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GENERATION OF BIOGAS FROM ANEROBIC DIGESTION OF VEGETABLE WASTE

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ABSTRACT

Biogas, a renewable form of energy, could be a very well substitute of natural gas which is depleting very fast. A research work was conducted to investigate the production ability of biogas from vegetable waste. Five laboratory scale digesters were made to experiment the effect of co-digestion of vegetable waste and cow-dung in various proportions. The digesters were made of plastic container of four litre capacity each. Vegetable waste was used from 200 gm to 300 gm, and cow-dung was used from 0 gm to 300 gm to make vegetable waste to cow dung ratios from 1:0 to 1:1.5. From 2 to 3 mm sized vegetable waste was used in the experiment. The digester was feed on batch mode and operated at ambient temperature for about 15 days. In the slurry, total solid concentration was maintained 8% by mass for all of the observations. The maximum amount of biogas was yield 1200 ml/Kg of wastes at the vegetable waste and cow dung ratio 1:1.

Key words: Anaerobic Digestion, Biogas, Vegetable Waste, Cow Dung.

1. INTRODUCTION

Despite rapid globalization, Bangladesh, like other third world countries, is an agro based country. Although her arable land is shrinking gradually because of unplanned urbanization, landslide, flood, cyclone, and other natural calamities; almost 80% of her population directly or indirectly depends on agriculture. Among the total annual harvest a significant portion of land is devoted for vegetable cultivation across the country. In the winter season, a plenty of vegetables are harvested across the country. But, because of the deficiency of efficient transportation and preservation a huge amount of those vegetables are wasted firstly in the land where it was grown and then in the vegetable market. Moreover this waste is not treated properly, which is a consequence of severe environmental pollution. Since methane gas generation from uncontrolled anaerobic digestion of that waste is very threatening to the environment. Investigation is yet to be done to estimate the actual amount of vegetables is destroyed each year, which can be a good source of biogas as a renewable energy, and its residue can be an excellent organic fertilizer. An attempt was done to utilize those wasted vegetables and this paper demarcates briefly the prospect of vegetable waste for biogas generation in Bangladesh.

Numerous studies, researches, and implementation of findings have been going on globally to produce biogas from food waste especially from vegetable waste and India is one of the harbingers in this field**.** Indian researchers Biswas et al. [1] conducted a comprehensive study on biogas kinetics and they used the municipal wastes as the source of biogas. They used a 10 dm^3 anaerobic batch digester equipped with a mechanical agitator under controlled environment at pH 6.8 and temperature 40 °C for that purpose. Later **Biswas et al.** [2] developed a deterministic mathematical model to predict the characteristics of an anaerobic digester of biogas generation satisfactorily. They operated an anaerobic digester of 10 litre capacity in batch mode at an optimum temperature of 40 °C and at a pH of 6.8, feeding vegetable/food residues. **Kameswari et al.** [3] established a demonstration plant of capacity 30 tonnes per day for biomethanation of vegetable market waste. The biomethanation plant was designed for 30 tonnes per day, organic loading rate of 2.5 kg of VS/day/m^3 with biogas generation of 2500 m^3 of biogas per day. The source of feedstock for **Kamaraj** [4] study was vegetable market waste. Through the study, he concluded that vegetable waste could be used for biogas production using biphasic system. **Kale et al.** [5] established a biogas plant in which biogas was produced from kitchen waste using thermophilic microorganisms. The biogas plant was constructed using a mixer/pulper for crushing the solid waste, premix tanks, pre-digester tank, solar heater for water heating, main digestion tank, manure pits, and gas lamps for utilization of the biogas generated in the plant. Italian researcher **Cojolon et al.** [6] investigated the technical, socio-economical, and environmental aspects of biogas generation using rural household wastes. They found that anaerobic digestion of vegetable waste, daily produced by small households, generated biogas sufficient for daily cooking of those households.

The prime object of this research work was to

investigate the prospect of vegetable waste for biogas generation as a renewable energy source by means of co-digestion with cow dung and ultimate protection of environment from the bad effect of methane gas that would be produced by uncontrolled anaerobic digestion of those wastes.

