IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

PRODUCTION OF BIOGAS USING KITCHEN WASTE

Shwetal Ramesh Bantey

Student

Santa gadge Baba Amravati University

ABSTRACT

In our institute we have canteen having their own individual mess, where daily a large amount of kitchen waste is obtained which can be utilized for better purposes. Biogas production requires Anaerobic digestion. Project was to Create an Organic Processing Facility to create biogas which will be more cost effective, eco-friendly, cut down on landfill waste, generate a high-quality renewable fuel, and reduce carbon dioxide & methane emissions. Overall, by creating a biogas reactor on campus in the backyard of our canteen will be beneficial. Kitchen (food waste) was collected from canteen of Prof. Ram Meghe College Of Engineering And Management, Badnera's Mess as feedstock for our reactor which works as anaerobic digester system to produce biogas energy. The anaerobic digestion of kitchen waste produces biogas, a valuable energy resource Anaerobic digestion is a microbial process for production of biogas, which consist of Primarily methane (CH4) & carbon dioxide (CO2). Biogas can be used as energy source and also for numerous purposes. But any possible applications require knowledge & information about the composition and quantity of constituents in the biogas produced. The continuously-fed digester requires addition of sodium hydroxide (NaOH) to maintain the alkalinity and pH to 7. For this reactor we have prepared our Inoculum than we installed batch reactors, to which inoculum of previous cow dung slurry along with the kitchen waste was added to develop our own Inoculum. A combination of these mixed inoculum was used for biogas production at 37°C in laboratory (small scale) reactor (20L capacity) In our study, the production of biogas and methane is done from the starch-rich and sugary material and is determined at laboratory scale using the simple digesters.

1.INTRODUCTION

1.1 GENERAL

Kitchen waste is bio-material having the high energy value and calorific value to microorganisms, that's why efficiency of biogas generation can be expanded by several ways of magnitude. The dumping of food waste is the main cause of pollution can be finished in low cost and environment friendly way. Considering cost Result, Discussion and conclusion and future scope of distribution system. Kitchen waste is bio-material having the high energy value and calorific value to microorganisms, that's why efficiency of biogas generation can be expanded by several ways of magnitude. The dumping of food waste is the main cause of pollution can be finished in low cost and environment friendly way. Considering cost effective is not the target the dumping of waste must be done in proper way for maintaining hygiene. The disposal of food in areas and making the places unhygienic and it needs the solution. Installation of biogas plants give the proper way of utilizing and proper storage of waste.Biogas is a clean-burning, "green" fuel used for heating and cooking, transport and power generation.

Keywords: bio-material, dumping of food , microorganisms

1.2 Importance of Bio Gas

Energy is one of the basic requirements of all living beings. The unsustainability of conventional energy resources and their associated environmental pollutions made renewable energy the prime need of present time. Solar energy, wind energy, different thermal and hydro sources of energy, biogas are all renewable energy resources. But biogas is distinct from other renewable energies because of its characteristics of using, controlling and collecting organic wastes and at the same time producing fertilizer and water for use in agricultural irrigation. Biogas does not have any geographical limitations nor does it require advanced technology for producing energy, also it is very simple to use and apply.

1.3 PROBLEM STATEMENT:

Scarcity of petroleum and coal threatens the supply of fuel throughout the world also problem of their combustion leads to research in different corners to get access the new sources of energy, like renewable energy resources. Deforestation is a very big problem in developing countries like India, most of the part depends on charcoal and fuel wood for fuel supply which requires cutting of forest. Also deforestation leads to decrease the fertility of land by soil erosion. Use of dung, firewood as energy is also harmful for the health of the masses due to the smoke arising from them causing air pollution. We need an ecofriendly substitute for energy.

1.4 Aim and Objective

1.4.1 Aim:

The aim of the study is to convert biodegradable kitchen waste into bio-gas.

