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Study & Development of Two Stage Biogas Digester at Enhanced Thermal Conditions

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***Abstract* – The present research work focuses on the biogas making from kitchen waste generated at the VTC, Miraj canteen and mess to study the effects of the key process parameters like pH and temperature, by working a pilot scale setup in two stage thermophilic and mesophilic digestion conditions in 1st batch experiment one setups were operated in mesophilic, thermophilic conditions respectively. Checked parameters changes over the operation period of 10 days. In 2nd and 3rd batch setup the pilot scale setup was based on two stage thermophilic and mesophilic digestion process and operated s a batch reactor. Checked for parameters of temperature COD, pH. From the project work signifiesthat change in temperature can alone change the gas generation time. Digestion process is comparatively enhanced and the duration for biogas generation is reduced.**

I.INTRODUCTION

Anaerobic digestion is one of the most widely used, proven processes that is being used for the treatment of the solid wastes. The history of anaerobic digestion technology in India dates back to late 19th century when the first biogas plant was established in Mathunga (Mumbai) in the year 1897. Anaerobic digestion is a process in which the biological processes like biodigestion by the microbes occur. Anaerobic digestion processes breakdown the organic matter in the feed materials in anaerobic conditions i.e., in the absence of oxygen. These processes stabilizes these waste materials against rapid decomposition. The conversion process is conservative in nature which produces a stable digestate that can be used as a bio-fertilizer. The methane (CH_4) gas and carbon Di-oxide (CO_2) are also produced which are together known as biogas. Thus in addition to treatment of the solid wastes, anaerobic digestion also allows recovery of energy value by conversion of the volatile solids into biogas. The process also function as a waste material disposal system.

The biogas produced by anaerobic digestion process has methane as its major element. Biogas is a renewable energy source that is used as a fuel. This biogas can be used as a fuel to produce heat, through combustion. Biogas is also used at many places across the world for production of electricity in combined heat and power system. The CHP systems in addition to meeting the energy required for the functioning of the biogas plants also produce enough energy that can be further used to produce electricity.

II. OBJECTIVES

- To develop two stage digester lab scale model for biogas generation and collection.
- To study the model for its biogas generation potential during day time and night time for various substrates.
- To upgrade the model suitably to maintain its temperature at enhanced thermal condition for prospective biogas generation studies.
- To study the kinetics involved for the gas generation at desired conditions.

III. METHODOLOGY

- Setting up pilot scale at design value of 5litre + 10litre.
- Inserting feed which is mixture of food waste and water.

Readings-

- Parameters checking-
  1) pH
  2) Temperature
  3) COD
  4) Gas generation
- Digestion period – 10 days
- 3 days in first digester (Thermophilic)
- 7 days in second digester (Mesophilic)
- Digester was added with calcium carbide (CaC_2) for generation of heart to maintain thermophilic condition. Here secondary digester was covered with aluminium foil.

Basic process mechanism 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.

BIOLOGICAL PROCESS (MICROBIOLOGY)

1. HYDROLYSIS
2. ACIDIFICATION
3. METHANOGENESIS.

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 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 bounded oxygen. Hereby, the acid producing bacteria creates anaerobic

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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 bacteria 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 bacterias. The main difference lies in the makeup of the bacteria's cell walls.

Symbiosis of Bacteria:
Methane and acid-producing bacteria act in a symbiotical way. Acid producing bacteria create an atmosphere with ideal parameters for methane producing bacteria (anaerobic conditions, compounds with a low molecular weight). On the other hand, methane-producing microorganisms use the intermediates of the acid producing bacteria. Without consuming them, toxic conditions for the acid-producing microorganisms would develop. In real time fermentation processes the metabolic actions of various bacteria acts in a design. No single bacteria is able to produce fermentation products alone as it requires others too.

