Thermophilic Biogas Digester for Efficient Biogas Production from Cooked Waste and Cow Dung and Some Field Study

Nirmal Halder*

*Department of Mechanical Engineering, PhD research scholar, IIT Kanpur, Kanpur, U.P, India
(subho.nirmal@gmail.com)

Received: 23.12.2016 Accepted:13.03.2017

Abstract- In present investigation, for efficient biogas production from cooked waste or kitchen waste, a thermophilic biogas digester was designed. Thermophilic environment was maintained by heating the water with the help of a thermostat valve and the water was kept inside the outer jacket of digester. Copper constant thermocouples were inserted at several locations inside the digester for monitoring temperature. Temperature reading of thermocouples was being displayed with the assist of a Data Accusation System. Biogas production was examined with variation of temperature and different amount of feed material. It is observed that thermophilic digestion is more efficient as compared to mesophilic digestion. Biogas production was increased by increasing the amount of cooked waste in feed material.

Keywords Biogas, multi feed, digester, mesophilic, thermophilic.

1. Introduction

Due to unavailability and high increasing price of fossil fuel and also its worse impact on environment particularly greenhouse gas emissions, has stimulated mankind to search for a alternative source of energy which will be environment friendly as well as abundantly available also economically viable [1]. The main alternative sources of energy are Hydropower, Biomass and biofuels, Wind power, solar power, Geothermal. Among these hydropower, wind power site specific where as solar power is very costly. Cheapest and abundantly available alternative energy is biomass and biofuel. One of the easiest and cheapest ways for obtaining energy from this biomass is anaerobic fermentation of cellulose organic material [2]. Cattle dung is used extensively as feed material in biogas production in India [3, 4]. Due to economic conditions, most farmers in Indian villages are having inadequate bovine rearing leading to the deficit of cattle dung. However, there is abundant reserve of biomasses generated from agriculture and from kitchens of Indian villages. Similarly, large amount of bio-waste from urban areas are also generated posing health hazard and sanitation problem. Hence, importance on use of the alternative feedstock like cooked kitchen waste, to generate biogas and dispose the slurry as bio-fertilizer is an attractive proposition to maintain sanitation, health as well as to reduce the use of fossil fuel in cooking, home lighting, etc. The temperature affects the success of the digestion process, as the activities of the anaerobes causing waste decomposition are temperature dependent. The optimal temperature ranges are the mesophilic, namely 30–38°C, and the thermophilic 44–57°C, respectively. Apart from this, there is also a temperature range, named Psychrophilic which is valid for below 15°C but psychrophilic temperature is not suitable for anaerobic digestion. Several studies has been carried out to investigate the performance of mesophilic anaerobic digestion with cattle dung, olive mill wastewater, fruit and vegetable waste, mixture of manure and straw, cheese whey as a feed material [5-15]. Also several researchers examined the behaviour of thermophilic digestion by using olive mill wastewater, paper mill waste, agricultural waste, coffee-bean extract, garbage, swine manure, dairy cattle manure as a feed material [16-26]. Thermophilic digestion has become in recent decade an important alternative to mesophilic digestion because it offers several potential advantages compared to mesophilic temperature. First, hydrolysis and biochemical reactions are faster than those at low temperatures [27]. Second, the maximum specific growth rates of microorganisms increase with temperature [28, 29]. Third, the destruction of pathogens organisms and weed seeds are more efficient at higher temperature [30]. Moreover, specific biogas production rates are higher under thermophilic conditions than under mesophilic conditions which may lead to an improvement in the energy balance [31]. The thermophilic temperature range is worth considering because it will lead to give faster reaction rates, higher gas production, and higher rates of the destruction of pathogens and weed seeds than the mesophilic temperature range [32]. From the Characterization of Cooked waste [33] it was found that cooked waste has very high COD (chemical oxygen demand), very high total solid content (55.01%) and low ash content. This makes cooked waste as most potential feedstock for biogas production. Higher moisture, high fixed-carbon content in cooked waste indicates it's lower biodegradability. So for a efficient digestion and biogas production, cooked waste needs thermophilic digestion. This is comprehensively supported by S.E.M (Scanning Electron Microscope) and TGA (Thermogavimetric) analysis. From the literature review it is quite explicit that lower bio-degradable complex feed materials are difficult to digest in a conventional biogas digester. There are very few reports are available on feed materials, like cooked waste instead of abundant availability.

However methane production has been investigated by several authors [34]. Biogas prduction from cafeteria waste (CW), vegetable waste (VW) and fruit waste (FW) also has been inspected [35]. A cow-dung fed digester has been also supervised by different author [36]. Several applicaton of biogas has been discussed by varous author [37-38]. Anggono et al. Discussed about the behaviour of biogas [39]. I.Syaichurrozi et al. produced biogas from various waste [40]. M. Ilbas et al. discusses the combustion behaviours of biogases [41].

2. Material & Methods

2.1. Basic concept & Design

In present study cooked waste has been considered as a feed material, but due to presence of high oil in cooked waste, hydrolysis process in biogas generation becomes a problem which inhibits biogas production. Also cooked waste requires high heating value for complete digestion. In order to achieve high heating value and easy hydrolysis process, conventional digester will not be suitable. Hence our present aim is to design a thermophilic type biogas digester which involves low cost. To maintain thermophilic temperature, other researchers have spent a lot of money as well as their method is quite complicated. But here we have followed some convenient as well as less cost involved method. In current inspection, thermophilic environment is created by heating the water with a immersion heater controlled by a thermostat valve and the water is kept inside the outer jacket of digester.

