WOLKITE UNIVERSITY (WKU)

COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF CHEMICAL ENGINERING

Thesis on: - Production of biogas from animal dung

Submitted to Chemical Engineering Department In partial fulfillment of the requirement for degree of bachelor science (BSc) In Chemical Engineering

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DECLARATION

We hereby declare this project report entitled production of biogas from animal dung submitted to Wolkite University, Chemical Engineering Department, and that no part has been copied without citations and reference. We further declare that the work reported in this project has not been submitted and will not be submitted for the award of any other degree in this University.

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SYMBOLS AND ABBREVIATIONS

BOD: - Biological oxygen demand

CH_4:- Methane

CH_3COOH:-Acetic acid

CO_2:- Carbon dioxide

EMS: - Electronic Scale Measurement

FS: - Fixed solids

GHG: - Greenhouse gas

H2S:- Hydrogen sulphate

HRT: - Hydrolytic retention time

N/C: - Carbon/Nitrogen ratio

NH3:- Ammonia

NH4+:- Nitrogen digestion

TS: -Total solid

VS: -Volatile solid

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ABSTRACT

Energy is a critical component of development and one of the most significant resources. Our country now has a limited supply of energy to meet the needs of society in order to complete various duties. Biogas is a gas that is created when organic matter is broken down in the absence of oxygen. It's made from locally sourced raw materials and repurposed garbage. So, instead of utilizing charcoal or other energy sources, the problem of energy scarcity can be solved by employing biogas energy. This is especially true for individuals who live in rural areas. The goal of this research is to create biogas from animal dung as a domestic alternative energy source. Cow dang is the undigested plant stuff that passes through the cow's gut. It has a dark brown color and a high ammonia content. The manufacturing method consists of four steps: hydrolysis, acidification, acetogineses and methane creation, with the effect of temperature, retention duration, and cow waste potential on biogas production being studied. We have done four experiments experiment1, experiment2, experiment3 and experiment4, from those experiment we get the best result 0.21L, 0.2L, 0.19L and 0.2L amount of biogas respectively. Therefore we compare four experiment and the best biogas product is from experiment one.

Keywords: Animal dung; anaerobic digestion; biogas production.

CHAPTER ONE

1 INTRODUCTION

1.1Background

Energy is a critically important resource that can be obtained from both renewable and nonrenewable sources. As the world's energy demand rises, it's time to explore for alternative and renewable energy sources to replace the increasingly dwindling fossil fuels. The rapid growth of the world's population has resulted in the development of industrial and commercial agriculture, both of which demand significant amounts of energy and generate large amounts of trash that are difficult to dispose of without negative environmental consequences and expenses. Furthermore, the finite sources and amounts of nonrenewable energy (oil, natural gas, and fossil coal) combined with their detrimental effects on human health and the environment need the development of new and renewable energy sources. Biogas, which is created from green energy crops and organic waste, is one of the renewable energy resources [1]. Biogas is a gas that is created when organic matter is broken down in the absence of oxygen. It, like solar and wind energy, is a renewable energy source. Biogas is an environmentally friendly and carbon dioxide (CO_2) neutral fuel made from locally available raw materials and recovered waste. Anaerobic digestion or fermentation of biodegradable materials such as manure, sewage, municipal waste, green waste, plant material, and crops can also create its [2].The chemical makeup of the substrate determines the gas composition. Dairy dung waste is made up of feed and water that has previously been digested anaerobically in a cow's stomach, along with some waste feed and potentially flush water. The use of anaerobic digestion for dairy farm wastes has several environmental benefits, including the reduction of odors, flies, and pathogens, as well as the reduction of greenhouse gas (GHG) and other undesirable air emissions. It also helps to keep the manure stable and minimizes the requirement for biological oxygen demand (BOD).Biogas is a potential energy source that can be collected and utilized. Acid- and methane-forming bacteria are involved in the process, which takes place in an anaerobic (oxygen-free) environment. That breaks down the organic material and produces biogas, which is a gaseous mixture of methane (CH_4) and carbon dioxide (CO_2).The first biogas factory was built in India in 1859, while the first facility in the United States was built in 1989[3]. It first debuted in England in 1895. In the United States, biogas production and utilization began in the 1970s [4].The 1973 and 1979 energy crises rekindled interest in developing inexpensive biogas process systems for methane production as a source of energy. In response to the issue, India, China, and Southeast Asian countries increased their biogas production significantly. The majority of biogas production systems were tiny digesters that used a combination of human, animal, and kitchen waste. Many community digesters were set up to generate enormous amounts of biogas for village electrification. In addition, Europe, North America, and the Soviet Union became active in biogas research for the manufacture of methane from animal dung. Biogas production trials have been carried out in several African countries. The significant population growth in these countries' rural areas continues to raise environmental concerns. In 1957/58, a biogas facility was built at Ethiopia's Ambo Agricultural College to generate the energy needed for welding. Over 1000 biogas plants were built for government organizations, the corporate sector, and communities between 1980 and 2000, the majority of which were built for demonstration purposes [5].

1.2 Statement of the Problem

Energy is a critically important resource that can be obtained from both renewable and nonrenewable sources. It is a crucial component of human development. As the world's energy demand rises, it's time to explore for alternative and renewable energy sources to replace the increasingly dwindling fossil fuels. Our government now has a limited supply of energy to meet the needs of society in order to complete various duties. So the problem of energy scarcity can be solved by employing renewable energy for long-term sustainability, especially for people living in rural areas who can benefit from biogas instead of charcoal or other methods. As a result, these projects look at the production of biogas from animal feces as a domestic alternative.

1.3 Objectives

1.3.1 General objectives

The main objective of this project work is to produce Biogas from animal manure (dung).

1.3.2 Specific Objectives

- To determine the total solid (TS), volatile solid (VS), and moisture content of animal excrement.
- To measure the working conditions (temperature and pH) throughout the anaerobic digestion
- To determine the quantity and quality of biogas produced using animal dung

- To carry out material balance and Energy balance for cow dung

1.3 Significance of the study

In most of the developing countries, biogas produced from anaerobic digesters is used as fuel Substitute for kerosene oil, cattle dung cake, agricultural residues, and firewood. Burning of those fuels causes environmental pollution. Biogas technology is considered to provide the benefits of reducing the emission of GHGs and then mitigating Global warming in ways of replacing firewood for cooking, replacing kerosene for lighting and cooking, replacing chemical fertilizers and saving trees from deforestation.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Biogas production in Ethiopia

Biogas technology was first introduced in Ethiopia in 1979, when the Ambo Agricultural College built the first batch type digester. Around 1000 biogas plants, ranging in size from 2.5 m3 to 200 m3, have been built in houses, communities, and government facilities around the country in the last two and a half decades. Up until 2008, over 40% of biogas plants that were built were not operational due to a lack of effective administration and follow-up, technical issues, loss of interest, reduced animal holdings, departure of ownership, water issues, and other factors[6].Biogas is a renewable, alternative, and long-term energy source. Biogas technology not only aids in the production of an alternative energy source, but it also aids in the preservation of the environment and the improvement of health conditions. When fermented anaerobically, that is, in the absence of oxygen, the energy in plant vegetation, animals, industrial, and residential waste matter can be liberated in the form of a useful gas.

Biogas is produced by the decomposition of organic wastes and is channeled or carried to households for use in cooking, powering engines, generating electricity, and heating with little or no pollution. Many countries now use this gas on a considerable scale. Anaerobic digestion has been used in the treatment of various organic wastes as a waste-to-energy method. When applied to organic material, this process creates methane, CO_2, ammonia, traces of gases, and organic acid with a low molecular weight. Because of their lack of knowledge about this technology, the majority of people in underdeveloped nations such as Ethiopia rely on solid fuels such as wood to supply their cooking and lighting demands. Biogas is a flammable gas combination.

It is mostly composed of methane (CH_4) and carbon dioxide (CO_2) and is produced by anaerobic bacterial breakdown of organic substances, i.e. without the presence of oxygen. The gases produced are waste products of these decomposer bacteria' respiration, and their composition varies depending on the substance being degraded. Methane generation is limited when the material comprises primarily of carbohydrates such as glucose and other simple sugars, as well as high molecular compounds (polymers) such as cellulose and hemicellulose. When fat content is high, however, methane generation is also high. The combustible portion of biogas is made up of methane and any additional hydrogen present. Methane is a colorless, odorless, and flammable gas with a boiling point of -162°C and a blue flame. Methane is also the most abundant component of natural gas (77-90 percent).Methane is the simplest form of the alkanes and belongs to them chemically. Methane has a density of roughly 0.75 kg/m^3 at normal temperature and pressure. Biogas has a slightly higher density of 1.15 kg/m^3 than carbon dioxide because carbon dioxide is somewhat heavier. Anaerobic digestion is a natural process in which bacteria break down organic matter to produce biogas. It can be found in marshes and wetlands, as well as ruminants' digestive tracts. The bacteria are also active in landfills, where they are the primary decomposers of food waste and other biomass.

2.2 Alternative sources of raw materials

The stomach and digestive system of a cow are divided into chambers and intestinal portions that fulfill various tasks. Some chambers use fermentation and microbes to start the food breakdown process, while others absorb water and other minerals. Each stage of the cow's digestive process adds new chemicals and compounds to the chemical makeup of the dung as a result of this complex series of stages. The metabolic residues of living tissue and elements of the food that it was unable to digest, such as cellulose and lignin, are the primary components of cow's feces.

