THE VALUE OF HEAT PRODUCED BY BIOGAS GENERATED FROM FARM WASTE VIA ANAEROBIC DIGESTIÓN

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ABSTRACT

The Philippines is a predominantly agricultural country, with most of its land dedicated to farming. However, the top subsectors of agriculture generate a significant amount of waste. This waste is often left scattered, contributing to the country's pollution and solid waste problem. Nevertheless, biogas produced from farm waste through anaerobic digestion is a promising alternative to non-renewable sources of energy, especially as a fuel for heating. However, more research is needed to determine the amount of heat produced by biogas generated from farm waste. Thus, this study aims to determine the value of heat produced by biogas generated from farm waste via anaerobic digestion. In this study, two treatments with two trials each were formulated using pig dung and cow dung, respectively, and mixed with mineral water in a 2:1 ratio. Calorimetry was used to determine the amount of heat produced by each treatment. The results showed that the two trials of pig dung generated a mean value of 7252.125413 calories of heat, while two trials of cow dung produced a mean value of 5108.9068815 calories of heat. The data was the analyzed using T-test. Results revealed that there is no significant difference in the amount of heat produced by pig dung compared to cow dung. The biogas generated from a small quanti of pig and cow dung within a short duration of time has a comparable heating value to dry firewood. Thus, it is advisable to use biogas from pig and cow dung as a fuel source for heating.

CHAPTER I

THE PROBLEM AND ITS SCOPE

This chapter is divided into five parts: (1) Background of the Study, (2) Statement of the Problem and the Hypothesis, (3) Significance of the Study, (4) Definition of Terms. (5) Scope and Delimitation of the Study.

Part One, Background of the Study and Conceptual/Theoretical Framework of the Study, presents the introduction to the study and discusses the rationale for choosing the study.

Part Two, Statement of the Problem and the Hypothesis, includes the purpose of the investigation generally and specifically using both descriptive and inferential questions.

Part Three, Significance of the Study, includes the benefits to be derived from the results of the study.

Part Four, Definition of Terms, alphabetically lists and defines difficult words or terms in the study for clarity and understanding.

Part Five, Scope and Delimitation of the Study, gives the brief and concise scope or boundaries of the study

Background of the Study

The Philippines is an agricultural country where about 40 percent of its land is used for agriculture (The World Bank, 2020), With fishing, farming and livestock being the top subsectors of agriculture, these sectors generate a lot of waste. Farmers let them scattered anywhere. Some farmers would even strategically place their animal pens near bodies of water. This is to let animal manure wash away.

Biogas is one of the renewable sources that use organic wastes (Environmental and Energy Study Institute, 2017). To generate biogas, the materials must have methane and carbon dioxide (Zongliu, 2017). The researchers would let the bacteria break down the organic waste in manure to get methane and carbon dioxide. This is done in the absence of oxygen. This process is known as anaerobic digestion (Environmental Protection Agency, 2022).

The waste just continues to pile up and the effort to lessen these problems is very minimal. There is no concrete solution being made so far. The trash just adds to the ongoing problem of pollution and solid waste the Philippines faces. Humans are reliant on non-renewable resources which are limited and not sustainable. Also, the garbage adds to the global warming the world is experiencing.

Hence, it is worth exploring farm waste's biogas potential. Biogas could help the community lessen their farm waste. It could also reduce the pollution that waste generates. Biogas could also be used for emergency heating. The by-products of biogas could be utilized as a fertilizer.

Statement of the Problem and the Hypothesis

This study aims determine the value of heat produced by biogas generated from farm waste via anaerobic digestion

Specifically, this study aims to answer the following questions

1. What is the amount of heat produced by each treatment?
2. Is there a significant difference between the beat produced by the biogas generated from pig dung compared to cow dung?

In the view of the preceding problems the following hypothesis was advanced:

1. What is the amount of heat produced by each treatment?

Conceptual Framework

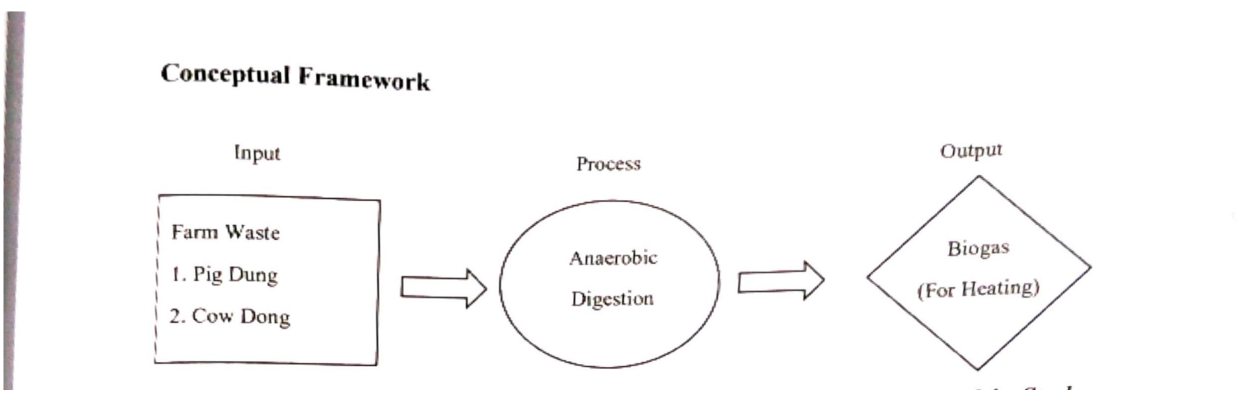


Figure 1.1 *The schematic diagram of the Input, Process, and Output Approach of the Study*

Theoretical Framework

The biogas theory put forth by Kaltschmit, Thrän, and Smith (2001) is the foundation for this study. According to this theory, methane-producing microorganisms break down cellulose and other organic materials in animal and plant waste to produce biogas. Anukam, Mohammadi, Naqv, and Granström (2019) claim that the basis of anaerobic digestion is the efficient conversion of organic matter into biogas, which has methane (CH4) as its main combustible component. Anaerobic digestion occurs in four stages: hydrolysis, acidogenesis, acetogenesis, and methanogenesis. First, the complex chemical compounds in the spent wash or pot ale are hydrolyzed using the extracellular enzymes of the bacteria to break down the long-chain molecules and create glucose, fatty acids, and amino acids. Then, acid-forming bacteria will acidify these acids to create volatile fatty acids (VFA), and the acetogenesis process will turn the volatile fatty acids into acetate, hydrogen, and carbon dioxide. Methanogenesis, which transforms the acetate into methane, completes the process (Stewart, 2022).

Moreover, there are a huge number of anaerobic digesters in use across the world. But very little is known about how different substrate combinations affect the population of methanogens. This is because each anaerobic digester has a distinct microbial ecosystem of its own. Knowing the makeup of the consortium of anaerobic bacteria present in anaerobic digesters processing various input combinations of raw material would be crucial for the most effective control of anaerobic operations (Kushkevych et al., 2018). Pig manure usage and valorization is a significant topic with tightening laws focused on ecological and safety considerations. Pig dung is a poor substrate for biogas production on its own because it contains too much nitrogen in comparison to the organic carbon that is readily available. Since methanogenesis can be hindered by such an alkaline substrate, more substrates with a high organic carbon content must be added (Gaworski et al., 2017). On the other hand, Abubakar and Ismail (2022) investigated the effectiveness of cow dung for biogas production. The results show that cow dung is a viable feedstock for biogas generation, producing high yields. Total biogas output with consistent performance. The effect of varied organic compositions will be studied in the future. The loading rate of semi-continuous anaerobic digestion of cow manure. Several studies show that farm wastes can be used to produce renewable sources of energy in the form of biogas.

The biological process that turns animal waste into energy is called methane generation. Methane (CH4) and carbon dioxide (CO_2) dominate the content of biogas, which is produced by bacteria from the breakdown of organic waste in manure (Zongliu, 2017). Dague (1968) claimed that the actions of two main types of bacteria coexisting in the digester cause methane formation. The first group is called the acid-forming bacteria or the acid-former. This group is in charge of changing complicated chemical compounds into simpler organic compounds. The second group, which consists of methane-forming bacteria or methane formers, feeds on simpler organic compounds. This group is in charge of producing carbon dioxide and methane gas.

Scope and Delimitation

This study was limited only to determining the amount of heat produced by biogas generated from pig dung and cow dung via Anaerobic Digestion for seven days per treatment. The farm wastes were collected at Pungtod, Cabatuan, Iloilo. For seven days, each treatment was stored in a 10-liter water container, and was connected to a Bunsen burner. The biogas produced were used to vaporize 200 grams of distilled water and the amount of heat produced by each treatment were measured through calorimetry. This study was conducted in Pungtod, Cabatuan, Iloilo from February 1 to May 10, 2023.

