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DESIGN AND CONSTRUCTION OF ANAEROBIC DIGESTER FOR BIOGAS PRODUCTION.

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ABSTRACT

Biogas production from waste could be one better way addressing the issues of waste management and energy problem in Nigeria. Biogas produced through the proper waste management in an anaerobic digestion has a huge potential to be an alternative source of energy to fossil fuel. In this project, a 200 liter capacity batch sheet metal biogas plant operated at mesospheric temperature under 40 day hydraulic retention time, Fabricated at Mechanical engineering Fabrication center, Federal Polytechnic Nekede, Owerri, Imo State was used for biogas production of from agricultural waste (pig dung, cow dung, poultry dropping) and kitchen waste. 21.25kg of each waste was mixed with water of same weight at a ratio of 1:1 and charged. The pressure of the slurry was monitored for a certain period of time. The sample gags production was passed through the gas chromatography to determine the percentage composition (mol%

dry basis) of the biogas content. The result of biogas before refining were 58.10 mol% dry CH_4, 35.9mol% dry CO_2 and 0.99 mol% dry H_2S, which conformed with literature values of 50-70% mol dry CH_4, 30-40% mol dry CO_2 and 0-3% mol dry H_2S 58.15% mol dry N_2, 0.02% mol dry O_2, 0.05% mol dry NH_3, 0.47% mol dry H_2.

Keywords: Biogas Digester, Purification Tank Potassium per Magnate, Lime Water, Flange, Flange Bolt, Digester Stand, Discharge Valve, Discharge Hose, Charging Valve

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CHAPTER ONE

1.0 INTRODUCTION

Biogas refers to a gas produced by the breakdown of organic matter or biodegradable material such as agricultural waste (Crops, animal dung, plants, grasses etc.), industrial waste, Kitchen waste, sewage in the absence of Oxygen. It is regarded variously as biogas, sludge gas, landfill gas and synthetic gas depending on the source of the substrate for the gas production, and also widely regarded as bio energy and fuel of the future.

For the past years, developing countries and particularly Nigeria has experienced increase in level of waste generation, inadequate power supply due to population explosion, increased agricultural activities and industrial growth. Consequently there is intense scrutiny of possible alternative of solid waste utilization through biogas production using organic residue like poultry drooping cow dung, and kitchen waste. Government and industries are constantly on the outlook for technology that will allow for effective and cost effective waste treatment (Gurnaswamy et al, 2003) and (Alvarez et al, 2006). A certain technology that has proved itself worthy of successful treatment of organic fraction of waste, having advantages of producing energy, yielding high quality fertilizer and preventing disease transmission is "Anaerobic Digesters"

The digestion process takes place in an air tight container at room temperature and this produces a product called "Biogas". This biogas composed of 50-70% methane (cooking gas) CH4, 30-40% carbon dioxide (CO) (fire extinguisher), 0-3/% Hydrogen sulphide HS and traces of other gases CO, NH3, N2, H2 and water vapor. The Composition of the biogas produced can vary depending on the Substrates (organic materials) used. (Okeke, O.R, 2009).

The biogas when refined of carbon dioxide and Hydrogen Sulphide by passing it through Lime or potassium hydroxide and activated charcoal or potassium permanganate (KMnO4) improves its efficiency and thermal content so as to Use for cooking and generation of power. A biogas system becomes flammable when its methane content is at least 45% (Http.design-tutorhtm, 2003). Methane has a heating value 22Mj/m^2 (15.6mj/kg) (FAO, 1979). For optimum biogas yield in an anaerobic digester system the necessary factors for proper growth and effective action of microorganisms on the substrates must be ensured. In an anaerobic digestion process three temperature ranges are identified: 0.20°c for psychrophilic organisms, 20-40°c for mesophilic organisms, 50-60°c thermophilic organisms (des mes ett al, 2003).

A temperature range between 32-35°c is more efficient for stable and continuous production of methane (I.O Itodo et al, 1995).

According to Sambo et al, (1995); temperature has significant effect on biogas production as temperature magnitude in excess of 60°c causes gas production to slow down and eventually stop.

There are other factors that affect biogas production like PH, Carbon to Nitrogen ratio, Stirring, nature of Substrate etc. The effluent Of this process is a residue rich in essential inorganic elements needed for healthy plant growth known as bio-fertilizer which when applied to the soil enriches it with no detrimental effects on the environment (Energy Commission 1998).

1.1 BACKGROUND OF STUDY

A lot of research has been done on the generation of biogas from animal dung, agricultural waste, few from industrial waste.

Owing to the fact that most kitchen waste are energy producing substances having the essential nutrients for bacterial growth and the considering the refuse disposal problem in Nigeria this research work tends to deviate from the normal substrate of biogas production by making maximum use of kitchen waste and animal waste (cow dung and poultry dropping) in other to improve the quantity of biogas produced, cleaning the gas so as to remove carbon dioxide and Hydrogen sulphide in other to improve the thermal content or produce burnable gas. This work also extent its arm to reveal the factors that affect biogas production techniques for enhancing biogas production, types of biogas plant and feeding method of biogas plants.

1.2 STATEMENT OF PROBLEM

Energy is a key factor for the growth and development of a country. Most developing countries in which Nigeria is one suffers from energy and waste treatment, management crisis, these has attributed to depletion of locally available energy resources, high dependency on fossil fuel and environmental destruction.

As more and more waste generated through Kitchen and agricultural activities are disposed in an uncontrollable manner, the impact on the environment like pollution, disease transmission global warming, erosion etc. becomes significantly visible. Poor power supply for domestic and industrial use has led to the death of so many small scale businesses even discourage its existence thereby leading to poor economic growth of the nation Nigeria. Biogas technology in Nigeria could be an importance intervention to the problem of energy supply waste management both in urban and rural communities since these waste generated has the potentials fore biogas production. Biogas technology provides alternative source of energy which is environmental friendly. Bio-slurry, a by-product of biogas, is a quality organic fertilizer and conditioner for the soil that has the potential to replace chemical fertilizer.

1.3 OBJECTIVES OF THE STUDY

1. To provide a renewable source of energy that is environmental friendly.

2. To provide a technology that is effective for waste treatment and management.

3. To reduce the rate of Carbon dioxide and methane emission to the atmosphere consequently minimizing the rate of global warming.

4. To reduce high depending on fossil fuel for energy.

5. To encourage afforestation and conservation of natural resources.

6. To provide bio-fertilizer

7. To reduce high rate of falling of wood used in the rural areas for cooking and the hazard of exposing oneself to poisonous snakes in the forest.

1.4 SIGNIFICANCE OF STUDY

Utilization of agricultural and kitchen waste for biogas production can be justified as follows;

1. Utilization of agricultural and kitchen waste for biogas production could be useful in solving energy problem of the country.

