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A STUDY ON EFFECT OF VOLATILE FATTY ACID ON BIOMETHANATION OF WATER HYACINTH

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ABSTRACT

A study on the effect of volatile fatty acid on biomethanation of Water Hyacinth (WH) was carried out in 250 ml batch digesters for a 60 days retention period. Biomethanation was carried out in mesophilic temperature range of 30 to 37°C. Fermentation slurry with total solids, 7% was prepared using dried and ground water hyacinth. All biodigesters were fed with the fermentation slurry and were seeded with inoculum obtained from an anaerobic primary sludge digester. Acetic acid (lower volatile fatty acid) 10% by volume was added in different amounts to each of the biodigester. A maximum cumulative biogas yield of 0.4 l/g VS was produced by the digester which was fed with 0.4 ml of acetic acid. The overall results showed that the addition of acetic acid in an optimum quantity has a remarkable effect on the cumulative biogas production. However addition of acetic acid more than the optimum quantity evolved very less quantity of biogas because of imbalance in syntrophic interaction between acetogens and methanogens, which might have caused accumulation of volatile acids thus increasing the p^H of fermentation slurry.

Key words: *Water hyacinth, biomethanation, syntrophic interaction, biogas yield, volatile fatty acid.*

[1] INTRODUCTION

1.1 Water hyacinth

The water hyacinth, *Eichhornia crassipes*, is a tropical species belongs to the pickerelweed family [1]. It is listed as one of the most productive plants on earth and is considered one of the world's worst aquatic plants. It can double its size in 5 days and a mat of medium sized plants may contain 2 million plants per hectare that weigh 270 to 400T. These dense mats interfere with navigation, recreation, irrigation, and power generation [2]. Water hyacinth is blamed for reduction of biodiversity and increased evapotranspiration. It also acts as a good breeding place for mosquitoes, snails and snakes [3]. Water hyacinth has apparently become a problem in different parts of the world due to its uncontrolled and rapid growth. Therefore, there is a need to manage its spread through suitable control measures. However, the fact remains that the water hyacinth has successfully resisted all attempts of its eradication by chemical, biological, mechanical, or hybrid means [4]. At present these methods succeed only in keeping the weed infestation in check at enormous costs. It is against this background that this research is undertaken with the view to suggesting ways by which the weed

can be put to better use and curbing its menace. Water hyacinth has attracted the attention of scientists to use it as a potential biomass for the production of biogas because of its high growth yield and availability in large amount throughout the year and allover the world. Methane yields have been reported for water hyacinth feedstock using a variety of digesters [5] found average methane yields of 0.24 l/gVS of shredded water hyacinth reported methane yields of 0.19 and 0.28 l/gVS of water hyacinth and a 3: 1 water hyacinth/primary sewage sludge blend, respectively [6]. reported average methane yields of 0.32 and 0.17 l/gVS of water hyacinth shoot and root samples,
respectively, in a bioassay test of 100 ml culture volume.

1.2 Biomethanation

Biomethanation is a complex process consisting of a series of microbial reactions catalyzed by consortia of different bacteria [7]. In this process organic compounds are mineralized to biogas (mainly consisting of CH_4 and CO_2) through a series of reactions mediated by several groups of microorganisms. This process involves four major steps: hydrolysis, acidogenesis, acetogenesis and methanogenesis [8] [9] as shown in figure 1.

Hydrolysis is the first step in biomethanation, which 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. This step is carried out by strict anaerobes such as Bactericides, Clostridia and facultative bacteria such as *Streptococci etc*., Acidogenesis is the second step where there is further breakdown of the remaining components by acidogenic (fermentative) bacteria. The third stage of biomethanation is acetogenesis. Here simple molecules created through the acidogenesis phase are further digested by acetogens to produce largely acetic acid as well as carbon dioxide and hydrogen. The terminal stage of anaerobic digestion is the biological process of methanogenesis. In this step, 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.). A simplified generic chemical equation for the overall processes outlined above is as follows

$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$ [10].

[2] MATERIALS AND METHOD.

2.1 Sample collection

Water hyacinth used for the study was obtained from a lake at Kengeri Satellite town (Bangalore, Karnataka, India). Primary sludge was collected from Vrishabhavathi sewage treatment plant near R V College of Engineering (Bangalore, Karnataka).

