

# Production of Biogas Using Food and Vegetable Leftovers

Sandeep A. Toshniwal

Lecturer, Department of Microbiology, Shri R.L.T. College of Science, Akola, Maharashtra, India

**ABSTRACT:** Biogas is an eco-friendly fuel produced by anaerobic digestion of organic waste, which generally comprises of 55-65 % methane, 35-45 % carbon dioxide, 0.5-1.0 % hydrogen sulfide and traces of water vapours. The objective behind present work was daily biogas production from kitchen wastes (**vegetables and leftover food**) rather than using cattle dung. In present study, the initial time period for setup of biogas production was reduced from **50 days** to **22 days**. Gas flame with an intense blue colour which indicates presence of biogas (Methane) was observed, when lit on **22<sup>nd</sup> day**. During the study, it was found that a **domestic scale** biogas plant digester (1000 litres) that produces **0.75m<sup>3</sup>** biogas/day requires **kitchen wastes (2-3 Kg/day)** and or **cow dung (6-9 Kg/day)**. Domestic scale (**plastic based**) biogas plants were found to be more useful for both **rural** and **urban** regions for its **low space** and **small investment** requirements along with long **durability** (15-20 years).

**KEYWORDS:** - Biogas, Durability, Eco-friendly, Investment, Kitchen wastes, LPG Cylinders, Methane.

## I. INTRODUCTION

Energy plays a crucial role in diverse processes and activities that take place in the society. Most of the energy sources are substitutable to each other due to the fact that some form of energy can be converted to other form (Ramachandra *et. al.*, 2003). Biomass (Bio-gas) is one such renewable, which accounts for nearly 33% of a developing country's energy needs. In India, it meets about 75% of the rural energy needs (Ramachandra *et. al.*, 2007).

### BIOGAS:

Biogas is produced by bacteria through the bio-degradation of organic material under anaerobic conditions. Natural generation of biogas is an important part of bio-geochemical carbon cycle. It can be used both in rural and urban areas.

### COMPOSITION OF BIOGAS

Biogas from sewage digesters usually contains from 55 to 65 % methane, 35 to 45 % carbon dioxide and < 1 % nitrogen, biogas from organic waste digesters usually contains from 60 to 70 % methane, 30 to 40 % carbon dioxide and < 1 % nitrogen, while in landfills methane content is usually from 45 to 55 %, carbon dioxide from 30 to 40 % and nitrogen from 5 to 15 % (Ras *et. al.*, 2007).

### MICROBIOLOGY OF THE BIOGAS:

Efficient production of biogas relies on a complex microbiological process. Controlling the biogas process in an efficient manner to ensure maximum yield requires some advanced knowledge of how microorganisms work and the microbiology underlying the biogas process. Many different organic materials can be decomposed to biogas in a digestion chamber (Gunaseelan 1997).

### PROCESS OF FORMATION OF BIOGAS:

In a biogas process, large organic molecules (proteins, sugars and fats) are successively broken down into methane and carbon dioxide, a gas mixture called biogas. The presence of several different microbial communities is

# International Journal of Innovative Research in Science, Engineering and Technology

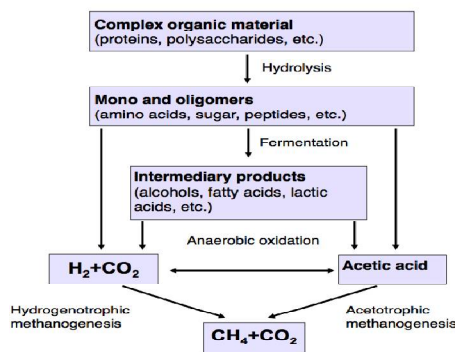
(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 2, February 2017

required for the biogas process to work. In order to form biogas as an end product, these active microorganisms also have to work together (Zinder 1986).

