Production and Analysis of Biogas from Kitchen Waste

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Abstract - *In Nehru College of Engineering and Research Centre, there are two canteens, and both having their own individual mess, where daily a large amount of kitchen waste is obtained which can be utilized for better purposes. Biogas production requires anaerobic digestion. This project is to create an Organic Processing Facility to create biogas which will be more cost effective, eco-friendly, cut down on landfill waste, generate a high quality renewable fuel, and reduce carbon dioxide and methane emissions. Overall by creating a biogas reactor on campus in the backyard of canteens will be beneficial. Kitchen (food) waste will be collected from two canteens of NCERC as feedstock for the reactor which works as anaerobic digester system to produce biogas energy. The anaerobic digestion of kitchen waste produces biogas, a valuable energy resource. Anaerobic digestion is a microbial process for production of biogas, which consists of primarily methane (CH_4) and carbon dioxide (CO_2). Biogas can be used as energy source and also for numerous purposes. But, any possible applications requires knowledge and information about the composition and quantity of constituents in the biogas produced. The continuously fed digester requires addition of sodium hydroxide (NaOH) to maintain the alkalinity and pH to 7. For this reactor, an Inoculum should be installed in batch reactors, to which inoculum of previous cow dung slurry along with the kitchen waste will be added to develop new Inoculum. A combination of these mixed inoculum will be used for biogas production at 37°C in laboratory (small scale) reactor (20L capacity). In this project, the production of biogas and methane can be done from the starch rich and sugary material. The rate of production can be determined at laboratory scale using the simple digesters.*

Key Words: Biogas; Anaerobic digestion; Kitchen waste

1. INTRODUCTION

Scarcity of petroleum and coal threatens the supply of fuel throughout the world also problem of their combustion leads to research in different corners to get access the new sources of energy, like renewable energy resources. Solar energy, wind energy, different thermal and hydro sources of energy, biogas are all renewable energy resources. But, biogas is distinct from other renewable energies because of its characteristics of using, controlling and collecting organic wastes and at the same time producing fertilizer and water for use in agricultural irrigation. Biogas does not have any geographical limitations nor does it requires advanced technology for producing energy, also it is very simple to use and apply.

Deforestation is a very big problem in developing countries like India, most of the part depends on charcoal and fuel wood for fuel supply which requires cutting of forest. Also deforestation leads to decrease the fertility of land by soil erosion. Use of dung, firewood as energy is also harmful for the health of the masses due to the smoke arising from them causing air pollution. We need an ecofriendly substitute for energy.

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 order 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.

Mankind can tackle this problem successfully with the help of methane, however till now we have not been 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 using low calorific inputs like cattle dung, distillery effluent, municipal solid waste (MSW) or sewage, in biogas plants, making methane generation highly inefficient. We can make this system extremely efficient by using kitchen waste or food wastes.

In 2003, Dr. Anand Karve (President ARTI) developed a compact biogas system that uses starchy or sugary feedstock material and the analysis shows that this new system is 800 times more efficient than conventional biogas plants

2. BIOGAS

2.1 Biogas

BIOGAS is produced by bacteria through the bio-degradation of organic material under anaerobic conditions. Natural generation of biogas is an important part of bio-geochemical carbon cycle. It can be used both in rural and urban areas

Table -1: composition of biogas

component	Concentration (by volume)
Methane (CH_4)	55- 60%
Carbon dioxide (CO_2)	35- 40%
Water (H_2O)	2- 7%
Hydrogen Sulphide (H_2S)	20- 20.000 ppm (2%)
Ammonia (NH_3)	0- 0.05%
Nitrogen (N)	0- 2%
Oxygen (O_2)	0- 2%
Hydrogen (H)	0- 1%

2.2 characteristics of biogas

Composition of biogas depends upon feed material also. Biogas is about 20% lighter than air has an ignition temperature in range of 650 to 750°C.An odorless and colorless gas that burns with blue flame similar to LPG gas. Its caloric value is 20 Mega Joules (MJ) /m3 and it usually burns with 60 % efficiency in a conventional biogas stove. This gas is useful as fuel to substitute firewood, cow-dung, petrol, LPG, diesel and electricity depending on the nature of the task and local supply conditions and constraints.

