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Feasibility analysis of the cow manure *(Bos taurus)* biodigester as a renewable energy source in the Ahuaycha district, 2023

Análisis de factibilidad del biodigestor de estiércol de vaca (Bos taurus) como fuente de energía renovable en el distrito de Ahuaycha, 2023

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ABSTRACT

The objective of the research was to analyze the viability of the cow manure biodigester *(Bos taurus)* as a source of renewable energy in the district of Ahuaycha. The methodology was applied research, and direct observation was also used to determine the manure content and the size of the biodigester. The results showed the amount of manure produced by cows per day, month and year, 1 cow *(Bos taurus)* produces 4 kg of manure per day, to find the amount of the 12 cows (sample) mathematical operations were carried out, which gave a result of 48 kg/day of manure. The biodigester will be tubular and will consist of 4 main parts: the inlet container, which serves to introduce the mixture of organic matter to the reactor; biol outlet, which is used to discharge waste from the reactor; biogas outlet, which is used to take advantage of the gas accumulated in the Biodigester. Therefore, it is concluded that the implementation of the biodigester is viable, because it performs better than domestic gas due to its high concentration of methane, it is also economical and a tool to promote changes in the management of organic waste, thus promoting a more sustainable development. in the district of Ahuaycha.

***Keywords*:** Cattle manure, Biodigester, Biogas, renewable energy.

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RESUMEN

El objetivo de la investigación fue analizar la viabilidad del Biodigestor de estiércol vacuno *(Bos taurus)* como fuente de energía renovable en el distrito de Ahuaycha. La metodología fue la investigación aplicada, además se usó la observación directa para determinar el contenido de estiércol y el tamaño del biodigestor. Los resultados evidenciaron la cantidad de estiércol que producen las vacas por día, mes y año, 1 vaca *(Bos taurus)* produce al día 4 kg de estiércol, para hallar la cantidad de las 12 vacas (muestra) se realizó operaciones matemáticas, lo que dio un resultado de 48 kg/día de estiércol. El biodigestor será tubular y constará de 4 partes principales: el recipiente de entrada, que sirve para introducir la mezcla de materia orgánica al reactor; salida del biol, que sirve para descargar residuos provenientes del reactor; salida de biogás, que sirve para poder aprovechar el gas acumulado en el Biodigestor. Por lo tanto, se concluye que la implementación del biodigestor es viable, porque rinde mejor que el gas doméstico por su alta concentración de metano, además es económico y una herramienta para impulsar cambios en la gestión de residuos orgánicos, así promover un desarrollo más sostenible en el distrito de Ahuaycha.

***Palabras clave*:** Estiércol vacuno, Biodigestor, Biogás, energía renovable.

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INTRODUCTION

A cow manure *(Bos taurus)* biodigester is an innovative technology that takes advantage of natural resources and organic matter generated by livestock farming to produce renewable energy and organic fertilizers.

In a world increasingly aware of the importance of sustainability and proper waste management, cattle manure biodigesters have become an essential tool to address the environmental and energy challenges associated with agriculture and livestock farming. (Toscano, 2015).

Some gases in the atmosphere are formed by the decomposition of organic matter from animals and plants (Cabrera, 2011).

Biodigesters can reduce animal waste that has a negative impact on the environment by being contributors to global warming, releasing gases such as methane (CH4) and carbon dioxide (CO2) (Rodríguez and Urbina, 2012).

In a global context of growing environmental awareness and search for sustainable solutions for energy production, this feasibility analysis focuses on the evaluation of the implementation of a manure biodigesterbovine,as a source of renewable energy in the district of Ahuaycha, in the year 2023.

This initiative arises in response to the need to address local challenges related to the availability of energy and the adequate management of organic waste, while seeking to promote the sustainable development and improve the quality of life of the district.

The Ahuaycha district, like many other regions around the world, is facing increasing demand for energy, as well as the need to find clean and affordable energy alternatives that reduce dependence on non-renewable sources. Furthermore, proper management of organic waste, such as manurebovine, is essential to minimize environmental impacts and promote sustainable agricultural practices.

In this context, the manure biodigesterbovine,It is presented as a promising solution, since it allows the generation of biogas, a renewable energy source, from organic waste.

This biogas can be used to generate electricity, heat or as a cooking fuel, providing a sustainable energy source and reducing greenhouse gas emissions.

The objective of the research is to analyze the viability of the manure biodigesterbovineas a source of renewable energy in the Ahuaycha district, from different perspectives, including technical, economic, environmental and social.

