INVESTIGATION OF BIOGAS GENERATION FROM KITCHEN WASTE OF BUET CHATTRI HALL

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ABSTRACT

Biogas is a renewable source of natural gas produced by the microbial degradation of organic matter in a process called anaerobic digestion. It can be a good practice for solid waste management. The research work is based on the effectiveness of bio-gas production from residential kitchen waste, collected from BUET Chattri Hall. It is seen that 73% of the kitchen waste is biodegradable, which is high, so it can be a good source of bio gas generation. For proper anaerobic digestion microorganisms have used, collected from the bio-gas plant of Jahangirnagar University, Savar. In last experiment to overcome the lack of balanced nutrition, Urea and DAP fertilizer are used for the nutrition supply like nitrogen and phosphorus. The digestion process of the sample has been observed in two ways- batch feed study, Semi continuous feed study. Four experiments have been done; among them 1st, 2nd, 4th experiment are done as batch feed study and 3rd one is done as semi continuous feed study. Biogas generation rate is found in the range of 0.021 m^3/kg of VS added to 0.069 m^3/kg for batch feed study, 0.0073 m^3/kg of VS added to 0.049 m^3/kg of VS added for batch study with nutrients, 0.029 m^3/kg of VS added to 0.19 m^3/kg of VS added for semi continuous feed study.In experiment one, two and three pH varied from 4 to 6. So, in experiment four we tried to increase pH by adding NaOH and then pH became almost stable in the range from 6.36 to 7.38. From this research, it is seen that gas has been produced successfully but after a certain time gas production has been stopped and consumption of gas is also noticed.

Keywords: *Waste, Biodegradability, Biogas, Anaerobic, Digestion*

1. INTRODUCTION

Waste management is a challenging task and global concern all over the world. Bangladesh is also facing similar adversity as the amount of waste generated from domestic and commercial activities is increasing day-after-day in the large cities including the megacity Dhaka (DoE, 2013). North City Corporation (DNCC) and Dhaka South City Corporation (DSCC) collectively generate about 1.6 million tons of municipal waste per year, which emit approximately 1 million tons of GHG annually. A study by Department of Environment (DoE) revealed that Dhaka's problem regarding solid wastes is worse compared to cities in other developing countries. Everyday a lot of solid waste is producing in the kitchen of a residential area. So, we can try to convert our waste into resource. A very simple method is producing biogas. Most part of our kitchen waste is biodegradable. Hence, it can be a good source of biogas production. Biogas is a renewable source of energy. It can be an important fact of sustainable development. Biogas can be used for lighting, cooking, fuel and the use of biogas will reduce the demand of other energy sources like electricity, natural gas, fossil fuels etc. The residue of anaerobic digestion can be used as good fertilizer, which is also helpful. 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. 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. In addition, it emits unpleasant odour & methane which is a major greenhouse gas contributing to global warming. A large fraction of kitchen waste is biodegradable organic material having the high calorific value and nutritive value to microbes and can be efficiently converted to biogas. The proper disposal of kitchen waste of Chattri Hall, BUET will be tried to done in eco-friendly and cost-effective way. Anaerobic digestion (AD) is a promising method to treat the kitchen wastes. Physical and chemical characteristics of the organic wastes are important for designing and operating digesters, because they affect the biogas production and process stability during anaerobic digestion. They include moisture content, volatile solids, nutrient contents, particle size, & biodegradability. The biodegradability of a feed is indicated by biogas production or methane yield and percentage of solids (total solids or total volatile solids) that are destroyed in the anaerobic digestion.

Dr. Anand Karve (ARTI) developed a compact biogas system that uses starchy or sugary feedstock (waste grain flour, spoilt grain, overripe or misshapen fruit, nonedible seeds, fruits and rhizomes, green leaves, kitchen waste, leftover food, etc.). Just 2 kg of such feedstock produces about 500 g of methane, and the reaction is completed with 24 hours. Thus, the system developed by Dr. Anand Karve is 20 times as efficient as the conventional system, and from the point of view of reaction time, it is 40 times as efficient. Thus, overall, the new system is 800 times as efficient as the conventional biogas system (Karve. A.D, 2007); for that reason, in this research same type of waste is used instead of cow dung, sewerage etc.

Biodegradable waste includes any organic matter in waste which can be broken down into carbon dioxide (CO_2), water (H_2O), methane (CH_4) or simple organic molecules by micro-organisms. The main objective of the study is to investigate quantity of biogas from kitchen waste in reactors. Specific objectives of the study are-

1. To observe the batch feed study and semi continuous feed study.
2. To determine the digestion time or detention time for kitchen waste.
3. To study the effect of nutrients like nitrogen, phosphorus on biogas production.

2. METHODOLOGY

Kitchen waste is collected from Chattri Hall, BUET. After that biodegradable portion of waste is separated and cut into around four-millimetre small pieces and weighted by weighing machine for experiment. To determine the quantity of gas from anaerobic digestion of Residential hall kitchen waste, small gas plant suitable for laboratory use is taken to run the experiment. Four sets of gas collection system are used to measure Biogas. In this research, biodegradable components are used only. Hence, we need to know the percentage of biodegradable components in kitchen waste. To determine the percentage, waste is collected from hall kitchen. Waste is collected for 7 days and then the average percentage of biodegradable kitchen waste is determined.