LAB SCALE BIOGAS PLANT SETUP

Fig 1: Image of lab scale biogas plant

IV.RESULT

Batch 1

- Primary Digester

i) Variation of pH with Time

Table 1: pH v/s Time

Days	pH
1	5.6
2	5.1
3	4.8

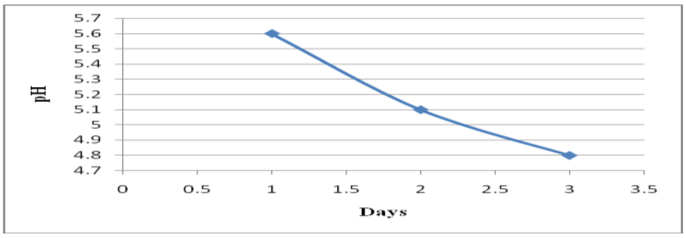


Chart 1

Graph and table number 1 gives information about variation of pH with time. From graph we can say that pH decrease with Time.

ii) Variation of Temperature with Time

Table 2: Temperature v/s Time

Days	Temperature
1	47
2	46
3	48

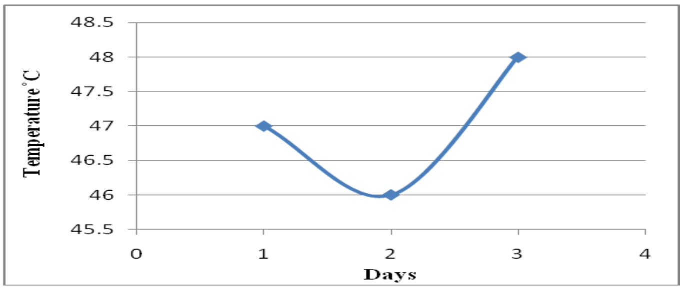


Chart 2

Graph 2 shows temperature variation with time. Primarily temperature decreases then it starts to increase and reaches its optimum level which is in favor of generation of biogas.

- Secondary Digester

iii) Variation of Temperature & gas generation with Time

Table 3: Temperature & gas generation with Time

Days	Temperature °C	Gas generation (ml)
1	30	0
2	29	10
3	31	10
4	28	20
5	24	30
6	29	20
7	26	30
8	31	70
9	30	60
10	34	90

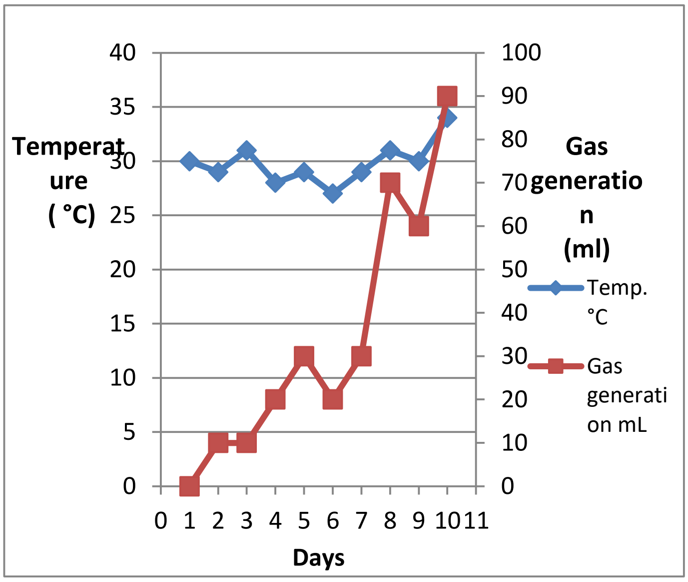


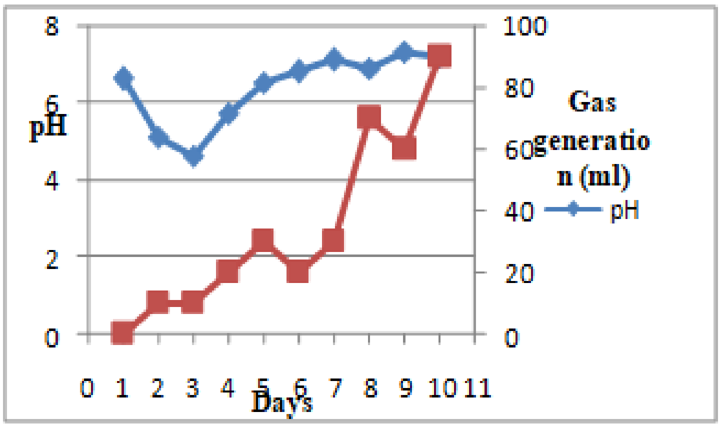
Chart 3

Graph 3 shows variation of two parameters with respect to time simultaneously within it clearly shows that with increase in temperature, gas generation also increases. It shows importance of temperature for generation of biogas. With increase in time generation of biogas is generally increases.

