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IMPACT OF DILUTION ON BIOMETHANATION OF FRESH WATER HYACINTH

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ABSTRACT

Water hyacinth (*Eichhornia crassipes*) is a noxious weed that has attracted worldwide attention due to its fast spread and congested growth, which lead to serious problems in navigation, irrigation, and power generation. The concept of using aquatic plants for conversion to energy is gaining attention in tropical and sub tropical regions of the world where warm climate is conducive to the plant growth through the year. Anaerobic digestion of animal, agricultural and industrial wastes has been widely studied. However, very little work has been done using aquatic plants particularly water hyacinth. The literature review indicated that water hyacinths can be rich in nitrogen, up to 3.2% of DM and have a C/N ratio around 15. The water hyacinth can be used as a substrate for biogas production. The sludge from the biogas process contains almost all of the nutrients of the substrate and can be used as a fertilizer.

In the present work biomethanation of fresh water hyacinth with different amount of water was carried out in mesophilic temperature range of 30°C to 37°C for a period 60 days. Fermentation slurry of water hyacinth to water in the ratio 1:4 (FWH-1:4) produced maximum biogas yield of 0.245 l/gVS, followed by FWH-1:5 and FWH-1:3.

Key words: Water hyacinth, Biomethanation, Acidogenesis, Acetogenesis, Biogas .

[1] INTRODUCTION

In recent times where fossil fuels are gradually depleting, in addition to rising costs and instability in the major producer countries, renewable energy has become one of the best alternatives for sustainable energy development [1]. Conversion of organic matter (usually animal or human waste) to biogas is a well established technology. However, very less work has been done on production of biogas using aquatic plants. Water hyacinth (*Eichhornia crassipes*) is aquatic biomass species that exhibits prolific growth in many parts of the world. It is a floating perennial herb of pickerel weed family (*Pontederiaceae*) which propagates itself profusely and has become a menace to navigation, in addition to problems of fishing, evapotranspiration, reduction in aquatic biodiversity, hydroelectricity power generation etc. Attempts to control the weed have caused high costs and labor requirements, leading to nothing but temporary removal of the water hyacinths [2]. In developing country like India the most favorable conditions for the growth of the water hyacinth often are found, very limited resources have been put into curbing them. Fighting the water hyacinth generates neither food nor income. Fast growth is a feature of water hyacinth, this would therefore have a great potential, if seen as raw material for biogas production as it is rich in nitrogen, essential nutrients and has a high content of fermentable matter [2]. However, since water hyacinth biomass is lighter than water, it floats and clogs the digester. Therefore, it is not feasible to feed it even after chopping, to the conventional biogas digesters [3].

Water hyacinths are more difficult to biodegrade than animal manures. This is because water hyacinths 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, in the present work, biomethanation of water hyacinth is carried out by chopping, grinding water hyacinth to fine powder and diluting with different quantity of water. Chopping and grinding the water hyacinths increases the specific surface of the substrate and thereby enhances the access of microbes to the plant material [4].

The anaerobic biological conversion of organic matter occurs in three steps. The first step is hydrolysis is carried out by strict anaerobes such as Bactericides, Clostridia and facultative bacteria such as Streptococci, etc. this step involves, the enzyme-mediated transformation of insoluble organic material and higher molecular mass compounds such as lipids, polysaccharides, proteins, fats, nucleic acids, etc. into soluble organic materials, i.e. to compounds suitable for the use as source of energy and cell carbon such as monosaccharides, amino acids and other simple organic compounds. In the second step (acidogenesis and acetogenesis), another group of microorganisms ferments the break-down products of hydrolysis to acetic acid, hydrogen, carbon dioxide and other lower weight simple volatile organic acids (propionic acid and butyric acid) which are in turn converted to acetic acid. In the third step (methanogenesis), acetic acid, hydrogen and carbon dioxide are converted into a mixture of methane and carbon dioxide by the methanogenic bacteria (acetate utilizers like *Methanosarcina spp*.and *Methanothrix spp* and hydrogen and formate utilizing species like *Methanobacterium, Methanococcus*, etc.) [5]. The three stages of methane fermentation are shown in Fig.1.

