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Performance Analysis of Biogas Production

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ABSTRACT

The main aim of this study is to produce the biogas from food wastes. In our institute we have two hostels and having their own mess, where daily a large amount of Food waste is obtained which can be utilized for better purposes. Biogas production requires anaerobic digestion. Project was to create an Organic Processing Facility to create biogas which will be more cost effective, eco-friendly, cut down on landfill waste, generate a high-quality renewable fuel, and reduce carbon dioxide & methane emissions. The continuously-fed digester requires addition of sodium hydroxide (NaOH) to maintain the alkalinity and pH to 7. In our study, the production of biogas and methane is done from the starch-rich and sugary material and is determined at laboratory scale using the simple digesters.

Keywords : Biogas, Biomass, Anaerobic Digestion, Methane, Renewable Energy

I. INTRODUCTION

In recent years the interest in bio fuels has been increasing, motivated on the one hand by the need for reducing greenhouse gas emissions and on the other hand by the desire to improve energy security by reducing our dependence on imported fossil fuels. During the last few weeks the desire was rocketed driven by the tremendous increase in oil prices. The economics of India depends to a large extent on the wheels of fuel. The spectre of economy ruin due to depleted oil reserves has changed the interest of scientist and research work towards alternative fuels for motor vehicle. Viable substitute for motor spirit are gaseous hydrocarbons, hydrogen gas, alcohol & electricity that run on hydrocarbon gas & electricity are still in the experimental stage. India is largest cattle breeding country. There is abundance of raw material for producing biogas. Also municipal sewage can be used for this purpose.

The use of methane separated from biogas as a fuel will substantially reduce harmful engine emission and will help to keep the environment clean. Biogas consists of approximately 55-60 % of methane. It is economical and slurry can be used as organic manure. One of the alternate technologies is the biogas plant that utilizes human excreta as its raw input. In the last 20 years, it has setup a hundred such plants throughout India. The plants twin outputs, similar to those of cattle biogas plants, are nutrient-rich sludge and methane-rich biogas. The sludge is used primarily as manure, and the biogas either as cooking fuel or as street-lighting gas. In today's energy demanding life style, need for exploring and exploiting new sources of energy which are renewable as well as eco-friendly is a must. In rural areas of developing countries various cellulosic biomasses (cattle dung, agricultural residues, etc.) are available in plenty which have a very good potential to cater to the energy demand, especially in the domestic sector. In India alone, there is an estimated over 250 million cattle and if one third of the dung produced annually from these is available for production of biogas, more than 12 million biogas plants can be installed Biogas technology offers a very attractive route to utilize certain categories of biomass for meeting partial energy needs. In fact proper functioning of biogas system can provide multiple benefits to the users and the community resulting in resource conservation and environmental protection.

II. BIOGAS PRODUCTION

Biogas is a colorless combustible gas produced by organic decomposition of organic materials; Occurring in the absence of oxygen. Biogas comes from "biogenic materials" and is produced from biodegradable materials such as biomass, dung green waste and agricultural residues such as cassava, sugarcane, etc.Biogas contains a mixture of various gases, mainly methane (CH4), carbon dioxide (CO2), hydrogen (H2), including 1 – 5% of other gases. The Gas is produced by bacteria occurring during the bio-degradation of organic materials under anaerobic, which makes it an attractive source of energy.The energy that is released from biogas makes it a suitable fuel in any country for heating and cooking purpose. Biogas can also be used in an anaerobic digester where the energy in the gas is converted into electricity and heat using gas engine.In as much as the biogas constitutes mainly methane and carbon dioxide, which are greenhouse gases that are harmful to the environment. It is therefore important that it undergoes a burning process before releasing it to the atmosphere. The physical, chemical and biological characteristic of cassava and other potential biomass can influence the biogas composition and yield . In general, three key methods are in the thermo-chemical conversion of biomass.

