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Biogas Production from Food Waste and Cow Manure

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ABSTRACT

The purpose of this study was to examine the energy potential of cow dung and food waste by turning them into biogas through a fermentation process. Tests were conducted on the fermented biogas. This study aims to determine whether food waste, cow dung, and a combination of food waste and cow manure may produce biogas using methane. The biogas produced by fermenting food waste, cow dung, and a mixture of food waste and cow manure is stored by the researcher. The researcher employed readily available, affordable materials to build the product, fermentation process for both food wastes, cow dung, and mixtures of food waste and cow manure. This device is required to verify whether the gas or biogas in the tank or container exceeds the prescribed limit. The food scraps were collected from the local community in Davao City's Bankerohan Public Market. However, by asking the store owner whether we could get cow dung, the researchers were able to receive it from Puan, Bago Gallera, Davao City. The researchers utilized a table scale to measure food waste and cow dung accurately so that the researchers might have to ensure an equal value for both food waste and cow dung, we employed a table scale for accurate measuring. After being manually blended, the food waste was treated separately to facilitate its breakdown. Following the hand mixing, a single mixture was created from all of the trash. Biogas production is a sustainable method for generating energy from organic waste like food scraps and cow dung through anaerobic digestion, primarily producing methane and carbon dioxide. Food waste undergoes anaerobic digestion, producing biogas and a slurry called "digestate" with water and organic components, while microorganisms break down trash, producing methane and carbon dioxide. Biogas production from food waste and cow dung provides a sustainable, eco-friendly solution for managing organic waste, reducing greenhouse gas emissions, and improving waste management techniques.

1. INTRODUCTION

Now, the world is facing a dreadful energy crisis caused by the continuous growth of the world's population, continuous reliance on fossil fuels, and increasing demand for energy for various purposes (Singh et. al., 2021). The long-term utilization of fossil fuels has encountered a series of problems: depletion of fossil fuel reserves, global warming and other environmental concerns, geopolitical and military conflicts, and, most recently, a continued and significant increase in fuel prices (Asif & Munner, 2007).

China and India, two Asian countries, faced their worst energy crises in a long time. After the lifting of COVID-era restrictions, energy consumption surged to a level that was higher than China's and India's coal reserves. China's authorities were left with no choice but to limit daily energy use. Many businesses had to run for three to five hours each day before closing shop. In the meantime, days-long electricity blackouts hit many residential consumers due to a lack of coal energy supplies. Coal is India's main source of energy. Coal produces 70% of India's electricity. India's coal reserves drastically reduced in August 2021 (Ozili & Ozen, 2023).

According to Mondal, M., A. H., et al. (2018), the Philippines' energy sector faces the dual challenges of heavy reliance on fossil fuels and imported energy and high energy demand. The Philippines, with its soaring economy and population, is contingent heavily on fossil fuels. Consequently, it's a big issue if the Philippines' economic advancement is connected to ecological sustainability (Raihan, 2023). The Philippines' final energy consumption grew from 19.7 Millions of tonnes of oil equivalent (Mtoe) in 1990 to 29.6 Millions of tonnes of oil equivalent (Mtoe) in 2015 at an average annual growth rate of about 1.7%. During this period, energy consumption in the transport sector grew the fastest at an average annual rate of 3.5%, followed by the industry sector with 1.9%.

In a study conducted by Espina, R. U. (2016), the researchers analyzes the impending water and energy crisis in Davao City. The problem arises due to the high cost of living in a housing mainly because of the energy usage, to achieve low expense housing it needed Low Energy Consumption to lower the energy usage. Population growth and economic development have pushed the demand for all forms of resources especially water and energy. The application of the Biomimetics approach on building envelope hoped that will become a building advantage and enhance housing quality in Davao City.

Renewable energy is the answer to today's mounting energy challenges. Renewable energy sources, such as solar, wind, biomass, wave, and tidal energy, are plentiful, limitless, and environmentally beneficial (Asif & Munner, 2007). According to Molina & Nanna (2023), anaerobic digestion is considered to be a useful tool that can generate renewable energy. Furthermore, anaerobic digestion is the most commonly used tool and effective technique for treating different toxic pollutants as well as the waste itself **.** Also, anaerobic digestion is good for the treatment of organic waste such as cow manure, since it produces biogas, a renewable energy source and a digestate that can be used as organic fertilizer (Khan & Rahman, 2023**)**. Food waste was really a big problem to people, to the environment, and to society because people might risk themselves and also their surroundings by just throwing it everywhere without knowing the consequences of it. Secondly, the waste of cow or Cow Manure. It can also be a problem because they were having a hard time on where they should throw the waste, and also the smell stinks. To reduce the wastes and can also have a use of it they can utilize Anaerobic digestion (FAO, 2015)..

