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Scope of Biogas generation from Kitchen wastes and its economical adoptability

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Abstract: The main objective of this review is to give an insight and update of the state of biogas technology research in some selected Indian states in peer reviewed literatures by highlighting the production of Biogas, Factors affecting its generation from various organic matters like food wastes, kitchen wastes, municipal wastes and also strengths and weaknesses in biogas research and development capacity. In Modern age the extensive demand for fossil fuels becomes a threat to the environment and a challenge for researchers. Some alternative renewable sources like Methanol, Ethanol, Hydrogen, Natural Gas, LPG, CNG, LNG, Biogas and Biodiesel, plastic fluids, etc which may be produced at a reasonable cost from various wastes. The fuels extracted from refused food wastes may be used either for running IC engines or cooking purposes at a very low cost. The reviews of different research results claim that biogas may be the cheapest and useable non-conventional energy sources.
Key words: Biogas research, kitchen waste, anaerobic digestion, Bio Digester.

1. Introduction

The depletion of fossil fuels and increasing of taxes on energy sources evokes to find another source for energy production. Bio fuels are attracting global attention as an alternate transportation fuels due to advantages of their being produced from locally available renewable resources, lower pollution potential, and biodegradable nature [1].Energy is a treated as a tool for economic growth, social development, human welfare and improving the comfort of life. The energy demand for agriculture, industry, transport, commercial and domestic purposes increases exponentially all over the world. Thus excess consumption of energy resulting the world a dependent on fossil fuels and creating a threat to the environment. But also the depletion of fossil fuels and increasing taxes of energy sources for that region will find another source of energy. Production of an alternative fuel used as an energy input to us and pointing the economical development of the world and shows economic prosperity and quality of life. The alternative fuel production comes to our mind because after the main energy resources that are fossil fuel will be depleted within next several decades, growth in population and industrialization the world is unavoidably faced with shortage of fossil fuel. In India, demand for petrol and diesel fuels is very high and imported petroleum products a large amount of capital is required and for that the economic development is become downward. Biomass energy systems create many environmental issues like global warming, greenhouse gases effect. This Biomass fuel sources are easily available in rural and urban areas all over the world.

In 1884, Guano who was a student of Pasteur had an aerobically produced biogas by mixing of the cattle manure and water solution and prepares slurry at 35^0C and he was capable to produce a gas of 100 L/m^3 of manure. Biogas produced by the biological breakdown of organic matter in the absence of oxygen and the organic waste like dead plants, animal materials, animal dung and kitchen wastes, and some biodegradable materials like biomass, manures, sewage, municipal waste, plant material and crops is converted by the anaerobic digestion and produce a gaseous fuels and treated as biogas. Biogas is the composition of some gases like methane (CH_4) and carbon dioxide (CO_2) and a small quantity of hydrogen sulphide (H_2S) and moisture (H_2O) and can be easily combusted with oxygen. As we know that the mixture of gases that is methane, hydrogen sulphide and carbon -monoxides which can easily burn out and could produce a high amount of energy as a fuel. Many countries depend on biogas for any type of heating, cooking and running the vehicles, etc. As it contains some amount of water vapours and the moisture, it causes variations in heating temperatures during burning. The organic wastes which are normally left as untreated, releases two main green house gases like Nitrogen dioxide (NO_2) and carbon dioxide (CO_2) and causes global warming.

2. Biogas and its Characteristics

2.1 Composition of Biogas

Anaerobic decomposition of different municipal wastes which is biodegradable in nature can produce biogas. The natural decompositions of such wastes by bacteria produce the gas in both rural and urban areas. 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. There are two types of processes for anaerobic fermentation, 1st one is the Continuous and 2nd one is batch. In case of a continuous process is suitable for the material which is free-flowing and for the batch process is used for light materials.

