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Purification of Biogas

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Abstract: The following paper describes production of biogas and purification of biogas. We have performed experimentation on biogas production. The raw material used for biogas production are kitchen wastes. The paper describes the anaerobic digestion process used for biogas production. This paper describes the properties the properties of biogas like colorless odorless, etc. and advantages and disadvantages. Biogas has numerous purposes and also can be as an energy source. Biogas involves different components of gasses like Methane, Carbon Dioxide, Hydrogen Sulphide, and moisture content. Purification biogas means removal of Carbon Dioxide, Hydrogen Sulphide, and moisture content.

Keywords: Biogas purification, Biogas processing, Biogas production.

I INTRODUCTION

BIOGAS is produced by bacteria through the bio-degradation of organic material under anaerobic conditions. Natural generation of biogas is an important part of biogeochemical carbon cycle. It can be used both in rural and urban areas. Due to the scarcity of petroleum and coal, it threatens 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, due to deforestation, It leads to decrease the fertility of land by soil erosion. Use of dung, firewood as energy is also harmful to the health of the masses due to the smoke arising from them causing air pollution. We need an eco-friendly substitute for energy. Kitchen waste is an organic material having the high calorific value and nutritive value to microbes, that’s why the efficiency of methane production can be increased by several order of magnitude as said earlier. 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 a 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 & methane which is a major greenhouse gas contributing to global warming. Mankind can tackle this problem(threat) successfully with the help of methane, however till now we have not been benefited, because of ignorance of basic sciences – like the output of work is dependent on the energy available for doing that work.

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 %

II COMPONETS AND PRODUCTION PROCESS

A typical biogas system consists of the following components:
(1) Manure collection
(2) Anaerobic digester
(3) Effluent storage
(4) Gas handling
(5) Gas use.

Biological Process (Microbiology)
1. Hydrolysis
2. Acidification

1. Hydrolysis
In the first step, the organic matter is enzyme lysed 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.

2. Acidification
Acid-producing bacteria, involved 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 bacteria creates an 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.

