Assessment of Biogas Potential at IUT from Cafeteria Waste

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Dedication

It is with our deepest gratitude and warmest affection that we dedicate this thesis

*to our professor **Dr. Hamidur Rahman**.*

Who has been a constant source of knowledge and inspiration.

Acknowledgement

In the name of Allah, the Most Gracious and the Most Merciful.

All praises to Allah and His blessing for the completion of this thesis. We thank God for all the opportunities, trials and strength that have been showered on us to finish writing the thesis. We experienced so much during this process, not only from the academic aspect but also from the aspect of personality. Our humblest gratitude to the holy Prophet Muhammad (Peace be upon him) whose way of life has been a continuous guidance for us.

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May God shower the above cited personalities with success and honor in their life.

Abstract

Biogas is a source of clean energy and one kind of renewable energy resource which has highly influence in waste management. Anaerobic digestion is used in formation of biogas from different organic materials and it makes sustainable, reliable and renewable energy possible. The kitchen waste and food waste have the potentiality for biogas production and at the same time the waste themselves can be treated to minimize the environmental impact and provide nutrient rich organic fertilizer. Biogas is comprised primarily of methane and carbon dioxide. It also contains smaller amounts of hydrogen sulphide, nitrogen, hydrogen, methylmercaptans and oxygen [1]. In this study will focus on production of biogas from IUT cafeteria waste and design the biogas plant. From food and kitchen wastes of Islamic University of Technology (IUT) is about 1380 kg of wastes is assessed within a month. The total biogas which can be produced is calculated 2.3 m^3/day and the total biogas plant size is 5.8327 m^3. This quantity of biogas can be used for cooking, lighting and electricity production.

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1 Introduction

Energy is an essential part of our daily life, often taken for granted by populations which enjoy the comforts of modern society. In the face of the continually rising energy demands reported globally, however, millions of communities and households, particularly in developing countries, still lack access to basic energy services such as electricity, liquid fuels, and natural gas. To achieve sustainable development in these regions, it is imperative that access to clean and affordable (renewable) energy is made available.

In this study, the use of existing biomass such as cafeteria food waste, kitchen waste and cow dung for producing clean and renewable energy through anaerobic digestion (AD) in IUT campus would improve waste management system of IUT, the campus environment and the economic conditions. AD is a biological process that converts organic matter into energy-rich biogas in the absence of oxygen. Biogas is a mixture primarily consisting of CH_4 and CO_2 – can be used as a clean renewable energy source for cooking, generating heat and electricity, and can be upgraded into biomethane for use as a transportation fuel as well. Biogas digestate, a nutrient-rich residue following digestion, can be used as a soil conditioner and/or organic fertilizer. Thus, AD can play a significant role in addressing all of the aforementioned concerns plaguing underdeveloped and developing nations while simultaneously increasing agricultural productivity[2].

A digester is a sealed vessel or container in which anaerobic digestion of organic matter occurs. The bacteria “feed” off the manure and, in the process, release biogas as a by-product. This process is referred to as anaerobic digestion, and the sealed vessel or container is thus usually referred to as an anaerobic digester[3].

1.1 Biogas

Biogas is originated from different bacteria of bio degradation of organic materials in a specific process according to anaerobic condition (without air). Biogas is clean fuel that created from anaerobic digestion. Biogas can occurs in industrial process for produced biogas as a fuel. Biogas mainly contain methane, Carbon dioxide and formed from anaerobic bacterial dicomposion of organic mixing (without oxygen). If we think about organic matter, for example food waste and animal waste, break down in an anaerobic environment (an environment absent of oxygen) then they release a mix of gases, to start with methane and carbon dioxide. Biogas used in terms of different perspectives such as electricity generation, for heating process and also vehicle fuel[4].

Table 1 Different constituent of biogas[5]

Biogas composition	Percentage
Methane (CH_4)	55-75%
Carbon dioxide (CO_2)	24-44%
Nitrogen gas (N_2)	5-6.5 %
Hydrogen sulphide (H_2S)	0.2-0.4%

