THE PRODUCTION OF METHANE GAS AND COMPOST FROM ORGANIC WASTE

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NOVEMBER 2004

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SUBMITTED TO THE DEPARTMENT OF CHEMICAL ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA,

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE

AWARD OF BACHELOR OF ENGINEERING DEGREE (B. ENG) IN

CHEMICAL ENGINEERING

NOVEMBER 2004

DECLARATION

I hereby declare that this project was done by me under the guidance and full supervision of Mr. U. G. Akpan of the department of Chemical Engineering, Federal University of Technology, Minna, Niger State. I further state that this work has not to the best of my knowledge been presented elsewhere for any purpose whatsoever.

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(Student)

23 . Nov . 2007
Date

CERTIFICATION

This is to certify that this project was carried out by AGU IFEOMA ADA (98/6839EH) in the Department of Chemical Engineering, Federal University of Technology, Minna, Niger State.

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Date

EXTERNAL SUPERVISOR

Date

DEDICATION

This work is dedicated to the memory of my late father, Mr. Eric Agu, whose loving care knew no bounds. May his soul rest in perfect peace.

ACKNOWLEDGEMENT

This work wouldn't have been possible but for the Almighty God, Thanks for keeping me alive and giving me all the strength to put this work in order.

The assistance of my supervisor, Mr. U. G. Akpan, won't go unnoticed within his tight schedule, he still took the pains to correct and improve the manuscript. His comment and review of the work has been most valuable.

The presence of my head of department, Dr. F. Aberuagba, would be greatly treasured, his advice and helpfulness throughout my stay in department.

My profound gratitude goes to all the lecturers of chemical engineering d3epartment who through one way or the other contributed to my stay in the department.

I am greatly indebted to my mother, Mrs. Nneka Agu, whose moral and financial support saw me through the finishing of this work, not also forgetting my siblings, Vivian, Eric (Jr), Uche, and Chioma, whose encouragement kept me focused.

My profound gratitude goes to the Udofia's family, Ola's family, and Onumeagbu's family, Ufaruna's family, Oguma's family, the Mbubo's, Barrister N. D Nkire.

I will also like to thank my friends, Harry, Rose, Bamaiyi, Muyiwa, Damaris, Victor, Gloria, Ichehor, Mathias, Alhamdu, Rotimi, Mike, Mayowa, Imade, Nancy, Maxwell, Emmanuel, Tope, John, Godwin, David, Alozie, Daniel, Femi, Arome, Dare, Amechi, Izu, Kola, Vicky, Osawe, Chinwe, Segun, Funrunsho and Bola.

ABSTRACT

The production of biogas and compost from organic waste is gaining in the third word countries. This research work is based on using organic waste to produce methane and compost under operating condition.

Poultry dropping were used for the experiment and amount of gas yield was recorded. For the waste a laboratory digester was employed. The operating conditions for this digestion are: temperature-25°C, pH is within the range of 6.8 to 7.0. From the experiment and results, it shows that poultry dropping can be used for the production of gas and compost under operational conditions.

It emphasizes practicable environmental option available to Nigeria in the management and treatment of waste.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

Waste can be defined as any material whose usefulness has been fully explored and may no longer work for the purpose it was acquired. In another form it is an unwanted material. If waste is not desired, then what comes to mind is doing away with it. The process of getting rid of waste is what leads to the elegant topic of waste disposal and management.

Over the years, especially in this part of the world, different crude have been adapted in the process of waste disposal, some of which have serious environmental and ecological effects.

1.1 General Background

Generation of solid waste is a daily affair to every living soul worldwide and its management is a problem to mankind globally. Every country works out the best suitable methods based on its local resources and technology.

Introduction of local technology into solid waste management in Nigeria will bring the system under a good control and make the national policies in the industries workable. Many of what has been referred to as waste will be converted through the waste treatment process to raw material for the industries, thereby contributing to industrial and economic growth of our nation, and serving as tool for sustainable development.

In dealing with waste management problem in Nigeria, there is a need to understand its nature and type of resources available for the treatment of such waste. A survey conducted by J. Sandra (1982), revealed that an average of 0.46kg of solid waste is generated by every Nigerian per day. Considering the fact that factors used by J. Sandra to arrive at that figure have improved tremendously, the average rate of generation obtainable in Nigeria now is between 0.5kg to 0.6kg. From experiment, not less than 65% of our domestic waste is vegetable while the rest 33% are of plastic, rubber, cotton, leather, metals and glasses etc. From the analysis above, it is clear that the management of organic waste will considerably reduce waste problem and even provide a good means of income. As such this research projected is centered towards producing useful products from organic waste. Based on the type of resources that is available I n Nigeria, two methods are considered; the conversion of organic waste to compost and the conversion of organic wastes to biogas (methane). Using these methods will not only ensure a reliable system for waste disposal but will also consider the safety to life and environment.

The organic waste management consists of various stages from collection to disposal through to treatment and recycling or generation of new products. The conversion of organic waste into compost is a biochemical process, which involve decay of organic matter by aerobic organisms being monitored under appropriate design and process operating conditions.

Composting preparation of solid waste include preparing the refuse and degrading the organic matter present by introducing aerobic micro-organisms. The process involved in composting of solid waste include presorting of waste, grinding, decomposing, curing, blending with additives, bagging and then finally sending it to the market. The compost which is an organic fertilizer is applied to the soils, thereby increasing plant yield.