Much of the alternative sources of energy focuses on solar, wind, hydropower, and geothermal energy while biomass energy remains relatively underutilized. Also, there is little knowledge about the production of biogas from food waste in comparison to cow manure. This paper looks deeply into

this issue.

It is in this context that the researchers find the urgency to address the gap by conducting a study that will focus on the production of biogas from food waste and cow manure. The results of the study will help institutions in the possibility of producing biogas from food waste. It is further believed that conducting this study will benefit the community in using biogas as an alternative source of energy.

The results of this study will be disseminated through presentations at national and international research forums. Furthermore, the study's findings will be disseminated to participating faculty of basic education institutions. In addition, an online publication of this paper is being considered for easy access.

Statement of the Problem

This study aims to develop Biogas from food and cow manure waste, to reduce the environmental problems and provide a renewable energy source. Specifically, it sought to answer the following questions:

1. What is the total amount of cow manure that had produce biogas when fermented after a week/s based on the trial/s in terms of:

1.1 five and three-fourth (5¾) kilograms of cow manure;

1.2 three and one-half (3 ½) kilograms of cow manure; and

1.3 two and one-half (2½) kilograms of cow manure?

2. What is the total amount of food waste that had produce biogas when fermented after a week/s based on the trial/s in terms of:

2.1 five and three fourth (5¾) kilograms of food waste;

2.2 three and one half (3 ½) kilograms of food waste; and

2.3 two and one half (2½) kilograms of food waste?

3. What is the total amount of food waste and cow manure mixture that had produce biogas when fermented a week/s based on the trial/s in terms of:

3.1 five and three-fourth (5¾) kilograms of food waste and cow manure mixture;

3.2 three and one-half (3 ½) of food waste and cow manure mixture; and

3.3 two and one half (2½) kilograms of food waste and cow manure mixture;

Significance of the study

The project relies on food waste and cow manure from households to farmlands in the Philippines, are then converted to biofuel instead of being simply discharged, the amount of environmental pollution will be drastically reduced and provide a sustainable source of energy. It can provide affordability, sustainability, and potential contributions to modern economic applications to both culinary aspects, Department of Energy, City of Government of Davao, and future researchers.

*Culinary***.** The study benefits the culinary aspect since it produces fewer pollutants than any other fuel; it also promotes sustainable and clean energy consumption**.**

Department of Energy. The study of biogas aligns with the Department of Energy's goal of promoting renewable energy to reduce dependency on non-renewable energy.

City Government of Davao. The biogas systems can provide affordable energy to local communities, including urban and rural areas, while promoting sustainability. Additionally, the research promotes sustainability and responsible food waste consumption by integrating biogas.

Future Researchers. The study provides a solid foundation for future exploration of biogas technologies and their possible applications. They can adopt the study to improve its possible uses in renewable energy production and encourage the local communities to support biogas, as an alternative gas.

Scope and Delimitation of the Study

The study is focused on developing a biogas by utilizing food waste and cow manure funded by the researchers to ferment and produce renewable gas that were bought from Talomo-Bago Gallera near Puan and Bankerohan Public Market, Davao City. Proper sealing of the container is necessary to prevent pressure leaks, which could result in explosions and health problems. It is necessary to plan the materials to be used before performing the experiment. Food waste maybe produced methane if the researchers use the process of anaerobic digestion. Although the biogas was produced in a month, the researchers had anticipated that the cow manure could be produced in two weeks. The cow manure is supposedly 75% that should be enclosed into the container; if higher than the 75% of cow manure is enclosed, the cow manure will explode.

