Review on Biogas Plant by using Canteen Waste

Mr. Sachin Rahinj[1] Akash Devde[2] Akshay Hraimkar[3] Nikhil Haral[4] Pritish Khutal[5]
[1,2,3,4,5]Dr. D YPatil School of Engineering and Technology, Pune 412105, India

Abstract— The extraction of energy from biomass wastes by its anaerobic degradation with the help of various technologies adopted and will be leading to the use of renewable energy systems effectively and efficiently. There are various methods to extract the biogas from biomass wastes, which includes Animal wastes, Agriculture wastes, Kitchen wastes etc…are the installation and generation of biogas plant. In our institute we have two hostels and they both have combine canteen. In our canteen daily around 10-15 kg waste is obtained, which can be easily used for production of biogas. This process is to create an organic processing facility to generate biogas which will be eco-friendly and cost effective, reduced methane emissions and carbon dioxide. By installing biogas plant behind the canteen will be more beneficial. The canteen waste collected is used as feed stock for biogas plant. The biogas produced can be used as energy source for cooking and also for various purposes. The biogas released acts as an environmentally sustainable energy source. This work is also deals with pilot study of kitchen waste generation and fuel saving by using biogas plant in engineering college hostel of Maharashtra state.

Keywords: Biogas, Kitchen Waste, Eco-Friendly, Anaerobic Digestion, Methane Production

I. INTRODUCTION

Presently India is facing severe problem in the sector of Energy production, which may be more serious in the coming decade or so. With the rapid decrease in our underground natural resources (such as Petroleum and Coal) quantity and level throughout the world and problem related to their effective combustion, the growing demand to get access to the new sources of energy, like renewable energy and their resources is measuring their margins. The demand for petroleum products and their necessary utilization in the modern world is increasing with every passing day. The modern scientist and researches are grapping and hovering so as to invent various ways to tackle such imminent problems. India has been spending a large amount of capital to import these products from overseas like, the Arabic region, the Persian gulf , OPEC (oil & petroleum exporting countries) etc. The key issues faced by most developing and developed countries of the world today are mainly future energy security and better use of natural resources. There is a vast loop hole in terms of energy production and consumption in this country. This situation may get more aggravated as it is in the long term with unemployment and low gross domestic products (GDP). Limited availability and lack of energy remains one of the most important hindrances affecting industrial development in the country. On the other side India is also facing serious natural calamities like environmental pollution, disturbance in weather and global warming. Greenhouse effect is certainly a matter of serious concern for the survival the human species and nature. Deforestation and environmental clearance is a matter, where serious thinking is to be done. We need to rejuvenate the same to attain prosperity and up-hold the nature-human relationship. Most of the part of our country lives on charcoal and fire wood for fuel supply and living which requires cutting down of trees, which in turn decreases the fertility of soil and causes soil erosion. Though conventionally, a large population of rural India lives on wood, cow-dung cakes, charcoal, etc. due to its ease of use, availability throughout the year, but there are problems associated with the by-product generated, causing diseases due to smoke and harmful gases evolving out of it.

India is presently going through the critical phase of population explosion and the growing population demands more energy output. Therefore, there is a need of clean energy for India to satisfy this augmented energy demand and at the same time it must be environmental friendly to meet national developmental needs. Solar energy, wind energy, thermal energy and biogas are all renewable sources of energy. The Biogas plant is a boon to Indian farmers and common households. Biogas is different from these because of its characteristic feature like its uses, controlling and collecting Organic wastes and at the same time producing fertilizer for use in irrigation and, agriculture. It could provide the population with a decent standard of living.

The two major byproduct of Biogas plant are enriched compost matter and methane. Methane which is an efficient fuel and compost manure acts as a fertilizer and provides to meet the fertilizer requirement of farmers in agriculture in a most economic and adequate texture and boost agriculture production. It may be in a demand stage for the time being but is capable of vital development in future. Biogas is capable of replacing and turning the table round to minimize the import of oil and pollution. This could be anticipated to secure and work as a best alternative to India's persistent energy requirement. Biogas is produced by anaerobic digestion with fermentation of biodegradable materials such as manure, sewage, municipal waste, green waste, plant material, and crops.

Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude. It means size of reactor and cost of biogas production is reduced. Also in most of cities and places, kitchen waste is disposed in landfill or discarded which causes public health hazards and diseases like malaria, cholera, typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences: It not only leads to polluting surface and groundwater and further promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. Also, it emits unpleasant odour & methane which is a major greenhouse gas contributing to global warming. So Instead of discarding it as waste, this so called waste could be utilized subsequently to substantiate the production of fuel. In most rural and urban areas, the disposal and overhanging of these waste causes environmental pollution and diseases. Allocating this waste into a biogas plant also means that higher efficiency, reduced cost of fuel is inherited.

II. BIOGAS

Name of the Gas	Composition in Biogas (%)
Methane (CH_4)	50-75
Carbon Dioxide(CO_2)	25-50
Hydrogen (H_2)	0-10
Nitrogen (N_2)	0-1
Water Vapour (H_2O)	0.3
Hydrogen Sulphide (H_2S)	0-0

Table 1: Composition of Biogas

It's a mixture of gases produced by the microorganisms during the anaerobic fermentation of biodegradable materials. Anaerobic fermentation is a biochemical process in which a particular kind of bacteria digests biomass in an oxygen-free environment resulting in production of CH4, CO2, H2 and traces of other gases along with decomposed mass.

A. Properties of Biogas

Biogas is a mixture of different components and the composition varies depending upon the characteristics of feed materials, amount of degradation, etc. Biogas predominantly consists of 50 to 70 per cent methane, 30 to 40 per cent carbon dioxide and low amount of other gases. Methane is a combustible gas. The energy content of biogas depends on the amount of methane it contains. The composition and the properties of the biogas are given in the following table.

B. Anaerobic Digestion

Biogas is produced by an anaerobic digestion of organic waste through synergistic metabolic activities of consortia of hydrolytic and acetogenic and methane genic bacteria on organic materials. It is the transformation of organic materials under oxygen free environmental into Biogas, a mixture of mostly CO2 and methane. In practice anaerobic digestion is the engineered methane genic decomposition of organic matter in reaction vessel that is relatively simple to construct and operate. As much as 90% of the biodegradable organic fraction of waste can be stabilized in anaerobic treatment by the conversion to methane gas. Methane is combustible gas. The energy content of biogas depends on the amount of methane it contains. During the process complex organic molecule present in the biomass are broken down to sugar, alcohols, pesticides and amino acids by acid producing bacteria. The resultant products are then used to produce methane by another category of bacteria.

The biogas production process involves three stages namely:

1) Hydrolysis
2) Acid formation and
3) Methane formation

1) Hydrolysis

The complex organic molecules like fats, starches and proteins which are water insoluble contained in cellulosic biomass are broken down into simple compounds with the help of enzymes secreted by bacteria. This is the stage where the complex polymers break into simple monomers.

2) Acid formation

The resultant product (monomers) obtained in hydrolysis stage serve as input for acid formation stage bacteria. Products produced in previous stage are fermented under anaerobic conditions to form different acids. The major products produced at the end of this stage are acetic acid, propionic acid, butyric acid and ethanol.

3) Methane formation

The acids produced in the previous stages are converted into methane and carbon dioxide by a group of microorganism called "Methanogens". In other words, it is the process of production of methane by methanogens. They are obligatory anaerobic and very sensitive to environmental changes. Methanogens utilize the intermediate products of the preceding stages and convert them into methane, carbon dioxide, and water. It is these components that make up the majority of the biogas emitted from the system. Methanogenesis is sensitive to both high and low pHS and occurs between pH 6.5 and pH 8.

Major reactions occurring in this stage is given below:

$$\underset{\text{Acetic acid}}{CH_3COOH} \longrightarrow \underset{\text{Methane}}{CH_4} + \underset{\text{Carbon dioxide}}{CO_2}$$

$$\underset{\text{Ethanol}}{2\,CH_3CH_2OH} + \underset{\text{carbon dioxide}}{CO} \longrightarrow \underset{\text{Methane}}{CH_4} + \underset{\text{Acetic Acid}}{2\,CH_3COOH}$$

$$\underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Hydrogen}}{4\,H_2} \longrightarrow \underset{\text{Methane}}{CH_4} + \underset{\text{Water}}{2\,H_2O}$$

