Biogas production from water hyacinth blended with cow dung

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Abstract

Water hyacinth and cow dung are the two waste which can be used to generate energy through biogas which is an alternate fuel save on the fossil fuels conventionally. In this study, the possibility was explored to determine the efficiency of lignocellosic waste from water hyacinth blended with cow dung for a biogas yield at a laboratory scale. A different combination of cow dung and water hyacinth were done. The digestion of residues was undertaken by batch-type anaerobic process, it was operated at a temperature 35°C for a period of 30 days. Gas chromatography was used to quantify the different component of biogas produced by the substrate. The results indicated that lignocellosic waste blended with Water hyacinth (WH) yield a methane of 24% in the combination of (50%)WH + (50%) CD. The lignocellosic waste was analysed for total solids, volatile solids, total dissolved solids, moisture and pH content before and after the treatment for methane production in anaerobic digestion. This study thus forms an attempt in a lab scale level to use the unwanted weeds as substrates for methane production

Key words: Biogas, anaerobic digestion, methane, water hyacinths, methanogens

1. Introduction

The worldwide distribution of Water hyacinths (*Eichhornia crassipes*) generally considered as an aquatic weed, has become a persistent and expensive aquatic problem damaging the environment, cause ecological and economic problems by impeding navigation and fishing activities, clogging irrigation systems and by creating a chronic shortage of dissolved oxygen harmful to the fauna and the flora [1] [2] [3] in the lake. However, recent studies have found that this nuisance weed is a very good source of renewable energy for the biosynthesis of biofuel [4]. Since the plant has abundant nitrogen content, it can be used a substrate for biogas production. Biomass experiments involving the use of water hyacinth for the production of biogas for cooking seemed to present a viable option. Biogas is an ecological fuel that may replace firewood. Water hyacinth's abundant biomass can be used to produce renewable energy locally, simply fermenting it in anaerobic digester.

Hence, the use of organic wastes in biogas production would provide a means for their disposal as well as an added benefit of energy production. Anaerobic digestion of lignocellulosic substrates is a much more complex process, requiring the syntrophic and cooperative interaction between several types of microorganisms. It is a complex, natural, multi-stage process of degradation of organic compounds through a variety of intermediates into methane and carbon dioxide, by the action of a consortium of microorganisms [5] [6] [7] and [8]. It is a process divided in four key stages, with different trophic groups intervening in each one of them. In the first, the hydrolysis stage, organic macromolecules are broken down into monomers like sugars, fatty acids and amino acids. In the second, the acidogenesis stage, these components are further broken down into VFAs (volatile fatty acids: short-chained fatty acids like acetate, butyrate or propionate), organic acids and alcohols, along with small amounts of hydrogen. The largest fraction of H_2 and acetate comes from the third step, the acetogenesis stage, in which bigger VFAs and other organic acids from the previous stage are converted into the two aforementioned substances. After the final stage, the methanogenesis, methane and carbon dioxide are formed as the main final products [9]. Better yields of biogas are obtained using mixture of animal waste and lignocellosic waste since the animal waste particularly the cow dung has the significant syntrophic mechanism enhanching bacteria. Therefore, this work was carried out to explore the potential of biogas production from co-digestion of cow dung with lignocellosic materials viz., water hyacinth. Hence, in this study an effort was made to study the cumulative biogas generation during fermentation and other parameters like Total Solids (mg/l), Total Dissolved Solids (mg/l), Total Suspended Solids (mg/l) and Total Volatile Solids (mg/l) were also measured.

2. Materials and methods

2.1. Sample collection and processing

Cow dung sample were collected from the animal slaughter house at Taramani, Chennai. Water hyacinth (WH) was collected from a pond located in Karapakkam south–east of Chennai, Kanchipuram district of Tamil Nadu. The water hyacinth were cleaned to remove soil and dead plant materials and it was chopped separately to about 20mm pieces later it was grinder with water. The cow dung was diluted with water to 1:2 ratio (w/v) [10] [11] [12].

The temperature of the digesting substrates was measured through the temperature measuring devices and pH was checked using pH probe. The inoculation and filling of the vials were done strictly under aseptic condition. The vials were fitted with butyl rubber stopper and sealed with aluminum crimps after inoculation. The vials were subjected to nitrogen flushing for several minutes to remove air and make the system anoxic. Each digester vial contained different percentage of cow dung and lignocellosic substrate. 100% cow dung and lignocellosic waste acted as the control. Triplicates were maintained. Cumulative biogas production was monitored throughout the period of the study.