CONCEPTUAL FRAMEWORK

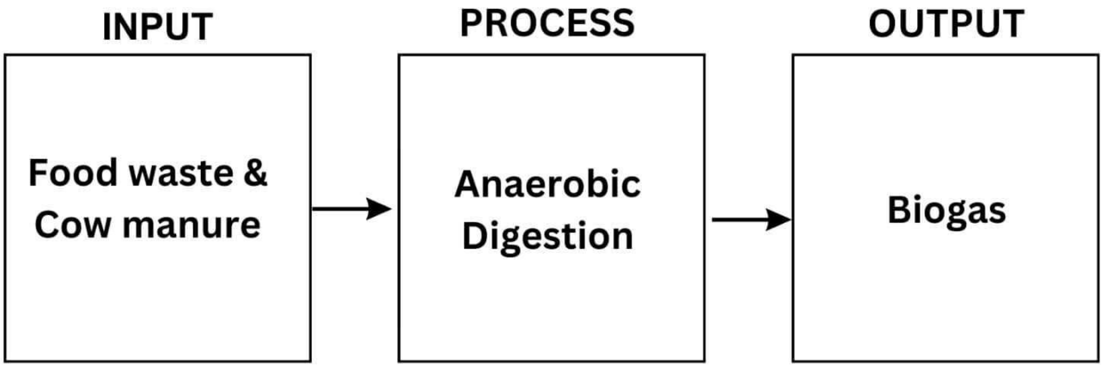

Figure 1.

Figure 1 illustrates the INPUT, PROCESS and OUTPUT. Where INPUT are Food waste and Cow manure; Food waste and cow manure, both rich in organic matter, are key ingredients for producing renewable biogas. Food waste represents a significantly fraction of municipal solid waste. Proper management and recycling of huge volumes of food waste are required to reduce its environmental burdens and to minimize risks to human health. Food waste is indeed an untapped resource with great potential for energy production. An ever increasing demand for animal protein products has posed serious challenges for managing the increasing quantities of livestock manure. The choice of treatment technologies is still a complicated task and considerable debates over this issue still continue.

Where PROCESS is anaerobic digestion; This process, known as anaerobic digestion, harnesses the power of microorganisms to break down these materials in the absence of oxygen, generating a mixture of gases primarily composed of methane and carbon dioxide. According to a study conducted by Morales-Polo, C., et al. (2018), Anaerobic Digestion process represents a way of recycling, recovery (in form of energy and industrial use as fertilizer), and a reduction system of landfill disposal; partial if digestate is eliminated, or complete if digestate is re-used.

Where OUTPUT is Biogas; The environmental benefits of biogas technology are often highlighted, as a valid and sustainable alternative to fossil fuels. Together with the reduction of greenhouse gas (GHG) emissions, biogas can enhance energy security, thanks to its high energetic potential. The exploitation of some fossil fuels such as oil, intended as gasoline or diesel fuel, natural gas and coal, currently satisfy the majority of the growing world energy demand, but they are destined to run out relatively quickly. Therefore, it is clear that a solution to the energy problem can be obtained only through the use of renewable sources and by means of the exploitation of new low-polluting fuels.

2. LITERATURE REVIEW

This section contains the literature and empirical studies relevant to the study. These are selected for their relevance and significance to the topic under investigation. The discussion follows the following topics: Cow Manure, Food Waste, and effectiveness of both in terms of producing methane.

Food Waste Problem.

The Philippines is among the Asian countries—particularly in Manila—that faces significant food waste problems. Despite millions of Filipinos experiencing hunger, the volume of food waste produced in the Philippines is still alarmingly high. Food waste happens at the production stage mainly due to insufficient skills, natural calamities, lack of proper infrastructure, and poor practices. In 2013, the United Nations Food and Agriculture Organisation (FAO) published a report examining the effects of worldwide food waste on the environment. They recognized trends in food waste worldwide. They discovered that in middle to higher income nations, food waste happens during the "downstream" stage of production, as they observed that consumers and commercial enterprises wasted the food. They also found that developing nations were more prone to contribute to food waste in the "upstream" segment of the production process, often because of infrastructural issues like insufficient refrigeration, inadequate storage options, and limitations in harvesting methods, among others. Food waste is a common problem that occurs at various stages of the food supply chain, such as production, processing, transportation, and consumption. Moreover, a further element leading to the problem is the lack of sufficient planning. Food waste triggers the emergence of various diseases and plays a role in harming the environment (Ar Salan and Hossain, 2024). So, food waste can really affect the environment in multiple ways, including the production of greenhouse gases, depletion of natural resources, and pollution.

Effectiveness of Food Waste as a Producer of Methane.

Food waste can also have a significant advantage such as producing methane that can be turned into biogas, whereas, through anaerobic digestion microorganisms decompose organic material without the presence of oxygen.

Food Waste and Cow Manure.

Food waste is a food that is fit for consumption but consciously discarded at the retail or consumption phases. The causes of food waste or loss are numerous and occur throughout the food system, during production, processing, distribution, retail and food service sales, and consumption. Overall, about one-third of the world's food is thrown away. Food waste is not ultimately consumed by humans that is discarded or recycled, such as plate waste (i.e., food that has been served but not eaten), spoiled food, or peels and rinds considered inedible. The wasted food is not an only humanitarian concern, but an environmental one.

