OPEN ACCESS
Saudi Journal of Engineering and Technology
Abbreviated Key Title: Saudi J Eng Technol
ISSN 2415-6272 (Print) |ISSN 2415-6264 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

Production of Bio Gas from Cow Dung and Tomatoes Waste

Abbas Mustapha[1*]

[1]Department of Petroleum and Natural Gas Processing Petroleum Training Institute, Effurun, Delta State, Nigeria

DOI: 10.36348/sjet.2021.v06i10.005 | **Received:** 06.09.2021 | **Accepted:** 11.10.2021 | **Published:** 13.10.2021

***Corresponding author:** Abbas Mustapha **Email:** abbas_m@pti.edu.ng

Abstract

This research is focused on biogas production from two substrates; cow dung and tomato waste for co-digestion process. A laboratory digester was constructed in the form of modular digester. The pressure reading indicates the presence of gas which confirms that it is possible to produce useful gas from slurry and vegetable waste mixed together. In an instance where this waste was not collected and digested, it is sure that there would be emission of gas into the atmosphere. With the waste management process, the gas emissions and smell intensity is reduced. Although this was done in a small scale because of research purposes, it can also be done in large scale for commercial purposes based on preference. The production was carried out with a pressure gauge during the construction of the digester. This serves as an alternative for gas collection in a gas holder/ tyre tube which is a more efficient way of detecting the presence of produced gas in the system. For faster yield of gas, the production was done in a thermophilic condition, at higher temperature range. Adequate methane gas was produced with co digestion of substrates at balanced ratio of mixture.

Keywords: Biodigester, Feedstock, thermophilic condition, co-digestion.

1. INTRODUCTION

Biogas typically refers to a mixture of various gases produced by the breakdown of organic matter in the absence of oxygen. It is a renewable source of energy and can be gotten from various feed stocks such as, manure, green waste, plant material, sewage, kitchen waste, municipal waste e.t.c. It is produced using an anaerobic digester which digests anaerobic organisms, material inside a closed system, or fermentation of biodegradable materials. Anaerobic digestion process produces a higher biogas yield when running on a mixture of animal manure and vegetable/ crop waste rather than animal manure alone, and biogas production is considered the most suitable bio energy technology in China (Wu CZ *et al*. 2009). The slurry and residues from the biogas process can be used as an organic fertilizer to replace the chemical fertilizer on the farm (HUGO 2008; Zhou Cx *et al*. 2004; Liu y *et al.* 2008 and chem. RJ 2007). The composition of bio gas is methane, which is the primary gas (50-75%), carbon dioxide (25-50), Nitrogen (0-10%), Water (0-1%). The produce gases from this process are methane (CH4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S). Biogas is a sour gas and contains impurities which form acidic combustion products. It can be used for heating purposes such as cooking and it can also be used in a gas engine to convert the energy in the gas into electricity and heat.

In 2008, about 19% of global final energy consumption came from traditional biomass, which is mainly from heating and 3.2% from hydroelectricity. In other words, agricultural waste provides a high ratio of bio gas and their utilization is important for economic and environmental aspect processing suitable for climatic and ecological condition. The use of fossil fuel has been the predominant way of producing gas over the years since the discovery of petroleum. This form poses a threat to the environment such as are released into the atmosphere especially during production process. This in turn causes air pollution, global climate change, and environmental degradation and health problems. As a matter of fact, it is capital intensive and involves a long chain of processes before the gas can be obtained. Improper waste management is a major problem confronting developing nations which is due to increased industrial, agricultural and environmental activities resulting in the generation of large quantity of waste. Apart from the health implications, they also make the environment look unattractive and unpleasant (Ozor *et al*., 2014). It is therefore necessary to develop technology that combines the management, valorization and production of green energy starting from these wastes to improve the energy balance.

This research work is centered on producing bio gas using tomato waste in co- digestion with cow manure. The production of bio gas covers a wide range of articles but for this project we shall be limited to only producing the gas.

