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The Production of Biogas Using Kitchen waste

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Abstract---Kitchen waste is the best alternative for biogas production in a University level Biogas Plant. It is produced when bacteria degrade organic matter in the absence of air. Biogas contains around 55-65% of methane, 30-40% carbon dioxide. The calorific value of biogas is appreciably high around 4700 Kcal**.** The biogas yields have been determined using batch anaerobic thermophilic digestion tests for a period of 90 days. Characteristic oscillation was observed in the rate of methane production, which may be due to the presence of methylotroph population in the activated sludge, which uses methane as a carbon source for their growth. The total biogas generated in the system over the experimental period was the sum of methane and carbon dioxide. The anaerobic digestion of kitchen waste produces biogas, a valuable energy resource anaerobic digestion is a microbial process for production of biogas, which consist of primarily methane (CH4) & carbon dioxide (CO2). Biogas can be used as energy source and also for numerous purposes. But, any possible applications require knowledge & 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 we have prepared our Inoculum than we installed batch reactors, to which inoculum of previous cow dung slurry along with the kitchen waste was added to develop our own Inoculum. A combination of this mixed inoculum was used for biogas production at 37°C in laboratory (small scale) reactor.

KEYWORDS: Biogas; Kitchen waste; anaerobic digestion, fermentation

1 INTRODUCTION

Due to scarcity of petroleum and coal it threatens supply of fuel throughout the world also problem of their combustion led 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 require advanced technology for producing energy, also it is very simple to use and apply.

Anaerobic digesters also function as a waste disposal system, particularly for human waste, and can, therefore, prevent potential sources of environmental contamination and the spread of pathogens. The biogas technology is particularly valuable in agricultural residual treatment of animal excrement and kitchen residual. The anaerobic reactor has a chamber where various chemical and microbiology reactions take place; it should be air and water tight. In recent year varied modifications technological have been introduced to diminish the costs for the biogas production. Methods have been developed to increase the speed of fermentation for the bacteria gas producers, the reduction of the size of the digester, the use of materials for their production but durable, the modification of the feeding materials to ferment and the exit of the effluent for their best employment, as well as compacter the equipment to produce gas in the small housings, among others. The equipment employed in housings was developed with success

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2 PRINCIPLES FOR PRODUCTION OF BIOGAS

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 Sulfur (S) to form variety of organic compounds such as carbohydrates, proteins & lipids. In nature MOs (microorganisms), through digestion process breaks the complex carbon into smaller substances. There are 2 types of digestion process:• Aerobic digestion. • Anaerobic digestion. 15 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 "greenhouse gases" responsible for global warming. The digestion process occurring without (absence) oxygen is called anaerobic 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).

2.1 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.

2.2 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 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.

2.3 COMPOSITION OF KITCHEN WASTE OF ANDHRA UNIVERSITY

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.

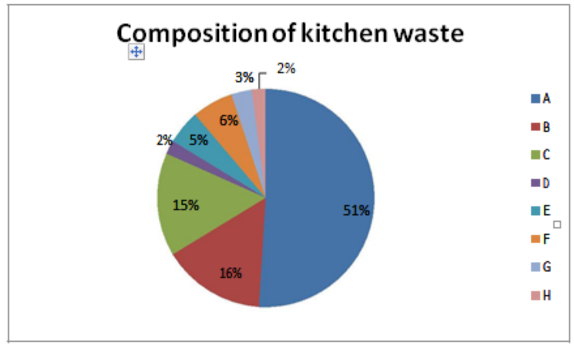


Fig. 2 Composition of kitchen waste

- Uncooked fruits & vegetables
- Cooked meat
- Uncooked meat
- Bread
- Teabags
- Eggs
- Cheese
- Paper

2.4 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 provides more efficient method of biogas production.

Table 3 : Biogas production in ml

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 acid genesis reaction is fast as organism utilize the waste more speedily than dung. And total solid decreases more in set2.

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

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

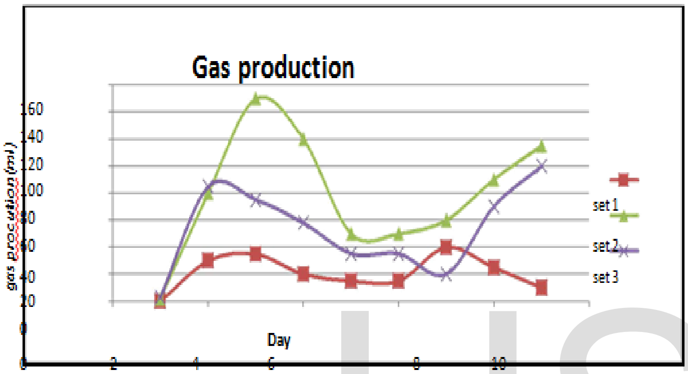


Fig. 3. Gas production V/s day for three sets

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 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.