When wasting food, it also wastes all of the energy and water that is in it. And also, the cost of wasted food is also a waste of valuable resources, water, energy, fuel, and human labor. As a result, wasting becomes an economic, environmental and socio-ethical problem and if food goes to landfill roots, it produces methane, a greenhouse gas even more potent that carbon dioxide. Cow manure, also known as cow dung, is mostly digested grass and, depending on the cattle's diet, grain, fruits, or vegetable. It's not just cow droppings, as it contains tracks of hay, straw, beddings, grains, and other organic matter used to feed the animals.

Cow manure is rich in nutrients and suitable for plant growth. It has 3% nitrogen, 2% phosphorus, and 1% potassium-3-2-1 NPK, making it the right type of fertilizer for almost all types of plants and crops. That's because it brings back nutrients balance to fields organically. However, cow manure is also rich in ammonia but, sometimes it can contain dangerous pathogens and bacteria, such as E Coli. So, an aging or decomposition process is necessary to breakdown the organic matter and eliminate the harmful substances before manure gets to fields. Cow manure composting is a cost-effective way to manage cattle waste and produce high-quality fertilizer for almost all types of plants. However, storing and managing cow droppings can be a challenge, and an incomplete decomposition process can harm your crops and environment.

Biogas.

Biogas are a class of renewable energy derived from living materials. The most common biofuels are corn ethanol, biodiesel, and biogas from organic products. Energy from renewable resources puts less strain on the limited supply of fossil fuels, which are considered nonrenewable resources. Biofuels function similarly to renewable fossil fuels. Both burn when ignited, releasing energy that can be used to power cards or heat homes. The main difference between them is that biofuels can be grown indefinitely and generally cause less damage to the planet.

Many of the world's major oil companies are now investing millions of dollars in advanced biofuels research, including Exxon Mobil Corp. (COM). America's largest oil company is focusing on advanced biofuels that do not compete with food or water supplies, with most of its allocated funds dedicated to transforming algae and plant waste into fuel that can be used for transportation. Biofuels can be solid, liquid or gaseous. They are the most useful in the latter two forms as this makes it easier to transport, deliver, and burn cleanly. It is a type of renewable energy source derived from microbial, plant, or animal materials.

Ethanol (often made from corn in the United States and sugarcane in Brazil), biodiesel (sourced from vegetable oils and liquid animal fats), green diesel (derived from algae and other plant sources), and biogas (methane-derived from animal manure and other digested organic material) is an example of biofuels. A lot of people were concerned about the biofuel's energy security and carbon dioxide emissions, and to see it as a variable alternative to fossil fuels. However, biofuels also have deficiency, eg., it takes more ethanol than gasoline to produce the same amount of energy, and critics contend that ethanol use is extremely wasteful because the production of ethanol actually creates a net energy loss while also increasing food prices.

Biogas also has a point of contention for conservation, it argues that bio-crops would go to better use as a source of food rather than fuel. It uses a large amount with specific concerns, such as arable land that are required to produce bio-crops, leading to problems such as soil erosion, deforestation, fertilizer run-off, and saline.

METHOD

This section presented the method of the study, including research design, and which contains three (3) phases; phase 1 – materials and ingredients preparation; phase 2 – undertaking of doing the study, and phase 3 – the data analysis.

Research Design

The study made use of the experimental quantitative method of research to gather relevant data and information. According to Stefan et. Al. (2015), in order to efficiently collect, handle, and analyze data for research on modern biology as well as to comprehend and anticipate the behavior of complex systems, computational and quantitative methods are becoming increasingly important. In addition, all study plans make an effort to reduce any risks to the validity of any scientific findings. In order to provide the best results, an effective research program will ideally combine mixed methods of inquiry with experimental designs. In addition, Little and Wu (2019) stated that all study plans make an effort to reduce any risks to the validity of any scientific findings. In order to provide the best results, an effective research program will ideally combine mixed methods of inquiry with experimental designs.

Specifically, this study utilized the true experimental design to describe the measure of biogas (gobar gas) from food wastes and cow manure produced when fermented. Before any research is conducted, Inglis et. al.

(2013) insinuated that a suitable experimental design must be established. The quasi-experimental design has a significant flaw in that it cannot tell if apparent differences between treatments are brought on by a constant shift in the bacterial community within a sample or by a relatively side impact in just one or a few samples. Therefore, whenever it is feasible to do so, a true experimental design should be adopted. Particularly, in the area of environmental energy source from food waste and cow manure conversion, the true experimental design is desirable since it gives a measure of the variation among samples.

