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A REVIEW ON BIO WASTE MANAGEMENT TECHNIQUES

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Abstract: Due to rapid growth in the population, the demand for energy and the problem of discharge of waste are increasing day by day. To overcome the energy crisis, alternative energy sources are the only remedy. Generation of energy from waste is one of the effective waste management technique. Dumping of waste without proper treatment will lead to ecological imbalance. The immediate after effects will be the outbreak of epidemic diseases. Accumulation waste will also creates severe environmental problems like climate change and global warming. The problem caused by waste can be reduced considerably through speedy and early treatment. In decentralized waste treatment system, anaerobic biomethanisation is commonly employed. This technology helps to treat the organic waste hygienically and valuable renewable energy and organic fertilizer can be produced. Biomethanisation is the most suitable technology to treat bio-degradable waste and to generate bio-energy without causing environmental problems. A detailed study on the scope of biomethanisation technology is required to rectify the problem of energy crisis and waste disposal. The paper reviews the anaerobic biomethanisation process and is various applications.
Keywords: biogas; anaerobic digestion; night soil; biomethanisation;

I. INTRODUCTION

Energy crisis and inefficient waste management are the most important problems faced by countries across the globe. Due to the increasing prices of fossil fuels, finding alternative, clean and economical sources of energy has nowadays becoming a major concern. To overcome the energy crisis, renewable energy sources are the only remedy. Generation of energy from waste is beneficial in many ways. It is the most suitable for eco-friendly waste disposal technique. There are two waste treatment systems. One is centralized and the other is decentralized. In decentralized waste treatment system, anaerobic biomethanisation / bio gas technology is commonly employes. This technology helps to treat the organic waste hygienically and valuable renewable energy and organic fertilizer can be produced. The biogas technology enables one to produce bio energy in the households by treating the wastes generated in the houses. This technology is also made applicable for treating the wastes produced from public places like markets, slaughter houses, hotels, convents etc and for generating electricity without causing any pollution to the atmosphere[1]. Anaerobic digestion process can be employed in different ways to convert bio waste into useful energy. It is an important tool for effective waste management. All the bio-degradable waste and organic waste water generated in every house can be hygienically treated at source for producing cooking gas-an alternative source of conventional fuel. Waste of food materials and bio degradable waste produced in the convents, hostels, hospitals and hotels and other industrial organizations can be treated in eco friendly way by hygienic waste disposal method and production of cooking gas in a very large scale. Night Soil from institutions like Hostel, convents, Hospitals can be treated to produce biogas as a sustainable source of energy. This plant is highly cost effective and avoids the construction of septic tanks. Easily degradable bio waste, waste water and blood generated in public markets, slaughter houses and such other public institutions can be treated at source using biomethanisation technology for the production of electricity. Integrated waste management system combining different technologies is another important scope of biomethanisation technology. The specialty of the integrated waste management system is that it will help to treat wastes of various types like fast decomposing, slow decomposing, non –degradable, blood and waste water. The paper analyses the different applications of biogas produced through anaerobic digestion process.

II. BIO GAS TECHNOLOGY

Biogas is a gas produced by anaerobic digestion (in the absence of oxygen) of organic material, largely comprised of methane (about two-thirds)[1]. Anaerobic Digestion is a microbiological process of decomposition of organic matter, in the absence of oxygen, common to many natural environments and largely applied today to produce biogas in airproof reactor tanks, commonly named digesters. A wide range of micro-organisms are involved in the anaerobic process which has two main end products: biogas and digestate.Digestate is the decomposed substrate, rich in macro- and micro nutrients and therefore suitable to be used as plant fertilizer. The process of biogas formation is a result of linked process steps, in which the initial material is continuously broken down into smaller units. Specific groups of micro-organisms are involved in each individual step. These organisms successively decompose the products of the previous steps[1]. The simplified diagram of the AD process, shown in figure 1 highlights the four main process steps: hydrolysis, acidogenesis, acetogenesis, and methanogenesis.