The production of methane from organic waste is a technological advancement in biogas technology. Methane which serves as a source of energy generated from waste, is used mostly as fuel. The technology used in the production of methane gas from organic waste (ie biogas technology) involves an anaerobic fermentation process by which there

Is an evolvement of flammable gas (methane) and offensive odour are eliminated along with the destruction of pathogens in the process. The evolved gas, which is methane, serves as a fuel which the residual sludge of the fermentation process can be used as fertilizer. One of the relevance of this process is that it can serve to control pollution and sanitation because of its deodorizing and sterilizing effects the biogas technology can be produced from a variety of biomass, including waste water, sewage sludge manure, solid waste and energy crops. The production the production from waste is essentially the conversion of volatile fatty acid and alcohol to mtethane and to a limited extent, carbon dioxide and traces of hydrogen sulphide. The conversion is carried out by strictly anaerobic and acid sensitive methanogens especially m ethanol –bacterium methanocous, methanobacilus, and methanosacana species which are basically the most metabolically versatile organism known at present.

1.2 Objective and Scope

The basic objective and scope of this project is to convert organic waste into useful products such as compost biogas (methane). This research project is also to emphasize the best practicable environment options (BPEO) available to Nigeria in the treatment and management of waste.

1.3 Justification

In analysis the justification of this project, other means of waste management especially for organic waste is looked into with a view of comparing the and its effect and hence bringing out the relevance of embarking on this project. Other methods used in organic waste disposal use incineration and land filling in incinerators of conventional design, refuse is burnt on moving grates in refractory –lined chambers; combustible gases and solids they carry are burnt in secondary chambers. Combustion is 85 to 90 percent complete for the combustible materials. In addition to heat, the product of incineration include the normal primary products of combustion – carbon dioxide and water as well as oxide of sulphur and nitrogen and other gaseous

pollutants; non-gaseous products are fly ash and unburned solid residue. Wet scrubbers, electrostatic preceptors and bag filters often control emission of fly ash and other particles.

Though the modern incinerators have been able to reduce the effect of environmental pollution but without increasing the cost of its purchase. Moreover incineration which reduces the thermal capacity of the refuse does not allow for utility of waste since by product of incineration is regarded as been useless. Another great disadvantage of using the incineration method as an organic waste management technology in Nigeria is that the technology is foreign and may require ordering for the parts which are not locally produced and even employment of foreign expatriates for the installation and maintenance of the incinerator.

Sanitary landfill is the cheapest satisfactory means of disposal, but only if suitable land is within reach of the source of the waste. A great disadvantage of using sanitary land fill in Nigeria is not unconnected to the fact that waste production are more in the cities where there is no land available to be used as land fill and in the rural areas where there is available land amount of waste production is low. Therefore, embarking on landfill as a major means of waste management in Nigeria, is cost ineffective; moreover land fill may cause an explosion if the amount of gas pressure build-up in it is so high. Pollution of surface and groundwater are also likely consequences of adopting landfill method of waste disposal. On the other hand, composting and production of biogas from organic waste, which is a resource recovery method of waste disposal ,is simple elegant and cheap. Safe and clean methods can be applied even domestically. It provides an option of regenerating old product. Since it emphasizes conversion of organic waste into useful materials, it is best practicable environment option (BPEO) available to us in Nigeria.

CHAPTER TWO

THEORETICAL PRINCIPLES/LITERATURE SURVEY

2.1 Fermentation

Fermentation process is common to the production of biogas and compost from organic waste. It is one of the oldest chemical processes conducted by mankind. Fermentation literally may be defined as a metabolic process in which chemical changes are brought about in organic substrate through the activation of enzymes secreted by the microorganisms. Fermentation has basically being carried out on a large scale to manufacture consumer products such as beverages, dairy products, fruit juices, alcohol baking products, etc among other food products in the processing industries.

Fermentation changes are known to be brought about by the presence of microorganisms, which are known to exist naturally. These micro-organisms which are important accessories in fermentation are limited because the microbial dissimulation they effect are of most diverse kinds and so the ones which are of interest are only employed. Microorganisms differ greatly in morphology, size and manner of reproduction, reaction with free oxygen, growth requirements, ability to attack different substrate, and in other noticeable ways.

2.1.1 Types of fermentation process

Fermentation process to be employed is generally dependent on this type, which of two basic categories namely anaerobic and aerobic fermentation.

Anaerobic fermentation is the dissimulation in which atmospheric oxygen is not involved but other substances such as aldehydes or pyretic acid serve as hydrogen acceptor. Examples are the production of alcohol, biogas etc. On the other hand aerobic fermentation is the dissimulation, which requires this oxygen to act as a hydrogen acceptor e.g. acetic acid, citric acid fermentation and also compost making. Kofler, J. H, Fermentation Process, Pergamen Press, 1962.

2.2 Composting

2.2.1 Introduction

Composting is the decomposition of plant remain and other once living materials to make an early dark crumbly substance that is excellent for adding to house plants or enriching garden soil. It is the way to recycle yard and kitchen wastes and is on critical step in reducing the volume of garbage needlessly and unobtrusively even indoors in apartment building and condominiums. Composting is not a new idea. In the natural word, composting is what happens as the leaves pileup on the forest floor and begin to decay. Eventually the rotten leaves are returned to the soil, where living roots can finish the recycling process by reclaiming the nutrient from the decomposed leaves.