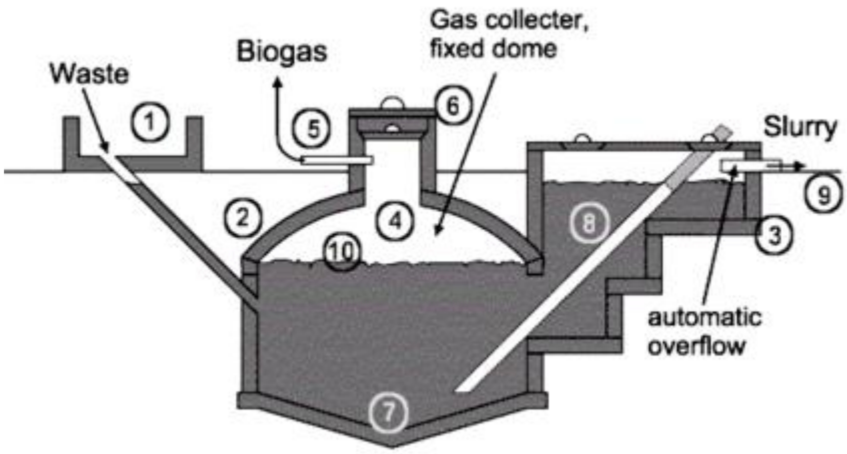

Figure 1 Basic element of fixed dome biogas plant

1. Mixing tank with inlet pipe.
2. Biogas digester
3. Compensation and removal tank
4. Gas holder
5. Gas pipe
6. Entry hatch, with gastight seal
7. Accumulation of thick sludge
8. Outlet pipe
9. Reference level
10. Supernatant scum, broken up by varying level

A permanent dome plant is a digester with a fixed, non-movable gas holder on top of the digester. The slurry is transferred to the compensation tank when gas output begins. With gas storing the amount of gas and the height difference between the slurry level in the digester and the level of slurry in the compensation tank, gas pressure is rising[6].

1.2 Why biogas?

Biogas play the important role in our daily activities. Its essentiality is broad in our surroundings. In Islamic University of Technology (IUT) has its significant roles. By the use of biogas we can easily save in our environment from different effects. Regarding the environment pollution biogas can prevent from different harmful condition under the proper used of waste. Also we can used biogas in Islamic University of Technology (IUT) for heating purpose such as cooking. If we utilize potentiality of IUT cafeteria waste, easily it can save energy production rate and it reduces economical cost. Biogas is good for controlling the climate and Carbon dioxide[7]. Biogas is an important technology being produced by the natural anaerobic digestion process. So, we decided to write about the importance of biogas to life in a Big City and also the importance of biogas to Rural Villages.[8] So overall we can say that in IUT biogas is very important.

2 Literature review

S. Cafeteria,et al[14] on "Design and Implementation of Biogas System from Dining Hall Waste of Students Cafeteria, in this study they have design a biogas plant based on cafeteria food and kitchen waste. They have collected data and calculated the potentiality of cafeteria waste and find the amount of waste gas that can be produced. They designed the digester of biogas plant.

M. Asmare, et al [13] on "Design of cylindrical fixed dome bio digester". In this paper, an attempt has been made to design and develop a cylindrical torpispherical fixed dome bio digester for cooking application in the condominium houses at Debiza site in Debre Markos, East Gojjam in Amhara Region.

U. States, et al[12] on "The Benefits of Anaerobic Digestion of Food Waste At Wastewater Treatment Facilities" This analysis puts together the findings of several labs, pilots and large scales. anaerobic co-digestion (ACD) wastewater sludge experiments of organic co-substrates Municipal solid waste, food waste, crude glycerol, farm waste and fat, petroleum and grain. Also addressed are the crucial factors affecting the ACD activity.

A. R. Pati, et al [9] on "The Anaerobic Digestion of Waste Food Materials by Using Cow Dung". In this study they have study the benefit of using cow dong in anaerobic digestion and how it works in digestion. Various digestive methods by using bacteria or microorganisms were listed in the open literature. Conversion costs rise with the use of bacteria or microorganisms. However, no details on the mechanism that explains the digestion of food waste without using the microorganism is explicitly published in the literature.

3 Anaerobic digestion

A digestion is a large reservoir in which substance are behave with heat to develop decomposition essential components[9]. Anaerobic digestion is a sequence of processes by which microorganisms break down biodegradable in the absences of oxygen[10]. Anaerobic digestion is widely used as a source of renewable energy. The process produces a biogas, consisting of methane, carbon dioxide, and traces of other 'contaminant' gases[11]. Bacteria are needed to make biogas by digesting food waste and kitchen waste. This perishable process can be done in a variety of ways. The cost of producing these bacteria or microorganism may increase. And without these bacteria, food waste and kitchen waste cannot be directly digested. For that, currently it has been made to digest food waste and kitchen waste to produce biogas using some techniques but it does not use bacteria directly. For that we can use anaerobic digester framework to deliver biogas. For the production of biogas, it would be better to use some cow dung in different ratios with food waste and kitchen waste. It acts as a methanogenic and acid forming bacteria or microorganism[12].

4 Data Collection

4.1 Data collection

In this study we have collected data for food and kitchen waste from IUT cafeteria. We are doing this study during pandemic situation that's why most of the student are out of the campus and only few students are living in hall. We have collected data for both during pandemic and before pandemic situation it is shown in table-2.