1.4.2 Objectives:

1. To generate energy from waste.
2. To study the different physical and chemical parameters of food waste.
3. Comparison of Bio Gas from conventional resources.
4. To improve the properties of the soil through the high quality organic fertilizer.
5. To find ecofriendly disposal method.
6. To generate revenue from the waste that is generation of wealth from waste.

1.5 Proposed Methodology

A brief of the methodology of conducting the before work involve the following steps:

1. Discussion on topic
2. Literature review
3. Data collection
4. Analysis of data
5. Research on various method

Literature review stage required a wide range of data collection related to this topic. This can be achieved by browsing many online data based and technical papers to various search engines. The data uses in research are collected by observation.

Day to day collection of data like download, searching, capturing and analysis of including team meeting, writing-texting, etc.

2. LITERATURE REVIEW

[12]Ashok kumarswork(1990) clearly shows that the biogas technology is economically a non viable technology, that is beset with many social problems of readjustment during the transition period of moving from one technology to another. For instance it is incorrect to assume that Dung the row material in the production of biogas is a waste product. It is used almost to the fullest possible extent, though the efficiency of such use may be questioned. Existing consumtion pattern will most definitely be disrupted and as Ashok kumar argues to the detriment of a larg section of the population. Though he has not mentioned it anywhere in his monograph his results suggest that expenditure of public money in such cases is better spent on Further technological work rather than on any larg scale application as it is presently being aimed.

[13]Abbasi(1993) In the present book ,detailed engineering design and costing of four most promising high-rate digester types has been done. Based on these studies a systems model has been developed which tells us the benefit-cost ratio when we feed it certain easy-to-obtain basic data .Prof. Abbasi presented in the book deal with the prevalent conditions they are also futuristic in their approach in the sense that they 8 address the questions of benefits and costs which are going to be asked more and more frequently with the increasing application of high rate anaerobic fermentation in India

[1] Shalini singh et al. (2000) studied the increased biogas production using microbial stimulants. They studied the effect of microbial stimulant aquasan and teresan on biogas yield from cattle dung and combined residue of cattle dung and kitchen waste respectively. The result shows that dual addition of aquasan to cattle dung on day 1 and day 15 increased the gas production by 55% over unamended cattle dung and addition of teresan to cattle dung : kitchen waste (1:1) mixed residue 15% increased gas production.

[9] Govt. of India‘s report(2002) on ―Evaluation Study On National Project on Biogas Development‖, presents a preliminary study of two highly successful rural biogas models wherein biogas is produced and utilized as a cooking fuel by the villagers. The two models studied were the Community Biogas plant established by SUMUL Dairy at Bhintbudrak, Gujrat and the Individual Biogas plants established by Bhagirath Pratisthan (an NGO) in south Konkan region of Maharashtra. Various aspects including design, operation, economics and benefits to the stakeholders had been described. The report ends with a comparison of the two models studied on the basis of their design, vision, performance, economics and benefits.

[2] Lissens et al. (2004) completed a study on a Biogas Operation to increase the total biogas yield from 50% available biogas to 90% using several treatments including a mesophilic laboratory scale continuously stirred tank reactor, and an up flow biofilm reactor, a fiber liquefaction reactor releasing the bacteria FibrobacterSuccinogens and a system that adds water during the process. These methods were sufficient in bringing about large increases to the total yield; however, the study was under a very controlled method, which leaves room for error when used under varying conditions

[3] Hilkiah Igoni (2008)) studied the effect of Total Solids Concentration of Municipal Solid Waste on the Biogas Produced in an Anaerobic Continuous Digester. The total solids (TS) concentration of the waste influences the pH, temperature and effectiveness of the microorganisms in the decomposition process. They investigated various concentrations of the TS of MSW in an anaerobic continuously stirred tank reactor (CSTR) and the corresponding amounts of biogas produced, in order to determine conditions for optimum gas production. The results show that when the percentage total solids (PTSof municipal solid waste in an anaerobic continuous digestions process increases, there is a corresponding geometric increase for biogas produced.