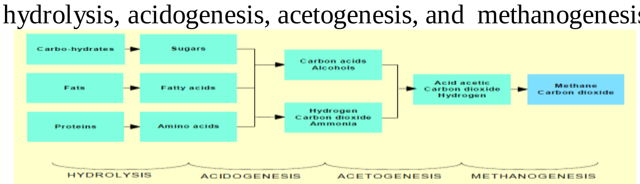

Fig.1 Process involved biogas production[1]

1) Hydrolysis: Hydrolysis is theoretically the first step of AD, during which the complex organic matter (polymers) is decomposed into smaller units (mono- and oligomers). During hydrolysis, polymers like carbohydrates, lipids, nucleic acids and proteins are converted into glucose, glycerol, purines and pyridines. A variety of microorganisms is involved in hydrolysis, which is carried out by exoenzymes, produced by those microorganisms which decompose the undissolved particulate material[1]
2) Acidogenesis: During acidogenesis, the products of hydrolysis are converted by acidogenic (fermentative) bacteria into methanogenic substrates. Simple sugars, amino acids and fatty acids are degraded into acetate, carbon dioxide and hydrogen (70%) as well as into volatile fatty acids (VFA) and alcohols (30%)[1].
3) Acetogenesis: Products from acidogenesis, which cannot be directly converted to methane by methanogenic bacteria, are converted into methanogenic substrates during acetogenesis. VFA and alcohols are oxidised into methanogenic substrates like acetate, hydrogen and carbon dioxide. VFA, with carbon chains longer than two units and alcohols, with carbon chains longer than one unit, are oxidized into acetate and hydrogen. The production of hydrogen increases the hydrogen partial pressure. This can be regarded as a „waste product "of acetogenesis and inhibits the metabolism of the acetogenic bacteria. During methanogenesis, hydrogen is converted into methane. Acetogenesis and methanogenesis usually run parallel, as symbiosis of two groups of organisms.
4) Methanogenesis: The production of methane and carbon dioxide from intermediate products is carried out by methanogenic bacteria. 70% of the formed methane originates from acetate, while the remaining 30% is produced from conversion of hydrogen (H) and carbon dioxide (CO2)[1].
The efficiency of AD is influenced by some critical parameters, thus it is crucial that appropriate conditions for anaerobic microorganisms are provided. The growth and activity of anaerobic microorganisms is significantly influenced by conditions such as exclusion of oxygen, constant temperature, pH-value, nutrient supply, stirring intensity as well as presence and amount of inhibitors (e.g. ammonia). The methane bacteria are fastidious anaerobes, so that the presence of oxygen into the digestion process must be strictly avoided. The AD process can take place at different temperatures, divided into three temperature ranges: psychrophilic (below 25oC), mesophilic (25oC – 45oC), and thermophilic (45oC – 70oC). The pH-value is the measure of acidity/alkalinity of a solution (respectively of substrate mixture, in the case of AD) and is expressed in parts per million (ppm). The pH value of the AD substrate influences the growth of methanogenic microorganisms and affects the dissociation of some compounds of importance for the AD process (ammonia, sulphide, organic acids). Experience shows that methane formation takes place within a relatively narrow pH interval, from about 5,5 to 8,5 , with an optimum interval between 7,0-8,0 for most methanogens. The stability of the AD process is reflected by the concentration of intermediate products like the VFA. Ammonia (NH3) is an important compound, with a significant function for the AD process. Microelements (trace elements) like iron, nickel, cobalt, selenium, molybdenum or tungsten are equally important for the growth and survival of the AD microorganisms as the macronutrients carbon, nitrogen, phosphor, and Sulphur.

A. Types of Feedstock

A wide range of biomass types can be used as substrates (feedstock) for the production of. The most common biomass categories used are as follows:

- Animal manure and slurry
- Agricultural residues and by-products
- Digestible organic wastes from food and agro industries (vegetable and animal origin)
- Organic fraction of municipal waste and from catering (vegetable and animal origin)
- Sewage sludge
- Dedicated energy crops (e.g. maize, miscanthus, sorghum, clover).