Significance of the Study

This study aims to help people to become more productive in using their waste and use it as an advantage. This study will benefit the following:

Farmers

Farmers can produce clean domestic fuel from wastes like animal dung, dry leaves, dry plants, etc, so it can provide energy independence for farms.

Community/Neighborhood

The waste products of one cow can provide enough energy to power a lightbulb for an entire day. In large plants, biogas can also be compressed to achieve the quality of natural gas and utilized to power automobiles.

Businessman

Generating biogas has traditionally been a good investment for those with the land to build and resources to build an anaerobic digestion plant and consistent access to relevant feedstocks at an affordable price.

Environment

Biogas also helps mitigate methane emissions that would have otherwise escaped from manure lagoons.

Future researchers

The results of this study can be a reference for future researchers.

CHAPTER II

REVIEW OF RELATED LITERATURE AND STUDIES

Review of Related Literature

This review includes the following parts: 1) Biogas, including its definition, uses, importance, types, advantages, disadvantages, and related studies about biogas; II) Anaerobic Digestion, where its definition, importance, functions, process, advantages, disadvantages, and related studies about anaerobic digestion are discussed; 111) Farm waste and its definition, functions, types, systems, advantages, and disadvantages.

Conceptual Literature

Definitions of Biogas

National Grid (2022) describes biogas as an energy source that is renewable and favorable to the environment. It is created during a process known as anaerobic digestion, in which microbes break down organic matter, such as food or animal manure, without the presence of oxygen. The waste material must be contained in an oxygen-free environment for this to take place. Biogas can be produced artificially or organically as part of industrial processes for fuel production.

Methane and carbon dioxide make up the majority of this energy source. Additionally, it might contain a little moisture, siloxanes, and hydrogen sulfide. Depending on the kind of waste used to create the resulting biogas, these relative quantities change. Biogas can be used to power vehicles when compressed or as a replacement for natural gas, which is used for cooking and heating.

Additionally, biogas energy-dense gas created when biomass is or untreated biogas may be thermochemically or anaerobically decomposed. Methane, a substance found in natural gas, and carbon dioxide make up the majority of biogas. Raw contains between 40% and 60% methane, with the majority of the remaining gas being carbon dioxide along with a tiny quantity of water vapor and other gases. Like natural gas, biogas can be used directly as a fuel or treated to remove carbon dioxide and other gases. Biomethane or renewable natural gas are alternative names for treated biogas. When anaerobic bacteria that cannot inhabit the existence of free oxygen consume and digest biomass and produce biogas, the anaerobic breakdown of biomass occurs. Natural habitats for anaerobic bacteria include soils, lakes, and swampy bodies of water, as well as the gastrointestinal tracts of people and animals. Landfills for municipal solid waste and ponds used to store animal manure both produce and collect biogas (U.S. Energy Information Administration, 2022).

According to Badurek (2022), biogas is composed mostly of methane gas, carbon dioxide, and an extremely small amount of nitrogen, hydrogen, and carbon monoxide. It naturally occurs in compost piles, as swamp gas, as a byproduct of intestinal fermentation in cattle and other ruminants, and in heaps of compost. Anaerobic digesters that use plant or animal waste or landfill trash can also produce biogas. It is either burned to produce heat or used to create electricity in combustion engines.

Furthermore, the use of biogas to heat bath water in Assyria during the 10th century is thought to have given rise to the concept of anaerobic digestion. However, in the 17th century, Jan Baptista Van Helmont, a Flemish physician, philosopher, mystic,and scientist, learned that eugenic matter decayed and released combustible excess of carbon dioxide and is even Helmont was the first scientist to recognize credited with coining the name "gas," which is taken from the word "chaos." Many other researchers on this subject were influenced by his work, including British natural philosopher Richard Boyle. Then, Count Alessandro Volta, an Italian chemist, and physicist who is credited with creating the first electric battery concluded that there was a direct association between the amount of decomposing organic waste and the amount of combustible gas created. Volta also made the discovery of methane by realizing that anaerobic activity happens naturally in some soils as well as in sediments found in the lake and oceanic basins. This was a significant turning point in the evolution of anaerobic digestion. Volta's efforts were followed by the ideas of Sir Humphry Davy, a Comishman. He is most remembered for developing the Davy lamp, a precursor to the arc lamp, but he was also the first to identify methane in the fumes released by cow manure (Birch Solutions, 2021).

These concepts about the definitions of biogas enabled the researchers to have a comprehensive knowledge of the basics of biogas production.

Uses of Biogas

Biogas can be utilized in many different ways. It is commonly used as a cooking gas, a source of electricity, for water and space (room heating), a fuel source for vehicles in its compressed state, and a carbon dioxide displacer on on-site combined heat and power (CHP) plants. The production of biogas also provides a byproduct that can be used as manure for plants. Transportation, lighting, and hydrogen fuel cells can also utilize the energy from biogas in order to function (Vedantu, 2021)

Moreover, in an article provided by Byju's (2020), biogas is stated to be environmentally safe and has a number of uses, such as in heating, cooling, drying, and cooking. It is used to create steam, methanol, and power. With the aid of a digester and a tube, biogas can also be utilized in the kitchen. Using it for cooking results in less pollution compared to other fuels. Additionally, fertilizer can be made from the byproducts of biogas production. Electricity can also be produced from this energy source. However, due to its low efficiency and high cost, its electricity application is limited to a few.

Thus, biogas has many applications as an energy source. These include being a lighting fuel, cooking fuel in burners, pumping water, running vehicles, generating power, and enabling fuel cell-linked biogas systems to function (Charu, 2021).

These related works of literature allowed the researchers to have a wide view of the different uses of biogas and its potential applications.

Importance of Biogas

As explained by Juliani (2020), biogas is clearly a more environmentally friendly choice when compared to virgin natural gas which is extracted by drilling into the soil. Fracking, a procedure in which water, chemicals, and sand are injected deeply into the ground to fracture rock formations, is used to extract a significant portion of natural gas.

Landscapes and ecosystems can sustain substantial harm from the fracking process. Using material that already exists and would otherwise go to trash, landfills and digesters create a comparable fuel without harming the environment, unlike fracking. In addition Nitrogen pollution and runoff into water resources are prevented by removing the environment's ample supply of animal manure and food waste. Additionally, methane emissions from landfills and manure lagoons that would have otherwise leaked are reduced by the use of biogas. By turning this methane into carbon dioxide, which has a global warming potential of up to 34 times less than methane, using it as fuel significantly lessens its impact on the climate.

Furthermore, similar to natural gas, biogas can be converted into renewable natural gas and used for energy generation, house heating, cooking, and vehicle propulsion. Particularly in rural areas in need of economic prospects, biogas is a potent engine for economic growth. Additionally, biogas helps maintain clean air and water, reduces greenhouse gas emissions, and enhances soil health. It transforms trash into useful resources, which would otherwise be an issue (Environmental and Energy Study Institute, 2019).

The aforementioned studies provided the researchers with enough information on the importance of biogas in its field of application.

Types of Digesters

According to Energypedia (2015), there are two types of digesters: small-scale and industrial. Small-scale digester consists of seven types: fixed dome biogas plant, floating drum plant, low-cost polyethylene tube digester, balloon plant, horizontal plant, earth-pit plant, and ferro-cement plant. A fixed-dome plant consists of a closed, dome-shaped digester, a displacement pit (sometimes known as a "compensation tank"), and an immovable, rigid gas holding. The digester's upper section is where the gas is kept. The slurry is moved into the compensating tank when gas production starts. The volume of gas held, or the height difference between the two slurry levels, increases with pas pressure. The gas pressure is low if there is little gas in the gas holder.

Second, the floating-drum plant is a moving gas container and an underground digester. The gas-holder either floats on top of the fermentation slurry of is submerged in its own water jacket. The gas drum, which slides up or down depending on how much pas is stored, collects the gas

Third, the Low-Cost Polyethylene Tube Digester type is made of tubular polyethylene film (two coats of 300 microns) that is twisted with recycled tire tube rubber strap and bent at each end to fit around a 6-inch PVC drainpipe.

The fourth type is a balloon plant consisting of a digester and gas holder combined in a heat-sealed plastic or rubber bag. The top of the balloon is where the gas is kept. The balloon's skin is immediately connected to the intake and outlet.

Meanwhile, Reecon (2020) explained that a horizontal biogas plant is a processing facility for food waste from a sizable neighborhood. The balloons used for storage contain purified gas. This gas is then directly piped to the common canteen burners after being further pressurized. Sulfur and moisture are already removed from the gas during pre-processing.

The sixth type is an earth-pit plant. In stable soil, masonry digesters are not required (e.g., laterite). In order to stop seepage, it is sufficient to line the pit with a thin layer of cement (wire mesh fastened to the pit wall and plastered). A ring of masonry that acts as both a bolster and an anchor for the gas bolder surrounds the pit's edge. A sheet of plastic or metal can be used to make the gas holder. If plastic sheeting is employed, it must be fastened to a wooden frame that reaches down into the slurry and is fixed to the ground to reduce the buoyancy of the slurry. Weights are put on the gas holder to create the necessary gax pressure. The slurry outflow is an overflow point in the side wall.