These undigested compounds are usually derived from the cow's consumption of plant cell walls. Bile salts, mucus, keratinized tissue, and calcium salts from fatty acids are some of the other components that can be found in cow's excrement. Cow dung is made up of organic waste, comprising fiber material that passed through the cow's digestive system, as well as liquid digesters that have been left over after fermentation, absorption, and filtration, acidification, and re-absorption. Carbon, nitrogen, hydrogen, oxygen, phosphorus, and other elements make up the majority of the chemical composition. As the digest passed through the digestive tract, salts, urea, mucus, cellulose, lignin, and hemicellulose sloughed off, along with some urea, mucus, and cellulose, lignin, and hemicellulose.

2.3 Biogas Composition & Properties

Biogas is a combination of gases produced by anaerobic microorganisms digesting organic materials under anaerobic conditions (i.e. without oxygen). The major components of biogas, according to most studies, are methane (CH_4) and carbon dioxide (CO_2), with methane ratios ranging from 55 to 70 percent and carbon dioxide ratios ranging from 30 to 45 percent. Other components of biogas that may be found in small amounts (traces) are: Hydrogen (H_2), Nitrogen (N_2), Hydrogen Sulfide (H_2S), Carbon monoxide (CO), Ammonia (NH_3), Oxygen (O_2) and water vapor (H_2O)[7] .

Table 2:1 Composition of Biogas. [8]

Methane	CH_4	55-70
Substance	Symbol	Percentage (%)
Carbon dioxide	CO_2	30-45
Ammonia	NH_3	1-2
Hydrogen	H_2	1-2
Nitrogen	N_2	1-2
Water vapor	H_2O	Trace
Carbon monoxide	CO	Trace
Hydrogen	H_2S	Trace

Carbon dioxide and methane are odorless and colorless gases. Hydrogen sulfide is colorless, but in addition to its toxicity, it has a rotten egg stench. Corrosive substances include carbon dioxide, hydrogen sulfide, ammonia, and water vapor [8]. Biogas, in general, is colorless, odorless, and lighter than air in all of its components [8].

2.3.1 Properties of biogas

The characteristics of biogas, like those of any pure gas, are pressure and temperature dependent. Moisture content has an impact on them as well. The following are the most important variables to consider:

- Change in volume as a function of temperature and pressure.
- Calorific value variation as a function of temperature, pressure, and water vapor content.
- Water vapor content changes as a function of temperature and pressure.

In many countries, biogas is used as an environmentally benign and future-oriented technology. Biogas has a calorific value of roughly 6kWh/m3, which is about half a liter of Diesel oil. The efficiency of the burners or appliances determines the net calorific value. When it comes to using biogas as a fuel, methane is the most valuable component.

2.4 Benefits of Biogas

Traditional fuels such as firewood, dried dung, and even kerosene are less convenient to utilize than biogas. Biogas facilities have a variety of environmental, social, and economic benefits [9]. Effects on the environment.

Reduction of the biomass resource depletion

Biogas plants can aid in the fight against deforestation, particularly in areas where households rely heavily on firewood or charcoal for cooking and heating. Indeed, if you consume a lot of firewood or charcoal, you can end up in an unsustainable situation where your wood consumption surpasses your wood supply.

Reduction of Green House Gases (GHG) emissions

When unsustainable wood is used for heating or cooking, it produces positive GHG emissions, whereas biogas is normally GHG neutral (provided that organic materials used to feed the bio-digester are renewable and that there is no methane leakage from the plant).As a result, biogas plants can replace the usage of firewood or charcoal in countries where wood supply is unsustainable, resulting in lower GHG emissions.

Social Impacts

Quality of life

Recipients' quality of life is improved by biogas plants. For starters, they lessen the amount of time it takes to perform common tasks like collecting firewood and tending to a fire. Furthermore, compared to firewood or charcoal stoves, cooking using biogas burners is more convenient and faster. Furthermore, biogas is far more environmentally friendly than firewood or charcoal. Cooking with firewood or charcoal can, in fact, produce soot, which can contaminate the kitchen and cooking equipment.

Gender equality

Because women are mostly responsible for household chores, improved gender equality is a direct result of the preceding statement. Women can spend more time on other hobbies and education as a result of their reduced burden, resulting in a reduction in gender inequities.

Health and sanitation

Interior smoke pollution from the usage of firewood or charcoal poses a health concern, including respiratory ailments (no particulate matter emission unlike firewood or charcoal). Furthermore, bio digesters lower the pathogen level of organic waste. As a result, domestic biogas units can improve the hygienic state of the family.

Education

Children may be able to study later in the evening if a biogas lamp is installed. Biogas lights do, in fact, provide superior lighting than traditional lighting methods (e.g. kerosene lamps).

Youngsters who have access to adequate illumination can study for up to two hours longer each evening than children who do not.

Food security

When compared to regular manure, using bio-slurry as a fertilizer increases crop yields. As a result, it helps beneficiaries and the community as a whole to be more food secure.

Economic impacts

Economic impacts for beneficiaries

Biogas can help homes save money on energy by displacing the usage of firewood or charcoal. Furthermore, the increased crop output associated with the usage of bio-slurry as a fertilizer may result in higher farm income. When utilized properly, bio-slurry can increase crop output by 10% to 50% or more when compared to regular fertilizers (e.g. compost).

Economic impacts for the community

In order to measure the true social, environmental, and economic benefits of domestic biogas on households, proper impact studies must be conducted. Survey campaigns on a suitable sample of potential and present household biogas users can be used to conduct these investigations.

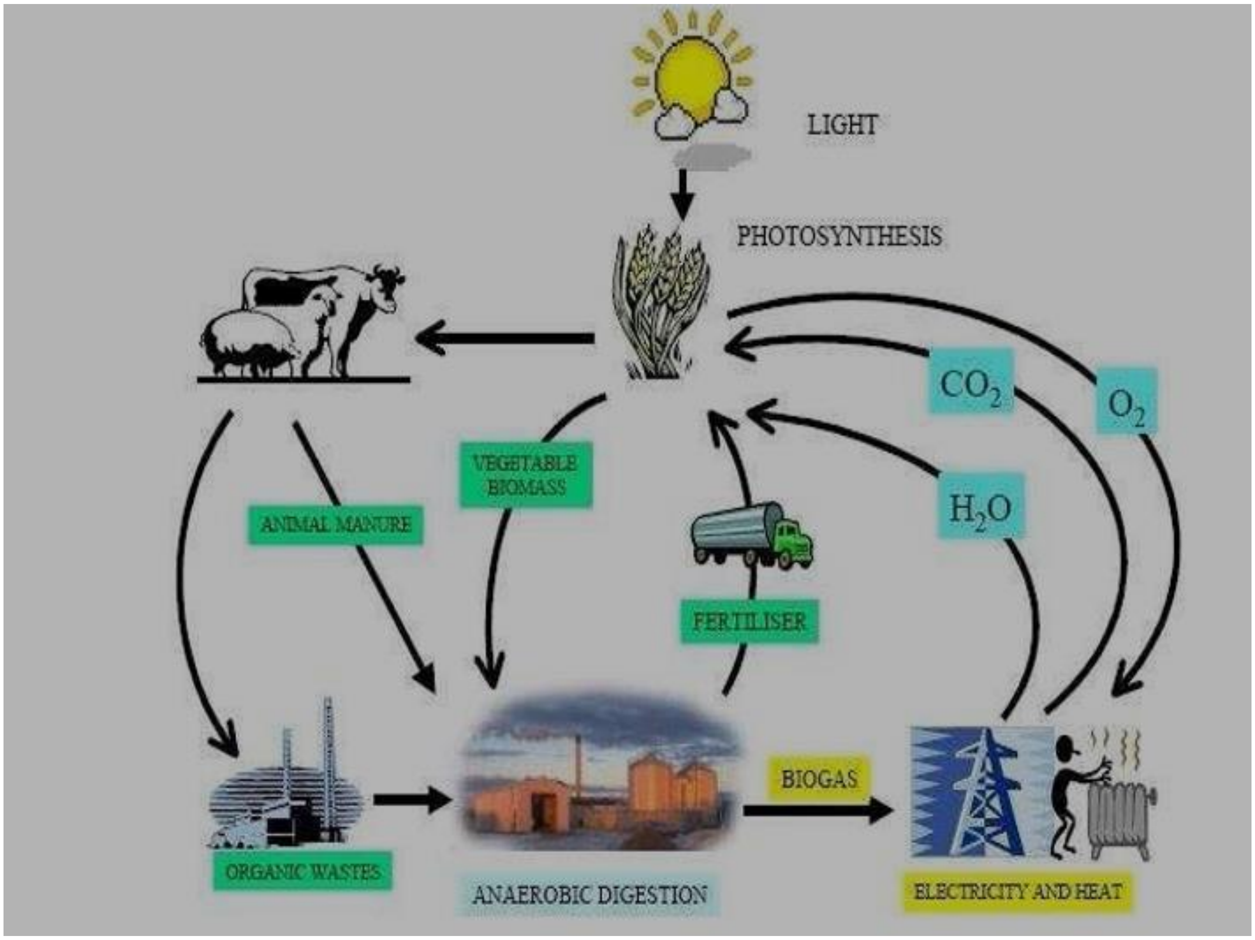


Figure 2.1: Biogas cycle

2.5 Biochemical Process of Anaerobic Digestion

Anaerobic digestion is a process of controlled decomposition of biodegradable materials under Managed conditions where free oxygen is absent, at temperatures suitable for naturally occurring Mesophilic or thermophilic anaerobic and facultative bacteria and Achaea species, that convert the inputs to biogas and whole digestate. It consists in the biochemical degradation of complex organic matter resulting in the biogas production, which has as main constituents' methane (CH_4) and carbon dioxide (CO_2), and trace amounts of hydrogen (H_2), nitrogen (N_2), ammonia (NH_3) and hydrogen sulfide (H_2S). The significant amount of biodegradable components (Carbohydrates, lipids and proteins) present in the microalgae biomass makes it a favorable Substrate for the anaerobic microbial flora that can be converted into biogas rich in CH_4 [11].The process occurs in the stomachs of animals, and the same biological process found in nature Can be replicated and controlled by engineers. There are four major steps of anaerobic digestion, Shown in figure 2.2 and described in detail in the following sections.