Composting may be at the root of agriculture as well. Some scientist have speculated as early people dumped food waste in piles their camp, the waste rotted and were terrific habitat for the seeds of any food plants that sprouted there. Perhaps, people began to the dump heaps were good places for food crops to grow, and began to put food there intentionally. For indoor composting, vermic-composting (using earthworm to recycle waste) is usually very useful.

2.2.2 Innovative uses of compost

2.2.2.1 Bioremediation and pollution prevention

Each year agricultural effluents industrial residues and industrial accidents contaminate surface water, soils, air, streams and reservoir. A new compost technology known as compost bioremediation is currently being used to restore contaminated soils, manage storm water, control odours and degrade volatile organic compounds.

2.2.2.2 Disease Control For Plants and Animals

Compost technology is a valuable tool already being used to increase yield by farmers interested in sustainable agriculture. Now, professional growers are discovering that compost-enriched soil can also help suppress disease and ward off pests. These beneficial uses of compost [illegible] growers save money, reduce their use of pesticide and conserve natural resources. In the poultry industry, composting has also become a cost effective method of mortality management, it destroy disease organisms and create a nutrient-rich products that can be used or sold.

2.2.2.3 Erosion Control, Sorf Remediation and Landscaping

Compost has being viewed as a valuable soil amendment for centuries. Most people are aware that the use of compost is an effective way to improve plant growth.

Compost-enriched soil can also reduce erosion and nutrient runoff, alleviate soil compaction, and help control disease and pest infestation in plants. These beneficial uses of compost can increase use of chemical fertilizers and conserve natural resources

2.2.2.4 Composting of Soil Contaminated by Explosives

Soils at more than 30 munitions sites across the United States are contaminated with explosives. Using this process, contaminated soil is excavated, mimed with other feed stocks and composted. The end product is contaminant-free humous that can enhance landscaping and horticulture applications. Composting cost traditional method used for these clean ups

2.2.2.5 Reforestation, Wetlands Restoration and Habitat Revitalization

The native plants within a habitat contribute much more to their surrounding than mere beauty. They provide food for nearly every other member of the habitat. They enrich the air through the gases they produce and mineral they exchange. Even when plant dies they continue to support grasses, flowers and trees by becoming the human or organic material in soil, that is so vital to living plants. Original wetland plants can be restored with the use of compost during planting. Compost provides tree seedlings added rigour for survival and growth.

2.2.3 Compost Production

The need to provide suitable means of disposing organic waste by making it reusable has led to compost production. The compost is produced from aerobic fermentation. It can be produced alongside with biogas.

2.2.3.1 Compost Fundamental

Good composting is a matter of providing the proper environmental conditions for microbial life. Compost is made up by billions of microbial (e.g. fungi, bacteria etc) that digest the yard and kitchen wastes, if the pile is cool enough, worm, insects and their relatives will help out the microbes. All of these would slowly make compost out yard and kitchen waste under any condition. However, like people, these living things need air, water and food. If the compost system is well maintained to supply the needs of microbes organic wastes will be turned into compost much quickly. The following should be noted when preparing compost.

I. **Air:** Composting microbes are aerobic and such they can't work well unless provide with air. In the absence of air, aerobic (non-air needing) microbes take over the pile. They cause slow decomposition and tend to smell like putrefying garbage.
   For this reason it is important to make sure that there are plenty of air passageways into the compost pile. Some compost ingredients such as green grad clippings or wet leaves mad down very easy into slimming layers that air cannot get through. Other ingredients, such as straws, don't mat down easily and are very helpful in allowing air into the center of the pile. To ensure adequate aeration for the pile and exclude air are thoroughly broken down and mimed.

II. **Water:** Ideally the ingredients to be composted should be moist as wrung-out sponges to fit the needs of compost microbes. At this moisture level, there is film of water, coating every particle in the compost system, making it very easy for microbes to live and disperse themselves throughout the pile. If the compost system is dried than this, it won't be a very good microbial habitat and composting would be slowed significantly. But if the pile is a great deal wetter the sodden ingredients will be so heavy that they will tend to mat down and exclude air from the pile, again slowing the composting process and perhaps creating anaerobic odour problems. If dry organic wastes are used, then it should be moistened before being added to the compost pile, but wastes such as kitchen fruits and vegetables generally have plenty of moisture.

III. **Food:** In broad term, there are two major kinds of food that composting microbes need; the 'brown' and the 'green'.

Browns are dry and dead plants materials such as straws, dry brown weeds, autumn leaves and wood chips or saw dust. These materials are mostly made up of chemicals that are just long chains or sugar molecules linked together. As such, these items are source of energy for the compost microbes because they tend to be dry, brown often need to be moistened before they are put into a compost system.

Greens are fresh (and often green plants) materials such as green weeds, kitchen fruit and vegetable scraps, green leaves, coffee grounds, tea bags, fresh horse manure etc. Compared to browns, greens have ore nitrogen in them. Nitrogen is a critical element in amine acids and protein can be thought of as a protein sources for the millions of multiplying microbes.

A good mix of browns and greens is the best nutritional balance for the microbes. This mix also helps out with the aeration and amount of water in the compost system. Browns for instance tend to be bulky and promote good aeration. Greens on the other hand ore typically high in moisture and balance out the dry nature of browns.

