GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

DRAWING BIOGAS FROM WASTE

Sushila Ekka[1] and Pappu Kumar[2]
[1]Lecturer, CSE Department GWP Ranchi
[2]Lecturer, EE Department, GWP Ranchi

ABSTRACT

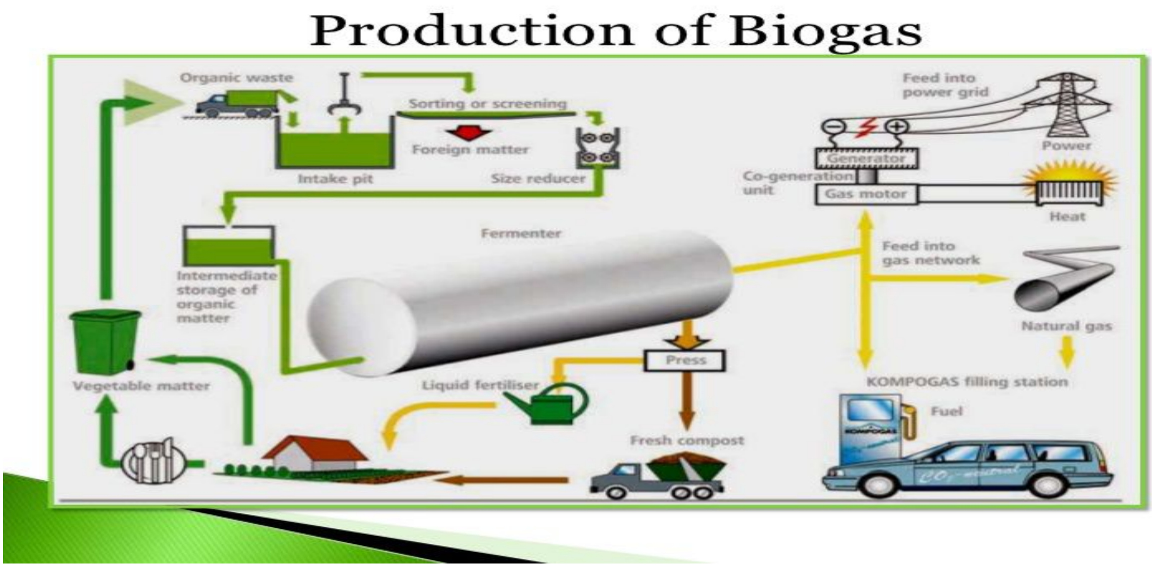
Waste such as sewage sludge, agricultural waste, industrial organic waste, food waste, household organic waste etc. are eliminated by applying biogas treatment. In recent years the performance of biogas rectors has been increased and improved thoroughly rectors design has improved on basis of mechanism and initialization .In order to improve economic feasibility of biogas production .A new concept of bio refinery has been introduced in the field of biogas treatment.Bio refining is based on the concept of 100% production by incoming biomass into energy or valuable by products. One of the currently investigated bio refinery concepts for biogas production from manure implies the separation of manure into a solid and a liquid fraction and their specific treatment in a UASB (up flow anaerobic sludge blanket) reactor and a CSTR (continuous stirred tank reactor), respectively..

Keywords- *Biogas, Factors affecting biogas production, Anaerobic digestion, bio-chemical reactions anaerobic digestion, biomass.*

I. INTRODUCTION

Biogas is a mixture of gases produced by anaerobic digestion.In the absence of air–typically in sealed tanks (digesters) anaerobic digestion converts organic matter into useful products. Inside the digester, materials experience a series of, stages in which different types of bacteria break them down and convert them into useful outputs. The gases produced typically consist of 60 % methane and 40 % carbon dioxide (CO_2). It is often 'upgraded' to pure methane by removing the $CO_2$for commercial uses. In addition to biogas, the process also yields a nutrient-rich dig estate.