Lastly, ferro-cement can be built with either an earth-pit liner or a self-supporting shell. Typically, the jar is cylindrical. Prefabricated plants are possible for very tiny plants (volume 6 m3). The Ferro-cement gas holder needs particular sealing procedures, just like in the case of a fixed-dome plant (proven reliability with cemented-on aluminum foil).

On the other hand, an industrial digester consists of a mixing pit, fermenter or digester, gas holder, slurry store, and gas-use element. Depending on the type of substrate, mixing pits come in a variety of sizes and shapes. It has propellers to mix and/or cut the substrate, as well as a pump to move the substrate into the digester. To prevent a temperature shock inside the digester, the substrate is occasionally pre-heated in the mixing pit. Insulated fermenter or digester composed of steel or concrete. Large digesters feature a longish channel shape to maximize substrate flow. Large digesters are frequently stirred by injected biogas or by gradually spinning paddles or rotors. Two or more separate fermenters are used by co-fermenters. Inside the digester, the gas can be collected and often covered with a flexible cover. It is also possible to entirely fill the digester and store the gas in a separate gas holder. Since gas holders are often made of flexible material, they are weatherproof. It can be planted in a separate "gas bag" or immediately above the substrate, in which case it behaves like a balloon plant. Sturry storage facility for storing slurry in the winter. The state can be either closed and connected to the gas holder to capture any remaining gas output, or it can be open like a typical open liquid manure storage facility. Before the slurry is applied to the field, the store is typically merely stirred, not heated. In 95% of situations, a gas-use component in Europe is a thermo-power unit that generates heat for homes, greenhouses, and other purposes in addition to electricity for farms and the grid. The advantage of the thermo-power unit is that it can generate the necessary energy from any combination of gas and fossil fuels. As a result, it can respond to periods of high energy demand and low gas output (Energypedia, 2015).

This information described and gave basic knowledge about what are the types of digesters.

System of Biogas

Greene (2014) explained that anaerobic digesters come in a variety of layouts and can operate at a variety of target temperatures, the most popular of which are mesophilic (95 F. 35 C) or thermophilic (125 F, 50 C). Different anaerobic bacteria communities flourish in various temperature ranges. In a single process reactor tank or two separate reactor tanks, digesters can combine all the major process chemistry phases (hydrolysis, acidification, acetogenesis, and methanogenesis). It incurs additional capital expenses for the additional tanks and monitoring, even though the separation of digestive steps provides for some greater process control.

There are two systems of biogas: wet digester and dry system. The term "Wet Digester" refers to the most popular type of digester since all of the substrates can be transported and mixed by pumps as liquid slurries. These digesters' contents typically range from 3-15% total solids in consistency. Retention times typically range from 20 to 40 days. Farm-based digesters can also be in-ground plug flow reactors or lagoons. An anaerobic membrane bioreactor (AnMBR), a more recent type of digester, uses a membrane filter at the facility's rear end to separate reactor slurry solids from digestate liquids and hold solids in the system. A multi-phased digester with hydrolysis and methanogenesis stages, occasionally with interstage solids separation of inert materials, is another device that can provide optimal residence time.

Meanwhile, in dry digesters, the substrates are kept in a stackable state and continue to be stacked throughout the digestive process. For structure and porosity, food waste is combined with green waste like yard trash, and placed in a stack inside a long. rectangular tank. The vessel is then preheated and tightly shut. The garbage stack is sprayed with warm water, or percolate, which is then collected and recycled. The biological activity of the percolate speeds up the digestive process. Percolate is delivered to a separate methanization digester tank, where it is recycled and biogas is produced. Additionally, there are vertical down-flow reactor designs where waste is fed in at the top and allowed to flow out at the bottom after a period of time while digesting along the way.

This bearing helped the researchers to know the different systems of biogas.

Advantages and Disadvantages of Biogas

Home Biogas (2022) mentioned that just like other energy sources, biogas has its own advantages and disadvantages. The first of its perks is being a clean, renewable energy source that relies on a carbon-neutral process, which means that when utilizing biogas, no additional carbon is discharged into the atmosphere. Second, it assists in keeping food waste out of landfills, which benefits the environment and the economy. Third, it maintains a healthy and secure environment for many communities throughout the world by reducing soil and water contamination from livestock manure and human waste. Finally, it slows down climate change while potentially having an immediate effect on the environment by reducing the amount of methane released into the atmosphere.

The use of biogas carries with it a number of benefits and downsides. Among its advantages are being a renewable source of energy, its utilization of waste materials, its production of a circular economy, and being a good alternative to cooking and electricity in developing areas.

On the other hand, biogas production also has some drawbacks. For instance, the process does not have an advanced technological framework, so it needs to be further worked out to ensure efficiency. Also, the process of anaerobic digestion is weather-dependent, requiring heat energy which is difficult to produce in cold climates. It is impossible to fully manage biogas production because it depends on a biological process. Also, because it performs better in hotter areas, biogas isn't available everywhere. Biogas also has wastes that emit a foul smell. Thus, biogas plants should be constructed away from residences and connontic centers (Energypedia, 20213.

These references gave the researchers useful insights into the advantages and disadvantages of biogas production and their corresponding impacts.

Definition of Anaerobic Digestion

The American Biogas Council (2022) defines anaerobic digestion as the process of biodegradable materials being broken down by bacteria without the presence of oxygen. It is also a biological degradation of organic matter in the absence of oxygen and converts the chemical energy in organic carbon to biogas. Another definition of anaerobic digestion is, it is a process in which organic matter such as animal manure, wastewater biosolids, and food waste is broken down by bacteria to turn into biogas. Reactors are created in a variety of shapes and sizes depending on the site and feedstock circumstances and are used to conduct anaerobic digestion for the production of biogas. Complex microbial populations are found in these reactors, which digest waste to produce biogas and digestate (the solid and liquid byproducts of the AD process), which are released from the digester (United States Environmental Protection Agency, 2022).

This information is important to the researchers because it gave basic knowledge about anaerobic digestion.

Functions of anaerobic digestion

Biogas production is one of the anaerobic digestion's functions. Additionally, it is utilized for managing agricultural manure, food waste, and wastewater sludge reduction and treatment (Vutai, 2018). The biogas produced by anaerobic digestion acts as an alternative and lessons the need fur renewable energy sources like fossil fuels. It can also be used as a clean energy source for power generation (Obileke, 2020)

This served as additional information to the researchers about the functions of anaerobic digestion.

Importance of Anaerobic Digestion

Anaerobic digestion is an important process as it can effectively transform diverse organic wastes into biogas (Harirchi et al., 2022). The biogas generated from anaerobic digestion can be an important attribute to the economy as it can lessen the cost of producing fuel and electricity. Anaerobic digestion is termed the "golden process" since they are crucial for reducing greenhouse gas emissions and the effects of global warming (Banu, 2019). Additionally, it plays a vital role in the emerging green economy (Puyol et al., 2016).

This bearing helped the researchers to know the importance of anaerobic digestion.

Processes of Anaerobic Digestion

Each of the four phases of anaerobic digestion-hydrolysis, acidogenesis, acetogenesis, and methanogenesis involves anaerobic microbes (Dutton, 2022) Organic macromolecules are broken down into smaller parts by the process of hydrolysis, which can be utilized by acidogenic bacteria. In the process of acidogenesis, acidogenic bacteria can make intermediate volatile fatty acids (VFAs) and other compounds by absorbing the hydrolysis byproducts through their cell membranes (Meegoda et al., 2018). About 50 different types of bacteria, including Clostridium, Bacteroides, Bifidobacterium, Butyrivibrio, Proteobacteria, Pacodomonas, Bacillus, Streptococcus, Eubacterium, d others, are involved in the hydrolysis and acidogenesis process (Wang et al., 2018) Acetogenesis stage occurs when acetogenic bacteria attack acidogenesis intermediates, turning volatile fatty acids and other intermediates into acetic acid, carbon dioxide, and hydrogen (Meegoda et al., 2018). Acetogenesis is caused by a number of bacteria. including Syntrophobacter wolinii (the propionate decomposer), Syntrophomones wolfes (the butyrate decomposer), and the acid formers Clostridium spp., peptococcus anaerobes, lactobacillus, and actinomyces (Dutton, 2022). The last phase of anaerobic digestion is methanogenesis. Methanogenic microbes use readily available intermediates as fuel to create methane. Methanogenesis is aided by bacteria including Methanobacterium, Methanobacillus, Methanococcus, and Methanosarcina (Meegoda et al., 2018).

This information helped the researchers in understanding the process of anaerobic digestion.