IV. **Temperature:** A common misunderstanding about compost system is that they must be hot to be successful. However, if there is good aeration and moisture and the proper ingredients mix, the composting system will be decomposed fine at a temperature of 10°C and above. Generally, hotter compost system will decompose faster. Hotter compost means more microbes or conditions that allow the microbes to have faster metabolism and therefore a faster composting process.

2.2.4 Composting System

These are tremendous numbers of options for containing the compost. The use of volatile or tumbling systems are industrially acceptable while composting is acceptable for domestic production of compost. The use of digesters, which is used in the production of both biogas and composts, is more commonly used in the industry.

2.2.5 Raw materials for Compost

The following items are list of material that can be used as a raw material for making compost grass/lawn, chipping, hay, kitchen wastes, leaves, manures, straws, weeds and other garden wastes, wood chips and saw dust. However, the following should be avoided when making compost for various reasons ranging from toxins, plants or human diseases, weed troubles etc. chemically treated wood products, diseased plants, human waste, meat, bone and fatty food waste, precious weeds and pet waste. "Taken from composting to reduce the waste stream, Northeast Regional Agricultural Engineering Service".

2.3 Methane

2.3.1 General Description

Methane is a colourless, odourless gas with a distribution in nature. It is the principal compost of natural gas, a mixture containing about 7.5% methane (CH_4), 15% ethane (C_2H_6) and 5% other hydrocarbons, such as propane (C_3H_8) and butane (C_4H_{10}). At room temperature, methane is a gas less dense air. It melts at −183°C and boils at −164°C. It is not very soluble in water. Methane is combustible, and mixtures of about five to fifteen percent in ore are explosive. Methane is not toxic when inhaled, but it can produce suffocation by reducing the concentration of oxygen inhaled. A trace amount of smelling organic sulphur compounds tertiary-butyl mercaptan, $(CH_3)_3$ CSH and dimethyl sulphide, CH_3-S-CH_3 is added to give commercial natural gas a detectable odour. This done to make gas leads readily detectable. An undetected gas leak could result in an explosion or asphyxiation. In the chemical industry, methane is a road material for the manufacture of methanol (CH_3OH), formaldehyde (CH_2O), nitromethane (CH_3NO_2), chloroform (CH_3Cl), carbon tetrachloride (CCl_4), and some freons (compounds containing carbon and fluorine and perhaps chloride and fluorine are triggered by light. When exposed to bright visible, mixtures of methane with chlorine and fluorine react explosively.

The principal use of methane is as a fuel. The combustion of methane is highly exothermic.

$$CH_{4(g)} + 2O_{2\,(g)} \longrightarrow CO_{2\,(g)} + 2H_2O_{(l)} \qquad H = 89kJ$$

The energy released by the combination of methane, in the form of natural gas, is used directly to heat homes and commercial buildings. It is also used in the generation of electric power. During the past decade, natural gas accounted for about 1/5 of the total energy consumption worldwide and about 1/3 in the United States.

Before it is distributed methane gas usually undergoes some sort of processing, usually the heavier hydrocarbons (propane and butane) are removed and marketed separately. Non-hydrocarbon gases, such as hydrogen sulphide must also be removed. The cleaned gas is then distributed throughout the country through thousands of miles of pipeline. Local utility companies add an odorant before delivering the gas to their customers.

2.3.2 Production

The needs for the generation of energy through alternative means has led to the special attention given to biogas technology in many countries. The concerted efforts used to exploit solar energy and industrial waste for better energy resources and fertilizer production shows the rate of attention concentrated in finding alternative energy source.

2.3.2.1 Raw Material

The treatment of waste by anaerobic digestion gives an exhaustive list of potential waste, which can be treated by the process. The characteristics of the analysed wastes will determine the relative digestibility of the organic materials present and the pollution load as measured by the chemical oxygen demand (COD), which can be reduced to 20-99% conversion. This conversion can be obtained by oxidizing the waste with a boiling acid dichromate solution. The process oxidizes almost all organic components to CO_2 and H_2O, the reaction usually processing to more than 95% completion.

The advantage of the COD measurement is that they are obtained quickly (within 3 hours) but the disadvantage is that it does not give information on the waste proportion which can be de-oxidized by bacteria or the rate at which bio-oxidation may occur. The higher the percentage reduction in COD, the more the rate at which methane is produced. Thus, good reduction in pollution load is usually associated with biogas production.

2.3.2.2 Operating Condition of Biogas Digestion for Methane Production

Biogas digestion is a microbial process and it therefore requires the maintenance of suitable growth condition for biogas producing bacteria. The provision of nutrient, oxygen, optimum temperature, pH and other environmental factors are vital for the activities of living bacteria. Only if this condition are met will the normal bacteria activities and subsequent gas production will be assumed.