Biogas technology is hailed as anarchetypal appropriate technology that meets the basic need for cooking fuel in rural areas as an alternate source of energy in rural India,. Using local resources, viz. cattle waste and other organic wastes, energy and manure are derived. The promotion of National Biogas Programme in a major way in the late 1970s as an answer to the growing fuel crisis is result due torealization of this potential and the fact that India supports the largest cattle wealth. Biogas isconcertedaction of various groups of anaerobic bacteria produced by organic wastes. An attempt has been made in this review on the work done by our scientists in understanding the microbial diversity in biogas digesters, their interactions, and factors affecting biogas production, alternate feedstock's, and uses of spent slurry.



II. CHARACTERSTICS OF BIOGAS

Composition of biogas depends upon feed material also. Biogas having an ignition temperature in range of 650 to 750 0C, it is about 20% lighter than air. Similar to LPG gas it is an odourless& colourless gas that burns with blue flame. Its caloric value is 20 Mega Joules (MJ) /m3 and usually in a conventional biogas stove it burns with 60 % efficiency. Depending on the nature of the task, and local supply conditions and constraints this gas is useful as fuel to substitute firewood, cow-dung, petrol, LPG, diesel, & electricity. After its anaerobic digestion(AD) that has superior nutrient qualities over normal organic fertilizer, as it is in the form of ammonia and can be used as manure systems provides a residue organic waste Biogas digester. Anaerobic biogas digesters also function as waste disposal systems, particularly for human wastes, and can, therefore, prevent potential sources of environmental contamination and the spread of pathogens and disease causing bacteria. Biogas technology is particularly valuable in agricultural residual treatment of animal excreta and kitchen.

- **ADVANTAGES OF BIOGAS TECHNOLOGY** • Traditional energy sources like firewood and animal dung replaced by generation of biogas, thus contributing to combat deforestation and soil depletion. • Biogas can contribute to replace fossil fuels, thus reduction of emitted greenhouse gases and other harmful emissions takes place. • using it as a source of energy by trapping biogas in biogas plant, 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). Production of high quality fertilizer by transforming organic waste. • 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

ADVANTAGES OF BIOGAS AS A FUEL - • It mixes easily with the air. • It is light fuel gas. • It has high calorific value. • Highly knocked resistant. • Thermal efficiency is higher due to uniform distribution. • It has a high octane number.

The inputs
Biogas inputs (known as feedstock) come from a wide variety of organic sources. Farm crops (known as biomass) are a common feedstock; they are either crops traditionally grown for food (such as maize and corn) or crops specifically developed for energy purposes. Human sewage can be used but is typically limited to the captive operations of wastewater management companies. Animal manure is another common feedstock. So is food waste, either from commercial operators (e.g. food processing factories, restaurants and retailers) or from domestic households.

The outputs
The biogas can be fed into the grid, which can be burnt to create electricity. This process also generates heat, which can be captured and used locally (e.g. for heating and drying). Alternatively, bio methane can be distributed through a gas pipe network, effectively being used in the same way as natural gas from fossil fuels.
The dig estate is a valuable fertilizer for farmers and is particularly useful in countries where soil quality has become degraded through over-intensive farming.

III. FACTORS AFFECTING BIOGAS PRODUCTION

Various factors such as biogas potential of feedstock, design of digester, inoculums, nature of substrate, pH, temperature, loading rate, hydraulic retention time (HRT), C : N ratio, volatile fatty acids (VFA), etc. influence the biogas production.

Sub layer composition

The feedstock used to produce biogas through anaerobic fermentation process (digestion). For the development and optimal metabolic activity of microorganisms involved in the process, it should ensure a favourable environment. The fermentation medium must fulfil several important conditions:

- Contain biodegradable organic matter;
- Have a pH between 6.8 – 7.3;
- C/N ratio should be between 15 and 25;
- Should not contain inhibitory substances for microorganisms (antibiotics, detergents, antiseptics, etc.).