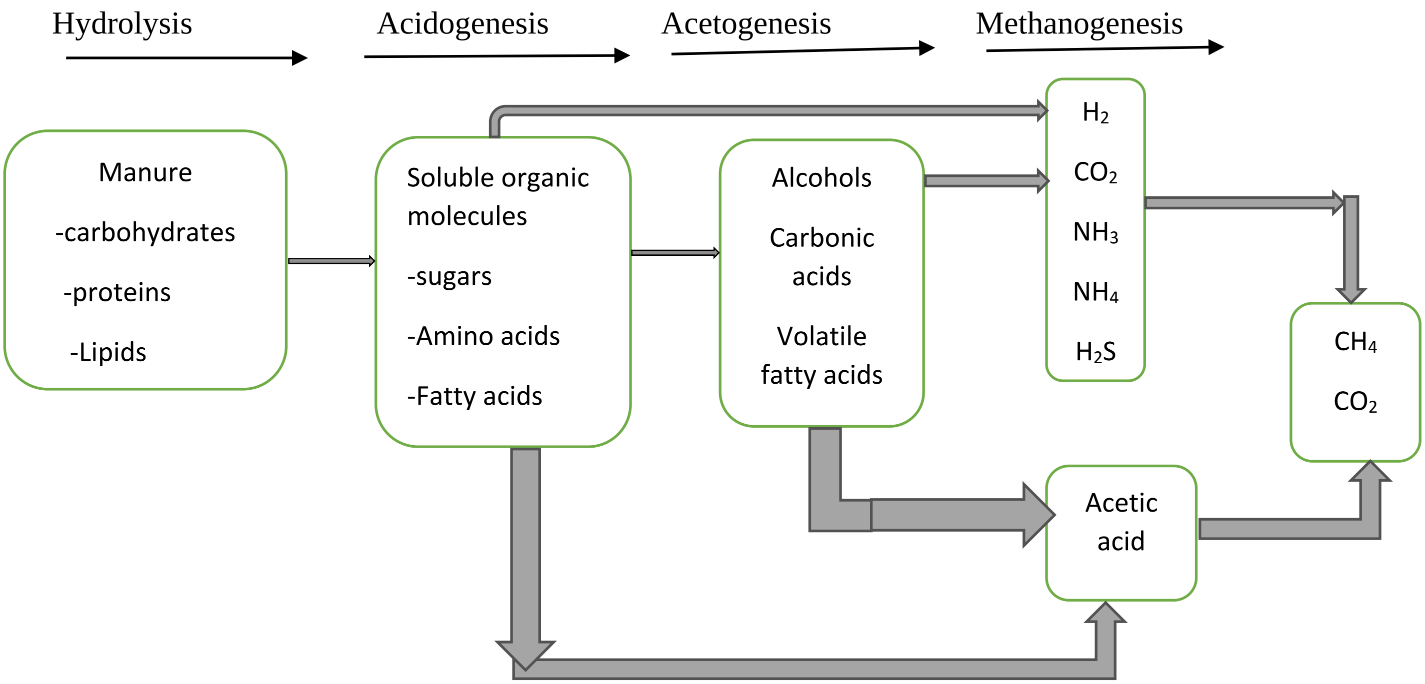


Figure2.2: The anaerobic digestion pathway follows four major steps: hydrolysis, acidogenesis, acetogenesis, and Methanogenesis. [12]

2.5.1 Hydrolysis

The organic matter is enzymalyzed externally by extracellular enzymes (cellulose, amylase, protease, and lipase) of microorganisms in the first step (hydrolysis). Bacteria break down lengthy chains of complex carbohydrates, proteins, and lipids into smaller components. Hydrolysis breaks down polymers including cellulose, carbohydrates, proteins, and lipids into soluble compounds. Polysaccharides, for example, are transformed to monosaccharide. Peptides and amino acids are separated from proteins.

$$\mathbf{n\,(C_6H_{10}O_5) + nH_2O \xrightarrow{hydrolysis} n(C_6H_{12}O_6)}$$

2.5.2 Acidification (Acidogenesis)

In the second step, acid generating bacteria transform the intermediates of fermenting bacteria into acetic acid (CH_3COOH), hydrogen (H_2), and carbon dioxide (CO_2). These bacteria are anaerobic and may grow in an acidic environment. They need Oxygen and Carbon to make acetic acid. They do this by using oxygen that has been dissolved in the solution or bounded oxygen. Hereby, the acid producing bacteria create an anaerobic condition which is essential for the methane producing microorganisms. Moreover, they reduce the compounds with a low molecular weight into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane. Amino acids, fatty acids, alcohols, CO_2, H_2, NH_3, and H_2S are among the soluble molecules that are transformed. Because bacteria alone are not capable of sustaining that type of reaction, this process is somewhat endergonic (i.e. only achievable with energy input).

n (C6H12O6) acid forming bacteria → 3n CH3COOH

2.5.3 Acetogenesis

In general, Acetogenesis is the creation of acetate, a derivative of acetic acid, from carbon and Energy sources by acetogens. These microorganisms catabolize many of the products created in Acidogenesis into acetic acid, CO_2 and H_2. Acetogens break down the animal waste to a point to Which methanogens can utilize much of the remaining material to create methane as a biofuel. In The third step of anaerobic digestion, acetogenic bacteria consume precursors and produce acetate (acetic acid). One example of this process is the consumption of glucose [10]

$$C_6H_{12}O_6 + 2H_2O \rightarrow 2CH_3COOH + 2CO_2 + 4H_2$$

2.5.4 Methane formation

In the final step, Methanogenes breakdown substances to low molecular weight. They use hydrogen, carbon dioxide, and acetic acid to make methane and carbon dioxide, for example. Methane-producing bacteria can be found in natural settings where anaerobic conditions are available, such as under water (for example, in marine sediments), in ruminant stomachs, and in marshes.

$$CH_3COOH \xrightarrow{\text{methane forming bacteria}} CH_4 + CO_2$$

Methanogenic bacteria produce methane in the Methanogenesis stage in one of two ways: by digesting acetic acid to methane (CH_4) and CO_2, or by reducing CO_2 with hydrogen gas or format produced by other bacterial species.

$$CO_2 + 4H_2 \xrightarrow{\text{reduction}} CH_4 + 2H_2O$$

They must be anaerobic and are quite sensitive to environmental changes.