2. Methane and Carbon dioxide which are main greenhouse gases that causes global warming produced during decomposition of waste will be reduced.

3. Effective means of waste treatment and management are provided.

4. To create awareness to the public of an alternative source of energy generation that is environmental friendly and cheap, thereby reducing the rate of dependency on fossil fuel.

5. The effect of mosquitoes, pathogens and odor from decayed organic material will drastically reduce from the environment.

1.5 SCOPE OF STUDY

The scope of this study is limited to the use of agricultural waste (Cow dung, poultry dropping) and kitchen waste to produce biogas, refining of biogas to reduce the carbon dioxide and hydrogen sulphide content.

1.6 LIMITATION OF THE STUDY

In the course of this work, the following problem may be encountered.

1. Difficulty of handling the waste due to its offensive smell and the belief that it has microorganisms that are harmful to health.

2. Lack of the assistance of engineer with technical knowledge of biogas plant construction.

3. Unavailability of material on similar seminar topic.

4. Difficulty in maintaining the necessary for biogas production.

5. Plant construction requires extensive care, any crack or a leak at ‘any part of the plant may hinder production of the gas.

6. Long period of time is taken for a burnable gas to be produced.

7. Cost, the materials required for success of this work are expensive.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 HISTORY OF BIOGAS TECHNOLOGY

Biogas technology which converts biological waste into energy is considered by many experts to be an excellent tool for improving life, livelihood, and health in the developing countries. About 16milion households worldwide use small-scale biogas digesters according to Renewable 2005. Global Status Report, a study by the World Watch Institute.

Isolated cases of using biogas technology were documented in China, India, Assyria and Persia beginning from 17th B.C, however systematic scientific research of biogas started in 18th Century. In 17th Century, Jan Baptista Van Halmount first determined that flammable gas could evolve from decay organic matter. In 1821 Avogadro Identified methane (CH_4). In 1859 first digestion plant was built in India. India being one of the countries with many biogas plants have enjoyed so many benefits of this technology called "Biogas Technology". Since 1970s there have been a big increase in number of biogas plant in India, presently there are about 3.7 million biogas plants in operation in India; over 10 million persons use biogas centrally as fuel.

In China, a speed up in biogas technology has been achieved since 1970s. According to record, more than 5 million small biogas digesters have been constructed and about 20 million persons use biogas currently as a fuel. Germany is Europe's biggest biogas producer (Eurobserver 2011), it is the market leader in biogas technology according to renewable made in Germany. In 2010 there were 5,905 biogas plants operating throughout the whole country in which lower Saxony, Bavaria, and the eastern Federal States are the main regions (Renewable made-in-Germany 2011).

In United Kingdom, there are currently about 60-non-sewage biogas plants most on the farm, but some large facilities exists of farms which are taking food and consumer Waste (The official Information Portal on AD). The presence of this technology in these countries has helped to reduce the rate of pollution, disease transmission, greenhouse emission, dependency on fossil fuel and encourage waste treatment / management, afforestation, provision of energy most especially to farmers in rural area and as well as provision of fertilizer for healthy and quality agricultural produce. Countries like America Sweden and Some parts of African countries like Rwanda, Senegal, Burkina Faso, Ethiopia, Tanzania, Uganda, Kenya, Benin and Cameroon have benefited immensely from this technology.

Nigeria is not left behind as such technology could be found in some part of its cities like Sokoto, Benin, Zaria, Ibadan, Lagos etc. The pioneer biogas plants are a 10m3 biogas plant constructed in 1995 by the Sokoto Energy Research Center (SERC) in Zaria an 18m biogas plant constructed in 1996 at Ojokoro Ifelodun piggery farm, Lagos by the Federal Institute of Industrial Research Oshodi (FIRO) Lagos (Zuru et al, 1998).

The biogas plant in Ibadan that runs on abattoir effluents is one of the largest plant in Arica providing gas to 5400 families a mouth around a quarter or the cost of queried natural gas (from non-biodegradable).

The plant in Benin, installed in Guinness Nigeria PLC operates for the treatment or brewery effluent. The existence of these plants have helped to improve sanitation, reduce pollution rate, greenhouse gas emission, provision of energy even bio-fertilizer and encourages afforestation and natural gas conservation. A result study assessed Nigeria’s biogas potential (Minimum value) from solid waste and livestock excrements, it revealed that in 1999, Nigeria’s biogas potential represents a total of 1.382 x 109m3 of biogas / year or an annual equivalent of 4.81 million barrels of crude oil (S.J Ojolo et al 2007).

The raw materials for biogas production include most agricultural and other organic waste. High percentage or Nigerians engages in agricultural practice like livestock farming, crop production, according to United State Environmental Protection Agency (EPA).

A single dairy cow produces approximately 120 pounds of wet manure per day by one dairy cow is equal to that of 20-40 people, considering the fact that one of the biggest challenges facing our country Nigeria is lack of waste management as approximately 70% of Nigeria's live in areas where no formal waste management system are in place (S.J Ojolo et al, 2007), the use of cow dung, poultry and kitchen waste will serve as the best for biomethane production in Nigeria.

2.2 BIOGAS PRODUCTION

Biogas is produced by the decomposition of organic matter by bacteria in the absences of air (Oxygen) that is under anaerobic condition, Biogas is lighter than air and has ignition temperature of approximately 700oC. The temperature of the flame is 870^{o}C. Conversion of organic matter through microbial action has become an alternative means (method) of waste treatment and resource recovery.

Biogas is produced in several waste treatment process Such as;

1. Agricultural waste

2. Anaerobic composting

3. Sanitary land fills

4. Sewage treatment plants,

AGRICULTURAL WASTE; Organic waste are produced through agricultural activities weather farming or subsequent food processing like rice and biogas can be produced from Such waste.

On many farms, plant and animal waste are treated in small

Anaerobic digesters that produce biogas (S.R Haggarnis et al, 1994).

ANAEROBIC COMPOSTING: Anaerobic composting has stand to be one of the effective means through which valuable components in organic waste can be recovered, and this has been making progress throughout the world. Modern anaerobic composting can produce compost of selectively collected organic waste, from domestic, kitchen, garden, food production activities which can produce a useful guaranty of biogas (Okeke O.R, 2009). The biogas can be converted to electricity band is partially and alternative because their gas tends to be relatively free of contaminants (Okeke O.R, 2009).

SANITARY LANDFILLS: All over the world, it remains a major part of the municipal waste disposal method. The use of landfill for disposing of municipal waste may decline in the future because of the organic content of the wastes, landfills produce per hour as this continues for many years after the closure of the landfill (S.R Hagarnis et al, 1992).