The various stages of decomposition and the microorganisms that are actively involved at Methanogenesis stage are described in a given below in figure 1:



Serial No.	Name of Process	Microorganisms Involved
1.	Methanogenesis	<i>Methanosaeta</i> and <i>Methanosarcina</i> , <i>Methanobacterium</i> , <i>Methanococcus</i> , <i>Methanogenium</i> and <i>Methanobrevibacter</i>
Reference: (Garcia <i>et. al.</i> , 2000, Liu and Withman 2008).		

Figure 1: The various stages of decomposition and the microorganisms that are active at Methanogenesis.

**BIO-GAS PLANT AND ITS COMPONENTS:** A physical structure designed to carry out anaerobic digestion of organic materials is called “Biogas plant”.

**Following are the components of biogas plants:**

1. **Mixing tank:** Cow dung is collected from the shed and mixed with the water to make a homogenous mixture (slurry) in the mixing tank.
2. **Feed inlet pipe/tank:** The homogenous slurry is let into the digester through this inlet pipe (KVIC biogas plants).
3. **Bio-Digester:** The fed slurry is subjected to anaerobic fermentation with the help of microorganisms inside the digester.
4. **Gas holder:** As a result of anaerobic fermentation, gas produced is stored in gas holder (Drum in the case of KVIC and in dome in the case of fixed dome biogas plants).
5. **Slurry outlet tank/pipe:** The digested slurry is let out from the digester through slurry outlet pipe (KVIC biogas plants).
6. **Gas outlet pipe:** Stored gas is released and conveyed through the gas outlet pipe present at the top of gas holder.

## II. AIM AND OBJECTIVES

1. Experimental Setup and Instrumentation of a pilot scale (10L) and Domestic scale (1000L) Biogas plant.
2. Preparation of starter culture/inoculums build-up and set up of Bio-gas plants.
3. Preparation of different types of organic substrates such as vegetable leftovers, cow dung etc. for biogas production.
4. Detection and measurement of biogas produced.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 2, February 2017

## III. RELATED WORK

### 1. Experimental Setup and Instrumentation of a pilot scale(10L) and Domestic scale(1000L) Biogas plant:

In the present study, two biogas plants having capacities 10L and 1000L respectively were used for producing biogas from food and vegetable leftovers. Both the Biogas plants used were of semi-continuous, floating drum type of biogas plants.

The advantages of using Floating drum type of Biogas plants are:

- i. The volume of the stored gas is directly visible.
- ii. The gas pressure is constant, and can be determined easily by the volume of the gas holding tank.
- iii. The construction is relatively easy, construction mistakes do not lead to major problems in operation and gas yield.
- iv. Less quantity of substrate is required.

A Biogas plant mainly comprises of following two components:

- a. Biogas holding tank.
- b. Bio-digester/Bioreactor

**1.1 Construction and designing of Pilot scale Biogas plant:** Stainless steel made biogas chamber of 10L slurry capacity was used under the outdoor simulation above the ground, so that the digester and dome both can direct receive the solar radiation. The height and diameter of the digester tank were taken as 27 x 22 in centimetres respectively. The dimensions of the Gas holding tank (7.5L) were taken as 22 x 19 in centimetres respectively. Stainless steel is more efficient to increase the sufficient temperature inside the digester which increases the production rate of biogas.

**Materials:** Two cylindrical shaped Stainless steel Containers having capacities 10L and 7.5L respectively. Two Narrow Steel pipes (3.5 cm and 2.5 cm in width respectively), Gas valve, and Black paint.

#### Methods used:

The Stainless steel containers having capacity 10L was used as bio-digester and the 7.5L capacity container was used as Gas holder tank. The gas holding tank (7.5L) was placed in an inverted position in the Bio-digester (10L) so that it may float freely on the bio-digester tank when biogas is produced. The steel pipe (3.5 cm in width) was welded in a parallel position at a distance of approximately 4-5 cm at the bottom of the Bio-digester tank as Inlet pipe to enable for input of substrates. The steel pipe (2.5 cm in width) was welded in an opposite direction at a distance of approximately 4-5 cm at the top of the Bio-digester tank as Outlet pipe to discard the digested biogas slurry and it should be perpendicular in position related to bio-digester. The Gas valve is placed on the top of the Gas holding tank (7.5L) to enable outflow of biogas produced. After this both the systems were painted with black coloured oil paint from outside and inside.

