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ANALYSIS AND CHEMICAL CHARACTERIATION OF KITCHEN WASTE FOR OPTIMISING THE POTENTIAL OF BIOGAS GENERATION

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Abstract - Due to scarcity of petroleum and coal, the supply of fuel is threatened throughout the world and leads us to research in different corners to get access for new sources of energy, like renewable energy sources. Solar energy, wind energy, different thermal and hydro sources of energy, biogas are all renewable energy resources. But biogas is distinct from other energy sources because of its characteristics of using, controlling and collecting organic wastes and at the same time producing fertilizer and water for irrigation. Biogas does not have any geographical limitations nor does it needs advanced technology for producing energy, also it is very simple to use and apply. Deforestation is very big problem in developing countries like India, most of the part depends on charcoal and fuel-wood for fuel supply which needs cutting of forests. Also, due to deforestation it leads to decrease the fertility by soil erosion. Use of dung and fire wood is also harmful for the health of masses due to smoke rising from them causing air pollution. Therefore it is needed to go an optimized eco-friendly substitute for energy.

***Key Words*: Kitchen waste, biogas, aerobic digestion, biomethanation**

1.INTRODUCTION

Organic substances exist in wide variety from living beings to dead organisms. Organic matters are composed of carbon (C), combined with elements such as Hydrogen(H), Oxygen(O),Nitrogen(N), Sulphur(S) to form variety of organic compounds such as carbohydrates, proteins and lipids. In nature MOs(microorganisms), through digestion process breaks the complex carbon into smaller substances. There are 2 types of digestion process:

1. Aerobic digestion
2. Anaerobic digestion

The digestion process occurring in presence of oxygen is called aerobic digestion and produces mixture of gases having carbon di oxide which is one of the main greenhouses responsible for global warming.
The digestion process occurring without oxygen is called anaerobic digestion which generates mixture of gases. The gas produced which is mainly methane produces 5200-5800 kJ/m^3 which when burned at normal room temperature and presents a viable environmental friendly energy to replace fossil fuels.

1.1 ANAEROBIC DIGESTION

Anaerobic digestion is controlled biodegradable process which allows efficient capturing and utilization of biogas (approximately 0% methane and 40% carbon di oxide) for energy production. Anaerobic digestion of food waste is achievable but different types, composition of food waste results in varying degrees of methane yields, and thus the effects of mixing various types of food waste and their proportion should be determined on case by case basis. Anaerobic digestion (AD) is a promising method to treat the kitchen wastes. While anaerobic digestion for treatment of animal dung is common in rural parts of developing countries, information on technical and operational feasibilities of treating organic solid waste is limited in those parts. There are many factors affecting the design and performance of anaerobic digestion. Some are related to feedstock characteristics, design of reactors and operation conditions in real time. Physical and chemical characteristics of the organic wastes are important for designing and operating reactors, because they affect the biogas production and process stability during anaerobic digestion. They include moisture content, volatile solids, nutrient contents, particle size and biodegradability. The biodegradability of feed is indicated by biogas production or methane yield and percentage of solids that are destroyed in the anaerobic digestion. The biogas or methane yield is measured by the amount of methane or biogas that can be produced per unit of volatile solids contained in the feedstock after subjecting to anaerobic digestion for sufficient amount of time under a given temperature which is taken to be laboratory temperature in our case.
It is also referred to as biomethanation , is natural process that takes place in absence of oxygen. It involves biochemical decomposition of complex organic material by various biochemical processes with release of energy rich biogas and production of nutritious effluents. The anaerobic digestion consists of the following steps,

i. Hydrolysis
ii. Acidification
iii. Methanogenesis

1.2 CHARACTERISTICS OF BIOGAS

Composition of biogas depends on feed material also. Biogas is about 20% lighter than air, has an ignition range of 50 to 750 ^{0}C, an odourless and colourless gas that burns with blue flame similar to LPG. Its calorific value is 20 Mega Joules/ m^3 and it usually burns with 55% efficiency in biogas stove .This gas can be used as substitute firewood, cow-dung, petrol, LPG, diesel and electricity depending on the nature of the task and local supply conditions and constraints .Biogas digester system provides a residue organic waste, after its anaerobic digestion that has a superior nutrient over normal organic fertilizers, as it is in the form of ammonia and can be used as manure. It also function as waste disposal systems, particularly the human waste, therefore can reduce the potential threats of environmental contamination and spread of pathogens and disease causing bacteria. Biogas technology is particularly valuable in agricultural residual treatment of animal excreta and kitchen refuse.Many factors affecting the fermentation process of organic substance under anaerobic conditions are,

i. The amount and nature of organic matter
ii. The temperature
iii. Acidity and alkalinity (pH value) of substrate
iv. The flow and dilution of material.