Biogas digester systems provides a residue organic waste, after its anaerobic digestion(AD) that has superior nutrient qualities over normal organic fertilizer, as it is in the form of ammonia and can be used as manure. Anaerobic biogas digesters also function as waste disposal systems, particularly for human wastes and can prevent potential sources of environmental contamination and the spread of pathogens and disease causing bacteria. Biogas technology is particularly valuable in agricultural residual treatment of animal excreta and kitchen refuse (residuals).

2.3 Properties of Biogas

1. Change in volume as a function of temperature and pressure.

2. Change in calorific value as function of temperature, pressure and water vapor content.

3. Change in water vapor as a function of temperature and pressure.

3. Literature Review

Shalini singh et al.[1] (2000) studied the increased biogas production using microbial stimulants. They studied the effect of microbial stimulant aquasan and teresan on biogas yield from cattle dung and combined residue of cattle dung and kitchen waste respectively. The result shows that dual addition of aquasan to cattle dung on day 1 and day 15 increased the gas production by 55% over unamended cattle dung and addition of teresan to cattle dung : kitchen waste (1:1) mixed residue 15% increased gas production.

ARTI – Appropriate Rural Technology Of India, Pune (2003) has developed a compact biogas plant which uses the waste food rather than any cow dung as feedstock, to supply biogas for cooking. The biogas plant is sufficiently compact to be used by urban households, and about 2000 are currently in use both in urban and rural households in Maharashtra. The design and development of this simple, yet powerful technology for the people, has won ARTI the Ashden Award for sustainable Energy 2006 in the Food Security category. 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 500g of methane, and the reaction is completed with 24 hours. The conventional biogas systems, using cattle dung, sewerage, etc. use about 40 kg feedstock to produce the same quantity of methane, and require about 40 days to complete the reaction. Thus, from the point of view of conversion of feedstock into methane, 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.

Lissens et al.[3] (2004) completed a study on a Biogas Operation to increase the total biogas yield from 50% available biogas to 90% using several treatments including a mesophilic laboratory scale continuously stirred tank reactor, and an up flow biofilm reactor, a fiber liquefaction reactor releasing the bacteria Fibrobacter Succinogens and a system that adds water during the process. These methods were sufficient in bringing about large increases to the total yield; however, the study was under a very controlled method, which leaves room for error when used under varying conditions.

Hilkiah Igoni[4] (2008) studied the effect of Total Solids Concentration of Municipal Solid Waste on the Biogas Produced in an Anaerobic Continuous Digester. The total solids (TS) concentration of the waste influences the pH, temperature and effectiveness of the microorganisms in the decomposition process. They investigated various concentrations of the TS of MSW in an anaerobic continuously stirred tank reactor (CSTR) and the corresponding amounts of biogas produced, in order to determine conditions for optimum gas production. The results show that when the percentage total solids (PTS) of municipal solid waste in an anaerobic continuous digestions process increases, there is a corresponding geometric increase for biogas produced.

A.Malakahmad et al.[5] (2009) constructed Anaerobic Biogas Reactor with a unique design and various profiles of microbial communities were developed within the reactor. Observations of microorganisms showed that, there exists a small amount of protozoa and fungi in the system, but almost 93% of microorganisms populations consists of bacteria. Due to the ability of activity in acetate environment, the percentage of Methanococcus Methanosarcina and Methanotrix were higher than other kinds of methane formers in the anaerobic baffled reactor (ABR).

Peter Wieland[6] (2010) reviewed the Current State And Perspectives Of Biogas Production, including the biochemical parameters and feedstock which influence the efficiency and reliability of the microbial conversion and gas yield.

S. Potivichayanon et al.[7] (2011) presented a paper on Enhancement of Biogas Production From Bakery Waste By The Addition Of Pseudomonas Aeruginosa. The by-product, Glycerol is very much suitable for the growth anaerobic microorganisms. The initial addition of Pseudomonas aeruginosa increased the biogas production in form of methane and carbon dioxide.

Ravi P Agrahari and G N Tiwari[8] (2013) compared different ratios of Kitchen Waste Under Aluminium Made Biogas Plant. Aluminium is also better alternative on the basis of biogas production and also safe for the environment because it can easily be disintegrated by microorganisms but plastic creates a lot of environmental problem due to its non-biodegradable nature. Black painted aluminium made biogas plant will be the best alternative under community level biogas production from kitchen waste.