The most used types of sub layers in biogas technology are represented by: manure, residues or by-products from agriculture, energetic crops (corn, rye, Miscanthus, sorghum etc.), organic waste from food industry (of plant and animal origin), organic fraction of municipal solid wastes, wastewater from food industry and zootechnics, sludge from wastewater treatment plants, food waste Temperature

To the development of anaerobic digestion process, having a strong influence over the quality and quantity of biogas production temperature choice and control are critical. The microorganisms participating in the process of anaerobic digestion (especially methanogenic ones), are divided into three large categories:

• Cryophiles (Psychrophiles), operating at temperatures from 12 to 24°C, digestion characteristic area under cryophilic regime;

• Mesophiles, operating at temperatures between 22-40° C, characteristic area for mesophilic regime digestion;

• Thermophiles, operating at temperatures between 50 – 60° C, characteristic area for thermophilic regime digestion.

The hydraulic retention time (HRT) and the retention time of the solids (SRT)

It is one of the parameter having major importance in the design of biological treatment processes. The hydraulic retention time (HRT) it is the average range in which the sub layer for anaerobic digestion process is retained in the digester, in contact with biomass (bacterial mass). Sub layers containing simple compounds are easily decomposed and require a short HRT, while a sub layer containing complex compounds are harder decomposed and requires a longer HRT.

$HRT = V_R/V_S$ [days],

Where: HRT – hydraulic retention time [days]; Vr – digester volume [m3]; Vs – amount of sub layer loaded per time unit [m3 /t].

Working pressure in the fermenter

Pressure has it great significance in the process of biogas production. The experiments have shown that when hydrostatic pressure in which the operating methanogenic bacteria increase over 400 - 500 mm H_2O, biogas production also increases. It resume's when the hydrostatic pressure falls below the mentioned value. This need must be taken into account in the digesters design. To digesters vertically disposed, where the height can reach tens of meters, release biogas is produce only up to maximum depth 4 - 5 m (the hydrostatic pressure of less than400 - 500 mm H2O), and the rest of the area occupied by the substrate does not produce biogas, that is why it is necessary to periodically bring the material into surface under the limit of reaction, by the stirring continued. Elimination of this short come is done by using horizontal-flow digesters, where the substrate height should not exceed 3.5 m, situation for biogas production.

