A Project Report

on

"BIOGAS FROM KITCHEN WASTE"

Submitted To

UNIVERSITY OF MUMBAI

In Partial Fulfilment of The Requirement For The Award of

Bachelor's Degree In
Mechanical Engineering

by

Shaikh Usama Javed Ahmed	15ME52
Sheikh Mohd Jaffar Sharief	15ME54
Thakur Viraj Sanjay	15ME60
Yadav Nitesh Subhash	15ME61

Under The Guidance of
Prof. Ubaid Shah

Department of Mechanical Engineering
Anjuman-I-Islam's Kalsekar Technical Campus
School of Engineering & Technology
Plot No. 2 3, Sector - 16, Near Thana Naka,
Khandagaon, New Panvel - 410206

2018-2019

Affliated To

UNIVERSITY OF MUMBAI

A Project Report
On

"BIOGAS FROM KITCHEN WASTE"

Submitted To

UNIVERSITY OF MUMBAI

In Partial Fulfilment of The Requirement For The Award of

Bachelor's Degree In
Mechanical Engineering

by

Shaikh Usama Javed Ahmed	15ME52
Sheikh Mohd Jaffar Sharief	15ME54
Thakur Viraj Sanjay	15ME60
Yadav Nitesh Subhash	15ME61

Under The Guidance of
Prof.Ubaid Shah

Department of Mechanical Engineering
Anjuman-I-Islam's Kalsekar Technical Campus
School of Engineering & Technology
Plot No. 2 3, Sector - 16, Near Thana Naka,
Khandagaon, New Panvel - 410206

2018-2019
Affiliated To

UNIVERSITY OF MUMBAI

Anjuman-I-Islam's Kalsekar Technical Campus

School of Engineering & Technology

Department of Mechanical Engineering

Plot No. 2 3, Sector - 16, Near Thana Naka,

Khandagaon, New Panvel - 410206

CERTIFICATE

This is certify that the project entitled

"BIOGAS FROM KITCHEN WASTE"

submitted by

SHAIKH USAMA JAVED AHMED	**15ME52**
SHEIKH MOHD JAFFAR SHARIEF	**15ME54**
THAKUR VIRAJ SANJAY	**15ME60**
YADAV NITESH SUBHASH	**15ME61**

is a record of bonafide work carried out by them, in the partial fulfilment of the requirement for the award of Degree of Bachelor of Engineering (Mechanical Engineering) at ***Anjuman-I-Islam's Kalsekar Technical Campus, Navi Mumbai*** under the University of MUMBAI. This work is done during year 2018-2019, under our guidance.

Date: / /

(Prof. UBAID SHAH)
Project Supervisor

(Prof. RIZWAN SHAIKH)
Project Coordinator

(Prof. ZAKIR ANSARI)
HOD, Mechanical Department

DR. ABDUL RAZAK HONNUTAGI
Director

External Examiner

Acknowledgements

We would like to take the opportunity to express our sincere thanks to my guide **Prof. Ubaid Shah**, Assistant Professor, Department of Mechanical Engineering, AIKTC, School of Engineering, Panvel for his invaluable support and guidance throughout our project research and technogy work Without his kind guidance & support this was not possible.

We are also grateful to **Prof. Suresh Ranade**,for his timely feedback which helped us track and schedule the process effectively. His time, ideas and encouragement that he gave has helped us to complete our project efficiently.

We would like to express our deepest appreciation towards **Dr.Abdul Razzak Honnutagi**, Director, AIKTC, Navi Mumbai, **Prof. Zakir Ansari**, Head of Department of Mechanical Engineering and **Prof. Rizwan Shaikh**, Project Coordinator whose invaluable guidance supported us in completing this project.

At last we must express our sincere heartfelt gratitude to all the staff members of Mechanical Engineering Department who helped us directly or indirectly during this course of work.

SHAIKH USAMA JAVED AHMED
SHEIKH MOHD JAFFAR SHARIEF
THAKUR VIRAJ SANJAY
YADAV NITESH SUBHASH

Project I Approval for Bachelor of Engineering

This project entitled ***"Biogas from kitchen waste"*** by ***Shaikh Usama Javed Ahmed, Sheikh Mohd Jaffar Sharief, Thakur Viraj Sanjay, Yadav Nitesh Subhash*** is approved for the degree of ***Bachelor of Engineering in Department of Mechanical Engineering.***

Examiners

1. ....
2. ....

Supervisors

1. ....
2. ....

Chairman

....

Declaration

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Student Name:
Roll Number:

ABSTRACT

India's economic growth is contributing to a massive increase in the generation of solid waste. Approximately 55 million tones of Municipal Solid Waste is generated annually by urban areas in India. Over 59 % of homes in urban India use Liquified Petroleum Gas (LPG) supplied in portable cylinders for their cooking needs

Our institute canteen (AIKTC) utilize several LPG cylinders and also generates large amounts of kitchen waste. The kitchen waste generated has high calorific value and moisture content; hence it can be anaerobically digested. The biogas produced can be used to supplement the fuel requirements of the campus kitchens that generate the kitchen waste. This study consists of carrying out survey, characterization of kitchen waste and exploring it's potential to be used for biogas production.

In this project we have carried out different processes such as pre-heat treatment, fine particle & coarse particle test, coffee ground addition to increase the yield of biogas production.The output of all these processes were campared and studied to find the effective way to produce biogas efficiently.

Contents

Achievements

List of Figures

List of Tables

Chapter 1

Introduction

Biogas is a gaseous fuel containing 60% methane, 40% carbon dioxide and small amount of hydrogen sulphide,nitrogen and hydrogen. It is obtained from biomass plant and animal materials by the process of anaerobic digestion or fermentation of which the in-feed to the biogas plant includes urban waste ,urban refuse, agricultural waste , cow dung case study.Biogas is used as biofuels which originates from biogenic material and used for running a vehicle.

1.1 Purpose

In today's energy demanding life style, need for exploring and exploiting new sources of energy which are renewable as well as eco-friendly is must. In rural areas of developing countries cellulosic biomass (cattle dung, agricultural residues, kitchen wastes, etc) are available in plenty which have very good potential to cater to the energy demand in India alone. Approximately 55 million tones of Municipal Solid Waste is generated annually by urban areas in India. Over 59% of homes in urban India use Liquefied Petroleum Gas (LPG) supplied in portable cylinders for their cooking needs.Biogas technology offers a very attractive route to utilize certain categories of biomass for meeting partial energy needs. In fact proper function of biogas system provides multiple benfits to the users and the community resulting in resource conservation and environmental protection.

1.2 Project Goals and Objectives

The goal of this project is to fabricate a biogas plant and test the outcome.

1.To fabricate biogas plant using available and non expensive material.
2.Test run a bio-reactor using kitchen waste to obtain biogas as a biofuel to be recommended as a substrate for the non-renewable and expensive domestic fuel.
3.To carry different processes on the feed waste to increase the outcome.
4.To make modifications in traditional plant by adding accessories.

Chapter 2

Literature Survey

2.1 Effects of Thermal Pretreatment on The Biomethane Yield and Hydrolysis Rate of Kitchen Waste

Yangyang Li a,, Yiying Jin a,, Jinhui Li a,, Hailong Li b, Zhixin Yu c

In this study, batch tests were performed to evaluate the effects of different thermal pretreatment temperatures (55–160 C) and durations (15–120 min) on the anaerobic digestion of kitchen waste (KW).Two the effects of the different pretreatment parameters on the biomethane yield, lag time and hydrolysis rate constant via data fitting. The subsequent anaerobic digestion of KW pretreated at 55–120 C presented greater efficiency, and longer treatment durations resulted in increased methane production and higher hydrolysis rate constants. These findings were obtained due to the lower nutrient loss observed in KW treated at lower temperature treatments compared with that found with higher temperature treatments. In general, the effects of thermal pretreatment on the lag phase and hydrolysis rate differed depending on the treatment parameters leading to the variations in the KW compositions. The soundness of the two model results was evaluated, and higher statistical indicators (R2) were found with the modified Gompertz model than with the approach developed by Koch and Drewes.

2.1.1 Advantages of Paper

a. Two kinetic study approaches were applied to investigate the influence of the thermal pretreatment parameters (55–160 C; 15–120 min) and assess the variations in the degradation kinetics and methane formation of subsequent AD process. Based on the assessment findings obtained. The effects of thermal pretreatment on subsequent AD process differed depending on the treatment parameters leading to variations compositions in the KW placed into anaerobic digesters. heating temperature of 120 C and a duration of 15 min. These conditions result in comparatively higher methane yields, shorter digestion durations and cost-effective feasibility.