Advantages and Disadvantages of Anaerobic Digestion

Anaerobic digestion is both an economically viable and environmentally beneficial technology because it produces clean energy at a low cost while producing no greenhouse emissions (Náthia-Neves, 2018). Furthermore, anaerobic digestion in business and agriculture can reduce pollution, recover embedded energy such as methane gas, recycle rubbish, and keep it out of landfills (Abdallah et. al, 2022).

Meanwhile, the disadvantages include that when done on a commercial basis on farms and at wastewater treatment plants, anaerobic digestion needs a huge investment in big tanks. Furthermore, if run inefficiently, anaerobic digestion might emit unpleasant odors. Moreover, the process takes longer to begin because methane-producing microbes develop at a slower rate than aerobic digestion. Additionally, digestate output contains ammonia, which must be treated carefully when spread on land to prevent ammonia gas from polluting the air (Stuart, 2022).

This information helped the researchers to understand what are the advantages and disadvantages of the anaerobic digestion process.

Definition of Farm Waste

Farm waste is any waste that is a typical by-product of farming operations in the Town; it excludes construction and demolition debris from any building or structure, compostable waste that can be placed out for curbside collection, recyclable waste that can be placed out for curbside collection, and another waste that the Ministry of the Environment deems unacceptable for disposal at a landfill site or that is prohibited by this By-law (Law Insider, 2022).

These concepts about the definitions of farm waste enabled the researchers to have comprehensive knowledge about the basics.

Importance of Farm Waste

Biodegradable hemicellulose and cellulosic components can be found in agricultural waste. They give plants an abundance of nutrients when they break down. Because it comes from animals and is packed with nutrients and microorganisms, cow dung is a common fertilizer in rural regions (Genex, 2020).

The researchers value this information because it provided them with a fundamental understanding of farm waste.

Functions of Farm Waste

Organic wastes are used in agriculture primarily to enhance the physical and chemical characteristics of the soil and as a source of nutrients for growing crops. Animal manure is the main source of organic waste utilized in agriculture, but a minor quantity of waste from the food industry, other industrial wastes, and municipal garbage are also spread on the ground. The properties of residues that are later put to land have changed as a result of increased environmental restrictions affecting farms over the past 35 years. particularly in the last 10 years. These rules have led to more alternatives for treating animal dung. Farms are being analyzed for their nutrient balances, and the best management options are being considered for the complete nutrient and manure management system. Organic wastes often need to be processed and/or moved to other farms, used for horticulture, or put to other purposes because there isn't enough space on the animal farm to store them (Westerman & Bacudo, 2005).

This bearing helped the researchers to know the alternative functions of farm

Types of Farm Waste

Crop residues, weeds, leaf litter, sawdust, forest trash, and livestock manure are all examples of agricultural waste. Researchers consistently favor animal waste as a feedstock for earthworms and as a bulking substrate for vermicomposting among the various agricultural wastes. Because of its low cost, ease of availability, enough nutritional content, and perfect C/N ratio, livestock waste is regarded as the most suitable organic amendment to improve the vermicomposting process (Sharm & Gard, 2019).

This knowledge provided the researchers with a framework for understanding the roles that farm waste plays in daily life.

Advantages and Disadvantages of Farm Waste

Animal manure and other agricultural wastes should not be used in a way that opens up new paths for the spread of pathogens and diseases to humans, animals, and the environment. Bacteria, viruses, intestinal parasites, and most recently TSE prions, can all be major pollutants,

For many years, it had been widely accepted and considered economically profitable to use animal by-products from slaughterhouses and fallen stock as feed. The acknowledgment that transmissible spongiform encephalopathies (TSE) may be spread by food and feed brought animal by-products to the attention of the European Commission. The attempts made over the years to guarantee food safety were this time concretized into an important decision to ban the use of animal by-products as feed. A comprehensive and strict veterinary regulation (EC) 1774/2002 came into force in May 2003 and is still in a state of continuing amendments. Regulation 1774 categorizes animal by-products and defines obligatory processing methods and acceptable final use of the by-products, stipulating very detailed health rules concerning collection, processing, and final disposal or use of animal by-products with the aim of preventing not only TSE but also other agents that may cause diseases in humans or animals.

Animal by-products fall into three categories, according to rule 1774. Category one waste must always be incinerated or, in rare circumstances, buried in specialized landfills following pressure sterilization because it poses the greatest harm to humans. animals, or the environment. Animal byproducts that don't fall under categories one or three, as well as dung and digestive tract contents, are all considered category two materials. These materials could, for instance, be given to biogas facilities for digestion after being pressure sterilized for 20 minutes at 133 °C and 3 bar (manure and digestive tract content is exempted from pre-treatment). Animal byproducts that would be suitable for human food but are not intended for human consumption due to business considerations fall under category three materials (Kirchmayr et al., 2003). After being pasteurized at 70°C for 60 minutes, materials from category three may be used in biogas facilities. For the time being, category three materials cannot be used to make feed.

Additionally, the future function of biological treatment procedures for animal by-products and other biological wastes will be significantly impacted by EC Regulation 1774. (Braun & Kirchmayr, 2003).

Additionally, the combination of temperature and retention time during anaerobic digestion has a pathogen-reduction impact. The most prevalent infections are eliminated by thermophilic during the hour of assured retention time at process temperatures of roughly 53°C (Saedi & Holm-Nielsen, 2004).

The researchers were able to better comprehend the benefits and drawbacks of farm waste thanks to this knowledge.

Related Literature

Biogas

Biogas from enzyme-treated bagasse with a patent number CN103620043A invented by M. Clejmanson (2014) consists of treating sugarcane pulp with an enzyme. Approximately three tons of bagasse or sugarcane pulp can be produced from ten tons of sugarcane plant. The bagasse used in the study is collected from manufacturing companies that use sugarcane. The bagasse is then powdered and the remaining extracted grit is collected. The bagasse is then divided into two groups. One group uses enzymes as a pre-treatment. The other one remains untreated. The temperature and pH value are also manipulated in this study. Both depend on what enzyme is used. The temperature is set between 30-40 °C when Alkaline phosphatase is used. For acid phosphatase, the temperature is adjusted between 20-70 °C. The microorganisms used in this study are then cultured and will act as an inhibitor of oxygen, providing anaerobic conditions. These microorganisms are then added to both biogas tanks. The researchers let it ferment for a few days in both digester tanks. The researchers then compare the two groups, the untreated bagasse and the treated one. The results show that the treated group generated more methane than the untreated group. The experiment chamber scale test reveals significantly higher biogas and lower value of by-products when an enzyme is added.

Another example is the method of treating a digestate from a biogas process with a patent number EP2874957A1, invented by Grönfors (2013) consists of treating mixed biodegradable materials. The biogas comprises food and beverage handling, feedstock, and farm waste. The materials are then digested by a biogas plant. The product is then collected and divided into two groups; the liquid part and the solid part. The liquid part will undergo a dewatering process. The dewatered material is obtained by adding iron salt. About 70 kg/ton of iron salt is added to the digester. The dwelling time is at least 30 minutes. The oxidizing agent, hydrogen peroxide, and per compounds are then added. About 50 kg/ton oxidizing agent is used. It is then left to dwell for at least 30 minutes. After that, 10 kg/ton of flocculating polymer is added. This step can be done simultaneously. The product is then passed on to sewer systems while the solid part is used as a fertilizer. The results show that the method is effective and the rejected water is clear and clean.

More so, the production of biogas from biodegradable material with a patent number US9416373B2 invented by Puntes, González, et al. (2012) consists of adding iron oxide nanoparticles to the biodegradable materials is another example. The biodegradable material is first added to the biogas digester. The process is carried out at a temperature between 30° C and 70° C. The nanoparticles of iron oxide with a concentration between 0.5 and 1 mg/ml are then added. The next step is inoculating mesophilic bacteria that will be added to the digester. These microorganisms will inhibit the oxygen, providing anaerobic conditions. After several days, the biogas is collected and analyzed. The researchers found out that it produces more biogas than biogas generated without iron nanoparticles. It shows that iron acts as a catalyst.

Lastly, in the study of Subramanian et al. (2017), the viability of biodegradable substances including cow dung and kitchen garbage as prospective biogas substrates was assessed. The non-biodegradable waste from the collected materials was eliminated. Then, using a mixer, these wastes were extensively mixed and pulverized to produce a homogeneous slurry.

In order to prepare the feedstock, it was blended in a kitchen blender, diluted with water, and then fed into the digester. Four hundred fifty grams of food waste and another 450 grams of cow manure were weighed and combined in a 1:1 ratio. The cow manure was thoroughly combined with the ground-up food waste. The mixture was then thoroughly incorporated with 900 milliliters of water. This was used as feedstock. Three units make up the experimental setup: a measuring instrument, a gas collection device, and a digester. A glass container with a 2.75-liter capacity is used as the digester. Gas from the digestion is collected using a gas pipe from the digester and placed into a fiveliter plastic container with a brine solution. The brine solution is compressed by the digester gas and then sent through the bottom exit of the gas collecting unit to the measuring cylinder.