Since landfills produce biogas with high methane content, they are collected and burnt either in a flame or utilized as an energy source (Okeke O.R 2009). Collecting landfill biogas and utilizing its potential energy to generate electricity is obviously the desirable alternative (S.R Hagarins et al, 1992).

SEWAGE TREATMENT PLANT: Most Municipal sewage treatment plants produce large amounts of sludge, the disposal of which has become a major problem. Sludge can be digested under anaerobic conditions, which makes it possible to recover the potential energy available in its organic content. The biogas produced can then be used to generate heat and electricity (Harganis and Panada, 1993) and Mails and Umesh, 2009).

In biogas production, three basic facts are outlined.

1. Most or the important bacteria involved in biogas production process are anaerobic and stow growing.

2. The greater degree of metabolic specialization is observed in these anaerobic microorganisms.

3. Most of the free energy present in the substance is found in the terminal product methane (B Ganda, et al 1996). Research has shown that one of its serious limitations is the availability of feedstock followed by defects in construction and microbial failure (Gadre et al, 1990).

2.3 PARAMETERS AFFECTING BIOGAS PRODUCTION

Different parameters affect biogas production as bacteria are sensitive to changes in their environment.

These parameters are

i. Temperature

ii. Nature of substrate

iii. Available nutrients

iv. PH level

v. Carbon / Nitrogen ratio

vi. Agitation / stirring

vii. Organic / Digester loading rate.

viii. Hydraulic Retention time

2.3.1 TEMPERATURE

The microbial activity is temperature dependent. The temperature inside the digest has a major effect on the biogas production process. Anaerobic digestion occurs in temperature ranging from 0 to 97°c (Bitton 1999). The microorganisms responsible for anaerobic digestion are destroyed completely at temperature below -10°c or above 90°c.

The process of organic material anaerobic digestion takes place in three main temperature ranges namely;

a. Psychrophilic digestion

b. Mesophilic digestion

C. Thermophilic digestion

PSYCHROPHILIC DIGESTION: This occurs at a temperature ranging from 0-20°c under a retention time over 100days. The rate of organic matter conversion into biogas is minimized since the activity of the microorganism is limited due to the low temperature. The consequence is to require a very large retention time, a very large volume of digester and high quantity of substrates. The action of the digester has been found to decrease sharply below 16°c (C.W Mgyakma and Akobundu, 2001).

MESOPHILIC DIGESTION: This occurs at a temperature ranging from 20-40'c, having a retention time over 20 days. Majority of methanogens (Microorganisms that form methane from organic matters) belong to the mesophilic. They grow quickly in this temperature range and exhibit high degree of conversion. In practice, this has direct implication in the design of biogas plant as they are the most stable operating plant. The stability and growth conditions in the digester at mesophilic condition makes the process more balanced, more resistant to chemical that inhibits digestion (e.g. Ammonia) and capable of treating efficiently a great variety of different biomass and waste even the most difficult treated. (www.biomassenergy.gr).

THERMOPHILIC DIGESTION: This occurs at a temperature ranging from 50-60°c and has a retention time over 8 days.

A small proportion of methanogenic organisms are thermophilic, meaning that they are attached perfectly to high temperature. Generally, at this temperature range, the bacteria's consume the organic substrates with high rate and grow faster. (www.biomassenergy.gr).

Due to this, the digester operated at thermophilic condition may be constructed in a small dimension while maintaining very high level of biogas. Thermophilic methanogenic bacteria are extremely sensitive to changes in anaerobic digestion to such an extent that even a small change of the operating parameters can impact negatively on their development. For example, a change in temperature greater than 1-2°C has a significant reduction in the amount of produced biogas. The variety of materials that can be processed in anaerobic thermophilic condition is low than that of mesophilic, mainly because of the chemical composition and stronger influence of some digestion inhibitors in the process.

Production of gas is most rapid between 28°Cand 41°c (mesophilic) or between 49°c and 60°c (Thermophilic) (C.W and Akobundu 2001). This is due to the fact that high temperature bacteria are much more sensitive to ambient influences.

2.3.2 NATURE OF SUBSTRATE

Many substrates are generally used as Feedstock in biogas plant the potential for biogas production varies with feedstock. It has been reported that the quality of the feedstock in use has a direct influence on the biogas produced (P.C Mahashewart and P.C Vasuda Van 1981) and (B. Megerson 1980). It is necessary that the organic waste material be easily degraded or digested by the concerned bacteria. It is further observed that the finer the organic waste (2mm size) is, the large the biogas produced. (K.K Meher at al 1990) Comparing the rates of biogas yield from pig dung and cattle dung fed digester, it has been reported that the biogas yield was higher in the former (K.M Mital 1996) and (Http.hear. org 2009). This was attributed to the pressure of Native micro Flora in the dung.

2.3.3 AVAILABLE NUTRIENTS

In order to grow, bacteria need more than just a supply of organic Substances as a source of carbon and energy. They also require certain mineral nutrients, In addition to carbon, oxygen and Hydrogen, the generation of biogas requires an adequate supply of Nitrogen, Sulfur, phosphorus, potassium, calcium, magnesium and a number of trace elements such as iron manganese, molybdenum, zinc, cobat tungsten, nickel, selenium etc. (S.J Ojolo et al, 2007) and (Alexander H, 1981). Poultry dropping procedures more biogas with high methane content due to the high content of nitrogen.

Table (i) shows the gas produced from different substrate. Table (i) shows the methane yield of animal waste.

TABLE I

Biogas produced from different substrate

Substrate	Gas production rate (L/kg waste)	Manure available kg/animal/day	No animal required
Cattle dung	40	10	2-3
Buffalo dung	30	15	2-3
Pig dung	60	2.25	7-8
Chicken dung	70	0.18	80
Human excreta	70	0.18	80

(1= FAO, 1997 and 2-Nagamani & Ramasamy No date)

TABLE II

Methane yield of animal waste

Animal	Typical experimental yield / kg of manure	CH4%	CO2%	Thermal content mj/m3
Cattle	200-350L	57.5	46.5	23

Poultry	550-650L	70.0	30.0	28
Pig	400-500L	65.0	35.0	26

(Alexander H 1981)

Higher concentration of any individual substance usually has an

Inhibitory effect so analysis is recommended to determine amount of each nutrient of the substrate(s), if any still needs to be added.

2.3.4 PH LEVEL

It has been well established that PH is an important parameter that affect the growth of methane producing bacteria during anaerobic fermentation. Anaerobic digestion will occur best with a PH range of 6.8 to 8.0 (B Nagamani et al, 998). More acidic or basic mixture has a toxic effect on the methanogenic bacteria thereby causing fermentation to occur at a low speed.