Phase I. Preparation of Materials and Ingredients *Preparation of Ingredients.*

The principal Ingredients used are cow manure, which was found at Bago Gallera, Puan, Davao City and food waste which was also found at Bankerohan, Metro, Davao City. The food waste is a household waste and the fresh cow manure with the same amount of water. The researchers made sure the ingredients were precise; they measured and weighed each one to prevent errors that could have reduced the amount of methane produced. Afterwards, when the food wastes and cow manure is done blending, it is put in a separated container; whereas the container that should have wastes are pure food waste, cow manure's waste, and a mix of both wastes that are mentioned.

Preparation of materials.

The researchers use materials which are gas hose, hose connector, gas container, pressure gauge/meter gauge, hose clamp, teflon tape, Motorcycle interior, gas hose valve, transfer valve, butane empty container, Paint with white color are all provided by the researchers.

Phase 2. Undertaking of Doing Study

The researchers bought the materials needed to assemble their research container. Researchers have traveled to Bago Gallera, Puan, Davao City and Bankerohan, Metro, Davao City to find resources that can produce Biogas. In the first trial, researchers came to a walking distance shop at Phoenix Gasoline Station The researchers made a hole in the center of the cap of the container. The researchers cut the Gas hose, put a Teflon tape into the hose connector to prevent gas leaking and connect each of them. After connecting the connector with a teflon tape to the gas hose, the researchers put another teflon tape into the motorcycle interior and connect the gas hose into it as well as to ready the assembled container. The researchers used a scale to accurately measure the food and ensure that the food are well measured to produce biogas. After measuring the ingredients, carefully place the ingredients inside each three (3) containers. The researchers covered the container with plywood to avoid heat from the sun and allowed it to produce gas after a few weeks/ a month. The researcher's took a picture and always observed weekly if the motorcycle interior has a gas inside on it by pressing it and the researcher's also observed if the meter gauge functioned and turn into measurable psi. The researcher's waited a weeks and the product showed up which made them believed that Biogas from Cow manure and Food waste really works. The researchers bought an empty container of

butane gas, painted it in a color white paint, and used it to transfer the biogas from the container.

Phase 3. Data Analysis

In August 13,2024, the data was collected, determined, turned up and evaluated using empirical tools. In analyzing the result of the study, The Researcher's use the following statistical tools.

Mean. This was used to measure each waste of Biogas from Food waste and Cow manure. Then proceed with the fermentation process, waiting for the waste to ferment and produce each production of methane. In terms of different 5 1 Kilograms of Food waste, 2 kilograms of food waste, and 3 kilograms of food waste; 1 kilogram of Cow manure, 2 kilograms of Cow manure, and 3 kilograms of Cow manure.

RESULTS

This chapter presents the findings, process by flow chart and result based on the data gathered from the first trial to the end of the trial that are used within the experiment as well as it was organized into three (3) sections; First (1) section; five and three-fourth (5¾) kilograms of cow manure, three and one-half (3 ½) kilograms of cow manure, and two and one-half (2½) kilograms of cow manure. Second (2) section; five and three fourth (5¾) kilograms of food waste, three and one half (3 ½) kilograms of food waste, and two and one half (2½) kilograms of food waste. Third (3) section; five and three fourth

(5¾) kilograms of food waste and cow manure mixture, three and one half (3

½) kilograms of food waste and cow manure mixture, and two and one half (2½) kilograms of food waste.