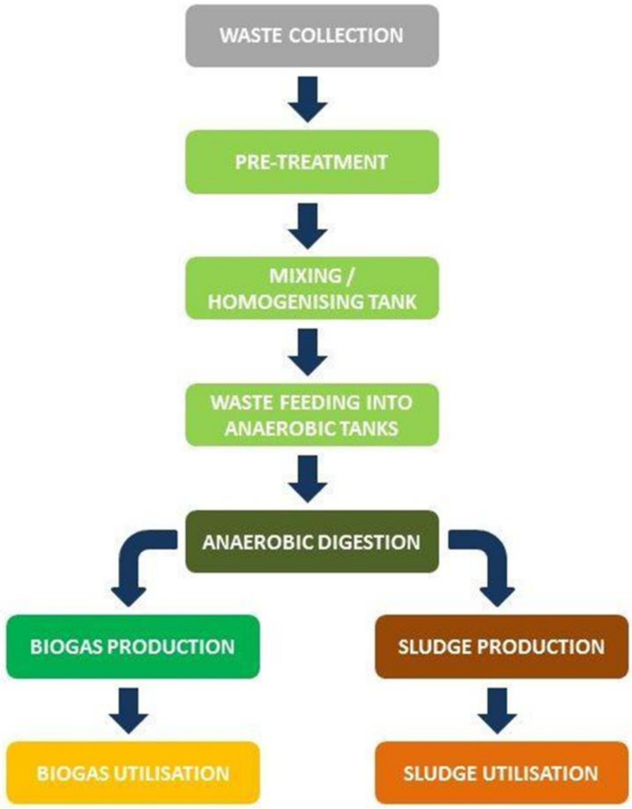


Fig.Biogas Production Process

III. ANAERBIC DIGESTION

The AD is a microbial degradation of organic waste in the absence of oxygen. Organic matter conversion to CO2 and CH4 gases occurs next to a sequence of biochemical reactions during an anaerobic process . As a result, a breakdown of organics takes place during the digestion, and this is made possible by anaerobic microorganisms. The AD of organic matter follows stages that are organized by different categories of microorganisms. Most biodegradable organic matter are converted to gases while only a small amount (about 10%) is converted to new cell mass through microbial growth . Methane produced by AD can be used to run a treatment plant; giving AD an economic advantage over aerobic digestion.

IV. PROCESS AND MECHANISM OF BIOMETHANATION

The anaerobic biological conversion of organic matter occurs in three steps. The first step involves the enzyme mediated transformation of insoluble organic material and higher molecular mass compounds such as lipids, polysaccharides, proteins, fats, nucleic acids, etc. into soluble organic materials, i.e. to compounds suitable for the use as source of energy and cell carbon such as mono saccharine, amino acids and other simple organic compounds. This step is called the hydrolysis and is carried out by strict anaerobes such as Bactericides, Clostridia and facultative bacteria such as Streptococci, etc. In the second step, acid genesis, another group of microorganisms ferments the break-down products to acetic acid, hydrogen, carbon dioxide and other lower weight simple volatile organic acids like propionic acid and butyric acid which are in turn converted to acetic acid. In the third step, these acetic acid, hydrogen and carbon dioxide are converted into a mixture of methane and carbon dioxide by the methanogenic bacteria (acetate utilizers like Methanosarcina and hydrogen) and formate utilizing species like Methanobacterium, Methanococcus, etc.

V. TECHNIQUES FOR ENHANCING BIOGAS PRODUCTION

Different methods used to enhance biogas production can be classified into the following categories:

(i) Use of additives
(ii) Recycling of slurry and slurry filtrate
(iii) Variation in operational parameters like temperature, hydraulic retention time (HRT) and particle size of the substrate
(iv) Use of fixed film/biofilters

Composition	55-70% methane,30-45% carbon dioxide, traces of other gases
Energy content	6.0-6.5 kW m^{-3}
Fuel equivalent	0.6-0.65L oil/ m^3
Explosion limits	6-12% biogas in air
Ignition temperature	650-750°C
Critical pressure	75-89 bar
Critical Temperature	-82.5°C
Normal Density	1.2 kg m^{-3}
Odour	Bad Eggs(the smell of hydrogen sulphide)

A) Use of additives

Some attempts have been made in the past to increase gas production by stimulating the microbial activity using various biological and chemical additives under different operating conditions. Bio logical additives include different plants, weeds, crop residues, and microbial cultures etc., which are available naturally in the surroundings. As such, generally these are of less significance in terms of their use in the habitat, however if used as additives in biogas plant could improve its performance significantly. The suitability of an additive is expected to be strongly dependent on the type of substrate.