2. REVIEW OF LITERATURE

2.1. Bio gas and its composition

Bio gas is a renewable form of energy. Unlike other forms of renewable energy like solar, wind energy it is gotten from organic matter. Bio gas produced during anaerobic digestion is primarily composed of methane. (CH_4), carbon dioxide (CO_2), with smaller amounts of hydrogen sulphide (H_2S) and ammonia (NH_3). Trace amounts of hydrogen (H_2), nitrogen (N_2), Carbon mono oxide (CO), saturated or halogenated carbohydrates and oxygen (O_2) are occasionally present in the biogas. Usually, the mixed gas is saturated with water vapour and may contain dust particles and siloxanes.

The composition of bio gas is different from the one of natural biogas but it is quite similar to land fill gas. Landfill gas often contains significant amount of halogenated compounds and occasionally the oxygen content is high when too much air is suck during the collection of landfill. The calorific value is 36.14MJ/m^3 for natural gas and 21.48MJ/m^3 for biogas.

The composition of biogas is linked to the waste composition and thus can vary.

2.2. Biogas utilisation

The aim of energy production is to: maximize the amount of methane produced; which partly depends on the raw material used; to efficiently convert this methane into electricity, heat or transport fuels. Bio gas can be used for all application designed for natural gas when subjected to further upgrading. Biogas can be used for heating using boilers in plants or producing water vapour for industrial processes. Boilers do not have a high gas quality requirement. Biogas is also used in combined heat and power (CHP) units. The utilization of biogas as a fuel for vehicles i.e. biomethane requires the same type of engine as those used for compressed natural gas. However, the gas quality demands are strict; thus, the biogas must be upgraded to obtain a given specification. Bio gas can be converted to electricity using a fuel cell, though this is still considered a research area due to the need for a very clean gas and the cost of fuel cells. However, using bio gas to fuel a combustion engine and in turn and electric generator is a proven mean of electricity generation.

2.3. Advantages of biogas

Anaerobic digestion of waste provides improved sanitation due to reduced pathogens; this has drastically improved the quality of the heath if users. Also, it provides a means of low cost of energy source for cooking, lighting, and other purposes since there is a cheap source of raw materials which is easily accessible and the cost of constructing a digester is relatively low. Digestate gotten as a bye product of anaerobic digestion can be utilized as fertilizer to improve crop yield. Methane is the second most important greenhouse gas after carbon dioxide and it has global warming potential over 20 times that of carbon dioxide. Hence, through combustion of methane and its conversion to carbon dioxide, less global warming. The emissions of nitrous oxide released from exposed animal waste reduced the quality of air. Hence, containing these waste materials increases the quality of air. Biogas also creates less demand for alternative fuel.

2.4. Anaerobic digestion

Anaerobic digestion (AD) is the breakdown of biodegradable organic material by microorganisms in the absence of air. It occurs extensively, for instance in landfills and the stomachs of cows (Dodson *et al*. 2011). Two useful products are obtained from this process: biogas and residual digestate (a nutrient-rich fertilizer). Anaerobic digestion technologies are well-proven and have been used in the Uk for over 100 years to treat sewage sludge. \In August 2011, 147 plants were treating 18.3 million tons (Mt) a year of wet sewage sludge, 66 plants were treating approximately 1 Mt a year of food and agricultural waste (NNFCC, AD plant map). Together these plants represent 151MWe of generation capacity which could provide electricity for around 300,000 homes annually (Renewable obligation Annual report, 2009-2010).

2.5. Anaerobic digestion processes

The major process involved is the conversion of substrates to bio gas is the anaerobic digestion process. This process is in three stages; hydrolysis, acidogenesis, acetogenesis and methanogenesis.

Hydrolysis

The breaking down of the larger molecules into smaller molecules and the dissolution of smaller molecules into a solution. Through hydrolysis the complex organic molecules are broken down into simple sugars, amino acids, and fatty acids. Acetate and hydrogen are produced in this stage which can be used in methanogenesis.

Acidogenesis

A biological process that involves further breakdown of the remaining components by aciditive bacteria. Volatile fatty acids (VFA'S), ammonia, hydrogen, hydrogen sulphide as well as other bye products are obtained through this process.

Acetogenesis

It involves further digestion of simple molecules produced during acidogenesis by microorganisms called acetogens (acetic acid forming bacteria). The byproducts of this process are acetic acid, hydrogen and carbon dioxide.

METANOGENESIS

It is a biological process which uses the intermediate products gotten from the preceding stages and converts them to methane, carbon dioxide and water. Methanogenesis is sensitive to both high and low pHs and occurs between pH 6.5 and pH 8 the remaining, indigestible material the microbes cannot use and any dead bacterial remains Constitute the digestate. The micro-organism used in this stage is. Methane-forming (methanogenis) such as arachea.