Table 2 Data table for cafeteria waste during pandemic and before pandemic

During pandemic		**Before pandemic**	
	Amount of waste(kg)		Amount of waste(kg)
Breakfast	04	Breakfast	10
Lunch	08	Lunch	14
Dinner	09	Dinner	12

In IUT there are two cafeteria but we are doing this study only for IUT central cafeteria. Data for kitchen and food waste in a day are shown in table-2. In the year 2020 average 350 people have taken their three times meal. The amount of waste might be vary day to day so we have taken average value.

Table 3 Types of cafeteria waste and its amount

Group of waste	Types	Time	Amount (kg)
Food Waste	Rice, Meat, Fish, Vegetable, Egg, Milk, Bread etc.	Breakfast lunch Dinner	10 14 12
Kitchen waste	Vegetable peelings, Onion peel, Garlic peel, Ginger, Cucumber, Carrot, Pawpaw, Sweet Pumpkin, Kitchen tea etc.		10

5 Methods

In this study we have taken into consideration the cafeteria food waste, kitchen waste and Cow dung. We have taken cow dung for anaerobic digestion. We can use, in Islamic University of Technology (IUT) campus student's cafeteria and kitchen wastes, potential have been assessed for one month.

According to data collected for 30 days; 1080 kg of dining hall wastes (food wastes) measured. 300 kg of kitchen wastes measured. Totally 1380 kg of wastes from both dining hall &kitchen wastes measured.

From different literature review we have gotten the density food waste is 1160kg/m^3[13].

Average mass food waste= 1080 kg /30 days=36 kg/day Average mass of kitchen waste =30010 kg/30 days =10 kg/day. Volume of food and kitchen wastes per day = (10 + 36)/1160 kg m^3=0.03965 m^3 / day. Total volume of both wastes (food and kitchen) = 0.03965 m^3 per day. Since the waste is wet, applying one to one ratio of water added to waters, volume of daily charge will be (0.03965*2) (m^3/day). Which implies that 0.079310 m^3 /day.

The volume of digester is defined as, the product of volume of daily charge (Q) and hydraulic retention time (HRT). But HRT, by referring different literatures, taken as 60 days.

Therefore, volume digester (VD) = Q*HRT = 0.079310 m^3 per day*60 days

$$Therefor, Volume\ odigester(VD) = Q \times HRT$$

$$= 0.079310\ m^3\ per\ day\ \times 60(HRT)$$

$$VD = 4.75m^3$$

Consequently, we have to take volume digester 4.7586m3. Organic loading rate is determined as a counter check for the digester volume. By referring different literatures assume that, -Ratio of volatile solid to total solid is 90%[14].

$$Organic\ loading\ rate(OLR) = Q \times \frac{S}{VD}$$

$$= 0.079310 \times 1160 \times \frac{0.9}{4.7586}$$

$$= \ 17.4\ kg\ substrate\ per\ m^3 per\ day$$

Therefore, organic loading rate is 17.4 kg substrate / m^3 / day. 17.4 kg substrate / m^3 / day are found to be acceptable and the calculated digester size then valid. Other studies have shown that the OLR for food waste can go as high as 10 kgVS/m^3. We have used; hydraulic retention (HRT) of this design is taken as 60 days.

6 Selection of biogas digester

6.1.1 Fixed dome biogas digester

This type of biogas digester is generally built underground and is commonly referred to as "Chinese" or "hydraulic" digesters. The biogas digester is designed to fill the digester with the entry pipe until the lower level of the expansion chamber is reached. In the upper part of the digester called gas storage, the biogas produced is accumulated and trapped under an airtight cover placed above the digester. The fixed dome biogas digester is shown in Figure 1.

6.1.2 Floating drum biogas digester

The floating biogas drum digester is designed in such a way that a drum is like an upside-down pot and floats above the gas digester. The floating biogas digester is designed in a way that the drum is like an upside-down pot and it floats over the digering sludge that catches the gas. The gasses produced from this type of digester are trapped under the floating cover of a central guide. The floating drum biogas digester is shown in Figure 2