iv) Variation of pH & Gas generation with Time

Table 4: pH & gas generation with Time

Days	pH	Gas generation (ml)
1	6.8	0
2	5.1	10
3	4.8	10
4	5.8	20
5	6.6	30
6	6.9	20
7	7.1	30
8	7	70
9	7.1	60
10	7.1	90



Graph 4 contains relation of variation between gas generation and pH. It shows that generation of gas increases with time but pH decreases primarily then increases upto 10 days and it becames basic.

v) COD removal efficiency with Time

Table 5: COD v/s Time

Days	COD
1	2000
2	2100
3	2000
4	1900
5	1600
6	1550
7	1450
8	1400
9	1300
10	1000

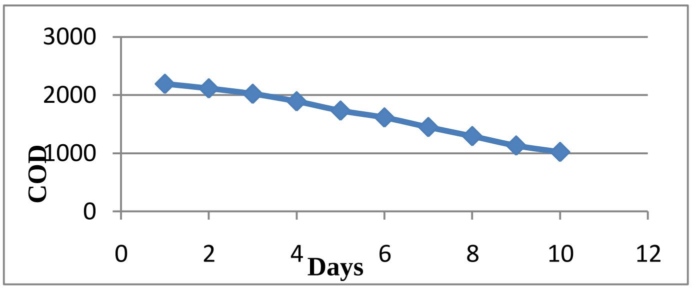


Chart 5

COD shows amount of active and inactive biomass in feed. From this we can predict amount of BOD presents in the feed easily within small duration. Above graph shows relation of COD with respect to days. COD of feed decreases with time .

Batch 2

- Digestion period – 10 days
- 3 days in first digester (Thermophilic)
- 7 days in second digester (Mesophilic)
- Digester was covered with black sheet for trapping the heat.
- Parameters checked:
  1) pH
  2) Temperature
  3) COD
  4) Gas generation
- Primary Digester

vi) Variation of pH with Time

Table 6: pH v/s Time

Days	pH
1	5.6
2	5.1
3	4.8

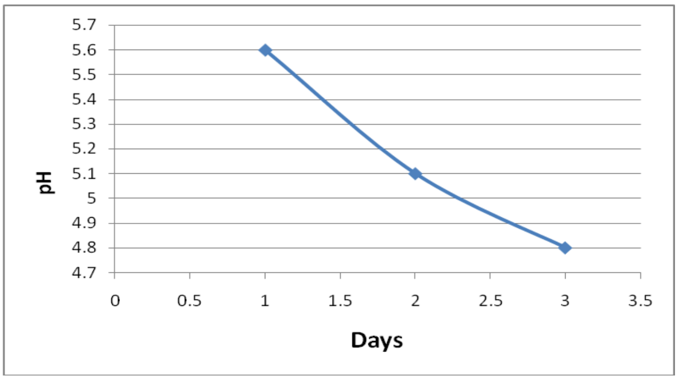


Chart 6

For batch 2 of duration 10 days. We measured variation of pH for first 3 days in primary digester for thermophilic condition. It shows decreasing in pH same as in first batch.

vii) Variation of Temperature with Time

Table 7: Temperature v/s Time

Days	Temperature
1	47
2	46
3	48

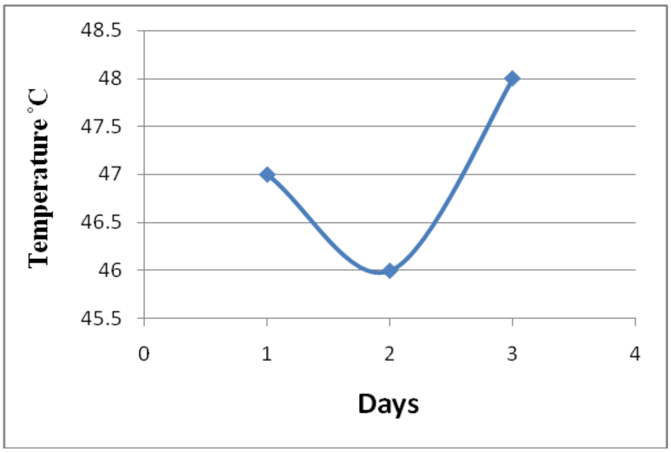


Chart 7

Temperature variation in primary digester shows U shaped curve . it is primarily decreases upto 24 hours then start to increase and reaches 48^{0}C which is favorable to thermophilic condition .