2.2. Design calculation

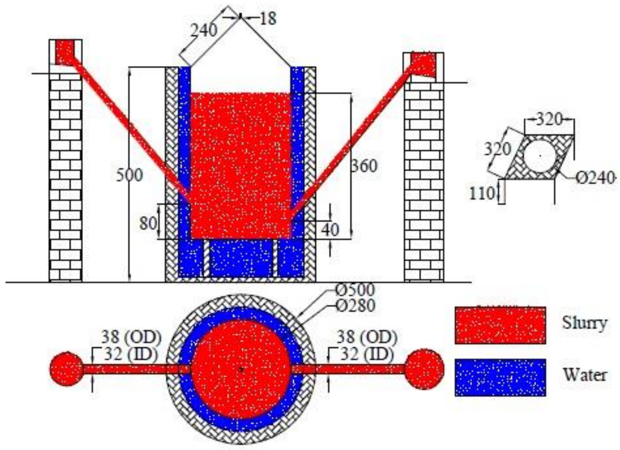

Fig. 1. Multi feed thermophilic biogas digester

Table 1. Dimension of thermophilic biogas digester

No	Particulars	Dimension (in mm)
1	Inlet Pipe	Length = 420
2	Outlet pipe	Length = 480
3	Diameter of pipe(inlet & outlet)	Outer diameter:38 Inner diameter:32
4	Diameter of inner cylinder	280
5	Diameter of outer cylinder	500
6	Height of the inner cylinder(without conic section)	450
7	Height of the outer cylinder	500
8	Clearance between bottom of outer cylinder & inner cylinder of digester	140
9	Clearance between outer cylinder & inner cylinder of digester	110

W=Weight of animal wastes fed per day (kg/day)

G=Gas production rate (m^3/day)

V_s=Active slurry volume in the digester (m^3)

V_{sd} =Slurry displacement volume (m^3)

$V_d = V_{Total}$ = Total volume of digester (m^3)

D=Diameter of the digester (mm) = 280 mm

R= radius of the digester (mm) = 140 mm

H=Height of digester (mm) =450 mm

d=Slurry displacement inside the digester (cm)

- Active slurry Volume of Digester, V_s :

$$V_{Total} = \pi r^2 H + (\pi r^2 h / 3) \quad (1)$$

Here R = 14 cm, H = 45 cm, r = 14 cm, s = 24 cm, h= 19.5 cm (by using Pythagoras formula)

$$V_{Total} = \pi r^2 H + (\pi r^2 h / 3)$$

$$= \pi.(14)^2.45 + \{ \pi.(14)^2 (19.5)\} / 3$$

$$= 31,711.23624\ cm^3$$

$$= 0.031711\ m^3$$

Therefore Active slurry Volume of Digester, $V_s = V_{Total} = 0.031711\ m^3$

- Gas production rate, G:

As per Thumb rule gas production rate, G will be one third of total volume of digester.

$$\text{Gas production rate, } G = 1/3 \text{ of } V_s \quad (2)$$

$$= 1/3 \text{ of } 0.031711\ m^3$$

$$= 0.0105\ m^3 \text{ per day}$$

- Amount of feed, $W_{un\text{-}diluted}$:

One kg of undiluted cattle dung roughly yields about 0.04 m^3 of the gas. Hence,

$$G= 0.04\ W_{un\text{-}diluted} \quad (3)$$

$$\Rightarrow W_{un\text{-}diluted} = G / 0.04$$

$$= 0.010570412 / 0.04$$

$$= 0.26425 \text{ kg per day}$$

$$= 264.2603 \text{ gm per day}$$

$$= 265 \text{ gm per day}$$

- Amount of feed material fed into the digester, W_{Total}

= (265 gm undiluted cattle dung + 265 ml water) per day

= 530 gm per day

- Total initial feeding:

$$= W_{Total} \times HRT \quad (4)$$

= 530 x 55 (Taking HRT as 55 days)

= 29,150 gm

= 29.15 kg

- Slurry displacement inside digester, d:

V_{sd} = Slurry displacement volume (m^3)

D=Diameter of the digester (cm)

d=Slurry displacement inside the digester (m)