The conditions include;

i. Strict Anaerobic Environment

All microbes that plays an important role biogas digestion are strictly anaerobic. They include acid producing bacteria and methane producing bacteria. The later are so sensitive to oxygen that digestion would be inhibited by an eve slight test of oxygen. The term oxidative reduction potential (ORP), is used to indicate the concentration of electron in aerobiosis and anaerobiosis. The optimum ORP for methane producing bacteria is 330 mV. When the ammonia-nitrogen concentration increases the volatile acid concentration and the ORP decreases but the methane content rises. With the charging of raw material, a lot of oxygen enters the digester, raising the ORP. However, during an initial aerobic phase, oxygen is quickly exhausted by anaerobic (oxygen loving bacteria) resulting in an attainment of an anaerobic environment. Facultative anaerobic bacteria too can consume some of the oxygen then play an active role in creating an anaerobic environment. As long as the digester is sealed, the coordinated effect of various bacteria can stabilize the ORP of biogas, fermentation at an optimum level.

ii. Suitable Fermentation Substrates

In biogas fermentation process, all organic materials, except mineral oil and lignin as suitable substrate, some organic materials such as animal manure, sludge and the effluent of fermentative industries or leather factories are more easily digested. Materials that are known to contain lignin should be reacted before used in a digester because its cellulose in carbohydrate.

iii. Maintaining an Optimum Temperature

In other to make fermentation of bacteria work at the required maximum efficiency a suitable temperature range is necessary (Ryther, J. H., 1981). There is a close relationship between the biogas fermentation and temperature. At a certain range, the higher the temperature, the higher will be the gas production. Two groups of bacteria are known to digest organic matter; those that work at high temperature (described as the thermophylic bacteria) and those that woks at relatively lower temperature (described as mesophylic bacteria). Their gas production occurs within different temperature ranges. Different set of acid producing and methane producing bacteria thrive in the respective temperature ranges.

2.3.2.3 Purification of biogas

The biogas process, which produces methane along with other gases, is known not be pure methane (United Nations Environmental Program, 1981) . In the process, the main impurities are CO_2 and H_2S among other gases. Carbon dioxide, a gas known not to support combustion reduces the combustion heat thereby making it corrosive. For this reason, the purification of biogas is important to standardize the methane gas produced for use. To design a purification system for biogas generated from digestion of organic waste it is necessary to have enough experimental data and information about the absorption of impurities in the biogas.

Types of Purification System

In other to ensure the purity level of methane gas to its standard state so as to suit the house hold use and electricity generation purpose, the design for purification to measure the amount and degree of the system is essential. Though the two types are different, but on the bans of the result obtainment either from small scale large scale (ranch type) system. The following brief description and analysis of the designs and operating conditions of the two types;

(a) Purification system of household type

The suggested equipment for this system is shown in fig 2.1 and fig2.2 the flow rate of methane gas for the burner is large the use of large amount of methane gas for the burner is large, the use of large amount of gas in a short time is necessary. It would better if a storage tank is provided between the MEA purification unit and burner. The biogas will be treated by MEA purification unit gradually and be stored in the tank, even during the time when methane gas is not used. In order to increase the pressure of the gas mixture in the digester. It is worthy of note that the methane storage tank may not be needed if methane gas is used as small flow rate. The purification system for house hold use is different from that used in the industry which operate usually at a high pressure. The pressure of biogas from the digester is low, but it is not convenient and economical to include a compressor in small purification system. A suggested design is to use a part long axial small diameter cylinder as the absorption column. The biogas enters the bottom distributor and bubbles through the column where CO_2 and H_2S are absorbed. The purified biogas exists from the top of the column. The purification units are as shown in fig 2.2

b) Purification system of the Ranch type; the production of biogas on a massive large scale followed by effective purification measure whose the produced gas on a more acceptable consumption level for use as cooking and electricity gene ration purposes. The use of the purified gas as energy source for electric generators requires the following measures;

i. Complete removal of H_2S to prevent corrosion from occurring in the generator by the addition of a secondary H_2S absorber.

ii. The use of a compressor to increase the pressure and flow rate for the purification system is shown in fig 2.3. The compressor will produce enough pressure head to increase the pressure in the storage and the flow rate of biogas for the MEA purification unit and secondary H_2S absorber. The compressor is located after the secondary H_2S absorber to avoid corrosion. A water removing unit is located between the MEA. Purification unit and the H_2S absorbed to removed water vapour and to increase the efficiency of the absorption and the life of absorbent in the H_2S absorber.

2.4 Digester

Digester system essentially consists of holding tanks of simple to complex design, within which a series of biological reaction decompose organic materials present in waste to methane, carbon dioxide, water, compost and a number of other simple chemicals. No simple design of digester can be considered as ideal, since many factors affect the design and operation.

Digesters are of five types namely; batch, continuous, high rate contact, filter and expanded bed. There are hybrids of all these type of digester and rapid growth in technology has result into the emergence of more variations. However, a number of basic designs are appearing to perform will and are commercially viable not only for the manufacturer but also for the operator. In other words, a digester is a plant that produces methane and manure simultaneously.

2.4.1 Designing and Development of Digester.

In recent time, conceptual development of digesters are noticeable, they include the following;

(a) plug flow system; shows promise of higher digestion rates than conventional mixed system .

(b) two phase anaerobic fermentors; this shows promise for improved efficiency over conventional digesters because the separation into phases results in a decrease in total digester size. The various components of the system were all well integrated and the system functions well.

(c) Up –flow reactors; this also shows promise for higher digestion rate than the conventional mixed system because the reduction of the active biomass in the reactor permits a very substantial reduction in the retention time for treated waste.