The introduction of raw material will often lower the PH and make the mixture more acidic, digestion will stop or slow down dramatically until the bacteria have absorbed the acids (OKeke O.R, 2009). A high PH will encourage the production of acidic carbon dioxide to neutralize the mixture (B. Nagamani et al, 1998) and (A.N Ofoefule and E.0.U Uzodinma 2006) for normal anaerobic fermentation process, concentration of volatile fatty acids in terms of acetic acid should exceed 200- 300mgll (Okeke O.R 2009). It was observed that above PH 5.0, the efficiency of CH_4 production was more than 60- 70% (A.U Ofuefule and E.O Uzodinma 2008). If the PH drops below 5.0 or above 8.0, the fermentation process may be inhibited or even stopped (A.U Ofoefule and E.O Uzodinma 2008).

2.3.8 CARBON/ NITROGEN RATIO

All feed material consist of nitrogen (N) and carbon (C) at different ration. Proper ratio carbon and nitrogen is required not only for the purpose of biogas production from organic waste but also for optimal yield of methane gas. For high yield of methane carbon is required for energy and nitrogen is necessary for building of cell structure of the methanogenic bacteria (G.C Okoli et al 2006), If nitrogen is in excess, ammonia is produced which makes the slurry alkaline and decrease the growth of bacterial. Carbon / Nitrogen (C/N) ratio of 20:1 to 30:1 are particularly favorable for optimal biogas production.

To obtain this range, it is been stated, the materials with high nitrogen content like pig dung, poultry dung, urine and faces should be mixed with the substrates having low nitrogen content and high carbon content like saw dust, farm waste, rice husks etc.

A high C/N ratio will leave carbon still available after the nitrogen has been consumed, starving some of the bacteria of this moisture, but slowing the process. Lower C/N ratio will leave correct ratio of carbon to nitrogen will prevent loss of ether fertilizer quality or methane contact.

2.3.6 AGITATION / STIRRING

Many substrates and various modes of fermentation require some sort of substrates agitation or stirring in order to maintain process stability within the digester. The most important objectives of stirring are:

· Removal of the metabolites produced by the methanogens · (Gas).

· Mixing of fresh substrate and bacteria (inoculation). · Prevention of scum formation and sedimentation.

· Avoidance of pronounced temperature gradients within the digester

· Provision of a uniform bacteria population density.

· Prevention of the formation of dead spaces that would reduce the effective digester volume.

According to A.S Samdo, stirring is important in digesters to prevent the formation of three layers (A.S Samdo et al 2006). In the upper part, the scum is formed and in the middle a liquid medium and sludge in the bottom, stirring breaks up these layers and makes for uniform distribution of feed stock and seeding bacteria to extend the contact surface of microbes with feed stocks thus speeding up the digestion rate and gas yield (Okeke, O.R 2009).

It ensure easy release of CO2 and CH4 from the slurry, in the case of digesters in which heating element is encomplated. Stirring helps in distributing the heat uniformly within the digester.

Vigorous and continuous stirring is not encouraged as this will prevent the coming together of the bacteria to react and produce gas (A.S Samdo et al 2006), slow stirring is better adopted.

2.3.7 ORGANIC LOADING RATE OR DIGESTER LOADING RATE

Gas production is highly dependent on loading rate. Organic loading rate or digester loading rate is amount of organic material that can be fed to a digester system at a particular time that will be suitable for gas production (D.D Schulte et al 1976) Digester loading rate indicates how much organic material per day has to be supplied to the digester or has to be digested. Methane yield was found to increase with a reduction in loading rate, if the loading digester is too high, the PH falls, the plant then remains in the acid phase because there is more feed material than methane bacteria.

It has been observed that a daily loading rate of 16kg Vs. m3 of digester produced 0.04 - 0.07m of gas 1kg of dung fed (M.R Smith 1980).

2.3.8 HYDRAULIC RETENTION TIME

This is the time for which fermentation material reside inside the digester. (P.H Smith and R.E Hungate 1958) and (A. A. Van Biran 1979). It also refers to the time water and bacteria remain in the reactor.

Normally, maximum gas production takes place within the first four weeks and then it triggers off gradually depending on the temperature and climate conditions and the substrates.

For most animal manure and plant material, the normal retention time is between 15 -30 days (F Van Kelsen and G. Letting 2000). Some factors have been identified to affect the retention time (A.R Webb and F.R Hankes 1985) and (R.S Wolfe and I.) Higains 1979). If the temperature could be raised, agitations of the concentrates inside the digester are capable of reducing the retention time of slurry in the digester.

2.4. BIOGAS PLANT TYPES

2.4.1 FIXED - DOME PLANT

A fixed- Dome plant consist of an enclosed digester with a fixed, non - moveable gas holder which sits on top of the digester. The waste manure, during human excrement) is fed into the digester. After that the mathanogenic bacteria "digest" the waste and produces gas and slurry (digested waste). When gas production commences, the slurry is displaced into the compensating tank while the gas is captured in the gas holder. The more the gas is produced the higher the level of the slurry outlet will be. The level of slurry in the digester depends on the loading rate, gas production and consumption. (Urmila B et al, 2008). Gas pressure increases with the volume of gas stored and the height difference between the slurry level in the digester and the slurry level in the compensating tank. (http://www.cd3cwd.com).

Therefore the volume of the digester should not exceed 20m3. If there is little gas in the holder the gas pressure is low. During gas production, slurry is pushed back sideways, displaced into the compensating tank. When gas is consumed, slurry enters back into the digester from the compensating, tank. As a result of these movements, a certain degree of mixing is obtained of slurry of different ages. Therefore this design approaches a mixed digester reactor (Stalin, 2007).

ADVANTAGES

1. The fixed - doom plant is relatively inexpensive.

2. It has no moving parts, no rusting steel parts, hence has a long life span up to 20 years (Giz, 1999).

3. The underground construction saves space and protects the digester from temperature changes.

4. The construction provides opportunities for skilled local employment.

5. DISADVANTAGES

1. The frequent problems with the gas - tightness of the brickwork gas holder (a small crack in the upper brickwork can cause heavy losses of biogas).

2. The gas pressure fluctuates substantially depending on the volume of the stored gas.

3. Fixed - Doom plants can be recommended only where construction can be supervised by experienced biogas technicians.

2.4.2 FLOATING – DRUM PLANT

The operation of floating - drum plant is not different from a fixed - doom plant. Floating - drum plant consist of an underground digester and a movable steel drum, the gasholder where the produced gas is collected. The steel gas holder floats either directly on the fermentation slurry or in a water jacket of its own. As gas is produced and collected in the gas holder, pressure increases and the steel drum rises, if gas is drawn off the digester it falls again. The gas drum is prevented form titling by a guide frame. The slurry is pushed out of the digester after digestion.

