Review Article

BIO-GAS GENERATION AND FACTORS AFFECTING THE BIO-GAS GENERATION – A REVIEW STUDY

Harilal S. Sorathia* , Dr. Pravin P. Rathod, Arvind S. Sorathiya

Address for Correspondence

Department of Mechanical Engineering, Government Engineering College, Bhuj – Kutch, Gujarat

ABSTRACT

Due to the increasing demand for fossil fuels and environmental threat, a number of renewable sources of energy have been studied worldwide. An attempt is made to assess the suitability of alternative fuels like Methanol, Ethanol, Hydrogen, Natural Gas, LPG, CNG, LNG, Biogas and Biodiesel for diesel engine operation with and without any modifications in its existing construction. The main objective of this paper is to investigate Bio-gas Generation and Factors Affecting the Bio-gas Generation from various organic matters by the biological breakdown. The investigated results show that biogas is the cheapest non-conventional energy produce from various organic wastes.

I. INTRODUCTION

Energy is an essential input for economic growth, social development, human welfare and improving the quality of life. Every sector of Indian economy– agriculture, industry, transport, commercial and domestic needs inputs of energy. As a result, consumption of energy in all forms has been steadily rising all over the country. This growing consumption of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. Increased use of fossil fuels also causes environmental problems both locally and globally. It is common knowledge that the world's main energy resources will be depleted within next several decades. The world is unavoidably faced with crises of fossil fuel shortage and environmental degradation as a direct result of growth in population, urbanization and industrialization. [1]

Most countries find themselves under considerable energy constraints, while the growing demand for domestic energy use decreases fuel wood reserves and increases deforestation rates. Foreign exchange earnings have to be spent on imported fuels. In India, energy demand for gasoline and diesel fuels is as high as ever and imported petroleum products account for a large proportion of the country's energy imports. [2]

II. PROSPECTS OF RENEWABLE ENERGY SOURCES

In many developing countries like India, so many people do not have access to modern energy sources. Energy use in India is characterized by a high use of traditional resources like fuel wood and coal. In India the pressure of population has reduced India's forests to a few scrubby trees way out on the horizon, causing extreme fuel shortages in rural areas.

To compensate for this, about 700 million tons of cow manure produced annually is burned for heating or cooking. This however causes tremendous medical problems. The acrid smoke leads to endemic eye disease, and the drying manure is a perfect breeding ground for flies of all types. The manure would also go a long way to improving the quality of the soil and hence increasing the harvest if these valuable minerals were returned to it instead of going up in smoke.

The above mentioned problem of destruction of forests and heath, energy need mostly for cooking purposes can be solved to great extent by using biogas for cooking it hardly releases smoke and is almost as efficient as LPG. Also the electricity is very scare especially in rural areas which are usually very remote and very poor, making it highly unlikely that they will ever be connected to the national grid due to financial constraints. Rural electrification increases local and eventually global energy demand which contributes to global warming.

Depletion of fossil fuels can have a negative effect on the local environment. Making sustainable energy available in rural areas in developing countries could lead to improved living conditions and improvement of the local environment. These factors have lead to an innovative global search for renewable sources of energy. Consequently, some alternatives, particularly renewable energy options, have been explored and discovered. Several feasible technologies in area of solar, wind, ocean, geothermal and biomass have been discovered, tested, perfected and are under popularization. Although the majority of renewable energy technologies are better eco-friendly as compared to conventional energy options, but their adoption is very slow because of various reasons such as economic constraints, lack of supply and users friendly technical know-how etc.

Further, the uses of these technologies are still limited to majority of the stationary operations mainly due to technological limitations and poor economics. [19] Hence, the scientists are looking for alternative fuels, which promise a harmonious correlation with sustainable development, energy conservation, management, efficiency, and environmental preservation, has become highly pronounced in the present context. In view of this, researcher found and analyze many energy sources like CNG, LNG, LPG, ethanol, methanol, hydrogen, biodiesel, biogas and many more. [1] [2] [3]

III. BIO-GAS

Biogas dates as far back as the 16th century, when it was used for heating bath-water in Persia. The discovery of biogas can be first traced back to the 17th century when Van Helmot noticed flickering lights beneath the surface of swamps and connected it to a flammable gas produced by decaying organic matter. In the scientific world, Volta noted as early as 1776 that biogas production is a function of the amount of decaying plant material and that the biogas is flammable under certain conditions. By 1884, a student of Pasteur in France, Gauon, had anaerobically produced biogas by suspending cattle manure in a water solution at 35 Celsius. At that time he was able to obtain 100 liters of biogas per metre cubed of manure. [4]

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Organic waste such as dead plant and animal material, animal dung, and kitchen waste can be converted into a gaseous fuel called biogas. Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal, green waste, plant material and crops.

