Comparative Analysis of Biogas Production Using Different Feed Stock

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Abstract

The demand of energy is increasing day by day. So we are forced to non-conventional energy sources. The bio energy place a major role to meet the energy demand. There are different sources of renewable energy available. But the Biogas technology is proved to be the most promising sources of renewable energy. The Biogas technology has the potential to meet the energy needs in rural/urban area. Biogas technology is found to be cheap, non-polluting, eco-friendly, and self-content. The amount of solid wastes generated in developing countries such as India has steadily increased over the last two decades as a result of population explosion and continuous growth of industries and agricultural practices. Particularly large quantities of fruits waste and flower waste generated, which could be used as biogas inputs to compliment the fuel usage alternative. In addition, a large number of families and educational institute (hostels) generate heavy waste in the kitchen on a daily basis, which could be converted to economic benefits. In this work a comparative study of biogas production from kitchen waste, mixed fruit waste and flower wastes was conducted under the same operating condition. The each waste mixed with water and loaded into the reactor. Biogas production was measured for a period of 20 days and at an average temperature of 33˚C. Biogas production started on the 5^{th} day and attained maximum value on the15th days of reactor. The average biogas production from fruit waste, kitchen waste and flower waste was measured. It's concluded that the waste can be managed through conversion into biogas, which is a source of income generation for the society.

Keywords**:** Biogas; feedstock; Temperature; Ph; Kitchen waste; mixed fruit waste; Flower waste.

1.Introduction:

Anaerobic digestion is a complex, natural, multi-stage process of degradation of organic compounds through a variety of intermediates into methane and carbon dioxide, by the action of a consortium of microorganisms. The interdependence of the bacteria is a key factor in the anaerobic digestion process. Instability during both the start-up and operation of the anaerobic degradation process can be problematic due to the low specific growth rate of the methanogenic microorganisms involved. Anaerobic digestion of waste and wastewater can be performed in batch, or as continuous processes. In normal batch digestion, reactors are filled once with fresh waste, with or without the addition of inoculums, and allowed to go through the degradation process leading to the formation of biogas. The beet leaves provide additional nitrogen to the system. The anaerobic mesophilic process (at about 35 ºC) is that most widely used. Generally, the anaerobic process is the subject of current research, as a result of the biogas evolved as a by-product of such a process. Degradation of volatile suspended solids (VSS) in the conventional mesophilic anaerobic process is about 40% at retention times between 30 and 40 days.

Component	**Concentration(by volume)**
Methane(CH_4)	55-60%
Carbon di oxide(CO_2)	35-40%
Hydrogen sulphite (H_2S)	20-20,000 ppm (2%)
Ammonia(NH_3)	0-0.05%
Nitrogen(N_2)	0-2%
Oxygen(O_2)	0-2%
Hydrogen(H)	0-1%
Water(H_2O)	2-7%

1.1.Characterstics 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 0C.An odorless & 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, & electricity, depending on the nature of the task, and local supply conditions and constraints. Contamination and the spread of pathogens disease cause bacteria. Biogas technology is particularly valuable in agricultural residual treatment of animal excreta and kitchen refuse (residuals).

1.2. 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.

2. Bio digestion of plant and animal waste

Anaerobic digestion consist of three phases,

(i) Hydrolyzes
(ii) Acid formation
(iii) Methane formation

2.1. Hydrolyzes

The process of hydrolyses is somewhat similar to that hydrolytic processes that occur in the digestion of food in the stomach and intestines of the human being. A simple example of such a process is the hydrolysis of starch to glucose. There are many enzymes to hydrolyse different materials. These steps may not be necessary if the raw material consist of soluble and organic substance occurring in nature.

2.2. Acid Formation

The bacteria all obtain energy by oxidizing all obtain energy by oxidation the organizing the organic substance are oxidized to acid (known as volatile acid) similar to that of formic, acetic, propone and butyric acid. The next phase of anaerobic digestion is methane fermentation.