III. METHODOLOGY

The waste is collected from the canteen and transported to plant. The required quantity of waste and water is mixed in the inlet tank and the slurry is discharged to the digester vessel for digestion. The gas produced through Methanogenesis bacteria in the digester is collected in the dome. The digested slurry flows to the outlet tank through the outlet. The slurry then flows through the overflow opening in the outlet tank to the compost pit. The gas is supplied from the dome to the point of application through a pipeline. When a biogas plant is underfed the gas production will be low; in this case, the pressure of the gas might not be sufficient to fully displace the slurry in the outlet chamber. It is important to design the plant keeping hydrostatic pressure higher at the inlet tank than the outlet tank. The hydrostatic pressure from slurry in the inlet and outlet tanks will pressurize the biogas accumulated in the dome. If too much material is fed into the digester and the volume of gas is consumed, the slurry may enter the gas pipe and to the appliance.

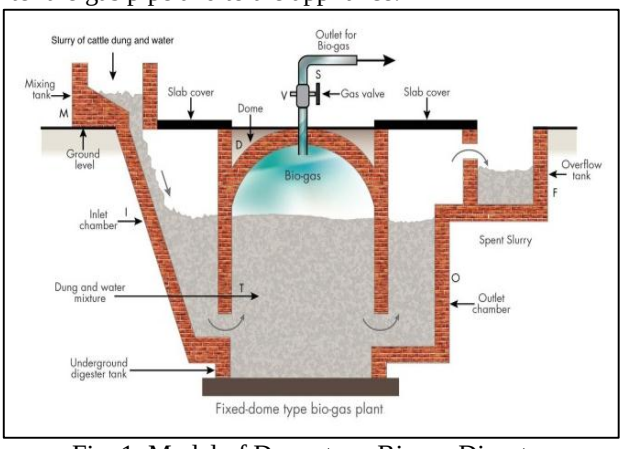

Fig. 1: Model of Dome type Biogas Digester

A. Typical Biogas System Consists Of The Following Components:

1) Waste store: As we are constructing the biogas plant for kitchen waste, the waste food collecting in the canteen is stored and transported to the site for feeding
2) Anaerobic digester: The digester in form of dome is the anaerobic digester.
3) Slurry storage: After the digestion the slurry coming out of the digester is the good quality fertilizer, this is stored in the compost pit provided at the outlet of the digester. Later that can be used for agriculture purpose.
4) Gas handling: The generated biogas is stored in the dome and at the top, the biogas trap hole is provided. From the trap hole the flexible pipe line is connected up to the kitchen, where it is connected to the biogas stove for cooking food.
5) Gas use: The biogas is having the different applications such as domestic cooking, lighting.

B. Composition of Kitchen Waste

An Average composition of kitchen waste was analyzed on various occasions. Over 50 % of waste was composed of cooked rice and 23% of uncooked fruits and vegetables. Eggs, raw meat, the main source of pathogens were relatively low in mass also about 7% of cooked meat was there.

Compositions of Kitchen Wastages are:

1) Cooked Rice
2) Cooked Vegetables
3) Uncooked Vegetables and Fruits
4) Cooked eggs and meat

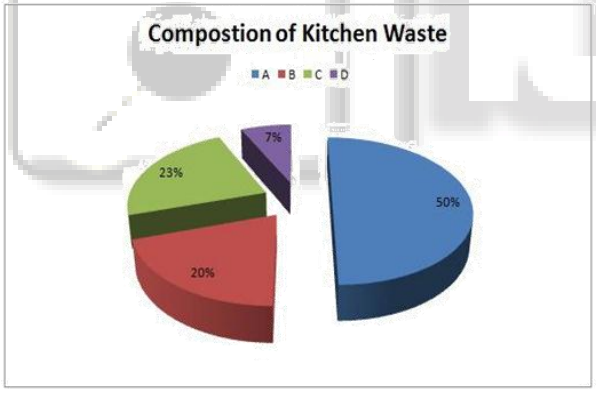

Fig. 2: Compositions of Kitchen Waste

IV. Conclusion

The effective implementation of plastic biogas digester for production of biogas by decomposing kitchen waste offers a relevant resource development solution and a rigid waste management system. Its low cost and its independent working conditions under suitable considered parameters prove that it is economic.

It is a technology that can be surely assured for processing organic kitchen waste using a plastic biogas digester .It has suddenly experienced a significant positive vibe in the recent go and is a strong contender in becoming the next renewable energy source.