The reaction medium pH

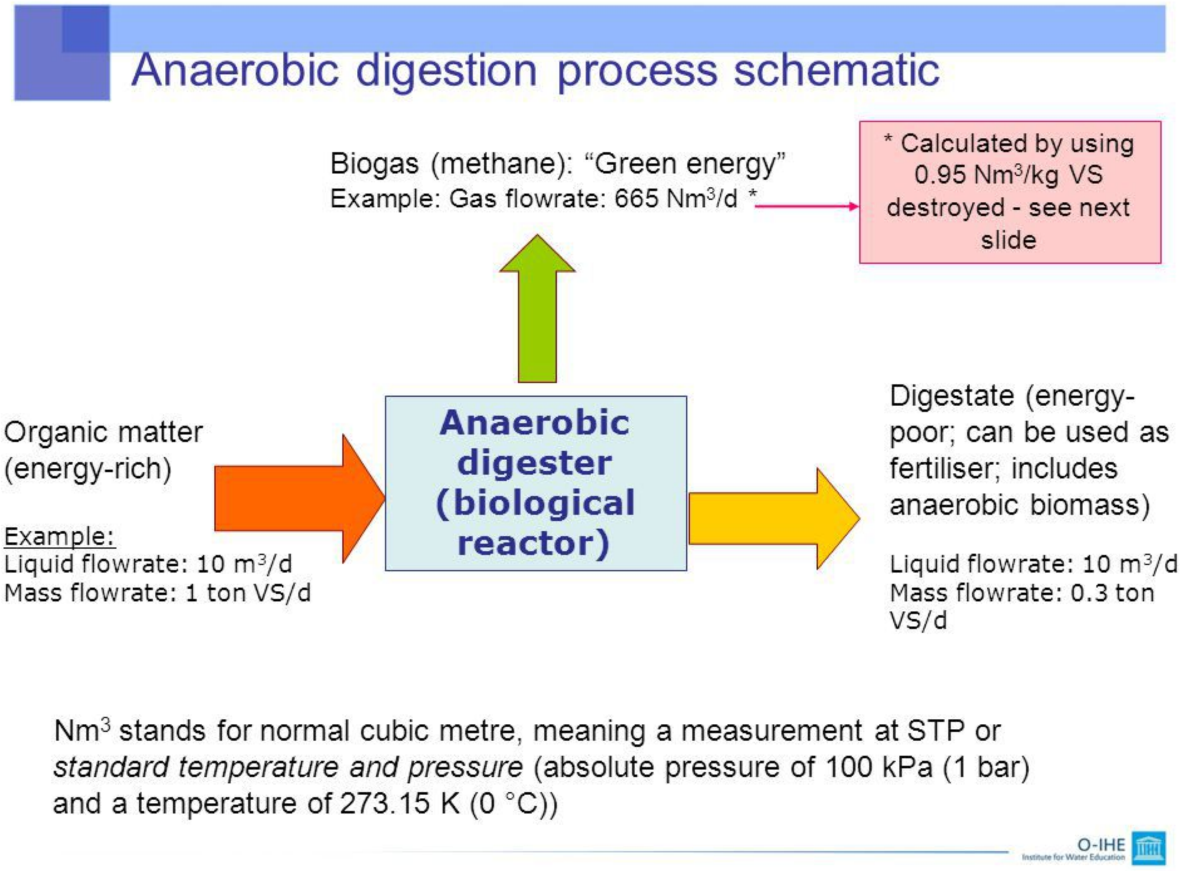
In anaerobic digestion, at well-defined values of pH all life process is carried out. Release occurs throughout the mass the material digest. In the hydrolytic stage, the acidogenic bacteria require a pH in the range 5.5 – 7.0, and in the final stages, methanogenic bacteria require a pH value ranging between (6.5 - 8.0). A major limitation to the processing of organic sub layers through the process of anaerobic digestion in a single phase is a lower value of pH in the reactor due to rapid acidification by production of volatile fatty acids (VFA).

Basics of anaerobic digestion

Anaerobic digestion is "a process of controlled decomposition of biodegradable materials under managed conditions where free oxygen is absent, at temperatures suitable for naturally occurring mesophilic or thermophilic anaerobic and facultative bacteria and archaea species, that convert the inputs to biogas and whole dig estate". It is widely used to treat separately collected biodegradable organic wastes and wastewater sludge, because it reduces volume and mass of the input material with biogas (mostly a mixture of methane and CO_2 with trace gases such as H_2S, NH_3 and H_2) as by-

ISSN 2348 – 8034
Impact Factor- 3.155

product.



IV. Biochemical reactions in anaerobic digestion

There are four key biological and chemical stages of anaerobic digestion

1. Hydrolysis
2. Acidogenesis
3. Acetogenesis
4. Methanogenesis.

Biomass is made up of large organic compounds in most of the cases. The organic matter macromolecular chains must first be broken down into their smaller constituent parts is required in order to access the chemical energy potential of the organic material microorganism in anaerobic digestion. For further processing these constituent parts or monomers such as sugars are readily available to microorganisms. The process of breaking these chains and dissolving the smaller molecules into solution is called hydrolysis. Therefore, the necessary first step of anaerobic digestion is the hydrolysis of high molecular weight molecules. It may be enhanced by mechanical, thermal or chemical pre-treatment of the waste. Hydrolysis step can be merely biological (using hydrolytic microorganisms) or combined: bio-chemical (using extracellular enzymes), chemical (using catalytic reactions) as well as physical (using thermal energy and pressure) in nature.