Biogas comprises primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S) and moisture. The gases methane, hydrogen and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel. Biogas can be used as a fuel in any country for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat.

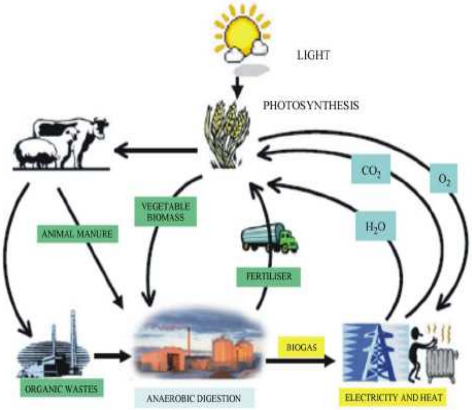

Figure – 1 Schematic representation of the Sustainable Cycle of anaerobic co-digestion of animal manure and organic wastes [5]

Biogas can be compressed, much like natural gas, and used to power motor vehicles. In the UK, for example, biogas is estimated to have the potential to replace around 17% of vehicle fuel. Biogas is a renewable fuel, so it qualifies for renewable energy subsidies in some parts of the world. Biogas can also be cleaned and upgraded to natural gas standards when it becomes bio-methane. The composition of biogas varies depending upon the origin of the anaerobic digestion process. Landfill gas typically has methane concentrations around 50%.

Advanced waste treatment technologies can produce biogas with 55–75% methane, which can be increased to 80-90% methane using reactors with free liquids gas purification techniques. As produced, biogas also contains water vapour. The fractional volume of water vapour is a function of biogas temperature, correction of measured gas volume for both water vapour content and thermal expansion is easily done via a simple mathematic algorithm which yields the standardized volume of dry biogas.

When biogas is used, many advantages arise. In addition, biogas could potentially help reduce global climate change. Normally, manure that is left to decompose releases two main gases that cause global climate change: nitrogen dioxide and methane. Nitrogen dioxide (NO_2) warms the atmosphere 310 times more than carbon dioxide and methane 21 times more than carbon dioxide. By converting cow manure into methane biogas via anaerobic digestion, the millions of cows in the India would be able to produce one hundred billion kilowatt hours of electricity, enough to power millions of homes across the India. In fact, one cow can produce enough manure in one day to generate three kilowatt hours of electricity; only 2.4 KWh of electricity are needed to power a single one hundred watt light bulb for one day. [6]

IV. BIOGAS GENERATION

It has been used in India for almost a hundred years. India has more cattle than any other country (450 million head, 19% of the world population) and the cow held in religious veneration and its products are considered purifying agents. Hence, there is a universal acceptance of even its dung, which otherwise would instinctively be thought of as repulsive. Cow dung is widely used in India as composted fertilizer and as a cooking fuel (dung cakes). Dung accounts for over 21 percent of total rural energy use in India, and as much as 40 percent in certain states of the country. [7] The Indian government introduced large-scale biogas production in 1981 through the National Project on biogas Development. 2 million biogas plants were in operation in 1995, and about 10 million rural Indians were benefiting from the electric power from electric power generator fueled with biogas, biogas supply as cooking fuel and also from the rich agricultural fertilizer the plant produces as a byproduct. [8] [9]

Biogas produced by extracting chemical energy from organic materials in a sealed container called anaerobic digester by the biological process or the biological gasification in the absence of oxygen. Biogas plants can be fed with organic waste such as dead plants, animal material, biodegradable wastes including sewage sludge, kitchen waste and cattle dung can be converted into a gaseous fuel called biogas. It is a naturally occurring microbiological process that converts the organic matter to methane and carbon dioxide producing renewable energy that can be used for heating, electricity generation, and many other operations. [8] [10]