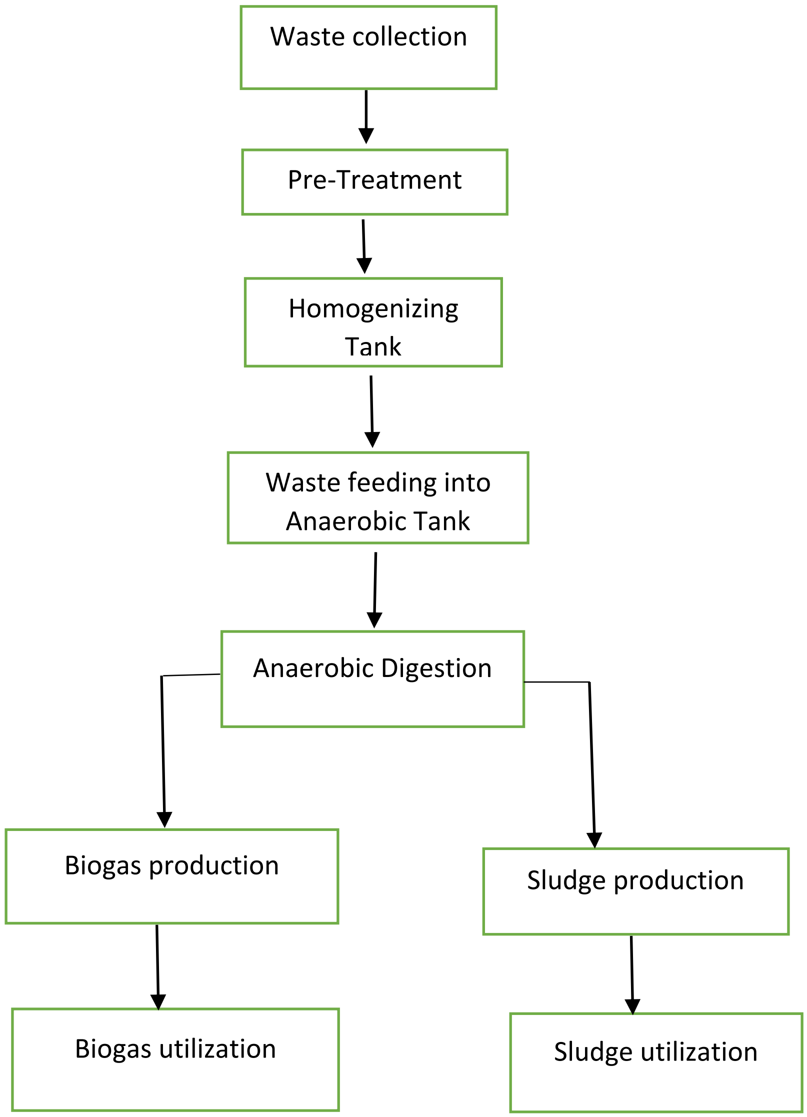


Figure 2.3: block diagram of production process

2.6 Factors Affecting Anaerobic Process

Many factors influence the digestive process inside the digester, as well as the amount of biogas produced. Microbe balance, temperature, substrate type, stirring, total solids or moisture, carbon/nitrogen ratio (C/N), time remaining of organics inside the digester, acidity (pH), and the presence of activators or inhibitors are some of these factors to consider. Any significant change in these variables can have a negative impact on biogas output. To operate the biogas plant efficiently, these parameters should be adjusted within the desired range.

2.6.1 Microbes Balance

Methanogens convert simple acids and hydrogen produced by fermentative bacteria species into methane gas and carbon dioxide, implying that the different types of anaerobic bacteria population should have stable ratios For example, if the population of acidogenic bacteria grows faster than the proper ratio, there will be an excess accumulation of acids inside the digester, increasing acidity (lowering pH), forcing methanogens to deactivate or cease working, and thus the digesting process. If the population of acidogenic bacteria declines dramatically, there will be insufficient acids for methanogenic bacteria, resulting in lower methane production. [7] [8] [10]

2.6.2 Substrate type

All organic compounds can be digested by anaerobic bacteria, however the time period necessary for complete digestion varies. That instance, some organic matter is readily digested and takes a short time (a few days to a few weeks), while others take a long time (months or years), and this is determined by the molecules that make up the organic matter. [8] [10]

2.6.3 Carbon to Nitrogen ratio (C/N ratio)

The carbon/nitrogen ratio is the proportion of carbon in organic matter to nitrogen in organic matter. The optimal C/N ratio is 20-30 carbon atoms per nitrogen atom (20-30 carbon atoms: 1 nitrogen atom) [8] [10].The digestion of the substrate will be hampered by a high or low C/N ratio. Increased ammonia generation, toxic consequences, and suppression of methane production arise from substrates with a low C/N ratio. A high C/N ratio indicates a deficiency of nitrogen, which has negative repercussions for protein production and hence the microorganism's energy and structural material consumption. A high carbon nitrogen ratio is likely to acidify, resulting in fermentation failure. Materials with a high C/N ratio should be blended with materials with a low C/N ratio to achieve the desired composite input average ratio. If the C:N ratio is high, injecting nitrogen in the form of animal urine or installing a latrine at the plant is recommended to boost gas production. Pig and bovine manure have a sufficient carbon nitrogen ratio, however human and chicken dung have a low carbon nitrogen ratio for successful digestion. Fresh vegetation has a high carbon nitrogen ratio, and old vegetation has a very high ratio, so these materials should be blended in the right quantities to start the fermentation process and increase biogas generation. As a result, biogas production fluctuates depending on the carbon/nitrogen ratio of the feedstock.

2.6.4 Temperature

Methanogenes can act on the substrate in wide range of the temperature from below freezing to above 57.2. [6]There are three ranges of temperature at which digestion process can be occurred and these ranges are: [10]

- Low temperature range: less than 35
- Medium temperature range: ranged b/n 29 and 40.
- High temperature range from 50 to55.

In general, the greater the temperature within the digester, the less time it takes to digest organic materials (producing more biogas), as more methanogenic bacteria operate on the substrate and disease-causing microbes are destroyed. Because methanogenic bacteria are highly sensitive to changes and variations in temperature inside the digester, especially at high temperature ranges (51.7-39.4), where biogas productivity drops dramatically, while it drops gradually at low temperature ranges, the temperature inside the digester should be stable (35-0).That is, unexpected or rapid temperature changes diminish or even cease biogas production, therefore temperature monitoring is critical, especially for biogas facilities that operate at high temperatures, and may require an additional heating system or sophisticated digester isolation. Because the temperature in most parts of the country is within this range, biogas facilities in Ethiopia are expected to run at a medium temperature.

2.6.5 pH value

The pH value has a significant impact on the development of bacteria during anaerobic digestion. By feeding the digester at the optimum loading rate, the pH value of the digester should be kept within the acceptable range of 6.8-7.2. The pH of the digestive liquid is lowered by acetate and fatty acids produced during digestion the ion bicarbonate equilibrium of carbon dioxide in the digester, on the other hand, is extremely resistant to pH changes. This resistance to pH change is known as buffer capacity, and it is measured by the amount of strong acid or alkali added to the solution to cause a pH shift. As a result, the presence of bicarbonate helps to minimize negative effects on bacteria produced by low pH induced by excessive fatty acid synthesis during digestion.

The buffering capacity and resilience to pH variations are aided by proteins and other organic as well as bicarbonate molecules. The pH naturally drops in the first few days as a result of Acidogenesis generating acids. Following the pH then steadied between 7.2 and 8.2, and the biogas production process likewise stabilized. The pH value of the feed night soil ranges from 6.9 to 8.4. In the case of significant pH rise when lime is being added to the digester contents (or with loaded organics), acidic materials such as sodium bicarbonate should be added to the digester contents (or with loaded organics).PH gradually rises as a result of nitrogen breakdown (generating NH_4+).

2.6.6 Stirring

The retention time is significantly reduced when optimal stirring is used. Stirring is critical for finishing the digestion process and increasing biogas output. Because stirring breaks down the scum that forms on the surface of the digester contents, it keeps the bacteria from becoming trapped in their own waste products. [10]For large-scale biogas plants, stirring is increasingly necessary. Small facilities can manually swirl digester contents using steel rods from the substrate introduction pipe or paddles, however large plants require more sophisticated stirring systems like as gas recirculation and mechanical stirrers. The digestion process is improved by thoroughly mixing organic wastes with water before feeding the slurry into the digester. The most important objectives of agitation are:

- Removal of the metabolites produced by the methanogens (gas)
- Mixing of fresh substrate and bacterial population (inoculation)
- Preclusion of scum formation and sedimentation
- Avoidance of pronounced temperature gradients within the digester
- Provision of a uniform bacterial population density
- Prevention of the formation of dead spaces that would reduce the effective digester volume

2.6.7 Total Solids (TS)

The number of solid particles in a unit volume of slurry is known as total solids, and it is usually stated as a percentage. Because sediments settle down or obstruct the flow of gas created at the lower part of the digester, the best biogas production occurs when total solids are between 7% and 10%[8] [10].As a result, dilution of organic substrate or wastes with water is required to reach the desired total solids percentage. TS=VS+FS

2.6.7.1 Volatile solids (VS)

The organic matter or degradable component that must be eliminated or stabilized during treatment is known as the volatile solids component. The VS component of dairy bovine feces makes up 80 to 86 percent of the total TS, with the rest being ash (FS)Any extraneous material entering the effluent stream, such as laneway dirt walked in on hooves, soil washed from earthen pads, or sand bedding, can diminish the VS to FS ratio. [8] [10].

2.6.7.2 Fixed solids (FS)

The leftover inorganic compounds (N, P, K, Ca, Cu, Zn, Fe, and so on) in a suspended or dissolved condition make up the fixed solids. These minerals are mostly dissolved in dilute effluents, making their removal from the effluent stream problematic.

2.6.8 Hydraulic retention time (HRT)

The majority of anaerobic systems are built to hold waste for a set amount of time. The hydraulic retention time is the number of days the materials remain in the tank. The amount of time it takes for the substrate to digest completely inside the digester is determined by the type of substrate, the size of the substrate particles, the amount of agitation, and, most importantly, the temperature of The shorter the retention time, the higher the digester temperature and the finer the substrate particle size. According to most data on the anaerobic digestion process, digesters working at temperatures between 20 and 35 have a retention time of 40 to 70 days the digester [8] [1].

2.6.9 Inhibitors and Activators

The presence of some compounds in the contents of the digester may trigger the digestive process, enhancing biogas production, but at larger quantities, they may become inhibitors.

2.7 Digester Loading Rate

The digester loading specifies how much organic material must be fed to the digester or processed each day. The organic dry matter loading in the digester is measured in kilograms per cubic meter of digester volume per day (kg ODM/m3/day). Low digester loading occurs as a result of long retention durations the pH drops when the digester loading is too high. Because there is more feed material than methane bacteria, the plant remains in the acid phase.