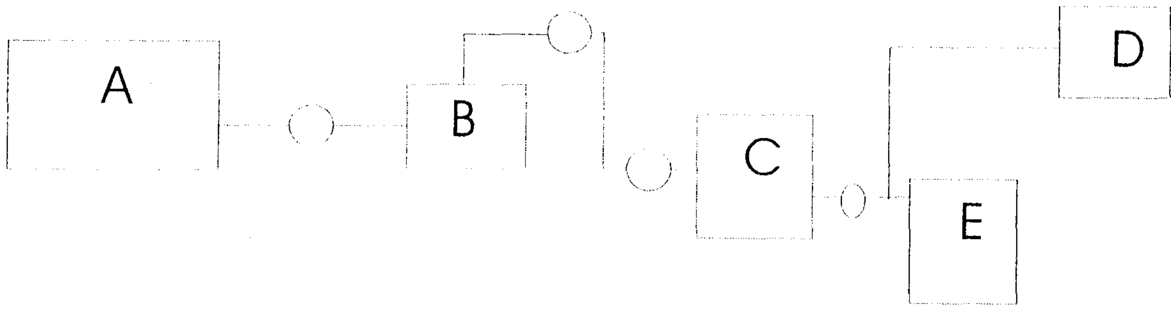

Fig. 2.1 Purification System For Household Use

A – Digester

B – MEA Column

C – CH_4 Storage Tank

D – Warm Water Heater

E – Burner

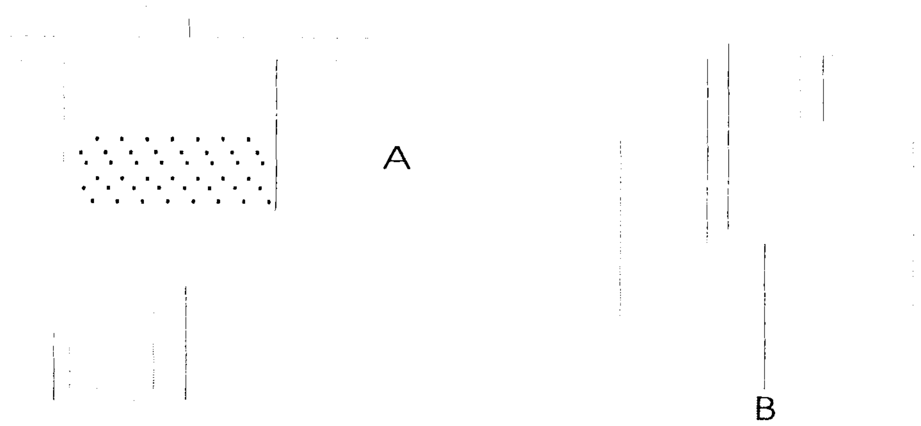

Fig. 2.2 Types of MEA Column

A – Porous Distributor

B – Perforated Tube

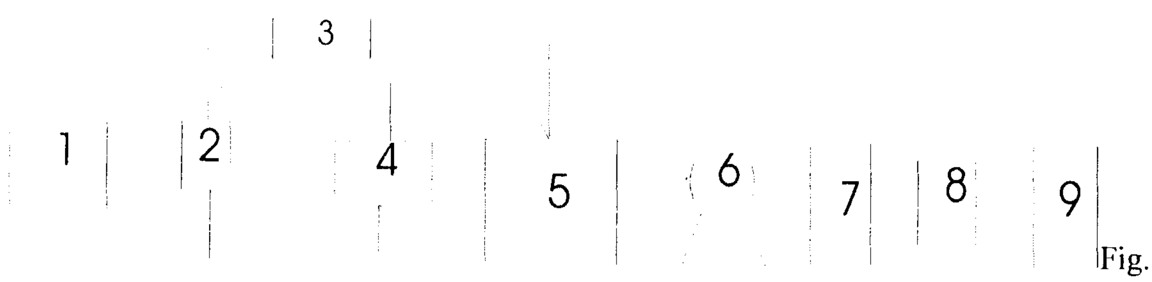

Fig. 2.3 Purification System For Power Generator

1 – Digester

2 – MEA Column

3 – Dehydrator

4 – Regenerator

5 – Secondary Hydrogen Sulphide tank

6 – Compressor

7 – Dehydrator

8 – Storage Tank

9 – Power Generator

CHAPTER THREE

EXPERIMENTAL PROCESS REVIEW

3.1 Introduction

There are basically two process for obtaining compost and methane from organic waste. The processes are parallel and series processes.

The parallel process produces methane and compost separately and independently. The compost is prepared from fresh organic waste an so also is the methane gas. This type is used domestically.

The series process type produces methane first, followed by compost. After the methane obtainable has been produced, the system is vented and special worm cultures are introduced into the system to produce compost (organic fertilizer). This is the type of process used industrially.

3.1.1 Materials

3.1.1.2 Collection of Samples

The poultry dropping was collected from a poultry house in a polythene bag and taken to the laboratory where it was used.

3.2 Experimental process

This experiment is to determine the amount of methane and compost that can be obtained from given amount of organic waste (poultry dropping). In carrying out this experiment the parallel process method of producing methane and compost was used.

3.2.1 Apparatus

The apparatus to be used in the process experiment are

i. Organic waste (Poultry dropping)

ii. Measuring cylinder

iii. Tap water

iv. pH meter

v. Lime water

vi. Digester

3.2.2 Experimental Process of the Production of Methane from Organic Waste.

In this experiment, poultry droppings were used to determine the amount of biogas that can be produced per day under laboratory conditions. Two glass bottles were connected in series by glass tubing. These were made such that one was dark, this served as the digester and it is done mainly to meet the requirement of the methane bacteria. The other glass which was left clear was made to serve as the gas holder as well as the water overflow collector. The digester was charged with 250g of slurry, 100g of manure an d 150g of water in the ratio of 1:1.5. The gas holder was completely filled with water. The stopper filter with the interconnecting glass tubing were inserted into the bottles. Gas evolved from digester pushed out an equal volume of water from the gas holder. The volume of the gas determined from the volume of water displaced and this is read from the measuring cylinder which has been previously calibrated. Measurement of the gas was done every day after which the gas collected was allowed to escape into the air. The gas holder was refilled with water after each reading has being concluded. The temperature in the room was generally kept at 25°C through the run. The pH was also measured by dipping the pH meter into the solution. The pH recorded was within the range of 6.8 to 7.0, the digester temperature was 26.3°C.