The chemical reaction takes place in the presence of methanogenic bacteria with water as an essential medium. The anaerobic digestion process, as the name states, is one that functions without molecular of oxygen. Ideally, in a biogas plant there should be no oxygen within the digester. However, efforts to completely remove it will be prohibitively expensive. Oxygen therefore exists in the digester, dissolved mainly in water. Fortuitously, some microbes within the digester are facultative anaerobes, i.e. they utilize oxygen and lower the dissolved oxygen concentration to levels suitable for other anaerobic microbes to perform their chemical reactions. [9] [10]

Oxygen removal from the digester is important for two main reasons. First, the presence of oxygen leads to the creation of water, not methane. Second, oxygen is a contaminant in biogas and also a potential safety hazard. Due to presence of oxygen, calorific value of biogas becomes low. Biogas comprises primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture, etc. The presence of methane in biogas can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel. Biogas can be used as a fuel in any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat. [9] Millions of cubic meters of methane in the form of biogas are produced every year by the decomposition of organic matter, both animal and vegetable. It is almost identical to the natural gas pumped out of the ground by the oil companies and used by many of us for heating our house, cooking our meals and fuel supply to automobile vehicles. The fermentation process for formation of methane from cellulose material through the agency of a group of organisms belonging to the family "Methanogenic bacteria" is a complex biological and chemical process. [8] [11]

There are two basic types of organic decomposition (fermentation) that is aerobic decomposition (in the presence of oxygen) and anaerobic decomposition (in the absence of oxygen). All organic materials, both animal and vegetable can be broken down by these two processes, but the products of decomposition will be quite different in the two cases. Aerobic decomposition (fermentation) will produce carbon dioxide, ammonia and some other gases in small quantities, heat in large quantities and a final product that can be used as a fertilizer. Anaerobic decomposition will produce methane, carbon dioxide, some hydrogen and other gases in traces, very little heat and a final product with a higher nitrogen content than is produced by aerobic decomposition. [8]

Anaerobic decomposition is a two-stage process as specific bacteria feed on certain organic materials. In the first stage, the chief micro-organism are ones, that break down complex organic materials, such as carbohydrates, chain molecules, fruit acid material, protein and fats. The disintegration produces acetic acid, lactic acid, butanoic acid, peptides, glycerol, alcohol, simple sugars, as well as carbon dioxide, hydrogen, H_2S and other non organic materials. When these compounds have been produced in sufficient quantities, a second type of bacteria starts to convert these simpler compounds into methane. These methane producing bacteria are particularly influenced by the ambient conditions, which can slow or halt the process completely if they do not lie within a fairly narrow band of temperature. Methane fermentation has the optimum activity at 35°C to 40°C. [7] [8]

Biogas is produced by anaerobic decomposition of organic wastes by suitable bacteria. It contains 55-65% methane, 30-40% carbon dioxide and the remainder is impurities like H_2S, N_2, H_2, gases.

The main source of production of biogas are crops residue, wet cow dung, vegetable wastes, water hyacinth, algae, poultry or piggery droppings, human waste, etc. Any organic material of animal or plant which is easily bio-degradable can be the source of biogas production.

Table – 1 Quantity of dung required for various plant sizes. [7]

Size of plant (gas production/day) (m^3)	Amount of wet dung required (kg)	No. of animals
2	35 – 40	2 – 3
3	45 – 50	3 – 4
4	55 – 60	4 – 6
6	80 – 100	6 – 10
8	120 – 150	12 – 15
10	160 - 200	16 - 20

Table – 2 Production of biogas from different types of raw material [7]

Material	Amount of gas (m^3/Kg of fresh material)	
	Winter	Summer
Cattle dung	0.036	0.092
Pig dung	0.07	0.10
Poultry droppings	0.07	0.16

Cattle dung can produce 0.037 m^3 of biogas per kg of cow dung. The calorific value of gas is 21000 to 23000 KJ/m^3 or about 25200 KJ/kg of gas. The material from which biogas is produced retains its value as fertilizer or as animal feed which can be used after certain processing. [41]

