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Design of Biogas plant: An unique approach to an alternative source of energy in Vignan's institute of information & technology

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Abstract. We have a hostel and two canteens at our institute, and each one has an individual mess, where a vast amount of food waste is generated every day and might be put to greater use. The project's goal was to build an anaerobic digestion plant to produce more cost-effective, eco-friendly biogas. The kitchen (food waste) was gathered from various sources throughout VIIT's Mess as a feedstock for our reactor, an anaerobic digestion unit to generate biogas fuel. Although solid waste management is a global phenomenon, inappropriate solid waste (SW) management endangers communities. Moreover, the issue of solid waste management (SWM) is also present in the academic area at VIIT, Visakhapatnam. As a result, there is an urgent need for better design and implementation of integrated SWM systems to improve the campus's environmental scenario. In addition, it needs complete information about the volume and type of SW generated and their physicochemical characteristics. Therefore, we erected batch reactors and added Inoculum from prior cow dung slurry and kitchen garbage. In a laboratory (small scale) reactor, this mixed Inoculum produced biogas at 37°C (20L capacity). Our study uses primary digesters to determine biogas and methane production from starch-rich and sugary materials. To reduce food waste disposal, we develop and estimate the cost of a biogas plant.

1. Introduction

Renewable energy has the potential to deliver the much-needed long-term rural rehabilitation in the majority of developing countries. It is an excellent choice because it may be more affordable for low-income populations. An ideal renewable energy source is readily available, inexpensive, and easily managed by local groups. Biogas is one of several technologies that enable decentralized methods to supply advanced energy services by generating energy from cow dung, human waste, and agricultural waste. It can be utilized to create heat and power, and the digester waste can be used as an additional fertilizer in agriculture. Biogas plants are reasonably straightforward and cost-effective to run small to big scale in urban and rural areas(1).

Microorganisms can break down biodegradable waste reasonably, converting it to co2, water, methane gas, or simple organic compounds. These wastes are produced due to household and industrial economic activity, with residential, commercial, and industrial regions as possible sources. These wastes have different characteristics depending on where they came from the society. Due to socioeconomic, cultural, and living situations, the content of garbage differs from urban to rural areas and from community to community. Examples of biodegradable waste are food and domestic waste, manure, farm and forestry waste, old newspapers, and fabrics. Different trash disposal methods are available, and eco-friendly choices must be chosen to safeguard the natural resources and the environment(2).

Biogas can be made of biological feedstocks, including those primary crops and organic matters from society. Animal dung and slurries from cow and pig production units and poultry and fish are abundant resources. Millions of metric tonnes of animal dung are produced in India every year. Animal dung can become a significant source of environmental pollution if not properly handled or controlled. It is estimated that the animal production sector's contribution is 18 per cent of total greenhouse gas emissions, as measured in carbon dioxide(3). Furthermore, the animal production industry accounts for 65 per cent of anthropogenic nitrous oxide emissions and 64 per cent of anthropogenic ammonia emissions worldwide. It is possible to use animal dung to generate renewable energy and provide nutrients for agricultural development when managed appropriately.

2. Research Objective

The primary goal of this study is to determine the amount of gas produced, its utilisation, and the resulting cost savings to construct an affordable biogas plant. C02 emissions that contribute to global warming are the primary cause of rising sea levels and consequent global warming. In addition, rising fossil fuel prices, especially crude oil prices, are hurting the price of gasoline and diesel, and adopting biofuel will positively impact our economy and lower operating costs(4)(5).

In this paper, an attempt has been made to study the biogas production rate in a small biogas plant. Here we analyse the various ratios of kitchen waste under biogas production and their composition under different temperatures throughout the retention period. The literature provides data on biogas production and its composition (CH4 fraction) with the slurry operating temperature. We have tried to evaluate the maximum biogas production rate through this paper. Additionally, we conducted a cost analysis on the project implementation on our campus.