- Secondary Digester

viii) Variation of Temperature & gas generation with Time

Table 8: Temperature & gas generation v/s Time

Days	Temperature	Gas generation
1	34	0
2	32	0
3	34	0
4	31	20
5	32	30
6	33	40
7	34	50
8	35	70
9	36	90
10	35	80

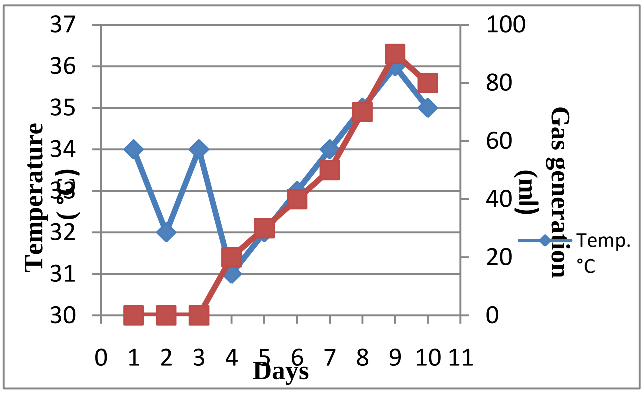


Chart 8

Graph 8 shows relations of gas generation with respect to days and effect of temperature. It is seen that with increase in duration, temperature and gas generation increases simultaneously.

ix) Variation of pH & gas generation with Time

Table 9: pH & gas generation v/s Time

Days	pH	Gas generation
1	7	0
2	5	0
3	5.1	0
4	5.9	20
5	6	22
6	6.2	40
7	7	50
8	6.9	70
9	7.1	90
10	7.5	80

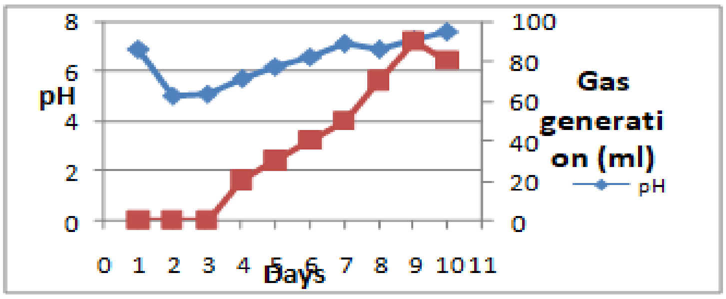


Chart 9

Graph 9 contains relation of pH and gas generation with time It is conducted for days graph shows that pH variation is primary in acidic with duration it goes in the basic condition and it helps for gas generation.

x) COD removal efficiency with Time

Table 10: COD removal efficiency v/s Time

Days	COD
1	2300
2	2200
3	2050
4	2000
5	1800
6	1700
7	1550
8	1400
9	100
10	1100

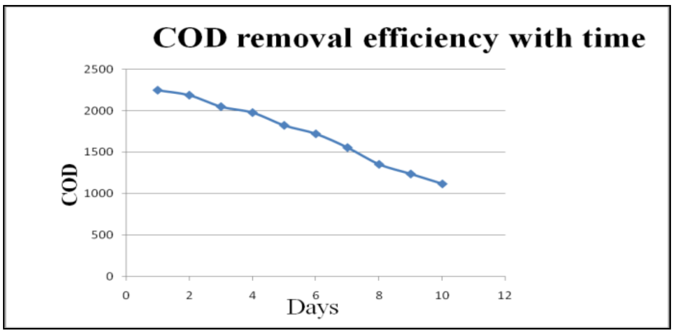


Chart 10

COD removal of second batch is shown in above graph 10 with this we see that COD decreases with time.

V. CONCLUSIONS

- The Biogas setup based on kitchen wastes was implemented on small scale setups to find the effects of the process parameters on the biogas production. It was found that the pH and temperature conditions had huge influence on the working of the biogas plant.
- The project work signifies that the kitchen waste can be used as a potential source for biogas production using two stage digestion process and thus effective waste management can be achieved.

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