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STUDY ON EFFECT OF PRETREATMENT METHODS ON BIOMETHANATION OF WATER HYACINTH

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ABSTRACT

A comparative study on the effect of different pre-treatment methods on the biogas yield from Water hyacinth (WH) was carried out in 250 ml batch digester for a 60 days retention period. Biomethanation was carried out in mesophilic temperature range of 30 to 37°C. WH was pretreated as: chopped, dried and ground (WH-CDG), treated with NaOH, dried and ground (WH-NaOH), ground WH combined with poultry waste (WH-PW), ground WH combined with primary sludge (WH-PS) while fresh water hyacinth (WH-F) served as control. The results of the study showed the highest cumulative biogas yield was from WH-PW, with yield of 0.38 liters/g VS. This was followed by WH-PS, WH-NaOH, and WH-CDG with cumulative biogas yield of 0.345, 0.31 and 0.281 liters/g VS respectively. The biogas yield of the fresh Water hyacinth (WH-F) was negligible. Gas analysis from WH-P shows Methane (65.0%), CO_2 (34.94%). WH- F contained Methane (60.0%), CO_2 (39.94%), and WH- NaOH contained Methane (71.0%), CO_2 (28.94%). The other gases were found in the same levels and in trace amounts in all the systems.

The overall results showed that blending water hyacinth with poultry waste and primary sludge had significant improvement on the biogas yield, and treating water hyacinth with NaOH increased the biogas yield slightly. It also indicated that water hyacinth is a very good biogas producer and the yield can be improved by drying and combining it with poultry waste and primary sludge.

Key words: Water hyacinth, biomethanation, Poultry waste, Sludge and Biomass

1. INTRODUCTION

Energy is one of the most important factors to global prosperity. The constant use of fossil fuels as primary energy source has lead to global climate change, environmental degradation, and human health problems [1]. Renewable energies play an important role in this process and in particular biomass could contribute in a significant way because it is a ‘‘carbon neutral” fuel [2]. Nowadays human beings have used anaerobic digestion of waste organic materials to generate biogas. Biogas comprises of methane (50 to 70%), carbon dioxide (30 to 40%) and traces of other gases which include CO, H_2S, NH_3, H_2, O_2 and water vapor etc. Biomethanation process is anaerobic process, it involves transformation of organic matter to methane and has become a method of waste management and resource recovery. This process is characterized by a series of biochemical transformations brought on by different consortia of bacteria. Biomethanation process involves hydrolysis, acidogenesis, acetogenesis and methanogenesis [3]. Each of these phases are interlinked reactions proceeding spatially as well as temporally in consecutive and parallel steps and hence, influence one another. Water hyacinth (*Eichhornia crassipes*) is a free floating aquatic weed belongs to Pontederiaceae family. It is abundantly found in India, Bangladesh, South East Asia, Amazon in South America [4]. Due to its fast growth and the robustness of its seeds, the water hyacinth has since then caused major problems such as physical interference with fishing, obstruction of shipping routes and loss of water in irrigation systems due to higher evaporation and increased sedimentation by trapping silt particles. It also restricts the possibilities of fishing from the shore with baskets or lines [5] and can cause hygienic problems [6]. Attempts to control the weed have caused high costs and labor requirements, leading to nothing but temporary removal of the water hyacinths [7].

Water hyacinth is rich in nitrogen, essential nutrients and has a high content of fermentable matter and hence it is a potential biomass for biogas production. Apart from biogas, the residual slurry obtained after anaerobic digestion is rich in essential inorganic elements needed for healthy plant growth hence is useful soil conditioner and manure with no detrimental effects on the environment. Water hyacinths exhibits prolific growth and have a high content of hemicellulose and cellulose, but the existing hemicellulose has a rather strong association with the lignin in the plant, which makes it unavailable for the microorganisms. To overcome this problem and to optimize biogas production, the plants must undergo some kind of pre-treatment [8]. Pre-treatment breaks down the complex organic structure into simpler molecules which are then susceptible to microbial degradation [9]. Pre-treatment involves chopping, drying and grinding, co-digestion with other organic wastes like primary sludge or animal manure (cow dung and poultry waste), alkali (NaOH) treatment.