3. Materials and Methodology

Food waste, including vegetables, fruits, and other commodities, is collected for research. Hazardous waste was generated during the treatment of food waste items. Chemical use has been one of the primary reasons behind this. Manufacturing food products is a procedure that must be carried out according to the tight regulations imposed by federal and state food regulatory agencies. Food manufactured is as diverse as the people it serves. Whether they are everyday staples or exotic delicacies, snack foods, or ethnic specialities, all food items undergo a controlled and exact production process, with safety always a priority(5)(6).

3.1 Study area

There are two kitchens at Vignan's Institute of Information Technology (VIIT). A significant amount of food trash is deposited in the shape of a large heap beside the college compound wall daily. As a result, there are numerous issues with the surrounding environmental factors. This dumping method pollutes the land, water, and air. As a result of this, groundwater reserves have been contaminated. Mosquitoes, flies, and other insects use these heaps as "breeding centres." Furthermore, pigs are posing a threat near the college grounds. Implementing a productive Solid Waste Disposal System is the only solution to liberate the VIIT campus from these challenges.

VIGNAN STUDENT CANTEEN KITCHEN

- Daily, around 30 kgs of vegetable waste are generated on an average
- The data is collected continuously for two weeks to calculate the average weight of raw manure. Apart from this weight of fruit waste is also gathered from the canteen's kitchen

VIGNAN HOSTLERS MESS KITCHEN

- The data collection Methodology is similar to the above

A mixed kitchen waste sample was obtained from leftovers in houses for the study. The wastes were pulverized in a household grinder to a particle size of between 0.2-and 1mm. After neutralizing with tap water, the FW slurry concentration was 50 per cent and then fed to the reactor.

3.2 Materials required

The study used a fully recyclable anaerobic reactor constructed from a cylindrical column of tempered glass with a total volume of 20L. The reactor structure was painted black to prevent direct sunlight from entering and process heat from escaping. The reactor system for anaerobic digestion of food waste is constructed utilizing a 20-litre container with provisions for feed, recirculation, and biogas measurement (6)

Solid tape, M-seal, PVC pipe 0.5" (length 1 m), Rubber or silicone cape (to cover container), Funnels (for feed input), Cape 0.5" (to cover discharge pipe), Pipe (for gas output; I used level pipe) (3-5 m), Bucket (15-20 litres) and Plastic containers – for capturing gas (2-10 lit.)

3.3 Experimental setup

Mini biogas plant:

It has mainly 3 stages

- Collection of food waste
- Adding cow dung
- Mixing

Here cow dung acts as an activator for anaerobic digestion. It takes nearly two weeks for the complete digestion of food waste