As cooking is usually done two times in a day, 50% of the gas produced in a day should be made available for one cooking span. But, as there is a continuous production of gas from the digester, the gas generated during the cooking time should also be considered. Assuming 3-hour cooking for evening and morning, variable gas storage V_{sd} can be expressed as,

$$(3G / 24) + V_{sd} = 0.5G \quad (5)$$

$$\Rightarrow V_{sd} = 0.375G$$

$$= 0.375 \times 0.010570412$$

$$= 0.003963\ m^3$$

$$\& \quad (\pi/4)D^2.\ d = V_{sd} \quad (6)$$

$$\Rightarrow \frac{\pi}{4}(0.28)^2.\ d = 0.003963$$

$$\Rightarrow d = 0.06437\ m$$

$$= 6.43\ cm$$

2.3. Design methodology

Total 12 no. of copper constant thermocouples (T Type) are inserted at the various location of all along the digester, for measuring the temperature of the feed material fed into it. 3 pieces of U, 3 pieces of Z, 3 pieces of W and 3 pieces of X thermocouples are kept 14, 10, 7, 5 cm inside the inner cylinder respectively. Also 4 thermocouples are inserted in the outer cylinder containing water, in order to measure the temperature of the water. 2 pieces of V and 2 pieces of Y thermocouples are kept 10, 8 cm inside the outer cylinder respectively. Thermocouples are inserted in the digester by placing them within a copper tube having 5 mm diameter. Temperature reading of each thermocouple is displayed through Data Acquisition System. It is observed that, while outside temperature of digester is maintained at 35°C, then a mesophilic environment (temperature at about 32°C) is found inside the digester. Similarly when outside temperature was maintained at 48°C then inside the digester, thermophilic environment (temperature at about 45°C) is achieved.

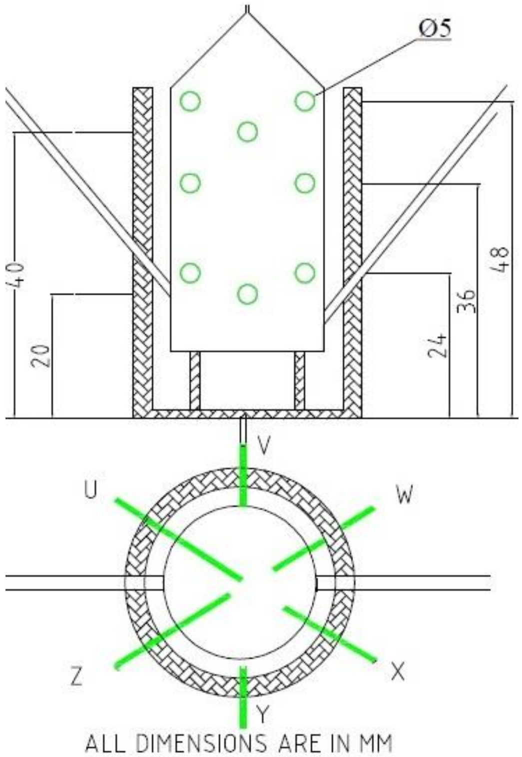

Fig. 2. Location of thermocouple in digester

To prevent the heat loss associated with the digester, proper insulation is done by wrapping the outer surface of outside cylinder with ceramic wool and asbestos sheet. Proper insulation of the digester helps to increase the gas production.

Measurement of the gas production is done by water column displacement method. Here a flexible pipe is so connected that one end of a flexible pipe is connected to the nozzle shaped extended part from outlet gate valve, while the other end is inserted in an inverted measuring cylinder.

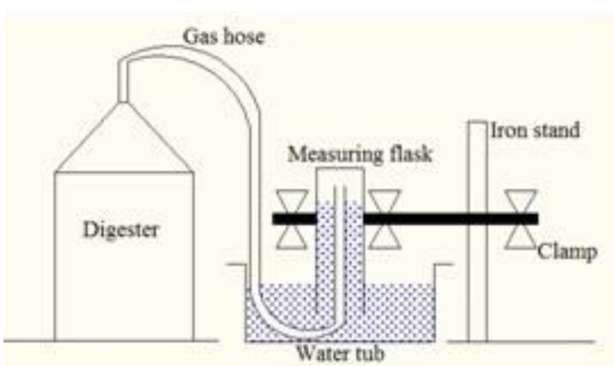

Fig. 3. Set up made for measurement of gas production of digester.

2.4. Mechanism of biogas technology

The digestion of manure occurs in four basic stages as mentioned below:

2.4.1 First step

The organic matter (carbohydrates, proteins, lipids) is hydrolysed to soluble compounds (amino acids and sugars) with the aid of cellulytic proteolytic lypolytic bacteria.

$$C_6H_{10}O_5 + 2H_2O \longrightarrow C_6H_{12}O_6 + 2H_2 \quad (7)$$

2.4.2 Second step

The soluble compounds (amino acids and sugars) are fermented into volatile fatty acids in the presence of fermentive bacteria

$$C_6H_{12}O_6 \longleftrightarrow CH_3CH_2OH + 2CO_2 \quad (8)$$

$$C_6H_{12}O_6 + 2H_2 \longleftrightarrow CH_3CH_2COOH + 2H_2O \quad (9)$$

$$C_6H_{12}O_6 \longleftrightarrow 3CH_3COOH \quad (10)$$

2.4.3 Third step

Fermentation-acetogenesis forms hydrogen, carbondioxide and acetate from fatty acid with the help of hydrogen producing bacteria

$$CH_3\,CH_2COO^- + 3H_2O \longleftrightarrow CH_3COO^- + H^+ + HCO_3^- + 3H_2 \quad (11)$$

$$C_6H_{12}O_6 + 2H_2O \longleftrightarrow 2\,CH_3COOH + 2CO_2 + 4H_2 \quad (12)$$

$$CH_3\,CH_3OH + 2H_2O \longleftrightarrow CH_3COO^- + H^+ + 2H_2 \quad (13)$$

2.4.4 Fourth step

Methanogenic bacteria produce biogas (consist of methane and carbon dioxide) from acetates and hydrogen by methanogenesis process.