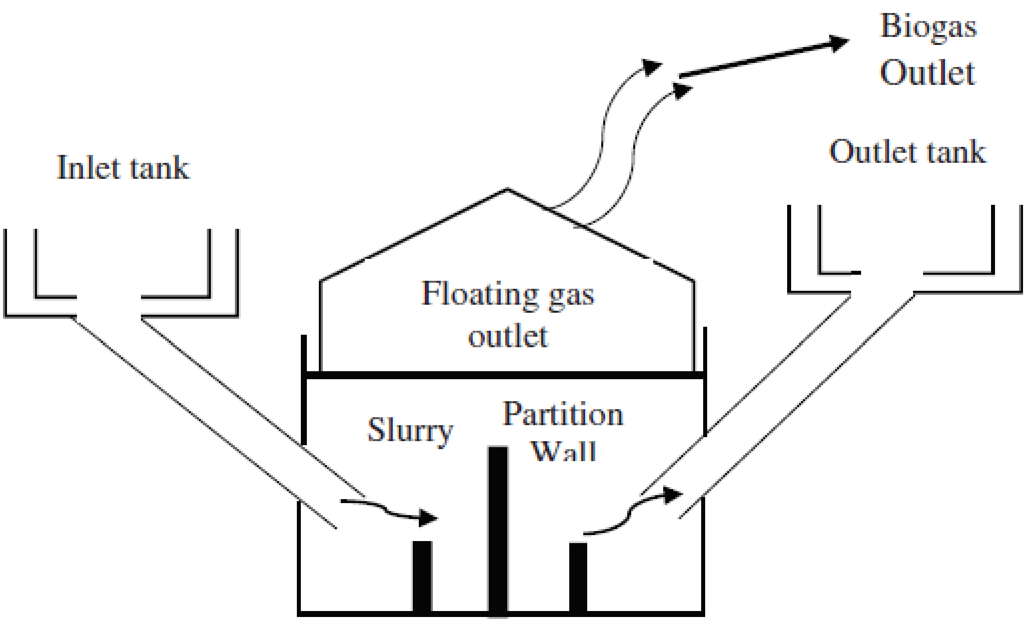

Figure 2 Flotation dome biogas digester

6.1.3 Balloon biogas digester

The balloon biogas digester is fabricated to store the produced gas in the top part of the ball. The entrance and the exit are directly connected to the balloon skin. The safety valves of this sort are important, as the pressure of the gas can be increased by putting weights on the ball. When choosing materials for these digesters, one aspect is that they must remain specially stabilized with a weather and UV resistance. The balloon biogas digester is shown in Figure 3[15].

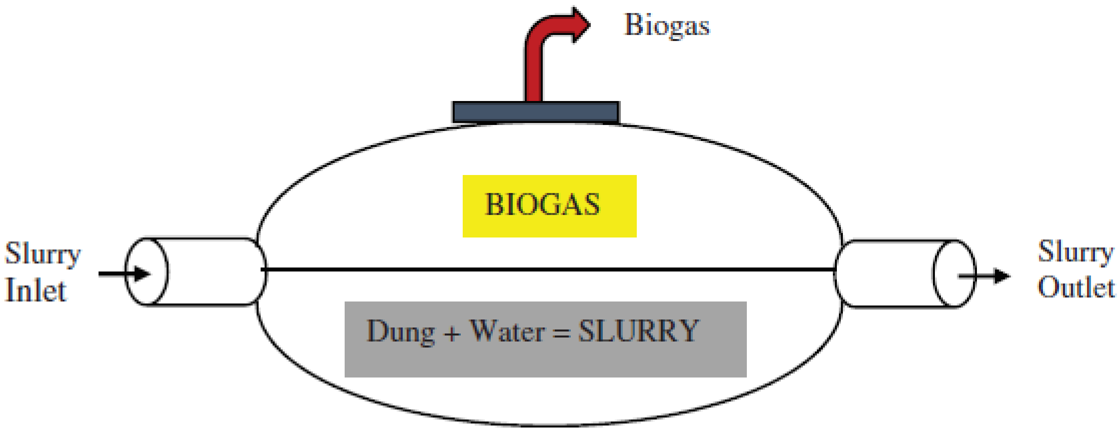

Figure 3 balloon biogas digester

6.2 Materials of biogas digester

6.2.1 Bricks/cement biogas digesters

Diverse studies have used brick and cement for the design and construction of various types of biogas digesters as the basic material. Originally designed in China, the fixed dome biogas digester is one of the most common designs fully constructed with bricks, cement and concrete. This digester contains a digester chamber, entrance chamber and outlet chambers. Some of other designs are partially made of cement and concrete including in-situ concrete digester and floating drum digester.

6.2.2 Plastics biogas digesters

For a long time plastics have been commonly used in biogas engineering. It is popular in countries such as China, India, Vietnam, Kenya, Bolivia, Bangladesh, Rwanda and Tanzania for the manufacture of biogas digesters. Manufacture of plastic biogas digesters stated to be due to high labor costs and leaks in convectional biogas digesters related to the use of bricks, concrete and concrete. For the fabrication of biogas digesters various types of plastics were used. Polyethylene (PE), polyvinylchloride, these plastics involve (PVC), Polystyrene, PMMA, and many more polymethyl methacrylate. Polyvinyl chloride (PVC) materials have been employed in a recent study to develop a versatile, cheap biogas digester fed by poultry waste and pig manure.[15]

6.2.3 Reinforced fiber biogas digester

Because of restrictions in the use of bricks and cement, the use of reinforced fiber in manufacturing biogas digester came to be. This has led to the creation of the biological gas digester from reinforced fibre-based material. Its main benefit is that it is airtight, simple, easy to maintain, and high gas generation in strengthened fiber digester.