[4]A.Malakahmad et al. (2009) constructed Anaerobic Biogas Reactor with a unique design and various profiles of microbial communities were developed within the reactor. Observations of microorganisms showed that, there exists a small amount of protozoa and fungi in the system, but almost 93% of microorganisms populations consists of bacteria. Due to the ability of activity in acetate environment, the percentage of MethanococcusMethanosarcina and Methanotrix were higher than other kinds of methane formers in the anaerobic baffled reactor (ABR)

[5] Peter Wieland(2010) reviewed the Current State And Perspectives Of Biogas Production, including the biochemical parameters and feedstock which influence the efficiency and reliability of the microbial conversion and gas yield.

[11]SuyogVij (2010-11) present this Project was to create an organic processing facility to create biogas which will be more cost effective, eco-friendly, cut down on landfill waste, generate a high-quality renewable fuel, and reduce carbon dioxide & methane emissions. Overall by creating a biogas reactor on campus in the backyard of our hostels will be beneficial. Kitchen (food waste) was collected from different hostels of National Institute of Technology, Rourkela's Mess as feedstock for our reactor which works as anaerobic digester system to produce biogas energy. The 4 anaerobic digestion of kitchen waste produces biogas, a valuable energy resource Anaerobic digestion is a microbial process for production of biogas, which consist of Primarily methane (CH_4) & carbon dioxide (CO_2). Biogas can be used as energy source and also for numerous purposes. But, any possible applications requires knowledge & information about the composition and quantity of constituents in the biogas produced. The continuously-fed digester requires addition of sodium hydroxide (NaOH) to maintain the alkalinity and pH to 7. For this reactor we have prepared our Inoculum than we installed batch reactors, to which inoculum of previous cow dung slurry along with the kitchen waste was added to develop our own Inoculum. A combination of these mixed inoculum was used for biogas production at 37°C in laboratory(small scale) reactor (20L capacity) In our study, the production of biogas and methane is done from the starch-rich and sugary material and is determined at laboratory scale using the simple digesters.

[10] Vaibhav Nasery(2011) Presents this report a preliminary study of two highly successful rural biogas models wherein biogas is produced and utilized as a cooking fuel by the villagers. The two models studied are the Community Biogas plant established by SUMUL Dairy at Bhintbudrak, Gujrat and the Individual Biogas plants established by Bhagirath Pratisthan (an NGO) in south Konkan region of Maharashtra. Various aspects including design, operation, economics and benefits to the stakeholders have been described. The report ends with a comparison of the two models studied on the basis of their design, vision, performance, economics and benefits.

[6] S. Potivichayanonet al.(2011) presented a paper on Enhancement of Biogas Production From Bakery Waste By The Addition Of Pseudomonas Aeruginosa. The byproduct, Glycerol is very much suitable for the growth anaerobic microorganisms. The initial addition of Pseudomonas aeruginosa increased the biogas production in form of methane and carbon dioxide.

[7] Ravi P Agrahari and G N Tiwari (2013) compared different ratios of Kitchen Waste Under Aluminium Made Biogas Plant. Aluminium is also better alternative on the basis of biogas production and also safe for the environment because it can easily be disintegrated by microorganisms but plastic creates a lot of environmental problem due to its non-biodegradable nature. Black painted aluminium made biogas plant will be the best alternative under community level biogas production from kitchen waste.

[8]Cunsheng Zhang et al. (2014) formed A Buffer System By Volatile Fatty Acids and Ammonia, resulting in higher methane yield and system stability. Co-digestion of food waste with other substances such as waste water could enhance the biodegradation of long chain fatty acids.

[17] Ziana Zuauddin, Rajesh P (2015) perform a project to create an organic processing facilities to create biogas which will be more cost effective, ecofriendly, cut down on land field waste, generate a high quality renewable fuel, and reduce carbon dioxide and methane emission. From their experiment they were able to produce around 10L of biogas daily in a 20L reactor. According to purpose of their project they were trying to design reactors of 1000L for each and every canteen.