2.6. Conditions and variables affecting anaerobic digestion

In order to obtain proper breakdown of the organic compounds several conditions must be applied. These parameters must be controlled to enhance the microbial activity and thus increase the efficiency of the digestion process.

Total solid content

There are three different ranges of solid content: low solid content (LS), contains 10% total solid (TS). Medium solid (MS) contains 15- 20% and high solid ranges from 22-40%. When increasing the total solid content, the volume of the digester decreases, due to lower water requirement.

Temperature

Anaerobic digestion occurs under two main temperature ranges. Mesophilic conditions occur between 20-40°C, usually 35°C and thermophilic conditions which occurs between 50-65°C, usually 55°C. Thermophilic systems operate at a faster rate, usually 12-14days rather than mesophilic at 15-30 days. They give a higher methane production and more effective sterilization although they require more energy input, a higher degree of operation and monitoring and they are a more expensive technology. The temperature for digestion may vary depending on the type or digester and feedstock composition but in anaerobic digestion processes, it should be sustained at a constant temperature for optimum yield of gas.

Retention time

Retention time is the time needed to achieve the complete degradation of the organic matter. It varies depending on the process parameters, such as process temperature and waste composition. The retention time for waste treated under mesophilic conditions ranges from 15 to 30 days and under thermophilic conditions retention time ranges from 12-14 days (Monet, 2003).

PH

pH is the level of acidity or alkalinity of a substance which takes numerical values from zero (maximum acidity) through seven (neutral) to fourteen (maximum alkalinity). The pi values for acidogenesis and methanogenesis are different. Acetic, lactic and propionic acids are formed during acidogenesis which causes the pH to fall. Low pH inhibits acidogenesis and pH below 6.4 can be toxic for 0methane- forming bacteria.

Feedstock

This is the most important factor to consider when applying anaerobic digestion process. Feedstock ranges from agricultural waste, plant material, municipal waste, green waste, and sewage or food waste. Biogas production is not the same but depends on the type of feedstock used.

Table-2.1: Characteristics of Agricultural Slurries

Feedstock	Biogas yield($m^3.kg^{-1}$ vs)
Pig slurry	0.25-0.50
Cow slurry	0.20-0.30
Chicken slurry	0.35-0.60

Table-2.2: Problems Linked with Agricultural Slurries

Feedstock	Unwanted Substances	Inhibiting substances	Frequent problem
Pig slurry	Sand, straw, wood shavings	Antibiotics, disinfectants	Scum layers, sediment
Cow slurry	Bristles, straw, wood, soil, NH_4^+	Antibiotics, disinfectants	Scum layers, poor gas yield
Chicken slurry	NH_4^+, grit, sand, feather.	Antibiotics, disinfectants	NH_4^+, inhibition, scum layers.

2.7. Factors to consider when choosing feedstock

The most important factor to consider when choosing a feedstock for a digestion process is the level of putrescibility. The more putrescible (digestible) a material, the higher the gas yield from the system. The moisture content is also a consideration. This largely affects the choice of digester to be used. The level of contamination is another key consideration. If the feedstock to the digester has significant level of physical contamination such as plastics, glass, metals, they would need to be removed to prevent the digester from blocking or malfunctioning. After removing the contaminants, there would be need for shredding, mincing or mechanical or hydraulic pulping of substrate to increase surface area for microbial action. This can be achieved by using a chopper pump. Substrate composition is another factor which determines the methane yield and production rate from a given biomass. C: N ratio of the feedstock should be considered. This is the relationship between the amount of carbon and nitrogen present in the organic matter. It is the balance of food a microbe requires to grow. The optimal C: N ratio for an anaerobic digester is 20-30: 1. A high C: N ratio indicates rapid consumption of nitrogen by the methanogens which results in low gas production. On the other hand, lower C: N ratio results in ammonia inhibition of digestion. Optimal C: N ratio can be achieved by mixing substrates of high and low C: N ratio organic solid waste and animal waste.