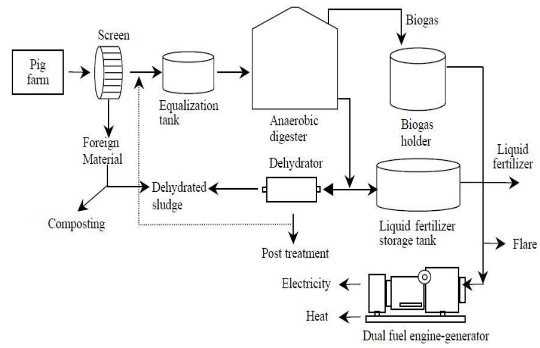

Figure – 2 Process diagram of the farm-scale biogas plant [13]

The process in general for formation of biogas, as discussed above, the biogas production from waste biomass is achieved by the action of anaerobic bacteria in presence of moisture and in the absence of oxygen. The conversion process is called bio-digestion or anaerobic fermentation. The bio-chemical process takes place in three stages as shown below. [9] [11]

Stage-I (Hydrolysis): Firstly the biomass having complex compound such as fats, proteins, carbohydrates etc. are broken down into simple water soluble organic compounds through the influence of water called hydrolysis. Bacteria decompose the long chains of the complex carbohydrates, proteins and lipids into shorter parts. For example, polysaccharides are converted into monosaccharide. Proteins are split into peptides and amino acids.

Stage-II (Acid formation): The micro-organism of anaerobic and facultative group (which grows in absence of O_2) called acid forming bacteria produce mainly the acetic acid and propionic acid at low temperature of about 25° with release of CO_2. In certain cases, the acid may be produced in such large quantities that all the biological activity is arrested. Thus, it becomes necessary to control the pH value of mixture. Acid-producing bacteria, involved in the second step, convert the intermediates of fermenting bacteria into acetic acid (CH_3COOH), hydrogen (H_2) and carbon dioxide (CO_2). These bacteria are facultative anaerobic and can grow under acid conditions. To produce acetic acid, they need oxygen and carbon. For this, they use the oxygen dissolved in the solution or bounded-oxygen. Hereby, the acid-producing bacteria create an anaerobic condition which is essential for the methane producing microorganisms. Moreover, they reduce the compounds with a low molecular weight into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane.

Stage-III (Methane formation): In this stage the anaerobic bacteria called as methane formers converts the organic acids formed in stage II into biogas having its main constituents as methane and carbon dioxide with other small trace of H_2S, H_2 and N_2 etc. These methane formers are sensitive to pH changes.

V.BIOGAS PLANT MODEL

This is a composite unit of a digester and gas holder wherein the gas is collected and delivered at a constant pressure to gas appliances through a distribution system. Depending on the amount of raw material to be handled, the digester may be of either a single-chamber or a double-chamber type. There are two types of processes for anaerobic fermentation: Continuous and batch. The continuous process is suitable for free-flowing suspended materials while the batch process is applicable to light materials. The process is continuous in the sense that as the material to be fermented is charged into the fermentation tank, the same volume of the fermented material overflows from it. [43]

There are three types of biogas plants in usage for the production of biogas. (1) Balloon type bio-gas plants. (2) The fixed- dome type of biogas plant. (3) The floating gas holder type of biogas plant.

Balloon Plants [9]

A balloon plant consists of a heat-sealed plastic or rubber bag (balloon), combining digester and gas-holder. The gas is stored in the upper part of the balloon. The inlet and outlet are attached directly to the skin of the balloon. When the gas space is full, the plant works like a fixed-dome plant - i.e., the balloon is not inflated; it is not very elastic. The fermentation slurry is agitated slightly by the movement of the balloon skin. This is favourable to the digestion process. Gas pressure can be increased by placing weights on the balloon. If the gas pressure exceeds a limit that the balloon can withstand, it may damage the skin. Therefore, safety valves are required. If higher gas pressures are needed, a gas pump is required. Since the material has to be weather and UV resistant, specially stabilized, reinforced plastic is given preference. Other materials which have been used successfully include RMP (red mud plastic), Trevira and butyl. The useful life-span does usually not exceed 2-5 years.