2.8 Basic types of biogas plant

Based on feed method they are classified as: [8]

- Batch feed plants
- Semi continuous
- Continuous feed plants

Batch plants are ideal for digesting straw, fibrous materials with high solids content, and for use as a simple demonstration plant in places with little annual rainfall. Continuous feed plants have a continuous supply of biomass through the digester, resulting in a near constant volume of slurry in the digester. Once or twice a day, such plants are fed. Batch plants are ideal for digesting straw, fibrous materials with high solids content, and for use as a simple demonstration plant in places with little annual rainfall. Continuous feed plants have a continuous supply of biomass through the digester, resulting in a near constant volume of slurry in the digester. Once or twice a day, such plants are fed. Continuous feed plants have the advantage of providing a consistent supply of substrate to the bacteria, allowing them to produce more biogas. The issue is that buoyant elements produce a thick layer of scum that obstructs biogas generation and may ultimately clog the plant. This disadvantage can be overcome by using appropriate agitators and increasing the retention period. Continuous feed biogas facilities are sized based on the desired organic material retention duration in combination with the digester load, which is a function of the current temperature and substrate type. Biogas is categorized into the following categories based on the type of construction:

- Fixed dome plants
- Floating drum plants
- Plastic tank plants

Two fundamental types of tested biogas plants that have acquired widespread recognition are fixed domed and floating drum biogas plants. **[10]**

Fixed dome plant

A closed, dome-shaped digester with an immobile, rigid gasholder and a displacement pit makes up a fixed dome plant (expansion chamber). The gas was collected in the digester's upper section. As the pressure in the digester rises, slurry is pushed into the displacement pit, where it flows back to the digester as soon as the gas is released. The expansion chamber has the same volume as the gas storage chamber. The difference in slurry levels between the inside of the digester and the expansion chamber creates gas pressure. A comparable amount of slurry flows back into the digester when gas is extracted. In a fixed dome plant, the gas pressure does not remain constant, but rather rises with the amount of gas stored. To achieve a consistent supply pressure, a special purpose pressure controller or a separate floating gasholder is required. Such plants' digesters are normally composed of masonry, with paraffin or bituminous paint applied to the gas-filled region to seal it off.

Advantages fixed dome plant:

- It has low cost compared to floating drum type as it uses cement and no steel.
- It has no corrosion trouble (problem).
- Heat insulation is better as construction under the beneath the ground, temperature is be constant.
- The design is compact, it saves space of construction
- Less need of maintenance drawback fixed dome plant:
- Gas production per cubic meter of the digester volume is less.
- Gas pressure fluctuates substantially and is often very high.
- Plant often not gas light (porosity and cracking often cause irreparable leaks.)

Fixed dome plant is only recommended in cases where experienced biogas technicians are available for building them, and when the user is amply familiar with how the plant operates.

Floating drum plant

The major components of this design are essentially identical to those of the permanent dome design, with the exception of the biogas collection system. The biogas was collected inside a mild steel drum that was adjusted over the top of the digester in this configuration this drum moves up and down according to the biogas pressure rise up under gas pressure, that is; when the quantity of biogas increases, the drum moves up and as the biogas consumed it is moved down. [8]

Advantage:

- Floating drum plants are easy to understand and operate
- They provide gas at a constant pressure
- Volume of stored gas visible directly
- Few mistakes in construction Drawback:
- High construction cost of floating drum
- Many steel parts liable to corrosion, resulting in short life(up to 15 years)
- Maintenance intensive due to the necessity of periodic painting & rust removal.

When using fibrous substrates, the gasholder has a propensity to become “stuck” in the resulting floating scum. Floating drum plants can be recommended as a mature, simple-to-operate, and functionally adequate source of biogas, especially when reliability is more important than cost. Water jacket plants are globally useful and particularly simple to care for.

Plastic tank digester: This method consists primarily of two pre-fabricated hard plastic tanks: one for the digestion of organic materials and the other for the storage of the biogas produced. As a result, this technology is rather simple to set up. Because the tanks are usually not buried, they are vulnerable to damage. Water tank technologies were used to create this digester. By analogy with water tanks, a lifespan of 20 years can be predicted. It should be noted, however, that the number of plastic tank digesters now in use is extremely low.

Merit

- Easy installation
- Quick biogas production start-up after installation (3-4 days)
- Small digester tank volume, therefore appropriate for limited livestock

Demerit

- Potentially damageable (not underground)
- Small digester volume available, hence low biogas production
- No employment creation ,Few existing installations, hence little feedback
- Dismantling and recycling of the unit

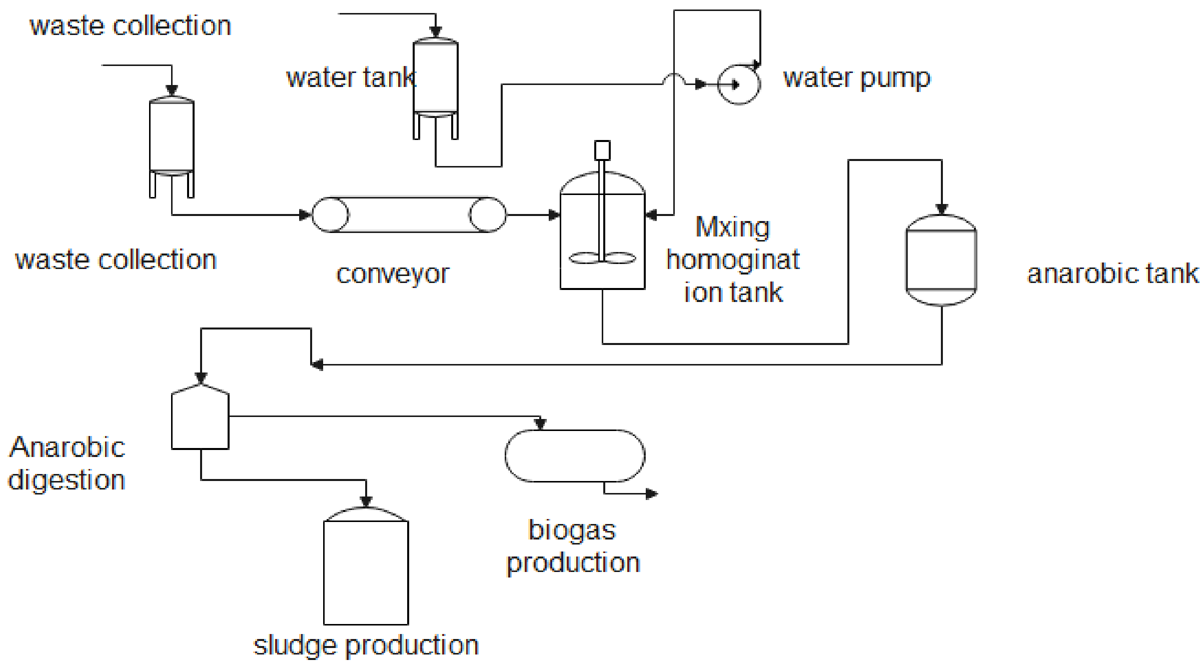


Figure 2.4: Process flow diagram of cow dung production

CHAPTER THREE

3 MATERIALS AND METHODS

The animal dung for experiment evaluation was taken from local area of Wolkite University and it was transported manually to department of chemical engineering laboratory.

3.1Material used

- Round bottom flask
- Plastic Hose 1.5 meters
- Furnace
- Glue
- Funnel
- Blade
- Marker
- PH meter
- Oven
- Thermometer
- Electronic scale measurement
- Meter
- Stirrer
- Saw for plastic

3.2 Chemicals

Saccharomyces yeast

Sodium hydroxide

3.3 Methodologies

Experimental procedure

- The raw materials were collected from local area around Wolkite University.
- The animal dungs were weighted by mass balance
- The raw material was characterized by using air oven.
- The water volume was measured by electronic scale measurement.
- The raw material and water fed in to bio digester in 1:2 ratio.
- To form perfect mixture stirring takes place for 20 minutes.

- The mixture is stayed in the digester for three weak
- The PH is measured by digital PH meter on three days interval
- Temperature is measured on three days interval by thermometer.
- Depending on measurement PH adjustment takes place by addition sodium hydroxide.
- At the end of process the biogas produced is characterized in terms of methane content.

3.4 Preliminary Analysis of Animals waste Materials

In order to determine moisture content, volatile solid and total solid of the physico-chemical parameters were measured before the anaerobic digestion process began. The samples were pre-treated by drying in an oven at 105^{o}C for 8 hours. The samples were weighted on sensitive balance.

Raw material characterization

Determination of moisture content, TS, VS, were made using standard procedure set by American Public Health Association- APHA, 2005. As per the standard procedure sample of animal dung 194g were dried at 105^{o}C to drive off water in the sample. The residues were then cooled, weighed, and dried again at 550^{o}C to drive off VS in the sample. The TS and VS were determined by comparing the mass of the sample before and after each treatment step. Freshly collected sample is weighed in a crucible. The crucible was placed inside an electric hot air-oven maintained at 105^{o}C.The crucibles is allowed to remain in oven for 8 hours, then taken out, cooled in desiccators, and weighed. The weight of the sample in the oven, gives the total solids and it is represented in percentage basis. Percent total solid content and percent moisture was calculated using following formula.