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O \quad (14)$$

$$2\,C_2H_5OH + CO_2 \longrightarrow CH_4 + 2CH_3COOH \quad (15)$$

$$CH_3COOH \longrightarrow CH_4 + CO_2 \quad (16)$$

3. Results and Discussion

3.1. Temperature profile inside digester

To obtain a comparison in performance between mesophilic and thermophilic digester, initially a mesophilic environment is maintained by keeping the temperature of water, outside the digester at about 35°C. Later on a thermophilic environment is maintained by maintaining the same at about 48°C.

Diameter of digester is 28 cm. At -4 cm, 0, +7 cm, +9 cm position there are Z, U, W, X thermocouples respectively. With thermostat valve outside temperature of digester maintained at 35°C. Here in radial direction we can take 3 sections inside the digester as indicated in figure 4. Taking the average value from three sections, Mesophilic Temperature profile in the radial direction inside the digester is plotted. It is observed that, inside temperature of digester along radial direction varies from 32 to 32.3°C.

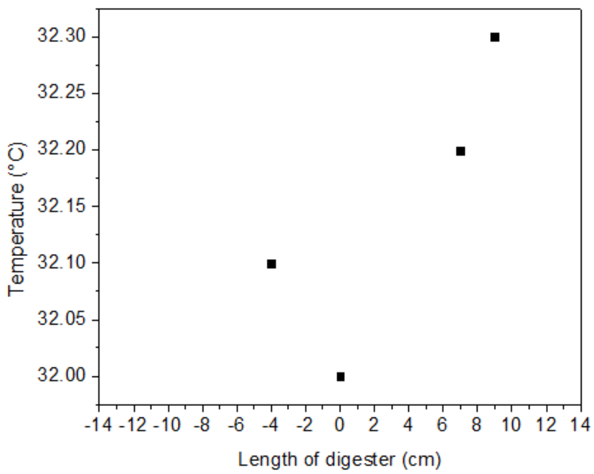

Fig. 4. Mesophilic Temperature profile in the digester along radial direction.

Height of digester is 45 cm. along vertical direction inside the digester at the height of 12.8, 24.8, 36.8 cm there are thermocouples. Also at -4 cm, 0, +7 cm, +9 cm position there are Z, U, W, X thermocouples respectively. At each position (as indicated in figure 5) there will be a vertical mesophilic temperature profile. Taking the average value from these sections, a vertical mesophilioc temperature profile of digester is shown. With thermostat valve outside temperature of digester maintained at 35°C. It is observed that, inside temperature of digester along vertical direction varies from 32 to 32.2°C.

In similar way by maintaining outside temperature of digester maintained at 48°C thermophilic temperature profile is retained in the radial as well as in vertical direction inside the digester as described in figure 6 and 7 respectively.

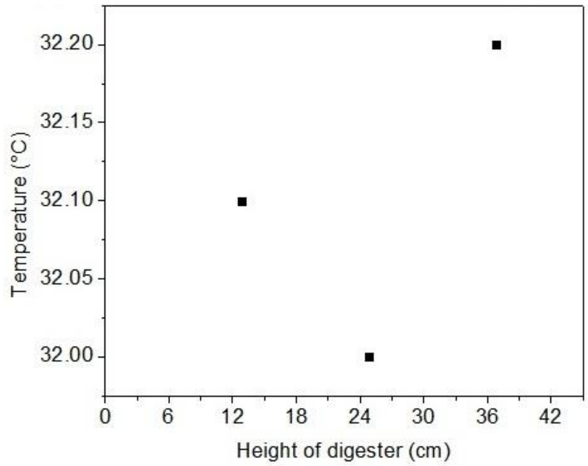

Fig. 5. Mesophilic Temperature profile in the digester along vertical direction.

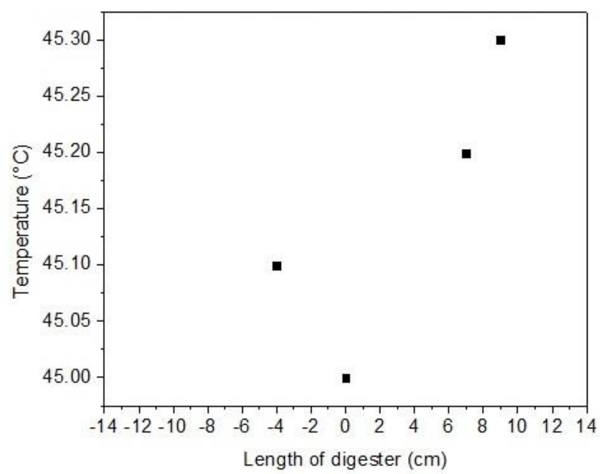

Fig. 6. Thermophilic Temperature profile in the digester along radial direction.