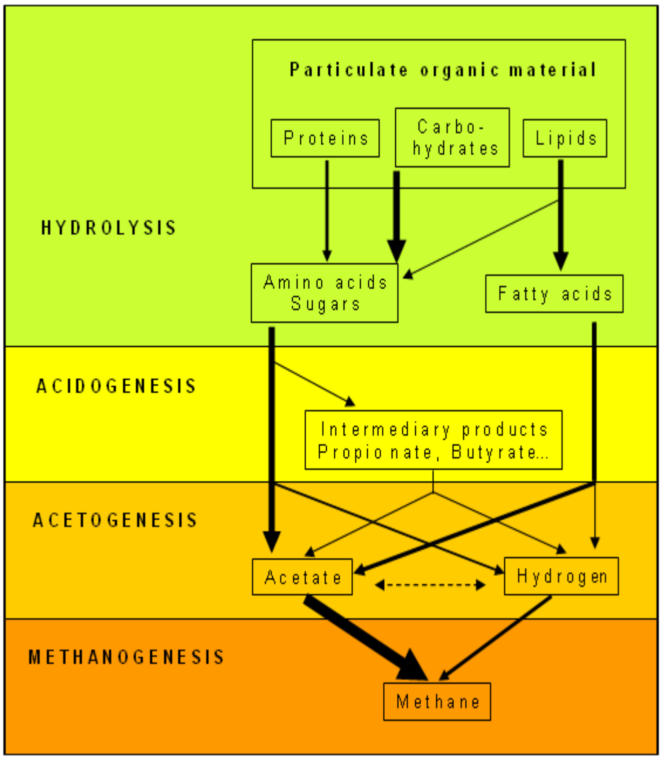

Fig 1 Flow chart for biodegradation

III DESIGN OF MODEL

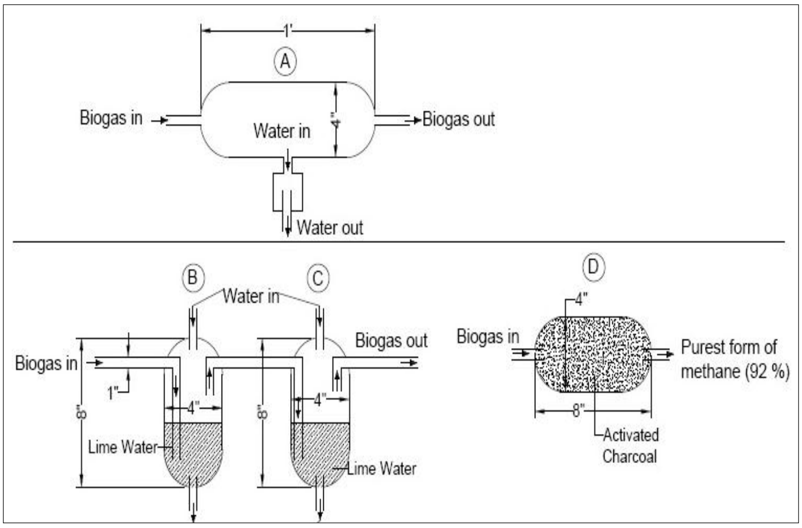

Fig 2 Design of Purification of Biogas

Table 2 PARTLIST

Sr. No.	Part Name	Qty.
1	Cylinders(30 cm)	4
2	Wooden Sqare(4*3)	1
3	Flexible Pipe(1/3 inch) (15 m)	1
4	T-Valve (1/3 inch)	4
5	PVC pipe(1/3 inch)	1
6	Burner	1

3.2 PRECAUTIONS WHILE COLLECTING SAMPLE

3.2.1 Kitchen Waste

1. A separate container for coconut shells, egg shells, peels and chicken mutton bones. These will be crushed separately by mixer grinders.
2. Different containers of volumes 5l to collect the wet waste, stale cooked food, waste milk products. The vegetables refuse like peels, rotten potatoes coriander leaves collected in bags.

3.2.2 Installations

An important aspect in the smoother running of the plant by avoiding the choking of the plant. This occurs due to thick biological waste that not reaches to the microorganisms to digest. The easy answer to this problem is to convert solid wastes into liquid slurry .mixer can be used to convert solid into a slurry.

3.3 Analysis of GAS produced in our reactor

Syringe Method

Syringe method was used for the measurement of the amount of methane and carbon dioxide in our gas produced. A syringe fitted with a flexible tube and dilute sodium hydroxide (NaOH) solution was used for carbon dioxide percentage estimation since NaOH absorbs CO2 but does not absorb methane.

3.4 Composition of Biogas Observed As

Methane (50 - 65%)
Carbon dioxide (30 - 40%)
Nitrogen (2 - 3%)
Water vapors (0.5%)

3.5 ANALYTICAL METHODS & CALCULATIONS

TOTAL SOLIDS (TS %) - It is the amount of solid present in the sample after the water present in it is evaporated. The sample, approximately 10 gm. is taken and poured in foil plate and dried to a constant weight at about 105 0C in the furnace.

TS % = (Final weight/Initial weight) * 100

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
5. Heat in the hot plate for 3 minutes
6. After cooling titrates 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

Method 2

Titration procedure for measurements of VFA and alkalinity according to Kapp

- Before analysis, the sample needs to be filtered through a 0.45µm membrane filter.
- 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.
- Initial pH is recorded
- The sample is titrated slowly with 0.1N sulphuric acid until pH 5.0 is reached. The added volume A1 [ml] of titrate is recorded.
- More acid is slowly added until pH 4.3 is reached. The volume A2 [ml] of the added titrate is again recorded.
- The latter step is repeated until pH 4. 0 is reached, and the volume A3 [ml] of added titrate recorded once more.
- A constant mixing of sample and added titrate is required right from the start to minimize exchange with the atmosphere during titration.