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), Borosilicate desiccators, silica glass crucibles, oven, grinding mill, temperature controlled water bath, water troughs, graduated transparent glass gas collectors, tap water, rubber cork, connecting tubes and biogas burner fabricated locally for checking gas flammability. AR grade acetic acid manufactured by Ranbaxy laboratories were used as procured without further purification.

2.3 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.

2.4 Fermentation slurry

Fresh water hyacinth (leaves, stem and root) on collection was chopped to small sizes of about 2 cm allowed to dry up 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 fermentation slurries DWH.B, DWH0.1, DWH0.2, DWH0.4, DWH0.6, DWH0.8 and DWH1. To study the effect of volatile fatty acid on biomethanation of water hyacinth, acetic acid (lower volatile fatty acid) 10% by volume was added in different amounts to the biodigesters. Table 1. gives the composition of various fermentation slurries. Each biodigester was given 20 gm of inoculum from an anaerobic primary sludge digester (35 days old). Inoculum from operating anaerobic digesters is commonly added as a microbial seed to initiate anaerobic digestion in new digesters [11][12]. Biomethanation of the digesters were carried out in duplication for a retention period of 60 days at 35^oC. Daily biogas production, slurry temperatures were monitored throughout the period of study. Digester DWH.B served as control.

[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 DWH0.4 produced the highest quantity of biogas (0.4 l/gVS), which is about one and half times that produces by the blank (0.281 l/g VS). This could be because of the addition of acetic acid, which has a remarkable effect on the digestion slurry as catalyst. However, addition of a larger amount of acetic acid (0.8 and 1 ml of 10% by volume) reduces the gas production rate as shown in fig. 1. This may be assigned to the fact that most of the biogas comes from the methyl group of the lower volatile fatty acid and the process is accomplished under methanogenic condition [13]. The survival of the methanogenic bacteria largely depends on the pH of the medium. A larger addition of acetic acid thus makes the medium more acidic reducing the activity of methanogens and hence a lower rate of gas production has been observed. This is in accordance with the general observation made by Mc Carty and Mc Kinney [14] [15] that methanogenesis is facilitated in the presence of lower volatile fatty acids in a certain range of concentration. In biomethanation intermediate stages, acetogenesis and methanogenesis are the most critical steps, in which acetogens (propionate and butyrate degrading bacteria) and methanogens (hydrogenotrophs and aceticlasts) form special constructions and are interrelated in what is called a “syntrophic interaction”.The poor performance of the digesters DWH0.8 and DWH1 could be because of imbalance in syntrophic interaction between acetogens and methanogens, which might have caused accumulation of volatile acids thus making process unstable [16] [17] [18] [19] [20] [21].

[4] FIGURES AND TABLES

Fig.1. Different stages of biomethanation process.