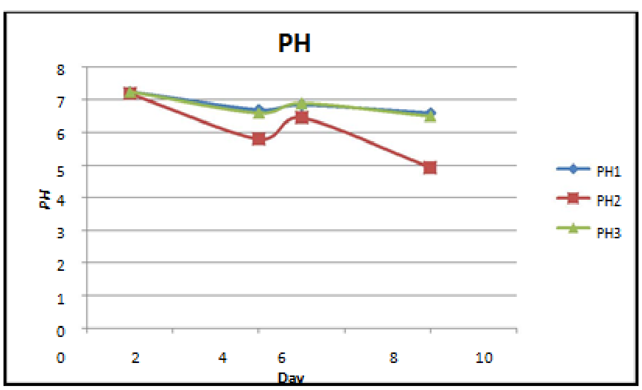
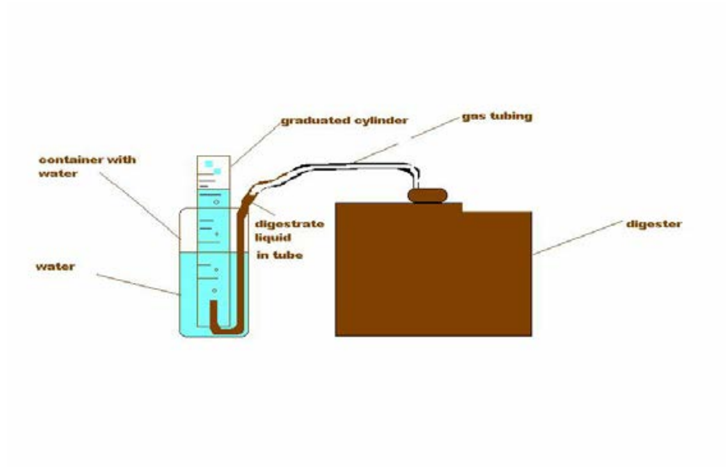


Fig.4. pH V/s day

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. Than water added to dilute and thus pH increases.

3 PLAN OF BIODIGESTOR



Both the digester was installed in environmental lab of biotechnology department. I used the 20 lit. Water container as digester. Following were the material used for 20 lit. Digester.

TABLE 5: List of materials used In Experiment No. 3

No.	Product Name
1	20 litre container (used for drinking water storage)
2	Solid tape
3	M – seal
4	PVC pipe 0.5'' (length ~ 1 m)
5	Rubber or plastic cape (to seal container)
6	Funnel (for feed input)
7	Cape 0.5'' (to seal effluent pipe)
8	Pipe (for gas output, I was used level pipe) (3-5 m)
9	Bucket (15-20 litter)
10	Bottle – for gas collection (2-10 lit.)

3.2 PROCEDURE AND START UP:

3.2.1 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.

3.2.2 EXPERIMENT 3(O):

This digester contains the following composition.

- Cow dung – 2.5 lit Inoculum - 3.8 lit
- Water – 13.5lit
- PH – 5.02
- NaOH& $NaHCO_3$ added to increase/adjust ph.
- 20lit digester.
- Cow dung + inoculum + water added.

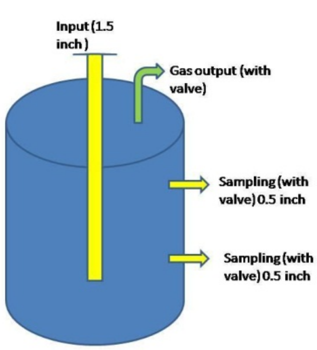


Fig. 6 Layout of experimental setup 3

3.3.3 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	600
5	6.33	6.66	1550	300
6	6.5	6.5	1700	550
7	6.54	6.8	1850	3200
8	6.6	7.05	2000	6500
9	6.9	7.2	1800	6500
10	6.7	7.16	2300	8500
11	6.5	7.2	2200	10600
12	6.51	7.51	2000	12850
13	6.74	7.34	1500	13600
14	6.52	7.3	900	7600
15	6.6	7.36	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	7.38	7500	9600
20	6.69	7.16	7600	10650
21	6.74	7.4	7250	11500
22	6.49	7.34	7000	11500
23	6.78	7.16	6800	10900

