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Portable biogas producing unit

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Abstract: Anaerobic digestion (AD) is a highly promising technology for converting biomass waste into methane, which may directly be used as an energy source. This paper describes an alternative low cost approach to anaerobic digestion and energy production. This mainly depends on waste materials like food, garden waste, animal waste, paper and kitchen waste etc. Some extra equipment like crusher is used to obtain the biogas. The biogas so obtained can be used for different purposes without affecting the environment. The household waste, agricultural waste and animal waste can be used to produce the energy. The large and the fixed biodigester is converted into a portable biodigester.

Keywords: Anaerobic digestion, Alternate, Biogas, Energy Methane, Waste

1.0 Introduction

Biogas is a renewable, high-quality fuel, which can be produced from a lot of different organic raw materials and used for various energy services. Biogas technology has been developed and widely used over the world. Biogas is produced when microorganisms degrade organic materials in the absence of oxygen. This process is also named anaerobic digestion (AD) [1]. Biogas is a mixture of methane (CH_4), carbon dioxide (CO_2), hydrogen (H_2), nitrogen (N_2), hydrogen sulphide (H_2S) and Water vapor. The production of methane during the anaerobic digestion of biologically degradable organic matter depends on the amount and kind of the material added to the system. So, leftover foods, fruit and vegetable wastes and cow manure may be subjected to anaerobic digestion for energy production in a variety of ways.

There are a lot of different types of biogas plants over the world, and they are accepted and widely used by different countries. For example, floating drum and fixed dome biogas plants are two major type of small to medium scale biogas digesters.

Floating drum and fixed dome biogas plant are not portable (larger in size) and are fixed in one place. This is one of the disadvantages of these biogas plants. So to overcome this portable (small in size) biogas plant can be used which is easier to maintain and use portable biogas plant consists of a hopper with crusher which is attached with the digester through pipe lines and further connected with the gas collector. The components and their concentration is shown in the table 1 below. Methane (CH_4) is the main component produced in the biogas which can be used for the further useful purpose as cooking, lightning etc. along with the methane gas some other gases such as carbon dioxide, hydrogen sulphide, ammonia, nitrogen and oxygen etc are produced [2].

Table 1 Composition of Biogas

Component	Concentration
Methane	55- 60%
Carbon dioxide (CO_2)	35- 40%
Water (H_2O)	2- 7%
Hydrogen Sulphide (H_2S)	2%
Ammonia (NH_3)	0- 0.05%
Nitrogen (N)	0- 2%
Oxygen (O_2)	0- 2%
Hydrogen (H)	0- 1%

2.0 Objective

The main objective is to convert the waste into useful energy by using a portable bio digester. The portable bio digester is small and requires low cost to make so each and every family of the village areas can afford it. Biogas helps to reduce the use of wood, dung cake, which emits harmful gases after burn.

3.0 Principles for production of biogas

Organic substances exist in wide variety from living beings to dead organisms. Organic matters are composed of Carbon (C), combined with elements such as Hydrogen (H_2), Oxygen (O_2), Nitrogen (N), and Sulphur (S) to form variety of organic compounds such as carbohydrates, proteins & lipids. In nature microorganisms, through digestion process breaks the complex carbon into smaller substances.

There are two types of digestion process:
Aerobic digestion
Anaerobic digestion
Aerobic digestion

The digestion process occurring in presence of Oxygen is called Aerobic digestion and produces mixtures of gases having carbon dioxide (CO_2), one of the main "green houses" responsible for global warming [3].

Anaerobic digestion

The digestion process occurring without (absence) oxygen is called anaerobic digestion which generates mixtures of gases. The gas produced which is mainly methane when burned at normal room temperature and presents a viable environmentally friendly energy source to replace fossil fuels (non-renewable) or anaerobic digestion is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. An anaerobic is micro-organism that lives and grows without oxygen. It uses oxygen available in the matter, by decomposition. The process takes place in the temperature range of 35 to 65^{o}C and about 80% moisture is essential for the reaction to take place. There are four stages in anaerobic digestion to produce methane gas.

The below Fig. 1 shows the four important stages of anaerobic digestion and also the stages are explained point by point [4].

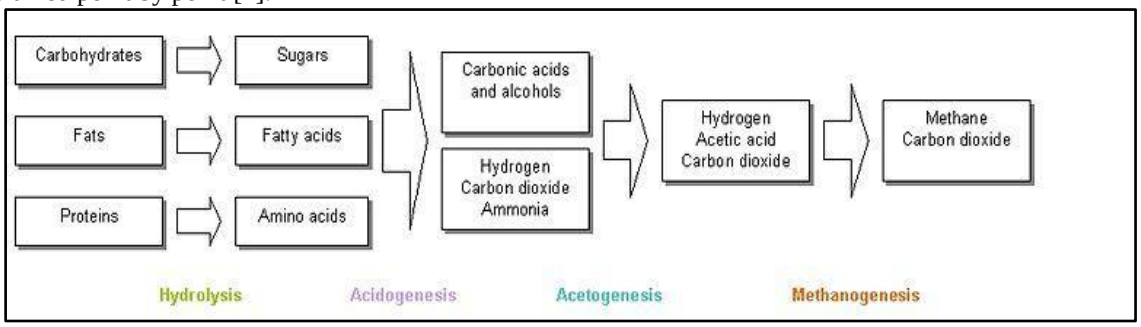

Fig. 1 stages in anaerobic digestion

Hydrolysis

In the first step (hydrolysis), the organic matter is enzymolyzed externally by extracellular enzymes (cellulose, amylase, protease and lipase) of microorganisms. Bacteria decompose the long chains of the complex carbohydrates, proteins and lipids into shorter parts.