2.3. Methane fermentation

The reaction in the above three phases has to so on simultaneously. Is any one of the reaction (especially acid formation) proceeds the other reaction, it will lead to an upset of the digester because of the lowering of the pH of the medium and consequent fermentation is known to be carried out by a specific group of micro-organism known as methane anaerobes and also to have ions scenario time. The methane bacteria cannot utilize the carbon and nitrogen source such as carbohydrate, fat and proteins. The only organic acids useful for these bacteria are short chain fatty acid (homologues of formic acid up to carbonic acid and homologues of simple alcohols such as methanol up to n-pentagon) hence to obtain maximum methane from the fermentation, it is imperatives that condition are made ideal for the formation of these volatile acid (and simple alcohol) and their fermentation into the gases.

3. Operating Conditions Of Biogas Digestion

Bio – gas digestion is a microbial process and therefore reactive the maintenance of suitable grown condition for bio-gas producing bacteria, the provision of nutrients, oxygen, optimum temperature, pH, and other environmental factors are vital for the activity of living bacterial. Only of these conditions are met, will the normal bacterial activity and scubas gas production be assured. The following are the main conditions received by methane – producing bacteria consortia.

3.1. Anaerobic environment

All microbes that play an important role in biogas digestion are strictly anaerobic. They include acid – producing bacteria and methane producing bacteria. The latter are so sensitive to oxygen that digestion would be inhibited by even the slightest trace of oxygen. The distinction between “aerobic” and “anaerobic” is however relative. The term oxidative reduction is the concentration of electrons in aerobics and anaerobic. The optimum oxidative reduction potential for methane productions bacteria is –330mr. There seems to be a direct relationship between the oxidative reduction potential, the concentration of volatile acid and of ammonia nitrogen, and the biogas yield. When the ammonia nitrogen concentration increases the volatile acid concentration increase the volatile acid concentration and ORP decreases, but the methane content rises. Some workers found clear correlations between the oxidative reduction potential, pH value, concentration of volatile acids and gas yield.

3.2. Suitable fermentation substrates

All organic material, except mineral oil and lighting, are suitable substrates for the biogas fermentation. Some organic materials, such as animals’ manure, sludge’s, and the effluents of fermentation industries or learners factories are more easily digested.

3.3. Total solid concentration

The optimum level of solid content in the feedstock should normally 7 to 0 percent of the total weight. Dilution of feed material is essential, because in natural state the solid content oil this material varies from 10 to 30%. The concentration of total solid is important for easy mixing and handling. Under rural conditions the total solid concentration is changed with change of season. It is lowered in summer, when gas production is highly and raised in winter.

Vegetable market waste	12.5
Canteen waste	19.5
Water hyacinth	8.0
Garbage	85.0

3.4. Maintenance of Optimum Temperature

Temperature is one of the prime factor influencing activities. Survival and growth of microorganism involved in production of biogas ultimately the performance of digested. In order to make the fermentation bacteria work at their maximum efficiencies a suitable temperature is necessary

There are two groups of bacteria that digest organic matter. Those that work at high temperature and those that works at relatively lower temperature.

Their gas production occurs within different temperatures ranges. Different methane productions bacteria drive in the respective temperature range.

3.5. Maintaining of optimum pH

The pH is a measure of the acidity or alkalinity of fluid. It has a profound effect on biological activities, and the maintenance of an appropriate pH is essential for all living beings.

The methane bacteria are very sensitive to changes in pH. A pH value ranging between 7.0 and 7.2 considered optimum for production of good amount of methane.

If the time concentration is too it will combine with co_2 in the digester and produce water insoluble calcium carbonate ($caco_3$).

$$3Co2 + Ca(OH) \rightarrow 2\,Caco3 + H2o.$$

This should be avoided, since it is known that in the biogas fermentation carbon dioxide (co_2) metabolically accept electrons, thus becoming methane. If the Co_2 the anaerobic metabolism will be inhibited.

4. Important Factors Affecting Biogas Yield

The following are the factors that affect generation of biogas.

