slurry of the water hyacinth was 38.55%, 10.52% and 137.14% more than that of digested slurry of cattle dung respectively. This will help to sort out the problems of cooking fuel, lightening, aquatic weed disposal, waste managementand sanitation etc.
Keywords: Water hyacinth, Modified Deenbandhu biogas plant, *phanerochaetechrysosporium*, Biomethanation

Introduction

Water hyacinth (*EichhorniaCrassipes*) has been identified by the IUCN as one of the 100 most aggressive invasive species (Tellez *et al.*, 2008) and recognized as one of the top 10 worst weeds in the world (Patel 2012). It is characterized by rapid growth rates, extensive dispersal capabilities, large and rapid reproductive output and broad environmental tolerance (Zhang *et al.*, 2010). Among all the control methods such as; physical process, chemical process or biological process, physical process is the best as it provides both rid of water hyacinth which is a major problem for hydrosphere and also provides proper waste disposal of the taken out weed from lakes. Biogas technology in comparison to all other renewable sources of energy is well developed and easy to adopt for any person, as its technological infrastructure is easily available at large scale in Indian market for generating biogas. Biogas is a product of biomethanation process when fermentable organic material such as cattle dung, kitchen waste, poultry droppings, night soil wastes, agricultural wastes etc. are subjected to anaerobic digestion in the presence of methanogenic bacteria. This process is better as the digested slurry from biogas plants is available for its utilization as organic manure in agriculture and horticulture as a substitute of chemical fertilizers, and in pisciculture as a nutritional feed for fish.

1. Materials and Methods

Figure 1: Collection and preparation of water hyacinth for pre-treatment

The study was conducted at the Department of Renewable Energy Engineering, College of Technology and Engineering, Udaipur (Rajasthan). Water Hyacinth was collected from the pond of the nearby village named Kanpur, Udaipur (Rajasthan), and was chopped using crusher machine under green house shed, as shown in Figure1.

For the microbial treatment of Water Hyacinth,a wood-rot fungus that is capable of degrading lignin via its lignolytic enzymes;*Phanerochaetechrysosporium* (NCIM 1197) was used.This organism is termed as “white rot fungus” because of its ability to degrade lignin. The cellulosic portion of wood is attacked to a lesser extent, resulting in the characteristic white color of the degraded wood. Degradation of material involves important extracellular enzymes such as lignin peroxidase, manganese dependent peroxidase, glyoxal oxidase and pyranose oxidase (located in the interplasmic space of the fungal cell wall) (Urek and Pazarlioglu, 2007).

The vials received from NCIM were kept as parental cultures from which sub-cultures were prepared in malt extract agar medium using slants of test tubes and secondary sub-culture in petri plates as shown in Figure 2.

ISSN : 2277-1581
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Figure 2: Sub-cultures of Fungus

Further these subcultures were used for preparing mother spawns. For this, one kg of wheat grains was soaked in 1 liter water for overnight. Next day the grains were boiled for 15-20 minutes, after boiling the grains, it was soaked in the same water for 10-15 minutes and then excess water was drained off using a wire mesh sieve. The grains were surface dried on white paper sheet and 12 gm gypsum ($CaSO_4$ $2H_2O$) and 3 gm calcium carbonate ($CaCO_3$) were mixed with these boiled grains, where the gypsum was added to prevent the grains from sticking to each other and calcium carbonate was used to bring the pH to 6.5. The grains were then filled in 500 ml conical flask up to three fourth of the capacity, plugged with non-absorbent cotton and sterilized in autoclave at 120°C $\pm$ 2°C and 15 lb psi for 1 to 1½ hours. Flasks were cooled at room temperature and then were inoculated with colonized mycelium of *Phanerochaete chrysosporium* by putting the two bits of agar (from petri plates) just opposite to each other in the inner side in the middle of flasks and then incubated at 25± 1°C for 2 weeks. The flasks were shaken every day to obtain homogenous growth of fungi. After 2 weeks of inoculation the flasks were ready as spawn culture (Pant *et al.*, 2006). A comparative view of grain filled flasks, before and after sub culturing is shown in Figure 3.