[18] S.Sharada (2016) made an attempt to assess the suitability alternate fuel like Biogas production from kitchen waste. Main ingredients of the food waste included rice, vegetables, banana peels etc. From the study it is evident that food waste can become a good feedstock for the biogas production. Food waste contains more biodegradable solids (9.3%), with higher volatile solids (94.9%) than cow dung.

[16] S. Shrestha (2017) carried out the studied to excess the production of biogas from canteen's organic waste as a solution for management of organic waste. There result indicates that biogas production using innovative urban biogas plant is better solution organic waste management. Further extensive and large scale research need to be carried out for the optimization of the biogas plant.

[14] Azza A. Mostafa (2019) studied the key factors controlling the production of volatile fatty acid during fermentation for methanogenesis represented in pH, temperature. Anaerobic digestion after some pretreatments will be very effective method in utilizing this easy digestible wastes and generation biogas.

[15] Dr. Pravinkumar D. Patil (2019) reviewed on biogas production from kitchen waste. He stated Biogas is a convenient source of energy. Kitchen waste from Hotels, Houses Hostel, Canteens, and Temples etc. are to be collected. Where it is a daily large amount of kitchen waste is obtained and Hence for better and effective utilization for better purpose. This biogas production also performs the function of waste disposal system.

3.Methodology

3.1 What is Biogas?

Biogas is a mixture of gases, primarily consisting of methane, carbon dioxide, and hydrogen sulphide, produced from raw material such as agricultural waste, municipal waste, plant material, sewage, green waste, and food waste.

Biogas is produced by bacteria through the bio-degradation of organic material under the anaerobic condition.

Natural generation of biogas is an important part of bio-geochemical carbon cycle. It can be use both in rural and urban areas.

3.2 Why this type of plant?

The proper disposal of PRMCEAM BADNERA's kitchen waste will be done in ecofriendly and cost-effective way. While calculating the cost effectiveness of waste disposal we have to think more than monetary prospects. The dumping of food in places and making the places unhygienic can be taken good care of. It adds to the value of such Biogas plants. Using the natural processes like microorganisms kitchen waste & biodegradable waste viz paper, leaves can be utilized.

Anaerobic digestion is controlled biological degradation process which allows efficient capturing & utilization of biogas (approx. 60% methane and 40% carbon dioxide) for energy generation. Anaerobic digestion of food waste is achievable but different types, composition of food waste results in varying degrees of methane yields, and thus the effects of mixing various types of food waste and their proportions should be determined on case by case basis.

Anaerobic digestion (AD) is a promising method to treat the kitchen wastes. While Anaerobic digestion for treatment of animal dung is common in rural parts of developing countries, information on technical and operational feasibilities of the treatment of organic solid waste is limited in those parts. There are many factors affecting the design and performance of anaerobic digestion. Some are related to feedstock characteristics, design of reactors and operation conditions in real time. Physical and chemical characteristics of the organic wastes are important for designing and operating digesters, because they affect the biogas production and process stability during anaerobic digestion. They include, moisture content, volatile solids, nutrient contents, particle size, & biodegradability. The biodegradability of a feed is indicated by biogas production or methane yield and percentage of solids (total solids or total volatile solids) that are destroyed in the anaerobic digestion. The biogas or methane yield is measured by the amount of biogas or methane that can be produced per unit of volatile solids contained in the feedstock after subjecting it to anaerobic digestion for a sufficient amount of time under a given temperature which is taken to be laboratory temperature in our case.

3.3 Composition of BiogasPlant:

Table-1. Composition of biogas,Ziana Ziauddin et al. (2015)

Component	Concentration (by volume)
Methane (CH4)	55-60%
Carbon Dioxide (CO2)	35-40%
Water (H2O)	2-7%
Hydrogen Sulphide (H2S)	20-20,000ppm (2%)
Ammonia (NH3)	0-0.05%
Nitrogen (N)	0-2%
Oxygen (O2)	0-2%

3.4 CHARACTERSTICS OF BIOGAS

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 0C. An odourless & colourless gas that burns with blue flame similar to LPG gas. Its caloric value is 20 Mega Joules (MJ) /m3 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).