ADVANTAGES

1. The operation of the plant is easy to understand and operate. 2. The volume of gas stored is directly visible.

3. Gas pressure is constant due to the weight of the drum.

DISADVANTAGES

1. High cost of construction since steel drum is relatively expensive, many steel parts liable to corrosion, resulting in short life span (up to 15 years, in tropical coastal region about five years for the drum), regular maintenance cost due to painting.

2. Steel drum can get struck.

In spite of these disadvantages, floating drum plants around always to be recommended in cases of doubt. Water jacket plants are universally applicable and especially easy maintain. The drum won't stick, even if the substance has high solids content. Floating - drums made of glass- fiber reinforce plastic and high density polyethylene has been used successfully, but the construction cost is higher than with steel. Floating - drums made of wire - mesh-reinforce- concrete are liable to hairline cracking and are intrinsically porous.

2.4.3 BALLOON PLANTS/ BAG DIGESTER

A balloon plant or also referred to as bag digester consist of a plastic or rubber digester bag. The gas is stored and collected in the upper part while the slurry (manure) in the low part. The inlet and the outlet are attached directly to the plastic skin of the balloon. The gas pressure is achieved through the elasticity of the balloon and by added weights e.g. stones placed on the balloon. When the gas is full, the plant works like a fixed doom plant i.e. the balloon is not inflated, it is not very elastic. The fermentation slurry is agitated slightly by the movement of the balloon skin. The balloon material must be U-V resistant.

Materials which have been used successfully include RMP (Red Mud Plastic).

ADVANTAGES

1. Balloon plant has low cost of construction

2. Transportation is easy

3. It maintains high digester temperature

4. Low construction sophistication, uncomplicated cleaning, emptying and maintenance.

DISADVANTAGES

1. It has a short life span. According to GIZ (unknown date) and Daxiong 1990, the effective life span of the bag is limited to 3 - 5 years.

2. Susceptible to physical damage

3. Hard to repair

4. High quality plastic is needed.

2.5 FEEDING METHODS OF DIGESTER

Three different forms of feeding methods can be distinguished. 1. Batch feeding for batch plants.

2. Continuous feeding for continuous plants

3. Semi - batch feeding for semi - batch plants.

2.5.1 BATCH FEEDING (MOSTLY SOLIDS)

This type of feeding is used mostly for solid vegetable waste, mixture of dung and vegetable waste. Batch plants are filled completely and then emptied completely after a fixed retention time. Depending on the waste material and operating temperature a batch digesters which will start producing Biogas after two to four weeks will slowly increase in production. Then drop off after three or four months. Batch digesters are best operated in groups so that at least one is always producing useful quantities of biogas.

2.5.2 CONTINUOUS FEEDING (MOSTLY LIQUIDS)

This type of feeding is mostly for fluid and homogeneous substrate continuous plants are filled and emptied regularly, normally, dally. Continuous plants are Suitable for rural households as the necessary work fits well into the daily routine. In a continuous feeding system, it is essential to ensure that the digester Is large enough to contain all the material that will be fed through in a whole digestion cycle.

2.5.3 SEMI CONTINUOUS FEEDING (SOLIDS AND LIQUIDS)

Biogas plants can be operated on a semi - continuous basis when a sold and a liquid waste are used as a feedstock. The feeding is done at interval depending on the waste material. Example when the straw and dung are to be digested together, the slowly digested straw- type material is fed in about twice a year as a batch load. The dung is added and removed regularly.

2.6 REFINING OF BIOGAS

As earlier noted, biogas produced constitute from anaerobic digestion of waste, constitute of other gases. Incombustible carbon dioxide reduces flame calorific value and flame velocity of biogas. The content of carbon dioxide which varies as a function conditions prevailing in a digester and digester feed composition, introduces constrains on the efficient operation of appliances, such as burner. It is necessary where possible to remove the gas from biogas before storage or use.

The refining f biogas can be achieved by direct reaction of carbon dioxide with solutions of alkalis where it is absorbed. Despite the low concentration of hydrogen sulphide, its presence in biogas is very undesirable. Hydrogen sulphide is a toxic gas with an unpleasant odor, similar to rotten eggs, forming sulphuric acid in combination with water vapor in biogas. The surphuric acid is corrosive and therefore reduces the life of the metallic (copper, steel, and lead) pipe, gasholder and metallic accessories. To prevent this effect, biogas must be refined of hydrogen sulphide.

Other effective methods of purifying biogas are by:

1) Water washing

2) Pressure swing absorption

3) Selexol absorption

4) Amine gas treating. The most prevalent method of all is water washing where high pressure gas flows into a column where the CO2H2S and other trace elements are scrubbed by cascading water running counter flow to

the gas. This arrangement could deliver 98% CH_4 with manufacturers guaranteeing maximum 2% CH_4 loss in the system.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 DESIGN CONSIDERATION

The genera consideration in designing this biogas plant is to produce system that can be used for waste treatment and biogas production for cooking. A system that will be efficient in to use, cheap to construct, maintain, safe and easily operated, easy to assemble and disassemble even mobile. Factors that affect the system were properly considered also. For adequate construction and better working standard, proper selection of adequate construction process and protective measures were employed.

3.2 MATERIAL SELECTION

The selection of proper material for engineering purpose is one of the most difficult problems facing the designer. The best material is one which serves the de sired objective at minimum costs as different materials Such as metal, plastic, concrete are used for biogas plant construction.

In selecting desired material, the following factors should be considered

a. Availability of the materials

b. Suitability of the materials for the working conditions in service.

c. The costs of the material and possible maintenance.

Material selected for a particular design should be expected to have some mechanical properties as well as thermal and chemical properties. For mechanical properties, strength is considered first, as the design is meant to function under various load distribution. A score chart developed to select the material is shown below comparing three selected materials.

Service Requirement	**Score chart** **Materials**		
	Metals **(mild** **steel)**	**Concrete Plastics**	**(PVC)**

1. Strength	2	3	1
2. Elasticity	3	1	2
3. Gas Tightness	3	2	1
4. Chemical Resistance	1	2	3
5. Easy to put to desired shape	3	2	1
6. Thermal conductivity	3	2	1
7. Ease to repair	3	2	1
8. Best finishing desired	3	2	1
9. Cost	2	1	3
10. Mobility	2	1	3
11. Stability to atmosphere	2	3	1
Total Score:	**27**	**21**	**18**

Score chart: for any desirable property, each material type was scored of 3marks (very good) -2marks (good) and 1 mark (fair).

From the chart above, metal (mild steel) was selected as the proper material to suit the design. Plastic materials fittings were introduced in the design due to some reasons such as cost availability and chemical resistance Brass fitting material were used at some points.

