

Development of Wet Waste Digester

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ABSTRACT: As fossil fuels are getting depleted and environmental issues are increasing, renewable energy is playing a very important role to meet the world energy demands. Biomass, a renewable energy source, is the indirect form of solar energy. Here, Plants does photosynthesis and store light energy in chemical form and anaerobic digestion of biomass produces biogas. Biogas is one of the effective alternative sources of energy for lighting, transporting, and cooking sector. The main objective of this work is to develop a wet waste digester to produce the biogas in an economically manner. This paper explains about production of biogas using kitchen waste such as uncooked fruits and vegetables, cooked food, leftovers, bread, coffee powder waste, eggs, cheese and paper which were used to develop a wet waste digester that is economically feasible, mobile and easy to assemble.

KEYWORDS: Wet Waste Digester, Kitchen Waste, Biogas, Economical

I. INTRODUCTION

Energy is an essential input for social development, human welfare, economic growth and improving the quality of life. Every sector of human society like industry, agriculture, transport, domestic and commercial needs requires energy. As a result, consumption of energy has been steadily rising all over the world. This growing consumption of energy resulted in increased dependence on fossil fuels such as oil, coal and natural gas. Increase use of fossil fuels cause environmental problems both locally and globally. It is common knowledge that the world's main energy resources will be depleted within next few decades. The world has been unavoidably facing environmental degradation as a direct result of urbanization, growth in population and industrialization as they increased the use of fossil fuels to fulfill the energy needs. Consequently, alternatives, particularly renewable energy options, have been explored and discovered to potentially meet the energy demands, reducing the usage of fossil fuels and to improve the environmental sustainability. Biogas is one such alternative source to fossil fuels.

Biogas does not have any geographical limitations nor does it require advanced technology for producing energy. Also, it is very simple to use and apply. Using the wet waste produced on daily basis and applying anaerobic digestion process, biogas can be produced. Composition of biogas depends upon feed material. Biogas is about 20% lighter than air and has an ignition temperature in range of 650 to 750 °C. Biogas is an odorless & colorless gas that burns with blue flame similar to LPG gas and it usually burns with 60 % efficiency in a conventional biogas stove.

Kitchen waste is organic material having higher calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude. It means higher efficiency and size of reactor and cost of biogas production is reduced. Also in most of the 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 these solid wastes leads to adverse consequences. It not only leads to polluting surface and groundwater through leach ate 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.

II. RELATED WORK

Suitable materials required for the digester was studied by Rafaela Lora Grando et.al [1]. When the market reality was assessed by authors, it was found that, crop waste receives little attention outside universities, while materials from industrial plants and municipal solid waste are the types of waste that attract most commercial interest. Effects of cow dung on digestion process were studied by Sonam Sandhu et.al [2], where ideal execution for co-assimilation of cafeteria, vegetable, and fruit waste with cow dung was accomplished at their blending proportions of VW/CM (25:75), CW/CM (50:50), and FW/CM (25:75) in the primary arrangement of tests which gave maximum yield. The process parameters affecting anaerobic digestion were studied by Jay N. Meegoda et.al [3]. They have pointed out 4 main parameters present in anaerobic digestion viz. hydrolysis, acidogenesis, acetogenesis and methanogenesis. Waste

generation and anaerobic digestion was studied by Carlos Morales-Polo et.al [4]. Pre-treating substrates constitutes a way of improving and increasing anaerobic degradation. Biodegradable waste generation was studied by Srinvasa Reddy.N et.al [5]. The authors have also pointed the uses of biodegradable waste conversion into high quality manure, environmental advantages. Production of biogas from kitchen waste and excess sludge was studied by Wen-biao Han. et.al [6]. Studies showed that with inclusion of anaerobic process with pure sludge and kitchen waste, higher output could be achieved.