**1.2 Construction and designing of Domestic scale Biogas plant:** A cylindrical biogas chamber made up of black coloured Plastic (PVC) of 1000L slurry capacity was used under the outdoor simulation above the ground, so that the digester and dome both can direct receive the solar radiation. The dimensions of the digester tank (1000L) were taken as 46 x 41 in inches respectively. The dimensions of the Gas holding tank (750L) were taken as 40 x 38 in inches respectively. Here plastic moulded biogas plant was used.

#### Materials:

Two cylindrical shaped Plastic Containers (tank) having capacities 1000L and 750L respectively. Two long and broad PVC pipes (3.5 inches and 2.5 inches in width respectively), Gas valve, Adhesive solution, Service valve

#### Method:

The container having capacity 1000L was used as bio-digester and the 750L capacity container was used as Gas holder tank. The gas holding tank (750L) was placed in an inverted position in the Bio-digester (1000L) so that it may float freely on the bio-digester tank when biogas is produced. The PVC pipe (3.5 inches in width) was attached in a

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 2, February 2017

parallel position at a distance of approximately 4-5 inches above at the bottom of the Bio-digester tank as Inlet pipe to enable for input of substrates. The PVC pipe (2.5 inches in width) was attached in an opposite direction at a distance of approximately 4-5 inches at the top of the Bio-digester tank as outlet pipe to discard the digested biogas slurry and it should be perpendicular in position related to bio-digester. The Gas valve was placed at the top of the Gas holding tank (750L) to enable outflow of biogas produced. Bricks were placed on the gas holding tank to increase the pressure of the biogas outflow.

## 2. Preparation of starter culture/inoculums build up and set up of Bio-gas plants:

Starter culture is the desired microorganisms or its group required for the initial set up of the process.

In the present study methanogens were used as starter culture. Methanogens are involved in the biosynthesis of methane which is final yield of bio-gas. Methanogens as absolutely anaerobic microorganisms inhabit anaerobic environment ecosystems, such as tundra's, marshlands, rice fields, bottom deposits, swamps, sandy lagoons, tanks where waste water is deposited, solid waste landfills, and ruminants stomach. Hence, cow dung was employed as a starter culture in the present study.

The microbial cells or spores required to inoculate large quantities of production medium in a fermentor (Bio-digester) are in high numbers, since a loopful of culture cannot meet the requirement of completing the fermentation run in the economically shortest time. Therefore, the volume of the culture is increased gradually step by step from 0.5% to 30% per inoculums.

**Materials:** Cow dung, Water, Containers, Hand Gloves, Thermometer, Stirrer, Weighing balance.

### 2.1 Preparation of starter culture for pilot scale biogas plant:

Fresh cow dung was collected from the Gorakshan Trust, situated at Income tax road in Akola district. Approximately 0.6-0.7 Kg of cow dung was mixed with tap water in a ratio of 1:1 using a stirrer or physically by our hands using hand gloves. Mixing of cow dung with tap water was done to dilute it and this mixture of cow dung and water makes the cow dung particles to freely suspend and evenly spread in the water. After this process, approximately 400-500ml of tap water was added to this mixture. This mixture was poured into the bio-digester through the inlet pipe. Now approx. 8.5-9L tap water was added to the bio-digester tank and Whole assembly was incubated at room temperature for 20-25 days.