2.1 Set up of laboratory scale gas plant

In each arrangement, a large glass bottle is used as reactor or digester with an inlet and outlet system. There are two holes bored in the cork, one for gas pipe and another for inlet glass tube. After placing sample, silica gel is used at stopper to make sure that the system is air-tight and no gas can escape from the digester.

Another two bottles are used for gas collection. Gas will be collected over water by water displacement method. Most components of biogas are non-soluble. When gas is not soluble in water, it can be collected over water. A rubber pipe from the reactor is connected with a glass bottle with sufficient amount of water. Another glass bottle with less amount of water is connected with the previous one. A measuring tape is attached to every glass bottle for measuring the amount of gas generated.

A heater is used for measuring the temperature of the system. Which is set to maintain the temperature at 32°C-35°C.

2.2 Waste Sample

For a representative sample, Kitchen waste of Chattri Hall was collected for 7 days. The biodegradable part of the waste was separated. Then each component of waste was separated to know the percentage of it on a weight basis. From 7 days survey, a representative composition of kitchen waste was found. This waste composition was used as the waste sample to digest anaerobically for producing biogas.

2.3 Collection of Microorganisms:

In Jahangir Nagar University, there is a biogas plant based on waste of residential Halls. For experiments, seed was collected from that biogas plant. The liquid of digester is full of microorganism. Hence, the inoculum was carried in a non-toxic container and collected just before starting of the experiment. Because this inoculum cannot be preserved, microorganisms may die for lack of nutrition or food in container.

2.4 Procedure of the experiment:

At first, survey was done in order to finding the ratio of biodegradable waste to non-biodegradable waste for one week. Then composition of biodegradable kitchen was calculated in percentage from the surveyed data. TS (Total Solid) and VS (Volatile Solid) percentage has been determined for the waste representative waste sample.

2.4.1 Batch Feed Study:

Experiment 1:
At first kitchen waste is collected and weighted. At 1st experiment 750gm waste and 1250ml inoculum is used in 1st set up. In another set up only 1250ml inoculum is used.

Experiment 2:
At 2nd experiment 250gm waste, 875 ml inoculum, 875ml water was used in 1st set up. In another set up 500gm waste, 750 ml inoculum, 750ml water was used.

Experiment 4:
At 4th experiment there were four set ups. In 1st set up 750gm waste+20gm Nitrogen+5gm Phosphorus are used (Set 1). In 2nd set up 750gm waste+15gm Nitrogen+3gm Phosphorus are used (Set 2). In 3rd set up 750gm waste+10gm Nitrogen+2gm Phosphorus are used (Set 3). In 4th set up

750gm waste+5gm Nitrogen+1gm Phosphorus are used (Set 4). For proper nutrition, nitrogen requirement is fulfilled from urea fertilizer (CH4N2O) and Phosphorus requirement is fulfilled from DAP [(NH4)2HPO4]. Fertilizers are diluted with water. In 1st set up 750gm waste, 34gm Urea, 25gm DAP,625ml inoculum ,566ml water is used. In 2nd set up 750gm waste, 27gm Urea, 15gm DAP,625ml inoculum, 583ml water is used. In 3rd set up 750gm waste, 18gm Urea, 10gm DAP,625ml inoculum, 597ml water is used. In 4th set up 750gm waste, 9gm Urea, 5gm DAP,625ml inoculum, 611ml water is used.

2.4.2 Semi-Continuous Feed Study:

The 3rd experiment was done by semi continuous feed system, in total four set ups. In 1st set up 1000gm waste, 500ml inoculum, 500 ml water are used. In 2nd set up 750gm waste, 625ml inoculum, 625 ml water are used. In 3rd set up 500gm waste, 750ml inoculum, 750 ml water are used. In 4th set up 250gm waste, 875ml inoculum, 875ml water are used. Data of gas generation is recorded at 24-hour interval. By assuming 20 days Hydraulic Retention Time (HRT);50gm,37.5gm ,25gm ,12.5gm sludge is removed and same amount of waste is fed semi continuously (three- and four-days interval in a week) in four set up respectively. In spite of daily feeding, waste is fed at three- and four-day's interval to avoid difficulties.

2.4.3 Data Recording:

Volume of gas in each 24-hour period was recorded. The recording of data was continued until the gas exhausted. pH is measured for every experiment by pH paper.

3. RESULT AND ANALYSIS:

The result of seven days survey is- biodegradable waste is 73% and non-biodegradable waste is 27%. The highest and lowest amount of waste is generally found on Saturday and Thursday respectively. Biodegradable waste part included- rice, potato, cauliflower, gourd, papaya, pumpkin, point-gourd where percentage of rice is the highest.

The value of TS is 33% and value of VS is 20.7%, determined from the average of three solid waste sample testing. From TS and VS value, we can understand the biodegradability property of solid waste since higher percentage of volatile solid indicates higher the percentage of biogas production.