2.8. Advantages of anaerobic digestion

It is a reliable technology for the treatment of wet, organic waste. Organic wastes from various sources are biochemically degraded in highly controlled, oxygen free conditions. Circumstances resulting in the production of biogas which can be used to produce both electricity and heat. It is suited for wet organic material and is commonly used for effluent and sewage treatment. This includes biodegradable wastes materials Such as wastes paper, grass clippings, leftover food, sewage and animal wastes. The exception is woody wastes that are largely unaffected by digestion as most anaerobic microorganisms are unable to degrade lignin (Zafar, 2016).

Tomatoes

Tomato Solanum lycopersicum), commonly known as tomato plant belongs to the nightshade family, Solanaceae. It is the second most highly produced vegetable in the world with an estimated generation of 164 Mt within 2013(FAOSTAT, 2015); about 50 Mt are cultivated for the processing industry that generates various by products (pomace. skins and seeds) that represents 4-13 % of a typical tomato (Ventura *et al.* 2009.) or a total amount of around 3 to 6 Mt/year (Calabro *et al*. 2015). Tomatoes waste is usually dumped near processing sites generating liquid emissions, odors and methane emissions due to an uncontrollable anaerobic fermentation (Calabro *et al*., 2015).

Properties of tomatoes

It is an edible, often red, fruit (berry), It is a perennial plant hence, cultivated annually, tomatoes are acidic, PH around 4, It contains an energy value of 74kJ (18 cal). Carbohydrate 3.9g, Sugars 2.69, Fat 0.2g, Protein 0.9g, Dietary fiber 1.2g, Fat 0.2g. Magnesium 3%, Manganese 5%, Phosphorus 3%, Potassium 5%, Water 94.5g, Lycopene 2573µg.

Uses

Tomato is consumed in different ways including raw, as an ingredient in many dishes, sauces, salads, and drinks. Tomatoes are suitable as a feedstock for the anaerobic digestion because it is, relatively rich in protein and fat, high fiber content crude fiber is in the 33-57% DM range, while lignin content has been reported to be around 4%. Also, it contains a relative amount of water. The acidic PH is a hindrance for its use as a substrate for anaerobic digestion. Therefore, it is either co- digested with another substrate or pretreatment before digestion. The use of tomatoes waste for bio-methanation production through anaerobic digestion has also been reported with yields that range from 199 to 384 NmL CH_4/gVS (Gunaseelan, 2004; Ward *et al.*, 2008; Dinuccio *et al*. 2010; Gonzàlez and Cuardros, 2013).

COWDUNG

Cow dung or cow manure is the waste product of bovine animal species such as cattle, buffalo, yak and water buffalo. It is the undigested residue of plant matter which has passed through the animal's gut. The colour is usually from greenish to black, often darkening soon after exposure to air. Cow dung is often used as manure. In some developing countries, caked or dried cow dung is used as fuel. Dung may be collected and used to produce bio gas to generate electricity and heat. In central Africa, cow dung is burned inside to repel mosquitoes. Nitrogen 3%, Phosphorus-2%, Potassium---1%. Cow dung can be used for bio gas because it rich in minerals since it contains undigested plant matter. It can produce a high level of methane, has high C: N ratio and contains anaerobic bacteria.

Anaerobic digester

A biogas plant is the name often given to an anaerobic digester that treats farm wastes or energy crops. It can be produced using anaerobic digesters (air-tight tanks with different configurations). These plants can be fed with energy crops such as maize silage or biodegradable waste including sewage sludge and food waste. During the process, the micro-organisms transform biomass waste into biogas (mainly methane and carbon dioxide digestate. Anaerobic digesters can also feed with specially grown energy crops such as Silage, in a case of dedicated biogas production. Digesters processing dedicated energy crops can achieve high level of degradation and biogas production. Anaerobic digesters were originally designed to use only sewage sludge and manures. This do not however has the highest potential of biogas generation as most of the biodegradable material has been taken out by the animal that produced it. Therefore, many digesters operate as co digestion of more than one feedstock. Systems that use only slurry are cheaper but produce far less energy than those using crops, such as maize and grass silages; by using a modest amount of crop material (30%), an anaerobic digestion plant can increase energy output tenfold for only three times the capital cost, relative to the slurry only system.