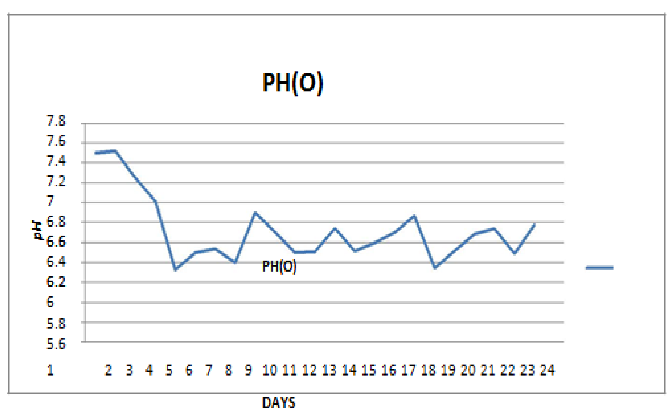


Fig. 7 Daily pH change of digester 3(O)

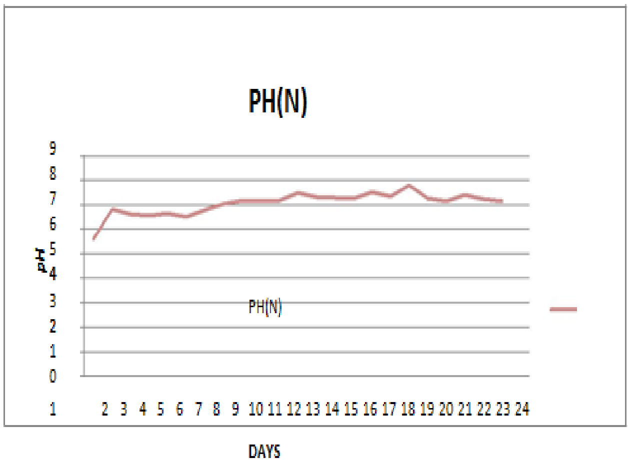


Fig. 8 Daily pH change of digester 3(N)

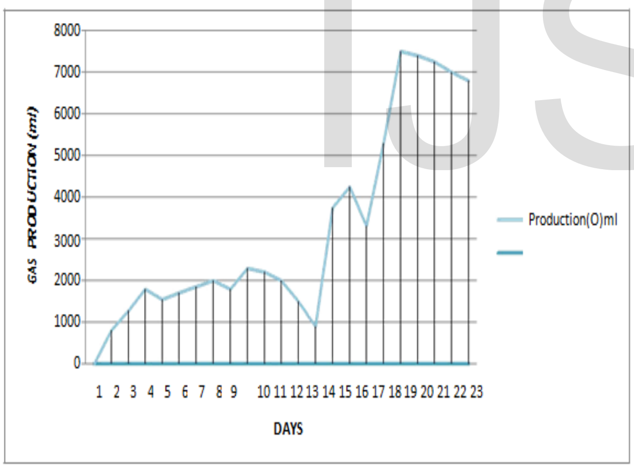


Fig. 9 Daily gas production of digester 3(O)

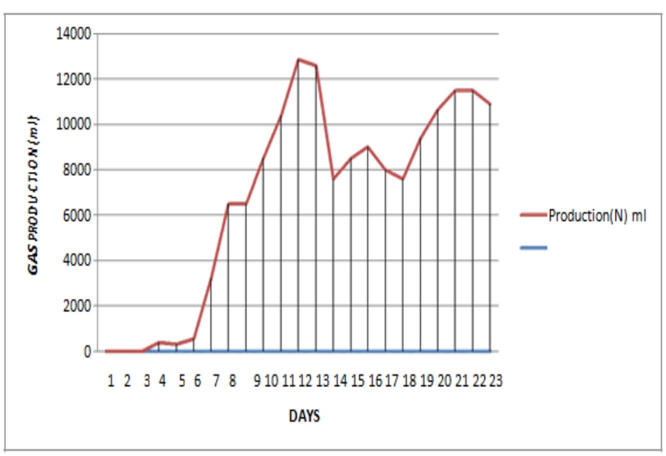


Fig. 10 Daily gas production of digester 3(N)