In the 1st experiment, at first gas produced from solid waste and inoculum and gas produced from only inoculum is measured. Later, Gas produced from only solid waste is calculated by subtracting the previous values. The total amount of produced gas from 1st experiment is shown below:

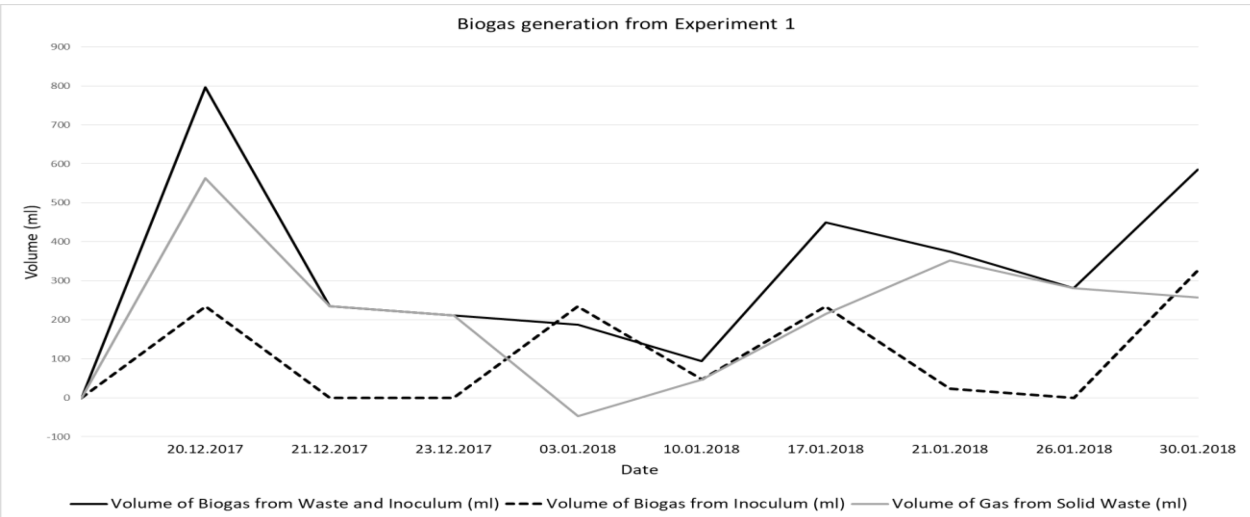

Figure 3.1: Bio-Gas generation from 1st experiment

From the graph it can be observed that at first gas production was high and the peak value is achieved in second day. Then the gas production decreased and after about ten days gas production started to increase. Gas is produced up to fifty-one days and then production of gas is exhausted. Temperature of the experiment is maintained around 32°C-35°C by a heater.

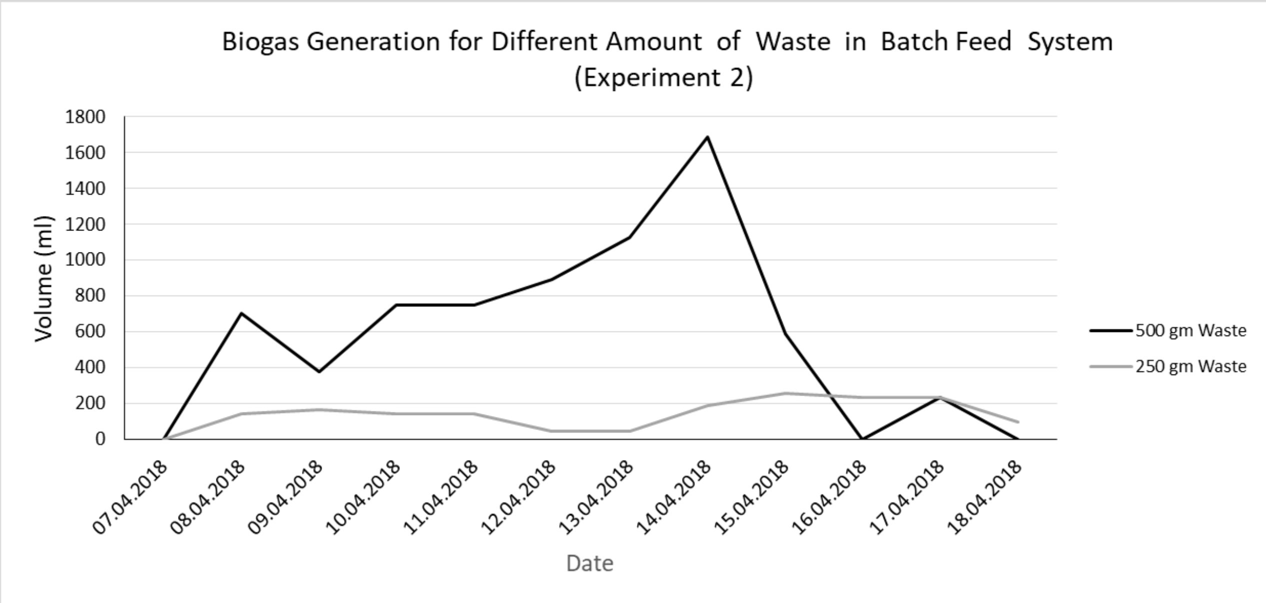

Figure 3.2: Bio-gas production from 2nd experiment

Gas production increased up to eight days for 500gm waste and then it started decreasing, and after twelve days gas production stopped. For 250gm waste, gas production gradually increased for seven days then after decreasing for two days it again started increasing up to eleven days and after that gas production finally stopped. Temperature of the experiment is maintained around (32°C-35°C) by a heater.