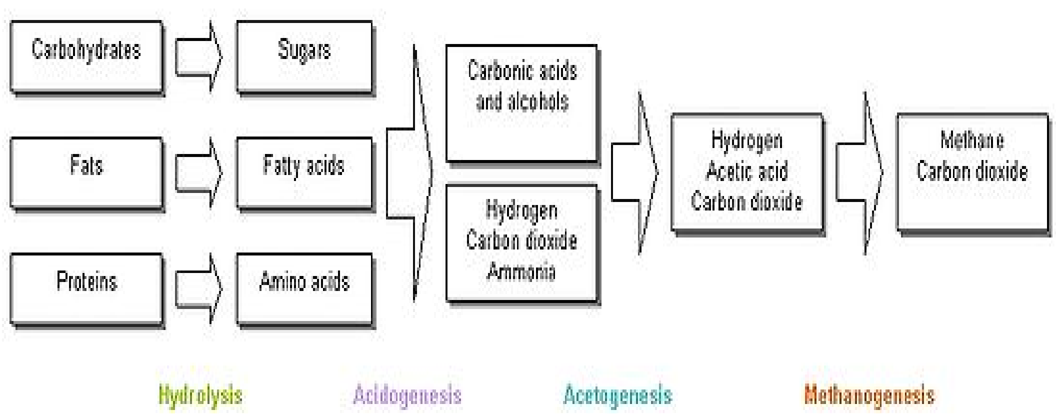

Fig.1. Different stages of biomethanation process.

[2] MATERIALS AND METHODS.

2.1 Sample collection

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.

2.2 Materials/Instruments

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 Tap water.

2.3 Biomethanation unit

It consists of a temperature controlled thermo bath which is maintained at 35^0C. It can accommodate 10 biodigesters. 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 (Fig2.)

Fig. 2. Biomethanation unit

2.4 Fermentation slurry

Fresh water hyacinth leaves on collection were chopped and ground to fine paste in grinding mill. This paste was used along with different quantity of water to prepare digesters FWH-1:1, FWH-1:2, FWH-1:3, FWH-1:4 and FWH-1:5. 20 gm inoculum was added to each of the digester. Addition of inoculums tends to improve both the gas yield and methane content in biogas. It is possible to increase gas yield and reduce retention period by addition of inoculum [6], [7], [8]. Table 1. gives the composition of various fermentation slurries. Each biodigester was given 20 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.

Table 1: Composition of digesters

Digester	Composition		Inoculum
	Water hyacinth	Water	
FWH-1:1	100 gm	100 gm	20 gm
FWH-1:2	100 gm	200 gm	20 gm
FWH-1:3	100 gm	300 gm	20 gm
FWH-1:4	100 gm	400 gm	20 gm
FWH-1:5	100 gm	500 gm	20 gm

[3] RESULT AND DISCUSSION

3.1 Biogas production

The biogas production with time from digesters FWH-1:1, FWH-1:2, FWH-1:3, FWH-1:4 and FWH-1:5 are shown in Table 2. Results plotted in figure 3 shows that, blending of water hyacinth in water is critical for producing maximum amount of biogas in a minimum time period. Fermentation slurry FWH-1:4 was observed to produce maximum amount of biogas, followed by FWH-1:5 and FWH-1:3. In contrast FWH-1:1 and FWH-1:2 produced very less gas. This observation could be explained by the density and leaf structure of water hyacinth. If sufficient amount of water is not added the biomass would not be soaked enough to go through the degradation process efficiently and hence a less amount of biogas is produced.

Biogas production for FWH-1:3, FWH-1:4 and FWH-1:5 started after 4 days while FWH-1:1 and FWH-1:2 started gas production after 10 days. The rate of specific gas production was very less initially for 20 days in all the digesters. This represents a greater lag phase of hydrolysis. The longer period of lag phase in our study may be as a result of the complexity of biodegradation involving lignin. Water hyacinths have a high content of hemicellulose and cellulose, but the existing hemicellulose has strong association with the lignin in the plant, which makes it unavailable for the microorganisms [9].