Materials used in construction of biogas plant.

TABLE IV

S/no	**Name of**	**Material type**
1	Hopper	Mild steel
2	Inlet pipe	PVC plastic

3	Outlet pipe	PVC plastic
4	2inch valve	PVC plastic
5	Bolt	Mild steel
6	Bearing	Mild steel
7	Gasket	Rubber
8	Stirrer	Mild steel
9	Handle	Mild steel
10	Frame	Mild steel
11	Nipple	Brass
12	Non-return value	Brass
13	¼ and ½ value	Brass
14	Stand	Mild steel
15	Handle	Mild steel
16	Gas pipe	Rubber

3.3 DESCRIPTION OF PLANT PARTS

1. HOPPER: The hopper is a funnel shaped metal with four sides. It serves as feed inlet unit where the prepared feed stock (Slurry) is been feed into the plant. This unit is designed in a way to accommodate a reasonable amount of feed.

2. INLET PIPE WITH VALVE: It is a 2 inches cylindrical shaped plastic pipe having 2inches plastic ball valve fitted to it. The inlet pipe with valve is located in between the hopper and the tank. It serves as the unit through which the fed feed s tock flows from the hopper to the tank. The attached valve is locked after feeding to prevent escape of gas during digestion.

3**. DIGESTER TANK**: The digester tank is the main frame of the plant. It is a 3mm thick metal tank in cylindrical form having a truncated cone designed metal form at the top and bottom. The digester tank comprises of the digestion unit and gas holding unit. Shaped metal of 3mm thickness mounted at the side of the tank.

4. GAS COLLECTION CHAMBER: It is a closed cylindrical storage before the refining or cleaning. It is where' biogases generated from the tank are moved for storage before the refining or cleaning.

5. IMPELLER TRIRRER: It is a 20mm round metal shaft having flat rectangular metal pieces attached to it an angle. The stirrer provides proper mixing of the slurry in the tank for effective bacteria action, scum breaking and proper digestion of slurry for proper gas yield.

6. STANDS: The stands are made of metal of 3.5 thick. They provide support and stability to the plant.

7. OUTLET PIPE WITH VALVE: 2inch cylindrical plastic pipe having 2inches plastic ball vale and 2inches plastic elbow fitted to it. The effluent (digested feed) flows out of the digester tank through this channel after digestion. The out pipe is fitted to the bottom of the tank.

8. GAS VALVES: The gas valves are of ½ inches and ¼ inch. One mounted on the tank and the other at the end of a gas hose. The values provide proper regulation of outflow of the gas. These valves are made of brass.

9. GAS HOSE: The as hose is made of plastic. It provides flow of gas from one chamber to another and final distribution. Deferent sizes of pipes are used at different points.

10. NON-RETURN VALVE: The non-return valve is mounted to the collection chambers, it is made of metal. Its function is to prevent the flow back of gas from the collection chambers to the digestion tank when there is pressure difference.

11. HANDLE: The handle made of metal assist in removing of lifting of the upper section replacement or maintenance operation is to be carried out. It also provides mobility of the plant.

12. PRESSURE GAUGE: Pressure gauge is mounted on the digester tank and gas collection chamber. These pressure gauges are used to measure gas pressure in the tank and gas collection chamber and to determine if these chambers are gas leak free. The pressure gauge on the tank is used to determine when there is low or non-production of gas in the tank.

13. FLANGE: Flange is one of the integral parts of the plant. It is round mild steel welded at the meeting ends of the cut sections of the tank. It provides access to the internal parts of the plant for easy maintenance, inspection repair and replacement of parts.

3.4 DESIGN CALCULATION

3.4.1 SCALING OF BOGAS PLANT

The general steps followed to calculate the 200liters capacity plant is given below

Step 1: calculation of the plant volume dimension specifications Upper cone truncated part

Small circle diameter 220mm radius (r2) = 110mm Big circle diameter 590mm radius (r2) = 25mm

Height 53mm

Lower cone truncated

Small circle diameter 50mm, radius (r2) = 25mm Big circle diameter 590mm, radius (r1) = 295mm Height 206mm

Cylindrical part

Diameter 590mm, radius ®= 295

Height 630mm

Formula tor volume of the outlined shaped volume of truncated cone

½ ∏ (r2 + (r1x r2) + r22) h

Volume of cylinder

∏r2 h

Computation of values

Upper truncated cone

1/3∏ (295)2 + (295 x110) + (1102) 53mm3

=2324491.667∏ mm3

Lower truncated Cone

1/3 ∏ (295)2 + (295 x25) + (252) 206mm3

=6525050 ∏mm3

Cylindrical part

∏ (295)2 630

=5482570∏mm3

Total volume VT

= volume of upper truncated cone + volume of lower truncated Cone + volume of cylinder

VT= 2324491.667 + 6525050 + 54825750) ∏mm3 VT= 200041828.5mm3

Note, by conversion

1x 109mm3 = 1m3

VT= 0.200042 m^2 6dp

By capacity conversion

1m = 1000liters

0.200042 m^3 = 200.042 liters

= 200 liters

Step 2

Computation of volume of gas holder Vgh from experience, the gas holder volume ranges from 10-25% of the total plant volume

Taking 15%

Volume of gas holder Vgh

Vgh = 15% VT

0.03m3= 30liters

Steps 3

Active slurry Volume

V/ active slurry = Vtotal -Vgas holder

(0.2-0.3) m3 x 1 1000 = 170 liters

Step 4

Hydraulic retention time in days = 40

Calculating the volume of the gas collection chamber Circle diameter = 65mm, r=32.5mm

Height 285mm

∏2h = (∏ (32.5)2 285) mm3

=30103125∏mm3

1 ×109 mm3 = 1m3

= 0.945 liter

= 1 liter Gas collection chamber capacity

3.5 PLANT DESIGN | CONSTRUCTION PROCESS

The steps involved in design and construction of the biogas plant Are as follows:

1. Measuring operation

2. Marking out operation

3. cutting and trimming operation

4. Folding operation

5. Welding operation

6. Surface finishing operation

7. Assembling operation

8. Pressure Testing Operation

9. Painting

1. MEASURING OPERATION: Measuring out from the parent material the desired dimensions for the design like; length, width, diameter from the selected materials was done by the use of measuring tape, try square and venire caliper.

2. MARKING OUT OPERATION: This is the second stage; the measured parts were marked out by the use of scriber.

3. CUTTING AND BORING OPERATION: After measuring and marking operation, cutting follows. This operation was done by the use of cutting machine for cutting of sheet material, angle iron and shaft. Cutting of plastic pipe was done by the use of hack saw. Boring of holes of different sizes was done by the Use of drilling machine. The rough edges of the cutout materials were trimmed with a grinding machine to achieve smooth surface edge.