Biogas generation from the 3rd experiment, which is done by semi-continuous feeding system is shown below:

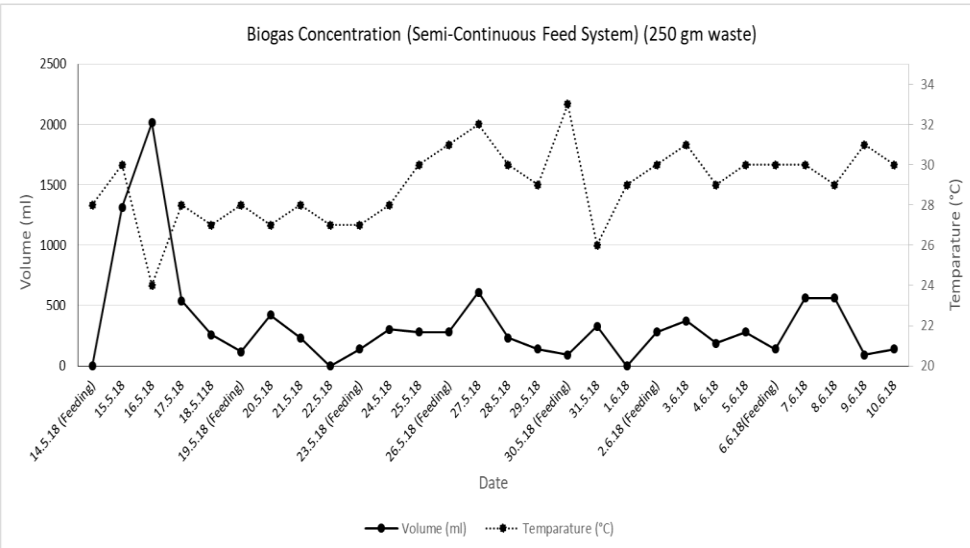

Figure 3.3:Bio-gas(black line) and temperature variation (ash line) for 250gm of waste

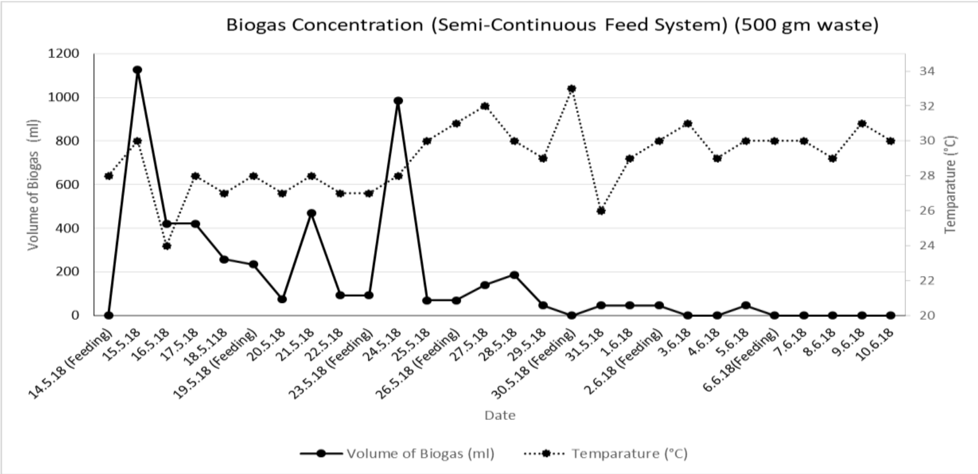

Figure3.4: Bio-gas(black line) and temperature variation (ash line) for 500gm of waste

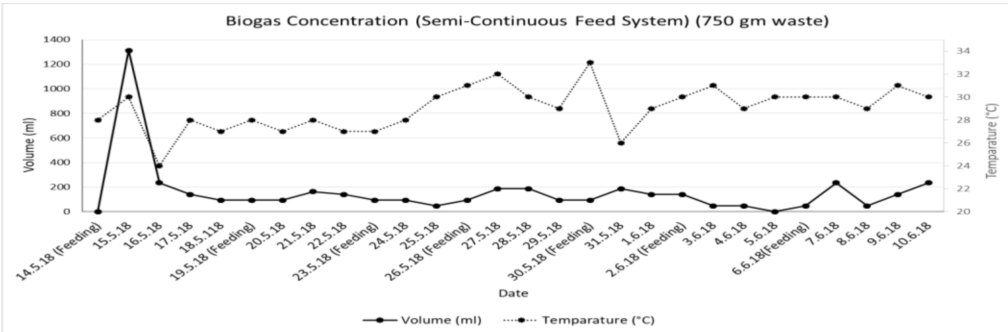

Figure 3.5:Bio-gas(black line) and temperature variation (ash line) for 750gm of waste