Figure 3: Before and after spawn growth

In field level the methodology adopted for treatment of water hyacinth is as under-100 kg of crushed Water Hyacinth was soaked (overnight) in 70-80 lt. of water containing 0.05 percent bavastine and 0.25 percent formaldehyde. This is done to sterilize the organic waste (Deshmukh and Deshmukh, 2013). For fungal treatment, mother spawn of *Phanerochaete chrysosporium* (prepared previously) was spread on substrate layer by layer in 3 canisters. These canisters were marked and kept at ambient temperature for growth of fungus for 3 days, as shown in Figure 4 (Ali, 2014). Further respectively first, second and third canister was used for feeding biogas plant so as to obtain sufficient growth of microbes for three days and simultaneously filled with fresh material and layer of microbes. This process was repeated till the end of the experiment.

Figure 4: Preparation of mixture of pre-treated water hyacinth and cattle dung

Figure 5: Deenbandhu Biogas Plant with Mixing Unit

 ISSN : 2277-1581
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Initially plant was fed with 100% cattle dung as seeding material to enhance the rate of reaction and then was replaced by pretreated water hyacinth (Ali, 2010) with reduction ratio of 20% (i.e. ratio between cattle dung and water hyacinth was maintained as 50:0, 40:10, 30:20, 20:30, 10:40, 0:50 respectively after every one week). A simple mechanical hand driven mixing unit was developed and installed in the Modified Deenbandhu biogas plant to solve the problems of choking experienced when using lignocellulosic material. It has an axle with four vertical and two horizontal baffles on both side of the centre. The whole unit was installed inside the biogas plant perpendicular to the flow of feed material in the plant having bearings on both sides for ease in rotation. Handle for operating the mixing unit was kept outside the plant. The speed of rotation was 4 rpm as shown in figure 5.

2. Results and Discussion

To check the feasibility of water hyacinth as a substrate and adduct for biomethanation, biochemical analysis of water hyacinth and cattle dung was done. All the analysis was done using standard methods as shown in Table No.1.

Table 1: Physico chemical analysis of water hyacinth and cattle dung

Constituents	pH	TS%	VS%	N%	P%	K%
Water Hyacinth	6.08	9.61	82.65	2.16	0.58	1.63
Cattle dung	6.82	10.72	81.54	1.38	0.52	0.55

The biochemical analysis of the feed material before and after digestion, with respect to pH, total solidcontent and volatile solid content were done by standard methods and are shown in table 2.

Table 2: Characteristics of feed material before and after digestion

Days of Observation	pH		TS		VS	
	BD	**AD**	**BD**	**AD**	**BD**	**AD**
10	6.08	6.83	9.60	9.10	82.90	82.78
15	6.06	6.83	9.54	8.70	82.50	81.25
20	6.05	6.85	9.58	8.50	82.60	80.40
25	6.05	6.92	9.62	8.10	81.85	78.40
30	6.07	6.92	9.61	8.00	82.68	77.10
35	6.09	6.95	9.59	7.80	82.73	75.80
40	6.08	6.96	9.62	7.50	83.18	74.52
45	6.09	6.92	9.64	7.46	82.56	74.00
50	6.10	6.91	9.64	7.10	82.60	73.72
55	6.09	6.87	9.63	7.30	82.87	73.56
60	6.10	6.90	9.64	7.40	82.50	72.83
65	6.10	6.89	9.62	7.12	82.89	72.75
70	6.09	6.87	9.60	7.18	82.63	72.80
Average	**6.08**	**6.89**	**9.61**	**7.78**	**82.65**	**76.14**

WH: Water Hyacinth, BD: Before Digestion, AD: After Digestion

pH value of the water hyacinth before digestion was nearly constant during the whole process. The average value of total solid content of water hyacinth was found to be 7.78% and of cattle dung was found to be 8.10%. Degradation in VS content of water hyacinth was found to be 12.11%, while that in case of cattle dung was found to be 11.10% which indicated the lower biogas production from cattle as compare to water hyacinth. The maximum and minimum temperature of the environment near biogas plant during digestion was found to be 45.70°C and 12.50°C respectively.

Production of biogas depends on the degradation of volatile solid matter and here degradation is higher in water hyacinth as compare to cattle dung which clearly indicates the reason of higher biogas production from water hyacinth as compare to cattle dung. Figure 6 shows the biogas produced from water hyacinth and cattle dung graphically, calculated using biogas flow meter during the digestion process.