The present study was undertaken to investigate the effect of different pre-treatment methods on the biogas yield from water hyacinth (WH) by using chopped, dried and ground water hyacinth (WH-CDG), treating water hyacinth with NaOH, dried and ground (WH-NaOH), ground WH and combining with cow dung (WH-C), ground WH and combining with poultry waste (WH-PW), ground WH combining with primary sludge (WH-PS).

2. MATERIALS AND METHODS

2.1 Materials/Instruments

Water hyacinth used for the study was obtained from a lake at Kengeri satellite town (Bangalore, Karnataka, India). Overnight, fresh poultry waste was collected from Suguna chicken center at Kengeri satellite town (Bangalore, Karnataka, India). Primary sludge was collected from Vrishabhavathi sewage treatment plant near R V College of Engineering (Bangalore, Karnataka, India).

The following materials/instruments were used for the purpose of this research: weighing balance(Systronics), gas chromatography (CHEMITO), pH meter (Systronics), a mercury in glass thermometer (range 0^0C to 100^0C), oven, grinding mill, temperature controlled water bath, water troughs, graduated transparent glass gas collectors, tap water, rubber cork, connecting tubes and biogas burner. NaOH (AR grade) manufactured by Ranbaxy laboratories.

2.2 Biomethanation unit

It consists of a temperature controlled thermo bath which is maintained at 35^0C. It can accommodate biodigesters of 250 ml capacity. Each biodigester is connected to a graduated gas collector by means of a connecting tube. A stand holds all the gas collectors. Biogas evolved is collected by downward water displacement method. Plastic water basins are used for water sealing.

2.3 Fermentation slurry

Different parts of fresh water hyacinth (leaves, stem and root) were collected, cleaned and then chopped to small sizes of about 2 cm, then allowed to dry under the sun for a period of 7 days, after which they were dried in an oven at 60^0C for 6hours. This oven-dried water hyacinth was then ground to fine particles using a grinding mill. This powder was used prepare digesters WH-CDG, WH-C, WH-P, WH-CP. The alkali (NaOH) treatment was effected by soaking chopped water hyacinth in 1% NaOH (by volume) solution for 2 days followed by sun drying and grinding. The resulting powder was used to prepare digester WH-NaOH. Wet paste of water hyacinth was used in digester WH-F. Details of the composition of various fermentation slurries are given in table1. Each biodigester was given 5 gm of inoculum from an anaerobic poultry waste digester as seed. Biomethanation of these digesters were carried out in duplication. Daily biogas production, slurry temperatures were monitored throughout the period of study.

3. RESULTS AND DISCUSSION

3.1 Biogas production

The trend of the daily biogas production with time from all the digesters is shown in figure 1. Biogas production for all the digesters commenced within five days. The fermentation slurry with dried and chopped water hyacinth combined with poultry waste (WH-PW) was observed to produce the highest quantity of biogas. This performance confirms the earlier reports by other researchers that combining animal dung with plant wastes catalyzes the biogas production with consequent increased yield [10], [11], [12]. The rate of biomethanation was highest for WH-PS than others in the beginning, after 20 days retention time, the rate decreased in comparison with WH-PW. However blending water hyacinth with primary sludge proved better pretreatment to produce biogas than remaining, as primary sludge has adequate nutrients required for the methanogens to act on. The alkali treated water hyacinth (WH- NaOH) gave a better yield of biogas over dried and chopped water hyacinth (WH-CDG) as bases are known to de-lignify plant structure [13]. The treatment with NaOH may have aided the breakdown of the lignin and cell wall of water hyacinth with an improved pH for the methanogens to gain access to nutrients trapped in the plant. However, alkali treatment did not bring about a significant increase in biogas yield when compared with WH-CDG. Evolution of biogas from WH-F had a lag period of 10 days, latter a very small quantity of biogas was produced. However biogas gas evolution stopped after 15 days. This could be because of lack of dilution in the digestion slurry. Liquid environment in the slurry is very significant, as it enables easy circulation of materials and contact between the bacteria and their food. Hence optimum dilution should be maintained in the digester to improve the biogas yield from WH-F.

Unlike most plant wastes whose pH range from 3 - 5, WH- F exhibited a rare quality not found in other plant wastes. This suggests that the level of lignin in water hyacinth is low when compared to other plant wastes [14]. These results indicate that co-digestion of dried and chopped water hyacinth with poultry waste or primary sludge is a more effective pre-treatment method. From economic point in to consideration drying and chopping to smaller sizes is more effective pre-treatment method than alkali treatment.

