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Original Article

Comparative study of biogas yield from animal manure in barn and farm

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ABSTRACT

The need for energy crops and animal manures for the production of biogas is rising globally. Farmers that raise cattle may use manure as an alternative energy source. Manure is partially converted into energy in the form of biogas by an anaerobic digester. To improve the biogas yield from animal manure must be taken into consideration the quality of manure. It is clear that the difference in the method of pasture has an important impact on biogas production. The study aims to compare the amount of biogas produced from manure animals in barns (closed pastures) and animals in farms (open pastures). The study included different types of manure cows, sheep, and poultry. Experiments were performed in a 2 L plastic bottle digester in a water bath at a 37°C mesophilic range. During the 12-day hydraulic retention period, a mixture of animal dung and water was employed in a 1:1 ratio (HRT). The volumetric water replacement method was used to calculate the amount of gas produced. The results showed that the barn manure had higher biogas production than the farm manure approximately 3 times because their feed had concentrated nutritional supplements.
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1. Introduction

Due to the significant climatic changes that the industrial revolution and the rise of civilization brought about as a result of traditional energy production methods, interest in the utilization of renewable energy sources have grown [1].
All organic materials can be converted into biomass, a popular source of renewable energy with a high energy output that can displace traditional fossil fuel energy sources [2]. Wastes, energy crops, and animal dung can all be converted into biogas .The use of animal manure as a biomass source for the production of biogas has considerable potential, as it can be broken down by bacteria into biogas and composted through a process known as anaerobic digestion (AD) [3]. Temperature, pH, mixing, and other parameters will all have an impact on how effectively anaerobic digestion occurs [4].
The organic makeup of the substrates has an impact on how quickly gases are produced. The quality of the manure is influenced by the animal's diet; the more nutrients (fat, protein, and soluble carbohydrates), the greater the quality of the manure and the production of biogas; however, some elements, such as fiber, may decrease the rate at which the manure is digested. Because they influence how well and how actively bacteria perform, these parameters must be controlled [5].
Bacterial dwell time affects gas production. For instance, Laski and Nedyah [6] investigated the production of biogas from various wastes and discovered that the volume of biogas produced is always a function of the digestion's residence duration and the concentration of organic matter in the experiment. Additionally, Al-Hamamre, et al. [7] assessed the state of biomass energy in Jordan and found that an estimated 428 MCM of biogas may be produced

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from a variety of biomass sources. Al-Jabri, et al. [8] also investigated the production of biogas from bio-waste in rural Palestine. They demonstrated how the Indian biogas model might be used to generate large amounts of biogas in rural Palestine. In addition, Maranon et al. [9] assessed the co-digestion of bovine dung with food waste and research to boost biogas generation. When they increased the organic load rate and decreased the high retention duration, they discovered a decreased methane output. In a different study, Esposito, et al. [10] assessed the enhanced bio-methane production from co-digestion of various organic wastes and discovered that mixing buffalo manure with the municipal solid waste's organic fraction produced methane volumes that were 12% and 30% higher after 30 and 15 days from the test start, respectively. According to research by Hammed et al. [11] in a separate area, 20% of the rural people might have their needs met by the conversion of animal waste into biogas. Al-Amin, et al. [12] quantified the generation of biogas and found that it occurred at a rate of 0.63 m^3 biogas per m^3 of agricultural waste.

My previous paper in (2022) examined improving cow, sheep, and poultry manure in two phases. The result in phase one showed the optimum pH for all substrates was 7. While in phase two the result showed painting the digester with black color enhance from biogas production [13].

Hammad, E. I. (2018) This study's goals were to increase biogas generation by employing a combination of cow and chicken dung and to look into how digested manure affected plant development. The amount of biogas created from the combination of cow and chicken manures was more than the amount produced from each manure separately, according to the results, which indicated increased biogas production. This quantity reached its peak after 28 days. During the creation of biogas, pH levels decreased, then BOD and COD were reduced. Conversely, increases in EC values were seen. When compared to the control sample, the yield of lettuce rose by 75% when digested manure was applied to the soil [14].

In a prior investigation, Wagner et al (2013). In order to evaluate their potential use as substrates for the production of biogas, batch anaerobic digesters were employed to test the effects of nine complex organic substrates from three groups (protein-, lipid-, and cellulose-rich). The findings demonstrate how the type of organic substrates affects the amount of methane in biogas (which typically contains between 50 and 70 percent biogas). High methane production was observed from protein-rich substrates, whereas issues arose from the fermentation of lactose, lipids, and cellulose. According to the study, substrate overloading and/or an excess of a readily available carbohydrate portion lead to H_2 release and low pH, which inhibit the synthesis of methane [15].