Methane formation in anaerobic digestion involves four different steps, including hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Different bacterial or archaea communities work in a syntrophic relationship with each other to form methane. In hydrolysis, complex carbohydrates, fats, and proteins are first hydrolyzed to their monomeric forms by exoenzymes and bacterial cellulosome. In the second phase (acidogenesis), monomers are further degraded into short-chain acids such as: acetic acid, propionic acid, butyric acid, isobutyric acid, valeric acid, isovaleric acid, caprionic acid, alcohols, hydrogen, and carbon dioxide. During acetogenesis, these short-chain acids are converted into acetate, hydrogen, and carbon dioxide. In the last phase, methanogens convert the intermediates produced into methane and carbon dioxide. Almost one-third of methane formation is due to reduction of carbon dioxide by hydrogen [2].

Table -1 Composition of Sample Biogas

Constituent	Percentage in Volume
Methane (CH_4)	55-60%
Carbon Dioxide (CO_2)	35-40 %
Hydrogen Sulphide (H_2S)	2%
Water Content (H_2O)	2-7%
Ammonia (NH_3)	0-0.005 %
Nitrogen (N_2)	0-2%
Oxygen (O_2)	0-2%
Hydrogen (H_2)	0-1%

2.2 Types of Biogas Digesters

According to the amount of raw material that is organic matter to be handled, the digester is classified as a single-chamber or a double-chamber type. The process is continuous in a sequence manner that the material which is use as a charged into the digester is produces a volume of gas at that time the same volume of the fermented material overflows from it. The three most common and most successful designs types of biogas plants in usage for the production of biogas form simple biogas digesters-

i. Balloon type bio-gas plants.
ii. The fixed- dome type of biogas plant.

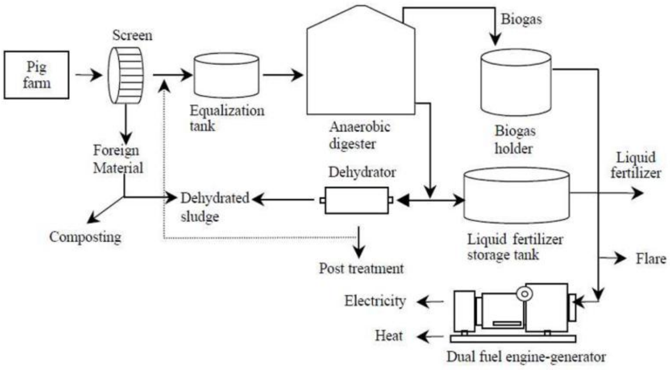
iii. The floating type of biogas plant.

3. Materials and Methods

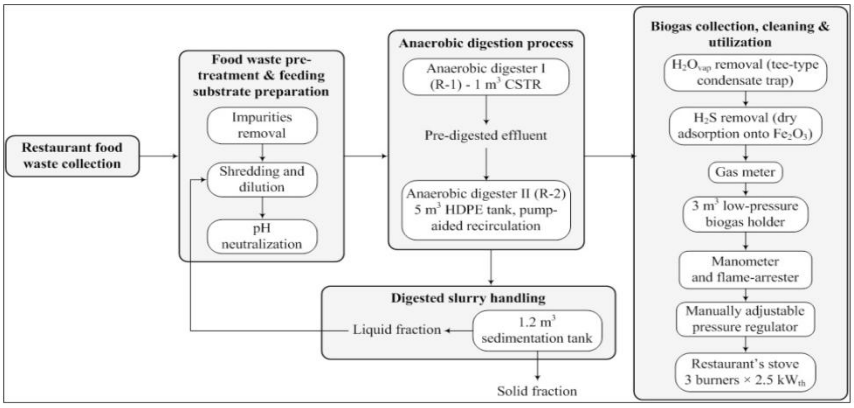
Biogas is produced by a chemical reaction of the organic materials put in a sealed container by the help of biological process in the absence of oxygen. Biogas plants may be fed with organic waste like dead plants, animal material, sewage sludge, kitchen waste and cattle which are converted into a gaseous fuel called biomass. It is a natural degradation process in which organic matter are brake down into simpler methane (CH_4) and carbon dioxide (CO_2) and generate the renewable energy which are used for many purpose.