3.4.1 PROPERTIES 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.

3.4.2 FACTORS AFFECTING YIELD AND PRODUCTION OF BIOGAS:

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

1. The quantity and nature of organic matter
2. The temperature
3. Acidity and alkanity (PH value) of substrate
4. The flow and dilution of material

Table- 2 Major characteristic of biogas.

Energy Content	6-6.5 kWh/m3
Fuel Equivalent	0.6-0.65 l oil/m3 biogas
Explosion Limits	6-12 % biogas in air
Ignition Temperature	650-750 *C
Critical Pressure	75-89 bar
Critical temperature	-82.5 *C
Normal Density	1.2 kg/m3
Smell	Bad eggs

3.5 BENEFITS OF BIOGAS TECHNOLOGY:

1. Production of energy.
2. Transformation of organic wastes to very high-quality fertilizer.
3. Improvement of hygienic conditions through reduction of pathogens.
4. Environmental advantages through protection of soil, water, air etc.
5. Micro-economical benefits by energy and fertilizer substitutes.
6. Macro-economical benefits through decentralizes energy generation and environmental protection.

3.6 PRODUCTION PROCESS

A typical biogas system consists of the following components:

1) Manure collection
2) Anaerobic digester
3) Effluent storage
4) Gas handling
5) Gas use.

Biogas is a renewable form of energy. Methanogens (methane producing bacteria) are last link in a chain of microorganisms which degrade organic material and returns product of decomposition to the environment.

3.7 PRINCIPLES FOR PRODUCTION OF BIOGAS

Organic substances exist in wide variety from living beings to dead organisms. Organic matters are composed of Carbon (C), combined with elements such as Hydrogen (H), Oxygen (O), Nitrogen (N), Sulphur (S) to form variety of organic compounds such as carbohydrates, proteins & lipids. In nature MOs (microorganisms), through digestion process breaks the complex carbon into smaller substances.

There are 2 types of digestion process:

1. Aerobic digestion.
2. Anaerobic digestion.

The digestion process occurring in presence of Oxygen is called **Aerobic digestion** and produces The digestion process occurring in presence of oxygen is called as Aerobic Digestion and produces mixture of gases having carbon dioxide (CO_2) which is one of the most "green houses" gas responsible for global warming.

The digestion process occurring without (absence) oxygen is called **Anaerobic digestion** which generates mixtures of gases. The gas produced which is mainly methane produces 5200-5800 KJ/m3 which when burned at normal room temperature and presents a viable environmentally friendly energy source to replace fossil fuels (non-renewable).

3.7.1 Anaerobic Digestion:

Anaerobic digestion (AD) is historically one of the oldest processing technology use in mankind. It is also referred to as biomethanization, is a natural process that takes place in absence of air (oxygen).It involves biochemical decomposition of complex organic material by various biochemical processes with release of energy rich biogas and production influents.

3.7.2 Biological Process:

1. HYDROLYSIS
2. ACIDIFICATION
3. METHANOGENESIS

3.7.2.1 Hydrolysis:

Hydrolysis is a reaction that break down the complex organic molecule into soluble monomers. Bacteria decompose long chain of complex carbohydrates, proteins and lipids into small chain. For example : Polysaccharides are converted into monosaccharides.

3.7.2.2 Acitogenesis :

Acid-producing bacteria, involved this step, convert the intermediates of fermenting bacteria into acetic acid, hydrogen and carbon dioxide. These bacteria are anaerobic and can grow under acidic conditions. To produce acetic acid, they need oxygen and carbon. For this, they use dissolved O2 or bounded-oxygen. Hereby, the acid-producing bacteria creates anaerobic condition which is essential for the methane producing microorganisms. Also , they reduce the compounds with low molecular weights into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane. From a chemical point, this process is partially endergonic (i.e. only possible with energy input), since bacteria alone are not capable of sustaining that type of reaction.

