Mathematical Model for Commercial Production of Bio-Gas from Sewage Water And Kitchen Waste

T.Subramani[1] M.Nallathambi[2]

[1]*Professor & Dean, Department of Civil Engineering, VMKV Engg. College, Vinayaka Missions University, Salem, India*

[2]*PG Student,of Environmental Engineering, Department of Civil Engineering, VMKV Engg. College,Vinayaka Missions University, Salem, India*

Abstract: Utilisation of Bio-Gas is increasingly applied to produce renewable energy to minimize environmental emissions both resulting in reduction of green house gas. Despite Government Grants, the production of Bio- Gas is not commercialized and people mostly depend on natural gas which is non-renewable and depleting fast. The project aims at operation a pilot scale model of 20 litres capacity to evaluate the maximum yield of bio-gas from domestic sewage and kitchen waste. The organic loading and Hydraulic retention time of 25 days will be studied to improve the production of bio-gas and model will be developed. Suggestion and recommendations will be made to commercialise the production of bio-gas. A computer programme will be developed for optimum allocation of the above factors to generate more Bio- Gas based on the feed stock an effluent samples characteristics, such as pH, total solids, volatile solids, number of days, alkalinity, volatile fatty acid. A various digestion options and operational factors will be analysed to make the commercial production of Bio-Gas. A model will be developed with computer programme on the biogas from Kitchen waste and sewage water. The project aims at the usage of distribution of Bio-Gas, is renewable resource instead of Coal, petroleum which are non-renewable resource and fast depleting. Thus when the Bio-Gas is used as fuel in Transportation and Power generation, definitely this will be a mile stone in the economical development of our country

Keywords: Mathematical Model, Commercial Production, Bio-Gas, Sewage Water, Kitchen Waste

I. Introduction- The Biogas

The economic development of India depends to the large extent on the wheels of transport and power generation. With the fast depletion of non-renewable energy sources such as coal, petroleum, the commercial production of bio gas and use will definitely give a drive for the development of our country. Biogas is the product of the digestion of organic materials under anaerobic conditions. Substrates such as manure, sewage sludge, municipal solid waste, biodegradable wastes or feedstock are transformed into methane and carbon dioxide. Purified methane gas can be used as replacement to LPG.

Typical composition of biogas

- 50-75 % Methane, CH_4
- 25-50 % Carbon dioxide, CO_2
- 0-10* % Nitrogen, N_2
- 0-1 % Hydrogen, H_2
- 0-3 % Hydrogen sulphide, H_2S
- 0-2* % Oxygen, O_2

often 5 % of air is introduced for microbiological desulphurisation

The process of anaerobic digestion is done by methane bacteria. Necessary milieu conditions are:

- Anaerobic milieu
- Temperatures between 15°C and 55°C
- PH-values between 6.5 and 8.0
- A variety of feedstock which is not that big
- Avoiding retardants, such as heavy metal salts, antibiotics, disinfectants
- Existence of trace minerals such as nickel and molybdenum

1.1 Sustainability Of Biogas

The production of biogas is sustainable, renewable, carbon neutral and reduces the dependency from imported fossil fuels. Often operators or beneficiaries of biogas plants are able to become fully energy self sufficient. They produce the heat and eletricity they consume. The use of biogas supports the objectives of the European Union of 20 % of renewable energy by 2020. Biogas is a carbon neutral way of energy supply. The substrates from plants and animals only emit the carbon dioxide they have accumulated during their life cycle and which they would have emitted also without the energetic utilization. On the whole, electricity produced from biogas generates much less carbon dioxide than conventional energy. 1 kW of electricity produced by biogas prevents 7,000 kg CO_2 per year.Other environmental benefits are:

- Reducing the emission of methane which is also a green house gas
- Establishing a decentralised energy supply
- Providing high quality fertilizers
- Reducing unpleasant local odours
- Strengthening regional economies and creating added value
- Fostering energy independence

1.2 The Potentials Of Biogas

Against the background of climate change and energy policy, there is a growing demand for sustainable, renewable and indigenous energy sources in Europe.Using materials for energy production, which otherwise are considered wastes or which disposal costs money, is convincingly clever.

In addition to the environmental benefits, the rising prices of conventional energy and the growing requirements for waste management of organic materials are further arguments in favour of biogas production.