Table -2 Production of biogas from different types of organic material

Materials	Volume of gas produced in m3/Kg out of fresh material	
	Summer	Winter
Cattle dung	0.036	0.092
Pig dung	0.07	0.10
Poultry droppings	0.07	0.16
Kitchen Wastes	0.243	0.149

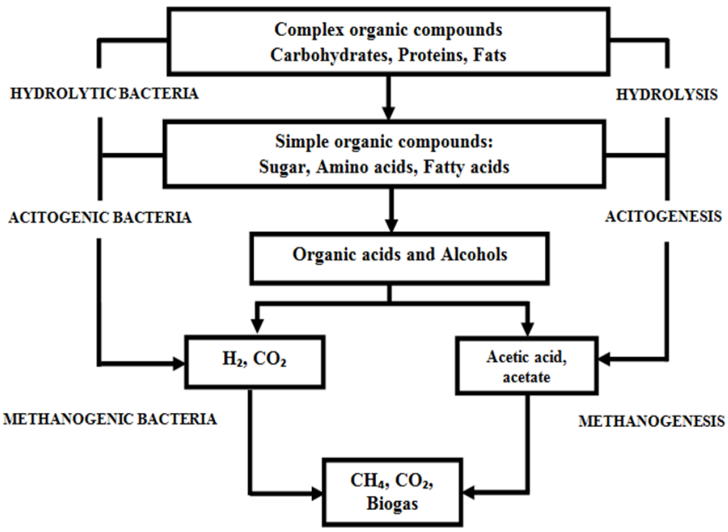


[Fig 1 Process diagram of the farm-scale biogas plant]



[Fig 3 Layout of operational sequences of the prototype biogas plant]

This chemical reaction takes place in the presence of methanogenesis bacteria mixed with water act as an important medium. The anaerobic digestion process the name implies that it is the functions of without presence of oxygen. The main conditions in a biogas plant there should be any oxygen presence in the digester. There are two basic types of organic fermentation that is aerobic decomposition (in the presence of oxygen) and anaerobic decomposition (in the absence of oxygen). In case of Aerobic fermentation will produce carbon dioxide, ammonia and some other gases in small quantities and a final product which is used as a fertilizer. Anaerobic decomposition will produce methane, carbon dioxide, some hydrogen and other gases in traces, but a little quantities of heat is produced and a final product will contain a higher nitrogen rather than which is produced by aerobic decomposition.



[Fig 4 Schematic diagram of anaerobic reactions occurred inside the digester.]

4. Factors affecting production of biogas

Temperature and Pressure

Temperature plays a vital role for effective biogas production. Methane can be produced in a progressive rate within a temperature range of 29°C - 41°C and the pressure is about 1.1 - 1.2 bars absolute. The high temperature bacteria are much more sensitive into ambient influences. The rate of gas production increases when the temperature is increase and it has a drawback is to reduce the methane percentage. When the difference between the temperatures is 32°-35°C are most efficient and stable and continuous for the production of methane. The biogas production is fastest in summer and it decreases in winter.

Solid Concentration and Loading Rate

The organic matter like cow dung, kitchen west, agricultural waste and all type of organic west are use as a input of the Biogas plant and that west are mixed with the water and supplied it as a feed to the digester. The proportions are: Cow dung(any organic west) + solid waste 1:1 that is the mixture which is contain about 10% of solid and 90% of water. The amount of slurry that is feed in to the digester per day is called Loading rate and it is depending on the plant size and capacity. The average loading rate is about 0.2 kg/m^3 of digester capacity.

When the amount of feeding is not maintained then the production of biogas is reduced and the loading must be carried out every day in the sunlight.

pH Value or Hydrogen Ion Concentration

The main objective of measuring the pH value by knowing the degree of acidity of a solution. The pH value is represented by the logarithm of the reciprocal of the hydrogen ion concentration in (gm/L of solution). The experimental range of the pH value is (0-7) and it is for acidic solution and when the range becomes (7-14) and it is for alkaline solution. Experimentally the value of pH is always lies between 7.0–8.0 and its value has some difference in 0.5. At the initial stages the value of pH lies around 6.0 or less. During methane formation stage the value of pH higher than 7.0and it is maintained. The value of pH is the ratio of acidity and alkalinity.