TABLE 7: DAILY VFA AND GAS PRODUCION

DAYS	VFA(O) mg/l	VFA(N) mg/l	Gas (O) ml	Gas (N) ml
1	1968.75	3762.5	-	-
2	1837.5	6562.5	800	-
3	1750	5337.5	1280	-
4	2012.5	3937.5	1800	600
5	2187.5	6125	1550	300
6	2800	6387.5	1700	550
7	2537.5	5687.5	1850	3200
8	2231.25	4287.5	2000	6500
9	2187.5	5512.5	1800	6500
10	2275	4375	2300	8500
11	2675	5162	2200	10600
12	2650	6300	2000	12850
13	2370	6562.5	1500	12600
14	2281	6763	900	7600
15	2685	5612	3750	8500
16	2194	5783	4250	9000
17	2300	5907	3300	8000
18	2250	4956	5300	7600
19	2012.5	4112.5	7500	9400
20	2080	3953	7600	10650
21	2199	3200	7250	11500
22	2208	3200	7000	11500
23	2259	2500	6800	10900

TABLE 8: DAILY A/TIC RATIO

DAYS	A/TIC (O)	A/TIC(N)	Kitchen Waste (O) gm	[illegible] (N) gm
1	0.65	0.96	-	-
2	0.65	0.865	20	-
3	0.471	0.88	-	-
4	0.52	0.874	20	-
5	0.65	0.853	-	-
6	0.524	0.892	20	20
7	0.55	0.817	-	-
8	0.646	0.75	20	20
9	0.586	0.64	-	-
10	0.662	0.520	20	20
11	0.61	0.656	-	-
12	0.563	0.69	-	-
13	0.534	0.315	-	-

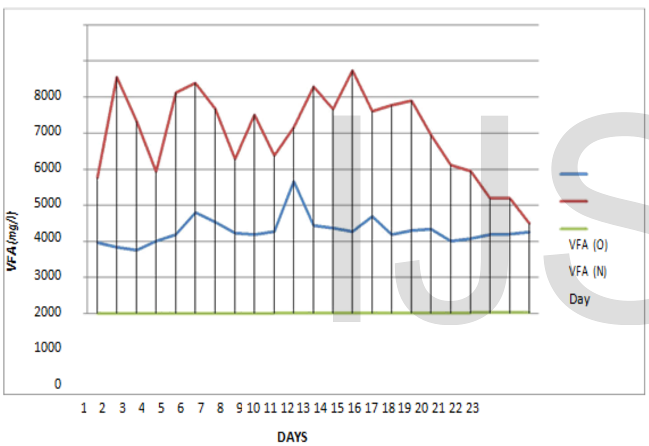


Fig.11 DAILY VFA CHANGE

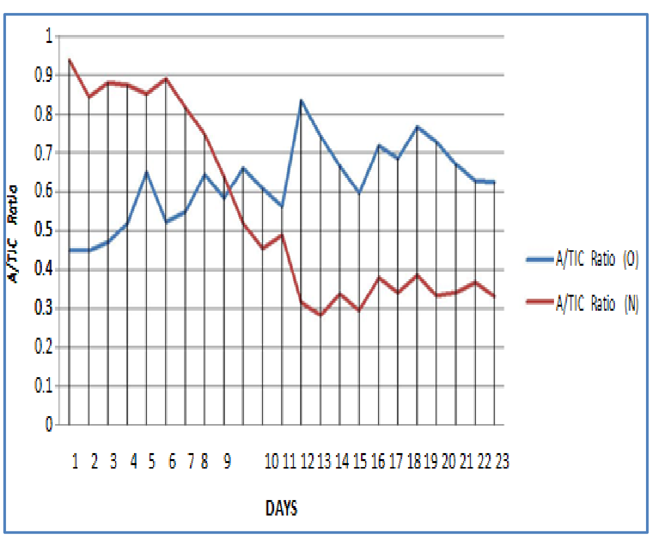


Fig.12 A/TIC ratio v/s day

4 CASE STUDY

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 hostel of Andhra University (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.).

4.1 ANALYSIS 1:

Calorific value of Biogas = 6 kWh/m^3
Calorific value of LPG = 26.1 kWh/m^3
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.

4.2 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 * 10^3 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 tankis used for 2 hours daily.

4.3 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 10: COMARISION OF CONVENTIONAL BIOGAS AND KITCHEN WASTE BIOGAS SYSTEM

Comparison with Conventional Bio-Gas Plants	Conventional Bio-gas Systems	Kitchen Waste Bio-gas System
Amount of feedstock	40kg + 40ltr water	1.5-2 kg + water
Nature of feedstock	Cow-Dung	Starchy & sugary material
Amount and nature of slurry to be disposed	80ltr, sludge	12ltr, watery
Reaction time for full utilization of feedstock	40 days	52 hours
Standard size to be installed	4,000 lit	1,000 lit

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.

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