1.3 KITCHEN WASTE

Kitchen waste is organic material having high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude as said earlier. It means higher efficiency and size of the reactor and cost of biogas production is reduced. And also in most of the cities and places, kitchen wastes are disposed in landfill and discarded which causes 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 diseases bearing vectors. Also, it emits unpleasant odour and methane which is a major greenhouse gas contributing to global warming.The proper disposal of kitchen waste will be done in eco-friendly and cost effective way. While calculating the cost effectiveness of waste disposal we have to think more than monetary prospects. The dumping of food in places and making the places unhygienic can be taken good care of. It adds value of such biogas plants. Mankind can tackle this threat successfully with the help of methane; however till now we have not benefited because of ignorance of basic sciences like output of work is dependent on energy available for doing that work. This fact can be seen in current practices of using lo calorific inputs like cattle dung, distillery effluent, municipal solid waste or sewage, in biogas plants, making methane generation highly inefficient. We can make this extremely efficient by using kitchen wastes/food wastes. In 2003, Dr. Anand Karve developed a compact system that uses starchy or sugary feedstock and that analysis shows this is much efficient 800 times the conventional biogas plants. In recent times varied technological modifications and improvements have been introduced to diminish the costs for the production of biogas. Different methods have been developed to increase speed of fermentation for the bacteria gas producers, reduction of size of the reactors, the use of starchy, sugary materials for their production, the modification of the feeding materials for the fermentation and the exit of the effluent for their better employment, as well as compaction of equipment to produce gas in small places like backyard. Larger facilities operating costs can be reduced, per unit; to the point that, in current economic framework, very large anaerobic digestion facilities can be profitable whereas small ones are not this is what economics of scale is. If energy prices continue to rise and the demand for local waste treatment, and fertilizers increase, this framework may change. In this research work an attempt was made to generate biogas from kitchen waste of ACCET hostel.

2. Preparation of cow dung waste

The cow dung samples were collected from the households near Sriram Nagar, Karaikudi. The collected cow dung was used as such as slurry. Thus the slurry of cow dung was stored in refrigerator as stock solution. The cow Dung slurry of required concentrations was prepared during the time of study from the stock solution.

Collection of food waste

The food waste was collected from the boys' hostel named Thiruvalluvar Illam of Alagappa Chettiar College of Engineering and Technology, Karaikudi. The type of sampling adopted was composite sampling. The duration of sampling was 24 hours. The collected sample was segregated to determine the composition of food waste. The same was then grinded in a mixer and was made as slurry. The slurry was then refrigerated as stock solution. The standard solution of required concentration was prepared during the time of study by diluting the stock solution.

EXPERIMENTAL STUDIES

The collected food waste was first segregated in order to determine and quantify the composition of the food waste. The same was then grinded in a mixer and was made as slurry. The slurry was analyzed in Environmental laboratory of ACCET Karaikudi in terms of pH, Alkalinity, Total solids, volatile solids and volatile fatty acids. Then two set of experimental study was carried out to assess and quantify the bio gas generation capacity of the Kitchen waste. First set of experimental study was carried out to analyze the effect of proper proportioning of kitchen waste with selected innoculum of cow Dung, effect of pH, effect of Volatile solids, Volatile Fatty acids and alkalinity. The second experimental study was carried out in a large scale with the optimized condition to quantify the biogas generated during this study. This study was carried out to assess the socio-economic feasibility of generate bio gas to replace the conventional LPG cylinders.

Composition of Solid waste

The food waste was collected from the boys' hostel named Thiruvalluvar Illam of Alagappa Chettiar College of Engineering and Technology, Karaikudi. The type of sampling adopted was composite sampling. The duration of sampling was 24 hours. The weight of the collected waste was first determined and then the collected solid waste was segregated manually as various vegetables. The segregated vegetable waste was then measured using a weighing balance. Then the proportion of each waste was determined as a percentage with respect to total weight of food waste.

Characterisation of Food waste

The food waste was collected from the boys' hostel named Thiruvalluvar Illam of Alagappa Chettiar College of Engineering and Technology, Karaikudi. The type of sampling adopted was composite sampling. The duration of sampling was 24 hours. The collected sample was segregated to determine the composition of food waste. The same was then grinded in a mixer and was made as slurry. The slurry was analyzed in Environmental laboratory of ACCET Karaikudi in terms of pH, Alkalinity, Total solids, volatile solids and volatile fatty acids. The procedure followed to determine the above said parameters were discussed below

Determination of pH

The pH of the food waste slurry was determined using portable pen type pH meter at room temperature. The pH meter was calibrated as per the standard procedure. The meter is switched on and the pH electrode about 2 to 3 cm was dipped into the pH standards buffer solution. pH calibration mode was activated by pressing CAL/MEAS key. The CAL icon appeared in the LCD. The upper display shows the default (un calibrated) pH measurement of pH electrode while the lower display indicates the pH standard buffer solution which was automatically recognized by the meter. The solution was swirled gently and the meter reading was allowed to stabilize. The upper display value is calibrated to the pH standard buffer solution. The lower display toggles between next two standard calibration points. The same procedure was repeated with other two standard buffer for better accuracy of the calibration. The electrode was rinsed in tap water before dipping into next standard buffer. Then the electrode was dipped about 2 to 3 cm into the test solution. The test solution was stirred gently and the meter reading was allowed to stabilize till the display shows "ready". Then the readings on the display were noted as pH of the test solution.