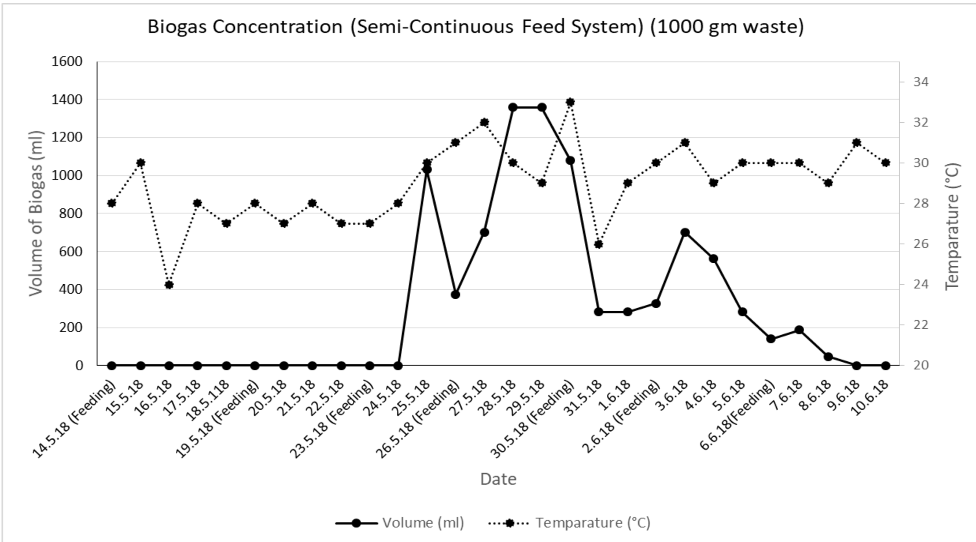

Figure 3.6:Bio-gas(black line) and temperature variation (ash line) for 1000gm of waste

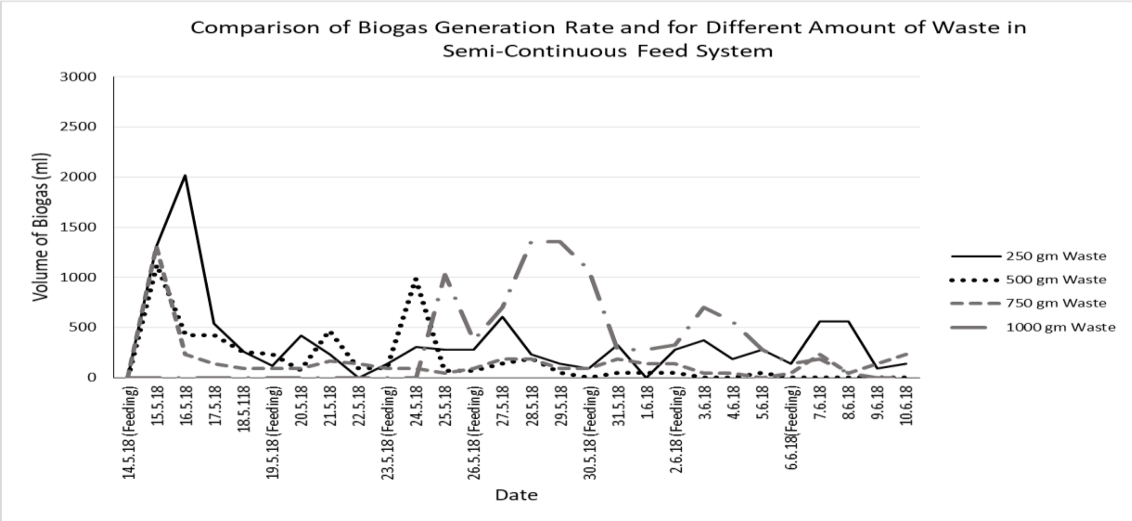

Figure 3.7: Bio-gas generation comparison from 3rd experiment

From figure 3.3 variation of temperature and biogas generation for 250gm, 500gm, 750gm and 1000gm waste is shown. From figure 3.4 it is seen that; the peak value of gas production is highest for 250gm waste among four and it also produce a good amount of gas than 500gm and 750gm waste throughout the time. On the other hand, after remaining stopped for ten days 1000gm waste then produced better amount of gas than 250gm waste and stopped gradually.

Bio-Gas generation for 4th experiment where nitrogen and phosphorus are added for showing a better result is shown:

