Biogas Production from a mixture of Water Hyacinth, Water Chestnut and Cow Dung

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Abstract—There is an increasing need to replace conventional energy with the renewable energy to save our natural resources and our environment. Bio-energy seems to be the most probable solution to this crisis. In this study, the biogas production potential of the mixture of water chestnut, water hyacinth and cow dung in the ratio of 1:1:2 has been discussed. The three variants were charged into a 20L portable bio-digester in the ratio of 1:1 with water. They were subjected to anaerobic digestion under a 35 day retention period and mesophilic temperature range of 26°C-35°C. Volume of per day biogas production was measured along with the retention time. Generation of biogas from a mixture of aquatic weeds and cow dung upholds the concept of waste to wealth in enhancing sustainability of development. The biogas generated can be utilized by producing energy from its combustion.

Index Terms—Aquatic weeds, Biogas, Water Chestnut, Water Hyacinth, Waste.

I. INTRODUCTION

Achieving solutions to possible shortage in fossil fuels and environmental problems that the world is facing today requires long-term potential actions for sustainable development. In this context, renewable energy resources appear to be one of the most efficient and effective solutions [1]. Bio-energy is now accepted as having the potential to provide a major part of the projected renewable energy provisions of the future [2-3]. Biogas, which is one of the byproducts of anaerobic digestion, comprises about 60% methane and 40% carbon dioxide [4]. It has been used as a source of fuel in several countries such as India, China, Sweden, Bangladesh etc. for lighting and cooking purposes. The content of biogas varies with the material being decomposed and the environmental conditions involved [5]. Biogas production comprises of three stages namely hydrolysis, acidogenesis and methanogenesis.

$$\text{(C}_2\text{H}_6\text{O}_3\text{n}) + n\text{H}_2\text{O} \rightarrow n\text{(C}_2\text{H}_5\text{O}_3\text{n}) \text{- Hydrolysis}$$

$$n\text{(C}_2\text{H}_5\text{O}_3\text{n}) \rightarrow n\text{CH}_3\text{COOH}\text{- Acidogenesis}$$

$$3\text{nCH}_3\text{COOH} \rightarrow n\text{CH}_4 + n\text{CO}_2\text{- Methanogenesis}$$

Various wastes have been utilized for biogas production and they include amongst others; animal wastes [6-8], industrial wastes [9] and food processing wastes [10]. Aquatic weeds are one of such biomass being considered as a potential feed stock [11-13]. A biogas system becomes flammable when its methane content is at least 45%. Methane has a heating value of 15.6 MJ/kg [14]. Consequently, biogas can be utilized in all energy consuming applications designed for natural gas [15].

Water Hyacinth is recognized as a very aggressive species of aquatic plant, which grows very fast and eliminates other aquatic species in its composition [16]. In many places in India, such as the lakes of Bhopal, water hyacinth continues to present daunting environmental and economic problems. Water chestnut is an annual, floating-leaved aquatic plant of temperate and tropical fresh-water wetlands, rivers, lakes, ponds, and estuaries. Water chestnut forms extensive dense beds in lakes, rivers, and freshwater-tidal habitats. Because of this tendency it is considered as a pest in the U.S. This causes displacement of aquatic plants, interference with fishing and boating, as well as the depletion of dissolved oxygen which adversely affects fish communities [17]. Bhopal is a city which has several lakes where water hyacinth and water chestnut are present in plethora. Consequently, this study was undertaken to investigate the production of biogas from these aquatic weeds.

II. EXPERIMENTAL

A. Digester Design

The bio-digester was made from a 20L water can as shown in figure 1. The neck of the can was closed with a cork. By using aeralyte the neck was made air-tight so as to prevent any escape of biogas. The cork was drilled and plastic T valve was inserted. One outlet was connected to a spherical mylar balloon and the other outlet was connected to Bunsen burner. The biogas when produced was stored in the mylar balloon. The bio-digester was placed in the bio-energy lab where optimum sunlight is available throughout the day. The study was performed during October-November 2012. The Bunsen burner was used to check the flammability of the gas.
B. Preparation and Feeding of Biomass

Water hyacinth (Jal Kumbhi) and Water Chestnut (Singada) was obtained from lakes of Bhopal. Cow dung was obtained from the nearby village in MANIT district. 500 gms of both the aquatic weeds were allowed to dry and then chopped as shown in figure 2. These dried and chopped aquatic plants were then mixed with freshly procured cow dung, in the ratio of 1:2 by volume. The bio-digester was fed with this mixture along with water in the ratio of 1:1 by volume, making net volume as 18L. The digester contents were stirred adequately and on a daily basis to ensure homogenous dispersion of the constituents of the mixture. Gas production measured in dm$^3$/kg of slurry (15kg) was obtained by measuring the diameter of mylar balloon using a measuring tape.

C. Analysis

Gas production was measured in dm$^3$ per kg of slurry (15kg) by obtaining the diameter of mylar balloon using a measuring tape. Flammability was checked by igniting the gas at Bunsen burner.

III. RESULTS AND DISCUSSION

The experiment was carried out under ambient temperature range of 26 to 36°C and within a retention period of 35 days. The daily biogas production is graphically presented in Fig 3. The digester commenced biogas production within 24hr of its charging. The output gas obtained became flammable within 24hr of charging the digester. The gas production and its flammability reduced drastically on the 17th day and increased after 22nd day. The cumulative biogas yield of the paper waste was lower in the first 17 days. When the biogas production resumed, it was observed that the production was quite high and continued long until the blend nearly stopped production. A highest of 1.21L of biogas was produced on the 19th day. The average per day production of biogas was 0.326L/day. However when the flammable biogas production resumed, it was observed that the gas production was quite high and continued long after the blend had nearly stopped production. Overall 11.41L of biogas was accumulated by the end of the retention period. The general accepted mean calorific value of biogas is 20MJ/m$^3$. The energy that can obtained by 11.41L of biogas would be 228KJ.

IV. CONCLUSION

The study has shown that water hyacinth and water chestnut which can be found in abundance everywhere including the lakes of Bhopal, are very good feedstock for biogas production. These aquatic weeds which interfere in the growth of other aquatic plants and clog lakes making it difficult for boating, fishing, and swimming, can be utilized for energy generation. The study has also shown the mixture of water chestnut, water hyacinth and cow dung gives sustained gas flammability throughout the digestion period of the biomass. The biogas obtained can be utilized to replace the cooking gas to some extent. Biogas can be produced by organizations near the lakes of the city. Biogas can also be used in engines by the route of combustion.
REFERENCES