Determination of Total Solids

The amount of total solids in the slurry of food waste was determined by separating the solids from the liquid present in the slurries by heating at 103-105^{0}C. An evaporating dish of suitable size was taken and dried at 103°C to 105°C for 1 hour. The dish was stored in the desiccator until it became cool. The initial weight of the dried and cooled dish was noted. 10 mL of the unfiltered well-mixed samples were taken in the evaporating dish. The samples taken in the dish is placed in hot air oven at 103°C to 105°C for 2 hours till all water particles were evaporated. Then the dish was cooled in the desiccator until it became cool and the weight of the cooled dish along with the solids was measured. The difference between the initial weight and the final weight of the dish was calculated to determine the total solids in the samples.

Determination of Total Volatile Solids

The amount of total solids in the slurry of food waste was determined by separating the solids from the liquid present in the slurries by heating at 103-105^{0}C. An evaporating dish of suitable size was taken and dried at 103°C to 105°C for 1 hour. The dish was stored in the desiccator until it became cool. The initial weight of the dried and cooled dish was noted. 10 mL of the unfiltered well-mixed samples were taken in the evaporating dish. The samples taken in the dish is placed in hot air oven at 103°C to 105°C for 2 hours till all water particles were evaporated. Then the dish was cooled in the desiccator until it became cool and the weight of the cooled dish along with the solids was measured. The difference between the initial weight and the final weight of the dish was calculated to determine the total solids in the samples. Then the dish was placed in the muffle furnace at 550^{0}C to separate the volatile suspended solids from the fixed suspended solids. The dish was cooled in the room temperature and weighed. The difference between the weight of the dish before kept in the muffle furnace and the weight of the dish after kept in the muffle furnace was calculated to determine the Total volatile solids present in the slurries.

Determination of Total Volatile Fatty acids

Volatile fatty acids (VFA's) are fatty acids with carbon chain of six carbon or fewer. They can be treated through fermentation in the intestine. Examples include: acetate, propionate, and butyrate. There are many titration methods for VFA measurement. 100 ml of the food waste slurry was taken in a conical flask. The food waste slurry was filtered and the filtrate was taken for the analysis. The pH of the food slurry was noted down and if the pH of the slurry was above 4, the pH of the sample was brought down to below 4 by adding 0.1 M HCl. The 0.1 M HCl was taken in burette and the volume of HCl required to bring down the pH to 4 was noted. After pH was brought down to 4, the slurry was heated in a hot plate for 3 minutes. Then the heated food waste slurry was cooled down and the same was titrated with 0.01 M NaOH. The titration was done until the existing pH of 4 raises up and reaches a pH of 7. The volume of NaOH consumed to change the pH from 4 to &7 was noted down as V_2. Then the Volatile Fatty Acid content in the food waste slurry in terms of acetic acid was determined as,

$$\text{VFA in} \frac{\text{mg}}{\text{L}} \text{of Acetic acid} = V_2 \text{ X } 0.085$$

Where,

V_2 = Volume of NaOH consumed to change the pH from 4 to &7

Determination of Alkalinity

After collection of sample , analysis must be done as soon as possible.100ml of sample is taken in a conical flask and 2 to 3 ml oh phenolphthalein indicator is added. If there is no change in colour , phenolphthalein alkalinity is said to be zero. If pink colour develops, titrate it with 0.02N H_2So_4 till the developed colour disappears or till pH reaches 8.3. Note the volume of H_2So_4 required (A). Next add 2 to 3 drops of methyl orange indicator to the same sample which produces orange colour in the sample, continue titration till the pH reaches 4.5 or till the orange colour changes to pink. Note the volume H_2So_4 added(B). Calculate the total volume of phenolphthalein and methyl orange alkalinity and express in mg/L as $CaCO_3$.

Experimental Study 1

The performance of the kitchen waste to generate bio gas with cow dung as an inoculum was carried out in a set of five batch reactor. The reactors performances were assessed in terms of volume of bio gas generated. This study was carried out to determine the proper proportion of cow dung with food waste, effect of pH, effect of total solids, Effect of total volatile solids and effect of alkalinity on the biodegradation of organic waste. Five one liter distilled water bottle was taken as a batch reactors. Each reactor was designed with working volume of 900 mL which was filled with the substrate and cow dung. The remaining 100 mL of the reactor was used as a gas collection chamber to collect the bio gas generated. The volume of the generated bio gas was measured by means of water displacement method.

Reactor setup

Five one liter distilled water bottle was taken as a batch reactors. Each reactor was designed with working volume of 900 mL which was filled with the substrate and cow dung. The remaining 100 mL of the reactor was used as a gas collection chamber to collect the bio gas generated. The volume of the generated bio gas was measured by means of water displacement method. The batch reactor labeled as A contains zero mL of Cow dung, 400 ml of food waste and 500 ml of distilled water. The batch reactor labeled as B contains 100 mL of Cow dung, 300 ml of food waste and 500 ml of distilled water. The batch reactor labeled as C contains 200 mL of Cow dung, 200 ml of food waste and 500 ml of distilled water. The batch reactor labeled as D contains 300 mL of Cow dung, 100 ml of food waste and 500 ml of distilled water. The batch reactor labeled as E contains 400 mL of Cow dung, 0 ml of food waste and 500 ml of distilled water. The reactor set up used for this study was shown in Fig 2.1.