The substrates for AD can be classified according to various criteria: origin, dry matter (DM) content, methane yield etc. The choice of types and amounts of feedstock for the AD substrate mixture depends on their DM content as well as the content of sugars, lipids and proteins. Substrates containing high amounts of lignin, cellulose and hemicelluloses can also be co-digested, but a pre-treatment is usually applied in this case, in order to enhance their digestibility. The potential methane yield is one of the important criteria of evaluation of different AD substrates. Almost all biomass is degraded to biogas in theory. However, the choice of substrate will depend on the availability of the raw material, type of the digester, and its operating conditions. Cattle manure is a traditional source for biogas production. The methane content is high in pig manure, around 60%, followed by cow dung with 50%. Kitchen wastes contain a high amount of fat in the form of animal fat and cooking oil. This high-fat content can enhance the biogas production .Combinations of different substrates often have a synergistic effect on biogas production .Co-digestion can improve the nutrient balance, maintains the pH, and results in positive synergisms. Moreover, in several studies co-digestion had a higher methane yield compared to mono substrate digestion

B. Properties of Bio Gas

Biogas is somewhat lighter than air and has an ignition temperature of approximately 700 °C (diesel oil 350 °C; petrol and propane about 500 °C). The temperature of the flame is 870 °C. Biogas consists of about 60 % methane (CH_4) and 40 % carbon dioxide (CO_2). It also contains small proportions of other substances, including up to 1% hydrogen sulphide (H2S). The methane content and hence the calorific value is higher the longer the digestion process. The methane content falls to as little as 50% if retention time is short. If the methane content is considerably below 50 %, biogas is no longer combustible[2]. The first gas from a newly filled biogas plant contains too little methane. The gas formed in the first three to five days must therefore be discharged unused. The methane content depends on the digestion temperature. Low digestion temperatures give high methane content, but less gas is then produced. 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; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat. Biogas can be compressed, the same way natural gas is compressed to CNG, and used to power motor vehicles. A biogas plant is the name often given to an anaerobic digester that treats biodegradable organic wastes.

III. SCOPE OF BIO GAS TECHNOLOGY

Biomethanisation technology has numerous application in various fields. The biogas produced using biomethanisation technology can be used for cooking, electricity production and various useful application. The scope of the bio energy projects ranges from domestic households to public places like hostels, hotels, markets, convents etc Treated biomaterials, coming out from the digester of the treatment plant, in the form of liquid or solid can be used as a very good organic fertilizer. This organic fertilizer helps to minimize the use of chemical fertilizer.

A. Domestic Bio waste treatment Biogas Plants

These plants are suitable for the treatment of all bio degradable wastes and organic waste water generated in the houses. This prevents the tendency to throw the waste on roads and in public places. Generation of cooking gas at household level helps to avoid fuel crisis to a large extent. The easily degradable waste from kitchen mixed with waste water from kitchen is fed into the plant through the inlet chamber of the plant. This waste is converted into biogas with the help of special type of anaerobic bacteria. The cow dung is used initially to provide a culture of suitable bacteria, which trigger the digestion process. The main component of gas produced is methane which is a non conventional source of energy. The space required for a domestic plant(1m3) is one square meter. Time required for installation is 4 hours. The gas generated from the waste of 5 member family is sufficient to work a single burner stove for 2 hours every day. It took about one month for the domestic bio waste treatment plants to reach to its full potential. Bio gas production from the biogas plant depends upon the quality the cow dung culture which is deposited in the plant during its initial stage. If the cow dung culture is of high quality within two or three days the bio gas production will initiates. During the primary stage the plant should be filled with 75% of its capacity with organic waste. The food wastes should be added only after three days. It took about one month to fill the plant to 100% of the capacity. It is sufficient to meet more than 50% of the energy required for cooking every day[5, 6, 7, 8]. A 1 m3 Biogas plant is sufficient to control the emission equivalent to 3.5 Metric tons of CO_2.

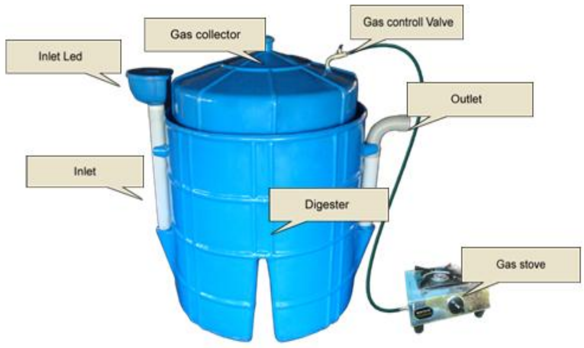

Fig 2 parts of a domestic biogas plant[3]

If plant capacity is not enough a predigester can be used.3.5 carbon credits could be replaced by a 1.5 m3 size plant. Average life cycle is 15-20 years. An approximate thumb rule is that from 10Kg of waste 1-1.5 m3 biogas can be generated. The return on investment of a domestic bio waste treatment – bio energy plant is also very good. A 1 m3 plant is sufficient to save the 70% - 90% consumption of fire wood or other cooking fuels every day.

