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ROLE OF VARIOUS INNOCULATION ON FOOD WASTE ANAEROBIC DIGESTION SYSTEM

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ABSTRACT

The present research work focuses on the biogas mainly methane production from kitchen waste generated at the our society and to investigate the effects of the key process parameters like pH and temperature, by operating a pilot scale setup in two stage thermophilic and mesophilic digestion conditions. In experimental setup, a comparison of the digestion of food wastes in small scale was done. In this experiment three setups were operated in mesophilic, thermophilic and two stage mesophilic and thermophilic conditions respectively. In batch condition, maximum of 7.45 Litres biogas was produced from the digestion of 6 kg of food wastes in 25 days. The initial total solid content of the waste slurry was measured to be 10.27% which was reduced to 5.51% on 25th day. The initial total carbohydrate and volatile fatty acid concentration was 61.2 g/L and 2475.5 mg/L respectively. After 24 days of digestion, the total carbohydrate concentration was decreased to 22.3 g/L, whereas volatile fatty acid concentration was increased to 4954 mg/L. The project work signifies that the kitchen waste can be used as a potential source for biogas production using two stage digestion processes and thus effective waste management can be achieved.

Keywords: Mesophilic, Thermophilic, Anaerobic, Digestion, Biogas.

I. INTRODUCTION

Anaerobic digestion is generally used, proven process that is being used for the treatment of the solid wastes. Anaerobic digestion is a process in which the biological processes like biodigestion by the microbes occur. Anaerobic digestion processes breakdown the organic matter in the feed materials in anaerobic conditions i.e., in the absence of oxygen. These processes stabilize these waste materials against rapid decomposition. The conversion process is conservative in nature which produces a stable digestive that can be used as a bio-fertilizer. The methane gas and carbon dioxide are also produced which are together known as biogas. Thus in addition to treatment of the solid wastes, anaerobic digestion also allows recovery of energy value by conversion of the volatile solids into biogas. The process also functions as a waste material disposal system. Food wastes have become a major source of substrate for the biogas plants due to their high organic content. A food waste has also been used as substrate in combination with animal dung in biogas plants to obtain an overall high production of biogas. The Biogas produced by anaerobic digestion process has methane as its major constituent. Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude. It means higher efficiency and size of reactor and cost of biogas production is reduced. Also in most of cities and places, kitchen waste is disposed in landfill or discarded which causes the public health hazards and diseases like malaria, cholera, typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences. It not only leads to polluting surface and groundwater through leachate and further promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. Also, it emits unpleasant odour and methane which is a major greenhouse gas contributing to global warming.

II. EXPERIMENTAL SETUP (SMALL SCALE)

Three different digesters were setups under different conditions with same initial composition were installed. The food waste used for the study in this project was collected from the society. The food waste samples collected consisted of mixed wastes i.e., cooked wastes, uncooked wastes. The indigestible wastes like onion peels, small twigs, egg shells, etc. were removed from the collected food wastes manually.

The food wastes were then weighed 400gm for each setup. The food waste was crushed using a mixer grinder along with diluting it to 1 liter with water to form homogenized slurry (the food waste was diluted at a rate of 1:1.5 with water). The initial analysis of the food wastes before it was put into the reactor were performed, the same day it was collected from the hall. The analysis was done as follows:

- The diluted food wastes collected on the 1st day were analysed for Total Solids (TS), Volatile Solids (VS), Total Carbohydrates (TC) and pH.
- The TS-VS content for each of the digester setup was measured every 5 days from the start of the setup.
- The total Carbohydrate content for each of the digester setup was measured using Phenol-Sulfuric acid method every 3 days from the start of the setup.
- pH was measured every 2 days and was adjusted by adding sodium hydroxide to regulate the pH around 7.
- Gas production of each setup was measured every day.
- The substrate in the setup was kept well mixed by shaking the setup 4-5 times a day.
- Hot water bath was used for heating and maintaining temperature during thermophilic stage.

2.1 Materials Used for the setup

- 3 separate 1.5liter plastic bottles.
- 400 gm grinded kitchen waste diluted to 1 liter with water for each setup.
- 100ml diluted cow dung slurry was added and used as inoculums.
- Rest space was left empty.

Setup: 1. 400gm food waste diluted with water to make 1litre then 100ml diluted cow dung slurry was kept under mesophilic conditions at room temperature. pH of the setup was measured and adjusted to 6.6 initially. This setup was operated only for 20 days.

Setup: 2. 400gm food waste diluted with water to make 1litre then 100ml diluted cow dung slurry. This setup was initially kept at thermophilic temperature (around 55° C) in a water bath for 2days and then under mesophilic conditions at room temperature and 50 ml more inoculums was added. pH of the setup was measured and adjusted to 6.7initially. This setup was operated only for 20 days.

Setup: 3. 400gm food waste diluted with water to make 1litre then 100ml diluted cow dung slurry was kept under thermophilic temperature (around 55° C) in a water bath. pH of the setup was measured and adjusted to 6.5 initially. This setup was operated only for 10 days.

III. EXPERIMENTAL SETUP (PILOT SCALE)

The pilot scale biogas plant was made from the following components:-

A. Inlet tank - From this tank the crushed food waste material was to be added. This part was made from a plastic bucket in which the slurry was prepared then added to the pre-digestion tank through the inlet of that pre-digester tank.

Material used – Plastic Bucket (1 Nos.)