TYPES OF DIGESTERS

Fixed dome plants

A fixed plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester, when gas production starts, the slurry is displaced into the compensation tank. 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 compensation tank. The cost of a fixed dome bio gas plant is relatively low. It is simple and has no moving parts. There are also no rusting steel pumps. The plant is constructed underground, protecting it from physical damages and saving space.

Floating drum digesters

A floating drum consists of a cylindrical or dome- shaped digester and a moving, floating gas holder or drum. The gas-holder floats either directly in the fermenting slurry or in separate water jacket. The drum in which the gas collects has an interval or an external guide frame that provides stability and keeps the drum upright. If bio gas is produced, the drum moves up, if the gas is consumed, the gas holder sinks back. It is easy to operate and understand. They provide gas at constant pressure and the gas- volume is easily understood by the position of the drum. The steel drum is relatively expensive, removing rust and painting has to be carried out regularly.

CO-DIGESTION

Codigestion refers to the anaerobic digestion (AD) of multiple biodegradable substrates (feedstock) in an AD System. ne more contemporary definition refers to the digestion of a combination or select biodegradable feedstock with a base substrate that an AD system was designed to handle. The general idea is to maximize the production of biogas in an AD plant by adding substrates that produce much more biogas per unit mass than the base substrate. Two readily available substrates municipal biosolids and agricultural manure are the base substrates most often utilized and are located near the bottom of the "biogas per unit mass" scale. However, the benefits that can be realized from co digestion, as well as the potential pitfalls that can be encountered, need to be carefully evaluated. In the case of low-cost or free high-energy potential substrates. One reason for the increased interest in co digestion is the creation of opportunities for the use of biodegradable wastes due to the being tremendous number of AD plants online and currently being constructed in the United States (Technologists, 2009).

Co-digestion of cow dung and tomatoes waste

From previous literature tomatoes waste is more efficient when co digested with another substrate of pretreated because of its high level or acidity. Hence co digesting tomatoes and cow dung is efficient. A research carried out by M. Saev, B. Koumanova and iv. Simeonov on the anaerobic co-digestion of tomatoes waste and cow dung, the study was carried out under mesophilic conditions at a retention time or 20 days in a semi continuous mode, C:N ratio of 15 which indicate that there was good nitrogen existence for the reaction gave a bio gas yield of 220dm'. Maximum CD/WT was obtained in the mixing ratio or 80:20.

Figure 2.1 Result of the experiment

SUBSTRATE/RATIO	BIO GAS PRODUCTION ($dm^3\ dm^{-3}d$)
CD	0.33
CD:WT(90:10)	0.5
CD:WT(80:20)	0.7
CD:WT(60:40)	0.41
CD:WT(40:60)	0.39
CD:WT(20:80)	0.49

Contaminant gases

The gas produced from the anaerobic digestion process contains various gasses. Most of these gases needs to be removed in order to obtain pure methane gas. These contaminant gases can arrect t the performance of the gas depending on the use and also can instill some negative effects. The process of removing these contaminant gases is gas upgrading.

Carbon dioxide (co_2)

It makes up about 25-50% of biogas. Removal of carbon dioxide enhances the energy of the gas to reach vehicle fuel standard or natural gas quality. This can be done using four different methods water Scrubbing, polyethylene glycol scrubbing, carbon molecular sieves, membrane separation.

Hydrogen sulphide (h_2s)

Hydrogen sulphide makes up about 0.1-0.5% of biogas. It is removed to avoid corrosion of the machine. The most common methods used for this process are air/ oxygen dosing to digester biogas, iron chloride dosing to digester slurry, iron oxide, activated carbon, water scrubbing, NaOH scrubbing.

Nitrogen

It makes up about 0-10% of biogas. It can form acidic oxides when exposed to oxygen.

Siloxanes

Organic Silicon compound are present in biogas which can Cause severe damages to CHP engines. They can be removed by absorption on a liquid medium, a mixture of hydrocarbons with a special ability to absorb the silicon compounds.

Causes of digestion failure

Low pH, low alkalinity, over loading, high volatile acids, toxic substances

- Temperature changes

Methane

Methane also known as marsh gas is a hydrocarbon which belongs to paraffin series. It is the simplest alkane and has a chemical formula of CH_4. It is the saturated hydrocarbon. It occurs abundantly in nature as a result of human activities. In nature, it is produced by the anaerobic bacterial decomposition of vegetable matter under water i.e. marsh or swamp gas. Other natural, sources include termites, volcanoes, and vents in and methane hydrate deposits.