4. FOLDING OPERATION: Rolling machine was introduced at this stage. The cut sheet materials were rolled or folded to desired diameter to suite the design.

5. WELDING OPERATION: The type of welding operations employed in the construction works are welding. Arc welding machine and mild steel electrodes were used to provide a permanent joint of the required metal parts. The welding was continuous so as to achieve an airtight joint.

6. SURFACE FINISHING OPERATION: Grinding machine having a grinding wheel was used to smoothen the rough welded parts.

7. ASSEMBLING OPERATION: Coupling together all the required components to bring out the desired structure of the biogas plant was done by different mechanical assembling materials. Assembling of sections with Flange, the gas collection chamber, the shaft and bearing was done by the use of bolt and nut. Non-threaded PVC pipes were assembled by the use of adhesive bond, threaded body parts where screwed into their respective positions. While gas rubber pipes fitted to their respective places where held tight with clip.

8. PRESSURE TESTING OPERATION: After assembling all the parts, a pressure testing machine was used to carry out pressure testing operation. This was done to dictate points or leakages for proper sealing.

9. PAINTING OPERATION: This is the last operation carried out. It is a surface finishing operation, anti-rust paints were used both on inside of the plant and outside for rust prevention and beautification of the design. The inner part was painted before assembling.

CHAPTER FOUR

4.0 RESULT OF DESIGN CALCULATION AND SPECIFICATION TABLE V

S/No	**Parameter**	**Values**
1	Capacity of plant	200 liters
2	Capacity of slurry	170 liters
3	Capacity of gas holder	30 liters
4	Elected HRT	40 days

5	Vol. of upper truncated cone	2324491.66∏mm3
6	Vol. of lower truncated cone	6525050∏mm3
7	Vol. of cylinder part	54825750∏mm3
8	Selected shaft diameter	
9	Selected bearing diameter	
10	Gas valves	¼ and ½ inch
11	Selected ball valves	2 inches
12	Capacity of gas collection chamber	1 liter

4.1 PERFORMANCE TEST

4.1.1 Material Collection

200 liter type, sheet metal biogas plant fabricated at mechanical engineering fabrication center, Federal Polytechnic Nekede, Owerri, Imo state. Pig dung, cow dung, poultry droppings and kitchen waste were the four waste used for this project work. Pig dung was collected freshly from co-operative farm, Ezeakiri Naze Owerri, Imo State. Dung was collected from Egbu Slaughter house Owerri, Imo State, while kitchen waste (bio-degradable) was collected from restaurants along the school road. The kitchen waste was reduced in size, and stored in a black sealed polythene bag.

4.1.2 LOADING OF PLANT AND TESTING

21.25kg of each waste type was measured and mixed with water of the same weight at a ratio of 1:1 in a mixing container ad stirred properly for some minutes to ensure homogeneity. The slurry was charged into the digester tank. The entire valves were closed to ensure air tightness. The slurry charged was stirred twice a day. The biogas was trapped in a balloon on the day a flammable gas was observed before and after refining. For analytical purpose. The refining solutions are potassium permanganate (KmnO4) for absorbing of hydrogen sulphide (Hs and lime water (Ca (OH) 2 (aq) for CO2 absorption. Later the gas hose was connected to a burner. The plant was operated at mesophilic temperature under hydraulic retention time of 40days with the slurry having initial PH level of 7.34. The pressure reading of the tank from the day the slurry was charged to the day refining took place was taken.

The time for a burnable gas to be produced was obtained

4.1 PERFORMANCE TEST

4.1.1 Material Collection

200 liter type, sheet metal biogas plant fabricated at mechanical engineering fabrication center, Federal Polytechnic Nekede, Owerri, Imo state. Pig dung, cow dung, poultry droppings and kitchen waste were the four waste used for this.

4.1.3 Result and Discussion

4.1.3.1 Result

Operating temperature = Mesophilic

PH level of slurry = 7.34

Pressure reading of gas in the tank before refining **TABLE VI**

Days	Pressure reading
1	0.00
2	0.65
3	0.70
4	0.70
5	0.65
6	0.78
7	0.80
8	0.70
9	0.80
10	0.80
11	0.80
12	0.80

13	0.90
14	0.92

TABLE SHOWING GAS ANALYSIS RESULT

TABLE VII

Gas source		**Composition of gas before refinement**	**Moisture (%) after refinement**
Agricultural; waste (pig dung, cow dung, poultry dropping) and kitchen waste	CH_4	58.10	58.15
	CO_2	35.9	3.07
	H_2S	0.99	0.01
	O_2	0.06	0.02
	NH_3	1.01	0.05
	H_2	0.47	0.47
	Others	0.17	35.68

The eight day, a fall occurred, leakage was detected, gas pressure triggered and remained constant from the twelfth day. Increase was observed from the thirteenth to fourteenth day of refining. Gas was tested unrefined on the ninth day was observed, this indicated the presence of methane. From the table Vii, it was observed that the percentage of H_2S CO_2 was largely reduced after refining. This improved thermal content of the gas. Few days of constant pressure reading, the volume of gas that escapes from the leaking points is compensated by the volume of gas produced. Chemical reaction showing the refining process and combustion of methane.

Equation for CO_2 absorption

$(OH)_2 (aq) + CO_2 (g)\ CaCO_3(s) + H_20 (l)$

Equation for H_2S absorption

$mnO_4 (aq) + 3H_2SO_4 (aq) + 5H_2S (g)\ K_2SO_4 (aq) + mmSO_4 (aq) + 8H_2O (l) + 5S(s)$

Biogas burns in oxygen to give C02, water and energy Content in ethane is released

H4 (g) + 2O2 (g) CO2 (g) + 2H2O (g) + Energy

2. BILL OF QUANTITY

TABLE VIII

S/No	Item	Description		Quantity Unit cost #	Amount #
1	Mild steel sheet	Ø 25mm	1	4500	4500
2	Bearing	Ø 25	2	550	1100
3	PVC Ball valve	2 inches	2	440	880
4	Iron elbow	2 inches	1	750	750
5	PVC elbow	2 inches	1	300	300
6	PVC socket	2 inches	2	250	250
7	PVC pipe	2 inches		250	250
8	Gate valve brass	½ inch	1	800	800
9	Ball valve brass	¼ inch	1	800	800
10	Pipe nipple	¼ inch	9	450	4050
11	Pipe nipple	½ inch	2	450	900
12	Mild steel adopter	½ by ¼ inch	3	100	300
13	Mild steel adopter	¼	3	100	300

14	Mild steel socket	½ inch	3	100	300
15	Non-return valve	½ inch	1	700	700
16	Mild steel angle iron	4mm			3500
17	Mild steel sheet	3mm	2	13500	27000
18	Pressure gauge 2.5 bar		2	2000	4000
19	Washer		20	10	200
20	Bolt and nut	17mm	2	20	40
21	Thread tape		5	200	1000
22	Electrode		1 pack	2200	2200
23	Gasket		1	1000	1000
24	Grinding Wheel		3	500	1500
25	Cutting wheel		3	500	1500
26	Paint		1 tin	2200	2200
27	Adhesive bond		8	200	1600
28	Weighing scale		1	1300	1300
29	PVC container		3	300	900
30	Pressure testing				15000
31	Hand glove		4	500	2000
32	Nose mask		4	500	2000

33	Spanner		4	200	800
34	Clip		11	30	330
35	Brush paint		2	80	160
36	Gas test				25000
	Total :				**120710**

MISCELLANEOUS COST

This includes the cost of transportation in buying material for the construction, transportation of waste and going to the workshop.