Likewise, evaluate aspects such as the availability of raw materials, economic costs and benefits, environmental impact and the potential for improvement in the quality of life of the community.

MATERIALS AND METHODS

Place of study

The place of study of this research is in the District of Ahuaycha, province of Tayacaja, department of Huancavelica.

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It is located at an altitude of 3287 meters above sea level, located at the latitude coordinates 12°24'27" and longitude 74° 53' 29".

Figure 1

Work area

Note: Own elaboration from Google Earth, (2023).

Investigation methodology

The research methodology used in this study was applied research, because it focuses on solving specific problems within a defined context. In addition, it seeks knowledge from various specialized areas to implement practical solutions and satisfy specific needs in the social and productive sectors (Vargas, 2009).

Data collection techniques and instruments

Direct observation: It was used to determine the content of cow feces and determine the size of the biodigester according to the amount that is stored.

Data collection: To determine the amount of manure produced from the 12 cows, the following must be done:

- Lock the cows in their stable, and let them remain in that place for 1 day, then after time they proceed to weigh the manure they discarded, the weight of the cows' manure (each one) was approximately 4 kg.
- The amount (4kg) of cow manure is multiplied by 12, since the study will be carried out with 12 cows, resulting in 48kg of manure per day.
- To determine the production of manure in a month, the multiplication 48 kg x 30 days is carried out again, thus producing 1440 kg of manure. Since our study will be carried out for one year, we multiply it by 12 months, giving us a final result of 17,280 kg of manure.
- In this way, the volume of the biodigester will be determined by the daily load of manure deposited by the 12 cows.
- It should be noted that the daily load will be based on the available manure, conditioned by wanting to produce a certain amount of biogas to be used in different elements to produce a certain amount of biol per day, week, month and year.

Consequently, a series of processes will be applied in the field to carry out our research, which are described below:

Identification of the study area

In the district of Ahuaycha there are families who are dedicated to raising cattle, and since they do not have waste management, the use of biodigesters in the area is proposed.

Analysis of the information

The parameters for the design of the biodigester focus on the number of cattle identified to project the approximate amount of excreta generation.

Selection and design of the biodigester

The biodigester used is tubular type because it has handling characteristics for the family. Where, in addition, the materials used in the manufacture of the equipment are easily accessible and economical.

Kind of investigation

This study was of two types, the first was descriptive because it attempts to understand common situations using descriptions of detailed actions, objects and processes. For this reason, the study allowed us to obtain data on the number of cattle necessary for the design of the biodigester, as well as to determine the necessary size and weight. The second was documentary because it is based on a bibliographic review to find precise answers in previous studies, using other texts as the main source of information.

Population and Sample

The population is made up of the population of the Ahuaycha district.

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In this research, the sample size is 1 family made up of 7 members who reside in the district of Ahuaycha.

RESULTS

This work was carried out at the facilities of the Instituto de Investigación Agroindustrial (IITA) of the Universidad Nacional del Santa (UNS). We are grateful to the office of the Vice Rectorate of Research (VRIN) - UNS, for the facilities in sending this manuscript.

In the district of Ahuaycha, there is a producer dedicated to raising cattle, it has a total of 12 cows *(Bos taurus)* that produces 4kg of manure per day, which allows the collection of excreta, based on this background the Table 1 has results of the manure data produced by cows by day, month and year in 2022.

Table 1

Manure produced by cows (Bos taurus) by day, month and year in the Ahuaycha district

Number of cows (Bos taurus)	Amount of manure per day	Amount of manure per month (30 days)	Amount of manure per year (12 months)
1	4kg	120kg	1 440 kg
12	48kg	1440kg	17 280kg

Note: The table shows us the amount of manure produced by 12 cows *(Bos taurus)* per day, month and year in the district of Ahuaycha. Own elaboration, (2023).

The amount of manure that 1 cow produces per day is 4kg, per month considering 30 days it reaches a total of 120kg/month and per year with 1,440 kg, in tons to 1.44 Tn. In this project we will work with 12 cows, that is, they produce 48 kg of manure per day, 1,440 kg (1.44 Tn) per month, and a total of 17,280 kg per year, in tons of 17.28 Tn (Table 1).

Table 2

Amount of methane gas produced per kg of cattle manure

No. of cows	Amount of methane produced per kg of cattle manure		
	1kg	4kg	48kg
1	0.4 m3	1.6 m3	19.2 m3
12	4.8 m3	19.2.m3	230.4 m3

Note: Amount of methane gas produced per kg of cattle manure (Cortés, 2019).