FOOD WASTE

COW DUNG

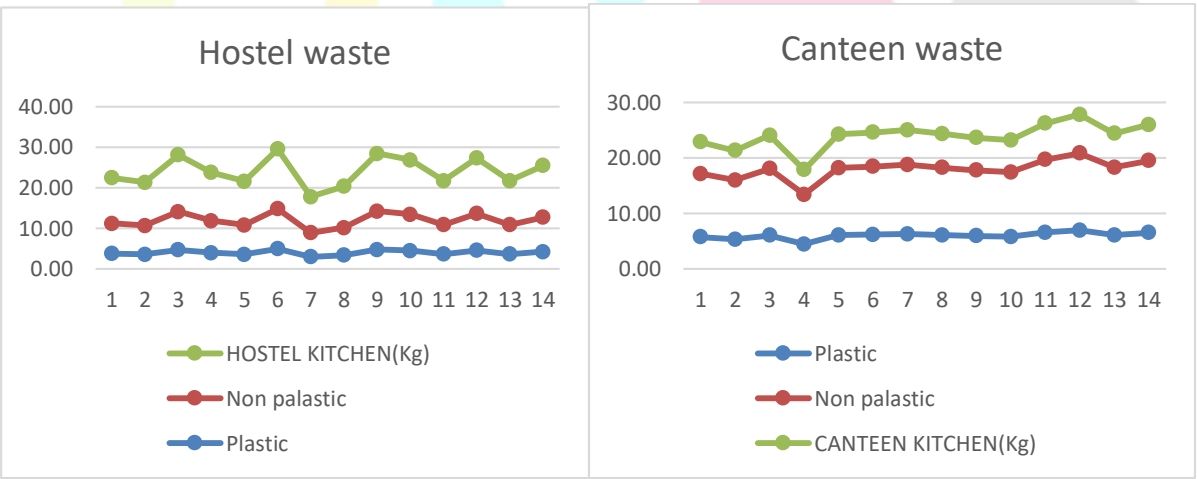
MIXING

- The feed is gathered from the hostel mess and transferred to the plant.
- The food waste and water are combined in the inflow tank, and the resulting slurry is transferred to the digestive vessel for digestion.
- The dome collects the gas produced by the anaerobic fermentation bacteria in the digester.
- The digested sludge tends to flow to the outlet tank via the maintenance hole.
- The slurry flows to the compost pit via the outlet tank's overflow opening.
- The pipeline transports the gas from the dome to the application site.
- When a digester is underfed, it produces insufficient gas.
- In this situation, the plant must be designed with a higher hydrostatic pressure.
- If an excessive amount of material is introduced into the digester, the digester consumes more gas, and the slurry penetrates the gas pipes and other appliances.
- As a result, the required precautions must be made to avoid this(5)(7)

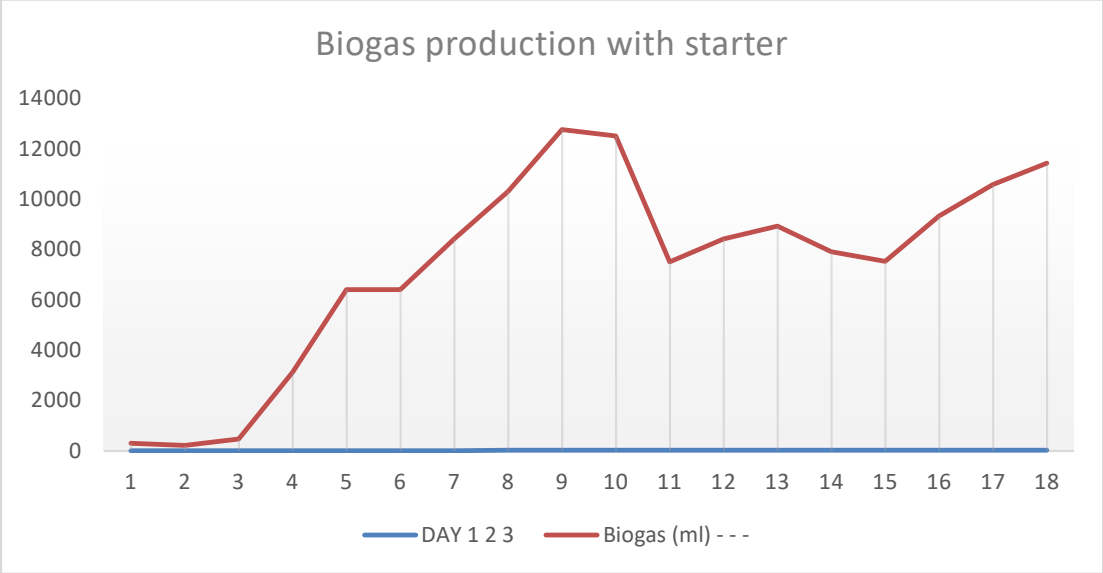
4. Results and discussion

The biogas plant used in this study is made of readily available components. However, it is important to remember that the plastic used should not be easily cracked, since this will ensure that there are no cracks or leaks throughout the drilling process. While the metallic materials utilised should not rust easily. As shown in the image, a digester has been developed.