The main types of portable domestic biogas plants developed by:

- *Ordinary Type*: Ordinary type biogas plants are made up of fiber glass. The main parts of the ordinary type biogas plants are digester and gas collector. The bacteria culture being used is cow dung. After the gas formation the gas collector floats. When it happens black slurry comes out across the sides. It is one of the disadvantages of the ordinary type portable biogas plants. Pressure block has to be applied at the top of the plant in order boost the pressure of the gas produced.
- *Water Jacket Type:* The water-jacket plant is a special case of the floating-drum plant. The drum floats in a water bath and not direct in the slurry. Water-jacket plants can handle substrates with a high solids content without danger of drum blockage due to crust formation. The shape is different from that of ordinary type. The water jacket type is more hygienic than the ordinary model. Water Jacket type is more costlier than the ordinary type. High capacity models are available in water jacket type. The water-jacket is particularly suitable where human excrement is to be digested. Of all simple systems, the water-jacket plant is the cleanest. The gas drum rusts less in the water jacket than if it were floating directly in the slurry. The water in the jacket evaporates quickly. For this reason the water level must be checked regularly. The inner wall of the water jacket is inside the gas space. Its upper part must receive a gaslight coating or rest on a gaslight ring, otherwise the gas will escape through the porous wall.
- *Anti Mosquito Type:* In this plant apart from the production of cooking gas by the treatment of bio waste, there is no possibility for the growth of mosquitoes. The gas collector of this plant is

capable of storing more than 50% of the quantity of biogas stored in other biogas plants of similar size. There are also facilities for regulating the high pressure generated inside the plant, and also to allow the gas to reach the stove even with the high pressure. This plant is available in different capacities ranging from 0.5 Cum to 6Cum size. By installing a plant of 1Cum size it would be possible to treat 2kg of bio waste and 20 to 30 liters of waste water having bio contents on each day. About 50% of gas required for cooking purposes can be produced from this plant from all days. On this account the cost of L.P.G amounting to about Rs 7200 per year can be saved.

C. Institutional Bio gas plant

The biogas plants in schools and hostels are bigger than the domestic ones. With a capacity range of 10m3 -25m3 each plant on an average can serve about 200 people. The digester tank is built by excavating a pit and constructing a brick or ferro-cement wall with an impervious lining on top. A steel drum coated with FRP floats on top and collects biogas. A digestor vessel is made up of two components: a precast (from ferro cement) digester sunk into the ground and a gas holder drum made from FRP(fiber glass reinforced plastic),which floats over the tank Large scale energy from waste plants are built from one or two 25 m3 biogas digesters and are installed in local councils or fish markets[6, 7, 8].

D. Night Soil based Bio gas Plant

The treatment of human excreta through biomethanisation is the remedy to overcome these two problems at a time. Like any other bio waste, human excreta can be treated with the help of anaerobic microbes (bacteria). These microbes are not harmful to human beings. When human excreta are treated with the help of biomethanisation process, the biogas is generated from this waste, through microbial action. This gas can be used either for cooking or for electricity generation. When a night soil plant is installed, there is no need of a separate conventional septic tank. The night soil (human excreta) generated will directly be fed into the treatment plant automatically in a hygienic way for production of biogas. Treated slurry coming out from the plant can be utilized as liquid fertilizer. All other easily biodegradable waste can be treated together with human excreta in the same plant. If there is a sewage treatment plant (STP), the efficiency of the STP can be increased through pre-treatment of human excreta by biomethanisation.