Weight of sample = 194g

Dry weight =46.56

Percentage of moisture content $=\frac{(\text{wet weight}-\text{dry weight})}{\text{wet weight}} * 100$

$$\frac{(194-46.56)}{194} * 100\% = 76\%$$

$$TS = \frac{\text{final weight of dung}}{\text{initial weight of dung}} * 100,$$

$$\frac{46.56}{194} * 100\% = 24\%$$

Where TS =Total solid of sample

To determine volatile solids the oven dried samples were placed in muffle furnace at 550°C for about 3 hours. After 3 hours, the weight of crucible and the ash weight were measured. Then the following formula was employed to calculate percentage of volatile solid (APHA, 2005).

$$VS\ (\%) = \frac{(DW-AW)}{DW} * 100\%$$

$$\frac{46.56-8.38}{46.56} * 100\% = 82\%$$

VS =82%TS =0.82*24% =19.7%

FS= TS –VS

=24% -19.7% = 4.3%

Where; VS (%) = percentage of volatile solid,

DW = dry weight

AW = ash weight.

FS = fixed solid of sample

Determination of water added to the digester

In biogas production the amount of solids in the fermentation slurry should be adjusted to a total solid (TS) of 7-10% (13). Water was added to the digester to improve the moisture content and enhance the digestion (Chynoweth et al., 2001). In the current study, 8% of TS solution (8% solids concentration) was used adjusted by following the formulae depicted below:

A= mass of fresh sample added= 2kg

B= mass of water added to get 8% total solid in the digesters.

mTS = mass of total solid

mTS=2kg*24%= 0.48kg

$$\frac{mTS}{A+B} = 8\%$$

$$\frac{0.48kg}{2kg+B} = 0.08$$

B =4kg

3.5 Feeding Digester

The mode of feeding used was a discontinued feeding (batch feeding). This simply means loading the digester at once and maintaining a close environment throughout the retention period. For different digesters were prepared for loading; these four digester are for the two wastes(cow dung and horse dung) by adding water, yeast and hot water and co-digestion of the two wastes(cow dung and horse dung in one digester) by adding water in 10L digester.

Experiment one (Biogas generation from cow dung using 1:2 waste to water ratio)

- 2kg cow dung
- 4L water

2 kg of cow dung was charged into the digester with 4 L of water by electronic scale measurement in the ratio of 1:2 of waste to water and the mixing ratio was determined by moisture content of the different wastes. The daily ambient and slurry temperature were measured using thermometer (28-32^{o}C) was used to measure the daily ambient and slurry temperatures. The pH values were monitored on three days by addition of sodium hydroxide to determine action of the methanogens, which utilize the acids, carbon dioxide, and hydrogen created by non-methane generating bacteria. The volume of biogas produced was measured using a downward displacement method using a hose, 2L bottle, 0.5L volume measuring beaker. The valve was used to test the gas's flammability.

Figure 3.1 Experimental set up for biogas production

Experiment two (Biogas generation from cow dung with addition of horse dung)

- 1.5kg cow dung
- 0.5kg horse dung
- 4L water

1.5kg of cow dung and 0.5 kg horse dung were charged into the digester with 4 L of water by electronic scale measurement in the ratio of 1:2 of waste to water and the mixing ratio was determined by the moisture content of the different wastes. The daily ambient and slurry temperatures were measured using thermometer (28-32^{o}C). The pH Values were monitored on 3 days by addition of sodium hydroxide to determine the action of methanogens, which utilize the acids, carbon dioxide and hydrogen produced by no methane producing bacterial using a digital pH meter. The volume biogas produced was measured by a downward displacement method using hose, 2Lbottle and 0.5L volume measuring beaker. The valve was used to test the gas's flammability.

Experiment three (Biogas generation from cow dung in the presence of yeast)

- 2kg cow dung
- 4L water
- Saccharomyces Yeast 10 gram

2kg of cow dung was charged into the digester with 4L of water by electronic scale measurement in the ratio of 1:2 of waste to water and to see the reaction add saccharomyces yeast the mixing ratio was determined by the moisture content of the wastes. The daily ambient and slurry temperatures were measured using thermometer (28-32^{o}C) .The pH Values were monitored on 3 days by addition of sodium hydroxide to determine the action of methanogens, which utilize the acids, carbon dioxide and hydrogen produced by non-methane producing bacterial using a digital pH meter. The volume biogas produced was measured by a downward displacement method using hose, 2L bottle and 0.5L volume measuring beaker. The valve was used to test the gas's flammability.

Experiment four (Biogas generation from cow dung using hot water (100ºC))

- 2kg cow dung
- 4L hot water

2kg of cow dung was charged into the digester with 4L of hot water to observe the changing in temperature by electronic scale measurement in the ratio of 1:2 of waste to water and to see the reaction the mixing ratio was determined by the moisture content of the different wastes. The daily ambient and slurry temperatures were measured using thermometer (18-32oC) .The pH Values were monitored on 3 days by addition of sodium hydroxide to determine the action of methanogens, which utilize the acids, carbon dioxide and hydrogen produced by no methane producing bacterial using a digital pH meter. The volume biogas produced was measured by a downward displacement method using hose, 2L bottle and 0.5L volume measuring beaker. The valve was used to test the gas's flammability.

Temperature measurement

A 30cm long mercury in glass thermometer was used to measure the temperature of the content of hydrolysis reactor and methanogenic overflow. This measurement done at specific time of the day on regular basis by inserting thermometer into its content and leaving it for some few minutes. The thermometer was thoroughly cleaned by washing it with detergent and wiping it dry before inserting it into another sample.

pH determination

The pH is considered as primary process variable in controlling the hydrolysis rate of anaerobic digestion of solid state fermentation. It seems that pH control even during pre-stage in imperative. The pH values of the influent (slurry before digestion) and effluent(slurry after digestion) were determine with aid of digital pH meter. Each sample in sample container was well shaken to allow a homogenize mixture and poured into 100ml beakers. The probe was than inserted and pH value digitally read and recorded.

CHAPTER FOUR

4 RESULTS AND DISCUSSION

Observation

Experiments were performed in four digester and changing the parameter in each digester .Unfortunately, gas chromatograph in lab is malfunctioning due to this presence of methane checked by finger pressing and the amount of methane generated were labeled as low, medium, high. Other parameter are analyzed by the available equipment in the lab and we measured the biogas by water displacement method.

Table 4.1: Weekly analysis for Experiment one (Biogas generation from cow dung)

Experiment 1	Temperature	Quantity(finger press)	Water displacement
Week 1	32	Low	0.125L
Week2	28	Medium	0.175L
Week 3	28	High	0.21L

Table 4.2: Weekly analysis for Experiment two (Biogas generation from cow dung with addition of horse dung)

Experiment 2	Temperature	Quantity(finger press)	Water displacement
Week 1	32	Medium	0.15L
Week 2	29	High	0.19L
Week 3	28	High	0.2L

Table 4.3: Weekly analysis for Experiment three (biogas generation from cow dung in the presence of yeast)

Experiment3	Temperature	Quantity(finger press)	water displacement

Week 1	32	Low	0.1L
Week 2	27	Medium	0.16L
Week 3	28	High	0.19L

Table 4.4: Weekly analysis for experiment four (biogas generation from cow dung using hot water)

Experiment 4	Temperature	Quantity(finger press)	water displacement
Week1	32	Low	0.125L
Week2	30	Medium	0.18L
Week3	29	High	0.2L

Table 4.5: Result for the whole Experiments

Experiment	Temperature	TS%	VS%	pH
1	30	8%	6.56%	6.8
2	30	10%	8.2%	6.6
3	30	9%	7.38%	6.7
4	30	8.5%	6.97%	6.5

Discussion

Experiment 1: The moisture content of the animal dung in the experiment one is higher than the other the percent of moisture content is 92%. Finally we find that total solid is 8%, volatile solid is 6.56% and pH is 6.8.

Experiment 2: In this case Horse dung as used for inoculum but the result is not better than cow dung. Moisture content is 90%, total solid is 10%, volatile solid is 0.082and pH value is 6.6.

Experiment 3: In this case use saccharomyces yeast 10 gram for 10 litter capacity round flask but this one is different from the rest the fermentation process is accelerates the result because the result 0.19L is obtained before17 days and then the process is stabilized. But the overall result is not better than experiment one. Total solid 0.09, volatile solid 0.0738, pH 6.7.