Figure 2.1. Reactor setup for experimental study 1

Evaluation of biogas

The Gas production was monitored, measured and recorded at specific time interval by water displacement method.

Effect of mix proportion of inoculum and substrate

This set of batch study was carried out to study the effect of the mix proportion of the inoculum with substrate. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The efficiency of the different mix proportion was evaluated in terms of daily generation of volume of biogas. The biogas generated daily was measured by water displacement method.

Effect of pH

This set of batch study was carried out to analyze the variation of pH during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The pH of each reactor was monitored daily and the same was noted down during the period of observation.

Effect of Total solids

This set of batch study was carried out to analyze the variation of Total solids during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The total solids of each reactor were monitored daily and the same was noted down during the period of observation.

Effect of Total volatile solids

This set of batch study was carried out to analyze the variation of Total volatile solids during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The Total volatile solid of each reactor was monitored daily and the same was noted down during the period of observation.

Effect of Total volatile Fatty acid

This set of batch study was carried out to analyze the variation of Total volatile fatty acids during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The Total volatile fatty acid of each reactor was monitored daily and the same was noted down during the period of observation.

Effect of alkalinity

This set of batch study was carried out to analyze the variation of alkalinity during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The alkalinity of each reactor was monitored daily and the same was noted down during the period of observation.

Experimental Study 2

This experimental study was carried out to assess the quantity of biogas generated under the optimized condition. The reactors performance was assessed in terms of volume of bio gas generated. The bio gas generated was measured by means of water displacement method. A 6.9 liter distilled water bottle was used as a batch reactor. Out of the five liter, 2.5 ml was kept as working volume in which both the substrate and cow dung was filled. The mix proportion of cow dung and the substrate was kept as the same as determined in the previous experimental study. The remaining volume was kept free as such as gas collecting chamber and used to collect the biogas generated. The collected bio gas was sent to the reactor nearby it containing water through the nozzle provided at the top and through the pipe. The volume of passed gas displaces the equal volume of the water in the reactor nearby. The displaced volume of water was collected in another reactor and the same was quantified. This set of batch study was carried out for 21 days. During this period of observation the volume of biogas generated daily was observed.

Reactor setup

A 6.9 liter distilled water bottle was used as a batch reactor. Out of the five liter, 2.5 ml was kept as working volume in which both the substrate and cow dung was filled. The mix proportion of cow dung and the substrate was kept as the same as determined in the previous experimental study. The remaining volume was kept free as such as gas collecting chamber and used to collect the biogas generated. The collected bio gas was sent to the reactor nearby it containing water through the nozzle provided at the top and through the pipe. The volume of passed gas displaces the equal volume of the water in the reactor nearby. The displaced volume of water was collected in another reactor and the same was quantified. The reactor set up used for this study was shown in Fig 2.2

Figure 2.2 Reactor setup for Experimental study 2

Estimation of biogas

This experimental study was carried out to assess the quantity of biogas generated under the optimized condition. The reactors performance was assessed in terms of volume of bio gas generated. The bio gas generated was measured by means of water displacement method. A 6.9 liter distilled water bottle was used as a batch reactor. Out of the five liter, 2.5 ml was kept as working volume in which both the substrate and cow dung was filled. The mix proportion of cow dung and the substrate was kept as the same as determined in the previous experimental study. The remaining volume was kept free as such as gas collecting chamber and used to collect the biogas generated. The collected bio gas was sent to the reactor nearby it containing water through the nozzle provided at the top and through the pipe. The volume of passed gas displaces the equal volume of the water in the reactor nearby. The displaced volume of water was collected in another reactor and the same was quantified. This set of batch study was carried out for 21 days. During this period of observation the volume of biogas generated daily was observed.

3. The collected food waste was first segregated in order to determine and quantify the composition of the food waste. The same was then grinded in a mixer and was made as slurry. The slurry was analyzed in Environmental laboratory of ACCET Karaikudi in terms of pH, Alkalinity, Total solids, volatile solids and volatile fatty acids. Then two set of experimental study was carried out to assess and quantify the bio gas generation capacity of the Kitchen waste. First set of experimental study was carried out to analyze the effect of proper proportioning of kitchen waste with selected inoculum of cow Dung, effect of pH, effect of Volatile solids, Volatile Fatty acids and alkalinity. The second experimental study was carried out in a large scale with the optimized condition to quantify the biogas generated during this study. This study was carried out to assess the socio- economic feasibility of generate bio gas to replace the conventional LPG cylinders.

Composition of Solid waste

The food waste was collected from the boys' hostel named Thiruvalluvar Illam of Alagappa Chettiar College of Engineering and Technology, Karaikudi. The type of sampling adopted was composite sampling. The duration of sampling was 24 hours. The weight of the collected waste was first determined and then the collected solid waste was segregated manually as various vegetables. The segregated vegetable waste was then measured using a weighing balance. Then the proportion of each waste was determined as a percentage with respect to total weight of food waste. The composition of the food waste was presented in table no 3.1

Table 3.1 Composition of food waste

S.No	Name of the food stuff	Weight in gm
1	Cooked Rice	500
2	Onion peels	150
3	Tomato	150
4	Radish	500
5	Potato peels	500
6	Beans and carrot	200
7	Bread	200

The composition of the same food waste was presented in pie chart and the same was shown in figure 3.1.