Table 2 shows the amount of methane gas produced by each cow, that is, for 1 kg of cow manure 0.4 m3 of methane is produced, for 4 kg of manure (1 cow) 1.6 m3 of methane is generated and for 12 cows produce 48 kg of manure, which generates 230.4 m3 of methane.

Table 3

Comparison of content and performance of domestic gas with biogas

Gas type	Content	Performance
Gas	0.01 m3	2 weeks
Biogas	230.4 m3	1 month

Note: Comparison of content and performance of domestic gas with biogas. Own elaboration, (2023).

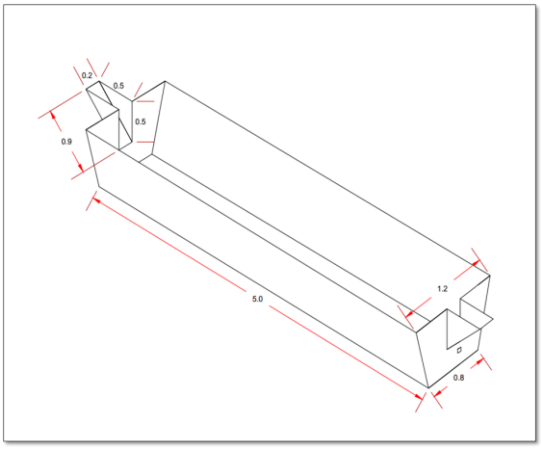
In table 3 it can be seen that the domestic gas content is 0.01 m3 with a performance of 2 weeks, on the contrary, the biogas content is 230.4 m3 with a performance of 1 month. In comparison, it is stated that biogas performs better than domestic gas due to its high concentration of methane, therefore, the viability of the biodigester is attributed for providing us with biogas, and it tends to be very efficient and its construction does not require much budget or time and the benefits it attributes to us offset all the expectations raised.

Biodigester design

The horizontal or tubular design of the biodigester makes it easier for the user to maintain it, and consequently its viability is also economical and simple.

Figure 2

Design of the tubular biodigester pit



Source: CIDELSA, 2014.

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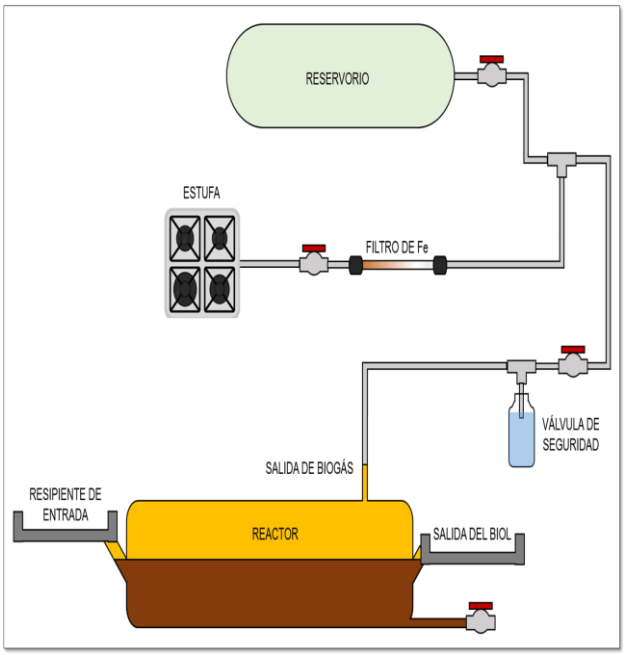
Figure 2 shows the structure of the pit where the reactor will be introduced. It is 5m long and 0.8m deep.

To accelerate the anaerobic activity of cattle manure, it is important that 75% of the reactor body be inside the pit and the remaining 25% outside, that is, if its diameter is 1 m, then 75 cm will be under the pit. ground and 25 cm will be outdoors (TvAgro, 2019).

Figure 3

Tubular biodigester installation system



Source: CIDELSA, 2014.

Figure 3 shows the proper installation of the tubular biodigester model and consists of 4 main parts: the inlet container, which serves to introduce the mixture of organic matter (water+feces) to the reactor; biol outlet, which is used to discharge waste from the reactor; biogas outlet, which is used to take advantage of the gas accumulated in the biodigester.

Materials used for the implementation of a tubular biodigester.