Total miscellaneous cost = ₦6,800

LABOUR Cost = ₦18,000

Research cost = ₦45,000

Total cost of the project = total material cost + miscellaneous cost + labor cost + research cost = ₦174,310.

CHAPTER FIVE

5.0 MAINTENANCE OPERATION

The maintenance of biogas plant comprises all work necessary to guarantee trouble free operation and a long working life of the plant. Repair reacts to break down of the biogas system. All doubtful measurements have to be verified. Often, one symptom has variety of possible reasons. Maintenance service should be carried out by a trained technique.

The following maintenance should be carried out;

1. Check the plant in respect of corrosion and if necessary new protective coating material.

2. Lubricate movable parts

3. Regular gas leakage check should adopt. All parts of the plant including pipe fittings should be checked of leakage with a special leakage detector.

4. Leaking points should be properly sealed.

5. In case of strong slurry odor, attributed by sub optimal fermenting condition. Substrate in take should be reduced and PH level should be corrected with adequate means.

5.1 SAFETY OF BIOGAS PLANT

Construction and operation of biogas is related to a number of important safety issues. Taking proper precaution and safety measure have the aim of avoiding the risks and hazardous situation and contributes to ensure a safe operation of the plant.

The safety measures are:

1. Proper personal protective equipment should be used during collection and preparation of waste.

2. before initiating any repair on the gasoline, gas supply should be cut-off

3. Plant should be operated at proper temperature under standard hydraulic retention time and PH, since they have direct influence on the sanitation efficiency of anaerobic digestion process.

4. Naked light should be off the plant area.

5. Gas mask should be worn during operation and repair of plant.

6. Clear warnings must be placed on the respective parts of the pant and the operating personnel must be trained.

7. Fire extinguisher should be provided in plant area. **Construction safety**

1. 1 All the necessary safety equipment like cover all, hand glove, face mask etc. should be provided during construction.

2. Proper care should be taken during cutting, welding and handling of the machines.

3. Adequate material selection should be done to avoid explosion of the plant.

5.2 CONCLUSION

The result of this project has shown that there lie some beneficial potential in waste materials that imposes threat to life and environment through production of flammable gas from pig dung cow dung, poultry dropping and kitchen waste when they are subjected to anaerobic digestion. These wastes are always available in our environment and can be used as a source of fuel if managed properly. This project further revealed that the thermal quality of biogas produced is imposed by H_2S and CO_2 reduction when refined and so can serve as a substitute for petroleum based cooking gas.

5.3 RECOMMENDATIONS

Improvements are always the norm in scientific projects like this and as such, in order to make the system better and to operate efficiently, we recommend the following:

1. Effort should be made at designing a biogas plant that will operate on continuous feeding.

2. 2 Point for thermometer fitting should be provided in subsequent plant design for temperature check.

3. proper rubber seal should be employed where necessary

4. Visual point should be incorporated on the design.

5. Fund should be made available by our educational system to enable students properly finance their project. Finance is a major factor in the realization of any project.

1. Biogas Digester

2. Purification Tank Potassium per Magnate 3. Lime Water

4. Flange

5. Flange Bolt

6. Digester Stand

7. Discharge Valve

8. Discharge Hose

9. Charging Valve

10. Charging Funnel/ Hopper

11. Stirrer Bearing

12. Starrer

13. Pressure Gauge

14. Collection Valve

15. Tank Valve

16. Gas Collection Hose

17. Gas Collection Chamber

18. Pure Gas Collection Tank

REFERENCE

1. Alvearz R; Villcas. Liden G (2006) Biogas production from ulama and cow manure at high altitude. Biomass bio energy 30:66 75

2. AOAC (1990): official methods of Analysis: Association of Analytical Chemists. 14" Edition, Washington UJSA, 22209.

3. Sambo A.S, B. garba, and B.G Dansheh (1995) "Effect of some operating parameter on biogas production rate" Renewable energy, Vol. 6, no 3 pp. 343 - 344, view at sscopousl.

4. Demas TZD, Stams, A.J.M, Reith, J.H, Zeeman G, (2003) Methane production by anaerobic digestion of waste water and solid wastes in : Reith, J.H Wryfels, R.H. Barten, H. (Eds). Bio-methane and Bio hydrogen. Status and perspective or biological methane and hydrogen foundation. Petten, The Netherlands, pp 58 - 102.

5. Balch E.E (1979), microbiology Rev pp 43, 260

6. Energy commission of Nigeria (1998); rural renewable energy needs and five supply technologies. Pp 40-42.

7. "European Biogas Barometer" Eurobserver. Retrieved 7 November 2011.

8. FAO (1979), China: Azolla Propagation and Small Biogas Technology Agricultural Service Bulletin No 41 FAO ROME.

9. Guruswamy T., Kannan N., Kumar V., (2003). Design. Development and evaluation of biogas using selected biomaterials as feed stock UE.J., 84:65

10. Beaker H.A (1936). Appi, Mikrobiol. Pp 7 420

11. Http:Flle://A: Design - Tutor.htm, 2003. Waste digester Design, University of Florida Civil Engineering P.3.

12. Indiani M.A, Laura R.D 1971. Increased production of biogas from cow dung by adding other agricultural waste materials .J. Sci. Food Agric, 164 - 167.

13. Itodo I.0, C.E Onuh and B.B Ogar (1995). Effect of various total solid concentration of cattle waste of Biogas yield. Nigeria Journal of Renewable Energy vol. 13 pp 36- 39.

14. Meher K.K, D.R Renade, and R.V Gardre (1990) factors affecting biogas production reds ind, Nepal Pp 115 - 117.

15. Singh, R., Jain M.K., Tauro P, 1983 Pre - digestion to improve production of biogas from cattle wastes P 167 - 174.