In Hindrichsen.K at el. (2005) studies, the impact of feeding on methane emission from dairy cows and their slurry was examined. The experiment concentrated on the impact of various diets on the emission of methane. Dietary concentrates high in pectin, fructan, sugar, starch, or fiber—both lignified and non-lignified—were employed. The slurry was kept in 60-L barrels for a period of 14 weeks in order to assess methane emissions. The findings indicate that methane emissions from the slurry made up 16.0% to 21.9% of all system emissions. The increase and decrease in CH_4 during slurry storage may be caused by a decline in the number of nutrients that are readily available over time or a decrease in the water content of the slurry [16].

The above-mentioned reports' drawback is that they concentrated on analyzing the biogas from a single type of manure. The impact of the various pasture management techniques on the production of biogas was not assessed. They also did not keep a steady temperature during the digestive process. Furthermore, little research has been done on how to quantify the generation of biogas. The authors of this study compared the volume of biogas generated by batch digesters operating at mesophilic temperature (37 °C) from animal dung in barns (closed pastures) and farms (open pastures).

2. Materials and Methods

2.1. Material

2.2. Tables

Three distinct types of farm and barn animal manure were used in experiments to see how grazing management affected the production of biogas. A 2 liter plastic bottle was used as the reactor during setup. Fig 1 depicts a schematic of the biogas generating unit. A displacement bottle and a water collector were connected to the reactor. The displacement bottles and reactors were connected by rubber tubes. The water bath was set at 37 °C to facilitate the digesting process.

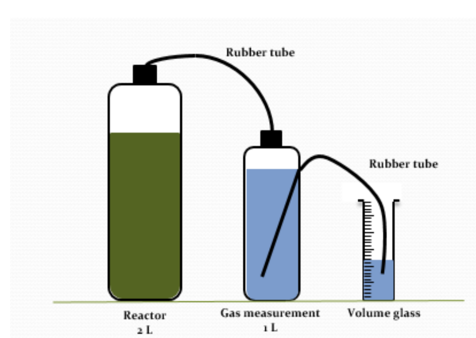

Fig 1. Biogas production unit.

After weighing each required amount of the substrate with an electronic balance, the substrates were fed in a mixing steel vessel where they were mixed with the required amount of water. The slurry was introduced into the digester from batch type. Finally, the inlet pipe is tightly closed, and put the reactor inside the water path.
The three reactors were operated in batch pilot-scale digesters and fed manually, the rate and the pattern of gas produced were monitored over a hydraulic retention time (HRT) of 12 days, and the measurement was daily. Biogas production from the digesters was measured by the water displacement method.
In this research, the experiment was carried out using fresh manure of poultry (PM), cow (CM), and sheep (SM). The experiment was conducted to investigate the best type of breeding between open grazing on farms and closed grazing in barns.

3. Results and Discussion

This experiment was conducted to verify the effect of animal production system and animal species on biogas production, the experiment was carried out using manure of poultry (PM), cow (CM), and sheep (SM) from farms (open system) and barns (closed system). The results of the experiments are shown in Table 1.

Table 1.The result of the experiment.

	Poultry		Cow		Sheep	
	Farm	Barn	Farm	Barn	Farm	Barn
Avg. daily gas production/ml	194.67	682	85.33	318	42	177.5
Ml gas/g manure	4.17	14.6	1.82	6.81	0.90	3.8

Fig 2 depictsthe daily biogas production over 12 days retention period from poultry manure from the farm (PMF) and poultry manure from the barn (PMB), the biogas gas production was higher during the first days and decreased gradually as the days passes. Production of biogas started on the first day with about 700 ml for PMF, and this was the highest gas production for PMF and reduced to 487 ml on the second day, and biogas production decreased with the passing of days, while PMB produced on the first day 540 ml and the biogas production increase to 900 ml on the second day and the highest gas production was on the third day by about 1220 ml and then the biogas production decreased to the end of the retention period.

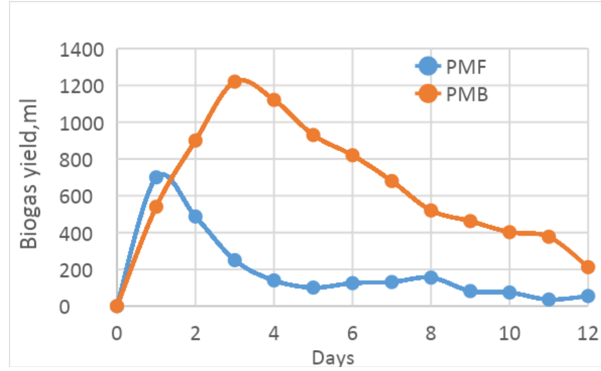

Fig 2.Biogas production from PMB and PMF.