Cunsheng Zhang et al.[9] (2014) formed A Buffer System By Volatile Fatty Acids and Ammonia, resulting in higher methane yield and system stability. Co-digestion of food waste with other substances such as waste water could enhance the biodegradation of long chain fatty acids.

4. PRODUCTION PROCESS

4.1 Biogas System

A typical biogas system consists of the following components:

1. Manure collection

2. Anaerobic digester

3. Effluent storage

4. Gas handling

5. Gas use

Biogas is a renewable form of energy. Methanogens (methane producing bacteria) are last link in a chain of microorganisms which degrade organic material and returns product of decomposition to the environment.

4.2 Principles of Biogas Production

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), and 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:

i. Aerobic digestion.
ii. Anaerobic digestion.

The digestion process occurring in presence of Oxygen is called Aerobic digestion and produces mixtures of gases having carbon dioxide (CO2), one of the main "green houses" responsible for global warming.

The digestion process occurring without (absence) oxygen is called An

`aerobic digestion which generates mixtures of gases. The gas produced which is mainly methane produces 5200-5800 KJ/m3 which when burned at normal room temperature and presents a viable environmentally friendly energy source to replace fossil fuels (non-renewable).

5. ANAEROBIC DIGESTION

It is also referred to as biomethanization, is a natural process that takes place in absence of air (oxygen). It involves biochemical decomposition of complex organic material by various biochemical processes with release of energy rich biogas and production of nutrious effluents. The three important biological process (microbiology) are,

Hydrolysis

In the first step the organic matter is enzymolysed externally by extracellular enzymes, cellulose, amylase, protease & lipase, of microorganisms. Bacteria decompose long chains of complex carbohydrates, proteins, & lipids into small chains. For example, Polysaccharides are converted into monosaccharide. Proteins are split into peptides and amino acids.

Acidification

Acid-producing bacteria involved in this step, convert the intermediates of fermenting bacteria into acetic acid, hydrogen and carbon dioxide. These bacteria are anaerobic and can grow under acidic conditions. To produce acetic acid, they need oxygen and carbon. For this, they use dissolved O_2 or bounded-oxygen. Hereby, the acid-producing bacterium creates anaerobic condition which is essential for the methane producing microorganisms. Also, they reduce the compounds with low molecular weights into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane. From a chemical point, this process is partially endergonic (i.e. only possible with energy input), since bacteria alone are not capable of sustaining that type of reaction.

Methanogenesis

(Methane formation) Methane-producing bacteria, which were involved in the third step, decompose compounds having low molecular weight. They utilize hydrogen, carbon dioxide and acetic acid to form methane and carbon dioxide. Under natural conditions, CH_4 producing microorganisms occur to the extent that anaerobic conditions are provided, e.g. under water (for example in marine sediments), and in marshes. They are basically anaerobic and very sensitive to environmental changes, if any occurs. The methanogenic bacterium belongs to the archaebacter genus, i.e. to a group of bacteria with heterogeneous morphology and lot of common biochemical and molecular-biological properties that distinguishes them from other bacteria. The main difference lies in the makeup of the bacteria's cell walls.

5.1 Benefits Of Biogas Technology

1. Production of energy.

2. Transformation of organic wastes to very high quality fertilizer.

3. Improvement of hygienic conditions through reduction of pathogens.

4. Environmental advantages through protection of soil, water, air etc.

5. Micro-economical benefits by energy and fertilizer substitutes.

6. Macro-economical benefits through decentralizes energy generation and environmental.

6. PROJECT DESCRIPTION

6.1 Project Objectives

1) Optimization of gas production

2) Comparison with conventional plants

3) Effect of different parameters like

i) Temperature

ii) PH

iii) Total & volatile solid concentration

iv) Alkalinity

v) C: N Ratio

4) To increase the production by using

i) Additives

ii) Nutrients

iii) Nitrogen source

5) Check optimization of gas production at lab scale and field scale.

7. METHODS AND CALCULATIONS

7.1 Analytical Methods & Calculations

1) Total Solids (Ts %)- It is the amount of solid present in the sample after the water present in it is evaporised.