- i. PH or hydrogen ion concentration.
- ii. Temperature
- iii. Total solid content of feed material
- iv. Loading rate
- v. Seeding
- vi. Uniform feeding
- vii. Diameter to depth ratio
- viii. Carbon to nitrogen ratio
- ix. Nutrients
- x. Mixing or stirring or agitation of the content of the digester

xi. Retention time or rate of feeding
xii. Type of feed stocks
xiii. Toxicity due and product
xiv. Pressure
xv. Acid accumulation inside the digester

5. Investigation On Fruit Waste

Experimental investigation using fruit waste with adding small quantity of fermented cow dung for fast growth of microbes as carried out in this project. Different parameter like temperature pressure, total solid concentration, volatile solid concentration (VS), C/N ratio, Hydro retention time (HRT), methane production, gas compositions and efficiency were studied.

1.	Mixed fruit waste	15 kg
2.	Fermented cow dung	2 kg
3.	Water	20 lit
4.	PH	6
5.	Capacity	80 lits
6.	Model	Closed dome type (batch process) & portable type

5.1. Procedure:

The mixed fruit waste with little amount of fermented cow dung mixed with water in the ratio of 1:1 and feed into the generator. The closed dome portable type has its capacity of 80 liters.

There valves are provided at top of the dome. Temperature pressure measuring device are provided, and since the gas collector near the top of the dome. The valve situated at top axis used for the collection of gas. Initially the gas valves are closed, when it's opened during hydro retention time (HRT) period. HRT means. "The initial gas formation to the final gas formation" of time periods. Solid balls are introduced in the generator for stirring purposes. Stirring take place every day up to HRT period starts. It prevents the top surface of the slurry from dry. Generator was sealed tightly.

Temperature measuring probes are placed inside the generator at different positions. In this two probes are introduced, one probes at middle of the generator and remaining one probes are placed at top of the sidewall of the generator.

Since experiment was conducted under mesophilic range of temperature. The mesophilic means temperature should be maintain between 30-40°C with the help of temperature probes placed in the generator.

Similarly, the pressure inside the generator should not reach above 40 cm of water column, which holms fermentation the bacteria formed inside the generator is destroyed. To avoid the bacteria decay, gas formed in the generator is collected through the gas valves, before the pressure reaches 40 cm in the water column. By using the U-tube manometer the pressure range is maintained and the readings were studied.

5.2 Analysis Of Feed Stock:

1. Temperature in °C
   (a) Maximum temperature 32°C
   (b) Minimum temperature 28°C

2. Total experimental days 20 days
3. Hydro retention time 5 days
4. C/N ratio 27:20
5. Moisture % 71
6. Total solid concentration in % 29
7. Volatile solid concentration 69
8. Total gas collected $0.269m^3$ /kg

Table 5.3 Observed Tabulation

HR (Days)	Ambient Temp. °C	Temperature °C			Pressure in CM
		T1	T2	Tavg	
1	27	28	29.5	28.75	0
2	30	29	30	29.5	.5
3	30	28.5	29.5	29	3.4
4	31	29	31	30	5.8
5	31	29.4	31.8	30.6	5.9
6	31	30	32	31	6.2
7	31	31	32.5	31.75	5.5
8	32	29	30.5	29.75	6.5
9	31	28.5	29.5	29	8
10	30	29.5	30.4	29.95	8.4
11	29	28	29.6	28.8	9
12	30	28.5	29.8	29.15	9.4
13	31	29.8	32	30.9	8.6
14	31	29.6	31.8	30.7	9
15	29	30	32	31	8.5
16	28	30.5	31	30.75	7.5
17	28/	30	32	31	6.6
18	31	31	32.5	31.75	5
19	32	30	32	31	5
20	31.5	31	33	31.5	4.5

6. Investigation On Kitchenwastes (Food, Fruits And Vegetable Wastes)

Anaerobic digestion of food and vegetables with adding small and fermented cow dung for fast growth of microbes as carried out in this project. Different parameter like temperature, pressure, total solid concentration, volatile solid concentration, C/N ratio, hydro retention time, methane production, has compositions and efficiency were studied.