4. CONCLUSION

Unlike most plant wastes studied so far, the present study has revealed that water hyacinth is a very good biogas producer needing minimal pre-treatment to enhance the biogas yield. The use of pretreated water hyacinth for biogas generation therefore, will be a good energy source for those residing in the coastal areas, which face the menace of clogging of waterways by the weed.

The result of the study has shown that dried and chopped Water hyacinth combined with poultry waste (WH-PW) had the highest cumulative biogas yield followed by dried and chopped water hyacinth combined with primary sludge (WH-PS), while the alkali treatment did not affect the biogas yield significantly. These results indicate that water hyacinth does not require chemical treatment. It also shows that drying and grinding to fine powder is a more effective pre-treatment method along with blending with poultry or primary sludge. Unlike most plant wastes studied so far, the present study has revealed that Water hyacinth is a very good biogas producer with minimal pre-treatment to enhance the biogas yield. The use of pre-treated Water hyacinth for biogas generation therefore, will be a good energy source for those residing in the coastal areas, which face the menace of clogging of waterways by the weed.

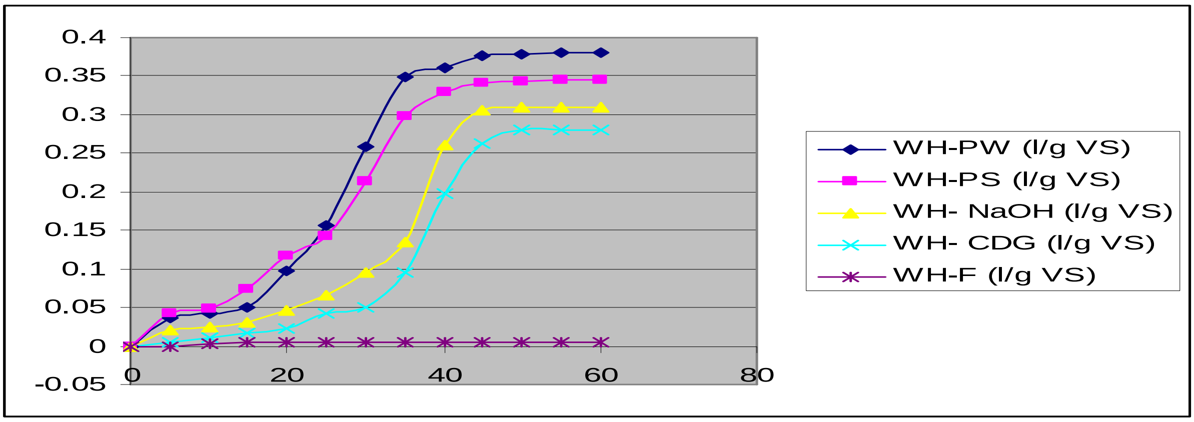
Table 1: Composition of digesters

Digester	Composition	Inoculum
WH-CDG	8 gm chopped, dried and ground (CHD) WH + 92 gm water	5 gm
WH- NaOH	8 gm NaOH treated, dried and ground WH + 92 gm water	5 gm
WH-PW	4 gm (CHD) WH + 16 gm poultry waste + 80 gm water	5 gm
WH-PS	4 gm (CHD) WH + 16 gm primary sludge + 80 gm water	5 gm
WH-F	100 gm fresh WH wet paste	5 gm

Table2. Trend of the biogas production

Days	**WH-PW (liters/g VS)**	**WH-PS (liters/g VS)**	**WH- NaOH (liters/g VS)**	**WH- CDG (liters/g VS)**	**WH-F (liters/g VS)**
0	0	0	0	0	0
5	0.036	0.042	0.021	0.006	0
10	0.043	0.048	0.025	0.011	0.004
15	0.051	0.073	0.031	0.016	0.006
20	0.098	0.118	0.046	0.022	0.006
25	0.156	0.142	0.066	0.042	0.006
30	0.258	0.213	0.095	0.051	0.006
35	0.349	0.298	0.135	0.096	0.006
40	0.360	0.330	0.260	0.197	0.006
45	0.376	0.341	0.305	0.262	0.006
50	0.378	0.343	0.310	0.281	0.006
55	0.380	0.345	0.310	0.281	0.006
60	0.380	0.345	0.310	0.281	0.006

Fig.1. Daily biogas production



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