B) Green biomass

Powdered leaves of some plants and legumes (like Gulmohar, Leucacena leucocephala, Acacia auriculiformis, Dalbergiasisoo and Eucalyptus tereticonius) have been found to stimulate biogas production between 18% and 40%. Increase in biogas production due to certain additives appears to be due to adsorption of the substrate on the surface of the additives. This can lead to high-localized substrate concentration and a more favorable environment for growth of microbes. The additives also help to maintain favourable conditions for rapid gas production in the reactor, such as pH, inhibition/promotion of acetogenesis and methanogenesis for the best yield, etc. Alkali treated (1%NaOH for 7 days) plant residues (lantana, wheat straw, apple leaf litter and peach leaf litter) when used as a supplement to cattle dung resulted in almost two fold increase in biogas and CH_4. Partially decomposed ageratum produced 43% produced 14% more gases compared to pure cattle dung and the addition of the tomato-plant wastes to the rabbit wastes in proportion higher than 40% improved the methane production. Crop residues like maize stalks, rice straw, cotton stalks, wheat straw and water hyacinth each enriched with partially digested cattle dung enhanced gas production in the range of 10 -80. Biomethanation of mango process wastes by several folds by the addition of extracts of seeds of Nirmali, common bean, black gram, guar and guargum at the rate of 1500 ppm. Mixture of Pistia stratiotes and cowdung (1:1) gave a biogas yield of 0.62 $m^3/(m^3$ day) (CH_4¼76.8%, HRT¼15 days) an increase of 40 – 80% in biogas production on addition of 1% onion storage waste (OSW) to cattle dung in a 400-l floating drum biogas reactor.

C) Microbial strains

Strains of some bacteria and fungi have also been found to enhance gas production by stimulating the activity of particular enzymes. Cellulolytic strains of bacteria like actinomycetes and mixed consortia have been found to improve biogas production in the range of 8.4 – 44% from cattle dung.All the strains exhibited a range of activity of all the enzymes involved in cellulose degradation, viz. Cl enzyme, exglucanase, endoglucanase, glucosidase. It seemed that endoglucanase activity was of central importance for the hydrolysis of cellulose.

VI. BASIC DESIGN

A typical biogas plant, should comprise of following parts:

a. **Digesting Chamber** (A) – a deep airtight circular pit, the digestion chamber is filled with organic solid waste mixed with water, fermentation (anaerobic decomposition) occurs and gas is produced and rises up within the chamber.
b. **Inlet Pipe** B – to be used to pour the raw material into base of digester.
c. **Outlet Pipe** C - meant to take out sullies from digester.
d. **Mixing Tank (Inlet)** D – to be used for preparing homogenous mixture of the raw material, usually an equal amounts of biomass and water to feed into digester.
e. **Compensation & Removal Tank (Slurry Outlet)** – solid (slurries) and liquid waste from digestion chamber "A" are collected through a pipe C and can be used as fertilizer being rich in nitrogen contents.
f. **Gas Accumulator** (F) - gas produced is collected in an accumulator that may be the floating drum or a concrete made dome over the digestion chamber.
g. **Gas Collection and Distribution** (G) - At the top of accumulator gas collection and distribution system is fixed, which is further channeled to the consumption unit.

The performance evaluation of the stove will be carried out by boiling water and cooking rice, and the time taken for the various tasks will be determined from a stop watch. Boiled water will be determined by observing bubbling and steam rising from the boiling water while the cooked material will be determined by pressing the rice between two fingers and crushing. The quantity of rice will be determined by weighing using an electronic weighing device. One litre of water will be used in the evaluation. Boiling of the water and cooking of the rice replicated thrice. The time taken for all the 35 jets of the stove to burn will also determined from a stop watch.