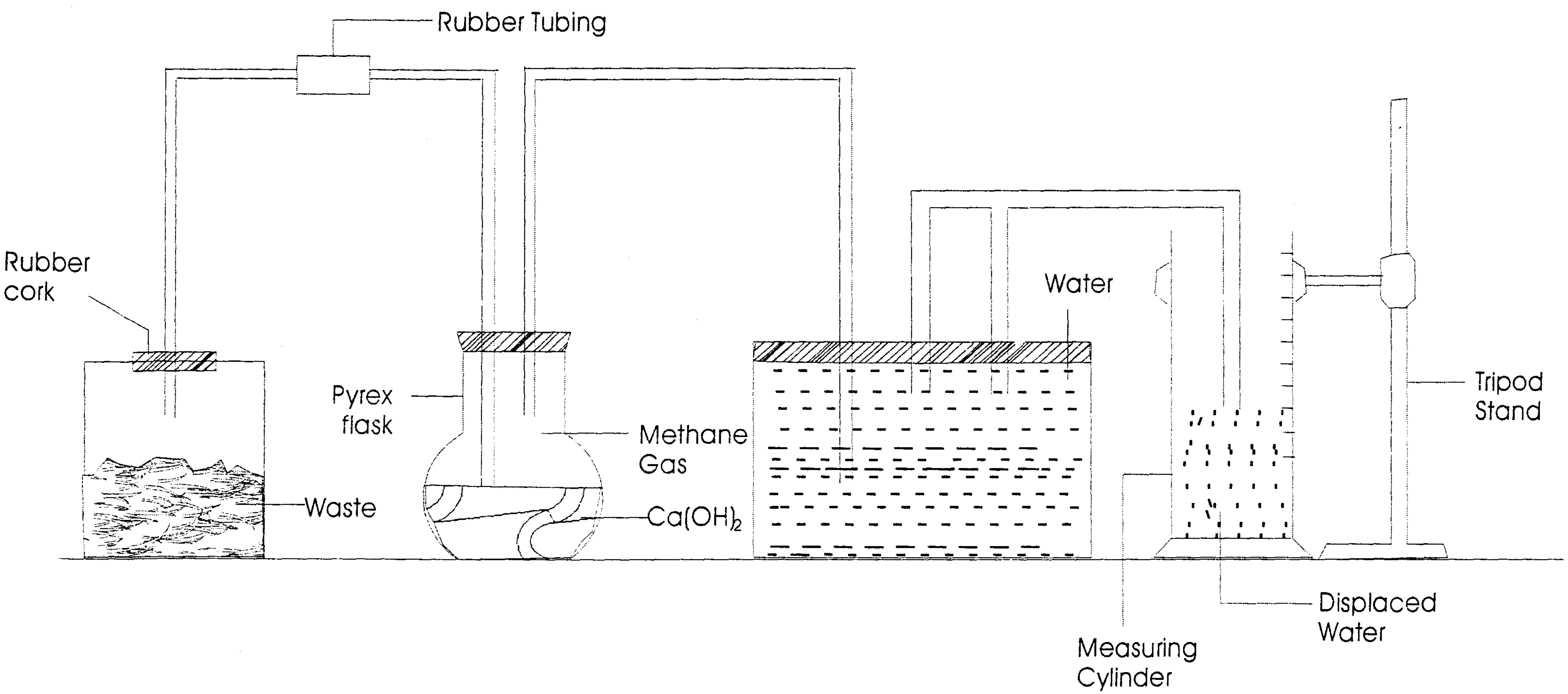

Fig.3.1 Laboratory Bench Digester with Stop valve

3.2.3 Experimental Process of the Production of Compost from Organic Waste

In this experiment, poultry dropping was used as waste. The experiment was made to obtain compost under laboratory conditions. Water just enough to moisten the surface of the waste was added daily, while the mixture is being stirred. Earthworms were introduced into the beaker containing the waste to enhance faster decomposition. The temperature in the room was maintained at 25°C throughout the period of experiment by ensuring that, there is no additional heat source apart from the normal atmosphere heat. This produced a sample.

3.3 Analysis for Methane and Carbon dioxide

This was carried out using a known volume of syringe to collect the biogas from the outlet tubing of the digester and injected into 30% Calcium Hydroxide to form calcium carbonate and this is indicated by a drop in the volume of calcium hydroxide. After this is done the syringe is brought close to a Bunsen burner which is ignited and burning is readily noticed. This indicated that only methane gas is left in the syringe after CO_2 has been absorbed by reacting with the lime water.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Experimental Result

The results obtained from the experiment for a period of 30 days at a 5-day interval is as shown in Table 4.1.