But use of animal manure, organic waste and other types of biomass as energy sources will depend to a large extent on availability. Availability and implementation is strictly dependent on national and EU agricultural, environmental and energy policies. Co-digestion of animal manure and other types of suitable organic waste in biogas plants is an integrated process. On the background of renewable energy production, the process includes intertwined environmental and Agricultural Benefits, Such As

- Savings For The Farmers
- Improved Fertilisation Efficiency
- Less Greenhouse Gas Emission
- Cheap And Environmentally Sound Waste Recycling
- Reduced Nuisance From Odours And Flies
- Possibilities Of Pathogen Reduction Through Sanitation, All This Connected To Renewable Energy Production

Natural gas, oil and solid fuels dominate the primary energy supply of Romania with an aggregate share of 74% of the total. Total consumption has been slightly increasing over the last 3 years, having exhibited a significant decrease over the period 1990-1999.

The shares of oil and natural gas have shown an important reduction since 1990 and the supply of oil is now below EU-27 average of 38%. In contrast, renewable sources have been steadily increasing, accounting for the 12% of gross inland consumption, which is much higher than the EU-27 average of 6%.40 % of Romania is agricultural area and ca. 30 % forest, but only 10 % of the biomass are used for energy production. Currently biomass is merely used for heating purposes, direct burning for cooking and hot water preparation accounting for the largest share.

1.3 The Standard Process Of Biogas Production

In the standard process of biogas (Figure.1) production, the bioorganic material is processed before being fed into the biogas plant. The plant consists of a mixer, two digesters and gas storage. The digesters are also called fermentation tanks and are the crucial components of the plant since they provide the anaerobic conditions in which the bacteria generate biogas. The substrates have to be constantly heated and stirred in order to ensure their homogeneity and the consistent discharge of gas. The gas holder is normally an airproof steel container that, by floating like a ball on the fermentation mix, cuts off air to the digesters (anaerobiosis) and collects the gas generated. In one of the most widely used designs, the gas holder is equipped with a gas outlet, while the digesters are provided with an overflow pipe to lead the sludge out into a drainage pit. Landfill gas is produced by wet organic waste decomposing under anaerobic conditions in a landfill. The waste is covered and mechanically compressed by the weight of the material that is deposited from above. This material prevents oxygen exposure thus allowing anaerobic microbes to thrive.

This gas builds up and is slowly released into the atmosphere if the landfill site has not been engineered to capture the gas. Landfill gas is hazardous for three key reasons. Landfill gas becomes explosive when it escapes from the landfill and mixes with oxygen.

Landfill gas is hazardous for three key reasons. Landfill gas becomes explosive when it escapes from the landfill and mixes with oxygen. The lower explosive limit is 5% methane and the upper explosive limit is 15% methane.

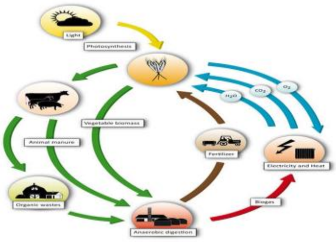


Figure.1. Process Of Biogas Production

1.4 Benefits Of Biogas

The ingredients like water vapour, hydrogen sulphide, and carbon dioxide and dirt particles are present in the biogas and hence it can be used after the extraction from the plant. However, after removing water vapour and carbon dioxide the biogas can be used like any clear natural gas. Input one other kind of using biogas is the feeding of gas into the gas network. Supplying biogas directly into the public natural gas grid requires biogas refinement to the quality of natural gas. Being as efficient as it is flexible, the biogas can be directed to the place where it is needed to be effectively used for generating electricity and heat.

II. OBJECTIVES

2.1 Goal

At present, bio gas is produced using cowdung in a digester. The methane content is 25% only. By mixing different proporation of kitchen waste, sewage water, it is possible to produce abundant bio gas which contains 60% methane and can be used as a replacement to coal and petrol for commercial purposes.

- Optimization of gas production
- Comparison with conventional plants
- Effect of different parameters viz.

1. Temperature
2. PH
3. Total & volatile solid concentration
4. Alkalinity
5. C:N Ratio

- To increase the production by using

1. Additives
2. Nutrients
3. Nitrogen source

- Check optimization of gas production at lab scale and field scale.
- Establishing mathematical model for production of bio gas.