**Preparation of starter culture and its scale up of for domestic scale:** Fresh cow dung was collected from the Gorakshan Trust, situated at Income tax road in Akola district. Approximately 30-40 Kg of cow dung was mixed with tap water in a ratio of 1:1 using a large stirrer or rod. Both the mixtures were added to the Bio-digester and were mixed homogenously. To the Bio-digester tank approx. 850-900L of tap water was added and whole assembly was incubated at room temperature for 15-20 days.

## 3. Preparation of different types of organic substrates such as vegetable leftovers, cow dung etc. for biogas production.

In the present study various organic wastes were used for biogas production. Organic substrates are easily available and have high moisture content which makes it readily biodegradable.

### Materials:

**Cow dung:** Fresh Cow dung was collected daily from the Gorakshan Trust, near Income tax office, Akola.

**Vegetable waste:** Sufficient amount of vegetable leftovers were collected daily from the Vegetable market situated near the college campus.

**Method:** To the pilot scale plant, daily addition of organic wastes was such as cow dung (200-300 g) and Vegetable wastes (20-30 g) respectively. Similarly, for domestic biogas plant the amount of organic waste required daily was cow dung (20-30 kg) and Vegetable wastes (2-3 kg) and respectively. Before adding the wastes to the bio-digester, all the substrates used in the work were chopped /mashed and shredded to about 2-5 mm in size and were mixed with tap water in the ratio 1:2 respectively.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 2, February 2017

## 4. Detection and measurement of biogas produced:

**4.1 Detection of biogas produced:** Presence of biogas produced or not was detected by observing the characters of flame observed. (Agrahari *et.al.*, 2013)

**Materials:** PVC gas pipe, Match box, Burner.

**Method:** A PVC gas pipe was attached to the gas outlet valve and the burner to facilitate the flow of biogas produced to the burner directly. The presence of biogas was detected by lighting the match sticks near the mouth of burner.

## 4.2 Measurement of amount of biogas produced in pilot scale biogas plant:

The amount of biogas produced was recorded daily by using the following formula:

$$\text{Volume of a cylinder} = \pi r^2 \cdot h$$

Where,

R=radius of cylinder

h=Height of cylinder.

The same method was employed by Agrahari *et. al.* (2013).

## IV. RESULTS

### 1. Experimental Setup and Instrumentation of a pilot scale (10L) and Domestic scale (1000L) Biogas plant:

In the present study, two modern biogas plants having capacities 10L and 1000L respectively were build and utilized successfully for producing biogas from different organic wastes. Both the Biogas plants used were of semi-continuous, floating drum type of biogas plants.

#### 1.1 Construction and designing of Pilot scale Biogas plant:

A pilot scale biogas plant having capacity 10L was designed and constructed by upgrading the conventional Gobar gas plants (Bio-gas plants which requires only cow dung/cattle dung as daily feed) to a new modern design.

Figure 2 (a) is a design of the Conventional floating drum type of Biogas plants (Gobar gas plants) that requires large space along with a pit and is a underground (Below ground) type of prototype/module. Figure 2(b) represents modern Biogas Plant that was a modified design and layout of the conventional Gobar gas plants. It is a floating drum type of prototype, but does not require any pit to be constructed as it was a surface (on ground) prototype/module.

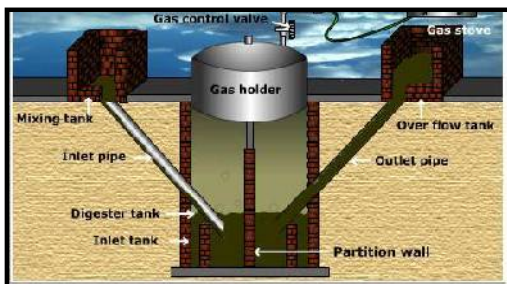


Figure 2(a) Conventional Gobar Gas plant.