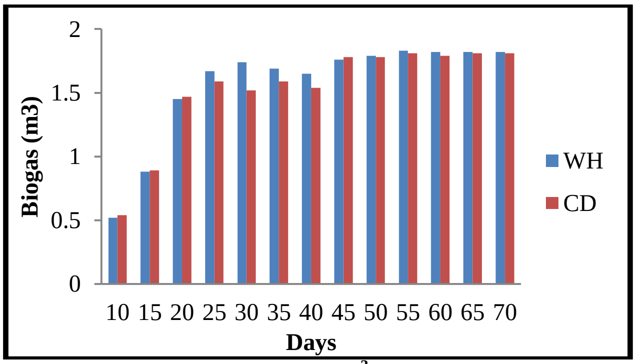

Figure 6: Biogas production in m^3 from the water hyacinth and cattle dung

Figure 7 and 8 shows the amount of methane and carbon dioxide content in biogas produced from water hyacinth and cattle dung graphically during digestion process. The maximum and minimum amount of methane content of the biogas produced from the water hyacinth was 68.70% and 45.80% respectively. The average methane content was found to be 63.33%. The maximum and minimum amount of methane content of the biogas produced from the cattle dung was 59.80% and 45.90% respectively. The average methane content was found to be 57.20%. Higher the amount of methane percentage in biogas clearly denotes the quality of biogas, which in turn increases the calorific value of biogas. The maximum and minimum amount of CO_2 content of the biogas produced from the water hyacinth was 51.80% and 28.80% respectively. The average CO_2 content was found to be 34.19%. Amount of CO_2 in biogas reduce the calorific value of biogas. Lower amount of CO_2 in biogas produced from water hyacinth indicates the higher calorific value as compare to that of cattle dung.

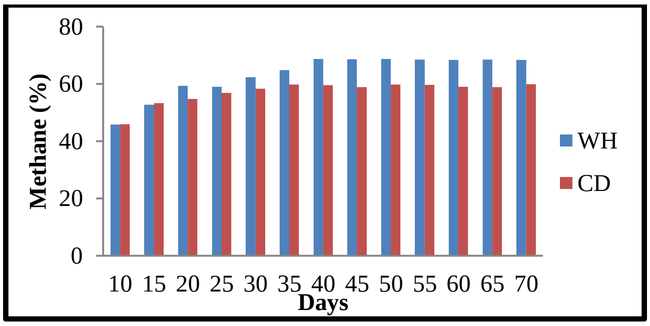

Figure 7: Methane percentage in the biogas

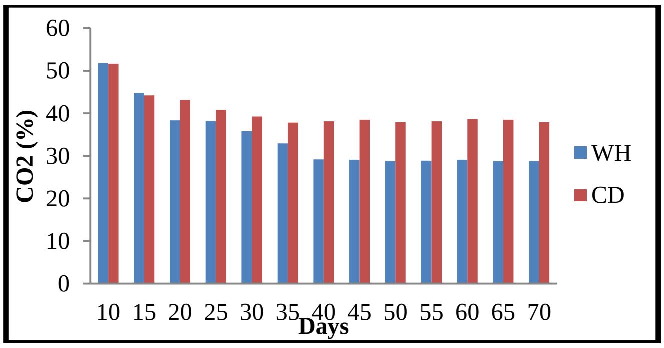

Figure 8: CO_2 percentage in the biogas

The biogas spent slurry was analyzed for nutrients like nitrogen, phosphate and potash at every 10 day's interval. Results are presented in figure 9,10and 11 respectively.

International Journal of Scientific Engineering and Technology
Volume No. 6, Special Issue 1, PP : 28-32

ISSN : 2277-1581
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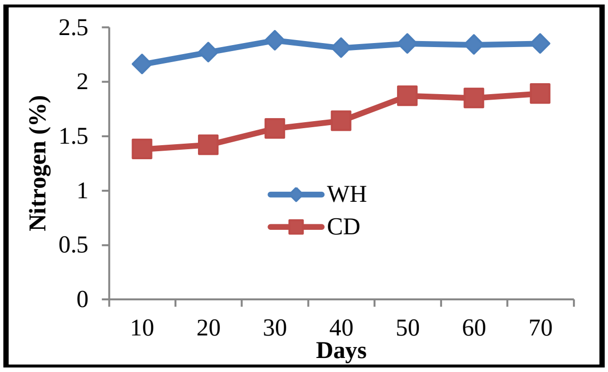