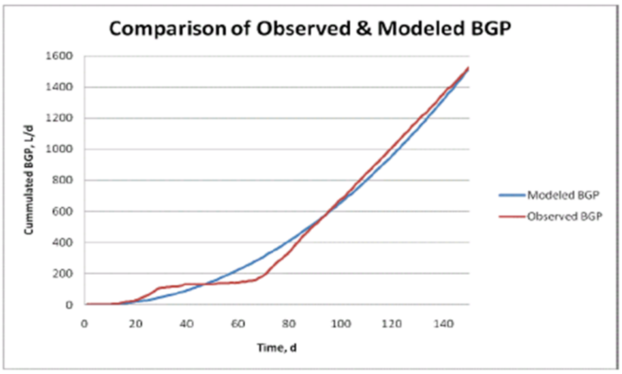
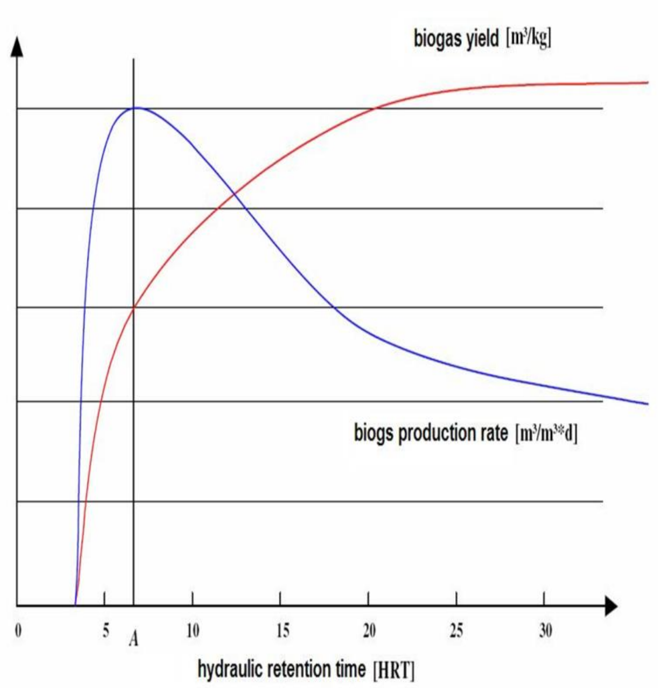
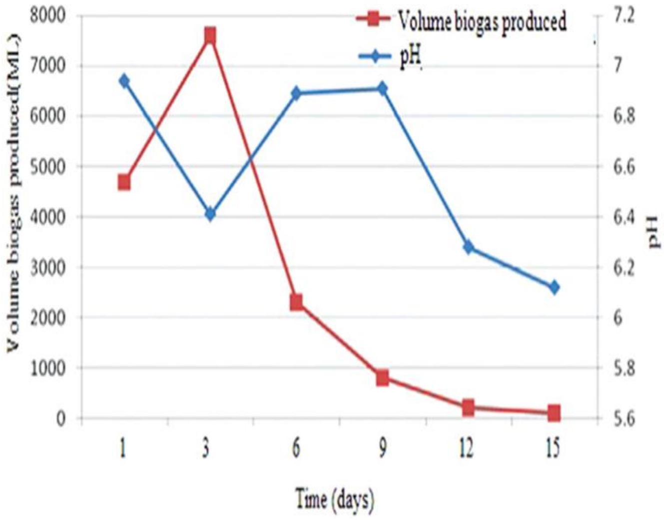


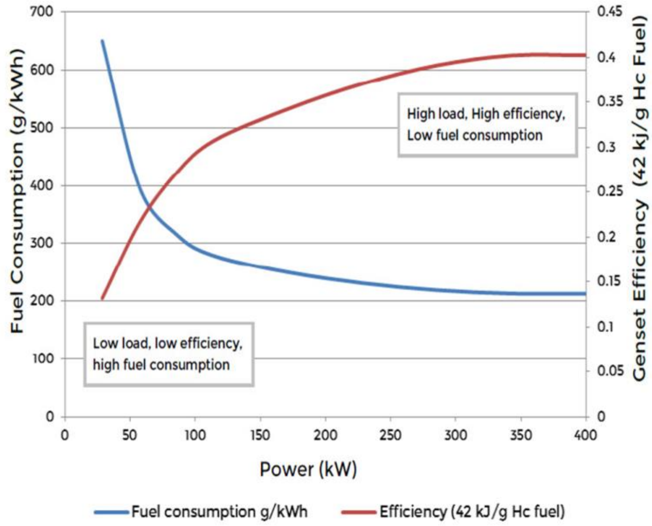
Figure 5: A curve fitting of observed and modeled biogas production.

Biogas Production

To produce biogas set up of biogas production was made.For production process vegetable waste of 5kg , cow dung of 25 kg and added water of 30 litre in a 200 litre capacity barrel.Barrel which is closed in a top surface for decomposing by anaerobic digestion process.Biogas is produced which is captured and stored. Stored biogas will used as a fuel for biogas stove and analyse the performance of biogas stove.







PH value (days vs volume mm³)

VII. CONCLUSION

This project will provide cheap energy resource to backward people in villages and will help the government to deal with energy crises This will lead to sustainable development. This project of this port will contribute for the improvement of life quality of the surrounding population, since the project includes the treatment of the landfill generated biogas, that for containing other composites beyond the methane in its constitution, they provoke distasteful smell in neighborhood.

Moreover, the project will also contribute for the reduction of explosion risks in the case of occurrence of high gas concentrations in landfill interior. The production of energy from wastes generates great opportunities for the landfill construction and operation market that starts to have a net recipe. So, the landfill operator will have financial resources for applying in pollution control equipment and initiatives, reducing landfill environment impact.

This project will illustrates cooking and biogas consumption rates for boiling water and cooking rice compared to results obtained from other countries and sources. The cooking rate for water and rice was lower for this stove than the values obtained from India and the other sources. This resulted in higher biogas consumption rates for this stove when compared to the values obtained from India and the other sources. This also played a major role in the biogas consumption rate as it determined the duration of the cooked material on the stove.

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