Advantages: Standardized prefabrication at low cost, low construction sophistication, ease of transportation, shallow installation suitable for use in areas with a high groundwater table; high digester temperatures in warm climates; uncomplicated cleaning, emptying and maintenance; difficult substrates like water hyacinths can be used. Balloon biogas plants are recommended, if local repair is or can be made possible and the cost advantage is substantial.

***Disadvantages*:** Low gas pressure may require gas pumps; scum cannot be removed during operation; the plastic balloon has a relatively short useful life-span and is susceptible to mechanical damage and usually not available locally. In addition, local craftsmen are rarely in a position to repair a damaged balloon. There is only little scope for the creation of local employment and, therefore, limited self-help potential. Balloon plants can be recommended wherever the balloon skin is not likely to be damaged and where the temperature is even and high. One variant of the balloon plant is the channel-type digester with folia and sunshade.

Construction of the Fixed Dome Type Biogas Plant [7] [9] [11]

The biogas plant is a brick and cement structure having the following five sections.

- Mixing tank present above the ground level.
- Inlet chamber: The mixing tank opens underground into a sloping inlet chamber.
- Digester: The inlet chamber opens from below into the digester which is a huge tank with a dome like ceiling. The ceiling of the digester has an outlet with a valve for the supply of biogas.
- Outlet chamber: The digester opens from below into an outlet chamber.
- Overflow tank: The outlet chamber opens from the top into a small over flow tank.

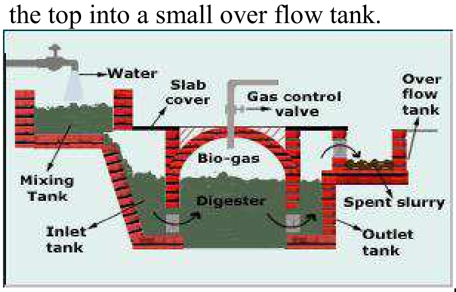

Figure – 3 Fixed dome type biogas plant. [7]

Working Fixed Dome Type Biogas Plant [7] [9] [11]

The various forms of biomass are mixed with an equal quantity of water in the mixing tank. This forms the slurry. The slurry is fed into the digester through the inlet chamber. When the digester is partially filled with the slurry, the introduction of slurry is stopped and the plant is left unused for about two months. During these two months, an anaerobic bacterium present in the slurry decomposes or ferments the biomass in the presence of water. As a result of anaerobic decomposition, biogas is formed, which starts collecting in the dome of the digester. As more and more biogas starts collecting, the pressure exerted by the biogas forces the spent slurry into the outlet chamber. From the outlet chamber, the spent slurry overflows into the overflow tank. The spent slurry is manually removed from the overflow tank and used as manure for plants. The gas valve connected to a system of pipelines is opened when a supply of biogas is required. To obtain a continuous supply of biogas, a functioning plant can be fed continuously with the prepared slurry.

Advantages of fixed dome type of biogas plant

- Requires only locally and easily available materials for construction.
- Inexpensive.
- Easy to construct.

Construction of the Floating Gas Holder Type Biogas Plant [7] [11]

The floating gas holder type of biogas plant has the following chambers/ sections:

Mixing Tank - present above the ground level.

- Digester tank - Deep underground well-like structure.

- It is divided into two chambers by a partition wall in between.

It has two long cement pipes:

- Inlet pipe opening into the inlet chamber for introduction of slurry.
- Outlet pipe opening into the overflow tank for removal of spent slurry.

Gas holder is an inverted steel drum resting above the digester. The drum can move up and down i.e., float over the digester. The gas holder has an outlet at the top which could be connected to gas stoves. Over flow tank - Present above the ground level

Working of the Floating Gas Holder Type Bio-gas Plant [7] [11]

Slurry (mixture of equal quantities of biomass and water) is prepared in the mixing tank. The prepared slurry is fed into the inlet chamber of the digester through the inlet pipe. The plant is left unused for about two months and introduction of more slurry is stopped. During this period, anaerobic fermentation of biomass takes place in the presence of water and produces biogas in the digester. Biogas being lighter rises up and starts collecting in the gas holder. The gas holder now starts moving up. The gas holder cannot rise up beyond a certain level. As more and more gas starts collecting, more pressure begins to be exerted on the slurry.