2.2 An Integrated Engineering System For Maximizing Bioenergy Production From Food Waste

Yingqun Maa, Weiwei Caia, Yu Liua,b,

In this study, an integrated engineering system was developed for bioenergy production from food waste pretreated with a cost-effective and highly active enzyme mixture, namely fungal mash which was also in-situ produced from food waste. Under the optimized conditions, 141.5 g/L of glucose was obtained with 67.5% of total solid reduction after hydrolysis of food waste by fungal mash, while 71.8 g/L of bioethanol was produced from subsequent glucose fermentation. The remaining hydrolysis residue was further anaerobically digested for biomethane production with 22.8% of total solid reduction. As the result, about 90% of total solid reduction of food waste was achieved in the integrated engineering system with the outputs of bio-renewable energy in the forms of bioethanol and biomethane. The cost-benefit analysis clearly suggests that the bioenergy production from food waste in the proposed integrated engineering system is technically feasible and economically viable

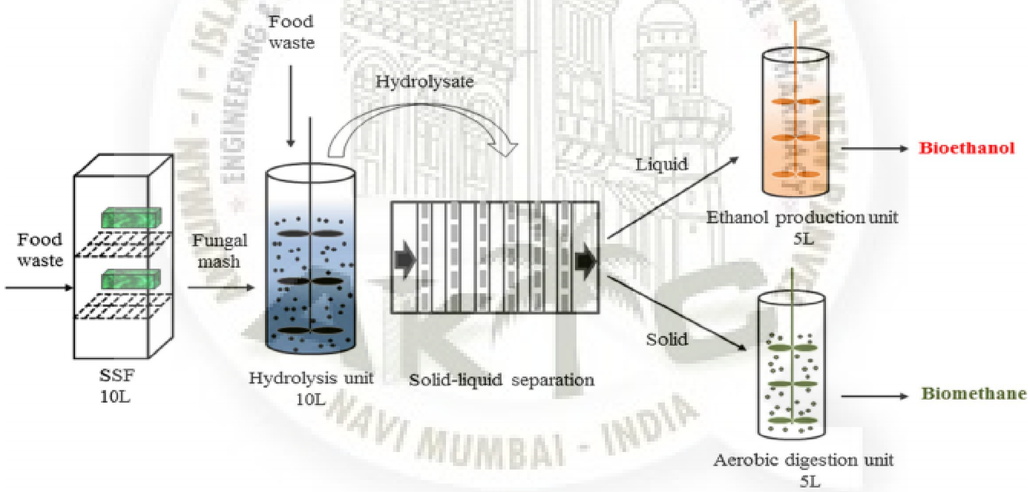

Figure 2.1: The Integrated Engineering System For Bioenergy Production From Food Waste

2.3 Anaerobic Digestion of Coffee Grounds Soluble Fraction at Laboratory Scale: Evaluation of The Biomethane Potential

Fábio Codignole Luz , Stefano Cordiner, Alessandro Manni, Vincenzo Mulone, Vittorio Rocco

The biochemical conversion of residual biomass may give a significant contribution to the flexible and programmable production of renewable electric and thermal power. In this perspective the use of residuals from coffee chain, which is one of the most popular beverage in the world, is of utmost importance due to the large quantity produced. Over 90% of this mass is discarded after use, becoming a significant waste source known as spent coffee grounds (SCG). SCG use as a raw material for biogas production emerges with great potential. SCG is a biomass that does not need pre-treatment, rich in lipids which can be easily recovered in bars and restaurants where it is properly separated. Lipids, which concentrations in SCG can reach more than 25% of its dry weight, have a good biogas production behavior, producing over 1 liter of CH4/g-VS. In this paper, the analysis of biogas yield potential of SCG recovery is presented using a laboratory scale batch anaerobic reactor, fed with the liquid fraction obtained by spent coffee filtration. The use of SCG liquid fraction in conjunction with cow manure has been monitored for 22 days at a temperature of 37 _C showing a specific SCG production contribution up to 254 ml CH4/gVS. An increase of ffi 10% in the methane fraction in Biogas production has been observed with an average LHV of about 28.24 MJ/kg. This result shows the SCG liquid fraction energy recovery potential using an anaerobic digestion process.

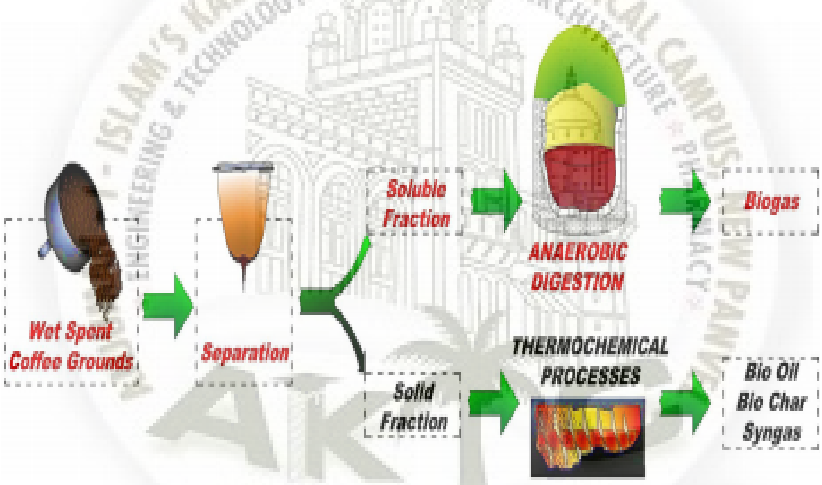

Figure 2.2: Separation Process

2.3.1 Advantages of Paper

a. This reduction has been attributed to a quicker first phase high- lighted by the Gompertz analysis with a reduction of almost a day in the lag phase

b. The produced biogas contains more than 50% of CH4 with peaks of about 60% when SCG is used

c. Group A presented a LHV 7% higher than Group B, respectively of 28,24 MJ/kg and 26,30 MJ/kg, with a biogas methane fraction 9% higher. Group A showed an higher carbon conversion efficiency of about 38% compared to Group B.

2.4 Two-Phase Anaerobic Digestion of Municipal Solid Wastes Enhanced by Hydrothermal Pretreatment: Viability, Performance and Microbial Community Evaluation

Wei Li a,b, Jianbin Guo a,, Huicai Cheng c, Wei Wang b, Renjie Dong a

The viability of hydrothermal pretreatment (HTP) to improve the efficiency of biogas production from municipal solid wastes (MSWs) is uncertain because there is always a trade-off between organic matters hydrolysis and recalcitrant melanoidins formation when applying HTP on different solid wastes. In this study, MSWs including waste activated sludge, fruit and vegetable residues, and kitchen wastes, with and without HTP were digested in the one phase and two-phase anaerobic digesters, respectively.Although the specific biogas production of MSWs in two-phase anaerobic digestion was significantly enhanced by HTP, no benefit could be found in one-phase anaerobic digestion because of the melanoidins formation. The specific biogas production of hydrothermally pretreated MSWs was much higher in twophase anaerobic digestion (0.71 L biogas/g VSadded) than that of MSWs in one-phase anaerobic digestion with or without HTP (0.53 L and 0.55 L biogas/g VSadded) when the butyric acid type fermentation dominated in the acidogenic phase. These findings indicated that the recalcitrant melanoidins formed in the HTP process were probably removed in the acidogenic digester. Differing from previous study, mixed-acid type fermentation, rather than ethanol type fermentation, was observed in the acidogenic digester fed with hydrothermally pretreated feedstock when pH was adjusted in the range of 4.0–4.5 with high oxidation reduction potential values of 49–97 mV. The succeeding specific biogas production of mixed-acid type feedstock was only 0.59 L biogas/g VSadded, which was lower than that of the butyric acid type feedstock. Microbial community structure was independent of the pH values and was substrate-specific in the acidogenic digesters. In the acidogenic digester with the HTP substrate, the phylum Firmicutes and Bacteroidetes increased, thereby possibly resulting from the increased content of soluble sugar and proteins in the HTP feedstock. Energy balance estimation of the four defined scenarios indicated that the combined HTP and two-phase AD in the MSWs treatment can achieve higher net energy output by 50.5–97.4% compared to the other three scenarios. This enables the combined process of HTP and two-phase AD to be a promising alternative way in the treatment of feedstock rich in protein and sugar.

2.5 Literature Survey

Kalyan Dombivali Municipal Corporation BARC Nisargruna Technology This plant can process biodegradable waste such as kitchen waste, paper, grass, gobar and dry leaves. It offers "Zero garbage and Zero effluent" and provides high quality manure and methane gas. Weed free manure obtained from such waste has high nitrogen contents and acts as an excellent soil conditioner. This plant could be set up for ecofriendly disposal of wet-waste generated in kitchens/canteens of big Hospitals/Hotels/Factories/residential complexes and can avoid health hazards due to dump sites. This technology of biphasic biomethanation has high potential of solving the solid waste management problems of the urban areas and provides organic manure and bio-gas as a fuel.