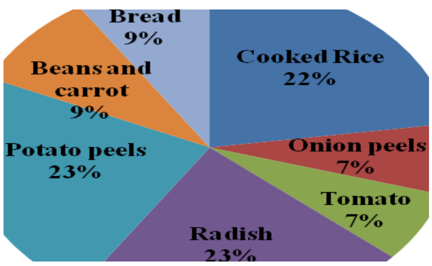

Figure 3.1. Composition of food waste

Characterisation of Food waste

The food waste was collected from the boys' hostel named Thiruvalluvar Illam of Alagappa Chettiar College of Engineering and Technology, Karaikudi. The type of sampling adopted was composite sampling. The duration of sampling was 24 hours. The collected sample was segregated to determine the composition of food waste. The same was then grinded in a mixer and was made as slurry .The slurry was analyzed in Environmental laboratory of ACCET Karaikudi in terms of pH, Alkalinity, Total solids, volatile solids and volatile fatty acids. The procedure followed to determine the above said parameters were discussed and tabulated in table no 3.2.

Table no 3.2 Characterization of food waste

S.No	Contents	Value
1	Total Solids	67500 mg/L
2	Total volatile solids	13230 mg/L
3	Total volatile fatty acid	437.5 mg/L of acetic acid
4	pH	5.7
5	Alkalinity	10.5 mg/L as $CaCO_3$

Effect of Mix Proportion of Inoculum and Substrate

This set of batch study was carried out to study the effect of the mix proportion of the inoculum with substrate. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The efficiency of the different mix proportion was evaluated in terms of daily generation of volume of biogas. The biogas generated daily was measured by water displacement method and the same was tabulated in table 3.3.

Table 3.3 Volume of biogas generated for various mix proportion of food waste and cow dung

Days	Volume of Bio gas in ml				
	Sample A	Sample B	Sample C	Sample D	Sample E
0	0	0	0	0	0
1	25	0	12	112	375
2	44	0	3	130	266
3	130	0	0	150	350
4	450	0	0	423	230
5	638	0	0	610	220
6	608	6	0	690	180
7	610	0	0	850	120
8	750	0	0	725	230
9	900	0	0	830	250
10	430	0	0	623	260
11	420	0	0	450	330
12	650	0	0	350	256
13	580	0	0	530	128
Total	6235	6	15	6473	3195

The volume of biogas collected daily was plotted in an ordinary graph with duration of observation along X-axis and volume of biogas generated along Y-axis and the same was shown in fig 3.2

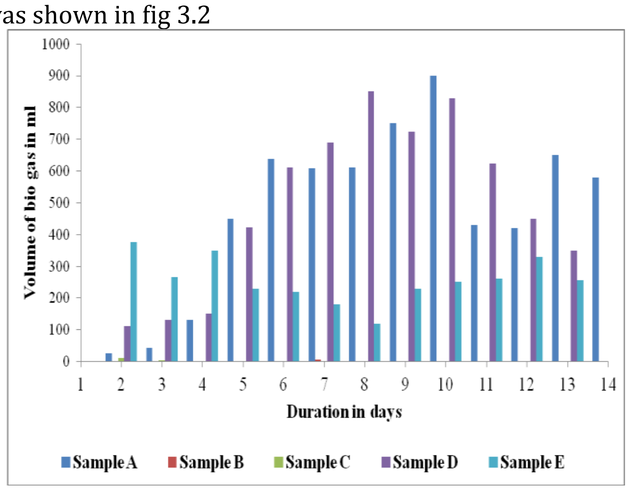

Figure 3.2. Volume of biogas generated for various mix proportion of food waste and cow dung

From the graph plotted above it is clear that the production of biogas was high for sample D that means for 75% cow dung and 25% food waste. Sample A ranks second in the production of biogas followed by sample E. The cumulative volume of biogas produced in the sample D was 6473 mL which is 3.6% more than the cumulative volume of biogas produced in Sample A and which is 51% more than the cumulative volume of biogas generated in Sample E. The least volume of biogas was generated in Sample B of 6 ml and followed by sample C of 15 ml of biogas for 14 days of observation. From this study it may be concluded that the mix proportion of 75% cow dung and 25% food waste can be used for better generation of biogas from kitchen waste.

Effect of pH

This set of batch study was carried out to analyze the variation of pH during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The pH of each reactor was monitored daily and the same was noted down during the period of observation and was tabulated in table no 3.4.