III. MATERIALS AND METHOD

The most important part of a biogas digester is the digester itself. For the digester, we have chosen a PVC based drum because of its anti corrosive property, mobility, low maintenance when compared to traditionally used bricks and mortar. In this work we have used three valves in total, out of which two are flow control valves to maintain the gas flow. Another one is T valve which is used as a junction valve. The rubber hose gas pipe is used to allow the flow gas from the digester to required domestic purpose. A plastic pipe has been used to remove the excess sludge and the over flow sludge in the digester. Plastic container is used to collect the effluents at the end. Clamps are used to tighten the pipes connection. A rubber tube is used as a collector, where the gas can be stored and used as and when required. The digester follows hydrolysis, acidogenesis, acetogenesis and methanogenesis stages of anaerobic digestion to produce the biogas. Later, the produced biogas is stored inside the rubber tube.

3.1 WET WASTE DIGESTER

A 50 litres plastic PVC drum is being used as our digester. It has anti corrosive property, high mobility, low maintenance cost and low capital cost. A gas valve is fitted at top of the drum for extracting the biogas produced inside the digester. This gas valve helps us in extracting biogas produced inside the digester. A plastic pipe along with bend pipe is fitted to the digester. The main purpose of this is to remove excess sludge formed inside the digester. A plastic container is used to collect all these excess sludge. A gas piping is in turn connected to the gas valve using a clamp as shown in fig. 3.1.

3.2 GAS PIPING

Gas piping is used in two primary places. Firstly, the rubber hose comes in contact with the gas valve in the digester and is connected to the first flow control valve. Now one gas piping goes to the rubber tube where the gas gets collected. Another one goes into the secondary flow control valve which can be used for secondary purposes like cooking, water heating. T valve is used as a junction valve to connect the two flow control valves and the storage as shown in fig. 3.1.

3.3 COLLECTORS

In the experimental setup, we have mainly three collectors. A plastic collector is used to collect all the excess sludge formed inside the digester. A secondary plastic container collects the escaped wet particles along with biogas from the container. This container is placed along with the second flow control valve. Finally, the most important collector in the setup is a rubber tube. Here, biogas formed inside the digester is piped and stored in. The amount of gas formed can be noticed as the rubber tube starts to inflate as shown in fig.3.1.

3.4 WET WASTE

Over 50 % of waste was composed of uncooked vegetable & fruit waste. Eggs the main source of pathogens was relatively low in mass at 1.5%. Also, about 15% of cooked food was used from the kitchen as shown in fig.3.2. In our study uncooked food and fruits are the major source of kitchen waste. This wet waste was mixed with cow dung to obtain the biogas.