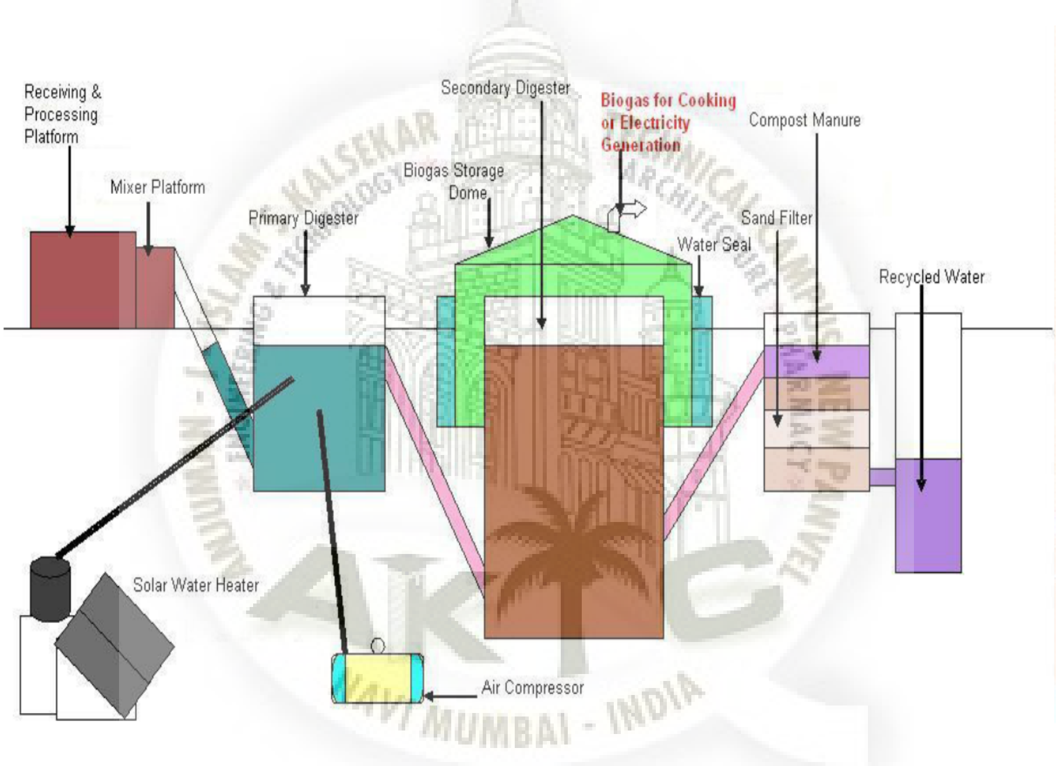

Figure 2.3: Kalyan Dombivali Municipal Corporation BARC Nisargruna Technology

Chapter 3

Biogas

Biogas is produced by bacteria through the bio-degradation of organic material under anaerobic conditions. Natural generation of biogas is an important part of bio-geochemical carbon cycle. It can be used both in rural and urban areas.

A biogas plant is the name often given to an anaerobic digester that treats farm wastes or energy crops. It can be produced using anaerobic digesters (air-tight tanks with different configurations). These plants can be fed with energy crops such as maize silage or biodegradable wastes including sewage sludge and food waste. During the process, the micro-organisms transform biomass waste into biogas (mainly methane and carbon dioxide) and digestate. Higher quantity of biogas could be produced when the wastewater is co-fermented with other residual from dairy industry, sugar industry, brewery industry. For example, while mixing 90% of wastewater from beer factory with 10% cow whey, the production of biogas is increased by 2.5 times compared to the biogas produced by wastewater from beer factory only.

3.1 Key process

There are two key processes: mesophilic and thermophilic digestion which is dependent on temperature. In experimental work at University of Alaska Fairbanks, a 1000-litre digester using psychrophiles harvested from ”mud from a frozen lake in Alaska” has produced 200–300 liters of methane per day, about 20%–30% of the output from digesters in warmer climates.

3.1.1 Dangers

The air pollution produced by biogas is similar to that of natural gas. The content of toxic hydrogen sulfide presents additional risks and has been responsible for serious accidents. Leaks of unburned methane are an additional risk, because methane is a potent greenhouse gas.

Biogas can be explosive when mixed in the ratio of one part biogas to 8–20 parts air. Special safety precautions have to be taken for entering an empty biogas digester for maintenance work. It is important that a biogas system never has negative pressure as this could cause an explosion. Negative gas pressure can occur if too much gas is removed or leaked; Because of this biogas should not be used at pressures below one column inch of water, measured by a pressure gauge.

Frequent smell checks must be performed on a biogas system. If biogas is smelled anywhere windows and doors should be opened immediately. If there is a fire the gas should be shut off at the gate valve of the biogas system.

3.1.2 Composition of Biogas

The composition of biogas varies depending upon the substrate composition, as well as the conditions within the anaerobic reactor (temperature, pH, and substrate concentration).Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55%–75% methane, which for reactors with free liquids can be increased to 80%–90% methane using in-situ gas purification techniques. As produced, biogas contains water vapor. The fractional volume of water vapor is a function of biogas temperature; correction of measured gas volume for water vapour content and thermal expansion is easily done via simple mathematics which yields the standardized volume of dry biogas.

In some cases, biogas contains siloxanes. They are formed from the anaerobic decomposition of materials commonly found in soaps and detergents. During combustion of biogas containing siloxanes, silicon is released and can combine with free oxygen or other elements in the combustion gas. Deposits are formed containing mostly silica (SiO2) or silicates (SixOy) and can contain calcium, sulfur, zinc, phosphorus. Such white mineral deposits accumulate to a surface thickness of several millimeters and must be removed by chemical or mechanical means.

Practical and cost-effective technologies to remove siloxanes and other biogas contaminants are available.For 1000 kg (wet weight) of input to a typical biodigester, total solids may be 30% of the wet weight while volatile suspended solids may be 90% of the total solids. Protein would be 20% of the volatile solids, carbohydrates would be 70% of the volatile solids, and finally fats would be 10% of the volatile solids.

Table 3.1: Composition of Biogas

Component	Concentration(By volume)
Methane(CH4)	55-60%
Carbon dioxide(CO2)	35-40%
Water(H2O)	2-7%
Hydrogen sulphide(H2S)	2%
Ammonia(NH3)	0-0.05%
Nitrogen(N)	0-2%
Oxygen(O2)	0-2%
Hydrogen(H)	0-1%

3.2 Characteristics of Biogas

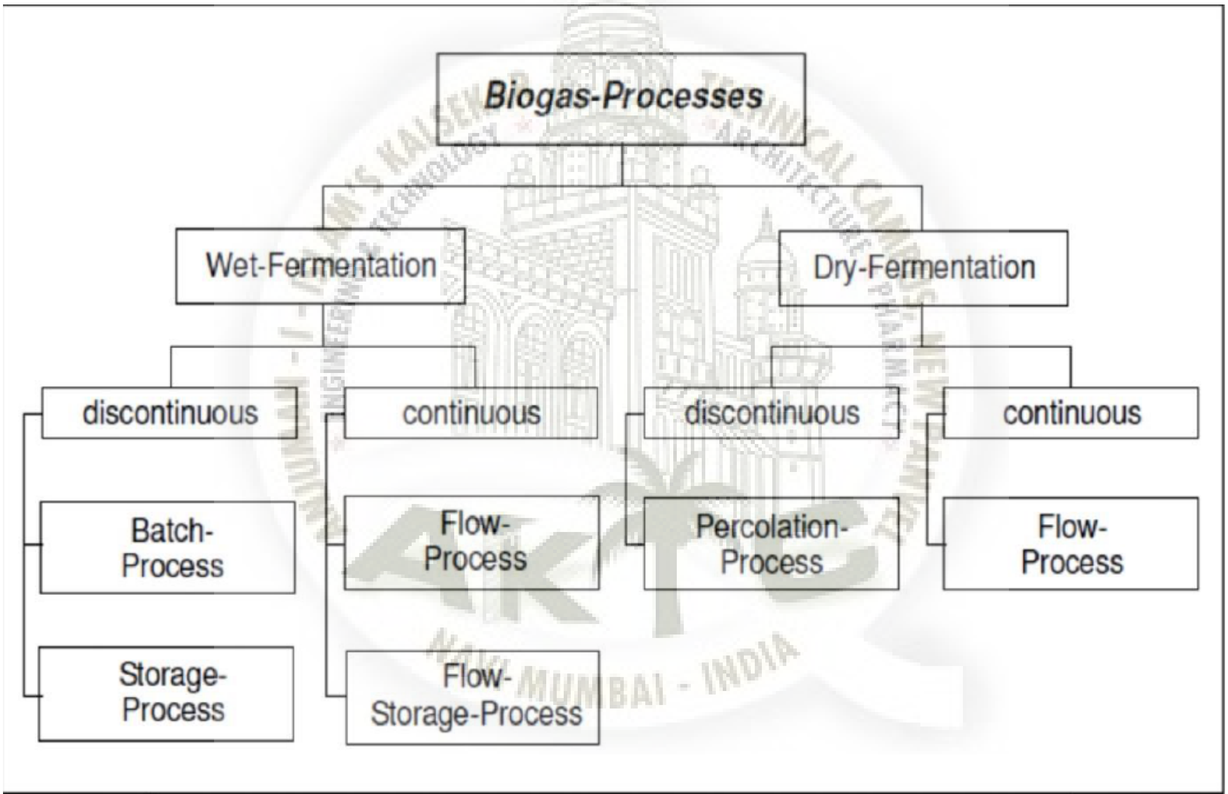

Figure 3.1: Classification of Biogas Processes

Biogas has methane as its main constituent that is produced by the anaerobic biodegradation of the organic material of the wastes by microorganisms in anaerobic conditions.It results in residual waste which is of superior nutrient quality as a fertilizer.