Figure 9: Nitrogen percentage in digested material

Nitrogen content of the fresh water hyacinth was found to be 2.16% and after digestion, an increase of 10.18% was observed. Range of the nitrogen content in the digested slurry of water hyacinth was found to be 2.16% to 2.38% and the average nitrogen content was found to be 2.30%. Nitrogen content of the fresh cattle dung was found to be 1.38% and after digestion, an increase of 36.95% was observed. Range of the nitrogen content in the digested slurry of cattle dung was found to be 1.38% to 1.89% and the average nitrogen content was found to be 1.66%. Due to higher value of nitrogen content in fresh water hyacinth than that of cattle dung, it is higher in digested slurry.

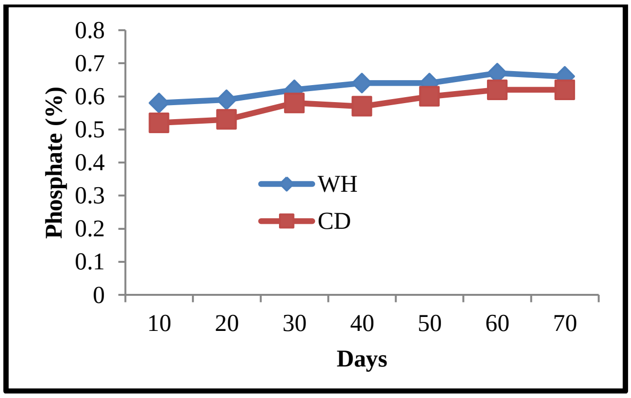

Figure10: Phosphate percentage in digested material

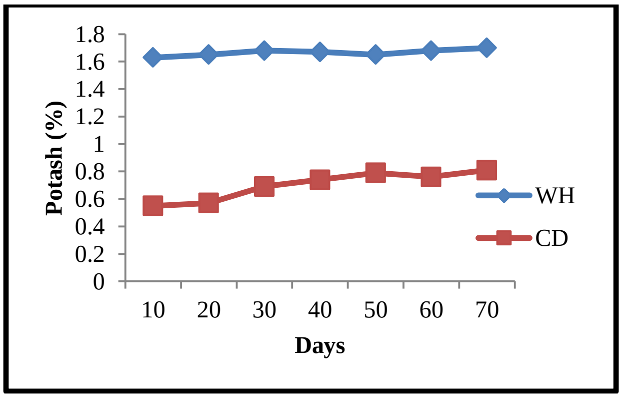

Figure 11: Potash percentage in digested material

Phosphate content of the fresh water hyacinth was found to be 0.58% and after digestion, an increase of 15.51% was observed. Range of the phosphate content in the digested slurry of water hyacinth was found to be 0.58% to 0.67%, the average phosphate content was found to be 0.63%. Phosphate content of the fresh cattle dung was found to be 0.52% and after digestion, an increase of 19.23% was observed. Range of the phosphate content in the digested slurry of cattle dung was found to be 0.52% to 0.62% and the average phosphate content was found to be 0.57%.

Potash content of the fresh water hyacinth was found to be 1.63% and after digestion, an increase of 4.29% was observed. Range of the potash content in the digested slurry of water hyacinth was found to be 1.63% to 1.70%, the average potash content was found to be 1.66%. Potash content of the fresh cattle dung was found to be 0.55% and after digestion, an increase of 47.27% was observed. Range of the potash content in the digested slurry of cattle dung was found to be 0.55% to 0.81%, the average potash content was found to be 0.70%.

3. Conclusion

In this study, an attempt has been made to utilize an obnoxious aquatic weed, water hyacinth. It is a serious hazard to various lakes, ponds or any other stagnant water body. This study has determined the potential of generation of biogas after a microbial pre-treatment, which will help to sort out the problems of aquatic weed disposal, waste management, sanitation, cooking fuel, fuel for lightening, organic manure production etc. The biogas production from the water hyacinth was 1.92% more than that of cattle dung but the methane content of the biogas from the water hyacinth was 10.71% higher than that of cattle dung. After biogas production, bio-chemical analysis of the digested slurry was done which concludes that the average NPK content of the digested slurry of water hyacinth was 38.55%, 10.52% and 137.14% more than that of digested slurry of cattle dung respectively.

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ISSN : 2277-1581
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