Physical and chemical properties

Methane is a gas but can also exist as solid or liquid methane lighter than air, having a specific gravity of 0.554. It is slightly soluble in water and burns readily in air giving off a pale, slightly luminous and Very not flame. Its melting point is -162°C and melting point -182.5C. At room temperature and standard pressure, methane is a colorless Odorless. As a gas it is flammable at certain concentrations and in air at standard pressure. The primary chemical reactions of methane are combustion, steam reforming to syngas, halogenations. Combustion of methane gives carbon dioxide and water at standard conditions.

Uses of methane

Methane is used in industrial chemical processes and may be transported as a refrigerated liquid i.e. liquefied natural gas (LNG). It is also used as fuel for ovens, homes, kilns, automobiles, turbines and other things. It is also used as fuel for ovens, homes, kilns, automobiles, turbines and other things. Methane is important for electricity generation by burning it as a fuel in a gas turbine or steam generator. In form or compressed natural gas, it is used as vehicle fuel which is environmentally friendly than other fossil fuels such as gasoline, petrol and diesel.

3. MATERIALS AND METHODS

3.1. Materials for digester construction

Convectional C-way bottle (20L), tyre tube, PVC pipe, flexible hose, funnel, clip, paint, soldering iron, glue, T- joint, check valve, painting brush, pressure gauge.

3.2. BIO- DIGESTER CONSTRUCTION

Two holes will be bored on the 10 litre reactor bottle using the diameter of the 4 PVC pipe and a solder iron; one at the top and the other at the side. The pipe will be cut into two and inserted into the two holes, applying glue to ensure it is tight. At the neck of the can, the hose diameter will be marked and the solder iron used to bore a hole of the hose diameter. Using glue and sand, the hose will be placed in position to ensure it is air tight. The reactor bottle will be painted black to avoid the formation of algae which stops the bacteria and hinders biogas production. The hose was connected to a T-joint where one outlet will be connected to the tyre tube, the other to the reactor and the other outlet to the check valve to, control flow. All the opening components will be properly sealed so that gas will not be lost and air will not enter the digester for optimum production of biogas.