Composition of biogas depends upon feed material also.Biogas is about 20% lighter than air has an ignition temperature in range of 650 to 750 C.It is an odorless colourless gas that burns with blue flame similar to LPG gas. Its caloric value is 20 MJ/kg and it usually burns with 60 % efficiency in a conventional biogas stove.

This gas is useful as fuel to substitute firewood, cow-dung, petrol, LPG, diesel, electricity, depending on the nature of the task, and local supply conditions and constraints.

Biogas digestor systems provides a residue organic waste, 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. 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 refuse(residuals).

The residual organic matter that is obtained after digestion of the feed material is rich in nutrients, like phosphates and can be used as a bio fertilizer. Anaerobic digestion of the human wastes not only serves as an energy retrieval system but also acts as a valuable waste disposal system in case of wastes like human wastes, kitchen wastes, agricultural wastes, etc. reducing the problem of dumping these wastes and the contamination due to these waste materials.

3.3 Characteristics of Biogas

1. Change in volume as a function of temperature and pressure.
2. Change in calorific value as function of temperature ,pressure and water vapour content.
3. Change in water vapour as a function of temperature and pressure.

3.4 Factors Affecting Yield of Biogas Production

Many factors affecting the fermentation process of organic substances under anaerobic condition are,

1. Solid Concentration and Loading Rate.

   The organic matter like cow dung, kitchen waste, agricultural waste and all type of organic west are use as a input of the Biogas plant and that west are mixed with the water and supplied it as a feed to the digester. The proportions are: Cow dung(any organic waste) + solid waste 1:1 that is the mixture which is contain about 10% of solid and 90% of water. The amount of slurry that is feed in to the digester per day is called Loading rate and it is depending on the plant size and capacity. The average loading rate is about 0.2 kg/m3 of digester capacity. When the amount of feeding is not maintained then the production of biogas is reduced and the loading must be carried out every day in the sunlight.

2. Temperature and Pressure.

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

3. Acidity and Alkanity (PH value) of substrate.

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

4. Particle size.

   The partcle size must be 2-12 mm.

5. Reaction Period.

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

3.5 Benefits of Biogas Technology

Composting is one of the important components of solid waste management (SWM). It is a form of source reduction or waste prevention, as the materials are completely diverted from the disposal facilities and require no management or transportation. Community-yard trimming composting programme, sourceseparated organic composting and mixed municipal solid waste (MSW) composting constitute the various recycling processes. A major portion of municipal solid wastes in India contain up to 70% by weight of organic materials.

In addition, certain industrial by-products – those from food processing, agricultural and paper industries – are mostly composed of organic materials. Composting, being an organic material, can significantly reduce waste stream volume. Diverting such materials from the waste stream frees up landfill space needed for materials that cannot be composted. Composting owes its current popularity to several factors, including increased landfill tipping fees, shortage of landfill capacity and increasingly restrictive measures imposed by regulatory agencies. In addition, recycling mandates indirectly encourage composting, as they consider it an acceptable strategy for achieving mandatory goals.

Composting may also offer an attractive economic advantage for communities where the costs of using other options are high. However, it is considered a viable option only when the compost can be marketed. In some cases, nevertheless, the benefits of reducing disposal needs through composting may be adequate to justify choosing this option, even if the compost is only used as a landfill cover. Compost, because of its high organic matter content, makes a valuable soil amendment and is used to provide nutrients for plants. When mixed with soil, compost promotes a proper balance between air and water in the resulting mixture, helps reduce soil erosion and serves as a slow-release fertiliser.

3.5.1 The Economic Benefits Obtained are:

1. The waste materials are treated at without becoming a problem to the environment in the form of air and water pollution. Fertilizer is obtained as a byproduct of the process which are rich in nutrients and can be directly used as manure in farms to improve soil fertility.
2. Biogas produced is a renewable energy source which can be used directly in cooking stones as an alternative of LPG or can be used to produce electricity.
3. The landfill space required for the dumping of the waste materials is reduced thus reducing the land requirement.
4. Benefits of manure derived biogas-
   High levels of methane are produced when manure is stored under anaerobic conditions. During storage and when manure has been applied to the land, nitrous

oxide is also produced as a byproduct of the denitrification process. Nitrous oxide (N2O) is 320 times more aggressive as a greenhouse gas than carbon dioxide and methane 25 times more than carbon dioxide. In fact, one cow can produce enough manure in one day to generate 3 kiloWatt hours of electricity; only 2.4 kiloWatt hours of electricity are needed to power a single 100-Watt light bulb for one day. Furthermore, by converting cattle manure into methane biogas instead of letting it decompose, global warming gases could be reduced by 99 million metric tons or 4%

3.5.2 The Social and Health Benefits Obtained are:

1. Biogas plant operation requires manpower for its operation thus creating job opportunities.
2. The fertilizer obtained are cheap and thus can be readily available to the farmers at low cost.
3. The chances of spreading of diseases causing microbes is reduced.
4. Environmental hazards are prevented through reduction of soil, water and air pollution.

Chapter 4

Anaerobic Digestion

4.1 Anaerobic Digestion

Anaerobic digestion is a collection of processes by which microorganisms break down biodegradable material in the absence of oxygen. The process is used for industrial or domestic purposes to manage waste or to produce fuels. Much of the fermentation used industrially to produce food and drink products, as well as home fermentation, uses anaerobic digestion. Anaerobic digestion occurs naturally in some soils and in lake and oceanic basin sediments, where it is usually referred to as ”anaerobic activity”.

The digestion process begins with bacterial hydrolysis of the input materials. Insoluble organic polymers, such as carbohydrates, are broken down to soluble derivatives that become available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. These bacteria convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide The methanogenic archaea populations play an indispensable role in anaerobic wastewater treatments. Anaerobic digestion is widely used as a source of renewable energy. The process produces a biogas, consisting of methane, carbon dioxide and traces of other ‘contaminant’ gases This biogas can be used directly as fuel, in combined heat and power gas engines or upgraded to natural gas-quality biomethane. The nutrient-rich digestate also produced can be used as fertilizer. With the re-use of waste as a resource and new technological approaches that have lowered capital costs, anaerobic digestion has in recent years received increased attention among governments in a number of countries, among these the United Kingdom (2011) Germany and Denmark (2011).

4.1.1 Process

Many microorganisms affect anaerobic digestion, including acetic acid-forming bacteria (acetogens) and methane-forming archaea (methanogens). These organisms promote a number of chemical processes in converting the biomass to biogas. Gaseous oxygen is excluded from the reactions by physical containment. Anaerobes utilize electron acceptors from sources other than oxygen gas. These acceptors can be the organic material itself or may be supplied by inorganic oxides from within the input material. When the oxygen source in an anaerobic system is derived from the organic material itself, the 'intermediate' end products are primarily alcohols, aldehydes, and organic acids, plus carbon dioxide. In the presence of specialised methanogens, the intermediates are converted to the 'final' end products of methane, carbon dioxide, and trace levels of hydrogen sulfide In an anaerobic system, the majority of the chemical energy contained within the starting material is released by methanogenic bacteria as methane.

4.1.2 User Classes and Characteristics

Identify the various user classes that you anticipate will use this product. User classes may be differentiated based on frequency of use, subset of product functions used, technical expertise, security or privilege levels, educational level, or experience. Describe the pertinent characteristics of each user class. Certain requirements may pertain only to certain user classes. Distinguish the favored user classes from those who are less important to satisfy.

4.1.3 Process Stage

The four key stages of anaerobic digestion involve hydrolysis, acidogenesis , acetogenesis and methanogenesis The overall process can be described by the chemical reaction, where organic material such as glucose is biochemically digested into carbon dioxide (CO_2) and methane (CH_4) by the anaerobic microorganisms.

$$C_6H_{12}O_6 = 3CO_2 + 3CH_4$$

Hydrolysis

In most cases, biomass is made up of large organic polymers. For the bacteria in anaerobic digesters to access the energy potential of the material, these chains must first be broken down into their smaller constituent parts. These constituent parts, or monomers, such as sugars, are readily available to other bacteria. The process of breaking these chains and dissolving the smaller molecules into solution is called hydrolysis. Therefore, hydrolysis of these high-molecular-weight polymeric components is the necessary first step in anaerobic digestion Through hydrolysis the complex organic molecules are broken down into simple sugars, amino acids, and fatty acids.

Acidogenesis

The biological process of acidogenesis results in further breakdown of the remaining components by acidogenic (fermentative) bacteria. Here, VFAs are created, along with ammonia, carbon dioxide, and hydrogen sulfide, as well as other byproducts The process of acidogenesis is similar to the way milk sours.

Acetogenesis

The third stage of anaerobic digestion is acetogenesis. Here, simple molecules created through the acidogenesis phase are further digested by acetogens to produce largely acetic acid, as well as carbon dioxide and hydrogen.