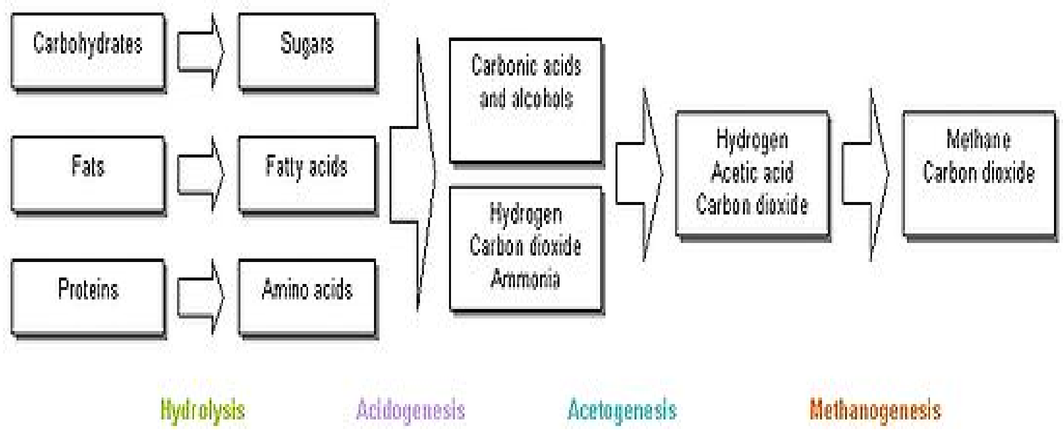


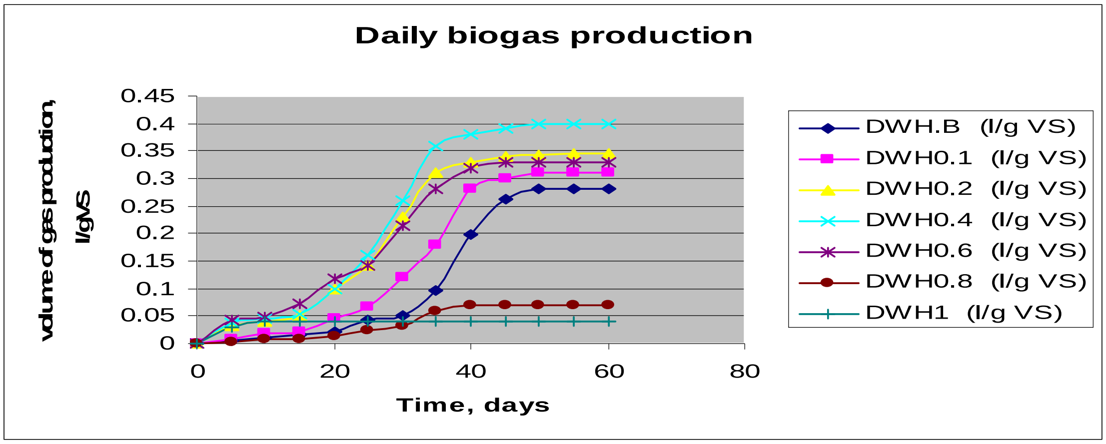
Table 1: Composition of digesters

Digester	Water hyacinth	Water	Inoculum	Acetic acid
DWH.B	10.5 gm	139.5 gm	20 gm	---------
DWH0.1	10.5 gm	139.5 gm	20 gm	0.1 ml
DWH0.2	10.5 gm	139.5 gm	20 gm	0.2 ml
DWH0.4	10.5 gm	139.5 gm	20 gm	0.4 ml
DWH0.6	10.5 gm	139.5 gm	20 gm	0.6 ml
DWH0.8	10.5 gm	139.5 gm	20 gm	01 ml
DWH1	10.5 gm	139.5 gm	20 gm	02 ml

Table 2. Trend of the biogas production

Days	Cumulative gas production in (l/g VS)						
	DWH.B	**DWH0.1**	**DWH0.2**	**DWH0.4**	**DWH0.6**	**DWH0.8**	**DWH1**
0	0	0	0	0	0	0	0
5	0.006	0.009	0.032	0.038	0.042	0.003	0.03
10	0.011	0.018	0.04	0.045	0.048	0.008	0.04
15	0.016	0.022	0.05	0.054	0.073	0.009	0.04
20	0.022	0.046	0.1	0.1	0.118	0.013	0.04
25	0.042	0.066	0.142	0.16	0.142	0.024	0.04
30	0.051	0.12	0.23	0.26	0.213	0.032	0.04
35	0.096	0.18	0.31	0.36	0.28	0.06	0.04
40	0.197	0.28	0.33	0.38	0.32	0.07	0.04
45	0.262	0.3	0.341	0.39	0.33	0.07	0.04
50	0.281	0.31	0.343	0.4	0.33	0.07	0.04
55	0.281	0.31	0.345	0.4	0.33	0.07	0.04
60	0.281	0.31	0.345	0.4	0.33	0.07	0.04

Figure 2. Daily biogas production.



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[5] CONCLUSION

Effect of volatile fatty acid was studied by performing a series of laboratory experiment using different amount of acetic acid (10% by volume) in fermentation slurry of water hyacinth (10.5 gm water hyacinth, 139.5 gm water and 20 gm inoculums). The most important finding from this study is that addition of volatile fatty acid (acetic acid) in required quantity has significant effect on cumulative biogas production. The fermentation slurry, which was given 0.4 ml acetic acid (10% by volume), produced maximum biogas. However, study also reveals excess amount of volatile fatty acids more than the required level, imbalances the syntrophic interaction between acetogens and methanogens, thus making process unstable and resulting in very less amount of biogas produced.

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