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Biomethanation Potential of Food Waste

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Abstract—*Alternative sources of energy are the requirement of the present day because fossil fuels are limited and are depleting fast. In urban India mostly Liquefied Petroleum Gas (LPG) is used for cooking needs. Food Waste (FW) as an amount of Municipal Solid Waste (MSW), about 45%, produced in India is a huge problem in terms of its collection, handling, its treatment and safe disposal. At most of the places FW is simply collected and dumped in landfills unscientifically. These practices lead to growth of flies, and rodents. The unscientifically managed landfill sites are responsible for ground water pollution and odor nuisance in addition to unsightly sites. As such, usage of FW for biogas generation will help to solve the problem of energy deficit and protect natural resources. At the same time, it will allow safe disposal of FW which is otherwise unscientifically dumped or discarded. In Indian context, most of FW has high energy values and it can be anaerobically digested. In the present study FW was used for biogas generation. The FW was characterized to study its ultimate analysis, and experimentally determined its biogas yield. FW has 82.5 % - 85.3 % moisture present, and 1162.7 kg/m^3 as discarded density. It is slightly acidic in nature in its fresh form. The other characteristics in average are COD : 400 g/l; Moisture content (%) : 82.5; TSS : 118 g/l; Volatile solids (%) : 87.8; VSS : 161 g/l and TS (%) : 11. The results ultimate analysis suggests that Chemical formula without sulphur is $C_{21.57}$ $H_{34.18}$ $O_{12.68}$ N. Using Modified Dulong's formula, energy content comes out as 18641.6kJ/kg.*

Keywords: Anaerobic digestion (AD), Feedstock, Biogas, Food waste (FW), Ultimate analysis.

1. INTRODUCTION

With rapid urbanization, the quantities of municipal solid waste, an important by-product of an urban lifestyle, is increasing at a rate faster than urbanization itself. In India, ten years ago, there were 2.9 billion urban residents, each generating 0.64 kg/capita/day of MSW. As per the study conducted in 2013, there are about 3 billion residents generating 1.2 kg/capita/day [1]. The MSW ranges from 250 gm to 700 gm per person with an average of 490 gm per day per person [4]. With such a rise in population growth, alternative sources of energy are the requirement of the present day because fossil fuels are limited and are depleting fast. Anaerobic digestion is one of the promising alternatives for the treatment and safe disposal of waste, due to the potential of technology for high energy recovery value.

About 40-45 % of MSW is Food Waste (FW). Disposal of FW in open dumps causes the public health hazards and diseases such as malaria, cholera, typhoid [1]. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences. It not only leads to polluting surface groundwater through leachate but also promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. Also, under uncontrolled conditions it emits unpleasant odor and of methane which is a loss of valuable energy source. Hence, there has been a strong need for appropriate FW management systems. Biomethanation is the anaerobic digestion of biodegradable organic waste in an enclosed space under controlled conditions of temperature, moisture, pH etc. FW is mainly organic matter, which can be converted to useful energy by biochemical process. If this waste processed anaerobically it will produce significant amount of biogas and manure also.

2. MATERIAL AND METHODS

The study [2] was focussed to devise suitable methodology to treat the food waste (FW) for its conversion into useful product i.e. Biogas. The food waste was collected throughout the day in plastic container at mess facility of Walchand College of Engineering, Sangli (Maharashtra). The mixed FW was weighed at 10 am every day. The data collected thus on everyday was expressed in relation with number of students served per day for waste generation. Intermittent data collection was carried out over the year so as to know the seasonal variation in food waste generation. The characterization was done by standard methods. The experimental set up as used in this study is shown in Fig. 1.

Lab scale experimental set up

The lab scale study was carried out to determine the experimental biomethanation potential of FW. The effective volume of the digester was 19 L. Cow dung was used as an inoculum. FW has been tested with different organic loading rate and seed: substrate ratio into the reactor. The optimum amount of gas production was observed by water displacement method.