2.2 Work Plan

This work is conducted in two phases, 1st at laboratory scale and 2nd at large scale in plastic tank.

2.3 Source Of Kitchen Waste

The waste used in this study is collected from my residence. Waste contains the cooked rice, vegetables and non-used vegetables waste. This waste is crushed by mixer grinder and slurry was prepared mixing with water.

2.4 Lab Scale

In lab scale this experiment was done in 1lit, 2lit & 20lit bottles, digester. Here different concentration & combination of wastes are used.

Different parameters of input and effluent like total solid, volatile solid, volatile fatty acid, pH, Temperature, Nitrogen, Carbon, Phosphorous will be measured. After that in 20 lit. plastic container study done to check the gas production.

2.5 Large Scale

Here two syntax tanks will be used, one of 1000 lit from digester and other of 750 lit for gas collector. Here also different parameter will be checked like

- Total solid – increasing the feeding rate from 100 gm to 5 kg and to check effect on gas production and effluent quality.
- PH – to check change in PH and control of PH
- Temperature effect

Quality and quantity of produced biogas

III. Precautions While Collecting The Sample

3.1kitchen Waste

- A separate container for coconut shells, egg shells, peels and chicken mutton bones. These will be crushed separately by mixer grinders.
- 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 Installations

Important aspect in smoother running of 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 slurry.

IV. Analysis Of Gas Produced In Our Reactor

4.1 SYRINGE METHOD

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

V. Procedure Followed

- Prepare 100 ml of dilute sodium hydroxide solution by dissolving granules of NaOH in about 100 ml of water.
- Take 20-30 ml sample of biogas produced during experiment into the syringe (initially fill syringe with H2O to reduce air contamination) and put end of the tube into the NaOH solution, then push out excess gas to get a 10 ml gas sample.
- Now take approximately 20 ml of solution and keep the end of the tube submerged in the NaOH solution while shaking syringe for 30 seconds.
- Point it downwards and push the excess liquid out, so that syringe plunger level reaches 10 ml. Now read the volume of liquid, which should be 3-4 ml indicating about 30-40% of gas absorbed so we can say the balance of 65-60% is methane.
- If the flame does not burn properly and you get over 50% methane (a reading of less than 5 ml of liquid) you must have nitrogen or some other gas present.

4.2 Composition Of Biogas

- Mehane (50 - 65%)
- Carbon dioxide (30 - 40%)
- Nitrogen (2 - 3%)
- water vapour(0.5%) 27

VI. Methods Of Analysis & Calculations

6.1analytical Methods & Calculations

6.1.1 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 0C in furnace.

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

6.1.2 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

where

V1= Weight of crucible.

V2= Weight of dry residue & crucible.

V3= Weight of ash & crucible (after cooling)

6.1.2 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, butyrate. I had used two method for VFA measurement.

Method 1

1. Take 100 ml sample in beaker
2. Filter the sample.
3. Check pH of filterate.
4. Take 20 ml of filterate and add 0.1M HCl until pH reaches 4
5. Heat in the hot plate for 3 mins 28 .
6. After cooling titrate with 0.01N NaOH to take PH from 4 to 7.
7. Amount of HCl and 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 the titrant is recorded.
- More acid is slowly added until pH 4.3 is reached. The volume A2 [ml] of the added titrant is again recorded.
- The latter step is repeated until pH 4. 0 is reached, and the volume A3 [ml] of added titrant recorded once more.
- A constant mixing of sample and added titrant 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

where
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).

$$\frac{A\ [mg/l] = VFA\ [mg/l]}{TIC\ [mg/l] = Alkalinity\ [mg/l]}$$

6.2 ORGANIC CONTENT

Organic dry matter weigh the sample and weigh remaining ashes Organic content = {Mass of TS - Mass of ashes}/Mass of TS 30

VII. EXPERIMENTS

7.1 Experiment 1 (Lab Scale)

Figure.2 Shows The Lab Model

FIGURE.2 LAB MODEL

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

Result

Gas production was found but not measured.

7.2 Experiment 2

Different sets of 1 litre & 2 litres bottles. Three different sets with different composition are installed as below.