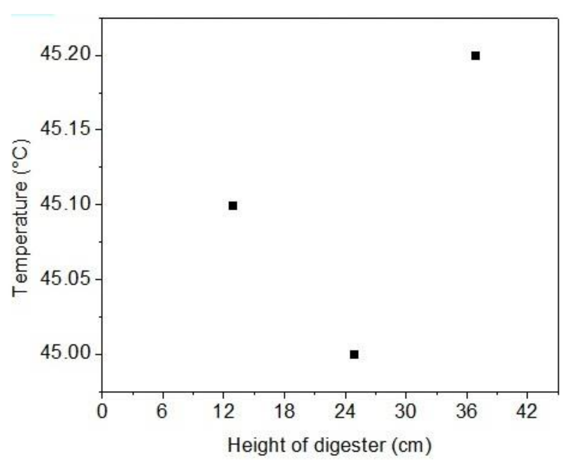

Fig. 7. Thermophilic Temperature profile in the

digester along vertical direction.

3.2. Mesophilic digestion with cow dung and cooked waste (cow dung: cooked waste = 1:1 in quantity)

Per day gas production, with feed material as a mixture of both cow dung and cooked waste in the ratio of 1: 1 in quantity, for mesophilic digestion, has been shown in the figure.8. From starting up to 10 days biogas produced, no longer becomes combustible (not started to burn) due to having lower content of methane. Therefore biogas discharged as unused. Production of combustible biogas (contains higher amount of methane) has been observed from 11th day onwards, and hence it has been collected. Here it is observed that, range of production of gas is from 0.005904 m^3 to 0.006232 m^3.

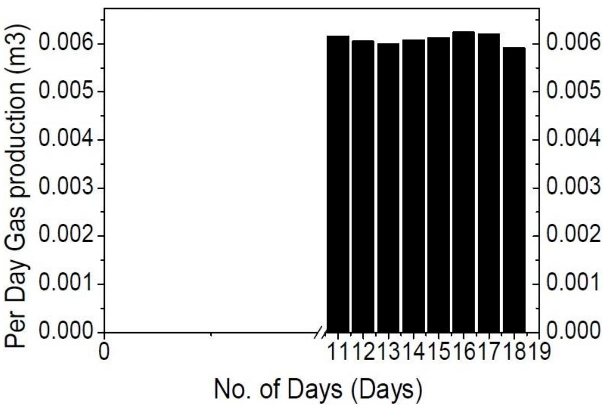

Fig: 8. Mesophilic digestion with cow dung and cooked waste (cow dung: cooked waste = 1:1 in quantity)

3.3. Thermophilic digestion with cow dung and cooked waste (cow dung: cooked waste = 1:1 in quantity)

Considering feed material as a mixture of both cow dung and cooked waste in the ratio of 1: 1 in quantity, Per day gas production, for thermophilic digestion, has been shown in the figure.9. It has been noticed that to produce combustible biogas (contains higher amount of methane), digester takes 14 days. So from 14th day onwards, biogas has been collected. Here it is observed that, range of production of gas is from 0.0072 m^3 to 0.0076 m^3

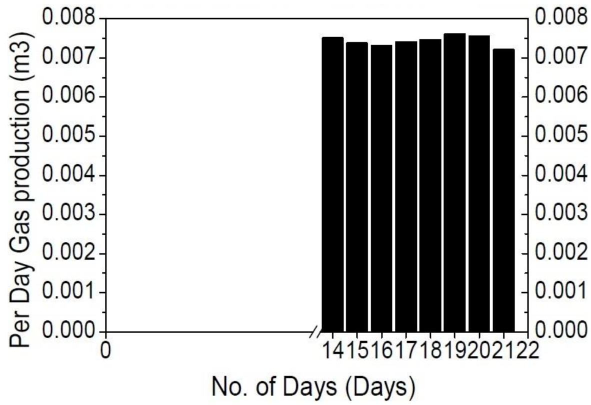

Fig. 9. Thermophilic digestion with cow dung and cooked waste (cow dung: cooked waste = 1:1 in quantity)

3.4. Comparison between Mesophilic and Thermophilic digestion with cow dung and cooked waste (cow dung: cooked waste = 1:1 in quantity)

Comparison in per day gas production, with feed material as cow dung and cooked waste in the ratio of 1: 1 in quantity, for mesophilc and thermophilic digestion, has been shown in the figure.10. Range of production of combustible gas for mesophilic digestion is from 0.005904 m^3 to 0.006232 m^3 and range of production for thermophilic is from 0.0072 m^3 to 0.0076 m^3. So near about 22% increase in gas production for thermophilic digestion as compared to mesophilic digestion, is observed.

Also it was noticed that, combustible gas production starts from 11th day onwards for mesophilic digestion, whereas for thermophilic it starts from 14th day onwards. The main reason behind it, is that low digestion temperature (mesophilic) give higher methane content as compare to high digestion temperature (thermophilic), but at the same time low digestion temperature (mesophilic) produce less amount of gas.

That's why mesophilic digestion produce less amount of gas, but the gas becomes combustible quicker than thermophilic digestion due to higher methane content.