The sample, approximately 10 gm. is taken and poured in foil plate and dried to a constant weight at about 105^{0}C in furnace.

TS % = (Final weight/Initial weight) * …….. (i)

2) Volatile Solids (Vs %) – Dried residue from Total Solid analysis weighed and heated in crucible for 2hrs at 500 0C in furnace. After cooling crucible residue weighed.

$$VS\ \% = [100-(V3-V1/V2-V1)] * 100 \quad \text{........ (ii)}$$

V1= Weight of crucible.

V2= Weight of dry residue & crucible.

V3= Weight of ash & crucible (after cooling)

3) Volatile Fatty Acid (VFA) - Volatile fatty acids (VFA's) are fatty acids with carbon chain of six carbons or fewer. They can be created through fermentation in the intestine. Examples include: acetate, propionate, and butyrate. There are many titration method for VFA measurement. Here two methods are used for VFA measurement

Method 1

1. Take 100 ml sample in beaker

2. Filter the sample

. 3. Check pH of filtrate.

4. Take 20 ml of filtrate and add 0.1M HCl until pH reaches 4

5. Heat in the hot plate for 3 mins

6. After cooling titrate with 0.01M NaOH to take pH from 4 to 7.

7. Amount of HCl & NaOH recorded

Total VFA content in mg/l acetic acid = (Volume of NaOH titrated) * 87.5 ... (iii)

Method 2:

Titration procedure for measurements of VFA and alkalinity according to Kapp :

i)Before analysis, the sample needs to be filtered through a 0.45μm membrane filter.

ii) Filtered sample (20-50ml) is put into a titration vessel, the size of which is determined by the basic requirement to guarantee that the tip of the pH electrode is always below the liquid surface.

iii) Initial pH is recorded

iv) The sample is titrated slowly with 0.1N sulphuric acid until pH 5.0 is reached. The added volume A_1 [ml] of the titrant is recorded.

v) More acid is slowly added until pH 4.3 is reached. The volume A_2 [ml] of the added titrant is again recorded.

vi) The latter step is repeated until pH 4. 0 is reached, and the volume A_3 [ml] of added titrant recorded once more.

vii) A constant mixing of sample and added titrant is required right from the start to minimize exchange with the atmosphere during titration.

viii) Calculation scheme according to Kapp:

$$Alk = A * N * 1000/SV \quad \text{...... (iv)}$$

Alk = Alkalinity [mmol/l], also referred to as TIC (Total Inorganic Carbon).

A = Consumption of Sulphuric acid (H_2SO_4, 0.1N) to titrate from initial pH to pH 4.3 [ml]. $A = A_1 + A_2$ [ml].

N = Normality [mmol/l].

SV = Initial sample volume [ml].

$$VFA = (131340 * N * B / 20) - (3.08 * Alk) - 10.09$$

VFA = Volatile fatty acids [mg/l acetic acid equivalents].

N = Normality [mmol/l]

B = Consumption of sulphuric acid (H_2SO_4, 0.1N) to titrate sample from pH 5.0

to pH 4.0 [ml], due to HCO_3/CO_2 buffer. $B = A_2 + A_3$ [ml]

SV = Initial sample volume [ml]

Alk = Alkalinity [mmol/l]

4) A/TIC-ratio

The A/TIC-method was developed at the Federal Research Institute for Agriculture (FAL) in Braunschweig, Germany. Used as an indicator of the process stability inside the digester, it expresses the ratio between Volatile Fatty Acids and buffer capacity (alkalinity), or in other words the amount of Acids (A) compared to Total Inorganic Carbon (TIC).

A [mg/ l] = VFA [mg/ l] /TIC [mg/l] = Alkalinity [mg/ l]

5) Organic Content – Organic dry matter weigh the sample and weigh remaining ashes Organic content = {Mass of TS - Mass of ashes}/Mass of TS

8. EXPERIMENTS

8.1 Experiment 1

- A 2 liter bottle
- 50 gm kitchen waste + cow dung
- Rest water (1.5 liter)

Result- Gas production was found but not measured.

8.2 Experiment 2

Different sets of 1 litre & 2 litres bottles.

3 different sets with different composition are installed as below.

1. 200gm cow dung was mixed with water to make 1lit slurry which is poured in 1lit bottle.