Methanogenesis

The terminal stage of anaerobic digestion is the biological process of methanogenesis. Here, methanogens use the intermediate products of the preceding stages and convert them into methane, carbon dioxide, and water. These components make up the majority of the biogas emitted from the system. Methanogenesis is sensitive to both high and low pHs and occurs between pH 6.5 and pH 8 The remaining, indigestible material the microbes cannot use and any dead bacterial remains constitute the digestate.

4.1.4 Temperature

The two conventional operational temperature levels for anaerobic digesters determine the species of methanogens in the digesters:

1. Mesophillic digestion takes place optimally around 30 to 38 C, or at ambient temperatures between 20 and 45 C, where mesophiles are the primary microorganism present.

2. Thermopillic digestion takes place optimally around 49 to 57 C, or at elevated temperatures up to 70 C, where thermophiles are the primary microorganisms present. The increased temperatures facilitate faster reaction rates, and thus faster gas yields. Operation at higher temperatures facilitates greater pathogen reduction of the digestate. In countries where legislation, such as the Animal By-Products Regulations in the European Union, requires digestate to meet certain levels of pathogen reduction there may be a benefit to using thermophilic temperatures instead of mesophilic.

4.1.5 Solid Content

In a typical scenario, three different operational parameters are associated with the solids content of the feedstock to the digesters:

1. High solids (dry—stackable substrate)
2. High solids (wet—pumpable substrate)
3. Low solids (wet—pumpable substrate)

High solids (dry) digesters are designed to process materials with a solids content between 25 and 40%. Unlike wet digesters that process pumpable slurries, high solids (dry – stackable substrate) digesters are designed to process solid substrates without the addition of water. The primary styles of dry digesters are continuous vertical plug flow and batch tunnel horizontal digesters. Continuous vertical plug flow digesters are upright, cylindrical tanks where feedstock is continuously fed into the top of the digester, and flows downward by gravity during digestion. In batch tunnel digesters, the feedstock is deposited in tunnel-like chambers with a gas-tight door. Neither approach has mixing inside the digester. The amount of pretreatment, such as contaminant removal, depends both upon the nature of the waste streams being processed and the desired quality of the digestate. Size reduction (grinding) is beneficial in continuous vertical systems, as it accelerates digestion, while batch systems avoid grinding and instead require structure (e.g. yard waste) to reduce compaction of the stacked pile. Continuous vertical dry digesters have a smaller footprint due to the shorter effective retention time and vertical design.

Wet digesters can be designed to operate in either a high-solids content, with a total suspended solids (TSS) concentration greater than 20%, or a low-solids concentration less than 15%.[3][4] High solids (wet) digesters process a thick slurry that requires more energy input to move and process the feedstock. The thickness of the material may also lead to associated problems with abrasion. High solids digesters will typically have a lower land requirement due to the lower volumes associated with the moisture.High solids digesters also require correction of conventional performance calculations (e.g. gas production, retention time, kinetics, etc.) originally based on very dilute sewage digestion concepts, since larger fractions of the feedstock mass are potentially convertible to biogas.

4.1.6 Complexity

Digestion systems can be configured with different levels of complexity. In a single-stage digestion system (one-stage), all of the biological reactions occur within a single, sealed reactor or holding tank. Using a single stage reduces construction costs, but results in less control of the reactions occurring within the system.

Acidogenic bacteria, through the production of acids, reduce the pH of the tank. Methanogenic bacteria, as outlined earlier, operate in a strictly defined pH range. Therefore, the biological reactions of the different species in a single-stage reactor can be in direct competition with each other. Another one-stage reaction system is an anaerobic lagoon. These lagoons are pond-like, earthen basins used for the treatment and long-term storage of manures. Here the anaerobic reactions are contained within the natural anaerobic sludge contained in the pool.

In a two-stage digestion system (multistage), different digestion vessels are optimised to bring maximum control over the bacterial communities living within the digesters. Acidogenic bacteria produce organic acids and more quickly grow and reproduce than methanogenic bacteria. Methanogenic bacteria require stable pH and temperature to optimise their performance.

Under typical circumstances, hydrolysis, acetogenesis, and acidogenesis occur within the first reaction vessel. The organic material is then heated to the required operational temperature (either mesophilic or thermophilic) prior to being pumped into a methanogenic reactor. The initial hydrolysis or acidogenesis tanks prior to the methanogenic reactor can provide a buffer to the rate at which feedstock is added. Some European countries require a degree of elevated heat treatment to kill harmful bacteria in the input waste. In this instance, there may be a pasteurisation or sterilisation stage prior to digestion or between the two digestion tanks. Notably, it is not possible to completely isolate the different reaction phases, and often some biogas is produced in the hydrolysis or acidogenesis tanks.

4.1.7 Residence Time

The residence time in a digester varies with the amount and type of feed material, and with the configuration of the digestion system. In a typical two-stage mesophilic digestion, residence time varies between 15 and 40 days, while for a single-stage thermophilic digestion, residence times is normally faster and takes around 14 days. The plug-flow nature of some of these systems will mean the full degradation of the material may not have been realised in this timescale. In this event, digestate exiting the system will be darker in colour and will typically have more odour. In the case of an upflow anaerobic sludge blanket digestion (UASB), hydraulic residence times can be as short as 1 hour to 1 day, and solid retention times can be up to 90 days. In this manner, a UASB system is able to separate solids and hydraulic retention times with the use of a sludge blanket. Continuous digesters have mechanical or hydraulic devices, depending on the level of solids in the material, to mix the contents, enabling the bacteria and the food to be in contact. They also allow excess material to be continuously extracted to maintain a reasonably constant volume within the digestion tanks.

4.1.8 Feedstocks

The most important initial issue when considering the application of anaerobic digestion systems is the feedstock to the process. Almost any organic material can be processed with anaerobic digestion. however, if biogas production is the aim, the level of putrescibility is the key factor in its successful application. The more putrescible (digestible) the material, the higher the gas yields possible from the system. Feedstocks can include biodegradable waste materials, such as waste paper, grass clippings, leftover food, sewage, and animal waste. Woody wastes are the exception, because they are largely unaffected by digestion, as most anaerobes are unable to degrade lignin.

Xylophalgeous anaerobes (lignin consumers) or using high temperature pretreatment, such as pyrolysis, can be used to break down the lignin. Anaerobic digesters can also be fed with specially grown energy crops, such as silage, for dedicated biogas production. The length of time required for anaerobic digestion depends on the chemical complexity of the material. Material rich in easily digestible sugars breaks down quickly where as intact lignocellulosic material rich in cellulose and hemicellulose polymers can take much longer to break down. Anaerobic microorganisms are generally unable to break down lignin, the recalcitrant aromatic component of biomass.

Anaerobic digesters were originally designed for operation using sewage sludge and manures. Sewage and manure are not, however, the material with the most potential for anaerobic digestion, as the biodegradable material has already had much of the energy content taken out by the animals that produced it. Therefore, many digesters operate with codigestion of two or more types of feedstock. For example, in a farm-based digester that uses dairy manure as the primary feedstock, the gas production may be significantly increased by adding a second feedstock, e.g., grass and corn (typical on-farm feedstock), or various organic byproducts, such as slaughterhouse waste, fats, oils and grease from restaurants, organic household waste, etc. Digesters processing dedicated energy crops can achieve high levels of degradation and biogas production. Slurry-only systems are generally cheaper, but generate far less energy than those using crops, such as maize and grass silage; by using a modest amount of crop material (30%), an anaerobic digestion plant can increase energy output tenfold for only three times the capital cost, relative to a slurry-only system.

4.1.9 Moisture Content

Second consideration related to the feedstock is moisture content. Drier, stackable substrates, such as food and yard waste, are suitable for digestion in tunnel-like chambers. Tunnel-style systems typically have near-zero wastewater discharge, as well, so this style of system has advantages where the discharge of digester liquids are a liability. The moisture content of the target feedstock will also affect what type of system is applied to its treatment. To use a high-solids anaerobic digester for dilute feedstocks, bulking agents, such as compost, should be applied to increase the solids content of the input material. Another key consideration is the carbon:nitrogen ratio of the input material. This ratio is the balance of food a microbe requires to grow; the optimal C:N ratio is 20–30:1. Excess N can lead to ammonia inhibition of digestion.