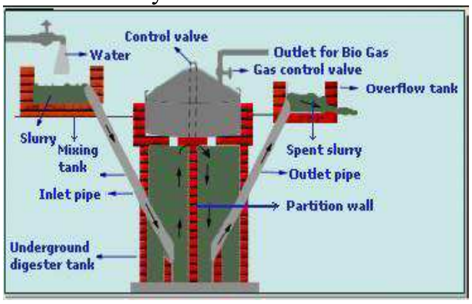

Figure – 4 Floating gas holder type biogas plant. [7]

The spent slurry is now forced into the outlet chamber from the top of the inlet chamber. When the outlet chamber gets filled with the spent slurry, the excess is forced out through the outlet pipe into the overflow tank. This is later used as manure for plants. The gas valve of the gas outlet is opened to get a supply of biogas. Once the production of biogas begins, a continuous supply of gas can be ensured by regular removal of spent slurry and introduction of fresh slurry. [7]

Disadvantages of floating gas holder type biogas plant are (a) Expensive (b) Steel drum may rust and (c) Requires maintenance.

Factors Affecting the Biogas Generation [7] [9]

Temperature and Pressure

Temperature for fermentation will greatly effect biogas production. Depending on prevailing conditions methane can be produced within a fairly wide range of temperature. The process of anaerobic fermentation and methane forming bacteria works best in the temperature between 29°C to 41°C or between 49°C to 60°C and pressure of about 1.1 to 1.2 bars absolute. This is due to fact that two different types of bacteria multiply best in these two different ranges, but the high temperature bacteria are much more sensitive to ambient influences. The rate of gas production increases with the increase in temperature but the percentage of methane reduces. It is found that temperature between 32°C-35°C are most efficient for stable and continuous production of methane. Biogas produced outside this range will have a higher percentage of carbon dioxide and other gases than within this range. The production of biogas is fastest during summer and it decreases at lower temperature during winter. If the temperature are lower than 20°C the rate of gas production falls sharply and it almost ceases at about 10°C. Also methanogemic micro-organisms are very sensitive to temperature changes, a sudden change exceeding 30°C will affect production, and therefore one must ensure relative stability of temperature. Thus, in cold climates, it is necessary to heat the digester to about 35°C.

Solid Concentration and Loading Rate:

The cow dung, water and various organic residues from agricultural waste are supplied as feed to the digester. The proportions recommended are: Cow dung + solid waste 1:1 by weight and forming to about 10% of solid content and 90% of water. The amount of feed supply per day to the digester is called loading rate. It is dependent on the size of the plant. The recommended loading rate is about 0.2 kg/m^3 of digester capacity. The under loading and overloading reduces the biogas production. The loading of feed must be carried out every day at the same time as to keep the solid concentration ratio constant in the digester.

Retention Period

It represents the time period for which the fermentable material remains inside the digester. This period ranges from 35 days to 50 days depending upon the climatic conditions and location of the digester. The longer retention period needs larger size digester and it allows more complete digestion of feed.

pH Value or Hydrogen Ion Concentration

pH value indicates the degree of acidity or alkalinity of a solution. The pH value is represented as the logarithm of the reciprocal of the hydrogen ion concentration in gm equivalent per litre of solution. pH value in the range 0-7 represents acidic solution and in the range 7-14 indicates the alkaline solution. The micro-organisms require a neutral or mildly alkaline environment – a too acidic or too alkaline environment will be detrimental. Ideal pH value is between 7.0–8.0 but can go up or down by a further 0.5. In the initial stages of acid forming stage of digestion, the pH value may be around 6.0 or less, however during methane formation stage the pH value higher than 7.0 is maintained since methane formers are sensitive to acidity. The pH value depends on the ratio of acidity and alkalinity and the carbon dioxide content in the digester, the determining factor being the density of the acids. For the normal process of fermentation, the concentration of volatile acid measured by acetic acid should be below 2000 parts per million too high a concentration will greatly inhibit the action of the methanogenic micro-organisms.