Acidogenesis

Acid-producing bacteria, involved in the second step, convert the intermediates of fermenting bacteria into acetic acid (CH3COOH), hydrogen (H_2) and carbon dioxide (CO_2). These bacteria are anaerobic and can grow under acid conditions.

Acetogenesis

In this stage, the simple molecules created through the acidogenesis phase are further digested by acetogens to produce largely acetic acid. The acid-forming bacteria has high growth and more tolerant to changing environment than methane-forming bacteria.

Methanogenesis

Methane-producing bacteria, involved in the fourth step, decompose compounds with a low molecular weight. Under natural conditions, methane producing microorganisms occur to the extent that if anaerobic conditions are provided.

4.0 Components and working process

4.1Components

Hopper

The waste materials such as kitchen waste, agriculture waste animals are feed to the hopper. It is the inlet for the digester. The waste feed in the hopper pass to digester through the crusher.

Crusher

A crusher is a device used to reduce the size of the large particles by crushing. Here the crusher is placed at the base or the bottom of the hopper and used to crush the waste materials into the small pieces which increase the digestion rate.

Pipes

A pipe is a tubular section or hollow cylinder object. Here Poly Vinyl Chloride (PVC) pipes are used to flow the crushed waste to the digester.

Valves

A ball valve is used to regulate, directs or controls the flow of a fluid (gases, liquids, fluidized solids or slurries) by opening, closing, or partially obstructing various passageways.

Digester Tank

A **biogas digester** is a large tank where inside biogas is produced through the decomposition/breakdown of organic matter through a process called anaerobic digestion. It is called a digester because organic material is eaten and digested by bacteria to produce biogas.

Collector

A circular shape gas collector is used to collect the gas produced from the digester tank. The gas produced in the digester is passed through the pipes to the gas collector where the gas is stored and can be used as per the requirement.

4.2 Working Process and Method

The portable biodigester consists of different components as hopper, crusher, pipes, valves, digester tank and collector. The waste like kitchen waste, household waste, animal waste and agricultural waste are feed to the digester through the hopper and passes through the crusher. The crusher is used to crushed the fed waste materials and reduce the size of the particles. The smaller sized particles can be digested at faster rate than the larger sized particles. The crushed waste is then passed to the digester where the digestion process takes place with the help of the anaerobic bacteria. Some of the additives are used to increase the digestion rate and to produce the high amount of gas. The gas produced in the digester is passed through the pipes to the gas collector where the gas is stored. The stored gas can be used as cooking and lighting etc. The slurry so formed after the digestion can be used for the agricultural purpose as good manure [5].

Here in our paper we have used the hostel waste as kitchen waste; food wasted by the students and put it in the digester with some amount of water to make slurry at the same time the connection between the digester and the gas collector is made joining the pipes. After two days, again we added some waste and the water and left it for digestion. After four days we saw that the gas has started collecting in the collector but it was too less and we thought that it will take more time to collect the required gas but on the next day we that the gas is collecting at faster rate. We also thought to make an outer cover for the digester so as to maintain the temperature in the digester. The following Fig. 2 shows the final setup of the portable biodigester along with the components.

Fig. 2 Final setup

5.0 Properties, Characteristics and Factors

5.1 Properties of Biogas

Some of the properties of bio gas are discussed below
Change in volume as a function of temperature and pressure.
Change in calorific value as function of temperature, pressure and water vapor content.
Change in water vapor as a function of temperature and pressure.

5.2 Characteristics of Biogas

Some of the characteristics of bio gas are discussed below
Composition of biogas depends upon feed materials.
Biogas is about 20% lighter than air.
Biogas has an ignition temperature in range of 650 to 750^{o}C.
Biogas is an odorless and colorless gas that burns with blue flame similar to LPG gas.
Biogas is useful as fuel to substitute firewood, cow-dung, petrol, LPG and diesel [6].

5.3 Factors affecting yield and production of biogas

Many factors affecting the fermentation process of organic substances under anaerobic condition are
Temperature
The optimum temperature for methane bacteria process is between 35 to 45^{o}C. The gas production rate reduces considerably at 20^{o}C and stops completely at the temperature of 10^{o}C. Thus, the digester temperature has to be maintained for good operation. Here we have used a plastic cover to maintain the temperature of the digester.
PH value
The pH value in range of 6 to7.5 for the slurry yields good gas production results. In this range microorganism will be active and hence result in a efficient digestion.
Solid Content of the Feed
A solid content of about 10 to 15% in the slurry can yield better gas production results. In our project, the solid content is about 15-20%. Here we use kitchen waste, agricultural waste with about 70-80% of water.
Loading Rate
The amount of feed supply per day to the digester is called loading rate. About 0.5kg of waste should be feeded daily to produce the continuous and constant rate of gas [7].
Reaction Period
Under optimum condition, 80-90% of total gas production is obtained within a period of 3-4 weeks.
Water Content
The percentage of water content plays an important role in the production of biogas. This should be about 70-80% of the weight of the total contents [8].

6.0 Conclusion

In this study, a method for generation of biogas is proposed. The proposed method has relatively low construction costs, less moving parts and absence of rusting steel parts. The biogas production from vegetable waste largely depends on the condition of the used vegetable waste and the additives added to it. In this study, the proposed method will be beneficial for the people living in villages as they normally have cows and buffaloes and hence cow dung so with the help of simple method the villagers can generate electricity for the domestic applications as well as the fertilizer for the agriculture needs.

7.0 References

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