2.2. Analytical techniques

The gas phase concentration from headspace of the vials was determined using a Gas Chromatograph (Chemito7610 series) equipped with a thermal conductivity detector (GC-TCD) and a stainless steel column (2 m x 1 /S") containing (Porapak Q) 80-100 mesh. The temperature ramp of the column, the injection port and the detector were 60˚C, 60˚C and 90˚C respectively. Nitrogen was used as carrier gas at a flow rate of 30ml min^{-1}. Gas samples (500µl) in the head space were collected using a pressure-lock gas syringe and quantified. The results were interpreted using the software available with the GC (Iris 32 Lite). [13]

2.3. Proximate and ultimate analyses

The composition of slurry at initial and final stage was analyzed for the moisture content in the test samples was determined according to ASTM- D 3173-87 (ASTM, 2002). The total dissolved solids (TDS), total solids (TS) and Total Volatile Solids (TVS) were determined by the method described in Standard Methods for the Examination of Water and Wastewater, 20th Edition [14]. The pH were

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recorded using a digital pH meter Eco-Scan (Eu-tech instrument Singapore) and EC was measured on board by using the portable probe (Elico India).

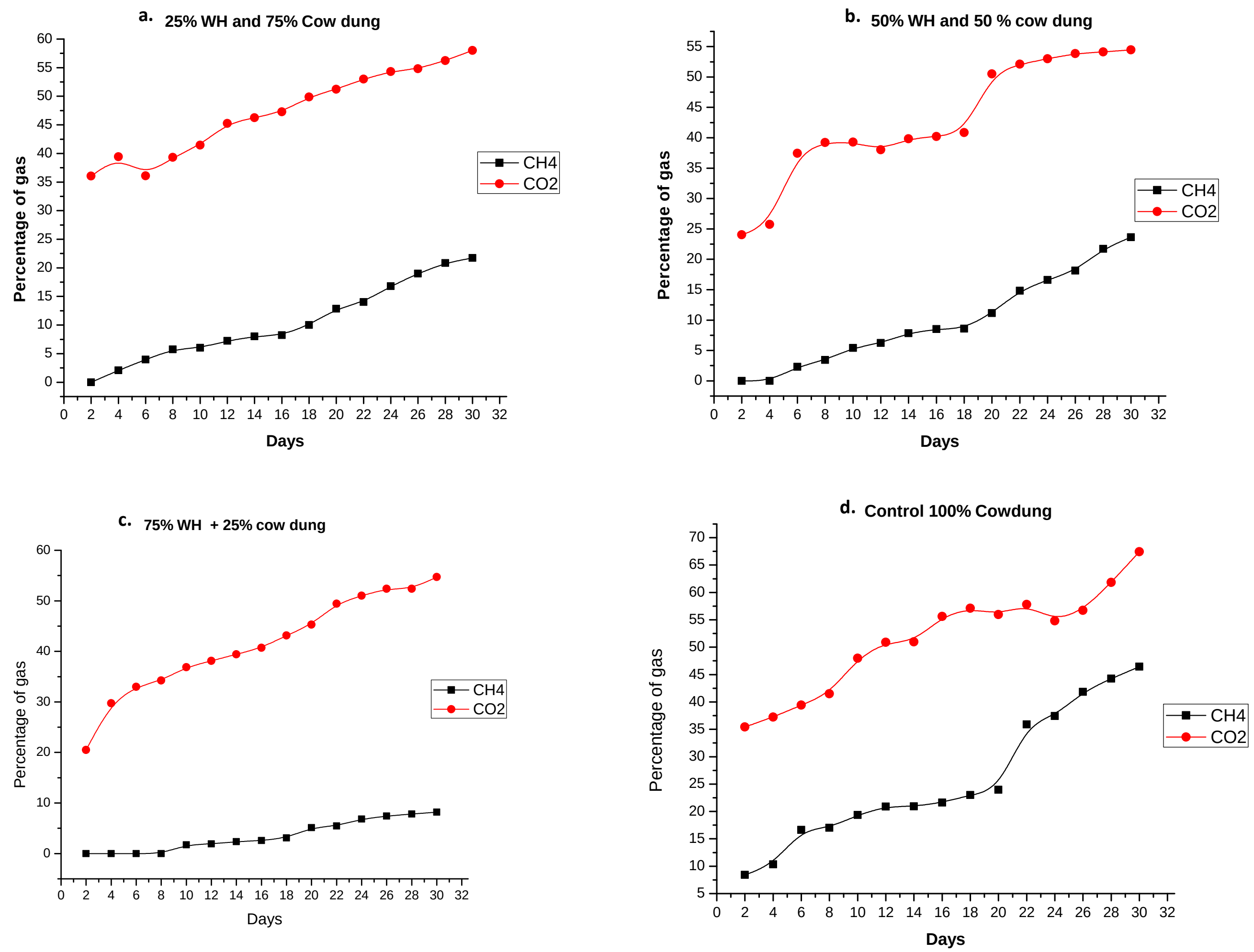
3. Results and discussion

The methanogenic evaluation for the production of methane gas using lignocellosic weeds such as water hyacinth along with cow dung were quantified. In this study, the maximum methane production was observed in 100% cowdung sample A (control) on 2nd day of incubation period followed by 50% WH + 50% CD which showed methane production of 2.8% on 7th day followed by 25% WH + 75% CD (1.25%). However, there was no methane production observed from 100% waterhyacinth (control) containing vials, but 55% of CO_2 was observed over the period of 30 days of incubation period. This wide difference may suggest that there was no contribution of biogas production from water hyancinth alone when incubated under anaerobic condition. Hence from the three different ratio, the final result indicates the maximum methane (24%) was obsered in the ratio of 50%WH + 50% CD followed by 25%WH + 75%CD (21.42%) on 30th day and 75% WH+25% CD combination showed very low level of methane (8.25%) Figure.1. It has been already reported that the mixture of cow dung and water hyacinth slurry has proven to produce more biogas than when used alone [15]

In addition co-digestion of organic waste with sludge or cow dung has been mentioned in the works of Anhuradha et al., [16] and God living and Mtui [17] with improvements in biogas production. Gadre et al., [18] from their investigation of the optimum time for the production of biogas from cow dung reported that 15 days retention time was the best for maximum production of biogas where as in the present study the retention time for the production of methane takes 48 hour for the cow dung and 7 days for the water hyacinth blended with the cow dung. The reason may be due to the complexity of biodegradation involving a high content lignin material present in the water hyacinth. Saev et al., [19] also reported a period of 20 days of minimal biogas production in their study of co-digestion of wasted tomatoes and cattle dung. It is well known that the composition of biogas as well as biogas yields depend on the substrates owing to differences in material characterization in each feed material [20] [21] [22] [23] and [24].