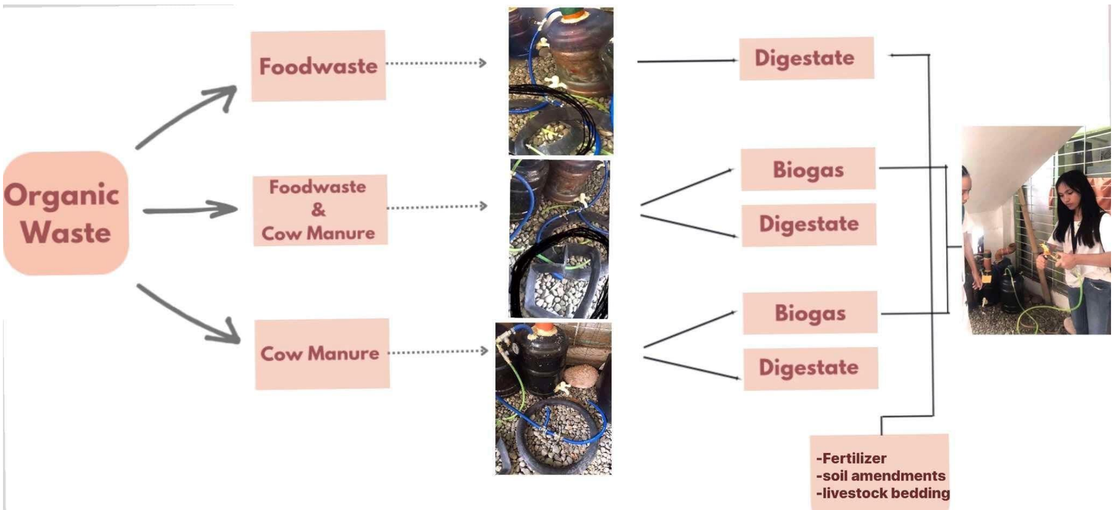

Figure 1. As shown above, Organic wastes (Cow manure and Food waste) showed that the methane itself exists.

Table 1

Amount of Cow Manure That Have Been Produced Into Biogas when Fermented After a Week/s

PURE COW MANURE		
Trial/s	**Weight/s**	**Result**
First (1)	5 ¾ kg	success
Second (2)	3 ½ kg	success
Third (3)	2½ kg	success

Presented in Table 1 is the amount of cow manure that has been produced into biogas when fermented after a week/s when tested in various trials to ensure accuracy. According to Steed, J., J. & Hashimoto, A., G., This study showed that the—previously reported estimates of MCF for some waste management systems were higher than was actually the case. Consequently earlier estimates of the amount of methane generated globally from manures were higher than those found in this study. It means that cow manure has a higher amount of biogas production.

Table 2

Amount of Food Waste That Have Been Produced Into Biogas When Fermented after a Week/s

PURE FOOD WASTE		
Trial/s	**Weight/s**	**Result**
First (1)	5 ¾ kg	failed
Second (2)	3 ½ kg	failed
Third (3)	2½ kg	failed

Presented in Table 2 is the amount of food waste that had been produced of biogas when fermented after a week. According to Lauria, M., (2024), Another way to reduce methane emissions is to compost food waste rather than dispose of it in the garbage. This is because at-home composting incorporates oxygen into the process, which means that harmful methane isn't produced by the bacteria that are common in anaerobic landfill conditions.

Table 3

Amount of Mixed; Food Waste and Cow Manure That Have Been Produced Into Biogas When Fermented after a Week/s

Mix (Food waste and Cow Manure)

Trial/s	**Cow Manure**	**Food Waste**	**Result**
	Weight/s	**Weight/s**	
First (1)	**3½ kg**	**3½ kg**	Success
Second (2)	**3 kg**	**3 kg**	Success
Third (3)	**2½ kg**	**2½ kg**	Success

Presented in Table 3 is the amount of food waste and cow manure mixture that have been produced into biogas when fermented after a week/s. According to Arifan, f., et al. (2021), Cabbage waste, tofu liquid waste, and cow dung is dangerous for the surrounding environment, which produces CH4 gas and has quite high BOD and COD values. It implies that, if the food waste putts or merges with cow manure can significantly produce biogas. A study conducted by Chibueze, U., Et al. (2017), A study combines cow dung and food wastes to produce biogas. The outcomes were success. However, food waste produces more biogas than cow manure.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The total amount of cow manure that had produced biogas when fermented after a week/s based on the trial/s: *1.1* five and three-fourth (5¾) kilograms of cow manure; The total amount of cow manure is sufficient if the container is larger than its amount (kilogram); due to small space and an over amount (kilogram) of cow manure inside the container, the cow manure explodes because of the lack of space for the pressure of biogas. *1.2* three and one-half (3 ½) kilograms of cow manure; The new container is too large for the pressure space, and the researchers added more water than the amount of cow manure, therefore the overall amount of manure is insufficient. Thus, the manure failed to yield. Lastly, *1.3* two and one-half (2½) kilograms of cow manure; The total amount of cow manure was adequate to make methane. The researchers made sure that the cow manure was suitable for its container and that the biogas pressure space was adequate to prevent explosions.
2. The total amount of cow manure that had produced biogas when fermented after a week/s based on the trial/s: *2.1* five and three-fourth (5¾) kilograms of Food waste; the total amount of food waste did not produce biogas. *2.2* three and one half (3 ½) kilograms of food waste; The total amount of food waste did not produce biogas. Lastly, *2.3* two and one half (2½) kilograms of food waste; The total amount of food waste did not produce biogas. In summary, these three trials has not produced biogas due to its inactive anaerobic bacteria.
3. The total amount of food waste and cow manure mixture that had been produced when fermented a week or so based on the trials in terms of: *3.1* five and three-fourths (5¾) kilograms of food waste and cow manure mixture; the total amount of the mixture of cow manure and food waste did not produce biogas due to excess wastes that were put in the container. *3.2* three and one-half (3 ½) of food waste and cow manure mixture; this second trial produced biogas. *3.3* two and one half (2½) kilograms of food waste and cow manure mixture; this third trial had also produced biogas.