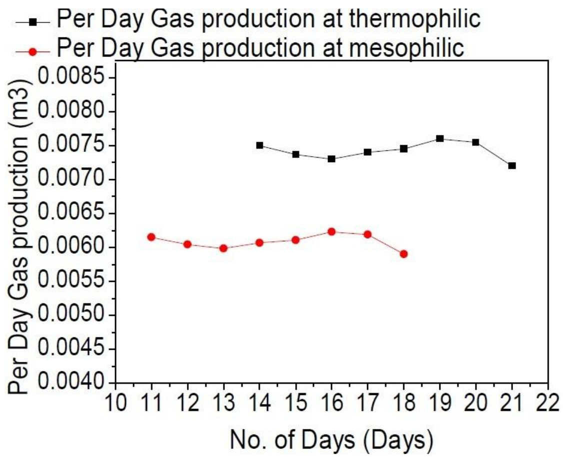

Fig. 10. Comparison between Mesophilic and Thermophilic digestion with cow dung and cooked waste (cow dung: cooked waste = 1:1 in quantity)

3.5. *Thermophilic digestion with cow dung and cooked waste (cow dung: cooked waste = 2:1 in quantity)*

Per day gas production, with feed material as mixture of both cooked waste and cow dung in the ratio of 2: 1 in quantity, for thermophilic, has been shown in the figure.11.From starting up to 14 days the biogas produced, no longer becomes combustible (not started to burn) and therefore discharged as unused. From 15th day onwards, biogas (contains higher amount of methane) has been collected. Here it is observed that, range of production is from 0.0082 m^3 to 0.0086 m^3.

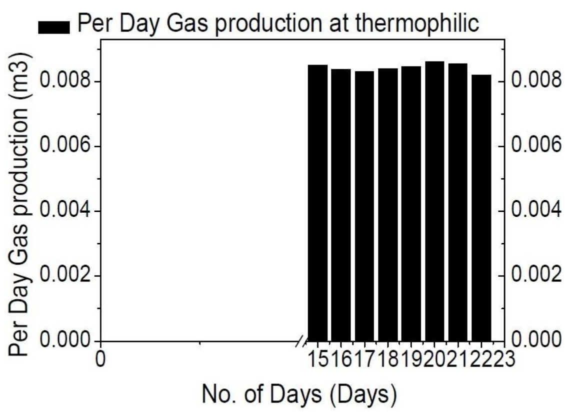

Fig. 11. Thermophilic digestion with cow dung and cooked waste (cooked waste: cow dung: = 2:1 in quantity)

3.6. *Thermophilic digestion with cow dung and cooked waste (cow dung: cooked waste = 2.5:0.5 in quantity)*

Per day gas production, with feed material as mixture of both cooked waste and cow dung in the ratio of 2.5: 0.5 in quantity, for thermophilic, has been shown in the figure.12.From starting up to 15 days the biogas produced, no longer becomes combustible (not started to burn) and therefore discharged as unused. From 16th day onwards biogas (contains higher amount of methane) has been collected. Here it is observed that, range of production is from 0.008750 m^3 to 0.009110 m^3.

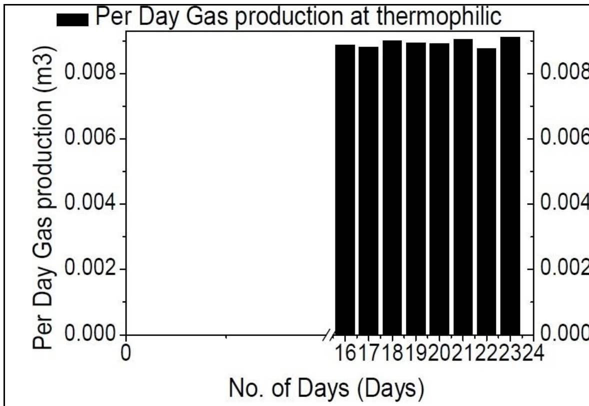

Fig. 12. Thermophilic digestion with cow dung and cooked waste (cooked waste: cow dung: = 2.5:0.5 in quantity)

3.7. *Thermophilic digestion with cow dung only*

Per day gas production, with feed material cow dung, for thermophilic, has been shown in the figure.13. From starting up to 11 days the biogas produced, no longer becomes combustible (not started to burn) and therefore discharged as unused. From 12th day onwards, biogas has been collected. This biogas contains higher amount of methane. Here it is observed that, range of production is from 0.0042 m^3 to 0.00455 m^3.

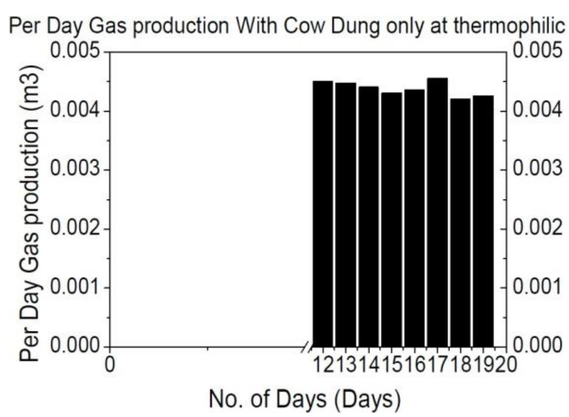

Fig. 13. Thermophilic digestion with cow dung only

3.8. *Comparison in feed material in Thermophilic digestion*

Comparison in per day gas production, due to changes in feed material for thermophilic digestion, has been shown in the figure.14. Range of production, for cow dung as feed material, is from 0.0042 m^3 to 0.00455 m^3 and range of production for mixture of cow dung and cooked waste (1:1 in quantity) is from 0.0072 m^3 to 0.0076 m^3, where for mixture of cooked waste and cow dung (2:1 in quantity) is from 0.0082 m^3 to 0.0086 m^3. For mixture of cooked waste and cow dung (2.5:0.5 in quantity) is from 0.008750 m^3 to 0.009110 m^3. Here near about 70% increase in gas production, for the feed material as mixture of cow dung and cooked waste (1:1), as compared to feed material as cow dung, is noticed. And near about 13% increase for mixture of cooked waste and cow dung (2:1), as compared to cooked waste and cow dung (1:1) is observed. Also near about 6% increment in gas production is noticed for mixture of cooked waste and cow dung (2.5:0.5) compared to mixture of cooked waste and cow dung (2:1).