2. 50gm grinded kitchen was mixed with 150gm cow dung and water is added to make 1lit solution which is poured in 1lit bottle.

3. 400gm cow dung was mixed with water to make 2lit slurry which is poured in 2lit bottle.

Results:

In all of the 3 sets gas production occurs and gas burned with blue flame. process continues, volatile fatty acids(VFA) are produced which causes the decrease in PH of solution.

8.3 Composition of Biogas in NCERC College Canteen

Average composition of kitchen waste was analyzed on various occasions. Over 50 % of waste was composed of uncooked vegetable & fruit waste. Eggs, raw meat, the main source of pathogens were relatively low in mass at 1.5% & 1.2% also about 15% of cooked meat was there.

(A) Uncooked fruits & vegetables (51%)

(B) Cooked meat (16%)

(C) Uncooked meat (15%)

(D) Bread (2%)

(E) Tea waste (5%)

(F) Eggs (6%)

(G) Cheese (3%)

8.4 Discussions

From the result it has been seen that in set2 which contain kitchen waste produces more gas, compare to other two set. In set2 with kitchen waste produces average 250.69% more gas than set 1 (with 200gm cow dung) and 67.5% more gas than set 3 (with 400gm cow dung). Means kitchen waste produces more gas than cow dung as kitchen waste contains more nutrient than dung. So use of kitchen waste provide more efficient method of biogas production.

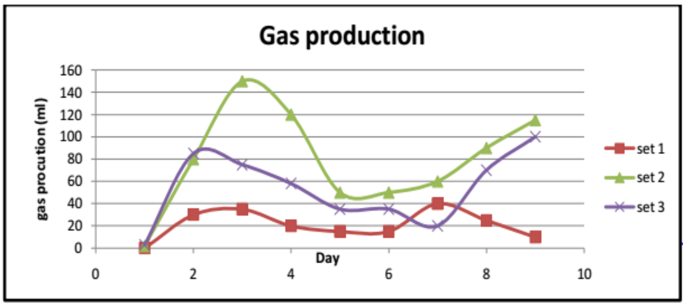
Table- 2: Biogas Production in ml

Set No/ day	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	avg
1	30	35	20	10	-	40	20	10	23.75
2	80	150	120	50	-	60	90	115	89.37
3	85	75	58	35	-	20	70	100	60.02

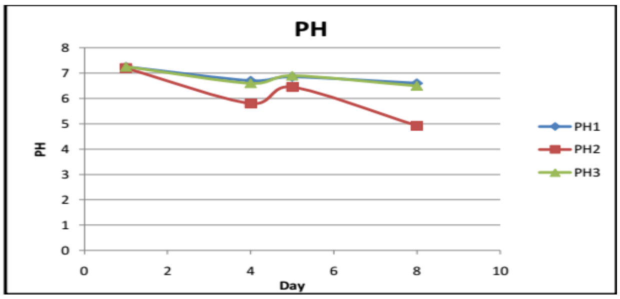
From results it has been seen that pH reduces as the process going on as the bacteria produces fatty acids. Here methanogens bacteria which utilize the fatty acids, is slow reaction compare to other so it is rate limiting step in reaction. In set2 which contains kitchen waste pH decreases highly means reaction is fast, means hydrolysis and acidogenesis reaction is fast as organism utilize the waste more speedily than dung. And total solid decreases more in set2.

Table- 3: pH and total solid concentration of setup

Day	Set 1		Set 2		Set 3	
	pH	TS%	pH	TS%	pH	TS%
1	7.25	8	7.2	6	7.25	8
4	6.7	7.6	5.8	5.4	6.6	7.5
5	6.85	7.6	6.45	5.4	6.9	7.5
8	6.65	7	4.92	4.7	6.5	7



Graph Analysis- It can be seen from the graph that gas production increases first up to day 3 but then it starts decreasing as acid concentration increases in the bottles and pH decreases below 7 after 4-5 days water was added to dilute which increases the pH, gas production again starts increasing. Therefore, we can infer that acid concentration greatly affects the biogas production.



GRAPH – This graph shows that first the ph is on higher side, as reaction inside the bottles continues it stars decreasing and after day 3 it becomes acidic. Then water added to dilute and thus pH increases.