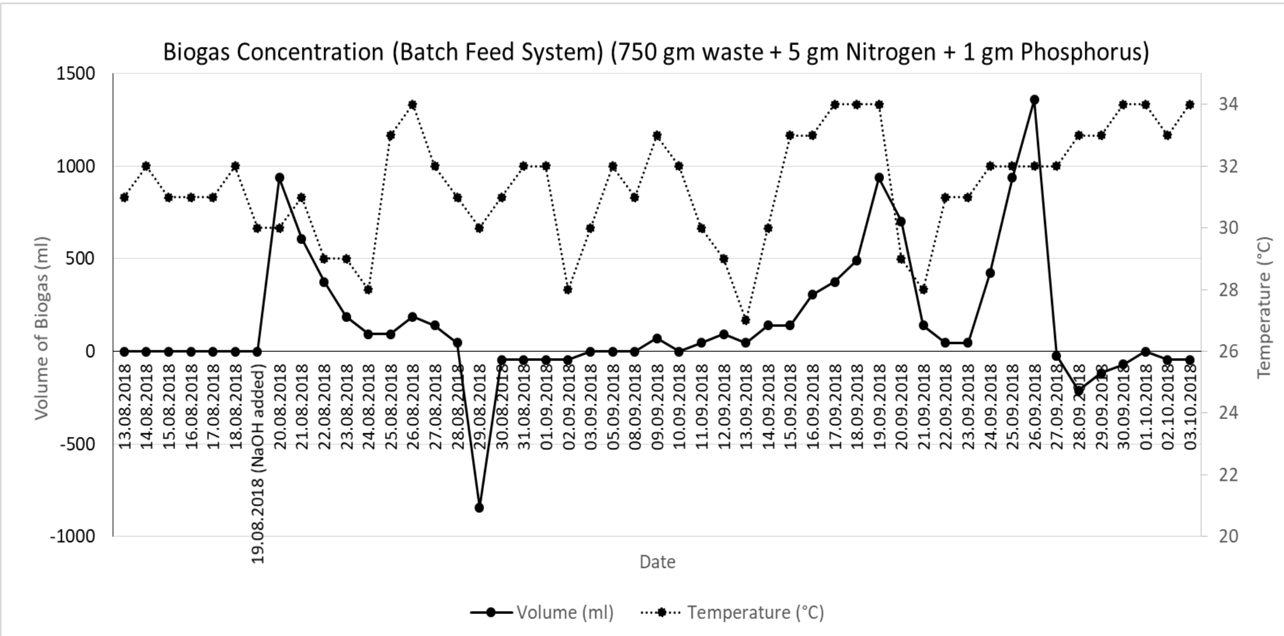

Figure 3.8: Bio-gas (black line) and temperature (ash line) variation for 750gm waste, 5gm Nitrogen, 1gm Phosphorus (Set 4)

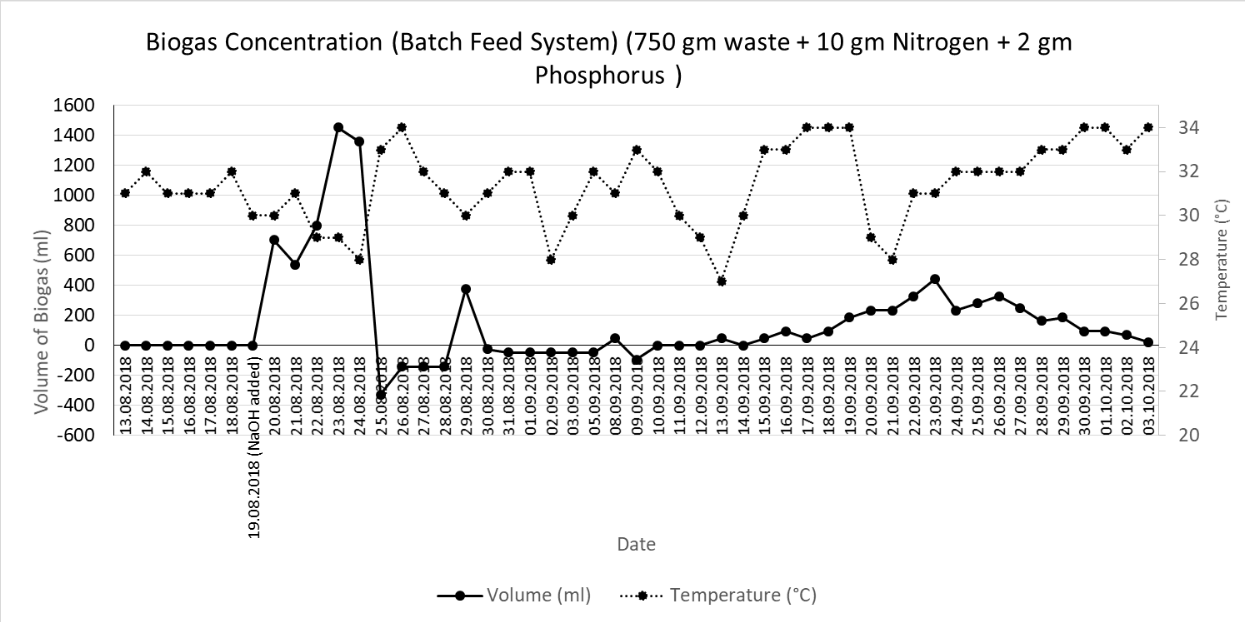

Figure 3.9: Bio-gas (black line) and temperature (ash line) variation for 750gm waste, 10gm Nitrogen, 2gm Phosphorus (Set 3)