Fig 3.1. Fabricated Wet Waste Digester

COMPOSITION OF WET WASTE

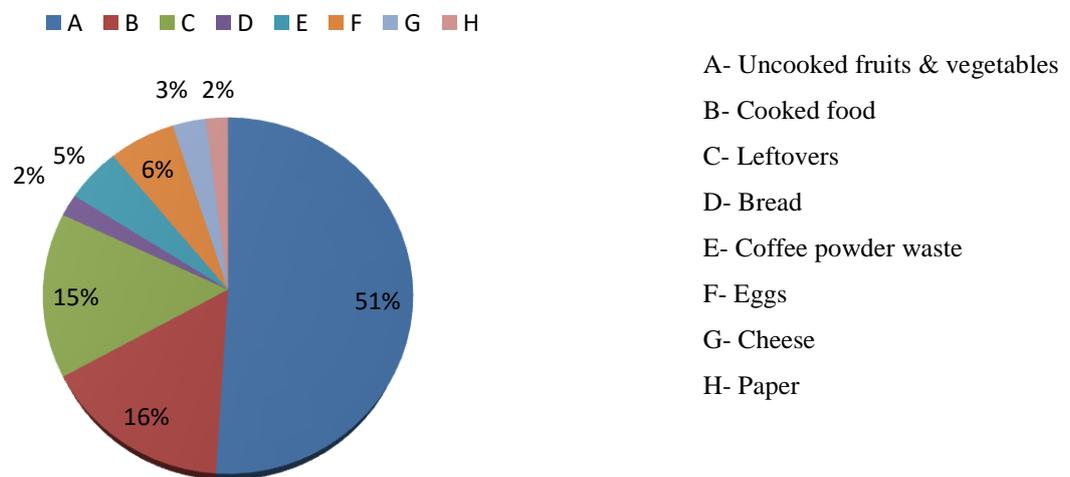


Fig. 3.2 Composition of wet waste

IV. EXPERIMENTAL RESULTS

The biogas is usually rich in methane and is useful for domestic purposes. A 50 litres PVC tank is taken as our main digester. About 70% (30 litres) of wet waste was initially fed to the digester. After day 3, the biogas started to collect inside the tube collector at slow rate. The amount of gas produced gradually increased from day 3 to day 15. At the end of day 15, the wet waste was reduced from 30 litres the wet waste was reduced to 18 litres as shown in Fig 4.1 and Table 4.1. In our work, we have used 30 litres of slurry composing 4500 gram of cow dung and 1500 gram of kitchen waste.

In the digester production occurs and gas was burned with **blue flame** and its **calorific value** was **32152.8 kJ/kg**. As the process continues, volatile fatty acids (VFA) are produced which causes the decrease in PH value of solution. The volume of gas accumulated at end of 15 days is **5177.70 cc** as shown in Fig. 4.2 and Table 4.2.