Fig 3 depictsthe daily biogas production over 12 days retention period from cows manure from the farm (CMF) and cows manure from the barn (CMB). The highest biogas production of CMB was on the second day with about 620 ml and about 320 ml for CMF on the first day.

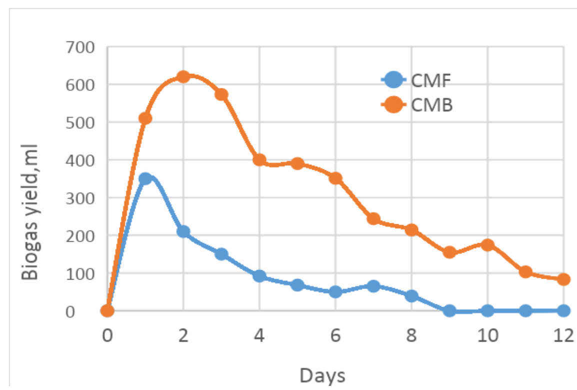

Fig 3. Biogas production from CMB and CMF.

Fig 4 depicts the daily biogas production over 12 days retention period from sheep manure from the farm (SMF) and sheep manure from the barn (SMB). The maximum gas yield of 453 ml was obtained for SMB on the 2^{nd} day, followed by 200 ml for SMF on the first.

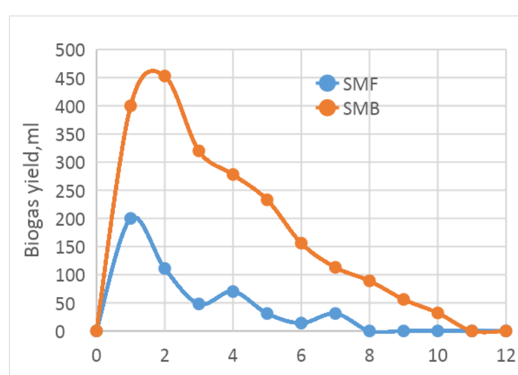

Fig 4. Biogas production from SMB and SMF.

Fig 4 depicts the total biogas gas production from barn animals was 3.5 to 4.22 times higher than the cumulative biogas gas production from farm animals because barn animals' feed is better. Farm animals depend on grass, straw, cereals, and flour for their feed, whereas barn animals' feed consists of cereals and also concentrate supplements that contain a large proportion of protein, fats, and carbohydrates, and these nutrients are considered the most influential on biogas production. Just as the nutrients that the barn animals take contain more proteins, carbohydrates, and fats, the nutrients also contain a large number of calories. During the process of producing gas, the bacteria need energy and this energy takes from calories that are found in the manure of barn animals, and this explains why the amount of gas in the barn animals is more than in farm animals. Figure 5 shows that the cumulative biogas production from poultry manure is more than the biogas production from cow manure by 144% and the biogas production from cow manure is more than the biogas production from sheep manure by 79% in the barn animal.

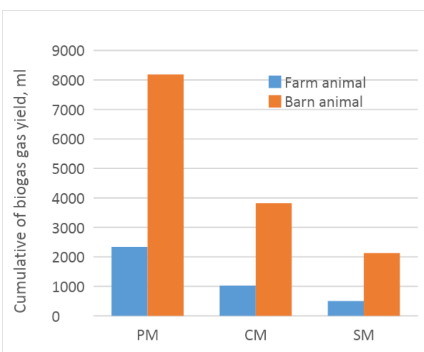

Fig 5. The cumulative of biogas gas production from barn and farm animals.

4. Conclusion

This study investigated the effect of feeding on biogas production from poultry, cow, and sheep manure (which are the most available in our location) in an anaerobic batch reactor with a retention time of 12 days. The results showed that the feeding of animals with concentrated nutritional supplements had significant effects on biogas yield and also the animal species, where the highest biogas production was recorded on poultry manure and then cow manure and sheep manure respectively.

5. Recommendations

It is advised to conduct experiments on other types of animal manure. Studying the effect of adding fermentation stimulants such as molasses to manure in an anaerobic digester in biogas production.

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Conflict of Interest

Regarding the publication of this paper, the authors declare that they have no conflicts of interest.

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