Also it was observed that, combustible gas production starts from 12th day onwards for thermophilic digestion with cow dung as feed material, whereas for mixture of cow dung and cooked waste (1:1 in quantity) at thermophilic starts from 14th day onwards. For the feed material as the mixture of cooked waste and cow dung (2:1 in quantity) at thermophilic, gas become combustible from 15th day onwards. But for the feed material as the mixture of cooked waste and cow dung (2.5:0.5 in quantity) at thermophilic, gas become combustible from 16th day onwards.

So, with increasing in quantity for cooked waste in the mixture of cooked waste and cow dung at thermophilic digestion, higher gas production is noticed, but at the same it takes more time to produce combustible biogas. This is because of, due to oil content high moisture content in cooked waste, hydrolysis becomes a problem, so it take higher time to produce combustible gas.

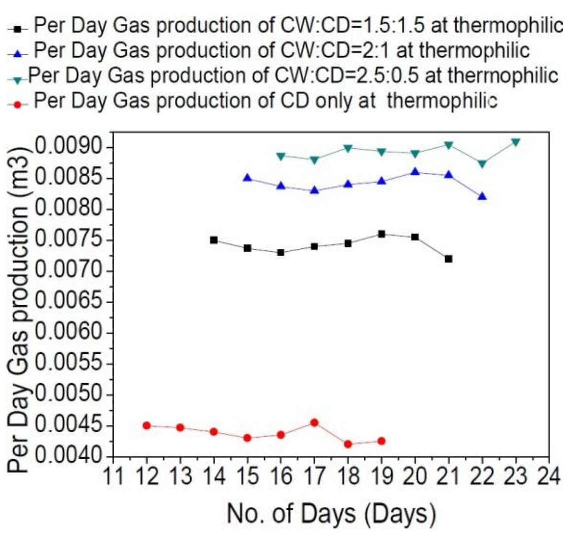

Fig. 14. Comparison in feed material in Thermophilic digestion. CW=cooked waste, CD=cow dung

4. Results and discussions of power consumption by immersion water heater and heat flow to water of outer cylinder

Power consumption by immersion water heater, P = Heat flow to water, Q

Power consumption by immersion water heater, P = V. I

where, V =Voltage in volt = 230 AC, I = Current in Ampere

Heat flow to water, Q = (m_w .C_{Pw} .dT) / (Time required to reach T_{final} from $T_{initial}$)

Where, m_w = Mass of water in outer cylinder = 72 Kg,

C_{Pw} = Specific heat of water = 4179 J/Kg.K (for 35°C) and 4182 J/Kg.K (for 48°C)

dT = Temperature difference between T_{final} and $T_{initial}$

= 35°C - 28 °C (for Mesophilic digestion), and

= 48°C - 28°C (for Thermophilioc digestion)

Time required to reach T_{final} from $T_{initial}$

= 58.8 minutes = 58.8 x 60 second (for mesophilic),and = 115 minutes = 115x60 second (for thermophilic)

For Mesophilic digestion,

Heat flow to water, Q = (m_w .C_{Pw} .dT) / (Time required to reach T_{final} from $T_{initial}$)

= (72 x 4179 x 7) / (58.8x60)

= 597 Watt

Also, Heat flow to water, Q = Power consumption by immersion water heater, P

Q= V.I

$\Rightarrow$ 597 = 230 x I

$\Rightarrow$ Current, I = 2.59 ampere

For thermophilic digestion,

Heat flow to water, Q = (m_w .C_{Pw} .dT) / (Time required to reach T_{final} from $T_{initial}$)

= (72 x 4182 x 20) / (115x60)