- 200gm cow dung was mixed with water to make 1lit slurry which is poured in 1lit bottle.
- 50gm grinded kitchen was mixed with 150gm cow dung and water is added to make 1lit solution which is poured in 1lit bottle.
- 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

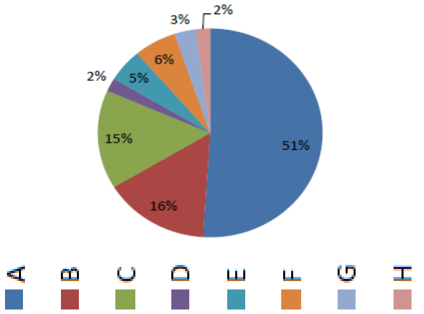


Figure.3 Composition Of Kitchen Waste

VIII. Composition Of Kitchen Waste

Figure.3 shows the Composition Of Kitchen Waste
(A) Uncooked fruits & vegetables
(B) Cooked meat
(C) Uncooked meat
(D) Bread
(E) Teabags
(F) Eggs
(G) Cheesse
(H) Paper

IX. DISCUSSIONS

From the result Table.1 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.1 BIOGAS PRODUCTION (ML)

Set no./day	1st day	2nd	3rd	4th	5th	6th	7th	8th	Average
1	30	35	20	10	16	40	25	10	23.25
2	80	150	120	50	46	60	115	80.37	93.87
3	85	75	58	35	18	20	70	100	57.6

From results it has been seen (Figure.4) 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.

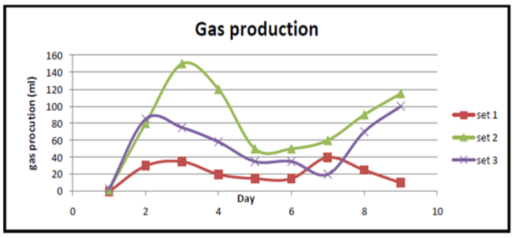


Figure.4 Gas Production Vs Day For 3 Sets

In set2 (Table.2.) 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.2. P^{h} And Total Solid Concentration Setup

Day	Set1		Set2		Set3	
	P^{H}	TS%	P^{H}	TS%	P^{H}	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 upto 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.

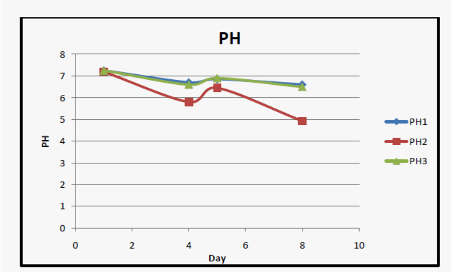


FIGURE.5 P^{H} V/S DAY

GRAPH – This graph (Figure.5) 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.

9.1 Plan Of Biodigestor

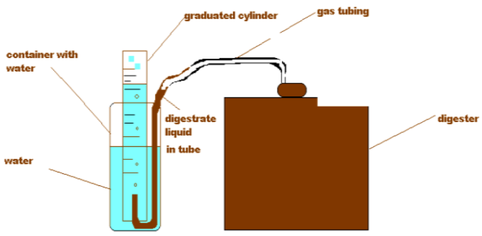


Figure.6. Diagram Of Bio-Digester
Figure.6. Shows the diagram of bio-digester

9.2 INSTALLATION

Both the digester was installed in TWAD water testing lab at Dharmapuri. I used the 20 lit. Water container as digester. Following were the material used for 20 lit digester. Table.3 shows list of materials used in experiment no. 3

Table.3. 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.)

9.3 Procedure And Start Up

Experiment 3(N) (Large Scale)

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. Figure.7. Shows anaerobic digester

Figure.7. Anaerobic Digester

9.4 EXPERIMENT 3(O):

Figure.8 shows Layout Of Experimental Setup 3

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 & NaHCO3 added to increase/adjust pH.