1.	Kitchen waste	18kg
2.	Fermented cow dung	3kg
3.	Water	20lit
4.	Ph	6.2
5.	Capacity	80 lit
6.	Model	Closed dome type (batch process) & Portable type

6.1 Procedure :

The food and vegetable wastes with little amount of fermented cow dung mixed with water in the ratio of 1:1 and feed into the generator. The closed dome type and portable type has its capacity of 80 liters. There valve is provided at top of the dome. Temperature pressure measuring device are provided and since the gas collected near the top of the dome. The valve situated at top axis used for the collection of gas. Initially the gas valves are closed, when it's opened during hydro-retention time (HRT) periods. HRT means: The initial gas formation to final gas formation" of time periods. Solid balls are introduced in the generator for stirring purposes. Stirring take place everyday up to HRT period starts. It present the top surface of the slurry from dry generator was sealed tightly. Temperature measuring probes are placed inside the generator at different positions. Since the experiment was conducted under mesophilic range of temperature. The mesophilic means temperature should be maintain between 30-40°C with the help of temperature probes placed in the generator.

Similarly, the pressure inside the generator should not reach above 40cm of water column, which harms fermentation the bacteria formed inside the generator is destroyed. To avoid the bacteria decay, gas formed in the generator is collected through gas values, before the pressure reaches 40 cm in the water column. By using the U-tube manometer the pressure range is maintained and the reading were studied. The gas passed through gas flow meter before it reaches the stabilizing tank. Gas flow meter is used to find the gas flow during the hydro retention time periods.

6.2 Analysis Of Feed Stock:

1. Temperature in °C
    (a) Maximum temperature 33°C
    (b) Minimum temperature 30°C
2. Total experimental days 20 days
3. Hydro retention time 5 days
4. C/N ratio 20.5
5. Moisture % 70.2
6. Total solid concentration in % 29.5

7. Volatile solid concentration 95.7
8. Total gas collected 0.725m^3/kg

Table 6.3 Observed Tabulation

HR (Days)	Ambient Temp. °C	Temperature °C			Pressure in CM
		T1	T2	Tavg	
1	28	29.5	31.4	30.45	0
2	31	30	32.2	31.1	10
3	31	31	32.5	31.75	11
4	30	31	32	31.5	10.5
5	30	31.8	32	31.9	13
6	30	33	33.5	33.25	11.5
7	31	32.5	33	32.75	9
8	30	30.5	32	31.25	10
9	31	29.5	32	30.75	10.5
10	30	30.4	31.5	30.95	10
11	31	29.6	33	31.3	10
12	30	32.4	34	33.2	10.3
13	31	32	31.9	31.95	12
14	31	31.8	32.5	32.15	12.2
15	30	32	33.8	32.9	11
16	29	32	34	33	13
17	29	32	33.8	32.9	12.5
18	31	32.5	32.6	32.55	12.8
19	32	32	34	33	13
20	32	33	33.5	33.25	13

7. Investigation On Flower Waste

Anaerobic digestion of flower waste with adding small quantity of fermented cow dung for fast growth of microbes as carried out this project. Different parameter like temperature, pressure, total solid concentration, volatile solid concentration, C/N ratio, hydro retention time, methane production, has compositions and efficiency were studied.

7.1. Anaerobic digester

1.	Flower waste	6kg
2.	Fermented cow dung	4 kg
3.	Water	15 lit
4.	pH	7.1
5.	Capacity	80 lit
6.	Model	Closed dome type (batch process) & Portable type

7.2. Procedure:

The flower and little amount of fermented cow dung mixed with water in the ratio of 1:1.5 and feed into the generator. The closed done portable type and has its capacity of 80 liters.There valves are provided at top of the dome. Temperature pressure measuring device are provided and since the gas collected near the top of the dome. The valve situated at top axis used for the collection of gas. Initially the gas valves are closed, when its opened during hydro retention time (HRT) periods. HRT means "the initial gas formation to the final gas formation" time periods. Solid ball are introduced in the generator for an stirring process. Stirring take place everyday up to HRT period starts. It prevent the top surface of the slurry from dry. Generator was sealed rightly. Temperature measuring probes are placed inside the generator at different position.