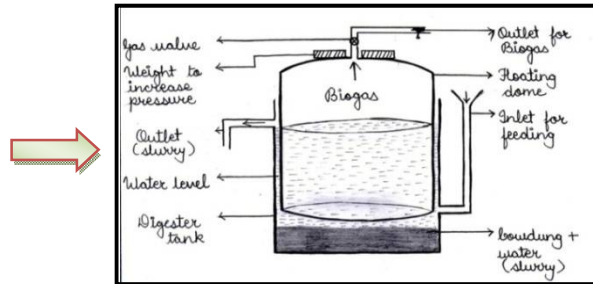


Figure 2(b) Modern Bio-gas plant.

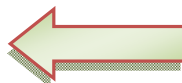


Figure 2(c) Photograph showing the constructed **Modern Pilot scale (10L) bio-gas plant.**

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 2, February 2017

## 1.2 Construction of Domestic scale Biogas plant:

By the same design used for making the pilot scale biogas plant (10L), a large domestic scale biogas plant having capacity of 1000L was constructed and used for making bio-gas.



Figure 2(d): Photograph of **DOMESTIC SCALE BIOGAS PLANT (1000L)** that was constructed and used in the present work.

## 2. Preparation of starter culture/ inoculum build-up and set up of Bio-gas plants:

In the present study, Cow dung being a waste product of ruminants, it was found to be a rich source of methanogens and other anaerobes and was used as source of methanogens.

Also it was easily available and found to be present in large quantities in the Gorakshan Trust, Akola which was near to our locality.



Figure 3(a) showing the place visited for collecting starter culture (cow dung)



Figure 3(b) Photograph showing the ruminants as source for obtaining starter culture.



### 2.1 Preparation of starter culture for pilot scale biogas plant:

Fresh cow dung was used as both, initial source of organisms as well as a substrate for the initial start up. Starter culture was obtained after incubation of these organisms under anaerobic conditions at room temperature for 15-20 days. The amount of starter culture used for making pilot scale bio-gas plant was 600 g in the form of slurry.

### 2.2 Preparation of starter culture and its scale up of for domestic scale biogas plant:

The starter culture for large scale domestic biogas plant (1000L) was obtained by using the digested slurry obtained from the pilot scale biogas plant i.e. 10L which was used as inoculum and the scale up of this inoculum was done to 30L; along with the inoculum fresh 30 kg cow dung slurry was used to speed up the process.

## 3. Preparation of different types of organic substrates such as cow dung and Vegetable wastes for biogas production:

In the present work two different types of organic substrates were used daily for biogas production in the form of slurry. Cow dung and vegetable wastes were used due to their availability in large quantities.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 2, February 2017



Figure 4(a) Photographs showing the place visited for collecting vegetable leftovers and availability of the vegetable wastes in the Vegetable market in Akola district.



Figure 4(b) Photograph showing the availability of cow dung.

### 3.1 Cow dung:

For the pilot scale (10L) biogas plant daily 250 g of Cow dung slurry was prepared by using tap water in the ratio 1:2 and was used for biogas production.

While, for the domestic scale (1000L) biogas plant, 25 Kg of cow dung slurry was used daily for biogas production.

### 3.2 Vegetable waste:

For the pilot scale (10L) biogas plant daily 25 g of vegetable wastes slurry was prepared by using tap water in the ratio 1:2 and was used for biogas production.

While, for the domestic scale (1000L) biogas plant, 2.5 Kg of vegetable wastes slurry was used daily for biogas production.

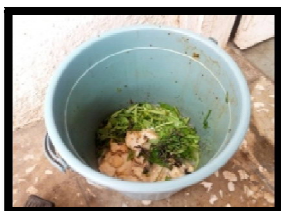


Figure 5: showing photograph of vegetable wastes that was used in the present study for biogas production.

## 4. Detection and measurement of biogas produced:

### 4.1 Detection of biogas produced:

The presence of combustible biogas was indicated by the burning of flame when burning match stick was held near the mouth of gas pipe or near the burner, while some traces of other non-combustible gases were also found to be present.

