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Construction and efficiency investigation of biogas plant

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Abstract
A biogas plant is modern energy source and is suitable to the necessities of the future. With the appropriate application of the digestion technology, the development of economically feasible biogas digesters systems for an institution is done. The central purpose of the study is to outline if any, the conditions under which biogas digesters would be feasible for an institution AVS College of Technology which is in Salem, Tamilnadu, India. The production of biogas by anaerobic digestion of organic waste is a mature expertise that may present tangible benefits to institution. Biogas technology can alleviate many grave problems in the developing countries, such as rural energy scarcity, low agriculture yield, and poor public health. In addition through the utilization of biogas technology toxic farm waste can be properly handled through anaerobic digestion; generation of natural fertilizers and ultimately lead to an increase in output and income. From analysis it will become apparent that farmers using digesters systems have greater earnings or benefits than those farmers who do not resulting in the preservation. An anaerobic digester contains an oxygen free environment that allows microorganisms to break down the organic material to produce biogas (methane). Once the biogas is produced it can be used for different applications to aid the developing world.

Keywords: biogas, digestion technology, anaerobic digestion, organic waste, environment, microorganism, methane

1. 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 [1]. 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 [2]. 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. 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 [3].

2. 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. 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 [4].

3. 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 meter cubed of manure. 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 (CH4) and carbon dioxide (CO2) and may have small amounts of hydrogen sulphide (H2S) and moisture. The gases methane, hydrogen and carbon monoxide (CO) can be combusted or oxidized with oxygen [5]. 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. 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 [6]. 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 (NO2) 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. [7]

4. 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. 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. 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] 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. 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 (CH4) and carbon dioxide (CO2) and may have small amounts of hydrogen sulphide (H2S), 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. 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. 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. 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. 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. 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 [9]. The material from which biogas is produced retains its value as fertilizer or as animal feed which can be used after certain processing 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 biodigestion or anaerobic fermentation. The bio-chemical process takes place in three stages as shown below.

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.

Table 1: Quantity of dung required for various plant sizes.

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

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. 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 [10]. The composition of biogas depends on a number of factors such as the process design and the nature of the substrate that is digested.

5. Cost estimation of plant

Table 2

S. No	Particulars	Nos.	Measurements	Cost (APPROX) ₹
1.	Water Tank	1	100 Litre	600
2.	PVC Pipe	1	4 Inches	200
3.	“L” bend	1	4 Inches	50
4.	Gate Valve	1	½ Inch	100
5.	Gate Valve (PVC Pipe)	1	4 Inches	200
6.	Gas Tube	1	----	200
7.	Funnel	1	----	150
8.	“L” Bend (Inclined)	1	½ Inch	5
9.	PVC Paste	1	----	150
10.	Reducer	1	----	50
			Total	₹1,705

Fig 1: Biogas Model

5. Reasons for Selecting Biogas as Alternative Fuel

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

7. Advantages of Biogas Technology [11]

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.

8. Advantages of Biogas as A Fuel [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.

9. Conclusion

From this study Biogas plant Produce renewable energy from organic waste. It Produce valuable fertilizers for agricultural. It 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. It Controls parameter which may increases the production of biogas. Bio-gas may convert into bio-methane for automobile fuel.

10. References

1. Nuttall WJ, Manz DL. A new energy security paradigm for the twenty-first century Technological Forecasting and Social Change. 2002-2008; 75:1247-59.
2. Yinghong Zhang, Baoping Lu. Prediction of global energy trend and analysis on energy technology innovation characteristics, Nat Gas Ind. 2015; 35(10):1-10.
3. William J, Nuttall Devon L, Manz. A new energy security paradigm for the twenty-first century, Technological Forecasting and Social Change, Volume. 2008; 75(8):1247-1259.
4. Roy NK, Das A. Prospects of Renewable Energy Sources. In: Islam M., Roy N., Rahman S. (eds) Renewable Energy and the Environment. Renewable Energy Sources & Energy Storage. Springer, Singapore, 2018.
5. Jiang C, Liu T, Zhong J. A study on compressed biogas and its application to the compression ignition dual-fuel engine. Biomass, 1989, 53-59.
6. Leif G, Pal B, Bengt J, Per S. Reducing CO2 emission by substituting biomass for fossil fuels. Energy, 1995, 1097-1113.
7. Uzodinma EO, Ofoefule AU, Oparaku OU. The Role of Biogas in Mitigating Climate Change Nigerian Journal of Solar Energy, 2014, 25.
8. Lungkhimba H, Karki A, Shrestha J. Biogas Production from Anaerobic Digestion of Biodegradable Household Wastes. Nepal Journal of Science and Technology, 2014, 11:167-172. https://doi.org/10.3126/njst.v11i0.4140
9. Banks C, Chesshire M. Biocycle anaerobic digester: performance and benefits Waste and Resource Management. 2011; 164(1):141-150.
10. Jeya Jeevahan Anderson A, Sriram V, Durairaj RB, Britto Joseph G Mageshwaran G. Waste into energy conversion technologies and conversion of food wastes into the potential products: a review. International Journal of Ambient Energy 0:0, 2018, 1-19.
11. Askari M, Fatemeh G, Saman M, Motamedi Mirhosseiny L. Advantages and Disadvantages of Biogas Energy. Bulletin of Advanced Scientific Research. 2015; 1(5):132-135. Retrieved from http://asdpub.com/index.php/basr/article/view/265.