3.7.2.3 Methanogenesis:

(Methane formation) Methane-producing bacteria, which were involved in the third step, decompose compounds having low molecular weight. They utilize hydrogen, carbon dioxide and acetic acid to form methane and carbon dioxide. Under natural conditions, CH4 producing microorganisms occur to the extent that anaerobic conditions are provided, e.g. under water (for example in marine sediments),and in marshes. They are basically anaerobic and very sensitive to environmental changes, if any occurs. The methanogenic bacteria belongs to the archaebacterial genus, i.e. to a group of bacteria with heterogeneous morphology and lot of common biochemical and molecular-biological properties that distinguishes them from other bacteria's. The main difference lies in the makeup of the bacteria's cell walls.

3.7.2.4 FLOW CHART FOR BIODEGRADATION :

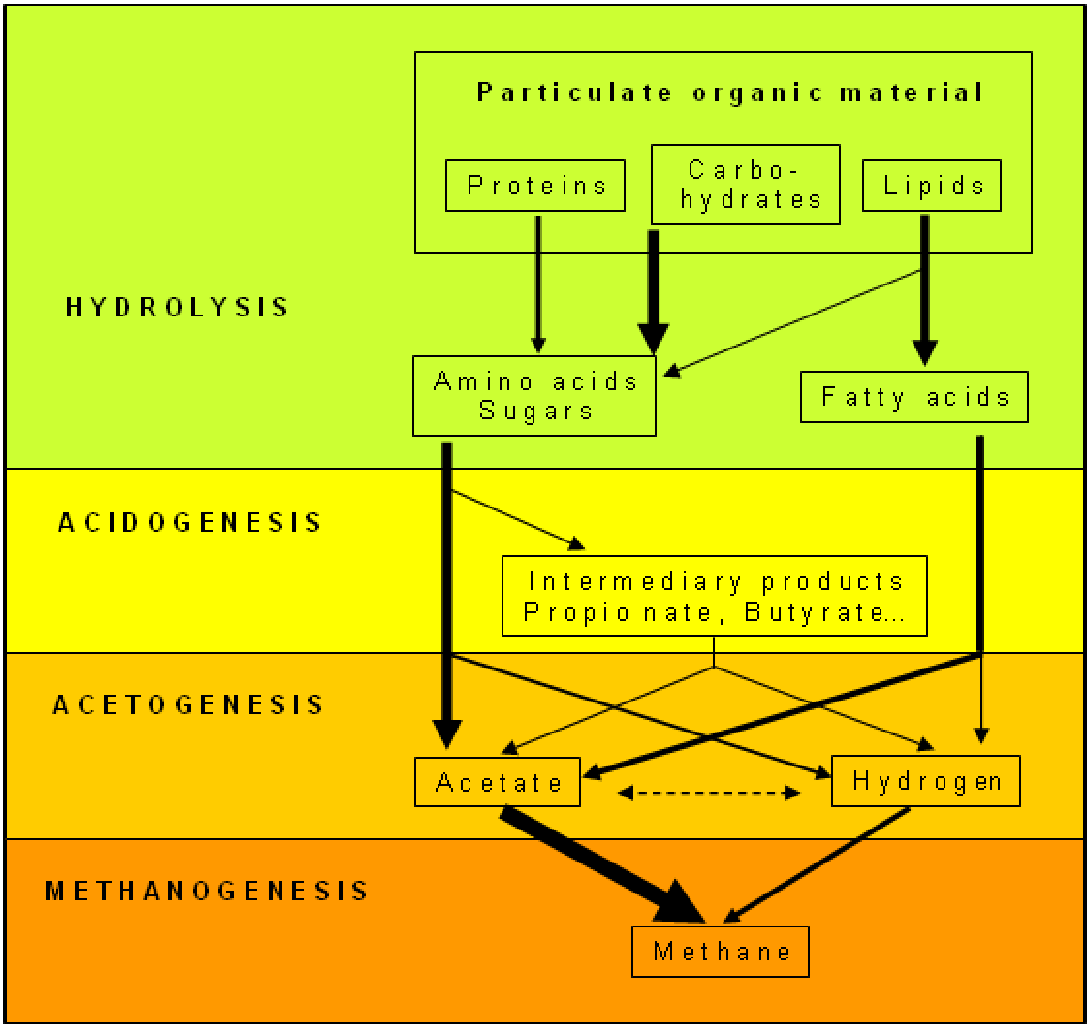

Fig. 1 Flow chart of anaerobic digestion

3.8 Advantage of anaerobic digestion:

1. Waste material is used to produce energy.
2. By anaerobic digestion, two types of products are formed- Fuel in the form of biogas and fertilizers in the form of sludge/slurry.