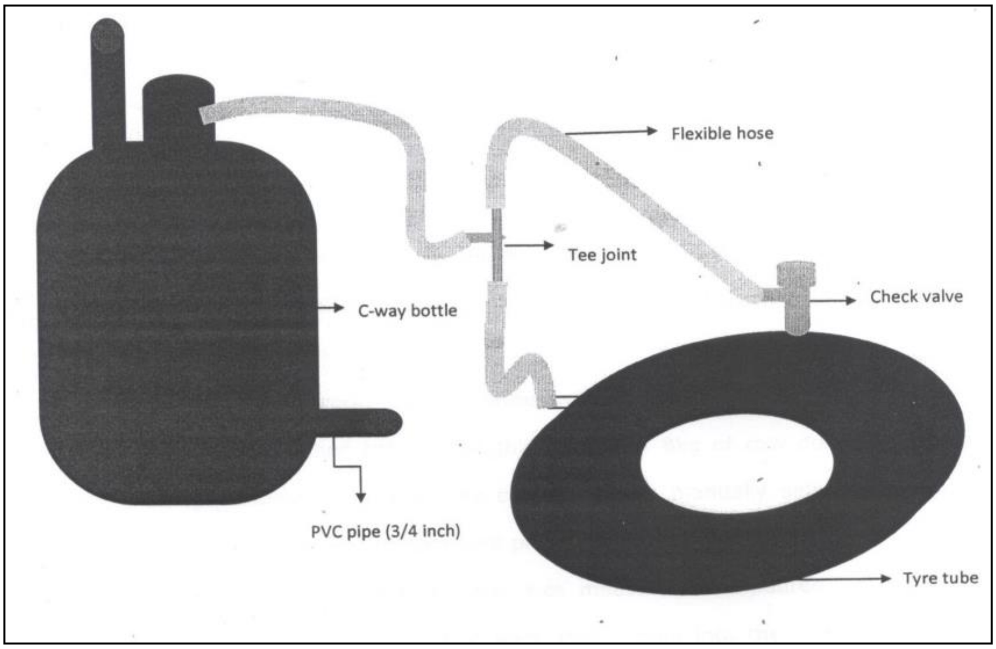

Fig-1: Laboratory Digestion Set-Up

3.3. RAW MATERIALS

Cow dung and Tomatoes waste

3.4. Preparation of sample

Wasted tomatoes were collected from Effurun market in delta state. Alongside, fresh cow dung was collected from an abattoir in Osubi road also in Delta state. Fresh cow dung and wasted tomatoes were collected. The feed stocks were then weighed using a weighing balance, 8kg of cow dung and 1.8kg of tomatoes waste. The cow dung was manually selected to remove any physical contaminant present in the feed while the tomato was blended. 9.8 litres of water was measured and poured into a mixing bucket. The substrates were then added into the water and stirred continuously until properly mixed. Afterwards, it was fed into the laboratory digester and properly sealed.

3.5. Procedure

Mixed slurry was fed into the cylindrical shaped anaerobic digester, its cap completely sealed. Mixing was aided by mechanical stirring i.e. shaking the digester to free trapped gases, ensure continuous mixing. After 7 days the pressure of the system was recorded and the volume calculated.

4. RESULT AND DISCUSSION

Bio gas was produced by anaerobically digesting cow dung and tomatoes waste in a laboratory digester. Weight of cow dung 8kg, Weight of tomatoes waste 1.8kg, Volume of water 9.8 litres, Volume of reactor bottle 20 litres, temperature condition 30°C

VOLUME OF GAS PRODUCED

The ideal gas equation PV=nRT is used to determine the volume of gas produced for each pressure reading. Where T=30°c, 30 + 273 = 300k, n = 1 mole, R = 8.314 J/mol^{-1} k^{-1}V = nRT/P, V_1 = 0.025L, V_2 = 0.012L, V_3 = 0.0099L, V_4 = 0.0083L, V_5 = 0.0071L, V_6 = 0.0055L, V_7 = 0.0049L.

Table-4.1: Table Showing the Retention Time, Pressure and Volume

RETENTION TIME (DAYS)	PRESSURE (PA)	VOLUME (L)
1	100000	0.025
2	200000	0.012
3	250000	0.0099
4	300000	0.0083
5	350000	0.0071
6	450000	0.0055
7	500000	0.0049

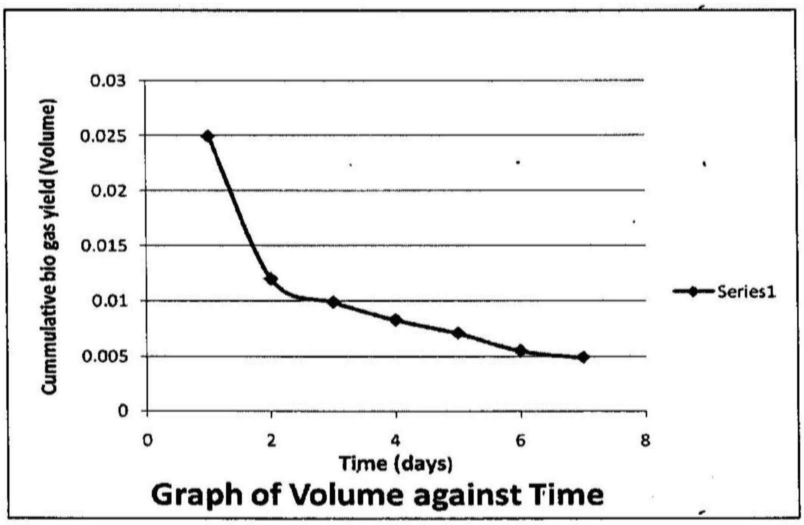

Fig-1: A graph showing the relationship between the volume and time

5. DISCUSSION OF RESULT

The production was carried out at 30°C mesophilic conditions given that the temperature falls between 30-50°C. It was done using 8Kg or cow dung and 1.8 kg of tomatoes wastes.

A pressure gauge was attached to the hose from the to detect pressure build up in the system which was monitored for seven days. The first day, it indicated a pressure of 1 bar; the second day indicated a pressure of 200000 Pa, third day, 250000 Pa and the fourth day, 300000 Pa. The fifth day indicated a pressure reading of 35000 pa, 450000 Pa on the sixth day and 500000 Pa on the seventh day. Table 1 shows the pressure recorded on each day. From Fig. 1, it is indicated that there was a constant increase in the pressure of the system.