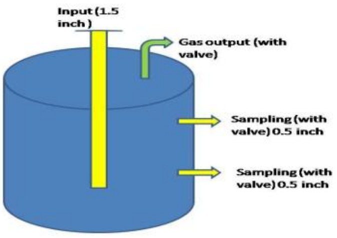


Figure.8 Layout Of Experimental Setup 3

9.5 RESULTS (FOR EXPERIMENT 3)

The results are shown in Figure.9,10,11,12,13&14. And Table.4,5 & 6

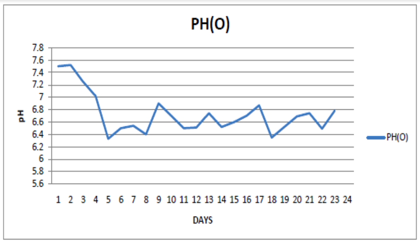


Figure.9. Daily Ph Change Of Digester 3(O)

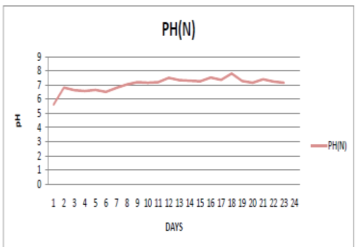


Figure.10. Daily Ph Change Of Digester 3(N)

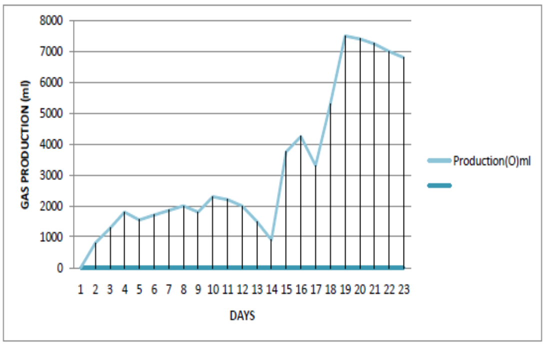


Figure.11. Daily Gas Production Of Digester 3(O)

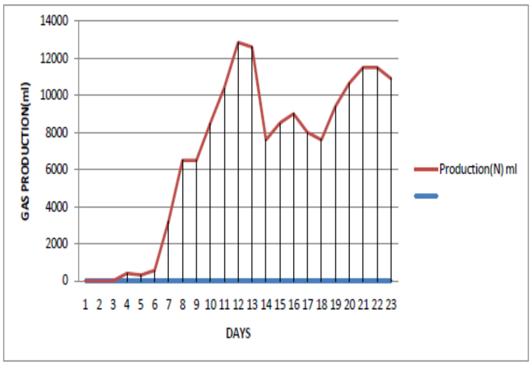
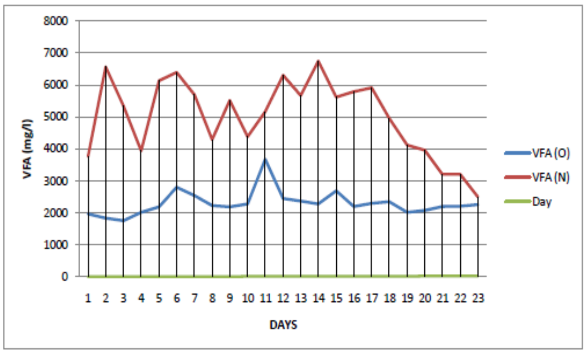


Figure.12. Daily Gas Production Of Digester 3(N)



:

Figure.13. Daily Vfa Change

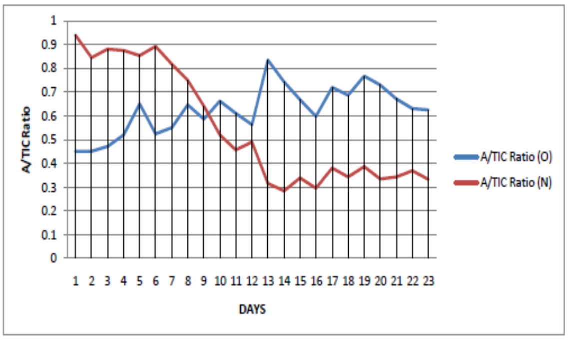


Figure.14. A/Tic Ratio V/S Day

Table.4 Daily Ph And Gas Production Of Digester 3

DAY	PH(O)	PH(N)	GAS(O)	GAS(N)
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	12600
13	6.74	7.34	1500	7600
14	6.52	7.26	900	8500
15	6.6	7.36	3750	9000
16	6.7	7.52	4250	8000
17	6.8	7.36	3300	7600
18	6.35	7.28	5300	9400
19	6.52	7.16	7500	7600
20	6.69	7.4	7400	9400
21	6.72	7.24	7250	10650
22	6.49	7.4	7000	11500
23	6.78	7.16	6800	11500