4.1.10 Applications

1. Power Generation

   In developing countries, simple home and farm-based anaerobic digestion systems offer the potential for low-cost energy for cooking and lighting. From 1975, China and India have both had large, government-backed schemes for adaptation of small biogas plants for use in the household for cooking and lighting. At present, projects for anaerobic digestion in the developing world can gain financial support through the United Nations Clean Development Mechanism if they are able to show they provide reduced carbon emissions. Methane and power produced in anaerobic digestion facilities can be used to replace energy derived from fossil fuels, and hence reduce emissions of greenhouse gases, because the carbon in biodegradable material is part of a carbon cycle. The carbon released into the atmosphere from the combustion of biogas has been removed by plants for them to grow in the recent past, usually within the last decade, but more typically within the last growing season. If the plants are regrown, taking the carbon out of the atmosphere once more, the system will be carbon neutral. In contrast, carbon in fossil fuels has been sequestered in the earth for many millions of years, the combustion of which increases the overall levels of carbon dioxide in the atmosphere. Biogas from sewage sludge treatment is sometimes used to run a gas engine to produce electrical power, some or all of which can be used to run the sewage works. Some waste heat from the engine is then used to heat the digester. The waste heat is, in general, enough to heat the digester to the required temperatures. The power potential from sewage works is limited – in the UK, there are about 80 MW total of such generation, with the potential to increase to 150 MW, which is insignificant compared to the average power demand in the UK of about 35,000 MW. The scope for biogas generation from nonsewage waste biological matter – energy crops, food waste, abattoir waste, etc. - is much higher, estimated to be capable of about 3,000 MW. Farm biogas plants using animal waste and energy crops are expected to contribute to reducing CO2 emissions and strengthen the grid, while providing UK farmers with additional revenues. In Oakland, California at the East Bay Municipal Utility District's main wastewater treatment plant (EBMUD), food waste is currently codigested with primary and secondary municipal wastewater solids and other high-strength wastes. Compared to municipal wastewater solids digestion alone, food waste codigestion has many benefits. Anaerobic digestion of food waste pulp from the EBMUD food waste process provides a higher normalized energy benefit, compared to municipal wastewater solids: 730 to 1,300 kWh per dry ton of food waste applied compared to 560 to 940 kWh per dry ton of municipal wastewater solids applied.

2. Vehicle Fuel

After upgrading with the above-mentioned technologies, the biogas (transformed into biomethane) can be used as vehicle fuel in adapted vehicles. This use is very extensive in Sweden, where over 38,600 gas vehicles exist, and 60% of the vehicle gas is biomethane generated in anaerobic digestion plants.

If concentrated and compressed, it can be used in vehicle transportation. Compressed biogas is becoming widely used in Sweden, Switzerland, and Germany. A biogas-powered train, named Biogaståget Amanda (The Biogas Train Amanda), has been in service in Sweden since 2005. Biogas powers automobiles. In 1974, a British documentary film titled Sweet as a Nut detailed the biogas production process from pig manure and showed how it fueled a custom-adapted combustion engine.In 2007, an estimated 12,000 vehicles were being fueled with upgraded biogas worldwide, mostly in Europe.

Biogas is part of the wet gas and condensing gas (or air) category that includes mist or fog in the gas stream. The mist or fog is predominately water vapor that condenses on the sides of pipes or stacks throughout the gas flow. Biogas environments include wastewater digesters, landfills, and animal feeding operations.Ultrasonic flow meters are one of the few devices capable of measuring in a biogas atmosphere. Most of thermal flow meters are unable to provide reliable data because the moisture causes steady high flow readings and continuous flow spiking, although there are single-point insertion thermal mass flow meters capable of accurately monitoring biogas flows with minimal pressure drop. They can handle moisture variations that occur in the flow stream because of daily and seasonal temperature fluctuations, and account for the moisture in the flow stream to produce a dry gas value.

3. Fertiliser and Soil

The solid, fibrous component of the digested material can be used as a soil conditioner to increase the organic content of soils. Digester liquor can be used as a fertiliser to supply vital nutrients to soils instead of chemical fertilisers that require large amounts of energy to produce and transport. The use of manufactured fertilisers is, therefore, more carbon-intensive than the use of anaerobic digester liquor fertiliser. In countries such as Spain, where many soils are organically depleted, the markets for the digested solids can be equally as important as the biogas.

Cooking gas By using a bio-digester, which produces the bacteria required for decomposing, cooking gas is generated. The organic garbage like fallen leaves, kitchen waste, food waste etc. are fed into a crusher unit, where the mixture is conflated with a small amount of water. The mixture is then fed into the bio-digester, where the bacteria decomposes it to produce cooking gas. This gas is piped to kitchen stove. A 2 cubic meter bio-digester can produce 2 cubic meter of cooking gas. This is equivalent to 1 kg of LPG. The notable advantage of using a bio-digester is the sludge which is a rich organic manure.

4.2 Digesters

There are 2 types of digestion process:

1. Aerobic Digestion: Aerobic sludge digestion is a biological process that takes place in the presence of oxygen. With oxygen, bacteria present in the sludge (activated sludge) consumes organic matter and converts it into carbon dioxide. Ovivo offer several technologies to encourage this natural process to thrive, producing consistent, high quality, results. Processes supplied by Ovivo can use coarse or fine bubble diffusers.

2. Anaerobic Digestion: Anaerobic digestion is recognised by the government, Defra, the Welsh Assembly, the Scottish Parliament, Friends of the Earth and the National Farmers Union as one of the best methods for food waste recycling and dealing with farm waste and sewage sludge.

   The word Anaerobic actually means 'in the absence of oxygen'. The biogas naturally created in the sealed tanks is used as a fuel in a CHP (combined heat and power) unit to generate renewable energy i.e. electricity and heat.

What's left from the process is a nutrient rich biofertiliser which is pasteurised to kill any pathogens and then stored in large covered tanks ready to be applied twice a year on farmland in place of fossil fuel derived fertilisers.

Every tonne of food waste recycled by anaerobic digestion as an alternative to landfill prevents between 0.5 and 1.0 tonne of CO_2 entering the atmosphere, one of the many benefits of anaerobic digestion.

4.2.1 Materials and Methods

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

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

Chapter 5

Component and Design of Floating Dome Biogas Plant

5.1 Component Used For Bio-digester

There are many types of digester can be used for biogas plant. In our plant we have used 500 Litres of capacity of tank. The material of drum is Polyvinyl Chloride.

5.1.1 Digester Tank

Figure 5.1: Digestor Tank

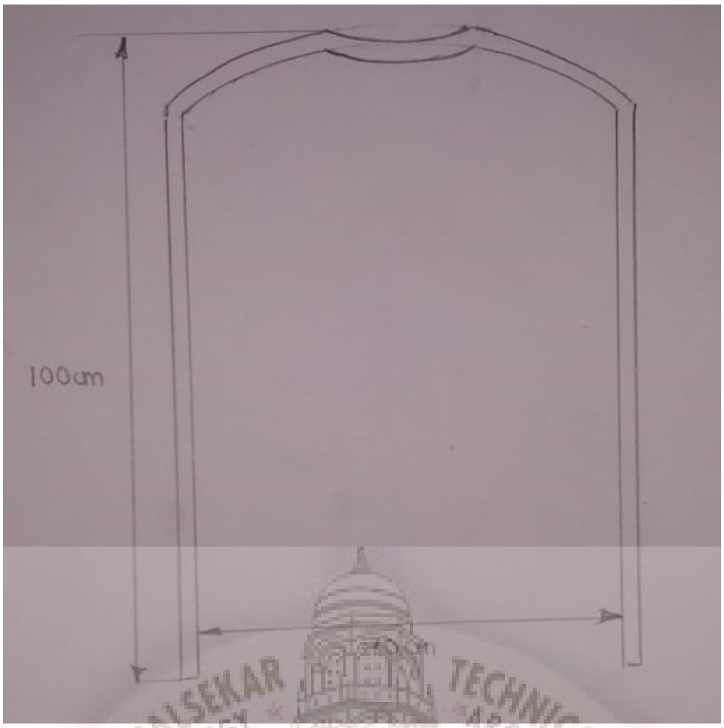

Figure 5.2: Floating Dome

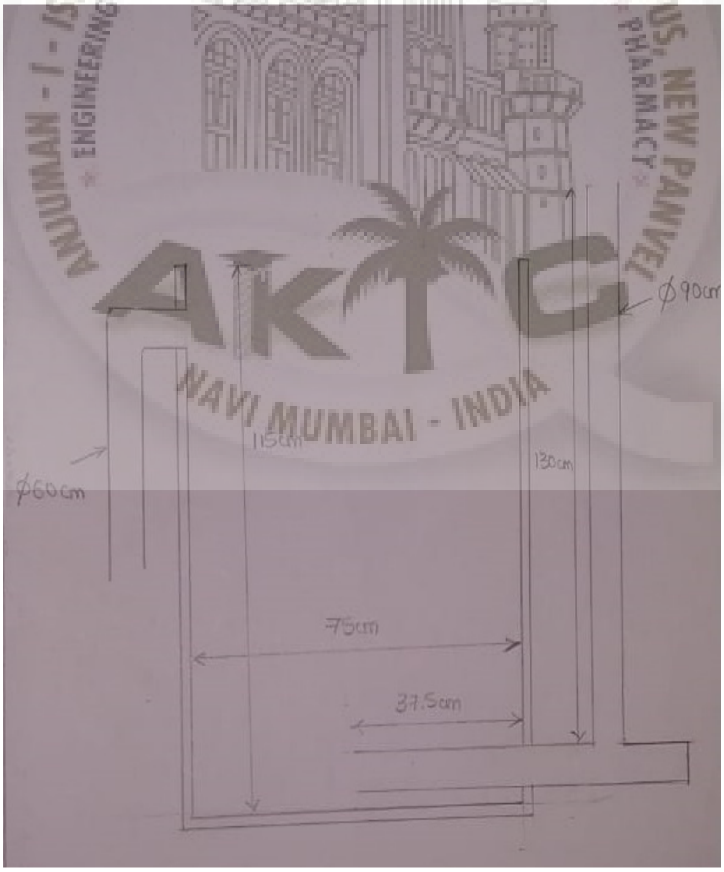

Figure 5.3: Dimensions of Tank

5.1.2 Gas Collector

In the biogas system gas storage is very Important function. So we have used car tyre tube to store the gas.