Table 3.4 variation of pH during the degradation of kitchen waste

Days	pH				
	Sample A	Sample B	Sample C	Sample D	Sample E
0	9.2	9	9.6	9.2	10.4
1	7.5	6.9	7.3	7.2	7.2
2	8.4	7.5	8.2	7.2	7.6
3	7.9	6.9	7.9	8.5	7.2
4	6.2	5.3	6.8	7.5	6.5
5	4	5.6	4.9	6.8	7.3
6	6.1	5.8	5.4	6.9	6.3
7	6.3	5.8	5.1	6.5	6.1
8	6.4	6.2	5.6	6.8	6.8
9	6.5	6	5.4	6.9	6.9
10	6.6	6.6	5.8	7.2	7.3
11	6.9	6.8	6.1	7.4	7.9
12	7.2	6.8	6.3	7.6	8.4
13	7.2	6.9	6.9	7.9	8.9

The variation of pH during the anaerobic degradation of kitchen waste was plotted in an ordinary graph with duration of observation along X-axis and pH along Y-axis and the same was shown in fig 3.3

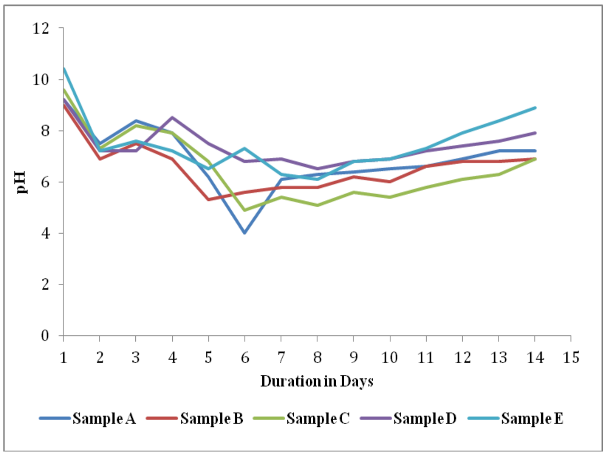

Figure 3.3. Variation of pH during the degradation of kitchen waste

From the graph plotted above it is clear that the pH value decreases first during the hydrolysis stage and then the value of pH slightly increases during the second stage of acidogenesis. The decrease in pH during hydrolysis stage is due to breakdown of larger organic molecules into proteins and amino acids. In the stage the pH value slightly increases and this may be due to the formation of lower soluble organic acids like acetic acid and propionic acid. After the second stage of degradation, the pH of the sample becomes alkaline and this may be due to the methanogenesis stage. In this stage the acetic acid formed in the second stage is further degraded by the methanogenic bacteria to methane and carbon-di-oxide.

Effect of Total solids

This set of batch study was carried out to analyze the variation of Total solids during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The total solids of each reactor were monitored daily and the same was noted down during the period of observation and was tabulated in table no 4.5.

Table 3.5 variation of Total solids during the degradation of kitchen waste

Days	Total Solids concentration in mg/l				
	Sample A	Sample B	Sample C	Sample D	Sample E
0	17	9	14	11	8
1	14	15	8	17	31
2	15	20	6	15	5
3	13	18	8	18	9
4	10	12	10	12	8
5	7	17	11	8	20
6	6	4	13	5	10
7	14	20	10	10	15
8	6	9	12	5	12
9	8	12	11	8	8
10	5	10	10	9	10
11	4	9	8	12	17
12	6	5	5	10	10
13	2	6	4	8	8

The variation of Total solid during the anaerobic degradation of kitchen waste was plotted in an ordinary graph with duration of observation along X-axis and Total solid along Y-axis and the same was shown in fig 3.4

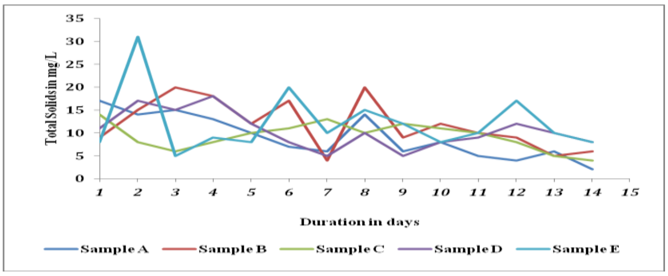

Figure 3.4. Variation of total solids during the degradation of kitchen waste

Effect of Total volatile solids

This set of batch study was carried out to analyze the variation of Total volatile solids during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The Total volatile solid of each reactor was monitored daily and the same was noted down during the period of observation and was tabulated in table no 3.6.

Table 3.6 variation of Total volatile solids during the degradation of kitchen waste

Days	Volatile Solids Concentration in mg/l				
	Sample A	Sample B	Sample C	Sample D	Sample E
0	15	7	24	17	19
1	6	6	3	7	16
2	8	12	11	9	17
3	10	15	15	8	15
4	9	6	8	10	12
5	4	2	3	32	39
6	3	12	5	17	13
7	5	15	3	15	12
8	6	12	2	20	15
9	5	13	0	25	18
10	8	15	5	27	13
11	10	16	7	24	10
12	13	18	8	23	8
13	16	20	5	20	10

The variation of Total Volatile solid during the anaerobic degradation of kitchen waste was plotted in an ordinary graph with duration of observation along X-axis and Total volatile solids along Y-axis and the same was shown in fig 3.5

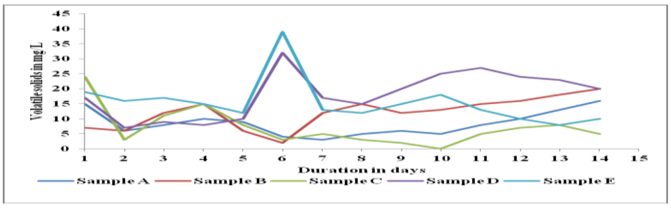

Figure 3.5. Variation of total Volatile solids during the degradation of kitchen waste

Effect of Total volatile Fatty acid

This set of batch study was carried out to analyze the variation of Total volatile fatty acids during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The Total volatile fatty acid of each reactor was monitored daily and the same was noted down during the period of observation and was tabulated in table no 3.7.