Table.5 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	400
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	3675	5162	2200	10400
12	2450	6300	2000	12850
13	2370	6562.5	1500	12600
14	2281	6743	900	7600
15	2685	5612	3750	8500
16	2194	5783	4250	9000
17	2300	5907	3300	8000
18	2350	4956	5300	7600
19	2012.5	4112.5	7500	9400
20	2080	3953	7400	10650
21	2199	3200	7250	11500
22	2208	3200	7000	11500
23	2259	2500	6800	10900

TABLE.6 DAILY A/TIC RATIO

DAYS	A/TIC (O)	A/TIC(N)	Kitchen Waste (O) gm	Kitchen Waste (N) gm
1	0.45	0.94	-	-
2	0.45	0.845	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	0.456	-	-
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	0.72	0.38	-	-
18	0.687	0.343	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	0.625	0.333	-	-

X. Analysis & Results

The bio gas production depends on

- PH
- VFA (volatile fatty acid)
- A/TIC alkality
- Total solid

Mathematically the bio gas production can be represented as follows:

Y=ax4+bx3+cx2+dx+e for polynomial model.

And y=ax+b for linear model.

The datas collected from the large scale model are analyised in the excel software for the above parameters and the are furnished in Table.7. and Figures 15,16,17,18 & 19

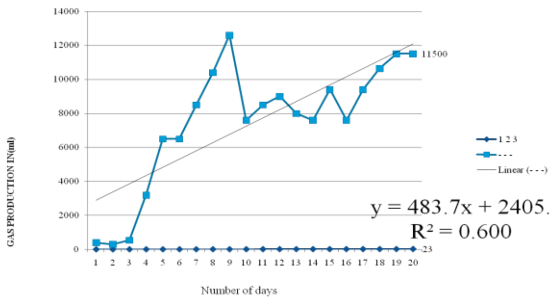


Figure 15. Linear Model 1

Table.7.Mathematical Model Analysis And Results

Gas production in (ml)	PH	Number of days	VFA	A/TIC Ratio	Total Solid %
-	5.6	1	3762.5	0.94	6
-	6.82	2	6562.5	0.845	5.8
-	6.63	3	5337.5	0.88	5.7
400	6.57	4	3937.5	0.847	5.4
300	6.66	5	6125.5	0.853	5.4
550	6.5	6	6387.5	0.892	4.7
3200	6.8	7	5687.5	0.817	4.8
6500	7.03	8	4287.5	0.75	4.9
6500	7.2	9	5512.5	0.64	5.3
8500	7.16	10	4375	0.52	5.4
10400	7.2	11	5162	0.456	6.2
12600	7.51	12	6300	0.49	6.2
7600	7.34	13	6562.5	0.315	6.9
8500	7.26	14	6743	0.284	4.3
9000	7.36	15	5612	0.339	5.3
8000	7.52	16	5783	0.295	4.3
7600	7.36	17	5907	0.38	5.1
9400	7.28	18	4956	0.343	6.9
7600	7.16	19	4112.5	0.386	6.8
9400	7.4	20	3953	0.334	6.7
10650	7.24	21	3200	0.343	6.6
11500	7.4	22	3200	0.369	6.4
11500	7.16	23	2500	0.333	6.3