WET WASTE

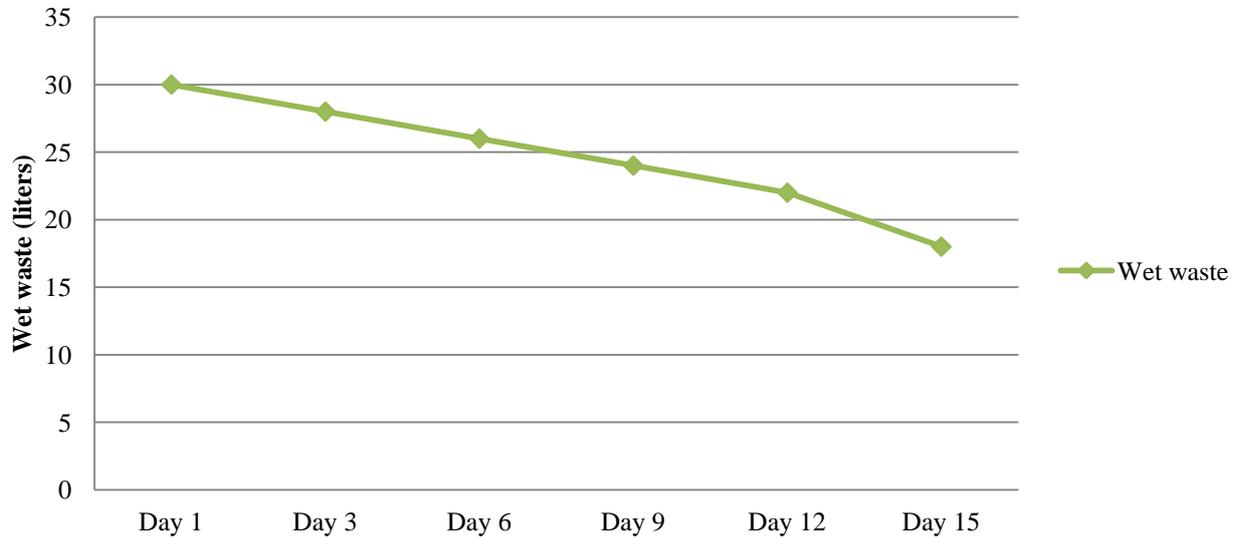


Fig. 4.1 Line graph of Reduction of wet waste day wise

Table 4.1. Day wise usage of wet waste

No of days	Wet waste (Litres)
1	30
3	28
6	26
9	24
12	22
15	18

Digestate is the solid remnants of the original input material to the digesters that the microbes cannot use. It also consists of the mineralised remains of the dead bacteria from within the digesters. Digestate can come in three forms: fibrous, liquor, or a sludge-based combination of the two fractions. Digestate typically contains elements, such as lignin, that cannot be broken down by the anaerobic microorganisms. Also, the digestate may contain ammonia that is phytotoxic, and may hamper the growth of plants if it is used as a soil-improving material. For these two reasons, maturation or composting stage like sun drying is being employed after digestion. Lignin and other materials are available for degradation by aerobic microorganisms, such as fungi, helping them reduce the overall volume of the material for transport. During this maturation (sun drying), the ammonia will be oxidized into nitrates, improving the fertility of the material and making it more suitable as a soil improver. Large composting stages are typically used by dry anaerobic digestion technologies. The final output from anaerobic digestion systems is water, which originates both from the moisture content of the original waste that was treated and water produced during the microbial reactions in

the digestion systems. This water may be released from the dewatering of the digestate or may be implicitly separate from the digestate.

BIOGAS PRODUCED

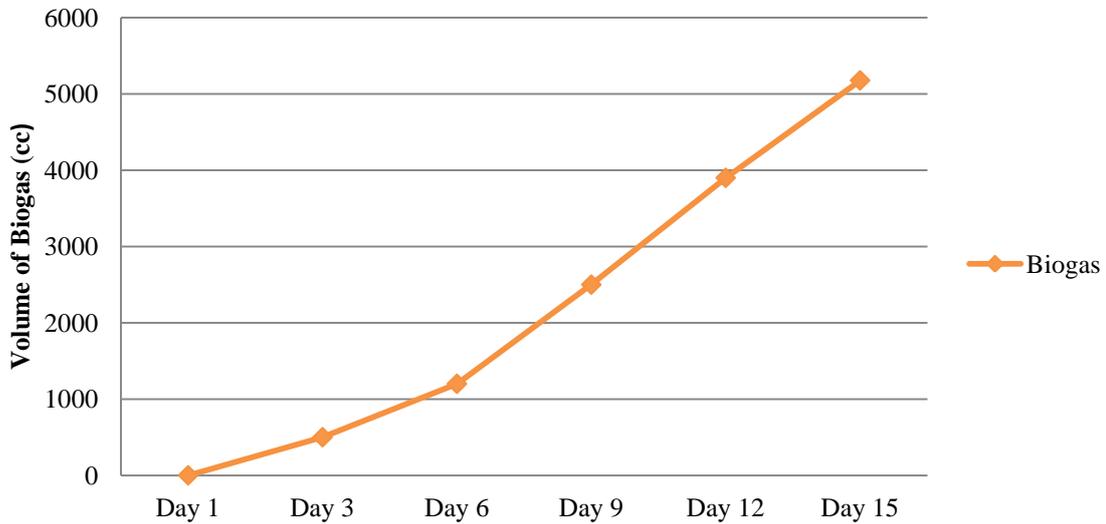


Fig. 4.2 Line graph of biogas produced day wise

Table 4.2. Volume of Biogas produced day wise

No of days	Volume of Biogas produced (cc)
1	0
3	500
6	1200
9	2500
12	3900
15	5177.70

V. CONCLUSIONS

This project showed that, multi-stage processes provide biological stability by keeping the acidogenesis and methanogenesis separately and allowing higher organic loading rate without shock to methanogenic bacteria. However, multi-stage systems are complex and the benefits do not justify high investment costs. Single stage anaerobic digestion processes are starting to dominate the market because of their simple reactor design, low investment and low operational cost. Even though large land acreage is required, it is not a problem for countries like India. Also the anaerobic digester system fits well as it generates biogas and dependence on fuel wood gets reduced. However, difficulties accompanying the collection as well as transportation of food waste should also be considered by taking an example of the Bengaluru city which alone produces 3000 metric tons of wet waste daily. This amount of wet waste



can be used to produce biogas in rural area to cut the dependence on crude forms of resources and self sustainability can be achieved. It also reduces the landfills benefitting the nearby villages as well as municipalities.

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