In summary, table 1, which is pure cow manure waste, has a higher production of biogas than the Food waste. Whereas Pure Food Waste has a failed result to produce biogas. The Mixture of Food Waste and Cow Manure produced biogas. It indicates that cow manure has a higher methane production than the food waste and mixture due to its inactive anaerobic bacteria.

Recommendations

Further study areas have been encouraged to improve the biogas systems and its performance as an alternative source of energy:

1. Alternative Source of Biogas. Avoid adding more amounts of water that can lead to a low amount of methane production.
2. Other researchers can use the process of anaerobic digestion.
3. Avoid putting too much amount of Cow manure in the container, Cow manure will expand which can lead to explosion. Fill only the container with an appropriate amount of cow manure waste to avoid explosion.

4. Food waste itself cannot produce a high amount of biogas due to low production of bacteria/s.
5. The other researchers can use the Cow manure as a plant fertilizer. Manure is a beneficial soil additive and fertilizer that has several uses, such as: Plant growth, soil quality, soil health, water quality, and yield stability.

With these recommendations, future iterations of this project might be done successfully.

REFERENCES

Anonas, S.D. S., Balite, P.H. M., Eugenio, F.D. T., Flores, B. F., Limjuco, L. A., Tomacruz, J.G. T., and Ocon, J. D., (2023), From Waste to Renewable Energy: A Policy Review on Waste-to-Energy in the Philippines, Energy Sustainability. https://doi.org/10.3390/su151712963

Bond, T., & Templeton, M. R. (2011). History and future of domestic biogas plants in the developing world. Energy for Sustainable Development.Volume 15, Issue 4, December 2011, Pages 347-354. https://doi.org/10.1016/j.esd.2011.09.003

Cao, Y., & Pawłowski, L. (2013). Effect of biofuels on environment and sustainable development. *Ecological Chemistry and Engineering S*, *20*(4), 799-804.

Google Scholar. (n.d.).

https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Anaerobic+digestion+theory&oq=Anaerobic+digestion+thekr#d=gs_qabs&t=1724493187301&u=%23p%3Dt4P-a5AvLxEJ

Jafari-Sejahrood, A., Najafi, B., Faizollahzadeh Ardabili, S., Shamshirband, S., Mosavi, A., & Chau, K. wing. (2019). Limiting factors for biogas production from cow manure: energo-environmental approach. *Engineering Applications*

of Computational Fluid Mechanics, *13*(1), 954–966.

https://doi.org/10.1080/19942060.2019.1654411

Jeswani Harish K., Chilvers, A. & Azapagic, A. 2020Environmental sustainability of biofuels: a review*Proc. R. Soc. A.*47620200351

http://doi.org/10.1098/rspa.2020.0351

Karmee, S. K. (2016). Liquid biofuels from food waste: current trends, prospect and limitation, *Renewable and Sustainable Energy Reviews*, *53*, 945-953.

https://www.sciencedirect.com/journal/renewable-and-sustainable-energy-revi ews

Khoshnevisan, B., Duan, N., Tsapekos, P., Awasthi, M. K., Liu, Z., Mohammadi, A., ... & Liu, H. (2021). A critical review on livestock manure biorefinery technologies: Sustainability, challenges, and future perspectives. Renewable and Sustainable Energy Reviews, 135, 110033.

https://doi.org/10.1016/j.wasman.2014.12.004

Kumar, J., Kavitha, S., Merrylin, J., Yukesh, R.K., Poornima, T. D., Rajesh, J.B. & Sivashanmugam, P. (2020). Food waste valorization: Biofuels and value-added product recovery, Bioresource Technology Reports, 11, Article 100524.

https://doi.org/10.1016/j.biteb.2020.100524

Lauria, M. (2024). The connection between food waste, methane, and climate change. *ONE5C* .https://one5c.com/foodwastemethane 136935965/#:~:text=Composting%20food%20waste%20is%20also,present%20to%20produce%20harmful%20methane .