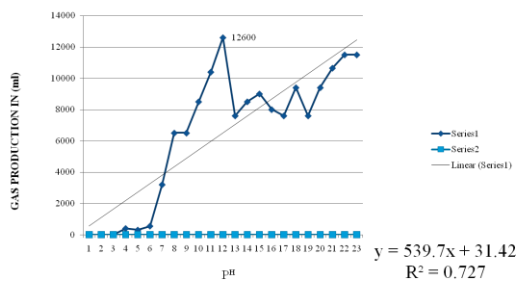


Figure 16. Linear Model 2

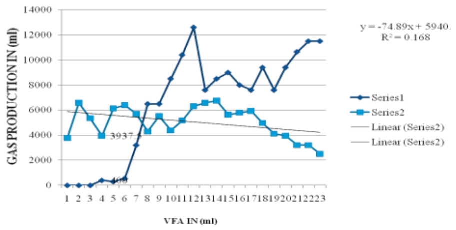


Figure 16. Linear Model 3

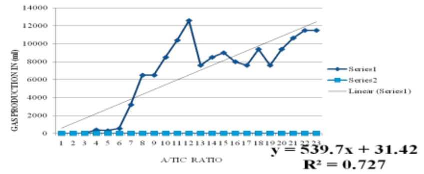


Figure 17. Linear Model 4

Figure 18. Linear Model 5

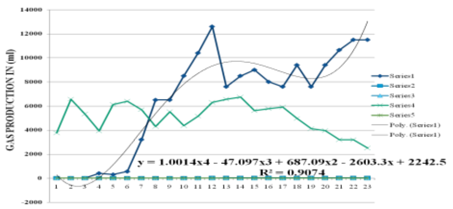


Figure 19. Polynial Model

XI. RESULTS

- From the mathematical model commercial production of Biogas is influenced by
  - 6<PH<7.5
  - 3200<VFA<4000
  - 0.5<A/TIC<0.6
  - 10<TS<15
- Thus PH,A/TIC,TS are supporting Biogas production and VFA is partially supporting Biogas production.
- Model equation

$y = 1.0014x^4 - 47.097x^3 + 687.09x^2 - 2603.3x + 2242.5$

$R^2 = 0.9074$

XII. Conclusion

When the R2 valve is greater than 0.5, it may be concluded that the parameter is supporting the production of bio gas. Accordingly PH, TS, A/TIC are supporting the production of bio gas, while VFA is partially supporting the production of bio gas.

11.1 Comparision 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. shows the Comparison of conventional biogas and kitchen waste biogas system

Table.8. Comparison Of Conventional Biogas And Kitchen Waste Biogas System

Comparison With Conventional Biogas 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, water
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.

References

[1] Kale, S.P and Mehele, S.T. kitchen waste based biogas plant.pdf. Nuclear agriculture and Biotechnology/ Division.

[2] Karve .A.D. (2007), Compact biogas plant, a low cost digester for biogas from waste starch. http://www.arti-india.org.

[3] Karve of Pune A.D (2006). Compact biogas plant compact low-cost digester from waste starch. www.bioenergylists.org.

[4] Shalini sing, sushil kumar, M.C. Jain, Dinesh kumar (2000), the increased biogas production using microbial stimulants.

[5] Hilkiah Igoni, M. F. N. Abowei, M. J. Ayotamuno and C. L. Eze (2008), Effect of Total Solids Concentration of Municipal Solid Waste on the Biogas Produced in an Anaerobic Continuous Digester.

[6] Tanzania Traditional Energy Development and Environment Organization (TaTEDO), BIOGAS TECHNOLOGY-Construction, Utilization and Operation Manual.

[7] The University of Southampton and Greenfinch Ltd. - Biodigestion of kitchen waste A comparative evaluation of mesophilic and thermophilic bio-digestion for the stabilisation and sanitisation of kitchen waste.

[8] Ranjeet Singh, S. K. Mandal, V. K. Jain (2008), Development of mixed inoculum for methane enriched biogas production.

[9] Kumar.s. Gaikward.S.A., Shekdar.A.K Srisagar.P.K..,Singh R.N (2004) Estimation method for national methane emission from Solid Waste Land fills Atmosphere environment 38:3481-3487

[10] Jantsch, T.G., Matttiason, B. (2004). An automated spectropphoyometric system for monitoring buffer capacity in anaerobic digestion processes. Water Research. 38: 3645-3650.

[11] Thomsen, A.B., Lissens, G., Baere, L., Verstraete, W., Ahring, B. (2004). Thermal wet oxidation improves anaerobic biodegradability of raw and digested biowaste. Environmental Science and Technology.38: 3418-3424.

[12] Meres, M., Szczepaniec-Cieciak, E., Sadowska, A., Piejko, K., Oczyszczania, M.P., Szafnicki, K. (2004). Operational and meteorological influence on the utilized biogas composition at the Barycz landfill site in Cracow, Poland. Waste Management Resource.