2. EXPERIMENTAL SETUP

A simple experimental setup was fabricated using three container namely digester, water chamber cum gas collector, and expelled water collector. Fig. 1 illustrates a schematic diagram of the setup. Digester was connected with water chamber by a plastic pipe (gas pipe) which was used to allow the produced gas to flow through it to the water chamber and hence expelled the same volume of water from the water chamber, which was then used to flow through another plastic pipe (water pipe) to the water collector. Both the ends of the gas pipe were inserted just at the top of the digester and the water chamber, and one end of the water pipe was inserted up to bottom of the water chamber and the other end of the pipe was inserted into the water collector. Both the gas pipe and water pipe were inserted into their respective container through corks which were maintained air tight firmly.

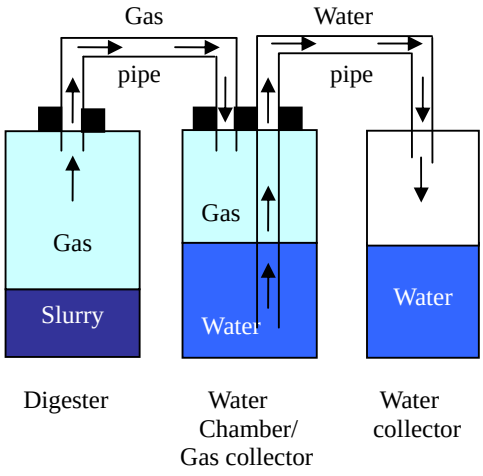

Fig 1. Schematic diagram of the experimental set-up.

3. MATERIALS & METHOD

3.1 Sources Of Wastes

The vegetable waste and the cow dung for the research work were collected from the student halls and the residential area of Chittagong University of Engineering and Technology, (CUET).

3.2 Slurry Preparation

In order to optimize the gas generation, feed stock was maintained 8% [7] of TS concentration by mass. From empirical analysis it was found that fresh cow dung and fresh vegetable waste have the TS of 18% and average 20.5% [7] respectively. So water was added 156.25 gm with each 100 gm of vegetable waste and that was 125 gm with each 100 gm of cow dung.

3.3 Data Collection Techniques

In this study the volume of the produced gas was measured by water displacement method considering the volume of the generated gas was equal to that of the expelled water in the water collector. Gas was produced after 7/8th operating day of the digester. Data was collected by every three hours from 9:00 AM to 5:00 PM everyday in the Thermal Engineering laboratory of CUET till the generation of the gas become zero.

3.4 Observations

Five observations were done feeding the digesters with the mixture of VW and CD with optimum amount of water. After feeding, the digesters were left for anaerobic digestion and gas was started to generate in the 7/8th operating day and that was almost terminated within 14/15th operating day of the digester. Produced gas was allowed to flow through the gas pipe and accumulated in the gas collector above water surface, which caused to expel the same volume of water (assumed) from water chamber and allowed to flow through the water pipe to the water collector. Volume of the gas was measured directly by measuring the volume of the expelled water in the water collector by a measuring plucks by every three hours. The system was kept air tight and each observation was continued till the flow of the expelled water was terminated. Table 1 bellow shows the amounts of VW, CD and water were added to prepare the slurry of 8% TS for the digesters.

Table 1: Relative wastes and water amounts in the slurry.

Compositions VW : CD	VW (gm)	CD (gm)	Water added for 8% of TS (mL)
1 : 1	300	300	775
1 : 1.5	200	300	635
1 : 0.67	300	200	745
1 : 0.33	300	100	545
1 : 0	300	0	430

4. RESULTS AND DISCUSSION

This study was carried out to investigate the generation of bio gas from VW with CD mixture. Data obtained from all of the observations were gas volume. To find out the optimum mixture, variations were done in the ratios of VW and CD. The findings of the observations are represented in the figures Fig. 2, to Fig. 4.

Fig.2 represents the total volume of gas was produced per Kg of wastes during the digester's operation at different proportions of VW and CD mixtures. Next Fig.3 illustrates the amount of gas generation per Kg of wastes per day during that period of time for the same proportions. And finally, Fig.4 shows the influence of the amount of CD in the feed stock on biogas generation.

Analyzing the figure Fig.2 it can be noticed that maximum volume of gas was generated at 1:1 ratio of

VW and CD. But no appreciable amount of gas was produced at 1:0 ratios, that is almost no production while CD was not added in the slurry. Again at the highest proportion of CD that is at 1:1.5 ratios the production was relatively lower.