3. The Energy requirement of industry like dairy farm can be met from anaerobic digestion of the waste.

4. The system is completely enclosed;the odours are contained. Digested slurry is odourless.

3.9 TYPE'S BIOGAS PLANT:

Mainly classified as

1. Batch type
2. Continuous type

a. Floating drum (constant pressure) type,
b. Fixed dome (constant volume)type

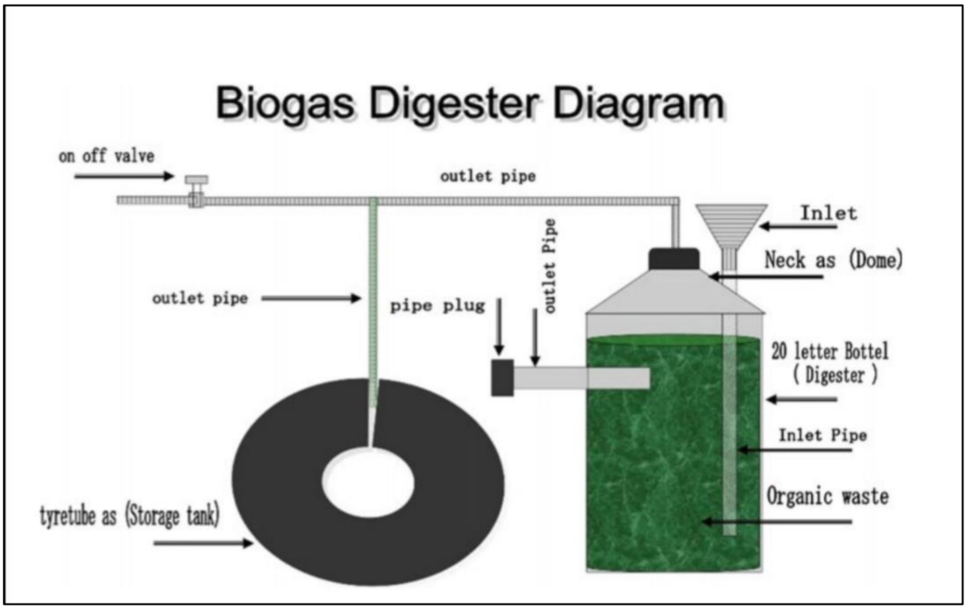

Fig. 2 Dia. Of Biogas Plant

3.9.1 Components of Biogas Plant:

The biogas plant consists of two components:

1. **Digester (fermentation tank):**

The digester is a cube-shaped or cylindrical waterproof container with an inlet into which the fermentable mixture is introduced in the form of a liquid slurry.

2. **Gas holder:**

The gas holder is normally an airproof steel container that, by floating like a ball on the fermentation mix, cuts off air to the digester (anaerobiosis) and collects the gas generated.

3.10 WORK PLAN:

3.10.1 Source of kitchen waste:

The waste used in this study is collected from Canteen of Prmceam, Badnera. Waste contains the cooked rice, vegetables and non-used vegetables waste. This waste is crushed by mixer grinder and slurry was prepared mixing with water.