6.2.4 Metallic biogas digester

Metals, especially mild steel are selected as a material for the construction of biogas digesters on the basis of their Strong tolerance and resistance to corrosion. The study showed that the manufactured biogas was inflammable and the construction material. It was relatively inexpensive. The study recommended the production of biogas as a panacea in solving the prevalent environmental issues because of waste disposal.[15]

Table 4 Advantage and disadvantage of different types of biogas digester with respective materials

Type of digester	Materials for construction/fabrication	Advantages	Disadvantages
Fixed dome	Bricks/cement/concrete/ plastic or reinforced fibre	Low initial cost and long useful life span, save spaces and well insulated	Gas leaks occur frequently, high technical skills required
Floating dome	Metal (mild steel), reinforced fibre plastics, high density polyethylene (HDPE) mixed material, bricks or reinforced concrete used for digester wall	Easy to operate and understand, gas tightness is not a problem, provide gas at a constant pressure	Steel drum is relatively expensive, short life span and rusting (corrosion) occurs frequently
Balloon digester	Reinforced plastics, red mud plastic (RMP), high strength PVC polyester fabric	Low cost, ease of transportation, high digester temperature	Low gas pressure and scum Cannot be removed during operation.

From table 4 we can see fixed dome digester has advantages that we required like low initial cost, long useful life span save space etc. So in our study we are interested to select fixed dome digester.

7 Design of fixed dome digester

7.1 Design of mixing pit

The size of mixing pit should be slightly greater than the volume of delay input. We are assuming that the shape of mixing pit is cylindrical and diameter (d) equal to height (h) and retention time 60 days. Retention time 60 days is chosen as minimum amount of time for sufficient bacterial action to take place to produce biogas.

$$V = \frac{\pi d^2 h}{4}$$

Where V is the volume of delay input

The volume of mixing pit with 10% safety factor is

$$V = \left(\frac{10}{100} \times 0.079310\right) + (0.079310)$$

$$= 0.087241\ m^3/day$$

$$Again, V = \frac{\pi d^3}{4} \quad as\ d = h$$

$$d = \left(\frac{4 \times 0.087241}{\pi}\right)^{\frac{1}{3}}$$

$$= 0.4807\ \text{m}$$

So, d = h = 0.4807 m

7.2 Design of hydraulic tank

Hydraulic tank is designed which contain 3 days of food waste for bacteria to do or work place and also, the feed flow rate of 0.07931 m^3 per day.

$$Hence, size\ of\ hydraulic\ tank = (HRT)_{ht} \times Q$$

$$V_{ht} = 3 \times 0.07931 m^3$$

$$= 0.23793\ m^3$$

In terms of diameter, hydraulic tank is cylindrical and its diameter (d) is equal to its height (h)

$$V_{th} = \pi r^2 h$$

$$0.23793 = \frac{\pi d^3}{4}$$

$$d = 0.6716\ m$$

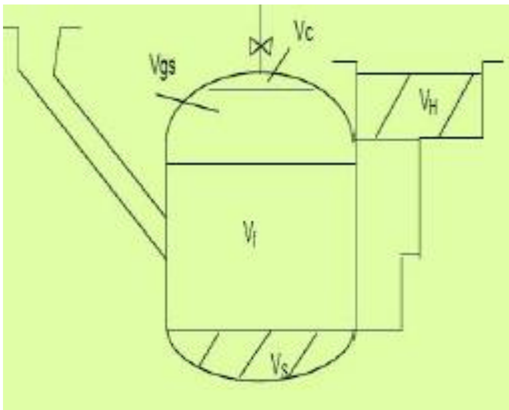

Figure 4 Cross section of fixed dome digester

7.3 Design of cylindrical dome

(i) Volume of gas collecting chamber =V_c
(ii) Volume of gas storage chamber =V_{gs}
(iii) Volume of fermentation chamber =V_f
(iv)Volume of hydraulic chamber =V_H
(v) Volume of sludge layer =V_s
(vi) Let R_1&R_2 is the crown radius of upper and bottom spherical layer of digester respectively.
(vii) S_1 and S_2 are the surface area of upper and lower dome respectively.
(viii) F_1&F_2 are max. Distance of upper and lower dome. For structure stability and efficient performance, fixed dome digester is expressed by the following correlation.