9. PLAN OF BIODIGESTER

No	Product name
1	20 litre container (used for drinking water storage)
2	Solid tape
3	M- Seal
4	PVC pipe 0.5” (length ~ 1m)
5	Rubber or plastic cape (To seal container)
6	Funnel for feed input
7	Cape 0.5” (To seal effluent pipe)
8	Pipe (gas output, 3- 5m)
9	Bike tyre tube for gas collection

10. PROCEDURE AND START UP

10.1 Experiment 3(N)

Fresh cow dung was collected and mixed with water thoroughly by hand and poured into 20 lit. digester. Content of previous experiment was used as inoculum. As it contains the required microorganism for anaerobic digestion. After the inoculation digester was kept for some days and gas production was checked. After some days kitchen waste was added for checking gas production.

10.2 Experiment 4 (O)

This digester contains the following composition.

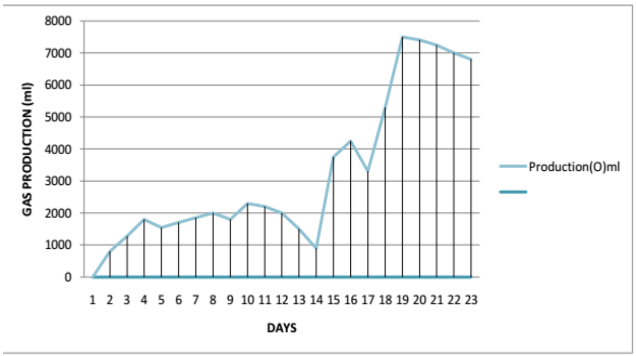
- 20lit digester.
- Cow dung + inoculum + water added.

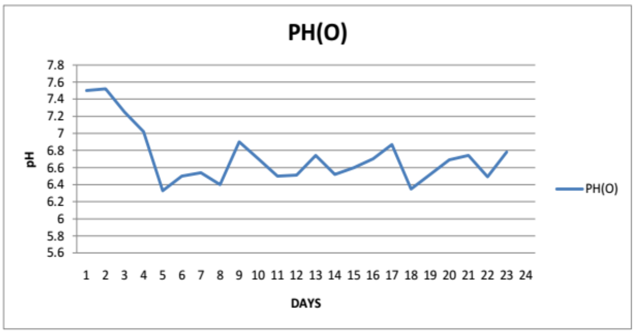
- Cow dung – 2.5 lit
- Inoculum - 3.8 lit
- Water – 13.5lit
- PH – 5.02
- NaOH & $NaHCO_3$ added to increase/adjust pH.

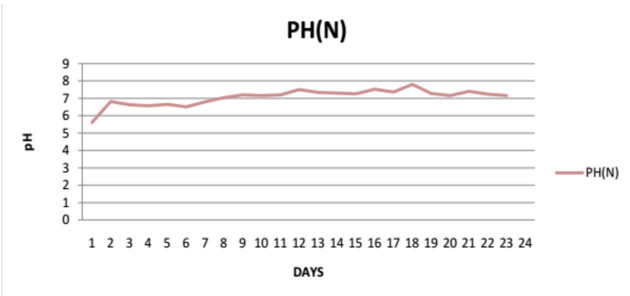
10.3 RESULTS

Table-4: Daily PH And Gas Production

Day	PH(O)	PH(N)	Gas(O)ml	Gas(N)ml
1	7.5	5.6	-	-
2	7.52	6.82	800	-
3	7.25	6.63	1280	-
4	7.02	6.57	1800	400
5	6.33	6.66	1550	300
6	6.5	6.5	1700	550
7	6.55	6.8	1850	3200
8	6.4	7.03	2000	6500
9	6.9	7.2	1800	6500
10	6.7	7.16	2300	8500
11	6.51	7.2	2200	10400
12	6.74	7.51	2000	12850
13	6.66	7.34	1550	12700
14	6.67	7.3	950	7400
15	6.7	7.26	3750	8500
16	6.87	7.52	4250	9000
17	6.35	7.36	3300	8000
18	6.52	7.8	5350	7700
19	6.7	7.28	7550	9400
20	6.36.745	7.16	7400	10450
21	6.5	7.4	7250	11600
22	6.8	7.24	7000	11500
23	6.8	7.16	6800	10000