As a result, the volume of water in the measuring jar increases when gas is produced. In this study, biogas is tested using the water displacement method since it is low-cost, easy to set up, and able to run for extended periods of time without requiring maintenance. The water level in the measuring cylinder is gauged every day. When gas was produced, there was an increase in the amount of water. By deducting the past water level from the present water level, one can determine the methane generation on a given day. Additionally, the amount of biogas produced overall for approximately was noted. The increase in water level is a sign that hingas has been produced. A line graph is then used to display the hiogas production rate.

These related studies about biogas helped the researchers to have more knowledge about the methods that are used in hiogas.

Anaerobic Digestion

According to Wang et al., (2018) a substrate with a high potential to produce methane by AD must have a large proportion of organic material. Though, other inhibitors, including ammonia and the accumulation of volatile fatty acids, typically result in inefficient biogas production and even process failure (Chen Ye et al., 2008).

Since anaerobic digestion is a biochemical process that involves a wide range of microbial groups, microorganisms are the foundation of the digesters. Numerous efforts have been made in the field of microorganisms to improve the effectiveness and stability of anaerobic digestion. Methanobacteriurn, Methanococcus, Methanobrevibacter, Methanomicrobium, Methanosarcina, and Methanosaeta are a few of the organisms known as methanogens that are responsible for the production of methane.

Moreover, the 2012 study by Abubakar and Ismail on the anaerobic digestion of cow dung to produce biogas came to the conclusion that cow dung is a suitable substrate for biogas production. In order to carry out this experiment, the researchers mixed fresh cow dung in a 1:1 ratio with tap water. Then as inoculums, palm oil mill effluent was used. A 10-liter jacketed fermenter apparatus that the researcher employed in this investigation was equipped with a pH probe, stirrer, sample ports, and temperature controls. The production was then carried out at a temperature of 53 degrees Celsius with an unregulated pH. After that, the motorized spinner was set to 150 rpm. Setting continuous feeding started from day ten, a known volume of the slurry was withdrawn daily from the reactor and replaced with fresh feedstock via the slurry sampling ports. The amount of biogas produced was calculated using the water displacement method. The findings indicate that less biogas was produced during the first three days of monitoring, primarily as a result of the lag phase of microbial growth. In contrast, biogas production significantly increases after four to six days of observation as a result of the exponential development of methanogens. Before the start of the biogas generation, the substrate began to degrade between days one and three. On day six, the highest biogas production rate of 3.4 L was recorded. The uncontrolled pH zone, which causes an increase in the concentration of ammonia acid which is harmful to anaerobes, disrupts the process and reduces digestion efficiency, Which causes a decline in biogas production

Lastly, Rezin's (2015) Portable High-Rate Anaerobic Digester Apparatus, which has the patent number US 9,073,770 B2, is an example of an anaerobic digester device.

Rezin's innovation aims to build a portable, automated, and infrequently plugged-in anaerobic digester. A digester tank, a drainage through near the top of the digester tank, an auger inside the drainage through, and a skimmer that directs waste into the drainage through make up this digester. The device additionally has a twin-valve chamber for the purging of heavy solids precipitated from the waste. A gas trap tank that maintains airtight drainage. A vertical pump tube and a propeller are also included. The waste digestion system was developed as an easily transportable, self-contained module. Methanogenesis, acidogenesis, and hydrolysis are the emphasis of these self-contained modules. A controller controls the opening and shutting of a first and second valve to fill or remove heavy solids from the digester device. The skimmer is also rotated by the controller in a first direction and a second direction. Agitating a digestive apparatus is another component of this digester. Depending on the kind of waste that needs to be handled, an agitation cycle is chosen. The controller directs the propeller's motion so that the waste in the digester device is suspended. As the type of waste changes, the agitation cycle adapts dynamically.

These related studies about anaerobic digestion gave information to the study of the researchers

Definition of Terms

For purposes of clarity and understanding, the following terms were specified in their conceptual and operational definitions:

Anaerobic digestion. Organic material, such as animal or food waste, is broken down by anaerobic digestion to produce biogas and biofertilizer. An anaerobic digester is a tank that is enclosed and devoid of oxygen where this process takes place (Biogen, 2022)

In this study, this refers to the process of breaking down farm waste and in need of bacteria and there is an absence of oxygen to generate biogas

Biogas. A type of biofuel naturally created from the breakdown of organic waste is called biogas. This organic material releases a mixture of gases when it is exposed to an oxygen-free atmosphere. Methane and carbon dioxide are released in the largest amounts, although other gases are also released in smaller amounts (between 50 and 75 percent, depending on the number of carbohydrates contained in the mixture) (Youmatter, 2020).

In this study, this refers to the fuel or resource that can be generated from farm waste through the process of anaerobic digestion

Farm waste. Any waste that results naturally from farming operations in the town, it excludes construction and demolition waste from any building or structure, compostable waste other than that produced when clearing land for farming operations, recyclable waste that can be placed out for curtinide collection, and any other waste that the Ministry of the Environment deems unacceptable for disposal at a landfill site (Law Insider, 2013).

In this study, this refers to the organic materials which are pig dung and cow dung where biogas can be generated using the anaerobic digestion process. 2022). Generate, It is to generate energy in a specific form (Cambridge University Press, 2009).

In this study, it pertains to the acquisition of generated biogas from farm waste using the process of anaerobic digestion.

Heat. Energy that is transferred from one body to another as the result of a difference in temperature (Britannica, 2023).

In this study, it refers to the heat emitted by the generated biogas.

Produce. It means to make or manufacture from components or raw materials (Oxford Languages, 2023).

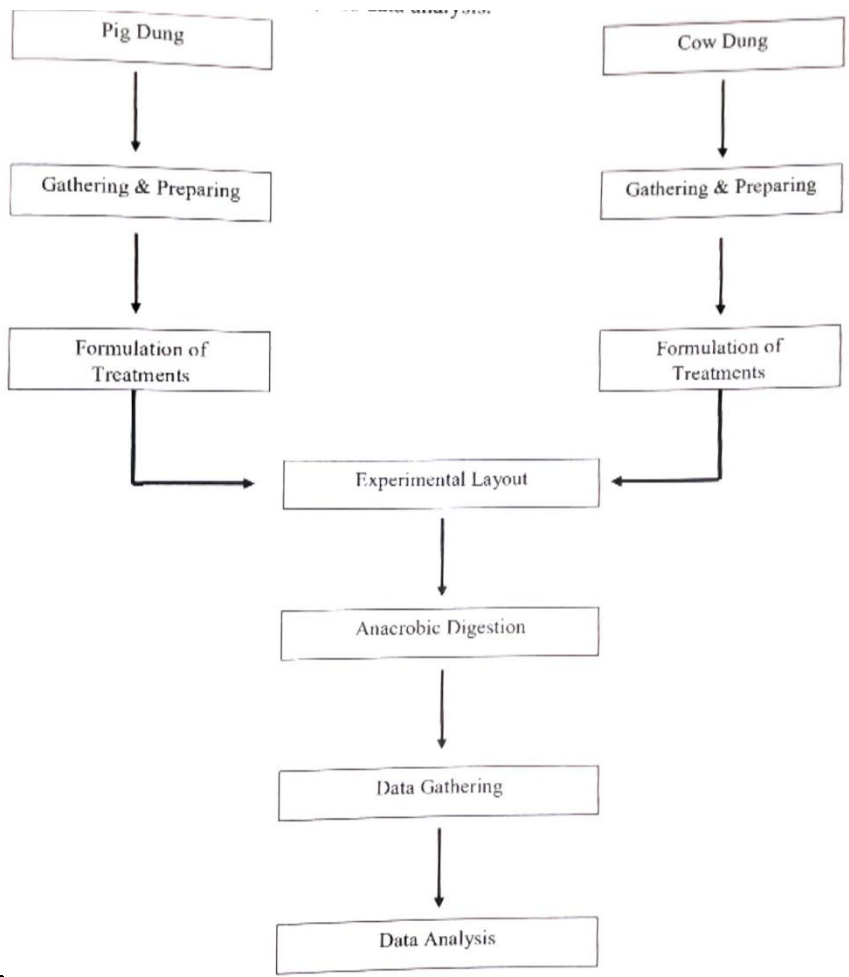
In this study, it refers to the amount of heat produced of the generated biogas from cow dung and pig dung slurry.

CHAPTER II

METHODOLOGY

This chapter presents the research design, description of the study variables, the gathering of materials, preparation of materials, experimental design and layout, experiment proper, data collection, and data analysis.

Figure 2.1 *Schematic Diagram of Research Methodology*



Research Design

The study was conducted to test the amount of heat produces of biogas from farm waste using the anaerobic digestion process. The experimental research design was employed since a scientific approach is needed to determine if there is a significant difference between the two sets of variables in the study. Specifically, a true experimental research design was used as statistical analysis is necessary in proving the study's hypothesis.