Since the experiment was conducted under mesophilic range of temperature. The mesophilic means temperature should be maintain between 30-40°C with the help of temperature probes placed in the generator. Similarly, the pressure inside the generator should not reach above 40cm of water column, which harms fermentation the bacteria formed inside the generator is destroyed. To avoid the bacteria decay, gas formed in the generator is collected through the gas valves, before the pressure reaches 40cm in the water column. Bu using the U-tube manometer the pressure range is maintained and reading are studied.The gas passed through gas flow meter before its reaches the stabilizing tank. Gas flow meter is used to find the gas flow during the hydro retention time (HRT) periods.

7.3. Analysis Of Feed Stock

1.	Temperature in °C	
	(c) Maximum temperature	36°C
	(d) Minimum temperature	33°C
2.	Total experimental days	20 days
3.	Hydro retention time	5 days
4.	C/N ratio	20.51
5.	Moisture %	84.20
6.	Total solid concentration in %	07.60
7.	Volatile solid concentration	79.70
8.	Total gas collected	0.575 m^3/kg

Table 7.3 Observed Tabulation

HRT (Days)	Ambient Temp. °C	Temperature °C			Pressure in CM
		T1	T2	Tavg	
1	33	32.8	34	33.4	0
2	34	34	34.9	34.45	8
3	33	33	34.8	33.9	13
4	33	32.6	34	33.3	14
5	34	33	34	33.5	16
6	33	33	34.8	33.9	15
7	34	34	36	35	14
8	34	34	35.6	34.8	16
9	34	34.8	36	35.4	18
10	34	33	37	35	15
11	35	34	37.5	35.75	15.5
12	34	34.2	35.4	34.8	16
13	33	33	34	33.5	16.5
14	32	33.2	34.6	33.9	17
15	34	34	35	34.5	18
16	34	34	35	34.5	16
17	35	35	36	35.5	16.5
18	33	32.5	34	33.25	17
19	34	34	35	34.5	15
20	34	33.5	35	34.25	16

8. Results and Discussion

Thus the experiment was conducted on fruit waste, kitchen waste, (food and vegetables) and flower waste as a feed stock under mesophilic temperature range of operation with help of many parameter, such as temperature, pressure, C/N ratio, hydro retention time are the factors influenced the activities, survival and growth of microorganism are studied. Finally the amount of methane production, gas composition were analyzed and graphs were drawn.

Table 5.3 Investigation On Mixed Fruit Waste

Duration in days	Temp. °C	Pressure in cm	Total Gas production in m^3/digester
1-5	30.6	5.9	0.021
6-10	29.75	8.4	0.029
11-15	31	8.5	0.043
16-20	31.5	3.8	0.176

Table 6.3 Investigation on kitchen waste

Duration in days	Temp. °C	Pressure in cm	Total Gas production in m^3/digester
1-5	31.9	13	0.112
6-10	30.95	10	0.117
11-15	32.9	11	0.215
16-20	33.25	13	0.281

Table 7.3 Investigation on flower waste

Duration in days	Temp. °C	Pressure in cm	Total Gas production in m^3/digester
1-5	33.5	16	0.182
6-10	35	15	0.195
11-15	34.5	18	0.222
16-20	34.25	16	0.276