The rate of specific gas production was nearly same for FWH-1:4 and FWH-1:5 for first 15 days. The rate of specific gas production increased for FWH-1:5 from 15 to 35 days. Later the rate increased steadily for FWH-1:4 to attain highest biogas yield of 0.245 l/gVS. However for FWH-1:1, the specific gas evolution rate was very less, and the digester choked after 25 days. This could be because of accumulation volatile fatty acids that decreased the pH of the slurry bellow 5. The decrease of pH could have diminished the growth of methanogenic bacteria and methanogenesis [10]Lack of dilution in the digester FWH-1:2 produced very less gas compared to the other digesters (0.12 l/gVS).

Table 2. Trend of the biogas production.

Days	FWH -1:1	FWH -1:2	FWH -1:3	FWH -1:4	FWH - 1:5
	(l/g VS)	(l/g VS)	(l/g VS)	(l/g VS)	(l/g VS)
0	0	0	0	0	0
5	0	0	0.001	0.002	0.002
10	0.001	0.001	0.005	0.01	0.01
15	0.005	0.006	0.013	0.025	0.025
20	0.006	0.009	0.022	0.038	0.045
25	0.008	0.014	0.031	0.051	0.07
30	0.01	0.019	0.035	0.083	0.115
35	0.01	0.038	0.06	0.13	0.16
40	0.01	0.066	0.145	0.197	0.197
45	0.01	0.1	0.184	0.235	0.215
50	0.01	0.12	0.195	0.245	0.215
55	0.01	0.12	0.2	0.245	0.215
60	0.01	0.12	0.2	0.245	0.215

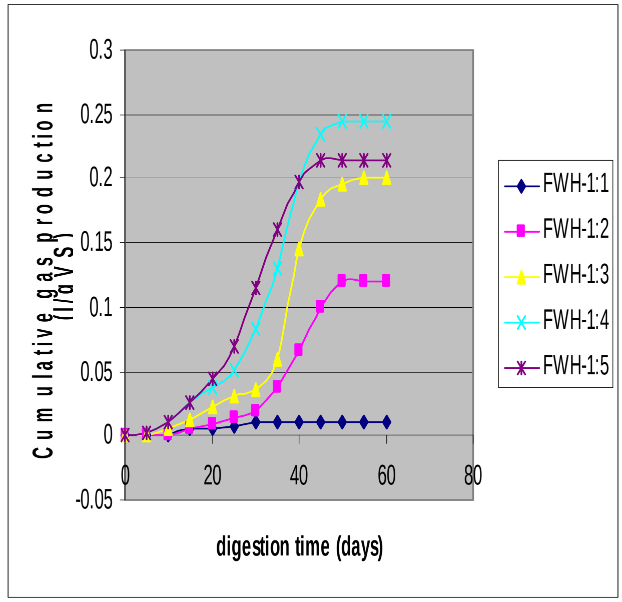

Figure 3. Daily biogas production

[4] CONCLUSION

The study has shown that, water hyacinth as a substrate for the production of biogas is an advantageous control strategy because it permits a "productive fight" against the plant's invasion. The stock, which is available in a given space and time, is renewable, and all of the harvested plants are replenished within a growing season.

The result of the study has shown that amount of dilution plays a significant role in biomethanation of fresh water hyacinth. Dilution ratio of 1:4(Water hyacinth to water) had the highest cumulative biogas yield (0.245 l/gVS) followed by 1:5 and 1:3. But transport of fresh water hyacinths means transporting a lot of water. Drying seems to be a reasonable treatment since it will both decrease the labor required for transport and the risk of water hyacinths emerging in the field, as well as improving their hygienic status. It can be assumed that as long as drying is carried out during the dry season, reaching a high enough dry matter content is possible [11].

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