The figures 6(a) and 6(b), shows flame observed in pilot and domestic scale biogas plants at the 22<sup>nd</sup> day from the start up, the presence of methane gas in the flame with an intense blue colour during burning confirmed the presence of biogas.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 2, February 2017

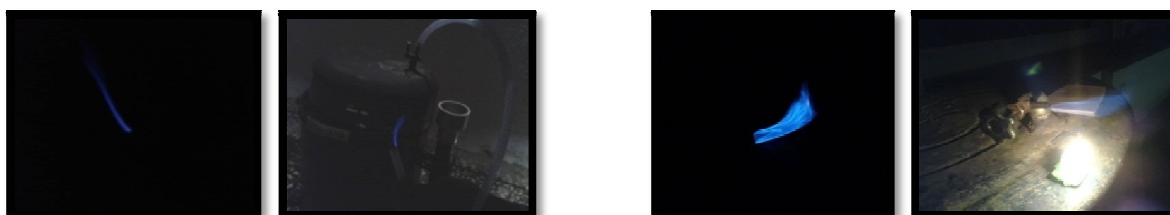


Figure 6(b) showing the biogas flame observed in domestic scale biogas plant.

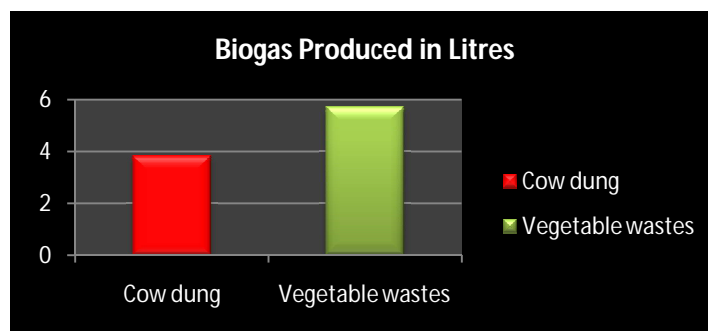
Figure 6(a) showing the biogas flame observed in pilot scale biogas plant.

## 4.2 Measurement of biogas produced:

The biogas produced in the gas holding tank was measured and recorded on the basis of the upliftment in the bio-gas holding tank i.e. height of biogas holding tank.

Serial. No.	Substrate Used	Time for biogas production	Upliftment in the gas holding tank observed (h) in cm	Biogas formed in Litres
1.	Cow dung slurry	3 days	10	3.81 L
2.	Vegetable waste slurry	3 days	18	6.85 L

Table no.4.2 showing the amount of gas produced in the Pilot scale biogas plant.



## IV. CONCLUSION

The present study was an attempt to construct and design bio-gas plants for production of biogas from different organic wastes such as vegetable wastes and cow dung. Attempts were made to reduce the time required for the biogas production process and to identify and measure the biogas produced. The process of preparing starter culture (inoculums) and its scale up from cow dung as the substrate was practiced. The biogas produced was found to be present at the 22<sup>nd</sup> day during the start up process with an intense blue coloured flame. During the study, the biogas produced from vegetables wastes was utilized for cooking purposes at households.

From the above study, it can be concluded that the modern biogas plants are **more efficient** than the conventional biogas plants i.e. Gobar gas plants. These modern biogas plants required low space, and are durable with cost effectiveness. The cow dung acts as a good substrate along with a source of starter culture. The use of vegetables wastes for biogas production is more feasible, instead of using cow dung as daily feedstock. For running a large biogas plant, with the digester (1000 L) and gas holding tank (750 L) which produces 0.75m<sup>3</sup> of biogas per day. It requires a daily feeding of **2-3 Kg of kitchen waste per day**. In case of cow dung, it requires about 20-30 Kg per day. The modern domestic bio-gas model requires **less space** with **small investment** and long **durability**. Though the minimal quantity of waste does not produce enough biogas for making dishes that require full flame, one can prepare food items



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 2, February 2017

that require a longer duration or need the flame to be simmered such as heating milk, preparing tea, coffee etc. Also the initial investment for the biogas plant is affordable because it becomes cost effective due to its durability.