3.10.2 Lab Settlement:

In lab scale this experiment was done in 1lit, 2lit & 20lit bottles, digester. Here different concentration & combination of wastes are used.

Here also different parameter will be checked like,

i. Total solid – increasing the feeding rate from 100 gm to 5 kg and to check effect on gas production and effluent quality.
ii. PH – to check change in PH and control of PH
iii. Temperature effect

3.11 Material and Method :

3.11.1 Designing procedure of the digester:

A plastic can of 20 litre capacity was used for the study. This can, acted as a digester. The physical parameters of the digester are tabulated in Table 1.

Table 3: Physical characteristics of the digester

Parameters	Values
Total capacity	20 liters
Digester height	40 cm
Si de water depth (liquid height)	27 cm
Free board line (empty volume)	13 cm
Liquid slurry volume	13.5 liters

The study was based on the principle of continuous feeding into the digester. Thus the digester was designed in such a way so that the waste can be easily put inside it. Following sequential steps were taken for designing of the digester. Two holes were made at the top of the digester with a drill. The holes were made about one inch in diameter. Two more holes of the same size were made on the sides of the digester, one at a height of 27 (cm) and 5 cm respectively. One of the above two holes were joined with the inlet chamber. The other one was fitted with a gas line. The side holes were joined with the over flow line and the outlet respectively. All the joining's were completely made air tight by M-seal.

3.11.1.1 Inlet System:

A pipe of 8.5 cm in length was joined with one of the hole made on the top of the digester. This inlet pipe was connected by means of a joint and a union. A tee was connected and its free end was joined with a pipe of 5 cm to act as a vent. The vent was made to prevent siphon during feeding of the slurry. The feed pipe outlet immersed into the slurry.

3.11.1.2 Gas line:

A pipe attached on the top of the digester carried the gas from the digester. Provision was given to connect pipe through the water seal by means of a tee. The gas was collected and measured by means of a water displacement method.

3.11.1.3 Outlet:

The outlet pipe was connected at the bottom of the digester. Its function was to take the digested slurry out of the digester. Side water depth is the height of the digester up to which the slurry is present inside. Similarly free board line is the height above the slurry which is free.

3.11.1.4 Water seal:

The pipe that carried the gas from the digester was given a provision to connect pipe through the water seal by means of a tee. Water seal is a trough of water. This is connected to take away the moisture of the gas. The other side of the tee was fitted with the plastic pipe of half an inch and was further fitted at the bottom of thegraduated beaker which was filled with water and kept upside down.

3.11.2 Material

Table 4. list of material used

Sr. no	Material
1	20 liter container (used for drinking water storage)
2	Solid tape
3	M-seal
4	PVC pipe 0.5”
5	Rubber or plastic cape
6	Funnel
7	Cape 0.5”
8	Pipe
9	Bucket
10	Bottle – for gas collection

3.12 Lab analysis and field analysis parameters:

Table 5: Parameters and instruments for lab analysis

Sr. No	Parameters	Method	Instruments
1.	Total solid	Oven drying	Hot air oven and dessicator
2.	Volatile solid	Gravimetric	Muffle furnance and dessicator
3.	Organic matter	Modified walkley and black	Burette, pipette
4.	Nitrogen	Kjeldahl digestion	Kjeldahl distillation assembly
5.	Carbon	Modified walkley and black	-
6	C:N ratio	From 4 and 5 (division)	-
7.	Phosphorus	Ammonium Molybdate	Spetrophotometer
8.	Potassium	Ammonium Acetate	Flame Photometer
9	pH	Potentiometer	pH meter

Table 6 : Parameters and instruments for field analysis

Sr. No	Parameters	Instruments
1.	Temperature	Lab thermometer and indoor/outdoor thermometer
2.	Volume of methane and CO_2	Gas analyzer
3.	Pressure	Pressure gauze
4.	Volume of biogas	Gas flow meter

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