Figure 5.4: Gas Collector

5.1.3 Motor

The motor is of 3 phase 1HP 1000RPM.

Figure 5.5: Motor

5.1.4 Crusher

Figure 5.6: Crusher

5.1.5 Crusher, Mixture and Blade

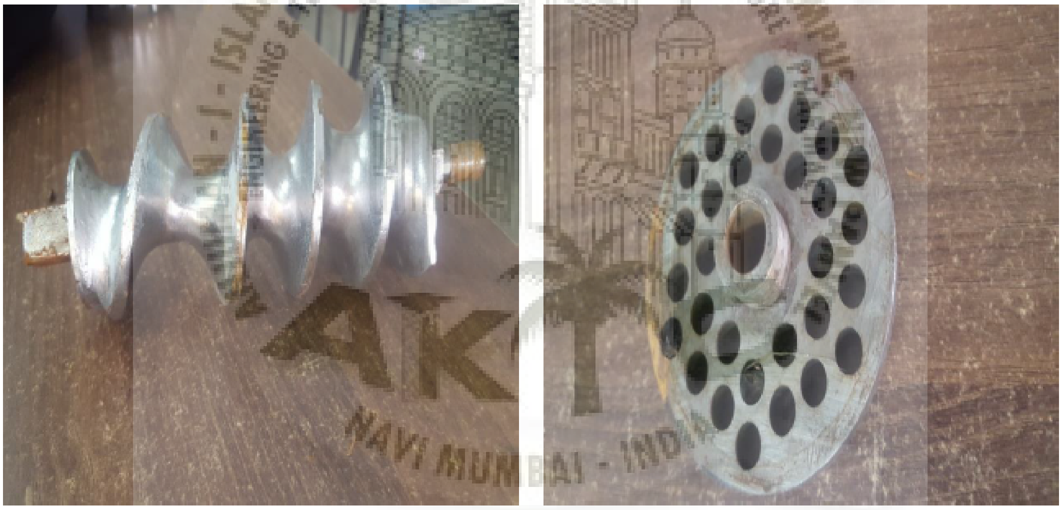

Figure 5.7: Mixture

5.1.6 Safety Requirements

Non Return Valve

A non-return valve allows a medium to flow in only one direction. A non-return valve is fitted to ensure that a medium flows through a pipe in the right direction, where pressure conditions may otherwise cause reversed flow.

Figure 5.8: Non Return Valve

Guide Beams

Guide beams are used to guide the floating drum without toppling to ensure safety.

Figure 5.9: Guide Beams

Chapter 6

Processes & Result Observed

Different processes were carried out during the project work to compare the results and chose the right process for production of biogas.The different process carried out are :

1. Preheat Treatment of feed.
2. Fine and coarse particle process.
3. Reaction with coffee grounds.

6.1 Preheat Treatment of Feed

The heat treatment of animal feed in the form of mixtures of mealy or granular materials allows formulas to have excellent nutritional qualities without the limitation of traditional granulation.The product is subjected to cooking by direct steam injection at atmospheric pressure and indirect heating via the double covering of the equipment.The temperatures used are from 60Âº C to 100Âº C and treatment periods vary from 30 seconds to 6 minutes.Proper heat treatment is followed by a drying operation (-14%)and the cooling to room temperature. The product can then be stored or distributed. In addition, the treatment allows the simultaneous injection of liquid additives (molasses), fats, etcâThe advantage is the better digestibility and the better use of products obtained in this process because the cooking of the raw materials leads the gelatinization of starch.Another important advantage is being able to remove the pathogens. The heat treatment under certain conditions of temperature, time and moisture, allows the elimination of salmonella in food and particulary birds. Moreover, the improving of the flow reduces the possibility of bacterial growth by preventing the retention and accumulation of the product.

System requirement definitions specify what the system should do, its functionality and its essential and desirable system properties. The techniques applied to elicit and collect information in order to create system specifications and requirement definitions involve consultations, interviews, requirements workshop with customers and end users. The objective of the requirements definition phase is to derive the two types of requirement.

6.1.1 Fine and Coarse Particle Process.

The effect of particle size of seven agricultural and forest residues used as feedstock for biogas generation through anaerobic digestion were investigated in batch digesters at 37ÂC. Out of five particle sizes (0Â·088, 0Â·40, 1Â·0, 6Â·0 and 30Â·0 mm), maximum quantity of biogas was produced from raw materials of 0Â·088 and 0Â·40 mm particles. For succulent materials such as leaves, large particles could be used. However, for other materials such as straws, large particles could decrease the gas production more effectively compared to those of leaves. Methane content of biogas was between 67 and 73% (v/v) for all materials except for straws which were around 60%.

The results support the concept that a physical pretreatment such as grinding could significantly reduce the volume of digester required, without decreasing biogas production, particle size.New fuels containing chemically liquefied wood derivatives mixed with kerosene oils and/or 2-ethylhexyl alcohol have been compared in internal combustion engines and burners, with straight kerosene. Fuel volatility caused problems when the blends were used in a spark ignition gasoline engine or a pot-type burner. Better performance was achieved using a diesel engine or a gun-type burner. Further work, required to optimize the use of the wood-based fuels, is discussed.

Figure 6.1: Fine Particle

6.1.2 Reaction with Coffee Grounds.

Biogas production from the mixing of spent coffee grounds liquid fraction with fresh cow manure has been studied to evaluate the separation by filtration process potentials in such residual biomass chain valorization. The reactors have been divided into two Groups, A and B. Group A represents the experiments performed with Spent coffee water mixed with manure and Group B the ones carried out with the only manure. Each single analysis has been repeated four times to assess repeatability. The used inoculum ratio was 1.5 which falls in the optimal range 0.25â2.5, in terms of g volatile solids (VS) substrate per gVS. The reactors have been maintained at a constant temperature of 37 C for twenty two days. The filtration of wastewater reduced the C/N ratio to 22.25, which is ideal for anaerobic digestion purposes.

Figure 6.2: Coffee Grounds

6.2 Composition of Kitchen Waste

Average composition of kitchen waste was analyzed on various occasions. Over 50% of waste was composed of uncooked vegetable fruit waste,eggs, raw meat,etc.The main source of pathogens were relatively low in mass at 1.5% 1.2% also there was 15% of cooked meat .

1. Uncooked fruits vegetables (30%)
2. Cooked meat (15%)
3. Uncooked meat (5%)

4. Rice material(50%)
5. Tea waste (10%)

Figure 6.3: Waste Composition

6.3 Method and Calculation

6.3.1 Analytical Methods Calculations

1. Total Solids (TS%) - It is the amount of solid present in the sample after the water present in it is evaporated. The sample, approximately 10 gm. is taken and poured in foil plate and dried to a constant weight at about 1050 C in furnace.

   TS% = (Final weight/Initial weight) * 100 .. (i)

2. Volatile Solids (Vs%) Dried residue from Total Solid analysis weighed and heated in crucible for 2hrs at 500 0C in furnace. After cooling crucible residue weighed.

   VS% = [100-(V3-V1/V2-V1)] * 100 .. (ii)

   V1= Weight of crucible.

   V2= Weight of dry residue crucible.

V3= Weight of ash crucible (after cooling)

Method 1: Titration procedure for measurements of VFA and alkalinity.

i) Before analysis, the sample needs to be filtered through a 0.45Îm membrane filter.

ii) Filtered sample (20-50ml) is put into a titration vessel, the size of which is determined by the basic requirement to guarantee that the tip of the pH electrode is always below the liquid surface.

iii) Initial pH is recorded

iv) The sample is titrated slowly
with 0.1N sulphuric acid until pH 5.0 is reached. The added volume A1 [ml] of the titrant is recorded.

v) More acid is slowly added until pH 4.3 is reached. The volume A2 [ml] of the added titrant is again recorded.

vi) The latter step is repeated until pH 4.0 is reached, and the volume A3 [ml] of added titrant recorded once more.

vii) A constant mixing of sample and added titrant is required right from the start to minimize exchange with the atmosphere during titration.

viii) Calculation scheme :

$$Alk = A * N * 1000/SV \quad ..(iv)$$

Alk = Alkalinity [mmol/l], also referred to as TIC (Total Inorganic Carbon).

A = Consumption of Sulphuric acid (H_2SO_4, 0.1N) to titrate from initial pH to pH 4.3 [ml].

A= A1 + A2 [ml].

N = Normality [mmol/l].

SV = Initial sample volume [ml].