## V. SIGNIFICANCE OF PRESENT WORK

**Waste management** is one of the major problems faced by the population living in rural as well as urban regions of India. The use of biogas technology may aid in proper management of organic wastes generated daily in all regions of India. The biogas plants used in the present study were **free from noise pollution, air pollution, water pollution and soil pollution**. They were made by using Plastic material which makes the biogas plant more durable and cost effective. Plastic can be **re-cycled, re-used** and are **non-corrosive** in nature, these properties of plastics made the biogas plant production more feasible.

## REFERENCES

1. Agrahari, R., and Tiwari, G., "The production of biogas using kitchen waste", *International Journal of Energy Science (IJES)*, 3(6), 408-413, 2013.
2. Anna, S., and Asa, J., "Microbiological Handbook for Biogas Plants", *Avfall Sverige Development U2009 03*, 2010.
3. Cirne, D.G., Lehtomaki, A., "Hydrolysis and microbial community analysis in two-stage anaerobic digestion of energy crops", *Journal of Applied Microbiology*, 103, 516-527, 2007.
4. Gashaw, A., Libsu, S., Chavan, R., "Evaluation of the Feasibility of Biogas Production from Leftover Foods of Bahir Dar University Students Cafeteria", *International Journal of Science and Research (IJSR)*, 3(5), 1122-1127, 2014.
5. Gunaseelan, N.V., "Anaerobic digestion of biomass for methane production: a review", *Biomass and Bio-energy*, 13, 83-113, 1997.
6. Gunaseelan, N.V., "Biochemical methane potential of fruits and vegetable solid waste feedstock's", *Biomass and Bio-energy*, 26, 389-399, 2004.
7. Hendrick, D.B., Guckert, J.B., and White, D.C., "The effect of oxygen and chloroform on microbial activities in a high-solids high productivity anaerobic biomass reactor", *Biomass and Bioenergy*, 1(4), 207-212, 1991.
8. Leven, L., Eriksson, A., and Schnurer, A., "Effect of process temperature on bacterial and archaeal communities in two methanogenic bioreactors treating organic household waste", *FEMS Microbiology Ecology*, 59, 683-693, 2007.
9. Nagamani B., and Ramasamy K., "Biogas production technology: An Indian perspective", 1990; Retrieved from the URL: <http://www.iisc.ernet.in/currsci/jul10/articles13.htm>.
10. Nordberg, A., "Anaerobic digestion of alfalfa silage with recirculation of process liquid", *Bioresource Technology*, 98, 104-111, 2007.
11. Ramachandra, T.V., "Ecologically Sound Integrated Regional Energy Planning", Nova Science Publishers, Huntington, New York, 2003.
12. Ras, S., Veijanen A., "Trace compounds of biogas from different biogas production plants", *Journal of Energy*, 32(8), 1375-1380, 2007.
13. Ziana Z., and Rajesh P., "Production and Analysis of Biogas from Kitchen Waste", *International Research Journal of Engineering and Technology (IRJET)*, 02(04), 622-632, 2015.
14. Zinder, S. H., "Patterns of carbon flow from glucose to methane in a thermophilic anaerobic bioreactor", *FEMS Microbiology Ecology*, 38, 243-250, 1986.
15. Patel A.H., "Industrial microbiology", *production strains*, 16-33, 2003.
16. Madigan, M.T., and Martinko, J.M., "Brock Biology of Microorganisms (11th ed.)", Pearson Education TLD. London, 2006.
17. Retrieved from the URL: [http://aqua.ucdavis.edu/Calculations/Volume\\_of\\_a\\_Cylindrical\\_Tank.htm](http://aqua.ucdavis.edu/Calculations/Volume_of_a_Cylindrical_Tank.htm).