Table 3.7 variation of Volatile Fatty Acid during the degradation of kitchen waste

Days	Volatile Fatty acids concentration in mg/l as acetic acid				
	Sample A	Sample B	Sample C	Sample D	Sample E
0	61.25	52.5	70	43.75	52.5
1	52.5	87.5	122.5	43.75	70
2	227.5	367.5	166.25	647.5	271.25
3	580.25	423.5	230	650.25	300
4	423.5	670	353.5	830.25	255.25
5	46	875	551.25	700	87.5
6	1050	262.5	525	787.5	700
7	787.5	875	350	192.25	420.5
8	218.75	612.5	743.75	420	350.75
9	354.25	452.25	550	530.25	225.25
10	556.5	540.75	265.75	226.75	120.75
11	431.25	620	220.5	220.5	230.75
12	113.75	262.5	630	590.75	580.5
13	120.75	225.75	225.25	320.5	620.25

The variation of Total Volatile Fatty acid during the anaerobic degradation of kitchen waste was plotted in an ordinary graph with duration of observation along X-axis and Volatile Fatty Acid along Y-axis and the same was shown in fig 3.6.

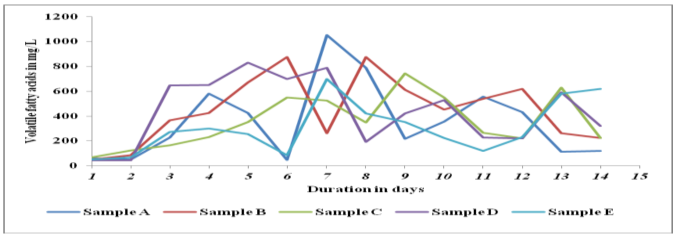

Figure 3.6. Variation of Volatile fatty acid generation during the degradation of kitchen waste

Effect of alkalinity

This set of batch study was carried out to analyze the variation of alkalinity during the anaerobic biodegradation of Kitchen waste. The inoculum used for this study was cow dung and the substrate used was kitchen waste. The first reactor was filled with 0% inoculum and 100% substrate to analyze the effect of substrate concentration alone in the generation of bio gas. The second reactor was filled with 25% inoculum and 75% substrate, whereas the Table 3.8 variation of alkalinity during the degradation of kitchen waste third was filled with 50% inoculum and 50% substrate, the fourth reactor with 75% inoculum and 25% substrate. The last batch reactor contains 100% inoculum without substrate to study the effect of inoculum alone on the generation of biogas from kitchen waste. This set of batch study was carried out for 14 days. The alkalinity of each reactor was monitored daily and the same was noted down during the period of observation and was tabulated in table no 3.8.

Days	Alkalinity in mg/l as $CaCo_3$				
	Sample A	Sample B	Sample C	Sample D	Sample E
0	5	25	12.5	5	10
1	15	20	25	5	10
2	15	20	10	10	10
3	10	20	10	15	15
4	5	15	5	15	10
5	5	10	15	10	5
6	10	15	15	10	20
7	10	20	15	10	10
8	10	25	20	5	10
9	15	15	25	5	15
10	10	10	20	10	10
11	5	15	25	5	10
12	20	20	25	10	5
13	15	20	20	5	5

The variation of alkalinity during the anaerobic degradation of kitchen waste was plotted in an ordinary graph with duration of observation along X-axis and alkalinity along Y-axis and the same was shown in fig 3.7.

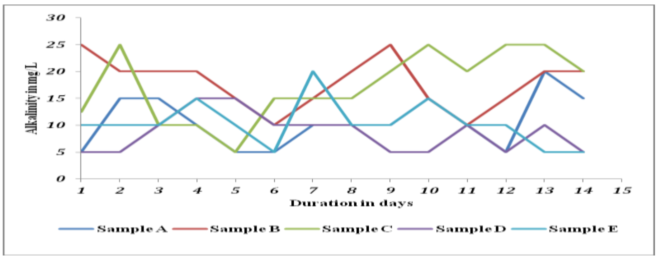

Figure 3.7. Variation of alkalinity during the degradation of kitchen waste

EXPERIMENTAL STUDY 2

This experimental study was carried out to assess the quantity of biogas generated under the optimized condition. The reactors performance was assessed in terms of volume of bio gas generated. The bio gas generated was measured by means of water displacement method. A 6.9 liter distilled water bottle was used as a batch reactor. Out of the five liter, 2.5 ml was kept as working volume in which both the substrate and cow dung was filled. The mix proportion of cow dung and the substrate was kept as the same as determined in the previous experimental study. The remaining volume was kept free as such as gas collecting chamber and used to collect the biogas generated. The collected bio gas was sent to the reactor nearby it containing water through the nozzle provided at the top and through the pipe. The volume of passed gas displaces the equal volume of the water in the reactor nearby. The displaced volume of water was collected in another reactor and the same was quantified. This set of batch study was carried out for 21 days. During this period of observation the volume of biogas generated daily was observed and the same was tabulated in table 3.9.