Supplementary Nutrients

In some organic matter we add some nutrients to it but in case of cow dung as it already contain all the nutrients which are capable of producing methane and therefore no need to addition of nutrients to it.

Reaction Period

At the optimum condition (80-90) % of total gas produce within (3-4) weeks and it is based on the Size of the digester tank. Experimentally it was found that the production of biogas per unit volume of digester is high when satisfied the condition that is the ratio of the diameter to depth is lies between (0.66 -1).

Water Content

Water is an essential parameter in production of biogas and experimentally it is 90% of the weight of the slurry. When excess amount of water is added, the rate of production per unit volume will fall down and if a less amount of water is used, it will accumulate the acetic acid.

5. Applications of Biogas

Cooking and Heating

Biogas produced from the household digesters is mainly used for cooking. The amount of biogas used for cooking purposes usually varies between 30 and 45 m^3 per month. This number can be compared with other commonly used fuels such as kerosene where the consumption is between 15 and 20 L, and Liquefied Petroleum Gas (LPG) between 11 and 15 kg per month, respectively. The energy equivalent was around 300, 200, and 150 kWh for biogas, kerosene, and LPG, respectively. The surplus biogas in the domestic digester could be used for water and space heating.

Biogas Stoves

Biogas burning is not possible in commercial butane and propane burners because of its physiochemical properties. However, it is possible to use these burners after some modifications .Burners are changed in the gas injector, its cross-section, and mixing chambers. The biogas burners are designed to meet a mixture of bio-gas and air in the ratio of 1:10 .Different burners like vertical flame diffuser, horizontal flame diffuser, and no diffuser with biogas have been examined. A vertical flame diffuser had a high heat transfer efficiency compared to other diffusers .The efficiency is obtained by calculating the heat gained by the water subjected for heating and the amount of fuel consumed during this process. The efficiency of the heat entering the vessel from the stove was high for biogas with 57.4%, followed by LPG, kerosene, and wood with 53.6%, 49.5%, and 22.8%, respectively .The biogas consumption and the thermal efficiency in the biogas stoves varied between 0.340–0.450 m^3/h and 59–68% .

Fertilizer

The digestate left over from the digester is rich in nitrogen, phosphorus, and potassium, and can be used as a fertilizer. Digestate increased the potato cultivation by 27.5% and forage by 1.5% compared to no added fertilizer. Due to the anaerobic digestion of organic matter, these nutrient concentrations were easily taken up by plants. The effluent can be directly used as a fertilizer in farming. Digestate has a high commercial value when exported. The dried effluent could also be used as an adsorbent to remove lead from industrial wastewater. Biogas slurry could be helpful in growing algae, water hyacinth, duck weed, and fish poly-aquaculture.

Lighting and Power Generation

The other major application of household biogas is for lighting and power generation. In many developed countries, biogas from the digesters is sent to a combustion engine to convert it into electrical and mechanical energy . Biogas requires a liquid fuel to start ignition. Diesel fuel can also be combined with biogas for power generation . For instance, in Pura (India), a well-studied community biogas digester can fuel a modified diesel engine and run an electric generator. Bari reported that carbon dioxide up to 40% will not decrease the engine performance using biogas as a fuel. Biogas can also be used to power engines when mixed with petrol or diesel, and it can also help in pumping water for irrigation. Cottage/small scale industries use biogas for pumping, milling, and for some other production activities.

6. Conclusion

The study reveals that biogas can be used as a better alternative fuel in the day of energy challenges and municipal sanitation. More research in the field of biogas production is required and its sustainability must be considered in the global renewable scenario. The operational conditions and parametric stabilization imparts a vital role for its vast productivity.

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