Acetates and hydrogen produced in the first stages can be used directly by methanogens. Other molecules such as volatile fatty acids (VFA's) with a chain length that is greater than methanogens. Where there is further breakdown of the remaining components by acid genic (fermentative) bacteria there is the biological process of acid genesis. Here VFA's are generated along with ammonia, carbon dioxide and hydrogen sulphide as well as other by-products. The third stage anaerobic digestion is acetogenesis. Here simple molecules created through the acidogenesis phase are further digested by acetones to produce largely acetic acid (or its salts) as well as carbon dioxide and hydrogen. The final stage of anaerobic digestion is the biological process of methanogenesis. Here methanogenic archaea utilise the intermediate products of the preceding stages and convert them into methane, carbon dioxide and water. It is these components that makes up the majority of the biogas released from the system. Methanogens is – beside other factors - sensitive to both high and low pH values and performs well between pH 6.5 and pH 8. The remaining, non-digestible organic and mineral material, which the microbes cannot feed upon, along with any dead bacterial residues, constitutes the solid dig estate.

Anaerobic digestion

Anaerobic digestion is collection of processes by which microorganism breakdown biodegradable material in the absence of oxygen. The process is used for industrial or domestic purposes to manage waste and to produce fuels. Much of the fermentation used industrially to produce food and drinks products as well as which fermentation, uses anaerobic digestion. For anaerobic digestion several different types of anaerobic processes and several different types of digesters are applicable. It is hard to say in advance, which digester type is most appropriate for treating the selected organic waste. Digestion of farm waste, for example, should be carried out in decentralized plants to serve each farm separately, to make it an economic and technological unit combined with the farm. In the same sense a town may be a unit in treatment of organic municipal waste. It is important to study the waste of each such unit carefully to be able to determine optimal conditions for substrate digestion. Organic waste can differ very much even in same geographical areas, therefore it is strongly recommended to conduct laboratory and pilot scale experiments before design of the full scale digester is made. Considering the costs of the full scale digester, conducting pilot scale experiments is a minor item, especially if you have no preceding results or experience. There are several processes available to conduct anaerobic digestion. Roughly, the digestion process can be divided into solid digestion and wet digestion processes. Solid digestion processes are in fact anaerobic composters. In this process substrate and biomass are in pre-soaked solid form, containing. 20 % of dry matter and 80 % water. Such processes have several advantages. The main advantage is reducing the reactor volume due to much less water in the system. Four times more concentrated substrate equals approximately four times less reactor volume. It is also possible that some inhibitors (such as ammonium) can have less inhibitory effects in solid digestion process. The biggest disadvantage of solid digestion process is the substrate transport. More energy is required for transport of energy in and out of the digesters for substrate in solid form. It is also a stronger possibility of air intrusion into the digesters, which poses a great risk to process stability and safety. Such processes have gained ground for a wider use has been recently known. To successfully conduct anaerobic digestion several reactor technologies are available. Roughly, they can be divided into batch wise and continuous processes. Furthermore continuous processes can be divided into single stage or two-stage processes. Microorganisms are completely mixed and suspended with substrate in the digester at most of the wet digestion processes. It is impossible to separate after the process, the suspended solids of substrate and microorganisms. We can apply flow-through processes, if the substrate contains little solids and is mostly dissolved organics liquid. In these processes microorganisms are in granules and granules are suspended in liquid which contains dissolved organic material. Microorganism's granules are easily separated from the exhausted substratein such anaerobic processes. Typical representative of such process is the UASB (Upflow Anaerobic Sludge Blanket) process

V. BATCH PROCESSES

In the batch process all four steps of digestion as well as four stages of treatment process happen in one tank. Typically the reaction cycle of the anaerobic sequencing batch reactor (ASBR) is divided into four phases: load, digestion, settling and unload. A stirred reactor is filled with fresh substrate at once and left to degrade anaerobically without any interference until the end of the cycle phase. This leads to temporal variation in microbial community and biogas production. Therefore, more precise measurement and monitoring equipment is required in batch processing to function optimally. Sometimes in batteries otherwise usually these reactors are built at least in pairs. For instant use it is achieved as more steady flow of biogas. The tank is usually emptied incompletely (to a certain exchange volume), which is up to 50% of total reactor volume in between the cycles. For the next cycle ,the residue in the tank serves as microbial inoculums. This makes batch reactors volume larger than of the conventional continuous reactors; however they do not require equalization tanks and the total reactor volume is usually less than in conventional processes. They can be coupled directly to the waste discharge; however this limits the use to more industrial processes (for example food industry) and less to other waste production. Typical cycle time is one day. Batch solid anaerobic digestion Alternative processes that treat wet organic waste in solid state is reported in literature as SEBAR - Sequential Batch Anaerobic Digester System. In this case the cycle is also divided into four phases, however somehow different than in an ASBR