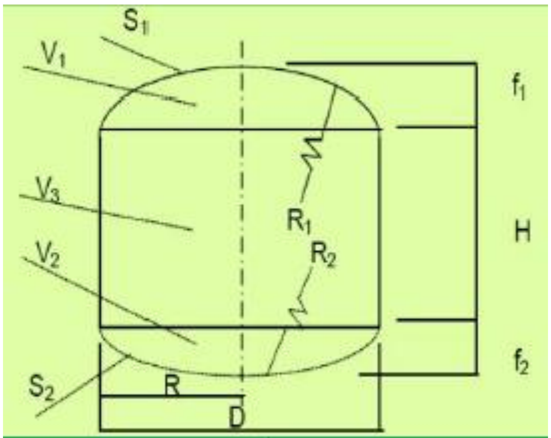

Figure 5 Geometrical dimension of the designed cylindrical fixed dome digester

Table 5 Correlation for structural stability of fixed dome digester[13]

For volume	For geometrical dimension
Vc ≤ 5% V	D=1.3078 X V_1/3
Vs ≤ 15% V	V_1=0.0827 D^3
Vgs + V_f = 80% V	V_2 = 0.05011 D^3
Vgs = VH	V_3 = 0.3142 D^3
Vgs = 0.5 (Vgs + Vf + Vs) K	R_1= 0.725 D
Where K = Gas production rate per m3 digester volume per day.	R_2= 1.0625 D
	f_1 = D/5
	f_2 = D/8
	S_1 = 0.911 D^2
	S_2 = 0.8345 D^2

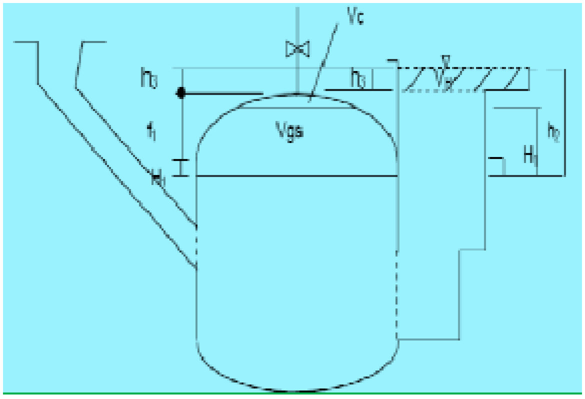

Figure 6 Complete drawing of a fixed dome digester

$$\boldsymbol{Volume\ of\ digester\ (V_d)}$$
$$V_d = V_3 + V_2$$
$$4.7586 = (0.3142 + 0.05011) \times D^3$$
$$D = 2.355\ m$$

$$R_1 = 0.725 \times D$$
$$= 0.725 \times 2.355$$
$$= 1.7074\ m^3$$

$$\boldsymbol{Volume\ of\ fermentation\ chember\ V_3 = V_f}$$
$$V_3 = 0.3142 \times D^3$$
$$= 0.3142 \times (2.355)^3$$
$$V_3 = 4.103731\ m^3$$

$$\boldsymbol{Volume\ of\ sludge\ layer\ V_2 = V_s}$$
$$V_2 = 0.05011 \times D^3$$
$$= 0.05011 \times (2.355)^3$$
$$V_2 = 0.65448\ m^3$$

$$\boldsymbol{Volume\ of\ gas\ collection\ chember\ V_c}$$
$$V_c = 0.05 \times 4.7586$$

$$V_c = 0.23793\ m^3$$

$$\boldsymbol{Maximum\ distance\ of\ upper\ dome\ f_1}$$

$$\mathrm{f}_1 = \frac{\mathrm{D}}{5} = \frac{2.355}{5} = \mathbf{0.471\ m}$$

$$\boldsymbol{Mximum\ distance\ of\ lower\ dome\ f_2}$$

$$f_2 = \frac{D}{8} = \frac{2.355}{8} = 0.294375\ m$$

$$\boldsymbol{Surface\ area\ of\ upper\ dome\ S_1}$$

$$S_1 = 0.911 \times D^2 = 0.911\ \times (2.355)^2 = 5.0524\ m^2$$

Volume of gas chamber V_1

$$V_1 = 0.08227\ \times\ D^3 = 0.08227\ \times (2.355)^3$$

$$= 1.0745\ \mathrm{m}^3$$

$$R_2 = 1.065\ \times D$$

$$= 1.065\ \times 2.355$$

$$= 2.5080\ \mathrm{m}$$

Surface area of lower dome S_1

$$S_2 = 0.8345\ \times\ D^2$$

$$\boldsymbol{= 4.6281\ m^2}$$

$$\boldsymbol{Total\ Volume, V_{total} =\ V_1 + V_2\ + V_3}$$

$$= 1.0745 + 0.65448 + 4.103731$$

$$= \mathbf{5.8327}\ \boldsymbol{M^3}$$

Volume of gas storage chamber

$$V_{gs} = 0.5\ \left(V_{gs} + V_f + V_s\right)K$$

$$V_{gs} =\ \frac{K\left(V_f + V_s\right)}{(2 - K)}$$

$$V_{gs} = \frac{0.4(4.103731 + 0.65448)}{(2 - 0.4)}\ \ (V_f\ = V_3)$$

$$\boldsymbol{V_{gs}} = \mathbf{1.18955}\ \boldsymbol{M^3}\ (V_s = V_2\ , K\ = 0.4\ )$$