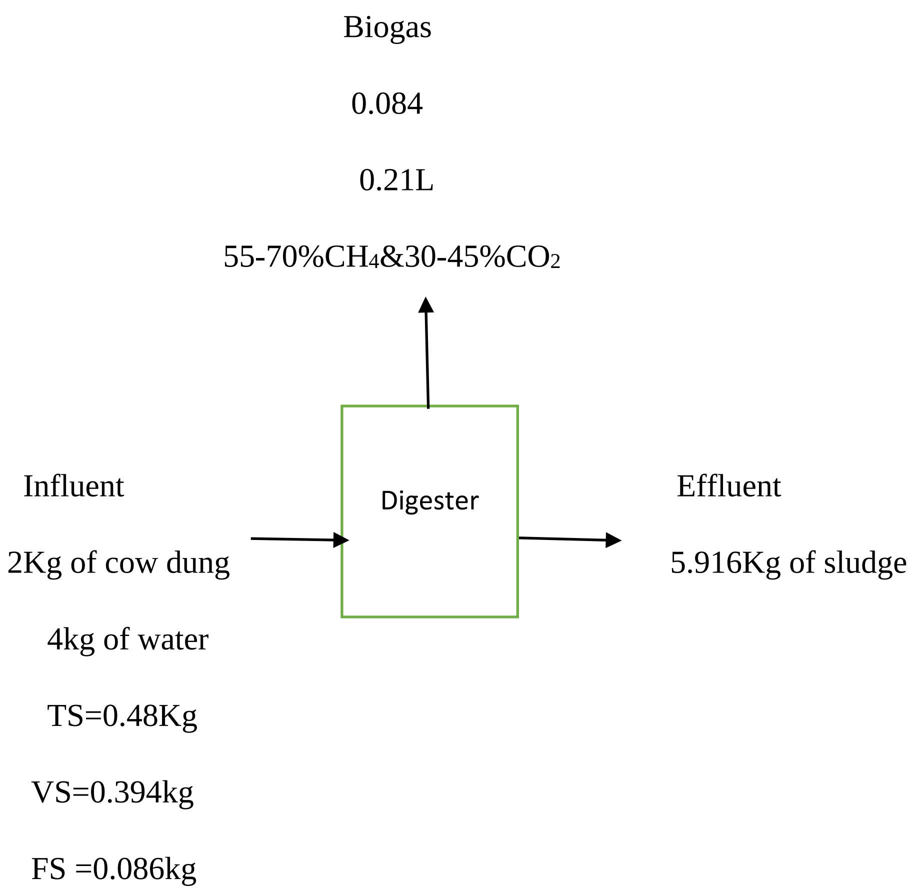
Experiment 4 : In this case use a hot water for hydrolysis the effect is better than the cold water the fermentation process is facilitate the gas .Total solid 0.85, volatile solid 0.0697 and pH 6.5.

Generalize the discussion

The production rate of biogas from the experiment is 0.21L. Also the production process depends on the pH value as the pH value decrease the production process decreases. The pH range is from 6.5 to 7.8. The results show that factors like temperature, pH, concentration of total solids, etc. affect the production of the biogas. The ambient and slurry temperature values were constantly changing because of Wolkite weather condition monitored in determining the rate of digestion and retention of the process, since temperature is very important. The ambient temperature affects the rate of digestion due to the outside walls of the digester surface make direct contact with the atmosphere, hence the digester walls absorb or loose heat depending on the temperature gradient between the digester and its immediate environment .This implies that seasons affect the rate of heat loss or gain from the digester which in turn affects the microbial activities in the slurry at each stage. The bacterial involved may not play its role completely. Ambient temperature fluctuated due to climatic conditions. With experiment carried out during the season showed that slurry temperature up to 32^{o}C can at times be recorded whereas ambient temperature varied between 20^{o}C and 32^{o}C. A pH of 6.8 was found to be the most favorable at the mesophilic task. The organic acids were always formed during the anaerobic decomposition process.

CHAPTER FIVE

5 MATERIAL AND ENERGY BALANCE



From the experiment we got 0.21L of biogas by water displacement method and 5.916kg of sludge by measurement on mass balance. For mass balance:

Mass in =Mass out

Mass of cow dung + Mass of water = Mass of Biogas + Mass of sludge

2kg + 4kg = Mass of biogas +5.916kg

Mass of Biogas = 0.084kg

The base of calculation is by use 2kg/day of cow dung from above experiment data. The TS is 24 % and VS from the total solid is19.7 %.

Total solid (TS) = percentage of total solid * mass of cow dung

= 0.24 * 2kg

= 0.48kg

Volatile solid (VS) = 0.197 * 2kg

=0.394kg

Mass of unconverted VS is calculated by characterizing in sludge by using oven at 105^oC.100gm sample sludge is taken and stayed in oven for 8hr. mass of total solid in 100gm of sludge after drying is unconverted VS plus FS = 2.45gm

Mass of water in 100gm sample sludge =100gm - (unconverted VS + FS)

=100gm -2.45gm

= 97.55gm

Since fixed solid is not involved in digestion process input fixed solid is equal to output fixed solid

FS=0.086kg in mass of sludge (5.196kg) but, in 100gm sample sludge is 1.45gm

TS = unconverted VS + FS

2.45gm =unconverted VS + 1.45gm

Unconverted VS = 1.0gm

$$\%VS = \frac{\text{mass of unconverted VS in 100gm}}{\text{mass of sample of sludge}} * 100$$

$$= \frac{1.0gm}{100gm} * 100$$

= 1%

Mass of unconverted VS in 5.916kg of sludge =mass of sludge *%VS

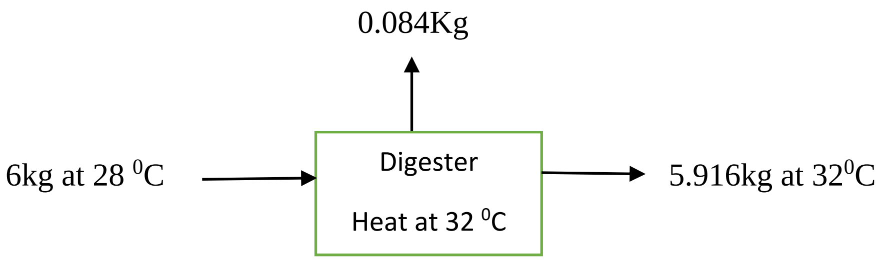
=5.916kg * 1%

=0.0591kg

Sodium hydroxide to cow dung ratio is 0.0367:1 ratio and yeast ratio is 0.0128:1

Daily sodium hydroxide = 0.0367 * 2= 0.0734Kg/day

Energy analysis on digester



Take base temperature =28^{0}C

Exothermic energy is released during fermentation; the amount of heat generated can be calculated. The outlet temperature is 32^{o}C. Biogas constant R 0.3009197 kJ/kgK, specific heat at constant volume Cv 0.8998976 kJ/kgK and that at constant pressure Cp 1.200817 kJ/kgK.

$$Q= Mmix*Cpmix *\Delta T$$

$$=0.084kg*1.200817KJ/ (kgK) *(32-28)\ K$$

$$=0.4035kJ$$

5.1 Material balance in industrial scale

Assume the scale up factor is 1000 and manufacturing capacity of factory of biogas in a year is about 2,000L.

Annual biogas production = 2,000L/year. Operation time =330 days/year.

One batch feed to the digester tank have 66 days for retention time.

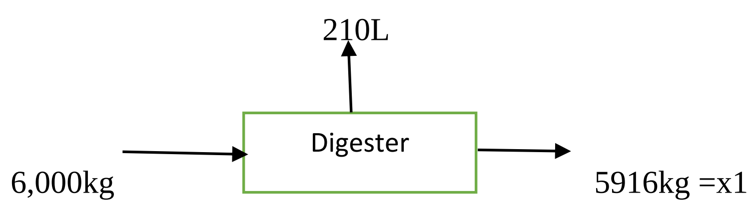
Daily biogas production = 2,000(L/year) / (330day/year) = 6.06L/day

Based on the laboratory experiment of 0.084kg biogas the composition is given as follows for 100g of mixture sample percent of composition is mention as below:

Table 5.1: Biogas composition in industrial scale

Substance	Symbol	Composition (%)	Industry scale(L/day)
Methane	CH_4	57*100/84=67.85	6.06* 0.6785=4.11
Carbon dioxide	CO_2	40*100/84=47.6	6.06* 0.476=2.88
Ammonia	NH_3	1*100/84=1.19	6.06*0.0119=0.072
Hydrogen	H_2	1*100/84=1.19	6.06*0.0119=0.072
Nitrogen	N_2	1*100/84=1.19	6.06*0.0119=0.072
Water vapor	H_2O	Trace	0
Carbon monoxide	CO	Trace	0
Hydrogen disulfide	H_2S	Trace	0

Wolkite University owned around 28 cattle .From each cattle around 2kg can be obtained in a day. So, total cow dung= 28*2kg*30day*12month=20,000kg /year. Now we take 2,000kg cow dung per batch from total storage of 20,000kg for one time.



Mass of biogas is =84kg

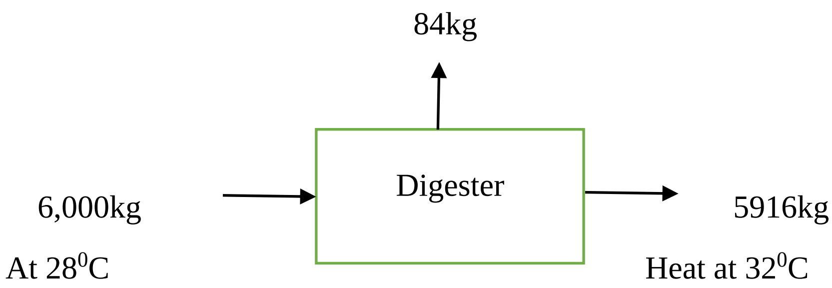
Mass in = Mass out

Mass of cow dung + mass of water =mass of biogas + mass of sludge

2 * 1000kg + 4 * 1000kg = mass of biogas +5.916 * 1000kg

Mass of sludge =5916kg

5.2 Energy balance for industrial scale



$Q = Mmix*Cpmix*\Delta T$

$= 84kg*1.200817KJ/(kgK)*(32-28) K$

$= 403.474512KJ$

CHAPTER SIX

6 COST ANALYSIS

6.1 Equipment purchasing cost

Equipment purchasing cost can be estimated using www.matche.com based on the equipment sized above.