Nutrients Concentration: T

he major nutrients required by the bacteria in the digester are N_2, P, S, C, H_2, and O_2 to accelerate the anaerobic digestion rate. Thus it is necessary that the major nutrients are supplied in correct chemical form and concentrations. The carbon in carbohydrates supplies the energy and the nitrogen in proteins is needed for building of growth of bacteria. The bacteria responsible for the anaerobic process require both elements nitrogen and carbon, as do all living organisms, but they consume carbon roughly 30 times faster than nitrogen. Assuming all other conditions are favourable for biogas production, a carbon-nitrogen ration of about 30:1 is ideal for the raw materials fed into a biogas plant with 2% phosphorous for maximum biological activity. A higher ratio will leave carbon still available after the nitrogen has been consumed, starving some of the bacteria of this element. These will in turn die, returning nitrogen to the mixture, but slowing the process. Too much nitrogen will cause this to be left over at the end of digestion (which stops when the carbon has been consumed) and reduce the quality of the fertilizer produced by the biogas plant. The correct ratio of carbon to nitrogen will prevent loss of either fertilizer quality or methane content. Thus, for acceleration fermentation and production of biogas nutrients like C, P and N2 are maintaining within the optimum range. Oil cakes and animal urine are found to be suitable nutrients for this purpose.

Supplementary Nutrients

In case of cow dung, as it contains all the nutrients needed by organisms for the production of methane there is no necessity for addition of nutrients to it.

Harmful Materials

The micro-organisms that help to produce biogas are easily affected by many harmful materials. The presence of ammonia, detergents, heavy metals are considered as harmful substance to micro-organisms since their presence reduces the fermentation rate. Also the digested slurry if allowed to remains in digester beyond certain time, it becomes toxic to micro-organism growth. Maximum allowable concentration of such harmful materials is shown in Table 5.3. These toxic materials should either not be present or their concentration should be diluted by addition of water.

Table – 3 List of Harmful Materials in Biogas Digester [7] [9]

Harmful Materials	Concentration
Sulphate (SO_4)	5000 parts per million
Sodium chloride (NaCl)	40,000 parts per million
Copper (Cu)	100 mg per liter
Chromium (Cr)	200 mg per liter
Nickel (Ni)	200-500 mg per liter
Cyanide (CN)	below 25 mg per liter
ABS(detergent compound)	20-40 parts per million
Ammonia (NH_3)	1,500-3,000 mg per liter
Sodium (Na)	3,500-5,500 mg per liter
Potassium (K)	2,500-4,500 mg per liter
Calcium (Ca)	2,500-4,500 mg per liter
Magnesium (Mg)	1,000-1,500 mg per liter

Water Content

This should be about 90% of the weight of the total contents. With too much water the rate of production per unit volume in the pit will fall, preventing optimum use of the digester. If the water content is too low, acetic acid will accumulate, inhibiting the fermentation process and hence production and also thick scum will be formed on the surface. The water content differs according to the raw material used for fermentation. Nature of organic materials, materials rich in cellulose and semi-cellulose with sufficient protenaceous substance produce more gas. Complex polysaccharides are more favorable for methane formation while only protenacous materials produce little quantity of gas.

Reaction Period

Under optimum condition 80-90% of total gas production is obtained within a period of 3-4 weeks. Size of the fermentation tank also decides the reaction period. It is found that the biogas production per unit volume of digester is high when its diameter to depth ratio ranges between 0.66 to 1.

Stirring or Agitation of the Content of Digester:

Some method of stirring the slurry in a digester is always advantageous, not essential. If not stirred, the slurry will tend to settle out and form a hard scum on the surface, which will prevent release of biogas. This problem is much greater with vegetable waste than with manure, which will tend to remain in suspension and have better contact with the bacteria as a result. Continuous feeding causes fewer problems in this direction, since the new charge will break up the surface and provide a rudimentary stirring action. Since bacteria in digester have very limited reach to their food, it is necessary that slurry is properly mixed and bacteria get their food supply. It is found that occasional mixing allows the masses that float at the top in the form of scum allow mixing with the deposits at the bottom. It helps in improving fermentation.

