



Prototype of a Biogas Anaerobic Digester from the Hostel Mess Kitchen Wastes

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ABSTRACT

Biogas is a non-exhaustible of energy which can be formed from anaerobic fermentation of different types of biodegradable waste such as food waste, plant waste, animal waste sewage and other organic waste. The typical composition of Biogas includes CH₄ (50–70%) which is responsible for maximum energy content along with CO₂ (25–50%) that can be collected, stored and supplied. Biogas acts as a multipurpose and an eco- friendly sustainable resource of energy which can be utilized for cooking, electricity generation, lightning, heating etc. Biodegradable waste specifically produced in large amounts as a kitchen waste. In modern society, the solid waste per capita has been consistently increasing as of increase in population and change in socio-economic-cultural habits. The biogas production through the kitchen waste thereof provides a solution of disposal of solid waste. The biogas production through anaerobic degradation pathways can be controlled and enhanced with the help of certain microorganisms and advancements of new technologies. In this research work, an attempt is being made to produce the biogas from kitchen and food waste collected from hostel mess of Chitkara University, Punjab and a novel method of production of microorganism has been also proposed for fast degradation of waste. Under this project, a survey for the estimation of daily production of organic waste from hostel mess has also been done for fifteen day.

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1. Introduction

Around the globe, Wealth from Waste technologies get recognized and adopted at a very fast pace to handle challenges such as increasing energy supply and waste management (Mutz *et al.*, 2017). Biogas production from waste is such a sustainable power technology proven as a great success in access to clean, affordable and renewable energy. In the developing countries like Bangladesh, Africa, Jordan, Sudan, Kenya biogas technology assured the electricity and clean fuel access in rural areas (Khan and Martin, 2016; Amin and Rahman, 2019; Addous *et al.*, 2017)

Biogas is a natural production of energy gas which is mingling of different gases formed during the fermentation of biodegradable organic material in the absence of oxygen gas. Biogas can be formed from simple materials, for example, kitchen waste, cow dung cake, waste food and vegetables, plant waste, human excreta as sewage, etc (Kumar and Yashika, 2020).

Biogas is created by anaerobic assimilation with anaerobic microbes or methanogens, which digest all biodegradable material inside a closed framework. This

closed framework or system is called an anaerobic digester, bio-fermentation tank, or a bioreactor (Yasar *et al.*, 2017).

Biogas is principally a mixture of methane (CH₄), hydrogen (H₂), carbon dioxide (CO₂) and may have limited quantities of hydrogen sulfide (H₂S), siloxanes, and Sulphur Dioxide (SO₂) with some oxygen and moisture. On combustion, the methane, and hydrogen gases oxidized and release a huge amount of energy. This energy discharge allowed the usage of biogas as a fuel for cooking or for power generation (Austin and Morris, 2012).

Biogas can also be filled under pressure and get compacted on the similar pattern as flammable gas is filled as Compressed Natural Gas (CNG), and used to control engine vehicles. In some developing countries, biogas fulfills the need for sustainable power sources. Here, the biogas compressed and filled according to petroleum gas laws. When it gets cleaned according to these norms and get converted into bio-methane then it can be used for transportation purpose also. Hence, biogas as bio-methane can be viewed as an eco-friendly, pollution-free and inexhaustible resource as there is no net production of carbon dioxide (Singh *et al.*, 2001). In the development of the biogas formation from

any material carbon dioxide discharge to the environment is a must as its formation involves the assimilation of carbon. Hence, every material which gets decomposed by the activity of microorganisms in a brief timeframe is known as biodegradable. Generally human excreta, animal waste, food squander; fruits and vegetable peels and natural product mash are biodegradable. All these substances promptly blend by the activity of microorganisms and get decomposed (Beedu and Modi, 2014). During deterioration, these materials discharge CH_4 , CO_2 , H_2S and some smelling salts. Thus, the discharged gases release through the rot of biodegradable squanders can be used for the different purposes and helps in saving exhaustible energy resources on the earth (Divya *et al.*, 2015).

Rupf *et al.*, 2016 checked the efficiency of biogas compact framework that utilizes sugary or sweet feedstock stuff to release the bio-gas and the results revealed this new framework is much more proficient than customary biogas plants. Benbelkacem *et al.*, 2015 examined the results of convergence of total solids (TS) of Municipal Solid Waste on the Biogas production in a Continuous Anaerobic bioreactor. The TS of the waste impact on the temperature, pH, and efficiency of the microbes during the deterioration. The different concentrations of TS has been investigated and compared in an anaerobic constantly mixed tank reactor to prepare bio-gas. Yasar *et al.*, 2017 conveyed that decomposition of cow's compost along with kitchen waste expanded the biogas creation utilizing microbial energizers. The biogas production can be done from various natural product mashes such as fruit pulp through anaerobic absorption procedure (Mir *et al.*, 2019). The aim of the study is (a) to generate renewable bio energy from kitchen waste (b) to decrease air pollution (c) to explore eco-friendly disposal methods (d) to promote and generate the microbial slurry for biogas production.

2. Materials

2.1. Slurry Preparation Tank

The anaerobic digester is comprised of a plastic tank. The dimensions of the plastic tank taken for the prototype are 120×200 mm.