Description of the Study Variables

Pig Dung. 4000 grams of fresh pig dung taken from one farm was used in the study.

Cow Dung. 4000 grams of fresh cow dung taken from one farm was used in the study.

Gathering of Materials

Gathering of pig dung

Four thousand grams of pig dung were manually gathered using a shovel in the researcher's pig pen early in the morning.

Gathering of cow dung

Four thousand grams of cow dung were manually gathered using a shovel in the researcher's backyard early in the morning.

Preparation of Materials

The researchers gathered, organized and prepared the materials to start the experiment. Two treatments were prepared with two trials each. Treatment A consisted of pig dung and Treatment B consisted of cow dung. All treatments were diluted with water at a ratio of 2:1. In every two kilograms of farm waste, one kilogram of mineral water was used. Two suitable containers were created for biogas production, which have an opening for the waste to enter and exit. The containers were submerged in water within a tub, and it was covered with an inverted plastic tank. A portable vacuum was used to make sure that the air inside the tank would be removed. A small hole for the biogas to go out of the container was created. Then it was attached to a Bunsen burner surrounded by a cardboard box with a plastic cover at the top and on the side. The plastic viewer was made by the researchers to periodically check the fire.

Experimental Design and Layout

The study consisted of two treatments and each was replicated twice. Completely Randomized Design (CRD) was used as the experimental layout design. Lottery method was used to randomize the treatment per set up.

Table 2.1 Experimental Layout of the Study

I	I
A	B
B	A

Legend:

A- Pig Dung

B- Cow Dung

I- 1st Replication

II -2nd Replication

Experiment Proper

This procedure, based on Abubakar (2022) with modifications, involved the construction of two 10-hectare anaerobic digesters for each treatment. Each digester was equipped with a feeder and gas tube on top. Each treatment was prepared by mixing four kilograms of dung with two kilograms of mineral water. The experiment was carried out under unregulated pH and temperature, and the digester was manually shaken for 15 minutes. The slurry was then left for seven days for biogas production. Subsequently, a Bunsen burner was connected to the gas tank, then 200 grams of distilled water was used to determine the amount of heat produced by each treatment through calorimetry.

Data Collection

The amount of heat produced was measured through calorimetry, by measuring the mass of the distilled water using beam balance, and by getting the temperature of water in an aluminum container, before and after boiling. The formula used to calculate the heating value is shown in Figure 3.2.

Q = Energy used

$$Q = m_{Al}C_{Al}\Delta T_{Al} + m_{H2O}C_{H2O}\Delta T_{H2O} + \Delta m_{H2O}L_{v\,(H2O)}$$

Figure 2.2 Formula in Determining the Amount of Heat Produced

Legend:

Q = Energy Used

MAl = Mass of Aluminum in grams

CAl = Specific heat of aluminum in calories per gram Celsius

ΔTAl–Change in temperature of aluminum after and before boiling in Celsius

mH20- Mass of water in grams

CH2O-Specific heat of water in calories per gram Celsius

ΔTH2O–change in temperature of aluminum after and before heating in Celsius

ΔmH2O–change in mass of water after and before boiling in grams

Lv(H2O)-latent heat of vaporization of water at certain temperature in calories per gram

Data Analysis

Using Microsoft Excel, the following statistical tools were used in summarizing and analyzing the data:

Standard Deviation. This is used to determine the homogeneity of results per treatment.

T-Test. This statistical tool was used to determine if there is a significant difference between the biogas generated per treatment in terms of the heating value.

The inferential analysis was analyzed using 0.05 alpha.

Disposal Procedures

The researchers dug a pit around the mango trees. The digestate was then put around the mango trees. After that, the researchers covered it again with soil, so that the digestate would serve as a fertilizer for the mango trees.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents the results obtained from the experiment conducted followed by discussion and interpretation of results.

Amount of Heat Produced by Generated Biogas

The table below displays the amount of heat produced by two different treatments: Treatment A (pig dung) and Treatment B (cow dung), measured seven days after the treatments were conducted. Both treatments emit fire, with Treatment A producing 5992.17 calories of heat in Trial I and 8512.09 calories of heat in Trial II. While Treatment B produces 4366.60 calories of heat in Trial 1 and 5851.21 calories of heat in Trial II. The pig dung emits a higher heating value in terms of calories per gram compared to the heating value emitted by the cow dung. The results of t-test indicate that there is no significant difference in the amount of heat produced by pig dung compared to cow dung.

Table 3.1 Anne Heat Prochewed by Each Treatment

Treatment	Amount of Heat Produced (calorie)		Treatment Total	Treatment Mean
	I	II		
Pig Dung	5992.17	8512.09	14504.25	7252.13
Cow Dung	4366.60	5851.21	10217.81	5108.91
Grand Total			24722.06	
Grand Mean				6180.52
Computed t			1.465	
Tabular t			4.303	
Standard Deviation			1719.536	
P-Value			0.28	

The amount of heat produced by each treatment of pig and cow dung was determined to be 7252.13 calories of heat and 5108.91 calories of heat, respectively.

These values were then divided by 4000 grams of raw pig and cow dung for comparison with the heating value of dry firewood provided by the World Nuclear Association (2023). To interpret the data, the heating values of both treatments were solved and analyzed. The mean of the amount of heat produced by each treatment were divided into 4000 grams of raw pig and cow manure, respectively. The data shows that the heating values of pig dung and cow dung, 1.81 cal/gram and 1.28 cal/gram respectively, are comparable to the heating value of dry firewood, which is 3.82 cal/gram. It is comparable because the biogas generated from both dung treatments did not reach its full potential, unlike the firewood which was completely burned. Therefore, it is recommended to use the biogas generated from 4000 grams of raw pig and cow dine for seven days as a fuel source for heating.

CHAPTER V

SUMMARY, CONCLUSION, IMPLICATION, AND RECOMMENDATION

Summary

This study aims to determine the heating value of biogas generated from Garm anaerobic digestion. The biogas digester was constructed on February 19, 2023. and conducted on February 24, 2023, at Brgy. Pungtod, Cabanan, Iloilo. The researchers were accompanied by their research adviser.

Two treatments were prepared with two trials each: Treatment A consisted of pig Jung and Treatment B consisted of cow dung. All treatments were diluted with water at a ratio of 2:1. Two containers were created for biogas production, which had an opening for the waste to enter and exit. A portable vacuum was used to remove the air inside the tank. Two 10-liter anaerobic digesters were built by the researcher for each treatment, with a feeder and gas tube on top.

The experiment was carried out under unregulated pH and temperature, and the digester was manually shaken for 15 minutes after putting the slurry in the digester. The slurry was then left for seven days for the biogas to produce. A Bunsen burner was connected to the gas tank and was used to measure the heating value through calorimetry.

A beam balance measured 200 grams of distilled water in 52.2 grams of the aluminum container. The amount of heat produced was measured through calorimetry, by measuring the mass of the distilled water, and by getting the temperature of water in an aluminum container before and after boiling and the change in mass of water. The data was analyzed through standard deviation and t-test.

The data gathered shows 5992.17 calories in Treatment A Trial 1 and 5512.09 calories in Treatment A Trial 11 while Treatment B Trial I shows 4366.6in calories of heat and Treatment B Trial II shows 5851.21 calories of heat. The t-test showed that there is no significant difference in the quantity of heat generated by pig manure compared to cow dung.

To interpret the data, the researchers computed the heating value of the treatment mean by dividing 4000 grams and it was compared with the heating value of dry firewood provided that was burned completely. The heating values of pig dung and cow dung. 1.81 cal/gram and 1.28 cal/gram respectively, are comparable to the value of dry firewood, which is 3.82 cal/gram. Hence, it is recommended to use the biogas generated from 4000 grams of raw pig and cow dung for seven days as a fuel source for heating.

Conclusion

The amount of heat produced in Treatment A Trial I was 5992.17 calories of heat and in Treatment A Trial II was 5512.09 calories of heat while Treatment B Trial I showed 4366.60 calories and Treatment B showed 5851.21 calories. There is no significant difference between the heat produced by the biogas generated from pig dung compared to cow dung. Hence, the researchers can accept the null hypothesis.

Recommendation

The researchers recommend using biogas digesters as a device for farmers to generate their own energy on-site and reduce their reliance on fossil fuels. This approach also helps farmers to reduce the amount of manure and other waste they need to store or dispose of while mitigating the odor and pathogens associated with livestock waste.

Additionally, biogas production can help farmers save money on fuel and fertilizer costs. For the community, the production of biogas can help reduce dependence on fossil fuels and lower the carbon footprint. It can also improve air quality by reducing the release of harmful gases, such as methane, which is a potent greenhouse gas that contributes to global warming. Furthermore, it reduces the amount of waste that needs to be disposed of in landfills, which reduces the environmental impact of waste disposal. The researchers also recommend that future researchers should use a large amount of fresh dung or organic materials, a digester with a large surface area, and a time period of 30-45 days for more biogas production. Additionally, a purifier should be added to eliminate impurities such as carbon dioxide, hydrogen sulfide, ammonia, and halogens, and the gas tank should contain pressure for better flame quality.