Fig 3 Night soil based biogas plant [3]

Through the installation of night soil based biogas plants, the beneficiary can treat all other degradable waste like cooked food, fish, meat and vegetable waste in the same plant. The size of the plant may be different depending upon the availability of human excreta and other degradable waste. The treatment plant can be installed either as a single unit or more units in different locations. The installation of a night soil plant is more convenient during the building construction time. The conversion of existing septic tanks to night soil treatment digester is a little expensive

E. Electricity From Biogas plant

The main advantage of the waste to electricity project is that no external power is required for the operation of the plant. The power generated in the treatment plant can be utilized to meet the in house requirement completely. Excess quantity can be utilized for any types of application, including street lighting, providing lights to the markets and the likes. Generally 1.5 KW of electricity can be produced from one cubic meter of biogas [6]. Depending upon the percentage of methane content in biogas, the power generation may vary slightly. The size of the generator can be fixed depending upon the availability and the quantity of gas and the duration for the requirement of power. The gas can be utilized as the operation fuel in generators. Before feeding biogas as the full generator, the gas has to be passed through gas scrubber to remove unwanted particles, gases, moisture and so on. Two types of generators are used for generating electricity from biogas. One is the dual fuel method and the other is the 100% biogas model. Dual fuel models are basically diesel generator sets. In this system, the biogas is connected to generator through air mix. Once the biogas is passed through generator, the consumption requirement of the diesel is automatically reduced. Usually, dual fuel generator work in 80%-20% mode. In the 100% biogas engines, no other fuel is required either for starting or for operating them. Any type of petrol engine can be modified for operating the same using biogas as operation fuel. The imported models of 100% biogas engines are very costly and the maintenance of such system is also very expensive [5].

F. Integrated Waste Management System

Waste generation increases with population expansion and economic development. Improperly managed solid waste poses a risk to human health and the environment. Uncontrolled dumping and improper waste handling causes a variety of problems, including contaminating water, attracting insects and flies, and increasing flooding due to blocked drainage canals or gullies. In addition, it may result in safety hazards from fires or explosions. Improper waste management also increases green house gas (GHG) emissions, which contribute to climate change like ozone layer depletion etc. Planning for and implementing a comprehensive program for waste collection, transport, and disposal along with activities to prevent or recycle waste can eliminate these problems. Integrated Waste Management (IWM) systems combine waste streams, waste collection, treatment and disposal methods into a practical waste management system that aims to provide environmental sustainability, economic affordability and social acceptance for any specific region. The key point is not how many waste management options are used, nor whether they all apply at the same time, but that they are combined in an optimum way as part of a single approach. IWM considers the total system and looks for the best mix of treatment methods to minimize economic costs and to maximize environmental protection and social benefits.

IV. CONCLUSION

The demand for energy is increasing day by day and so is the dependency for the fuels. In order to propel the development governments have been searching for new allies all over the world for the fuel. The burden can be cut down to a large extent if one can effectively exploit the potential of biomass resources. Access to energy resources, economic development and environmental pollution, which in turn threaten human health, are major challenges facing developing countries today. Economically feasible and efficient biogas could be the answer of solving some of these problems and needs. Most of the biogas digesters are concentrated in developing countries with India and China as leading countries accounting for the highest share [8]. More or less, every biodegradable organic waste can be treated in a biogas digester, providing energy for cooking, lighting and heating along with increased of dissolved nutrient concentration in the digestate, thus, providing farmers with an improved organic fertilizer. Many of small scale digesters do not require high maintenance and are more or less adaptable to the climate and condition of many of developing countries. The general public is depending upon the centralized projects for the treatment of organic waste [10]. Decentralized waste treatment plants discussed here are an efficient method of waste management. Most of the people are constructing good houses and providing good education to their children. But they do not seriously think about their hygienic living conditions for the future. The life of the coming generation on earth will become difficult mainly due to the atmospheric pollution. It is our paramount responsibility to provide better atmosphere to our children. Instead of depending on the government for all environmental protection activities, every individual should think themselves of being a part of climate protection activities. Installation of bio-waste treatment, bio-energy generation plants in houses and all institutions are the ideal projects to contribute ourselves for the protection of our Mother Earth. Further, full analysis are needed with a new approach to facilitate communication between the experts from different fields such as engineering, hydrology, biology, social science, economics and systems-modeling to identify and find the best possible optimum solution and strategies needed in effective implementation of the biogas plants[8,11].

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