This plant is more employable in urban region as more amount of organic waste is generated in urban region due to larger population. Whereas it is worth mentioning that it can also influence rural regions as this regions are deceived from sufficient fuel supply. In the long run it could reduce the consumption of LPG and thus curb dependence on imported fossil fuel.

Acknowledgment

The euphoria and satisfaction of the completion of this project would be incomplete without acknowledging the contribution of all those people who have helped us with their valuable suggestion and inputs from the very beginning.

First of all, I would like to humbly thank Mr. Sachin Rahinj and Mr. Ranjit Kapurkar Assistant Professor, Faculty of Mechanical Engineering Department, Dr. D. Y. Patil School of Engineering Technology, Lohegaon for their constant support and able guidance, without which the completion of this project would not have been possible.

I would also like to thank all the staff members of the Faculty of Mechanical Engineering Department, Dr. D. Y. Patil School of Engineering Technology, Lohegaon for their valuable suggestions from time to time.

I am also thankful to my friends in Dr. D. Y. Patil School of Engineering Technology, Lohegaon for their constant help and support during this period of the project work.

Thank You.

References

[1] Mr. Sarvesh S. Vede, Mr. Abhijeet G. Badade, Mr. Swajay S. Balikai, Mr. Swapnil D. Thokale, Prof. Prasad. B. Kulkarni. (2018). Design of Biogas Plant for College Mess Food Waste and Study of its Economical Feasibility. IJRTI [Online]. Vol. 3, Issue 3. Available: www.ijrti.org
[2] E.Aravindaraj, Dr. R. Prabhu, S.Kalaimani L.Natrayan. (2017, Mar.). Experimental Analysis of Biogas from Kitchen Wastes. IJIRS [Online]. Vol. 6. Available: https://www.researchgate.net/publication/319932847
[3] Apte, V. Cheernam, M. Kamat, S. Kamat, P. Kashikar, and H. Jeswani. (2013, Aug.). Potential of Using Kitchen Waste in a Biogas Plant. IJES&D [Online]. Vol. 4 No. 4. Available: www.ijesd.org
[4] Tom Bond, Michael R.-Templeton History and future of domestic biogas plants in the developing world|| Energy for Sustainable Development 15 (2011) 347-354
[5] Bouallagui, H., Touhami, Y., Ben Cheikh, R., Hamdi, M.,-Bioreactor performance in anaerobic digestion of fruit vegetable wastes||. Process Biochemistry 40, 2005(3-4), 989-995
[6] Misi, S.N., Forter, C.F., 2001.-Batch co-digestion of multi-component agro-wastes||. Bio Resource Technology 80(1), 19-28
[7] Jantsch, T.G., Matttiason, B. (2004), "An automated spectropphoyometric system for monitoring buffer capacity in anaerobic digestion processes" Water Research. 38: 3645- 3650.
[8] Karve of Pune A.D (2006), "Compact biogas plant compact low-cost digester from waste starch". www.bioenergylists.org.
[9] Q. Zhao, E. Leonhardt, C. MacConnell, C. Frear and S. Chen, "Purification Technologies for Biogas Generated

by Anaerobic Digestion", CSANR Research Report 2010 – 001

[10] Karve .A.D. (2007), "Compact biogas plant, a low cost digester for biogas from waste starch" http://www.arti-india.org.

[11] Dellena Gloria Alagcan , Sant K. Pratap, Manuel M.Alagcan , Ginasha, D.R , Nacanieli S.Tuivavalagi, S.K. Garg, "Use of Compact Biogas Plant for Biogas Production Utilizing Waste Food Materials, Fruits, and Vegetable Peelings of High Calorific Contents", International Journal of Engineering, ijesm Science and Metallurgy, Vol.2, No.1 (2012)

[12] Subbarao Chamarthi, Subbarao Chamarthi, Purnanand V Bhale , N.Srinivasa Reddy, Ch Chandra Mouli, "Laboratory Scale Experiments for Biogas Production using Gas Chromatography Analysis", IOSR Journal of Engineering, Vol. 3, Issue 7 (July. 2013)

[13] Ann C. Wilkie, "Biomethane from Biomass, Biowaste, and Biofuel", 2008 edition, ASM Press.