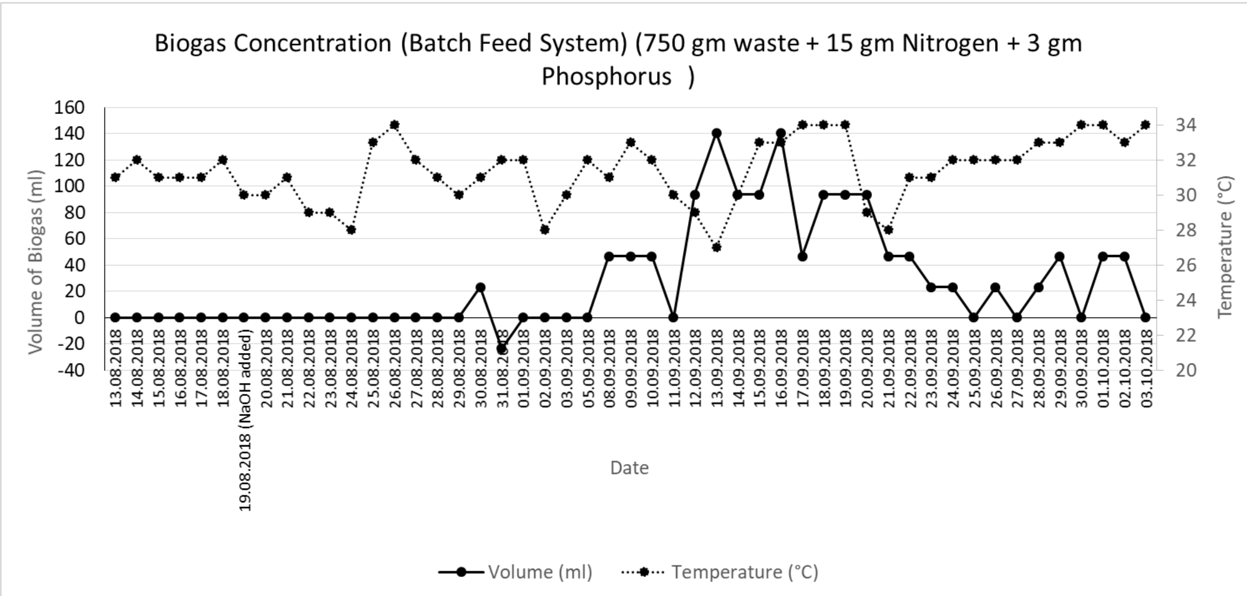

Figure 3.10: Bio-gas (black line) and temperature (ash line) variation for 750gm waste, 15gm Nitrogen, 3gm Phosphorus (Set 2)

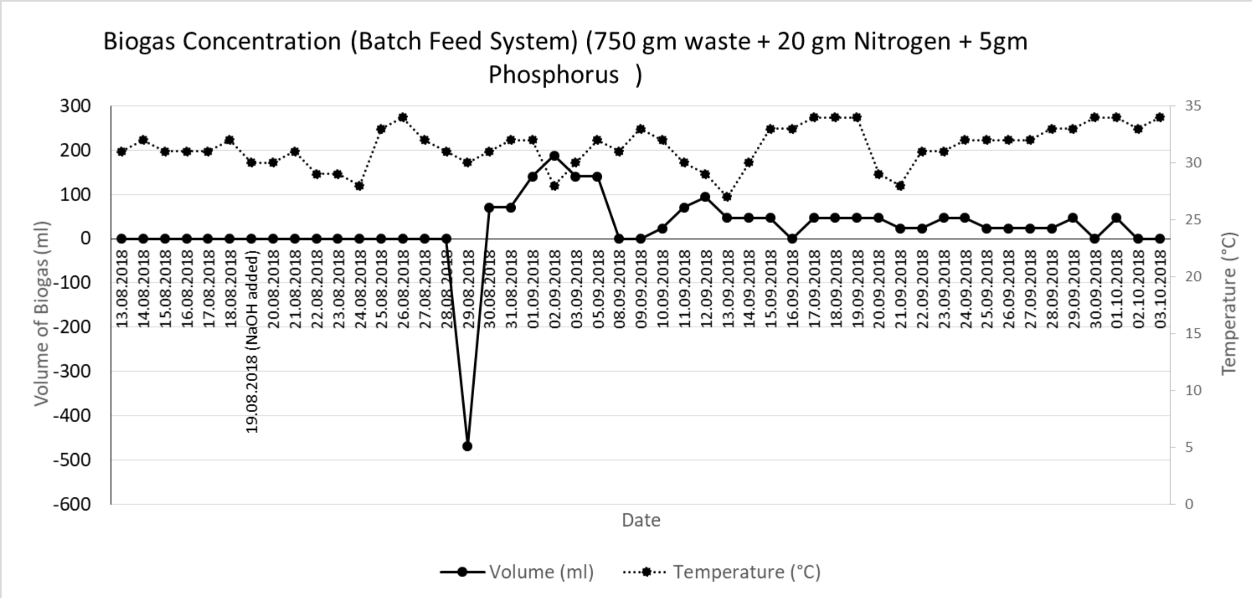

Figure 3.11: Bio-gas (black line) and temperature (ash line) variation for 750gm waste, 20gm Nitrogen, 5gm Phosphorus (Set 1).