ISSN 2348 – 8034
Impact Factor- 3.155

process. Digesters are required to be always in pairs in this process. Between the cycles the reactor is almost completely emptied therefore it requires inoculation through leach ate exchange between the two digesters (from the one in the peak biogas production to the one at the start of the process). Leach ate is self-circulated in the other phases. Typical cycle time is between 30 and 60 days. Although solid substrate reduces the reactor volume, the volume is still rather large due to long cycle times compared to conventional digesters that process liquid substrates. The advantage of this type of digesters are applicable in smaller scale as it is less complicated monitoring equipment.

VI. CONTINUOUS PROCESSES

Conventional continuous anaerobic digestion process is been used in most of the commercial biogas plants. At mesophilic temperature range (35-40°C), conventional means fully mixed, semi continuous or continuous loud and unload reactor. Rarely substrate is loaded continuously otherwise in majority of the cases the substrate is loaded to the reactor once to several times a day. Continuous load can lead to short circuit, which means that if mixing is too intense or input and output tubes are located improperly then fresh load can directly flow out of the reactor. Although they are built in pairs, they do not function as a stage separated process as the digester is usually single stage. In preparation tank, where various substrates are mixed and prepared for the loading, which also serves as a buffer tank usually digesters are equipped with such preparation tank. Places where treated substrate is completely stabilized and prepared for further treatment, there is addition of a post-treatment tank (it is also called post fermenter) in many of cases. The post-treatment tank can also serve as a buffer towards further treatment steps of the substrate. If the digester operates optimally the npost-fermenters do not contribute much towards overall biogas yield (up to 5%).Generally the size of the preparation and post treatment tanks are determined according to the necessary buffer capacity for continuous operation. The necessary of Hydraulic Retention Time (HRT) and Organic Loading Rate (OLR) that should be determined in pilot tests, help in determining the size of the digester. HRT divided by substrate flow rate and represents time (in days) in which a certain unit volume of the substrate passes through the reactor hence HRT is defined as digester volume. For mesophilic digesters, depending on the substrate bio-degradability the usual values are between 20-40 days. In thermophilic digesters HRT is smaller (between 10 and 20 days) to achieve the same treatment efficiency. Conventional single stage anaerobic digestion process Organic load rate OLR (sometimes also called volume load) is defined as mass of organic material fed to the digester per unit volume per day. Typical value for mesophilic digesters Anaerobic Treatment and Biogas Production from Organic Waste 17 is 2.0-3.0 kgm-3d-1. Typical value for thermophilic digesters is 5.0 kgm-3d-1. Maximum OLR depends very much of the substrate biodegradability; mesophilic process can rarely achieve higher loads than 5.0 kgm-3d-1 and thermophilic 8.0 kgm-3d-1. Locally in the digester for a short period of time higher loads can be achieved, however due to inherent instability it is not advisable to run continuously on such high loads. Separated process can be applied to achieve better biodegradation efficiency and higher loads stage. In this case, hydrolysis-acidogenic stage reactor the whole substrate or just portions of the substrate which are not easily degradable are treated first and after that in the methanogenic reactor. By separating the biological processes in two separate tanks each can be optimised to achieve higher efficiency with respect to one tank, where all stages of the digestion processes occur simultaneously. Giving considerable attention to this kind of processes many research data have been published. Both stages can be either mesophilic or thermophilic, however it is preferred that the hydrolysis-acidogenic reactor is thermophilic and methanogenic is mesophilic. Depending on the substrate biodegradability HRT for the thermophilic hydrolysis-acidogenic reactor is 1-4 days. Typical HRT for the methanogenic reactor is 10 - 15 days (mesophilic) and 10 - 12 days (thermophilic). Advantages of this process beside shorter HRTs are higher organic load rate (20 % or more). Many authors also report slightly better biogas yields. The only disadvantage is more sophisticated equipment and process control, yielding the operation more expensive.