BIBLIOGRAPHY

Abubakar, B. S. (2012). Anaerobic Digestion of Cow Dung for Biogas Production. ARPN Journal of Engineering and Applied Sciences, 169-172.

Badurek, C. (2020). Biogas. Retrieved from https://www.britannica.com/technology/biogas

Basic Information about Anaerobic Digestion (AD). (2022, December 19). Retrieved from United States Environmental Protection Agency: https://www.epa.gov/anaerobic-digestion/basic-information-about-anaerobic-digestion-ad#:~:text=Biogas%20is%20generated%20during%20anaerobic,water%20vapor%20and%20other%20gases

Benefits of Anaerobic Digestion. (2022, December 19). Retrieved from Agri-Food & Bioscience Institution (afbi): https://www.afbini.gov.uk/articles/1-benefits-anaerobic-digestion

Biogen. (2022). Retrieved from Biogen: https://www.biogen.co.uk/Anaerobic-Digestion/What-is-Anaerobic-Digestion

Birch Solutions (2021). The History of Anaerobic Digestion and Biogas. Retrieved from https://birchsolutions.co.uk/the-history-of-anaerobic-digestion-and-biogas/

Byju's (2020). Uses of Biogas. Retrieved from https://byjus.com/chemistry/uses-of-biogas/

Cambridge University Press (2022). Cambridge University Press. Retrieved from https://dictionary.cambridge.org/us/dictionary/english/generated

Charu, S. (2021). Applications of Biogas. Retrieved from https://www.geographynotes.com/biogas-2/applications/applications-of-biogas-top-8-applications-bioenergy/6675

Chen Y., Cheng J.J., and Creamer K.S. 2008. Inhibition of anaerobic digestion process: A review. Bioresource Technology. 99(10): 4044-4064

Council, A. B. (2022, December 19). What is Anaerobic Digestion? Retrieved from American Biogas Council: https://americanbiogascouncil.org/resources/what-is-anaerobic-digestion/#:~:text=Anaerobic%20digestion%20is%20a%20series,natural%20gas%20and%20transportation%20fuels

Dague, R. R. (1968). Application of Digestion Theory to Digester Control. Journal (Water Pollution Control Federation), 40(12), 2021–2032. http://www.jstor.org/stable/25036190

Dutton, J. A. (2022, December 20). Alternative Fuels from Biomass Sources. Retrieved from John A. Dutton e-Education Institute: https://www.e-education.psu.edu/egee439/node/727

Ehmann A, Thumm U and Lewandowski I (2018) Fertilizing Potential of Seperated Biogas Digestates in Annual and Perennial Biomass Production Systems. Front. Sustain. Food Syst. 2:12. doi: 10.3389/fsufs.2018.00012

Energypedia (2021). Advantages and Disadvantages of Biogas. Retrieved from https://energypedia.info/wiki/Advantages_and_Disadvantages_of_Biogas

Environmental and Energy Study Institute (2019). Biogas: Pro-Economy and Pro-Climate. Retrieved from https://www.eesi.org/briefings/view/052219biogas

Gaworkrski, M. et al., (2017). Enhancing biogas plant production using pig manure and corn silage by adding wheat straw processed with liquid hot water and steam explosion. Biotechnol Biofuels, 259.

Granström, K., Anukam, A., Mohammadi, A., & Muhammad, N. (2019). A Review of the Chemistry of Anaerobic Digestion: MDPI.

Grönfors, O. (2013). European Patent No. EP 2,874,957 A1. Retrieved from https://patents.google.com/patent/EP2874957A1

Home Biogas (2022). What is Biogas? A Beginner's Guide. Retrieved from https://www.homebiogas.com/blog/what-is-biogas-a-beginners-guide/

Insider, L. (2022, December 22). Farm Waste definition. Retrieved from Law Insider: https://www.lawinsider.com/dictionary/farm-waste

Islamiyah, M., Soehartanto, T., Hantoro, R., & Abdurrahman, A. (2015). Water Scrubbing for Removal of CO2 (Carbon Dioxide) and H2S (Hydrogen Sulfide) in Biogas from Manure. KnE Energy, 2(2), 126- 131. https://doi.org/10.18502/ken.v2i2.367

Juliani, T. (2020). Is Biogas a "Green" Energy Source? Retrieved from https://www.worldwildlife.org/blogs/sustainability-works/posts/is-biogas-a-green-energy-

source#:~:text=Biogas%20also%20helps%20mitigate%20methane,potent%20as%20a%20greenhouse%20gas.

Kaltschmitt, M., Thrän, D., & Smith, K. R. (2001). Renewable Energy from Biomass. Encyclopaedia of Physical Science and Technology, pp. 203-228.

Kannah, Y., & Banu, R. (2019). Anaerobic Digestion. BoD – Books on Demand.

K. Sharma PHD, V. G. (2019). Vermicomposting of Waste: A Zero-Waste Approach for Waste Management. Sustainable Resource Recovery and Zero Waste Approaches, 133-164.

Kushkevych, I., Vítězová, M., Vítěz, T., Kováč, J., Kaucká, P., Jesionek, W., Bartoš, M., & Barton, L. (2018). A New Combination of Substrates: Biogas Production and Diversity of the Methanogenic Microorganisms. Open life sciences, 13, 119–128. https://doi.org/10.1515/biol-2018-0017

Mayo, M. & Nicholson, A. & Hansen, Lee & Hansen, Jaron. (2011). Technical Note: Chemical Treatment of Algae to Facilitate Biogas Production by Anaerobic Digestion. Transactions of the ASABE. 54. 1547-1550. 10.13031/2013.39006.

Megoda, J. N., Li, B., Patel, K., & Wang, B. L. (2018). A Review of the Processes, Parameters, and Optimization of Anaerobic Digestion. International journal of environmental research and public health. https://doi.org/10.3390/ijerph15102224

Mei, R., Narihiro, T., Nobu, M. K., Kuroda, K., & Liu, W.-T. (2016). Evaluating digestion efficiency in full-scale anaerobic digesters by identifying active microbial source#:~:text=Biogas%20also%20helps%20mitigate%20methane,potent%20as%20a%20greenhouse%20gas.

Kaltschmitt, M., Thrän, D., & Smith, K. R. (2001). Renewable Energy from Biomass. Encyclopaedia of Physical Science and Technology, pp. 203-228.

Kannah, Y., & Banu, R. (2019). Anaerobic Digestion. BoD – Books on Demand.

K. Sharma PHD, V. G. (2019). Vermicomposting of Waste: A Zero-Waste Approach for Waste Management. Sustainable Resource Recovery and Zero Waste Approaches, 133-164.

Kushkevych, I., Vítězová, M., Vítěz, T., Kováč, J., Kaucká, P., Jesionek, W., Bartoš, M., & Barton, L. (2018). A New Combination of Substrates: Biogas Production and Diversity of the Methanogenic Microorganisms. Open life sciences, 13, 119–128. https://doi.org/10.1515/biol-2018-0017

Mayo, M. & Nicholson, A. & Hansen, Lee & Hansen, Jaron. (2011). Technical Note: Chemical Treatment of Algae to Facilitate Biogas Production by Anaerobic Digestion. Transactions of the ASABE. 54. 1547-1550. 10.13031/2013.39006.

Megoda, J. N., Li, B., Patel, K., & Wang, B. L. (2018). A Review of the Processes, Parameters, and Optimization of Anaerobic Digestion. International journal of environmental research and public health. https://doi.org/10.3390/ijerph15102224

Mei, R., Narihiro, T., Nobu, M. K., Kuroda, K., & Liu, W.-T. (2016). Evaluating digestion efficiency in full-scale anaerobic digesters by identifying active microbial

Puntes, V. F., González, E. E., Merendal, E. C., Mestre, A. G., Ramisa, L. D., Segura, X. F., & FERRER, A. S. (2012). United States of America Patent No. US 9,416,373 B2. Retrieved from https://patents.google.com/patent/US9416373B2/en

Regan, M. S. (2022, December 1). Learning About Biogas Recovery. Retrieved from United States Environmental Protection Agency: https://www.epa.gov/agstar/learning-about-biogas-recovery

Rezin, P. D. (2015). United States of America Patent No. US 9,073,770 B2.

Russia Patent No. RU110217U1. Retrieved from https://patents.google.com/patent/RU110217U1/en?q=biogas+plant&oq=biogas+plant

Saedi & Holm-Nielsen. (2004). Agricultural wastes. Waste Management Series, 207-215.