Table 8.1 Composition of gas

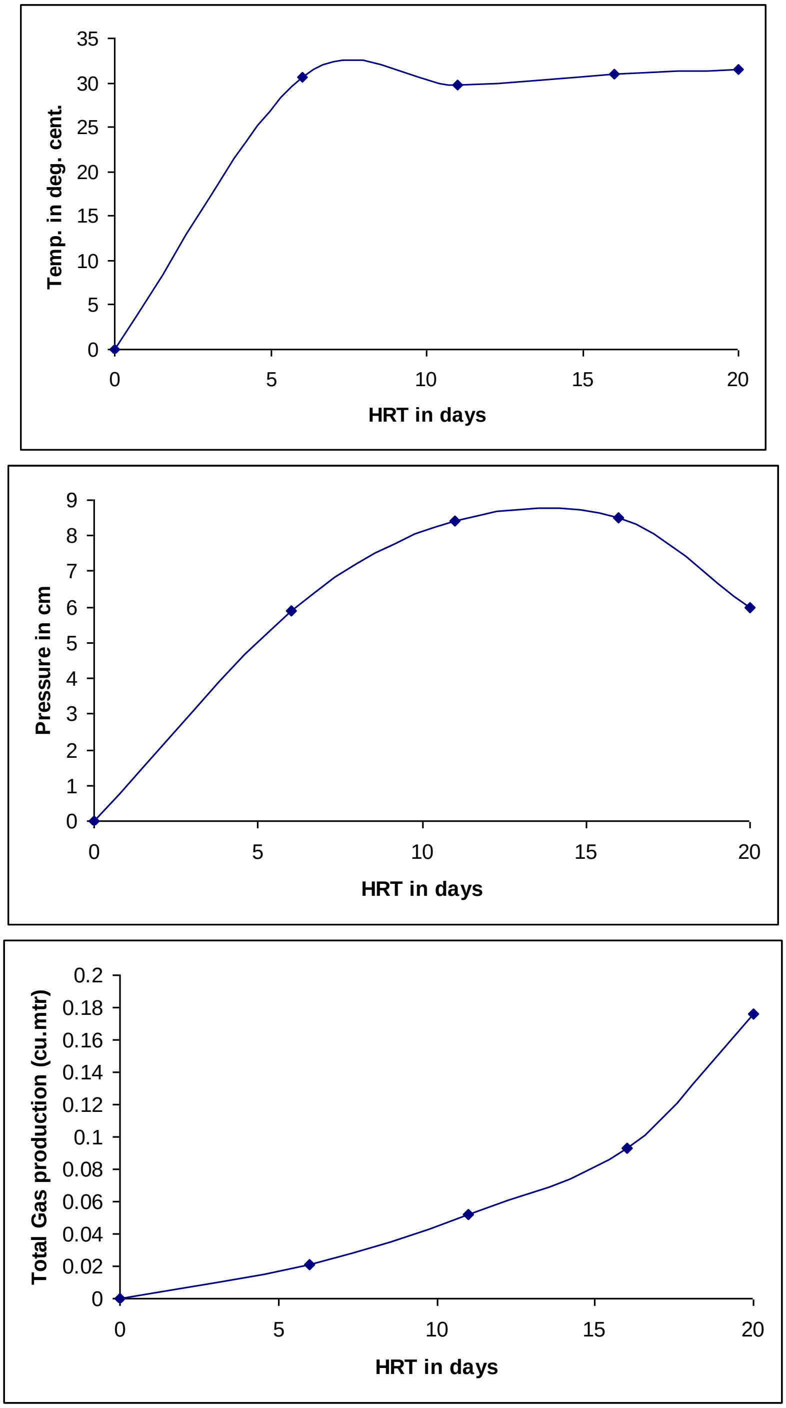
Substrate	CH_4	Co_2	Other
Mixed fruit waste	59	37	4
Kitchen waste	65	33	2
Flower waste	52	45	3