VII. FLOW-THROUGH PROCESSES

The flow-through processes, such as UASB process are used only for substrates where most of the organic material is in dissolved form with solids content at maximum 1-5 gL-1. Category are highly loaded wastewaters of industrial origin (e.g. from beverage industry) in this substrates. It usually needs additional treatment after the substrates has been digested.

VIII. BIOMASS

Biomass is the plant material derived from the reaction between CO_2 in the air, water and sunlight, via photosynthesis, to produce carbohydrates that form the building blocks of biomass. Typically photosynthesis converts less than 1% of the available sunlight to stored, chemical energy. The solar energy driving photosynthesis is stored in the chemical bonds of the structural components of biomass. If biomass is processed efficiently, either chemically or biologically, by extracting the energy stored in the chemical bonds and the subsequent 'energy' product combined with oxygen, the carbon is oxidised to produce CO_2 and water. The process is cyclical, as the CO_2 is then available to produce new biomass

The value of a particular type of biomass depends on the chemical and physical properties of the large molecules from which it is made. Man for millennia has exploited the energy stored in these chemical bonds, by burning biomass as a fuel and by eating plants for the nutritional content of their sugar and starch. In recent years fossilised biomass has been exploited as coal and oil.

IX. THE BENEFITS

Biogas replaces the use of fossil fuels and helps to reduce the emission of methane into the atmosphere. As a greenhouse gas, methane is 20–25 times more harmful than CO_2. Dig estate production avoids the environmental hazards associated with industrially produced fertilizers.

Using biomass to create biogas creates a carbon neutral cycle, in which the carbon emitted from burning the gas is absorbed by new crops grown as feedstock. Creating biogas from food waste means that fewer waste treatment facilities are needed and less organic matter goes into landfill sites (which typically release methane into the atmosphere over time.

X. COCNCLUSION

Although production of biogas technology has established and enhance itself as a technology with great potential which has exercised in the area of energy, rural etc. But it has not made any real impact on total energy scenario. Despite of the presence of about 1.8 million biogas digester there are serious limitation in the availability of feedstock defect in concentration and microbiological failure. But when on review's its literature and history it can be easily found a long list of alternate feedstock's and their potential for biogas production. It is time that substrate-specific biocatalysts are made available to reduce the lag period of biomethanation during the start-up. Regular supply of inoculums and quality control on the marketable inoculums will result in regulating the plant failures. Furthermore, designs to suit the microbial catalysts have been discussed for long, but have yet to be realized. This indicates that the technology transfer is not complete, and in order to translate this 'higher potential' technology into 'high performing' technology it requires coordinated efforts of scientists and engineers to overcome its limitation.

REFERENCES

1. *Dinsdale R. M., Premier G.C., Hawkes F.R., Hawkes D.L., (2000). "Two-stage anaerobic co digestion of waste activated sludge and fruit/vegetable waste using inclined tubular digesters." Bio resource Technology*
2. *Jönsson H., (2008). Higher pH and faster decomposition in bio waste composting by increased aeration. Waste Management.*
3. *Sewage Sludge as a Biomass Resource for the Production of Energy: Overview and Assessment of the Various Options, Energy Fuels.*
4. *Specification for whole digestate, separated digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials, Publicly Available Specification.*
5. *M., Hänninen K., (2011). Composting of bio-waste, aerobic and anaerobic sludge's– Effect of feedstock on the process and quality of compost. Bio resource Technology.*
6. *Hislop, D., Hall, D., 1996. Biomass Resources for Gasification Plant*
7. *ETSU B/M3/00388.*