Salyers, D. W. (2022, December 20). Anaerobic Digestion. Retrieved from Department of Environment & Conservation: https://www.tn.gov/environment/program-areas/sw-mm-organics/anaerobic-digestion.html

Sharma & Garg. (2019). Vermicomposting of Waste: A Zero-Waste Approach for Waste Management. Sustainable Resource Recovery and Zero Waste Approaches, 133-164.

Stewart, D. M. (2022). Chapter 21 - Co-products. Whisky and Other Spirits (Third Edition), 387-403.

Stuart, P. (2022, December 19). Review of the Advantages and Disadvantages of Anaerobic Digestion. Retrieved from StudyLib: https://studylib.net/doc/5897233/review-of-the-advantages-and-disadvantages-of-anaerobic-digestion

Subramanian, Sugumar & Pappupreethi, K & Muthu, S & Revathi, M & Rizwan, A. (2017). 35 Production of Biogas Using Food Waste from Srit Hostel. 2455-4200.

Tanigawa, S. (2017). Fact Sheet | Biogas: Converting Waste to Energy. Retrieved from https://www.eesi.org/papers/view/fact-sheet-biogasconverting-waste-to-energy

The Engineering ToolBox. (2023, June 21). Retrieved from The Engineering ToolBox: https://www.engineeringtoolbox.com/

The World Bank Group (2020). Agricultural land (% of land area) - Philippines. Retrieved from https://data.worldbank.org/indicator/AG.LND.AGRI.ZS?locations=PH

Uyminov, A. A. (2011). Russia Patent No. RU110217U1. Retrieved from https://patents.google.com/patent/RU110217U1/en?q=biogas+plant&oq=biogas+plant

U.S. Energy Information Administration (2022). Biomass explained. Retrieved from https://www.eia.gov/energyexplained/biomass/landfill-gas-and-biogas.php

Uzodinma, E.D. and A.U. Ofoefule. (2009) Biogas production from blends of field grass (Panicum maximum) with some animal wastes. Int. J. Phys. Sci., 4: 091-095.

Van, D. P., Fujiwara, T., Tho, B. L., Toan, P. S., & Minh, G. H. (2020). A review of anaerobic digestion systems for biodegradable waste: Configurations, operating parameters, and current trends. Environmental Engineering Research, 1-17. https://doi.org/10.4491/eer.2018.334

Vedantu (2021). Biogas: Uses of Biogas. Retrieved from https://www.vedantu.com/chemistry/uses-of-biogas

Wang, P., Wang, H., Qiu, Y., Ren, L., & Jiang, B. (2018). Microbial characteristics in anaerobic digestion process of food waste for methane production–A review. Bioresource Technology Vol. 248 Part A, 29-36. https://doi.org/10.1016/j.biortech.2017.06.152.

Westerman & Bacudo. (2005). Management Consideration for Organic Waste Use in Agriculture. Biosource Technology, pages 215-221.

Youmatter (2020, February 13). Biogas Definition: What Is Biogas Production? What Are Its Stages? Retrieved from Youmatter: https://youmatter.world/en/definition/definitions-biogas-definition-what-is-biogas/#:~:text=A%20Short%20%20Definition,free%20a%20blend%20of%20gases

Zongliu. (2017). Manure to Energy: Understanding Processes, Principles and Jargon. Texas Animal Manure Management Issues. Retrieved from https://tammi.tamu.edu/2017/07/17/manure-energy-understanding-processes-principles-jargon/#:~:text=Biological%20Process,-Methane%20production%20is&text=Biogas%2C%20which%20is%20produced%20from,present%20in%20relatively%20small%20quantities.

APPENDICES

APPENDIX A

CALENDAR OF EVENTS

February 2023						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1 Gatherin g of material s	2 Gathering of materials	3 Gathering of materials	4 Gathering of materials
5 Gathering of materials	6 Gatherin g of material s	7 Gathering of materials	8 Gatherin g of material s	9 Gathering of materials	10 Gathering of materials	11 Gathering of materials
12 Gathering of materials	13 Gatherin g of material s	14 Gathering of materials	15 Gatherin g of material s	16 Gathering of materials	17 Gathering of materials	18 Waiting for production of biogas
19 Making of biogas digester	20 Making of biogas digester	21 Making of biogas digester	22 Making of biogas digester	23 Making of biogas digester	24 Formulatio n of treatments	25 Waiting for Biogas Production
26 Waiting for Biogas Productio n	27 Waiting for Biogas Producti on	28 Waiting for Biogas Production				

March 2023						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1 Waiting for production of biogas	2 Waiting for production of biogas	3 Trial and error	4
5	6	7	8	9	10	11
12	13	14 Gathering of materials	15 Formulation of treatments	16 Waiting for production of biogas	17 Waiting for production of biogas	18 Waiting for production of biogas
19 Waiting for production of biogas	20 Waiting for production of biogas	21 Waiting for production of biogas	22 Trial and error	23 Gathering of materials	24 Gathering of materials	25 Gathering of materials
26 Making of new biogas digester	27 Gathering of materials	28 Gathering of materials	29 Gathering of materials	30 Gathering of materials	31 Formulation of Treatments	

April 2023						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1 Waiting for productio n of biogas
2 Waiting for production of biogas	3 Waiting for production of biogas	4 Waiting for productio n of biogas	5 Trial and error, making of two and revising the design of the digester. Formulation of treatments	6 Waiting for production of biogas	7 Waiting for production of biogas	8 Trial and Error
9 Formulation of treatments	10 Waiting for production of biogas	11 Waiting for productio n of biogas	12 Waiting for production of biogas	13 Waiting for production of biogas	14 Found some leakage in the digester during the conducting of experiment	15
16	17	18	19	20	21	22
23	24	25 Collectin g of cow dung and formulati on of treatment s	26 Waiting for Biogas Production	27 Waiting for Biogas Production	28 Waiting for Biogas Production	29 Waiting for Biogas Productio n
30 Waiting for Biogas Production						

May 2023						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3 Waiting for Biogas Production	4 Waiting for Biogas Production	5 Waiting for Biogas Production	6 Waiting for Biogas Production
7 Waiting for Biogas Production	8 Waiting for Biogas Production	9 Conduct and reading of results	10 Collecting of pig dung and formulation of treatments	11 Waiting for Biogas Production	12 Waiting for Biogas Production	13 Waiting for Biogas Production
14 Waiting for Biogas Production	15 Waiting for Biogas Production	16 Waiting for Biogas Production	17 Waiting for Biogas Production	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

APPENDIX B

EXPENDITURES

18	1	Pc.	Interior	Php 140	Php 140
19	1	Pc.	Tab	Php 289	Php 289
20	10	Pc.	Glue Stick	Php 4	Php 40
21	1	Pc.	Plastic Cover	Php 24	Php 24
22	4	Pc.	Illustration Board	Php 44	Php 176
23	1	Pc.	Digester	Php 250	Php 250
24	3	Pc.	Elmers Glue	Php 10	Php 30
25	1	Pc.	2 Cream Out	Php 40	Php 40
26	1	Pc.	2L Distilled Water	Php 45	Php 45
27	1		Labor	Php 1,500	Php 1,500
28			Miscellaneous Expenses	Php 3,000	Php 3,000
29			Contingency Amount	Php 1,407	Php 1,407
Total Price					Php 9105

APPENDIX C

COMPUTATIONS

Table C-1. *T-test: Two Samples Assuming Unequal Variances in Terms of Heat Produce Per Treatment*

	Treatment A (Pig dung)	Treatment B (Cow dung)
Mean	7252.125413 calorie	5108.9068815 calorie
Variance	3174998.25704464	1102027.83946966
Standard Deviation	1719.536	
T Stat	1.465	
P value (two-tailed)	0.28039434842501	

Figure C-1. *Formula in Determining the Amount of Heat Produced:*

Q = Energy used

$$Q = m_{Al}C_{Al}\Delta T_{Al} + m_{H2O}C_{H2O}\Delta T_{H2O} + m_{H2O}L_{v\,(H2O)}$$

Figure C-2. *Formula of the Comparison for the Amount of Heat Produced of Pig and Cow Dung to Firewood:*

Pig Dung

$$7252.125413 \div 4000 = 1.813031354 \text{ cal/gram}$$

Cow Dung

$$5108.9068815 \div 4000 = 1.277226558 \text{ cal/gram}$$

APPENDIX D
PICTORIALS

Plate 1. Constructing of digester

Plate 2. Gathering of pig dun

Plate 3. Gathering of cow dung

Plate 4. Formulation of Treatr

Plate 5. Formulation of Treatment B

Plate 6. Loading of slurry

Plate 7. Waiting for biogas prodution

Plate 8. Seven days of biogas

Plate 9. Treatment b preparing for calorimetry

Plate 10. Treatment A preparing for calorimetry

Plate 11. Measuring of distilled water

Plate 12. Conducting calorimetry for Treatment A

Plate 13. Conducting calorimetry for treatment B

Plate 14. Measuring water after performing calorimetry