Table 6.1 Equipment purchasing cost

Type of materials	UNIT	Quantity	Capacity	Construction of material	Price per unit birr	Total price birr	Remark
Digester	m^3	1	30	Concrete tank	8,5000	8,5000	Dome shape
Feed pump	W	1	727	Stainless steel	9,000	9,000	Rotary type
Feed storage tank	m^3	1	29.36	Stainless steel	9,5000	9,500	
Agitator	W	1	804	Carbon steel	8,000	8,000	
Inlet pipe	M	1	1.5	PVC	140	140	
Outlet pipe	M	1	1.5	PVC	140	140	
Gas pipe	M	1	2	PVC	140	140	
Dung collector	Kg	1	20,000	PVC	0.1	2,000	
Crusher	Ft	1	0.05	Stainless steel	10,000	10,000	
Water collector	m^3	1	40	PVC	0.25	500	
Total						47,920	

Equipment purchasing cost =47,920 birr

Purchased equipment cost (PEC) = 28% fixed capital investment (FCI)

47,920 = 0.28*FCI, FCI = 171,143 birr

6.2 Total Capital Investment

Total Capital Investment (TCI) = Fixed Capital Investment + Working Capital

Table 6.2: Total Capital Investment

Direct cost		
Purchased equipment cost PEC	28%FCI	47,920
Installation and painting(IC)	10%FCI	17,114

Instrumentation and control installed (ICC)	5%FCI	8,557
Piping installed (PC)	12%FCI	20,537
Land	3%FCI	5,134
Total		99,262
INDIRECT COST		
Construction expenses	10%FCI	17,114
Contingency	10%FCI	17,114
Total		34,228
Total Fixed Capital (TFC)	Direct+ indirect	133,490
Working Capital (WC)	20 % TCI	42,786
Total Capital Investment(TCI)	TFC +WC	TCI=FCI/0.8 =171,143/0.8 =213,929

Total capital investment (TCI) =fixed capital investment (FCI) +Working capital (WC)

TCI = 171,143+ 42,786

TCI = 213,929 birr

6.3 Estimation of total product cost

Total production cost = manufacturing cost +general expense

Table 6.3: Estimation of manufacturing cost and general expense

MANUFACTURING COST		
1.Fixed charges(FC)	15%TPC	0.15TPC
Depreciation	10%FCI	17,114
Local tax	3%FCI	5,134
Total fixed charge(TFC)		22,248+0.15TPC
2. Direct production costs		
Raw material	10%TPC	0.1TPC
Operating labor(OLC	20%TPC	0.2TPC
Utilities(electricity, heat and water)	20 %TPC	0.2TPC
Maintenance and repair(M & RC)	5%FCI	8,557
Patent	3%TPC	0.03TPC
Total		8,557+ 0.53TPC
Plant overhead cost	10%TPC	0.1TPC
2. GENERAL EXPENSE		
Distributing and selling	10%TPC	0.1TPC
Research and Development	5%TPC	0.05TPC
Financing (interest)	6%TCI	12,836

Total		12,836+ 0.15TPC

Manufacturing Cost = Direct Production cost + Fixed charges + Plant Overhead cost

= [8,557+ 0.53TPC] + [22,248+0.15TPC] + [0.1TPC]

= 30,805+0.78TPC

Total production cost = manufacturing cost +general expense=30,805+0.78TPC+12,836+0.15TPC

TPC = 623,443birr

6.4 Gross Profit and Net Profit

Gross profit = product sales revenue – total product cost – depreciation.

But, Product sales revenue =selling price *production capacity *working days.

Selling price of the biogas $0.02284 (current price of Ethiopian electricity cost) so,

4.448kwh is daily caloric value.

Product sales revenue =22.84*20.66*4.488*330*days/year = 698,865 birr

Plant service life = 5year

Therefore depreciation cost =17,114

Gross profit = product sale revenue - total production cost - depreciation cost

=698,865 -623,443-17,114

=58,307 birr

Net profit = gross profit (1- a), a= income tax = 34%,

=58,307 (1-0.34)

=38,483 birr

6.5 Profitability analysis

Minimum acceptable rate of return (Mar)

Minimum acceptable rate of return (mar) for new capacity with established corporate with low levels of risk=12%

Rate of Return an Initial Investment (ROI)

ROI =Np /TCI = 38,483/ 213,929=0.18

Since ROI value greater than mar (12%) the project is acceptable

6.6 Where to locate the biogas plant

The next planning step in a biogas project idea is to find a suitable site for the establishment of the plant. The list below shows some important considerations to be made, before choosing the location of the future plant:

- ✓ The site should be located at suitable distance from residential areas in order to avoid inconveniences, nuisance and thereby conflicts related to odors and increased traffic to and from the biogas plant.
- ✓ The direction of the dominating winds must be considered in order to avoid wind born odors reaching residential areas.
- ✓ The site should have easy access to infrastructure such as to the electricity grid, in order to facilitate the sale of electricity and to the transport roads in order to facilitate transport of feedstock and digestate.
- ✓ The soil of the site should be investigated before starting the construction.
- ✓ The chosen site should not be located in a potential flood affected area.
- ✓ The site should be located relatively close (central) to the agricultural feedstock production (manure, slurry, energy crops) aiming to minimize distances, time and costs of feedstock transportation.
- ✓ For cost efficiency reasons, the biogas plant should be located as close as possible to potential users of the produced heat. Alternatively, other potential heat users such as heat demanding industry, greenhouses etc. can be brought closer to the biogas plant site.
- ✓ The size of the site must be suitable for the activities performed and for the amount of biomass supplied.
- ✓ The required site space for a biogas plant cannot be estimated in a simple way. Experience shows that e.g. a biogas plant of 500 kwela needs an area of approximate 8 000 m^2. This can be used as a guiding value only, as the actual area also depends on the chosen technology.

6.7 Environmental impact assessment

Since biogas is renewable energy it has a positive impact towards the environment, because it replaces the nonrenewable energy which causes environmental degradation. Anaerobic digesters are biochemical systems that convert various waste streams into biogas and digester.

CHAPTER SEVEN

7 CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The result of this project on the production of biogas from cow dung, horse dung has shown that flammable biogas can be produced from these wastes through anaerobic digestion for biogas generation. These wastes are always available in our environment and can be used as a source of fuel if managed properly. The project revealed further that cow dung as animal waste has great potentials for generation of biogas and its use should be courage due to its early retention time and high volume of biogas yields. This is work using 10 liters capacity to inspect the anaerobic digestion in producing biogas. The digester was batch operated and weekly gas produced from the plant was observed for three weeks. Also in this project, it has been found that temperature variation, pH and concentration of total solid, moisture content, volatile solid etc., are some of the factors that affected the volume yield of biogas production. The operating temperature of digester were maintained within Mesophilic condition. The biogas production from cow dung increase from the first week to the third week between 0.125 and 0.21L.the pH of cow dung is gradually increase within the retention time. Anaerobic digestion of biomass offer important benefits, environmentally safe waste management and disposal, as well as energy generation. Biogas being cheap reliable and easy to construct can be sustainable, and as such is a necessary technology which needs exploration to benefit the rural population. In addition, generate electricity biogas could potentially help reduce global climate change

7.2 Recommendation

Based on the results of this study, the following recommendations are forwarded to increase the quality and quantity of biogas production:

- During this project we have faced a lot of challenges that affects our laboratory results like there was insufficient laboratory equipment's (like gas chromatograph and shortage of oven), Chemical (calcium carbonate), so we recommend that there should be appropriate and sufficient equipment's and chemicals to do laboratory experiments.
- Checking for toxic gases like hydrogen sulphide and ammonia with gas detection equipment should be carried out before entering an empty digester.

- Preheat water to accelerate fermentation process and yield high production of methane compare to at room temperature of water.
- The effect of temperature on methane content of biogas should be studied.
- The time taken for biogas production of domestic organic waste in different geographical and climatic areas should be studied.
- Upgrading the biogas produced to get better and more refined methane. That is to decrease the concentration of noncombustible components (undesirable components) such as H_2S, H_2O and $CO_2$from produce biogas by using biogas purification using chemical scrubbing such as KOH, NaOH and $CaCl_2$. The upgraded biogas could be used to run more engine

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APPENDIX

Composition of biogas matter	Chemical formula	Average percentage methane%	Average percentage for inoculums for horse	Average calorific value
Methane	CH4	60-68	72	150
Carbon dioxide	Co2	16	14	
Other		20	14	
Total		100	100	150

measuring PH value by PH meter

sucking of fermented animal dung in digester yo measure PH value

mass balance

adding the mixture of animals dung into digester animal