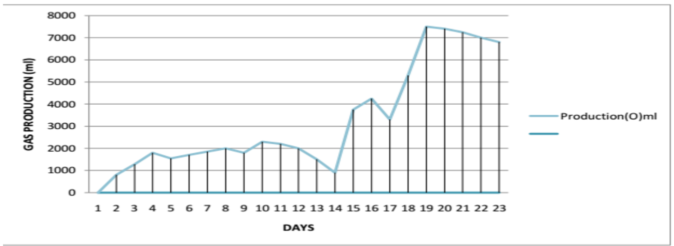


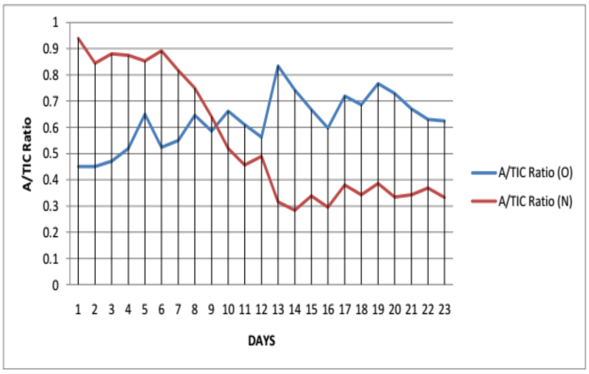
Table-5: daily VFA and gas production

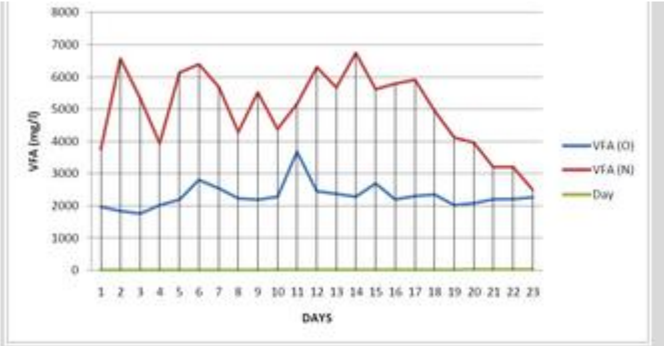
Days	VFA(O)mg/l	VFA(N)mg/l	Gas(O)ml	Gas(N)ml
1	1968	3762.5	-	-
2	1837.5	6562	800	-
3	1750	5337	1280	-
4	2012.5	3939	1800	400

5	2187.5	6125	1550	300
6	2800	6387	1700	550
7	2537.5	5687	1850	3200
8	2231.5	4287.5	2000	6500
9	2187.5	5512.5	1800	6500
10	2275	4285	2300	8500
11	3675	5162	2200	10400
12	2450	6300	2000	12850
13	2370	6562.5	1550	12700
14	2281	6743	950	7400
15	2685	5612	3750	8500
16	2194	5783	4250	9000
17	2300	5907	3300	8000
18	2350	4956	5350	7700
19	2012.5	4112.5	7550	9400
20	2080	3953	7400	10450
21	2199	3200	7250	11600
22	2208	3200	7000	11500
23	2259	2500	6800	10000

Table-6: Daily A/TIC Ratio

Days	A/TIC(O)	A/TIC(N)	Cow dung(O)gm	Kitchen waste(N)gm
1	0.45	0.94	-	-
2	0.45	0.845	20	-
3	0.475	0.88	-	-
4	0.54	0.874	20	-
5	0.65	0.853	-	-
6	0.524	0.892	20	20
7	0.55	0.817	-	-
8	0.646	0.76	20	20
9	0.586	0.64	-	-
10	0.662	0.524	20	20
11	0.61	0.456	-	-
12	0.563	0.49	-	-
13	0.834	0.315	-	-
14	0.743	0.284	30	30
15	0.668	0.339	-	-
16	0.597	0.295	20	20
17	0.74	0.39	-	-
18	0.687	0.346	30	30
19	0.767	0.386	-	-
20	0.73	0.334	30	30
21	0.67	0.343	-	-
22	0.63	0.369	30	30
23	0.652	0.333	-	-





11. CASE STUDY

Table -7: LPG Consumption

Sl No	canteen	LPG consumption/month
1	Nala	1413 kg
2	Nala 2	1460.1 kg

12. ANALYSIS

Calorific value of Biogas = 6 kWh/m3

Calorific value of LPG = 26.1 kWh/m3

Let us assume we need to boil water sample of 100 gm

We have Energy required to boil 100 gm water = 259.59 Kj

Hence, we need Biogas to boil 100 gm water = 12.018 lit

And, we need LPG to boil 100 gm water = 2.76 lit.