VFA = (131340 * N * B / 20) (3.08 * Alk)

VFA = Volatile fatty acids [mg/l acetic acid equivalents].

N = Normality [mmol/l].

B = Consumption of sulphuric acid (H_2SO_4, 0.1N) to titrate sample from pH 5.0 to pH 4.0 [ml], due to HCO_3/CO_2 buffer.

B = A2 + A3 [ml].

SV = Initial sample volume [ml].

Alk = Alkalinity [mmol/l].

3. A/TIC-ratio.
The A/TIC-method was developed at the Federal Research Institute for Agriculture (FAL) in Braunschweig, Germany. Used as an indicator of the process stability inside the digester, it expresses the ratio between Volatile Fatty Acids and buffer capacity (alkalinity), or in other words the amount of Acids (A) compared to Total Inorganic Carbon (TIC).

A [mg/ l] = VFA [mg/ l] /TIC [mg/l] = Alkalinity [mg/ l]

4. Organic Content â Organic dry matter weigh the sample and weigh remaining ashes Organic content = Mass of TS - Mass of ashes/Mass of TS

6.4 Plan for feed preparation.

Table 6.1: Component List

Sr.No.	Component
1	1 HP motor(3 phase)
2	Pulley
3	Crusher Machine
4	V-Belt
5	3 phase plug
6	Belt cover
7	Wood base
8	Shock absorber

6.5 Analysis of Gas Produced in Our Reactor.

6.5.1 Syringe Method

Syringe method was used for the measurement of amount of methane and carbon dioxide in our gas produced.A syringe fitted tube and dilute sodium hydroxide solution was used for carbon dioxide percentage estimation, since NaOH absorbs CO2 but dose not absorbs methane.

1. Prepare 100ml of dilute sodium hydroxide solution by dissolving granules of NaOH about 100ml of water.
2. Take 20 to 30 ml sample of biogas produced during experiment into the the syringe (initially fill syringe with H2O to reduce air contamination) and put end of the tube into the NaOH solution then push out excess gas a 10ml sample.
3. Now take approximately 20ml of solution and keep the end of the tube submerged in the NaOH solution while shaking syringe for 30 seconds.
4. Point it downwards and push the axcess liquid out , so that syringe plunger level reachs 10ml. Now read the volume of liquid which should be 3 to 4ml indicating about 30 to 40 percentage of gas absorbed so we can say the balance of 65 to 60 % is methane.

Figure 6.4: Syringe Test

Composition of Biogas Observed as:

1. Methane (40 TO 45%)
2. Other Gases (55 TO 60%) Like CO2,Nitrogen,water vapour.

6.5.2 Temperature and pH Test

The results show that as the temperature was increased the biogas production and methane was also increased, however the high amount of biogas production rate and methane content was observed in the digester operated at 35 C. During the study period, fermenters incubated at 35 C produced the highest biogas production.

Figure 6.5: Temperature Test

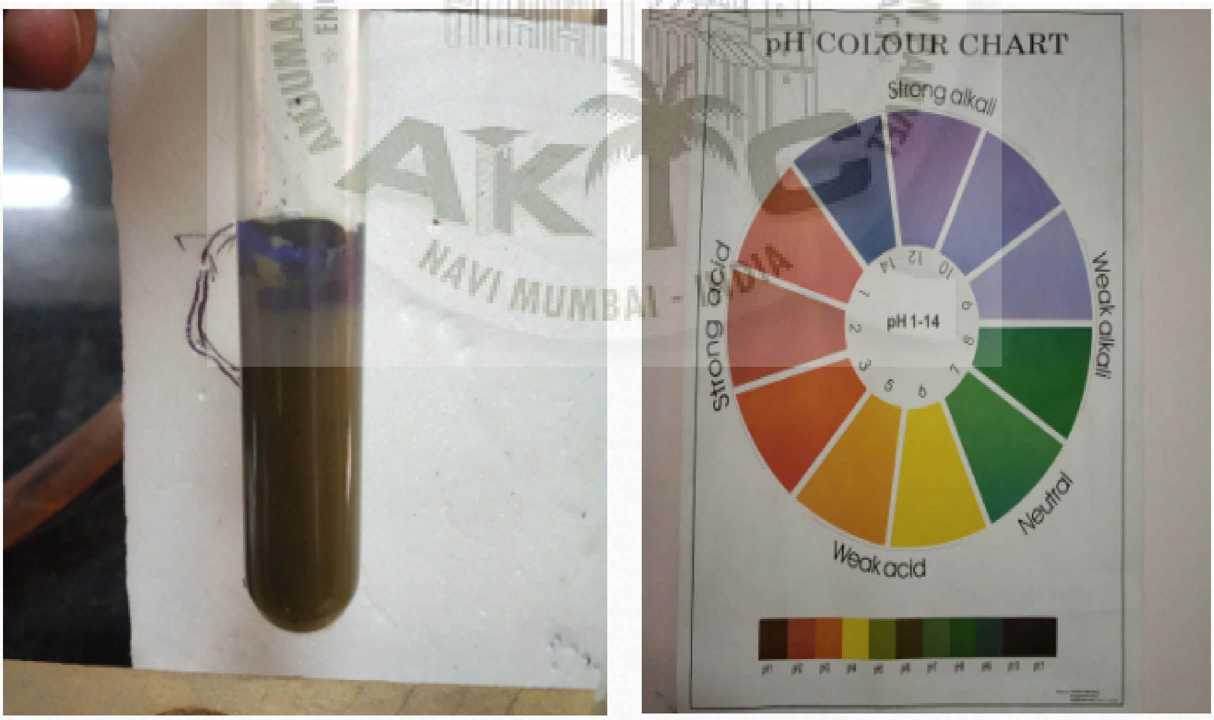

Figure 6.6: pH Test

Figure 6.7: Acidic Test

6.5.3 Result Observed by Volume.

Figure 6.8: Result Observed by Volume

Table 6.2: Result Observed

Day	Feed Rate(kg)	Gas Production(m3)
1	7	0.27
2	6	0.26
3	7	0.20
4	8	0.28
5	6	0.26
6	5	0.21

Chapter 7

Conclusion And Future Scope

7.1 Conclusion

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

7.2 Future Scope

Cooking and Heating.

Biogas produced from the household digesters is mainly used for cooking. The amount of biogas used for cooking purposes usually varies between 30 and 45 m3 per month. This number can be compared with other commonly used fuels such as kerosene where the consumption is between 15 and 20 L, and Liquefied Petroleum Gas (LPG) between 11 and 15 kg per month, respectively. The energy equivalent was around 300, 200, and 150 kWh for biogas, kerosene, and LPG, respectively. The surplus biogas in the domestic digester could be used for water and space heating.

Biogas Stoves.

Biogas burning is not possible in commercial butane and propane burners because of its physiochemical properties. However, it is possible to use these burners after some modifications .Burners are changed in the gas injector, its cross-section, and mixing chambers. The biogas burners are designed to meet a mixture of bio-gas and air in the ratio of 1:10 .Different burners like vertical flame diffuser, horizontal flame diffuser, and no diffuser with biogas have been examined. A vertical flame diffuser had a high heat transfer efficiency compared to other diffusers .The efficiency is obtained by calculating the heat gained by the water subjected for heating and the amount of fuel consumed during this process. The efficiency of the heat entering the vessel from the stove was high for biogas with 57.4%, followed by LPG, kerosene, and wood with 53.6%, 49.5%, and 22.8%, respectively .The biogas consumption and the thermal efficiency in the biogas stoves varied between 0.340–0.450 m3/h and 59–68%.

Lighting Generation.

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

References

[1] *Effects of thermal pretreatment on the biomethane yield and hydrolysis rate of kitchen waste*; Yangyang Li a, Yiying Jin a, , Jinhui Li a, Hailong Li b, Zhixin Yu c,www.elsevier.com/locate/apenergy, 17 March 2016.

[2] *Anaerobic digestion of coffee grounds soluble fraction at laboratory scale: Evaluation of the biomethane potential*; Fábio Codignole Luz, Stefano Cordiner, Alessandro Manni, Vincenzo Mulone, Vittorio Rocco,www.journals.elsevier.com/applied-energy, 12 June 2017.

[3] *An integrated engineering system for maximizing bioenergy production from food waste*;Yingqun Maa, Weiwei Caia,Yu Liua,www.journals.elsevier.com/applied-energy,21 August 2017.

[4] *Scope of Biogas generation from Kitchen wastes and its economical adoptability*;Amar Kumar Das,Shovan Nandi,Subrat Kumar Patra,www.ijlemr.com,May 2017.

[5] *International Research Journal of Multidisciplinary Studies*;irjms2015@gmail.com,March,2016.

[6] *Biogas from kitchen waste*;https://en.wikipedia.org/wiki/Biogas.

[7] *"Biogas Engines"*;www.clarke-energy.com. Retrieved 21 November 2011.

Achievements

Paper Presentatiion at “Rotary Club of Panvel Midtown”
Name of Paper: Biogas from Kitchen Waste
Name of Event: Young Social Innovator Award
Awarded as “Finalist”
Venue: Pillai’s College of Engineering,New Panvel