Calculation scheme according to Kapp

Alk = A * N * 1000 / SV

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= A1 + A2 [ml].
N = Normality [mmol/l].
SV = Initial sample volume [ml].

VFA = (131340 * N * B / 20) - (3.08 * Alk) – 10.9

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 = A2 + A3 [ml]
SV = Initial sample volume [ml]
Alk = Alkalinity [mmol/l]

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]

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

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

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

BIOGAS COMPOSITION

Biogas is constituted of different component gasses the majority of them being methane (CH_4), Carbon Dioxide (CO_2) with traces of Hydrogen Sulfide, and moisture. The composition of a typical biogas sample is given in the following table:

Table 3 Composition of Biogas

Constituent	% in Biogas
Methane (CH4)	50-70%
Carbon Dioxide (CO2)	30-40%
Hydrogen Sulfide (H2S)	Traces
Water Vapor (H2O)	0.3

Natural gas has 75-98% methane with small percentages of ethane, butane, propane whereas biogas contains about 60% methane and 40 % carbon dioxide. It is possible to improve the quality of biogas by enriching its methane content up to the natural gas. Methane is important constituent present in raw biogas and is combustible. Raw biogas contains so many impurities. Among which removal of carbon dioxide, hydrogen sulfide and moisture are important for upgrading biogas for vehicular application

IV EXPERIMENTS, TESTING & RESULTS

4.1 EXPERIMENT 1.

- 2-liter bottle
- 50 gm. kitchen waste + cow dung
- Rest water (1.5 liters)
- **Result**- Gas production was found but not measured.

4.2 EXPERIMENT 2

Different sets of 1 liter & 2 liters bottles. 3 different sets with different composition are installed as below.

1. 200gm cow dung was mixed with water to make a 1lit slurry which is poured in the 1lit bottle.
2. 50gm ground kitchen was mixed with 150gm cow dung and water is added to make a 1lit solution which is poured in the 1lit bottle.
3. 400gm cow dung was mixed with water to make a 2lit slurry which is poured in the 2lit bottle.

Results

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

4.3 COMPOSITION OF KITCHEN WASTE OF D.I.E.T. 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.

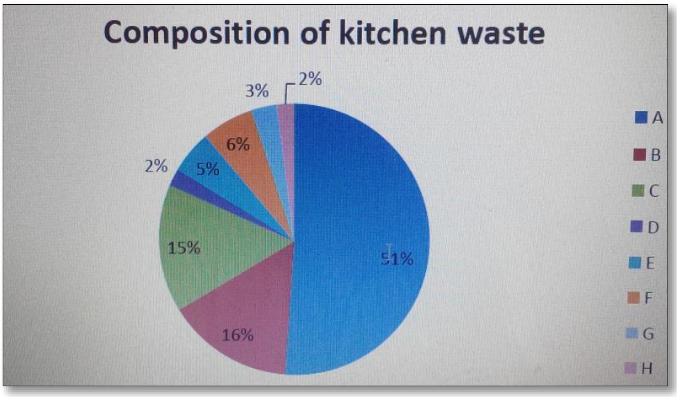

Fig. 3 Composition of kitchen waste

4.3.1 Composition of kitchen waste

1. Uncooked fruits & vegetables
2. Cooked meat
3. Uncooked meat
4. Bread
5. Teabags
6. Eggs

4.3.2 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 the use of kitchen waste provides more efficient method of biogas production.