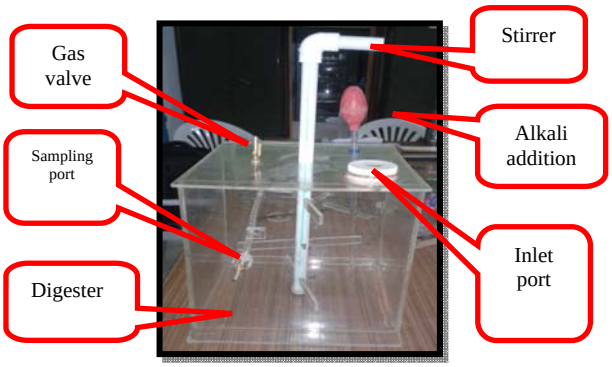

Fig. 1 Experimental Setup

The findings are discussed as follows.

3. RESULTS AND DISCUSSION

The initial characteristics of the CD slurry were, pH: 7.03; COD: 40000mg/L; and VSS: 150000 mg/L. Set up was properly sealed and joint should be leak proof to avoid any type of leakage. The total gas production was observed for specific digestion period. In this scope of the study particular attention was not given for temperature as parameter. The study area is a part of tropical region and ambient temperature range has been seen to be lying in mesophilic range. The range is favorable to maintain bacteriological activity for AD processes [7].

FW generation

FW generation rate for girls and boys mess at Walchand College of Engineering, Sangli was calculated. Out of the total waste more than 64% of the waste is mostly leftovers and remaining discarded food. About 36% of the total waste can be treated as waste getting generated through processing of raw material. Generation rate for the girls mess is 0.051 kg/ person /day, whereas for the boys it is 0.07 kg/person /day. The liquid waste arises at the rate of 4-4.5 L/d. It has low organic strength but has soap and detergent content which may hinder biomethanation process. Hence it is not a suitable material for digestion.

Characterization of FW

The characterization was essential to know the strength of FW. The process of digestion and production of biogas depends on the composition of feedstock and the fermentation products of the FW. The physical and chemical characteristics of the FW require careful consideration since they affect the biogas production and process stability during anaerobic digestion [8]. FW has 82.5 % - 85.3 % moisture present, and 1162.7 kg/m^3as discarded density. The FW is slightly acidic in nature in its fresh form. The other characteristics in average are COD: 400 g/l; Moisture content (%): 82.5; TSS: 118 g/l; Volatile solids (%): 87.8; VSS: 161 g/l and TS (%): 11. The VS amount gives an idea of the organic substance content available in the AD process [5].

Ultimate analysis

There are several techniques available to estimate the amount of biogas contained in a complex substrate such as FW including ultimate analysis. This technique of biogas estimation involves breaking FW into its elemental composition of carbon, hydrogen, oxygen and nitrogen. Knowing the general composition of the input material to the system is essential for calculating the amount and composition of the biogas produced as well as amount of energy contained in the biogas. Chemical formula for KW without sulphur is: $C_{21.57}$ $H_{34.18}$ $O_{12.68}$ N was estimated. Using Modified Dulong's formula, energy content calculated and it comes out as: 18641.6kJ/kg. Another study [3] related to ultimate analysis of FW, suggests chemical expression C_{48} $H_{6.4}$ $O_{37.6}$ $N_{2.6}$ and biogas yield of 1005 m^3/T VS. The difference could be due to the change in food composition. This value assumes that 100 % of the FW substrate is broken down. But practically, as found in this study about 40-65% of the organic material can be broken down. In an AD process, the acetogenic bacteria convert organic matter to organic acids, possibly decreasing the pH, reducing the methane production rate unless the acids were quickly consumed by the methanogens. pH in the range of 6.8 to 7.4 should be maintained in the anaerobic digestion process which is optimum range for methanogens growth [6]. The process is more stable at the loading of 1.5gVS/lit/d and causes gas generation of about 11 L/d.

4. CONCLUSION

The study carried out has shown that the anaerobic digestion of FW is a feasible alternative for biogas generation. Even though AD is effective, there are problems associated with this technology for operation of AD plants at conditions favorable for range of bacterial activities associated with stages of anaerobic digestion.

5. ACKNOWLEDGEMENTS

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