Harmful Effects of Chemical Fertilizers

The leftover of a biogas plant is an excellent fertilizer for the plants and can be used instead of chemical fertilizer. Chemical fertilizers contain a nutrient that a plant can use but it also contains some elements that are not taken by plants in significant amount, the result is that these elements remain in soil and create problem. For example nitrate of soda, the plant take much of nitrate but not soda which when combines with carbon forms carbonate of soda and soil becomes hard because of this. The leftover of a biogas plant is an excellent fertilizer for the plants and can be used instead of chemical fertilizers.

Gas Collection

The biogas in an anaerobic digester is collected in an inverted drum. The walls of the drum extend down into the slurry to provide a seal. The drum is free to move to accommodate more or less gas as needed. The weight of the drum provides the pressure on the gas system to create flow. The biogas flows through a small hole in the roof of the drum. A non-return valve here is a valuable investment to prevent air being drawn into the digester, which would destroy the activity of the bacteria and provide a potentially explosive mixture inside the drum. Larger plants may need counterweights of some sort to ensure that the pressure in the system is correct.

The composition of biogas depends on a number of factors such as the process design and the nature of the substrate that is digested. The table below lists the typical properties of biogas from digesters and a comparison with average values of natural gas.

VI. REASONS FOR SELECTING BIOGAS AS ALTERNATIVE FUEL

- In India, about 700 million tons of cow manure produced annually is burned for heating or cooking.

- Burning of cow manure causes medical problems and acrid smoke leads to eye disease.
- The manure would also go a long way to improving the quality of the soil and hence increasing the harvest if these valuable minerals were returned to it instead of going up in smoke.
- Most of fuel problems for cooking purposes can be solved to great extent by using biogas for cooking; also it hardly releases smoke and it almost as efficient as LPG.
- Also the electricity problem can be solved which is very scare especially in rural areas which are usually very remote and very poor.
- Making sustainable energy available in rural areas in developing countries could lead to improved living conditions and improvement of the local environment.
- Biogas is one of the best available sources to fulfill the energy demand of the world especially in the rural areas.

VII. ADVANTAGES OF BIOGAS TECHNOLOGY [12]

- The generated biogas can replace traditional energy sources like firewood and animal dung, thus contributing to combat deforestation and soil depletion.
- Biogas can contribute to replace fossil fuels, thus reducing the emission of greenhouse gases and other harmful emissions.
- By tapping biogas in a biogas plant and using it as a source of energy, harmful effects of methane on the biosphere are reduced.
- By keeping waste material and dung in a confined space, surface and groundwater contamination as well as toxic effects on human populations can be minimized.
- By conversion of waste material and dung into a more convenient and high-value fertilizer, organic matter is more readily available for agricultural purposes, thus protecting soils from depletion and erosion.
- Production of energy (heat, light, electricity).
- Transformation of organic waste into high quality fertilizer.
- Improvement of hygienic conditions through reduction of pathogens, worm eggs and Flies.
- Reduction of workload, mainly for women, in firewood collection and cooking.
- Environmental advantages through protection of soil, water, air and woody vegetation.
- Micro-economical benefits through energy and fertilizer substitution, additional income sources and increasing yields of animal husbandry and agriculture.

VIII. ADVANTAGES OF BIOGAS AS A FUEL [7] [11]

- It mixes easily with the air.
- It is light fuel gas.
- High calorific value.
- It is highly knocked resistant.
- Due to uniform distribution thermal efficiency is higher.
- Biogas has a high octane number.
- It reduces pollution.
- Higher compression ratio can be used with biogas.
- Plants capital cost is low.
- Domestic fuels for burners used in kitchen.
- No toxic to skin.
- Clean fuel.
- No residue produced.
- Economical.
- None polluting.
- Can be supplied through pipe lines.
- Burns readily - has a convenient ignition temperature.
- Uses of biogas for street lighting.
- Generation of electricity.

CONCLUSION

- Producing renewable energy from organic waste.
- Producing valuable fertilizers for agricultural.
- Reduces global warming effect by reducing methane formation from organic waste and animal dung.
- Methane has 21 times more global warming effect than the carbon dioxide.
- Controlled parameter may increases the production of biogas.
- Bio-gas may convert into bio-methane for automobile fuel.

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