Therefore, amount of water which can be boiled using this much Biogas = 5.408 lit/day Now, amount of LPG required to boil 5.408 lit of water per day = 149.26 lit So We can save up to 10 cylinders of LPG per day.

13. ANALYSIS 2

Let us use the Biogas produced in our plant for Breakfast & evening snacks (1 hr in morning and 1 hr in the evening)

650 lit if used for 2 hrs gives = 66.46 * 103 J /day

Let V be the amount of LPG used to produce same amount of energy

Hence, we get, V = 2827.56 lit i.e. Mass (m) of LPG = 6.079 kg

Therefore per month consumption of LPG = 182.38 kg which is equivalent to 12.84 cylinders

Result: - We can save abound 13 cylinders of LPG if Biogas from 1000 lit tank is used for 2 hours daily.

14. ANALYSIS 3

Comparison of my biogas digester with conventional

Biogas systems are those that take organic material (feedstock) into an air-tight tank, where bacteria break down the material and release biogas, a mixture of mainly methane with some carbon dioxide. The biogas can be burned as a fuel, for cooking or other purposes, and the solid residue can be used as organic compost. Through this compact system, it has been demonstrated that by using feedstock having high calorific and nutritive value to microbes, the efficiency of methane generation can be increased by several orders of magnitude. It is an extremely user friendly system.

Table -8: Comparison of conventional biogas system with kitchen waste biogas system

Comparison with conventional bio-gas plants	Conventional bio-gas system	Kitchen waste bio-gas system
Amount of feedstock	40kg + 40 ltr water	1.5-2kg + water
Nature of feedstock	cow dung	Starchy and sugary material

Amount and nature of slurry to be disposed	80 ltr, sludge	12 ltr, watery
Reaction time for full utilization of feedstock	40 days	52 hours
Standard size to be installed	4000 ltrs	1000 ltrs

In a kitchen waste biogas system, a feed of kitchen waste sample produces methane, and the reaction is completed in 52 hours. Conventional bio-gas systems use cattle dung and 40kg feedstock is required to produce same quantity of methane.

15. CONCLUSIONS

From my experiment I am able to produce around 10 lit of biogas daily in a 20 lit reactor (digester).

According to our purpose of our project we were trying to design reactors of 1000 lit for each and every canteen in NCERC, Pampady. (at the backyard of the mess, using kitchen waste directly as a feedstock)

Hence I can conclude that we can produce 650 lit of biogas daily in 1000 lit reactor, under ideal conditions (like maintaining pH , VFA , Alkalinity, etc.).

ACKNOWLEDGEMENT

It is a great pleasure for me to acknowledge all those who have assisted and supported me to lead my thesis to success. First of all, I would like to thank GOD Almighty for blessing me with his grace and taking my endeavor to a successful culmination. I submit this thesis work at the lotus feet of Beloved Late Dr. P. K. Das, Founder Chairman, Nehru College of Educational Institutions and Charitable Trust, Kuniamuthur, Coimbatore and seek his blessings. I am extremely thankful to Adv. Dr. P. Krishnadas, present managing trustee for all helps extended to me. I express my sincere thanks to Prof. Dr. P. N. Ramachandran, Director (R & D) and HoD of Electrical and Electronics Engineering of our institute for giving me proper directions and approving this thesis. I am very much grateful to Dr. A.S. Varadarajan, Principal of Nehru College of Engineering and Research Centre for giving me the opportunity to undertake this thesis and supporting me all along. I also thank Dr. N. K. Sakthivel, Vice- Principal of Nehru College of Engineering and Research Centre for his constant encouragement. I extend my sincere gratitude towards my guide and Class Advisor Mr. Rajesh P, Asst. Professor, Nehru College of Engineering and Research Centre, who gave me immense support and knowledge for completing this thesis on time. And also I would like to thank all my staffs and faculty members for the help they have extended. I finally thank my parents, family members and friends for their moral support.

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