Lewis, J. (2022). How Does Food Waste Affect the Environment?. EARTH.ORG.

https://earth.org/how-does-food-waste-affect-the-environment/

Liu, H., Huang, Y., Yuan, H., Yin, X., & Wu, C. (2018). Life cycle assessment of biofuels in China: status and challenges. *Renewable and Sustainable*

Energy Reviews.[1,2,1] *97*, 301-322.

https://doi.org/10.1016/j.rser.2018.08.052

Malik, W., Mohan, C., & Annachhatre, A. P. (2020). Community based biogas plant utilizing food waste and cow dung. *Materials Today: Proceedings*, *28*, 1910-1915. https://d012036oi:10.1088/1755-1315/623/1/

Marquez, G., P., B., et al. (2014). Seaweed biomass of the Philippines:

Sustainable feedstock for biogas production. Renewable and Sustainable Energy Reviews. Volume 38, October 2014, Pages 1056-1068. https://doi.org/10.1016/j.rser.2014.07.056.

Molino, & Nanna. (2013). Biomethane production by anaerobic digestion of organic waste. Fuel, 1003–1009.

https://www.sciencedirect.com/science/article/abs/pii/S001623611200631X

Mondal, M. A. H., Rosegrant, M., Ringler, C., Pradesha, A., &

Valmonte-Santos, R. (2018). The Philippines energy future and low-carbon development strategies. *Energy*, *147*, 142-154. https://doi.org/10.1016/j.energy.2018.01.039

Morales-Polo, C., Cledera-Castro, M. D. M., & Moratilla Soria, B. Y. (2018). Reviewing the anaerobic digestion of food waste: From waste generation and anaerobic process to its perspectives. Applied Sciences, 8(10), 1804.

https://doi.org/10.3390/app8101804doi.org

Muhammed, & Nishat. (2023). Relationship Between Microbes and the Environment for Sustainable Ecosystem Services. Book.

https://www.sciencedirect.com/science/article/abs/pii/B978032389936900015 1

Nicoletti, G., Arcuri, N., Nicoletti, G., & Bruno, R. (2015). A technical and environmental comparison between hydrogen and some fossil fuels. Energy Conversion and Management, 89, 205-213.

https://doi.org/10.1016/j.enconman.2014.09.057

Paolini, V., et al. (2018). Environmental impact of biogas: A short review of current knowledge. *Journal of Environmental Science and Health, Part A*, *53*(10), 899-906.

Pax, M. E., Muzenda, E., & Lekgoba, T. (2020). Effect of co-digestion of food waste and cow dung on biogas yield. *E3S Web of Conferences*, *181*, 01005.

https://doi.org/10.1051/e3sconf/20201810100

Pham, T. P. T., Kaushik, R., Parshetti, G. K., Mahmood, R., & Balasubramanian, R. (2015). Food waste-to-energy conversion technologies:

Current status and future directions. Waste management, 38, 399-408.

https://doi.org/10.1016/j.wasman.2014.12.004

Popp, J., Harangi-Rákos, M., Gabnai, Z., Balogh, P., Antal, G., & Bai, A. (2016). Biofuels and their co-products as livestock feed: global economic and environmental implications. *Molecules*, *21*(3). https://doi.org/10.3Biofuels and

Their Co-Products as Livestock Feed: Global Economic and Environmental Implications390/molecules21030285.

Pulido, L.B. J., (2023), DOE Seeks to Increase Biofuels Blend in PH Energy Mix, Republic of the Philippines(DEPARTMENT OF ENERGY)Kagawaran ng Enerhiya. https://www.doe.gov.ph/press-releases/%E2%80%8Bdoe-seeks-increase-biof uels-blend-ph energy-mix

Raven, R. R., & Gregersen, K. (2007). Biogas plants in Denmark: successes and setbacks. Renewable and Sustainable Energy Reviews, 11(1), 116–132. https://doi.org/10.1016/j.rser.2004.12.002

Santoso, F. C. (2021). Final Architectural Design Studio Design Of Davao City

Vertical Housing With Nearly Zero-Energy Building And Biomimetics Concept On Building Envelope.

https://dspace.uii.ac.id/handle/123456789/37228

Sims R et al. 2014 Transport. In *Climate change 2014: mitigation of climate change contribution of working group III to the fifth assessment report of the intergovernmental panel on climate change* (eds Edenhofer O et al.).

Cambridge, UK and New York, NY: Cambridge University Press.

Singh, P., Singh, S., Kumar, G., & Baweja, P. (Eds.). (2021). *Energy: crises, challenges and solutions*. John Wiley & Sons