$$\boldsymbol{V_3} = \frac{\pi D^2 H}{4}$$

$$H\ = \frac{4 \times 4.10373}{\pi(2.355)^2} = 0.942122m$$

$$V_c + V_{gs} = 0.23793 + 1.18955$$

$$= \boldsymbol{1.42748\ m^3}$$

$$V_1 = [\frac{\{(V_c + V_{gs}) - \{\pi \times 2.355 \times 2H_1\}}{4}]$$

$$\pi \times 2.355 \times 2 \times H_1 = (1.42748 - 1.0745) \times 4$$
$$\boldsymbol{H_1 = 0.09541\ m}$$

The value of the height of the above dome up to the end is h= 800mm

$$h = h_3 + f_1 + H_1\ , \qquad h = 800mm$$
$$h_3 = 0.80 - (0.471 + 0.09541)$$
$$= \boldsymbol{0.23359m}$$

7.4 Cost analysis

Table 6 Average cost for different materials of digester[16]

Size of Digester (m^3)	Materials	Average cost (USD)
6	Bricks/cements	450-470
	Plastic	1350
	Reinforced fibre	258-400
	Metallic	560-600

(The cost excludes labor, construction, and installation of biogas digester and land)
Building a digester is related directly to the cost of building materials. (Adeoti et al) estimated that construction costs for digesters for biogas are up to 65% and work and land for the remainder of 35%. The use of cement and steel is extremely costly[17]. Though we are having low cost for reinforced fibre it has some other limitation like fluctuation in prices, the secondary pollution after breakdown, short lifespan that lasts less than 3 years contributes to the drawback in the use of this material. That's why we are interested to select concrete as constructing materials.
Now we can calculate total cost for implementing biogas plant in IUT

$$= 470 + 470 \times 0.35$$
$$= 634.5\ \text{USD}$$
$$When\ \ the\ maximum\ construction\ cost\ for\ digester\ has\ taken\ into\ considaration$$

8 Total Gas Produced

8.1 Gas production from food waste

Now we can calculate total amount of gas produced from food waste. We already have calculated the amount of food waste per day is 36 kg. After studying many research paper we can take the gas production rate from food waste is 0.05 m^3/kg[13]
Total amount of gas produced from food waste can be calculated as, amount of food waste per day time its gas production rate.

$$Gas\ from\ food\ waste = amount\ of\ food\ waste\ per\ day\ \times its\ gas\ production\ rate$$
$$= 36\ kg \times 0.05$$
$$= 1.8\ m^3\ per\ day$$

8.2 Gas production from kitchen waste

Similarly, gas produced from kitchen waste per day,

$$= Amount\ of\ kitchen\ waste \times its\ gas\ production\ rate$$
$$= 10 \times 0.05$$
$$= 0.5m^3\ per\ day$$

8.3 Total gas production

Total gas production per day = (gas production from food waste) + (gas production from kitchen waste)

Total gas per day = (1.8 + 0.5) m^3/day
= 2.3 m^3/day

9 Result and Discussion

Volume of food and kitchen wastes per day	**0.03965 m^3**
Volume of daily charge (DC)	**0.079310 m^3 /day**
Volume of digester (DV)	**4.7586 m^3**
Total gas produced	**2.3 m^3/day**
Total Volume of the Digester	**5.8327 m^3**
Diameter of the Digester	**2.355 m**
Diameter of the hydraulic Chamber	**0.6716 m**
Volume of the hydraulic chamber	**0.23793m^3**

- The calculation shows that the total gas produced is 2.3 m^3/day.
- Other studies have shown that biogas production is depended on temperature and solar intensity of the atmosphere also the slurry temperature is always greater than the ambient temperature.

Conclusion

The design and implementation of biogas digesters have been studied here. The biogas installation contributes to higher cost reduction. Apart from the benefits of climate and sanitation. Choosing form and size of digester, retention period, waste, PH, temperature, total strength and volatile solid. Several studies have shown that biogas plants are vulnerable to failures. Cow dung is applied so that the process for bacteria generation quickly begins and speeds. Again we hope that the IUT Administration will consider its development in the near future. Biogas plant was not built practically as a result of the pandemic (Covid-19). The created gas is a major addition and saves on costs. The bio-slurry provided by methageonic helps planting and gardening in the IUT campus even as organic fertilizer. Improving the working standard of the cafeteria staff and their environment. Even if the initial investment is high to realize the facility, the total result shows that the project can be implemented. The addition of the second cafeteria waste will increase the total gas production capacity that will eventually be able to replace IUT reliance on natural gas and firewood and can also be used for generating and heating energy in a cold season.