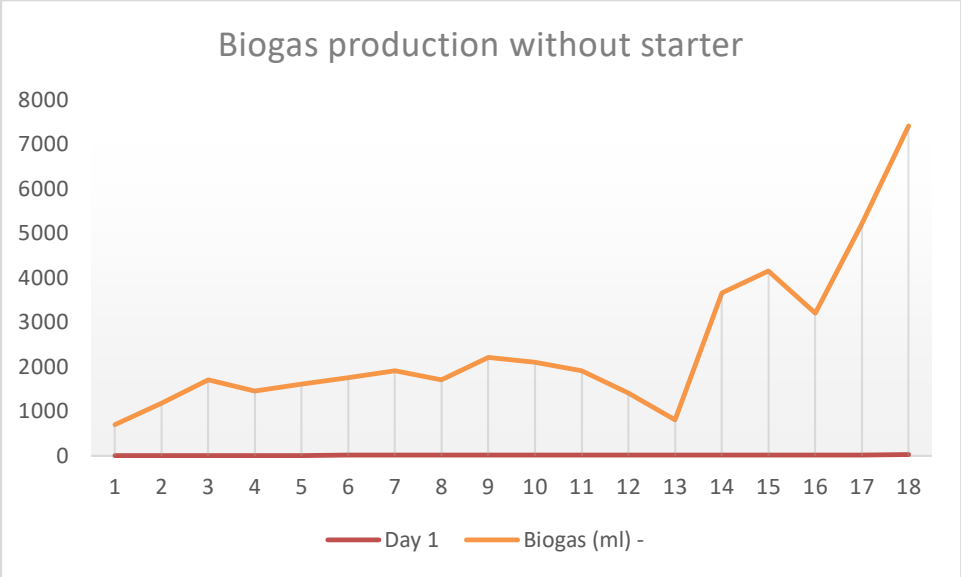
We conducted a survey in VIIT's hostels and canteens to determine how each individual contributes to the waste generated on campus. We learned from the survey that the number of plastic and non-plastic garbage differs significantly, so we created the following graphs(8).



Non-plastic waste were clearly shown in the graphs to be a significant contributor. According to our study, the majority of the non-plastic garbage comes from the hostel kitchen. The amount of food waste that accumulates in each mess each day is substantial. We noticed that these waste materials are either provided to pig farms or collected and burned, which harms the environment.



Fresh cow manure was gathered and carefully mixed with water by hand before being thrown into a 20-liter digester. The sampling experiment's content was utilised as an inoculum. Due to the fact that it includes the necessary microorganisms for anaerobic digestion. Following inoculation, the digester was retained for many days, and the gas output was monitored. After a few days, kitchen garbage was added and kept for monitoring gas production. The conventional method is also chosen to observe the difference in gas production with and without kitchen waste(9).



In the study, it was discovered that biogas using starter that contained kitchen trash produced significantly more gas when compared to the conventional approach that contained cow dung. Because of this, the usage of kitchen trash is a more effective form of biogas production.

5. Conclusion

Biogas systems take organic substances (feedstock) and place it in an airtight container, where bacteria break it down and create biogas, which is primarily methane with a small amount of carbon dioxide. The residue obtained can be utilised as organic compost, and the biogas can be used as a cooking and heating or other reasons. The effectiveness of methane production can be boosted up by various orders of magnitude by using feedstock with high calorific and nutritional value to bacteria, as illustrated by this compact system. It's a system that's quite easy to utilise.

In order to solve our energy crisis, we must work to improve research and diffusion of biomass fuel across the country. Deforestation, overall greenhouse gases, and fertilizer and pesticide runoff might all be reduced with sustainable bioenergy production). Finally, a compact biogas reactor was built and tested, and it performed well under ideal conditions. The anaerobic digestion of kitchen waste with cow dung has been shown to be a desireable method for

environmental preservation and energy savings, although it is evident that more realistic results can be produced with improved equipment and conditions.

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