9. Graphs

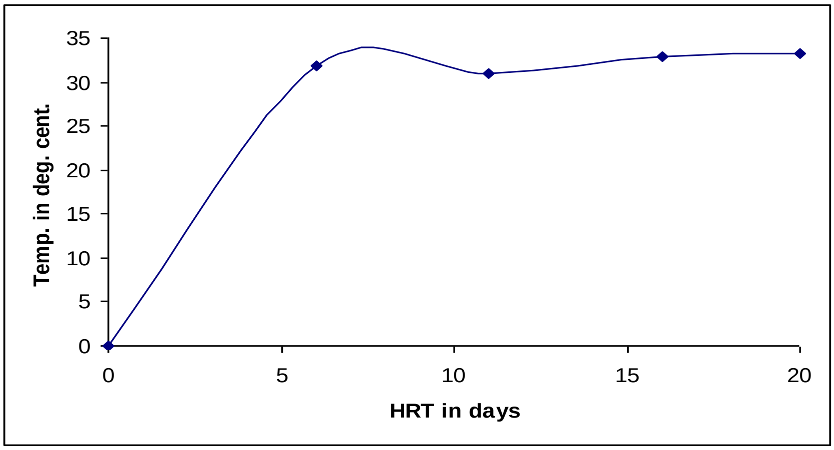
Gas production vs. Duration in days

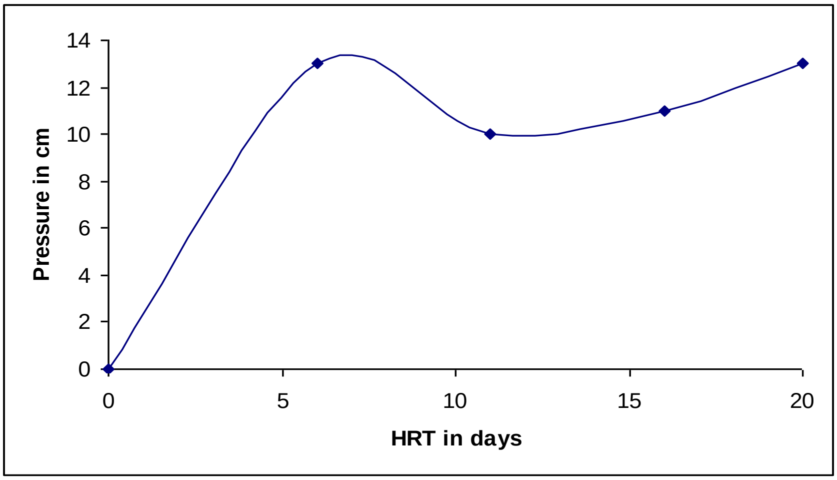
Pressure vs. Duration in days

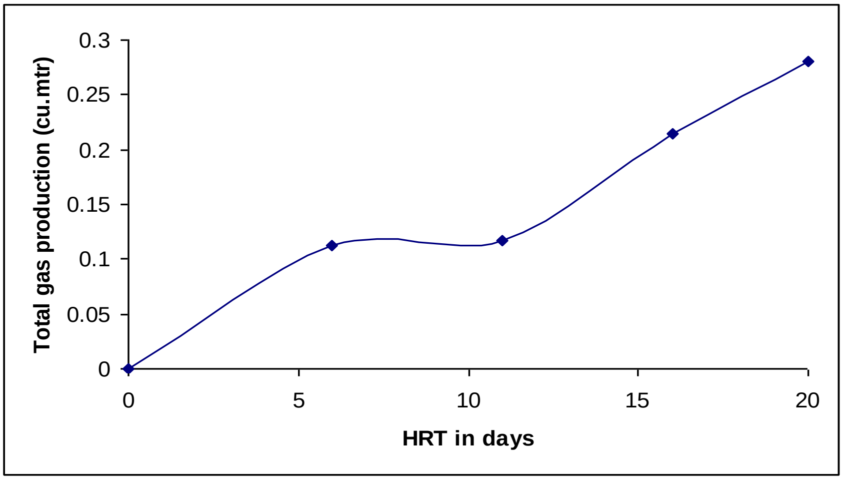
Temperature. Vs. Duration in days



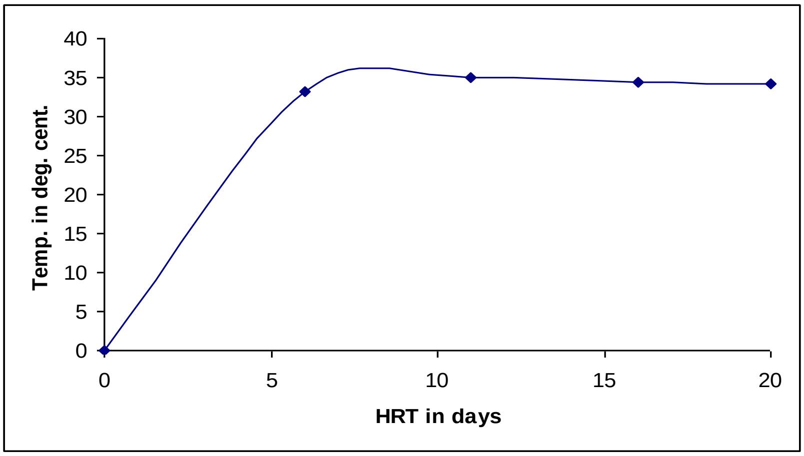
Investigations on fruit waste

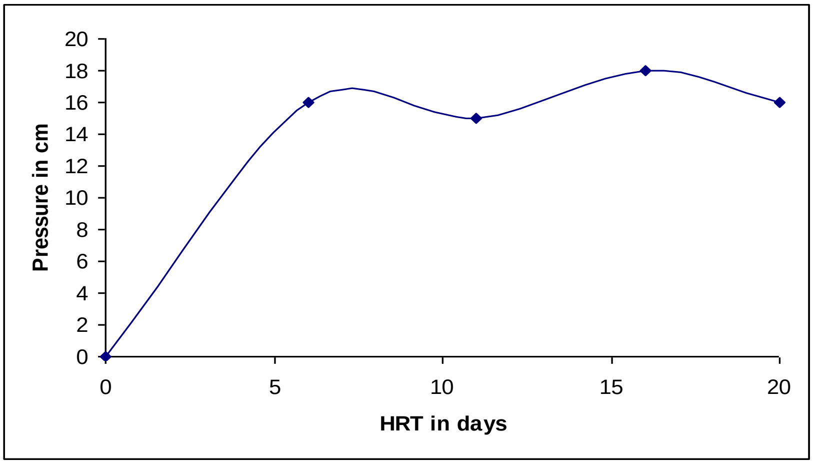


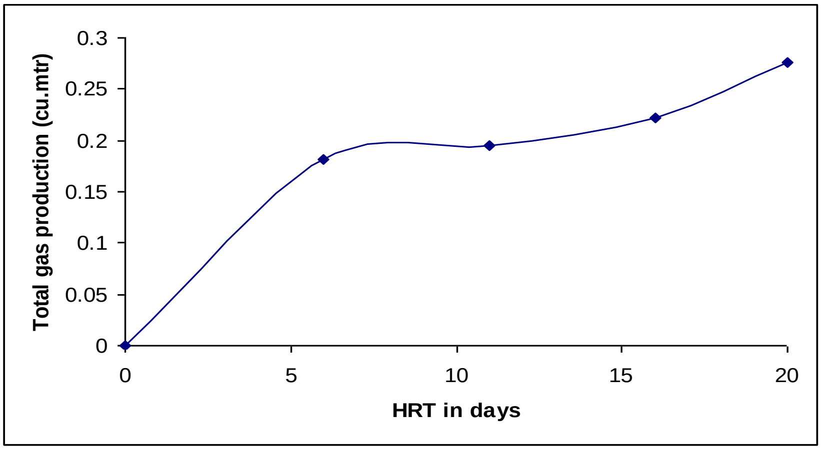




Investigations on kitchen waste







Investigations on flower waste

Experimental Setup

10. Conclusion

During this work various feed stocks such as (fruit waste, Kitchen waste and flower waste) were attempted for bio gas production using Bach type digester and the various bio gas compositions were analyzed in detail. Results revealed that the maximum gas production was found to be in kitchen waste and the maximum Methane production was achieved in kitchen waste. By considering the vast and cheap availability of feed stocks the biogas process can be used to fulfill the future energy demand in domestic/industrial purposes in an eco-friendly manner.

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