In the present study, the pH was found to neutral for all the prior digestion sample but later the neutral in case of water hyacinth. For increased gas yield, a pH between 7.0 and 7.2 is optimum, though the gas production was satisfactory between pH 6.6 and 7.6 as well. The pH of the digester is a function of the concentration of volatile fatty acids produced, bicarbonate alkalinity of the system, and the amount of carbon dioxide produced [25]. The gas production was significantly affected when the pH of the slurry decreased to 5.0 [26]. They observed that apart from the decreased methanogenic activity due to lower pH, the population of cellulolytic bacteria, amylolytic organisms, and proteolytic organisms reduced by 4 and 2 log orders, respectively. The use of water hyacinth as alternate substrate together with cattle waste for biogas digesters (Deshpande et al., [27] and Mallick et al*.,* [28]. Though, the control substrates (100% Water hyacinth) showed only CO_2 and H_2 there is no methane content. This could be due to its high water content (90.08%) lignin which is in conformity with the observations made by Gupta [29] with a variety of aquatic weeds. The moisture content of the WH sample is 88% which is similar to the result done by Katima [30]. The total solid was found to be 98-99 mg/l in all the combination (Table 1.). A considerable number of studies have been conducted to investigate anaerobic digestion of water hyacinth. Many studies have reported similar yields, in the range of 200–300 L biogas kg−1 VS and around 140–200 L methane kg−1 [31] [32].

Figure1: Analysis *of methane and carbondioxide from the cow dung blended with water hyacinth*



a. Cow dung (75%) blended with water hyacinth (25%); b. Cow dung (50%) blended with water hyacinth (50%); c. Cow dung (25%) blended with water hyacinth (75%); d. Cow dung (100%).

Table 1: Analysis of post digested sample

Substrate	Total solid (mg/l)	Total Dissolved Solids (ppm)	Total Volatile Solids (mg/l)	Moisture (%)	EC (mS)	pH
100%CD+0%WH	98.7	2220	15.5	75	1.8	5.4
75%CD+25%WH	98.6	2830	10	97.2	4.3	6.7
50%CD+50%WH	98.0	2460	13	63	4.1	6.9
25%CD+75%WH	98.6	2000	8	96.4	3.5	6.9
0%CD+100%WH	99.1	2120	5	98	4.0	6.8

4. Conclusion

The study revealed that it is possible to produce biogas from a mixture of water hyacinth and cow dung. This study forms an attempt to use the unwanted weeds as substrates for methane production. The different combination using cow dung and water hyacinth were tried and encouraging results were obtained when 50% Water hyacinth and 50% cow dung combination. Further studies are needed for the enhancement of methane generation from the different substrates for their further use in such systems. 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.

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6. References

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