Using the ideal gas equation, the volume at each given pressure was calculated 0.025L, 0.012L, 0.0099L, 0.0083L, 0.0071L, 0.0055L and 0.0049L. With increase in pressure there was a decrease in volume which shows an inverse relationship of pressure and volume at constant temperature. Relating the retention period to the average pressure of the system, it could be said that the process was relatively slow which might be as a result of some factors like fluctuations in temperature, trapped gasses e.t.c.

6. CONCLUSION

This study was based on the production of bio from two substrates; cow dung and tomatoes waste, hence, a co-digestion process. A laboratory digester was constructed as the digester and feedstock digested. The pressure reading indicates the presence of produce gas which confirms that it is possible to produce useful gas from slurry and vegetable waste mixed together. In an instance where this waste was not collected and digested, it is sure that there would have been an emission of gas into the atmosphere and possibly the waste will smell. With this waste management process, we have reduced the gas emissions, and reduced the smell intensity to an extent. Although this was done in a small scale because of research purposes, it can also be done in large scale for commercial purposes based on preference.

To carry out this production, it is advisable to put in place a pressure gauge during the construction of the digester. This can serve as an alternative to collecting the gas in a gas holder/ tyre tube and is a more efficient way of detecting the presence of produce gas in the system. For faster yield of gas, the production should be done in a thermophilic condition, that is, at a higher temperature range. Also, in co digestion of substrates, the mixing ratio should be balanced.

7. REFERENCES

- Adiotomre, K.O., & Ukrakpor E. F. (2015). Production of biogas from kitchen waste and cowdung. *International journal of innovative scientific & engineering technologies research*, *3*(2):52-64, 1-13.
- Calabro P.S, Greco. R., Evangelou A, Komilisi D. (2015). Anaerobic digestion of tomatoes processing waste: effect' of alkaline pretreatment. Proceedings of the 14th international conference on environmental nscience and technology. Rhodes, Greece.
- Dinnucio, E., Balsari, P., Gioelli, F., Menardo, S. (2010). Evaluation or the biogas productivity potential of some Italian agro-industrial biomasses. *Bioresource Technol.*, 101, 3780-3783.
- Encinar, J.M., Gonzalez, J.F., Martinez, G. (2008), Energetic use of the tomato plant waste. Fuel process. *Technol.*, *89*,1193-1200
- Faostat. (2015). Statistical database of the food and agricultural organization of the United Nations. Internet site: http://faostat3.fao.org/.
- Gonzalez-Gonzalez, A., Cuadros, F. (2013). Continuous biomethanization of agrifood industry industry waste: A case study in spain. *Process Biochem.*, *48*,920-925.
- Gunasseelan, V.N. (2004). Biochemical methane potential of fruits and vegetable solids waste feedstocks. *Biomass Bioenergy*, *26*, 39-399.
- Jennifer, D., Stephen, A., Jonathan, W. (2011, September). Anaerobic digestion. House of parliament, parliamentary office of science & technology. POSTNOTE Number 387.
- Saev, M., Koumanova, B., & Simeonov, I. V. (2009). Anaerobic co-digestion of wasted tomatoes and cattle dung for biogas production. *Journal of the university of Chemical Technology and Metallurgy*, *44*(1), 55-60.
- Monet, F. (2003). An introduction to anaerobic digestion of organic waste. Final report, 31.
- NNFCC, AD plant map. (n.d.). Retrieved from http://biogas- info.co.uk/maps/index2.html
- Ozor, O. C., Agah, M. V., Ogbu, K. I., Nnachi, A. U., Udu-Ibiam, O. E., & Agwu, M. M. (2014). Biogas production using cow dung from Abakaliki abattoir in South-Eastern Nigeria. *International Journal of Scientific & Technology Research*, *3*(10), 237-239.
- Salman, Z. (2016). Abattoir wastes disposal via anaerobic digestion
- Technologists. (2009, march 10). Co digestion: a developing trend and market. biocycle magazine
- Ventura, M.R., Pieltin, M.C., Castanon, J.I.R. (2009). Evaluation of the tomatoes crop by-products as feed for goats. *Anim. Feed Sci. Tech.*, *154*, 271-275.