B. Pre-digester tank - here the waste materials were heated around temperature of 50-60°C sothat thermophilic hydrolytic bacteria would grow. The substrate remained in this tank for 2 days. The heating helps in the faster digestion of the food waste.

Material used – Steel Tank (10 Liters capacity, 1 Nos.)

C. Main digestion tank – The waste materials after getting digested in the pre digester tanks for a 2 days was passed onto the main digester tank where the mesophilic methanogenic bacteria was allowed to grow with the addition of some new inoculums, which digest the food wastes further to produce methane gas.

Material used – Steel Tank (20 Liters capacity, 1 Nos.)

D. Gas collection unit – This unit was used to collect the gas that was generated from the digestion of the food wastes in the digester tanks. The gas was collected over water and was characterized to find the type of gas produced.

Material used – Plastic bottles (2 Liters capacity, 2 Nos.)

E. Slurry collection unit – This unit was be used to collect the digested slurry of the food wastes at regular intervals for the analysis. This slurry was be analyzed to study their characteristics.

Material required – Plastic beakers (1 Nos.)

Other Materials required – PVC pipes, silicon pipes and valves was be used to connect different units of the plant.

Table: Gas Production of the pilot scale setups with time.

Day	Gas Production	Day	Gas Production
1	7200	14	7100
2	7050	15	7400
3	4850	16	7150
4	5000	17	7259
5	4800	18	7450
6	5540	19	7300
7	5750	20	7450
8	6200	21	7350
9	6250	22	7200
10	6350	23	7300
11	6150	24	7200
12	6850	25	7450
13	7150		

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IV. CONCLUSION

The pilot scale plant was based on two stage thermophilic and mesophilic digestion process and operated as a batch reactor under controlled conditions of pH and temperature. A constant rate of gas production was achieved but accumulation of volatile fatty acids was also observed. In batch condition, it was observed that a maximum of 7.45 litres biogas was produced from the digestion of 6 kg of food wastes in 25 days. Initially the total solids of the waste slurry were measured to be 10.27% on the day of starting the reactor and 5.51% on 25th day. The total carbohydrates degradation was measured to be 61.2 g/L on the day of starting the reactor and 22.3 g/L on 24th day. The volatile fatty acid concentration was measured as 2475.5 mg/L on the day of starting the reactor and 4954 mg/L on 24thday. The future prospect of the project can be the improvement of biogas production from kitchen wastes by incorporating additives and optimization of other process parameters in the two stage anaerobic digestion process.

V. GAS ANALYSIS

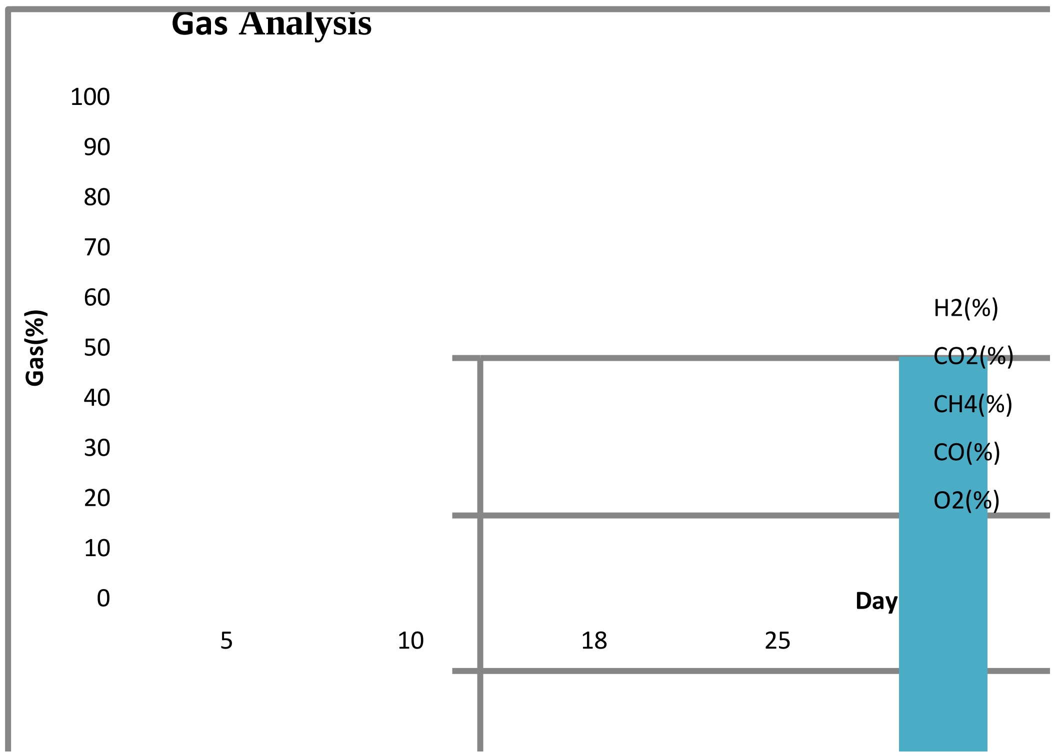

Table: Gas analysis of the pilot scale setup with time

Day	H_2(%)	CO_2(%)	CH_4(%)	CO(%)	O_2(%)
5	3.11	66.2	0	0.01	6.22
10	0	70	1.2	0.01	8
18	0	56.12	10.2	0.01	8.21
25	0	45.3	18.56	0.01	6.41

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