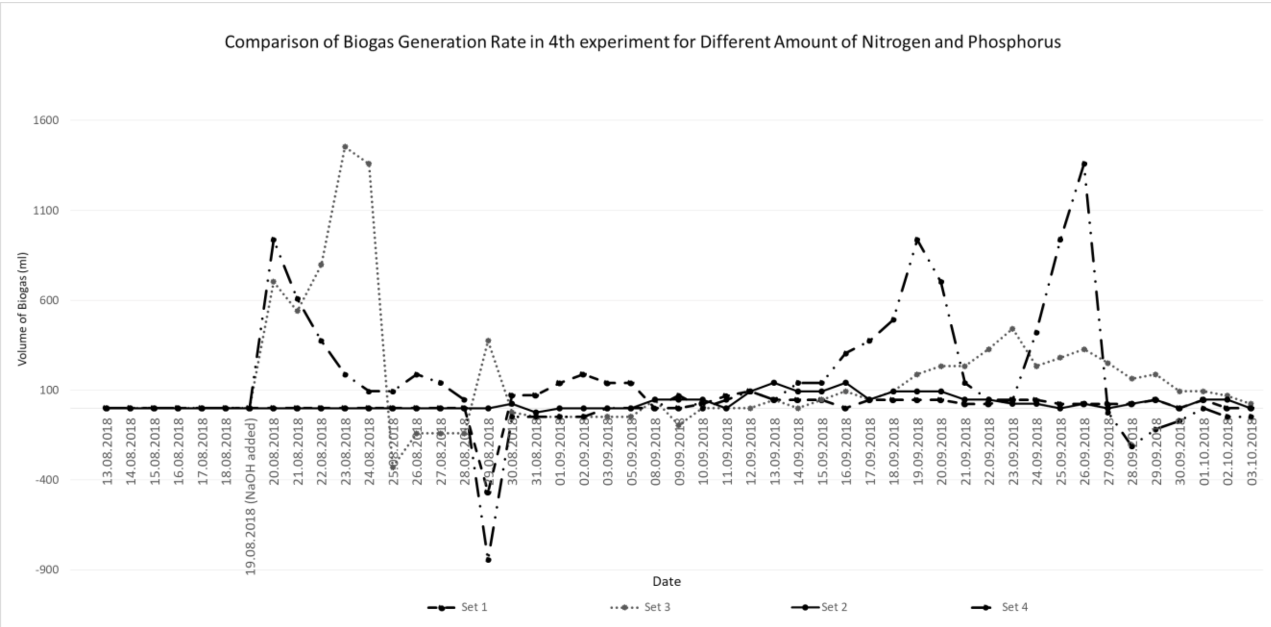

Figure 3.12: Bio-gas generation comparison from 4th experiment

From this comparison graph, it is seen that, set 3 and set 4 has shown comparatively better gas production than set 1 and set 2 even after consuming gas. For 6 days from starting, gas production was zero for all set so NaOH was added to increase pH value. For set 3 and 4 gas production varied according to variation of pH value proportionally. For set 2, it is seen that throughout the time it has higher value of pH but gas production was less than other sets. Biogas generation rates for all experiments are given below:

Experiment 1: 0.021 m3/kg of VS added (for 750gm waste).

Experiment 2: 0.033 m3/kg of VS added (for 250gm waste) and 0.069 m3/kg of VS added (for 500gm waste).

Experiment 3: 0.042 m3/kg of VS added (for 1000gm waste); 0.029 m3/kg of VS added (for 750gm waste); 0.047 m3/kg of VS added (for 500gm waste); 0.19 m3/kg of VS added (for 250gm waste).

Experiment 4: 0.0073 m3/kg of VS added (for set 1); 0.0088 m3/kg of VS added (for set 2); 0.049 m3/kg of VS added (for set 3); 0.048 m3/kg of VS added (for set 4).

In the experiments, we observed a low pH value ranging from 4 to 6 which represents acidic condition. It may be happened because of the production of various volatile fatty acids like Propionic acid, butyric acid, acetic acid, formic acid, lactic acid in the acetogenesis stage of anaerobic digestion.

4. CONCLUSIONS

In this research all observations, surveys, studies, experiments are done with great care but there may be some errors as practical works do not always follow theory properly. We tried our best to make an efficient and economical biogas production system to produce sufficient amount of gas from kitchen waste. From the whole research, we can establish some major findings, problems and difficulties, ways to overcome these.

- It is seen that 73% of the kitchen waste from hall is biodegradable. As the biodegradable portion is high, so it can be a good source of biogas generation.

- From solid waste sample, TS is found 33% and VS is found 20.7%. TS and VS indicate the biodegradability of solid waste.

- Biogas generation rate is found in the range of 0.021 m3/kg of VS added to 0.069 m3/kg for batch feed study, 0.0073 m3/kg of VS added to 0.049 m3/kg of VS added for batch study with nutrients, 0.029 m3/kg of VS added to 0.19 m3/kg of VS added for semi continuous feed study.

- In four experiments, different hydraulic retention times have been found. 51 days, 12 days, 28 days and 50 days are the retention time for four experiments respectively. From this, we can see that 1st and 4th experiment lasted for a long time.

- pH is one of the important parameters for biogas production. In experiment one, two and three pH varied from 4 to 6 which is acidic condition and is not desirable. So, in experiment four we tried to increase pH by adding NaOH and then pH varied from 4 to 9, and became almost stable in the range from 6.36 to 7.38 throughout the retention time.

- From this research, it is seen that gas has been produced successfully but after a certain time gas production has been stopped. In some cases, consumption of gas is also noticed.

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