Table 4.1 Experimental Results

Days	Parameters	Poultry droppings (g)
0	A	283.65
	B	308.65
	C	284.02
	D	284.44
5	A	283.65
	B	308.65
	C	287.82
	D	284.53
10	A	283.65
	B	308.65
	C	287.38
	D	284.52
15	A	283.65
	B	308.65
	C	287.38
	D	284.52

20	A	283.65
	B	308.65
	C	286.79
	D	284.42
25	A	283.65
	B	308.65
	C	286.30
	D	284.30
30	A	283.65
	B	308.65
	C	285.84
	D	284.28

A = Weight of dish

B = Weight of dish + Sample before drying

C = Weight of dish + Sample after drying

D = Weight of dish + Sample after ashing

Table 4.2 Analytical Result

Days	Vs remaining (S_1), g/L	Vs removed (S_o-S_1), g/L
0	25.00	0
5	24.71	0.20
10	24.58	0.42
15	24.23	0.72
20	23.79	1.21
25	23.34	1.65
30	22.98	2.02

Table 4.3 Methane Productions

Days	Daily methane production, m^3/day
0	0
5	0.006
10	0.008
15	0.014
20	0.024
25	0.033
30	0.040

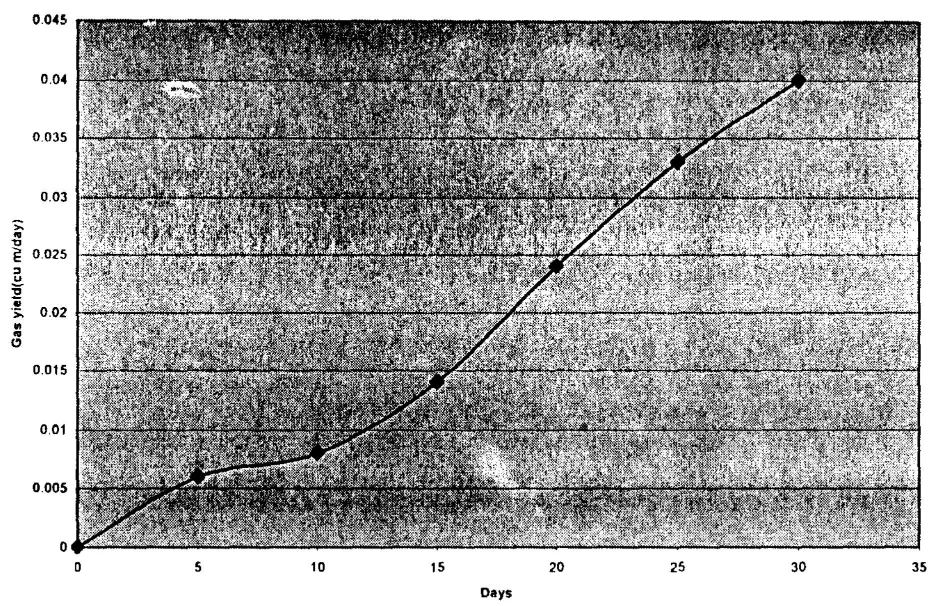

Fig. 4.1 Methane Production

4.2 Discussion of Results

From the graph, it can be observed that the production of gas started after 24 hours, for the first day there was no gas yield. There gas yield increased with time within a certain range of 0.001 to 0.007. The gas produced for the first 7 days was mainly methane. Methane production would have better results, if the glass bottle serving as biogas digester should be made darker by using a black polythene bag. The digester should be shaking each day to loosen up gas bubble trapped in the digester.

CHAPTER FIVE

CONLUSION AND RECOMMENDATION

5.1 Conclusion

Methane gas in the form of biogas can be produced from organic waste, this is also applicable in the production of compost. This can be optimized by converting the organic waste under optimum temperature. The production of organic waste into methane and compost is the best practicable environmental option (BPEO) in Nigeria. The extent of biodegradability was found to be 10% for the poultry dropping.

5.2 Recommendation

A. The application of the production of methane gas and compost from organic waste should be made use of as the measure method of waste management technology for organic waste in Nigeria.

B. Advance research should be carried out to produce better grades of biogas from organic waste such as the microbiology and biochemistry of the decomposition of the manure should be investigated.

C. Government should endeavor to invest in project like this and also grant subsidy for building biogas and compost plant.

D. Agriculturist and other industrialist should take advantage of this alternative of an inexpensive and even better source of energy.

E. Reactor design kinetics should be studied. This will ensure efficiency of the digester performance at steady state.

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APPENDIX

The volume of methane gas produced per day can be obtained from the following correlation,

$$G_u = 0.35m\,[S_o - S_1] / S_o$$

Where,

m = conversion ratio of chemical oxygen demand to the volatile solid. It is a constant value of 1.42

G_u = daily methane production

S_o = influent total substrate concentration, mass per volume, (g/L) = 25g/L

S_1 = effluent total substrate concentration mass/volume, (g/L)

G_u calculation for poultry droppings,

$$G_{u5} = \frac{0.35 \times 1.42}{25}(0.20) = 0.006$$

$$G_{u10} = \frac{0.35 \times 1.42}{25}(0.42) = 0.008$$

$$G_{u15} = \frac{0.35 \times 1.42}{25}(0.72) = 0.014$$

$$G_{u20} = \frac{0.35 \times 1.42}{25}(1.21) = 0.024$$

$$G_{u25} = \frac{0.35 \times 1.42}{25}(1.66) = 0.033$$

$$G_{u30} = \frac{0.35 \times 1.42}{25}(2.02) = 0.04$$