2.2. Valves and Pipelines

The valves used to regulates, manages, or coordinates the progression of a liquid (gases or fluids) through opening/closing, or halfway obstruct the different openings. All the screw valves and pipelines utilized for the prototype are made up of PVC. The varied dimension pipelines and valves are used according to the need to make the design of the prototype. Pipelines are utilized to stream the squashed food waste into the slurry tank. After that, the gas was streamed from the slurry tank to the gas assortment chamber.

2.3. Pressure Gauge

Numerous strategies have been created for the estimation of vacuum and Pressure. The device used to quantify pressure is known as pressure gauges or vacuum gauges. In this prototype, the pressure gauge is used to check the pressure inside the digester tank.

2.4. Food Waste

The biodegradable materials utilized for the experimental work are organic product peelings, food squander etc. and gathered from the hostel mess of Chitkara University. In the hostel of Chitkara University, there are approximately 1200 students are residing. The kitchen waste of the hostel mess has been used for experimentation.

3. Methodology

3.1. Production of Microbes

The preparation of microbes involves cow dung, water, and jaggery. The cow dung, jiggery, and water mixed in varying ratios of 2:1:1, 3:2:1, 4:2:1, 4:3:1 ratio are in different airtight containers and is kept for 30 days for the microorganisms to grow and following reaction occur in this mixture:



Also, the gas pressure built in the container is released as the process of microbes formation takes place in the absence of oxygen.

3.2. Preparation of Prototype for Bio gas Generation

The entire components plastic tank, valves, pipes, pressure gauges are assembled tightly with the help of m-seal as shown in Fig 1.



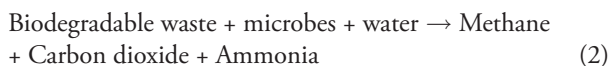
Figure 1: Prototype of Biogas Digester.

3.3. Production of Biogas

The waste material which is vegetable and food waste is transferred to the digestion tank where it is added with prepared microbial slurry and water. This mixture is then constantly mixed after an equal interval of time for 10 to 15 minutes. The microbes decompose degradable waste into CH₄ and CO₂ over time period of 3-4 hours. The methane gas gets collected in a storage chamber.

4. Result and Discussion

Anaerobic absorption is a progression of different steps in which microorganism's digests biodegradable material without oxygen and releases methane and other gases.



In the present research work, the microbial slurry has been prepared from the cow dung, jaggery and water mixed in varying ratios of 2:1:1, 3:2:1, 4:2:1, 4:3:1 ratio in different containers. The microbial growth has been estimated through froth formation within the container. It has been found that maximum froth formed occurs in the container with a ratio of 4:3:1 which results in formation of maximum microbial growth. Hence, this microbial slurry has been taken for further experimentation. The kitchen waste (vegetable & fruit peels and food waste taken for experimentation) from hostel mess is taken as biodegradable waste. From the daily survey of 15 days, it has been estimated that about 200 kg per day organic waste is produced kitchen mess of hostel of 1200 students. This kitchen waste has been used for experimentation.

The methodology used to convert biodegradable waste into biogas has been depicted in Fig. 2. In the digester, approx 2 kg of kitchen waste gets mixed with a suitable quantity of water through the inlet. At the inlet, there is a fine mechanical cutter that has been placed which chop the waste into small pieces.

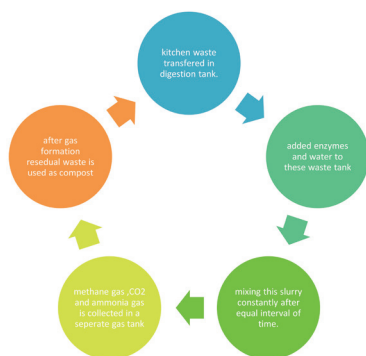


Figure 2: Process flow sheet of Anaerobic Digester

Initially, 500 ml of microbial slurry along with 10% cow dung is taken for 2 kg of waste in the digester. Cow dung is efficient for this process of slurry formation as it comprises bacteria called “*Estinia Fetida*” which is responsible for the enhancement of froth formation process which is the initial stages to indicate the biogas production (Singh *et al.*, 2010). After that, the ratios taken were 70% kitchen waste along with 20 % of microbes in aqueous form. The slurry mixture was siphoned into the digester tank where it gets blended continually with the assistance of blender and held almost for 48 hours. The acidogenic microbes transform the sugars and amino acids into CO₂, NH₃, and other natural acids (Kang *et al.*, 2010). The acetogenic microbes at that point transform these acids into CH₃COOH, alongside CO₂, NH₃ and hydrogen. At last, methanogens transform all the material to CH₄ and CO₂ (Singh *et al.*, 2010). Following 48 hours of development time because of miniaturized scale bacterial activities and anaerobic absorption without oxygen various gases, viz. CH₄, CO₂, NH₃, and SO₂ are produced. The methane gas was gathered in a chamber while the sludge collected in a separate container, that can be utilized as a bio-manure.

The level of CH₄ produce fluctuates from 60% to 70% and CO₂ changes from 20% to 25%. The remaining percentage is of smelling gases such as NH₃, and SO₂ (Banks *et al.*, 2011). The methane production can be enhanced by diminishing the carbon dioxide rate either with the use of quality anaerobic bacteria or by enhancing the amount of bacteria (Deressa *et al.*, 2015).

Conclusion

The demand and supply for energy sources can be decreased by changing over kitchen squander into biogas. The biogas can be utilized as a cooking gas and furthermore utilized in turbine to create power. The residual slop can be pressed and utilized as a fertilizer and manure for horticulture framing.

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