Table 3.9. Volume of biogas generated during the degradation of kitchen waste

S No	Date	Volume of Bio gas in ml
1	16.03.2015	0
2	17.03.2015	110
3	18.03.2015	430
4	19.03.2015	680
5	20.03.2015	1125
6	23.03.2015	2360
7	24.03.2015	1300
8	25.03.2015	1440
9	26.03.2015	1505
10	27.03.2015	1530
11	30.03.2015	2590
12	31.03.2015	1620
13	01.03.2015	1580
14	06.03.2015	4580
		20850

The variation of biogas generated during the anaerobic degradation of kitchen waste was plotted in an ordinary graph with duration of observation along X-axis and volume of biogas along Y-axis and the same was shown in fig 3.8

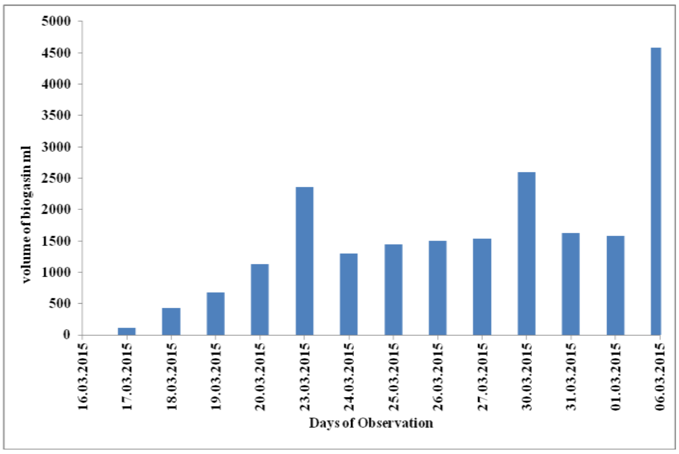

Figure 3.8. Volume of biogas generated during the degradation of kitchen waste

ANALYSIS

Net weight of LPG cylinder = 14.2 kg

1 kg of LPG = 2 liters of LPG

Hence the volume of LPG in cylinder = 28.4 liters = 0.0284 m^3

1m^3 of LPG gives 26.1 kWh of energy
0.0284 m^3 of LPG gives , 0.0284 x 26.1 = 0.7308 kWh of energy
= 2630.88 kWs of energy
= 2.63 J of energy (1000 kWs = 1 Joule)
1m^3 of biogas = 6 kWh of energy
When the same volume of cylinder is filled with biogas,

Then, 0.0264 m^3 of biogas gives, 0.0284 x 6 = 0.1704 kWh of energy
= 613.44 kWs of energy
= 0.61344 J
From the above analysis it is clear that 4 cylinder filled with biogas is equal to 1 cylinder filled with LPG.

4. CONCLUSION

In order to depict the actual scenario of biogas generation from kitchen waste a continuous flow mode study is necessary. From experimental study 1 it may be concluded that the mix proportion of 25% food waste as substrate and 75% cow dung as inoculum may be used as best proportion for bio gas generation. From 2.5 l of food waste with 75% cow dung , the amount of biogas generated can be used to replace the three-fourth volume of LPG cylinder. Since the variation of HRT and SRT affects the biogas generation during anaerobic process these effect have also to be taken care of to depict the actual scenario of bio gas generation

REFERENCES

[1] A. Apte, V. Cheernam, M. Kamat, S. Kamat, P. Kashikar, and H. Jeswani, Potential of Using Kitchen Waste in a Biogas Plant International Journal of Environmental Science and Development, Vol. 4, No. 4, August 2013.
[2] Alemayehu Gashaw, 2 Abile Teshita Co-Digestion of Ethiopian Food Waste with Cow Dung for Biogas Production International Journal of Research (IJR) Vol-1, Issue-7, August 2014 ISSN 2348-6848
[3] S.Mohan, K.Jagadeesan Production of Biogas by Using Food Waste International Journal of Engineering Research and Applications(IJERA)ISSN: 2248-9622 www.ijera.comVol. 3, Issue 4, Jul-Agu 2013, pp. 390-394
[4] Sunil MP, Ashik Narayan, Vidyasagar Bhat, Vinay S Smart Biogas Plant International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-3, Issue-3, August 2013
[5] Dupade Vikrant, Pawar Shekhar Generation of Biogas from Kitchen Waste -Experimental Analysis International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org Volume 2 Issue 10ǁ October. 2013 ǁ PP.15-19
[6] Vipul Vaid and Shivangi Garg Food as Fuel: Prospects of Biogas Generation from Food Waste International Journal of Agriculture and Food Science Technology (IJAFST) ISSN No. 2249-3050, Volume 4 No. 2 (2013)
[7] Ravi P. Agrahari, G. N. TiwariComparitive Study of Biogas Production: Utilization of Organic Waste International Journal of Environment and Resource (IJER) Volume 3 Issue 1, February2014.