References

[1] M. Balance, “Biogas Basics - energypedia.info,” pp. 2–7, 2020, [Online]. Available: https://energypedia.info/wiki/Biogas_Basics.

[2] K. C. Surendra, D. Takara, A. G. Hashimoto, and S. K. Khanal, “Biogas as a sustainable energy source for developing countries: Opportunities and challenges,” *Renew. Sustain. Energy Rev.*, vol. 31, pp. 846–859, 2014, doi: 10.1016/j.rser.2013.12.015.

[3] A. Digestion, “Indrotuction to biogas and anaerobic digestion,” pp. 1–8, 2021.

[4] M. Bolton, “What is Android? A beginner’s guide,” pp. 1–11, 2011, [Online]. Available: http://www.techradar.com/news/phone-and-communications/mobile-phones/what-is-android-a-beginner-s-guide-975482.

[5] K. K. Pandey, R. Randa, and N. K. Panday, “A Review on Production of Biogas by Different Techniques & its Utilisation,” *Int. J. Innov. Res. Sci. Eng. Technol. (An ISO Certif. Organ.*, vol. 57, no. 6, pp. 14073–14079, 2013, doi: 10.15680/IJIRSET.2015.0506039.

[6] Energypedia, “Fixed-dome Biogas Plants,” *Types Biogas Dig. Plants*, pp. 1–6, 2015.

[7] O. Successes, “Why Biogas,” pp. 1–3, 2014.

[8] F. Waste, A. D. Pumps, S. Sludge, S. C. Fo, and D. O. N. O. T. Accept, “The Importance of Biogas to a Big City and Rural Villages Part A – The Importance of Biogas to the London,” pp. 1–10, 2021.

[9] A. R. Pati, S. Saroha, A. P. Behera, S. S. Mohapatra, and S. S. Mahanand, “The Anaerobic Digestion of Waste Food Materials by Using Cow Dung: A New Methodology to Produce Biogas,” *J. Inst. Eng. Ser. E*, vol. 100, no. 1, pp. 111–120, 2019, doi: 10.1007/s40034-019-00134-4.

[10] US Environmetal Protection Acency, “How does anaerobic digestion work?,” *AgSTAR*, pp. 3–5, 2020, [Online]. Available: https://www.epa.gov/agstar/how-does-anaerobic-digestion-work.

[11] S. Aydin, “Anaerobic digestion,” *Waste Biomass Manag. - A Holist. Approach*, pp. 1–14, 2017, doi: 10.1007/978-3-319-49595-8_1.

[12] U. States, C. C. Mitigation, E. Benefits, D. Opportunities, and W. D. Goals, “The Benefits of Anaerobic Digestion of Food Waste At Wastewater Treatment Facilities,” *Digestion*, 2007.

[13] M. Asmare, “Design of Cylindrical Fixed dome Bio Digester in the Condominium Houses for Cooking Purpose at Dibiza Site, East Gojjam, Ethiopia,” *Am. J. Energy Eng.*, vol. 2, no. 1, p. 16, 2014, doi: 10.11648/j.ajee.20140201.12.

[14] S. Cafeteria, F. T. Mosisa, and G. S. Tibba, “Design and Implementation of Biogas System from Dining Hall Waste of Design and Implementation of Biogas System from Dining Hall Waste of Students Cafeteria at Jimma Institute of Technology , Ethiopia,” no. October, pp. 19–24, 2018.

[15] K. C. Obileke, H. Onyeaka, and N. Nwokolo, “Materials for the design and construction of household biogas digesters for biogas production: A review,” *Int. J. Energy Res.*, vol. 45, no. 3, pp. 3761–3779, 2021, doi: 10.1002/er.6120.

[16] T. Kishimoto, “Environmental research,” *NTT Rev.*, vol. 12, no. 5, pp. 36–41, 2000, doi: 10.1021/cen-v080n024.p020.

[17] A. Ten Caten, J. L. Safanelli, and L. F. C. Ruiz, “Mapeamento multitemporal da cobertura de terra, por meio de árvore de decisão, na Bacia hidrográfica do rio Marombas-SC,” *Eng. Agric.*, vol. 35, no. 6, pp. 1198–1209, 2015, doi: 10.1590/1809-4430-Eng.Agric.v35n6p1198-1209/2015.