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 the reaction. In set2 which contains kitchen waste pH decreases highly means the 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 4: Biogas production in ml

Set no./day	1st day	2nd	3rd	4th	5th	6th	7th	8th	average
1	30	35	20	10	-	40	25	10	23.75
2	80	150	120	50	-	60	90	115	89.37
3	85	75	58	35	-	20	70	100	60.02

kitchen waste pH decreases highly means the 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 5: 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

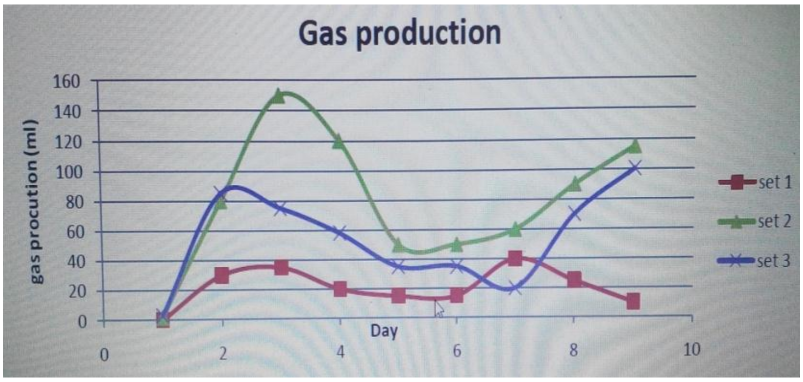

Fig. 4 Gas production V/s day for three sets

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 decrease 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.

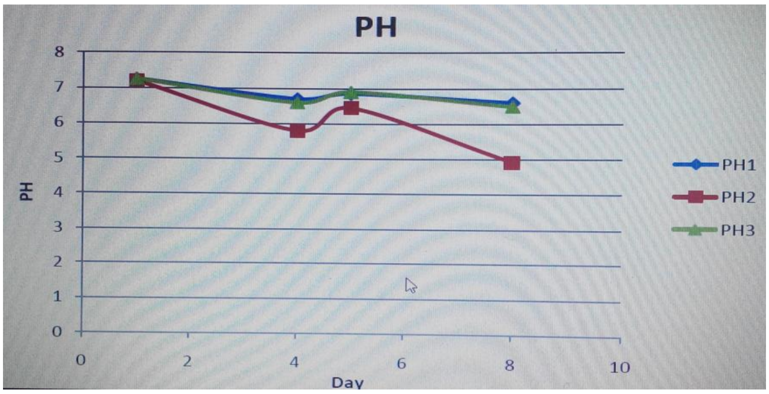

Fig.5 pH V/s day

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

EXPERIMENT 3(O)

This digester contains the following composition.

- 20lit digester.
- Kitchen waste +Sugar 100 gm + tea + water
- Water – 13.5lit
- PH – 5.02

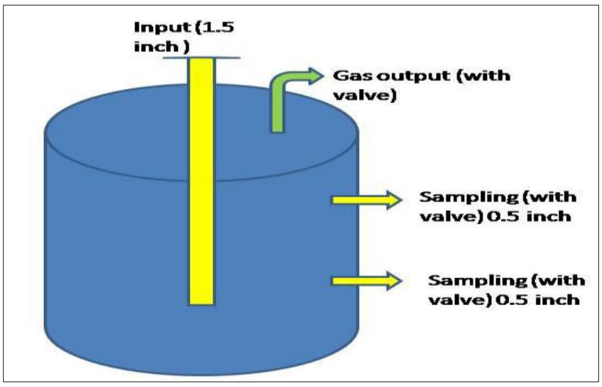

Fig. 6 Layout of experimental setup 3

4.4 RESULTS (for experiment 3)

TABLE 6: daily PH and gas production of digester 3

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	6.54	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	6.5	7.2	2200	10400
12	6.51	7.51	2000	12850
13	6.74	7.34	1500	12600
14	6.52	7.3	900	7600
15	6.6	7.26	3750	8500
16	6.7	7.52	4250	9000
17	6.87	7.36	3300	8000
18	6.35	7.8	5300	7600
19	6.52	7.28	7500	9400
20	6.69	7.16	7400	10650
21	6.74	7.4	7250	11500
22	6.49	7.24	7000	11500
23	6.78	7.16	6800	10900

CONCLUSION

In this paper we have discussed the generation of the biogas, the various methods to produce the biogas from the kitchen waste. The experimentation is also well analyzed and presented with the calculations and the actual results. The main objective of the paper is to give the various methods to produce biogas.

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