= 872.76 Watt

Also, Heat flow to water, Q = Power consumption by immersion water heater, P

$$Q = V.I$$

$$\Rightarrow \quad 872.76 = 230 \times I$$

$$\Rightarrow \quad \text{Current, } I = 3.79 \text{ ampere}$$

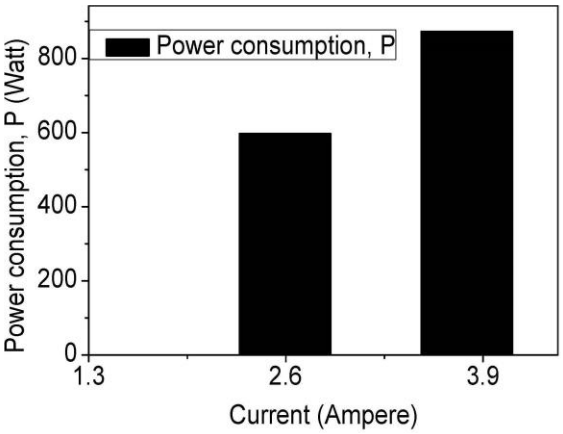

Fig: 15. Variation in power consumption with current

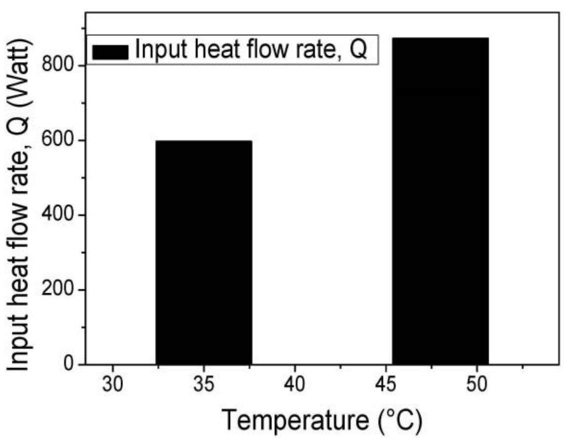

Fig: 16. Variation in heat flow rate with temperature

From above calculation and graph it can be concluded that

i. In case of immersion water heater, with the increase in current power consumption increases.

ii. In case of heat flow to water, with the increase in temperature difference (dT) heat flow increases.

5. Results and Discussions of Field Study

5.1. Field study of Angui hati shatra

Digester model: Deenbandhu model

Digester capacity: 3 m^3

Digester feed material: cow dung

Temperature maintained inside the digester: Mesophilic temperature

Volume flow rate (measured by flow meter) = 3.506 x 10^{-5} m^3 / second

5.2. Field study of IIT Guwahati (BDTC)

Digester model: Deenbandhu model

Digester capacity: 1 m^3

Digester feed material: Mixture of cow dung and cooked waste (cow dung: cooked waste =1:1 in quantity)

Temperature maintained inside the digester: Mesophilic temperature

Volume flow rate (measured by flow meter) = 2.262 x 10^{-5} m^3 / second

Also for thermophilic multi feed biogas digester

Digester capacity: 0.0105 m^3

Digester feed material: Mixture of cow dung and cooked waste (cow dung: cooked waste =1:1 in quantity)

Volume flow rate (measured by flow meter)

= 2.31 x 10^{-7} m^3 / second

6. Scaling up of digester volume flow rate for comparison

6.1. If scaling up is done for thermophilic multi feed biogas digester for making comparison with digester installed at Angui hati shatra, then after scaling Volume flow rate of digester installed at Angui hati shatra will be 3.51 x 10^{-5} m^3 / second

6.2. If scaling up is done for thermophilic multi feed biogas digester for making comparison with digester installed at IIT Guwahati campous (BDTC), then after scaling for thermophilic multi feed biogas digester Volume flow rate will be 6.60 x 10^{-5} m^3 / second

6.3. If scaling up up is done for digester installed at IIT Guwahati campous (BDTC) for making comparison with digester installed at Angui hati shatra, then after scaling Volume flow rate for digester installed at IIT Guwahati campous (BDTC) will be 6.79 x 10^{-5} m^3 / second

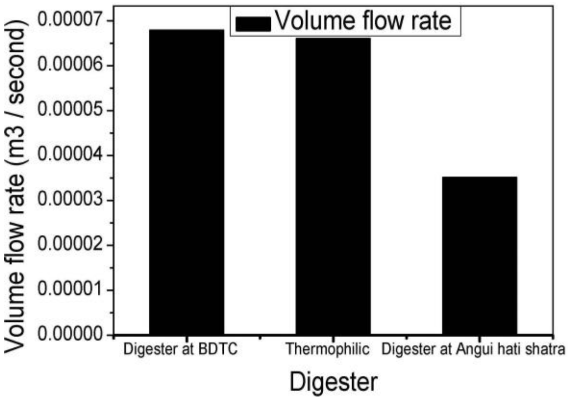

Fig. 17. comparison in performance of digester of different capacity

After scaling up it has been observed that volume flow rate of thermophilic multi feed biogas digester is nearly equal with digester installed at IIT Guwahati campus. Also, volume flow rate of thermophilic multi feed biogas digester is nearly 88.03% higher than digester installed at Angui hati shatra. Whereas, volume flow rate of digester installed at IIT Guwahati campus (BDTC), is nearly 93.44% higher than digester installed at Angui hati shatra.

7. Conclusion

With thermostat valve while outside temperature of digester is maintained at 35 °C and 48°C respectively then temperature profile is retained in the radial as well as in vertical direction inside the digester is mesophilic and hermophilic respectively.

Mesophilic digestion produce less amount of gas, but the gas becomes combustible quicker than thermophilic digestion due to higher methane content.

Cooked waste was found to be potential candidates for production of biogas. However, due to the presence of oil content in cooked waste, they have to be mixed with cow dung for effective digestion.

Near about 22% increase in gas production for thermophilic digestion as compared to mesophilic digestion, is observed while cow dung and cooked waste are in same proportion (cow dung: cooked waste = 1:1 in quantity). More amount of cooked waste in the feed material (mixture of cow dung and cooked waste) at thermophilic digestion, yields higher gas production.

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