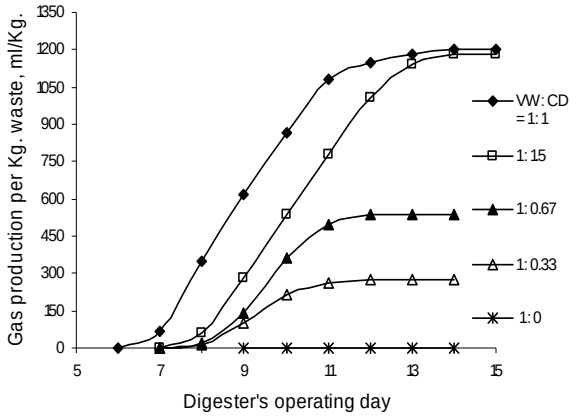

Fig 2. Operating days vs. total volume of gas production per Kg of wastes at different composition of wastes.

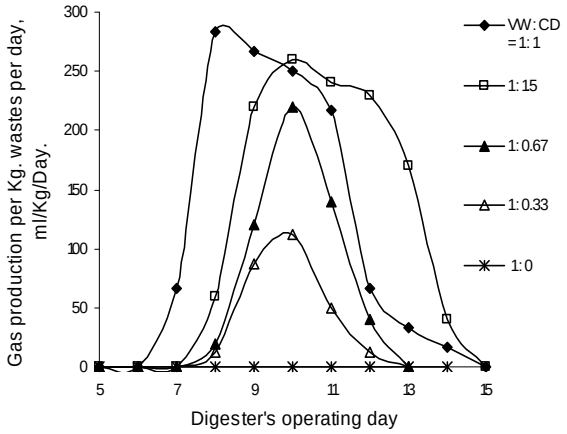

Fig 3. Operating days vs. volume of gas production per Kg of wastes per day at different composition of wastes.

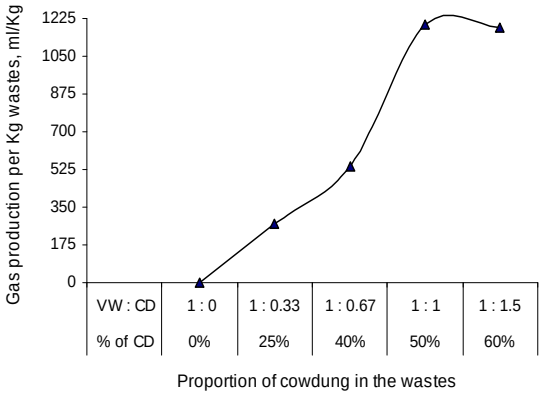

Fig 4. Proportion of CD in the wastes vs. volume of gas produced per kg of wastes.

Similar phenomena are true for Fig.4. When the percentage of CD was increasing the production of biogas per kg of solid wastes also was increasing almost moderately from 0% to 40% of CD. Further this trend was surprisingly rapid at 50% of CD, and the gas production was 1200ml/kg of wastes. However, the generation started to decrease beyond 50% of CD in the mixture. Besides Fig.3 illustrates that the generation of gas was started from 7/8th digester's operating day and continued to 14/15th operating day. Gas generation was peaked at 9/10th operating day to the maximum 170ml/day almost from zero production at 7/8th day and that was approximately the mirror view from 9/10th to 14/15th day.

5. CONCLUSIONS

Analyzing the experimental dataset it was found that, the production of gas was not uniform. The bio gas production from vegetable waste largely depends on the proportion of cow dung added with it and the condition of the used vegetable waste. If the amount of cow dung was changed, the production of the gas was also changed. Analyzing the figures it was found that 1:1 mixture of vegetable waste and cow dung was optimum. The maximum gas production was 1200 ml/kg of total wastes. Water was added in order to dilute the organic substances and to increase the breeding of micro-organisms. Addition of cow dung with vegetable waste was beneficiary way to reduce the retention time. It was a primary investigation to learn the production ability of biogas as a renewable source of energy from vegetable waste in Bangladesh, since she has a great potentiality of vegetable waste. It was a mesophilic anaerobic digestion. In the further study thermophilic digestion with periodic stirring into a prescribed digester will be investigated. P^H level also will be controlled in the next experiment.

6. ACKNOWLEDGEMENT

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8. NOMENCLATURE

Symbol	Meaning
VW	Vegetable Waste
CD	Cow Dung
TS	Total Solid

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