According to Estrella, (2002) in his research work titled "Design of a biodigester for animal excreta in the El Calvario community, Veracruz parish, Pastaza canton, Ecuador", the materials that will be used to make a biodigester will be the following:

a) **Ditch:**It is the place inwhichthe biodigester will be located.

b) **Earth bags:**The trench will have a suitable shape in the ground, as much as necessary.

c) **Old plastics, tarps or bags:**They will function as a protection for the biodigester, in whatever quantity is considered necessary.

d) **Reactor:**A double-sided plastic is used, so that it serves to cover the reactorlocatedin the trench, so that the gas does not escape.

e) **Inlet PVC pipe:**A 6" tube is used, since cow manure is used, a 1.5 m long tube with 90 cm inside the biodigester will be needed.

f) **PVC drain pipe:**A 6" tube is usedbecauseCow manure will be used so that it has greater resistance with the double-sided plastic.

g) **Tire tube:**They will be obtained from the tires of cars or motorcycles that must be cut into strips 5 cm wide, two rim chambers between 14 or 16 are needed.

h) **PVC accessories:**You need a PVC thread, a PVC female and male adapter, so that it can then be glued with the PVC pipes.

i) **Water pipes:**They will use everything necessary for a good installation with 1/2" pipes.

j) **Teflon:**1 Teflon with thread for greater comfort.

k) **Elbow and universal elbow:**Measuring 1/2" or 3/4".

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l) **Kitchen**: A stove that uses gas is required, which preferably has two burners.

Economic costs and benefits

Table 4

Total economic benefits (S/.) derived from the practice of the technology in a 7.2 m3 polyethylene biodigester for a period of 10 years

	YEARS			
	0	1	5	10
Benefits				
Biogas value	148.40	152.58	172.04	199.44
Effluent value	260.25	268.06	301.70	349.75
Functional value	35.15	36.20	40.75	47.24
Total benefits	408.65	420.91	473.74	549.19
Costs				
Facility	150.00	0.00	1.00	201.59
Driving	146.00	150.38	169.25	196.21
Total costs	296.00	150.38	170.25	397.80
Net profits per year	112.65	270.53	303.48	151.39

Note: Table 4 shows the values presented for 10 years corresponding to the benefits and expenses used for the installation of a biodigester (Aguilar & Botero, 2006).

Table 4 shows the benefits and costs for creating a 7.2m3 polyethylene biodigester. Which for its calculation was carried out based on the commercial value that the biogas will have, as well as the effluent that it will contain to replace the inputs (Aguilar & Botero, 2006). With respect to our project, it will serve as a reference, because the materials, as well as the costs, will be less, since a homemade biodigester is used, with materials that are affordable, since it is intended that said project will not be very expensive, that way more residents with livestock can use it in their homes and have natural gas.

Environmental and social perspective

The system reduces greenhouse gases, since the gas emanated by beef feces will be captured in the reactor to later be converted into thermal energy. The population, in that sense, benefits from using this type of energy, because apart from being cheap, it is friendly to the environment. The contamination of air, soil, water and others by livestock manure is a fact that is frequently underestimated; however, manure contributes 50% of the total ammonia emissions into the atmosphere, since its volatilization rate is higher. to 23% (BANR and BEST, 2003, given this reality, biodigester technology has been highlighted to alleviate the environmental problems caused by pig waste, because in addition to being an alternative source of renewable gas, it allows the reuse of pig waste. such that they will be prepared to improve the soil without compromising (Zanin, Bagatini, and Pessatto, 2009).

DISCUSSIONS

According to Toala, (2014) as traditional energy sources developed by humans have become harmful, insufficient, expensive and dangerous, and have caused various types of environmental pollution, new ways to mitigate the deterioration of the environment have been investigated. environment by making better use of natural resources. One of these alternatives is to use anaerobic digestion or biodigestion of organic waste through devices called biodigesters. It is important to mention that, in the livestock sector, manure is used as a raw material to produce biogas and biofertilizers, which helps reduce the accumulation of organic matter in the soil and offers a more sustainable way to obtain energy and fertilizers, without damaging environment.

Salazar & Torres, (2019) in his study mentions that biodigesters are an opportunity and a tool to contribute to a profound change in the management of organic waste (manure), due to these systems not only 'treating' these wastes, but also They help the recycling of nutrients through the use of the fertilizer produced, they also offer energy use through the capture and use of the biogas generated; In comparison with our study, what is sought in this study is to demonstrate the viability of the cattle manure biodigester as a source of renewable energy, from different perspectives, including technical, economic, environmental and social. Likewise, considering aspects such as the availability of raw materials, economic costs and benefits.

Authors like Tay León, (2017) refers to the fact that the production of biogas allows the production of renewable energy and also contributes to mitigating

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climate change, reducing methane emissions from the anaerobic decomposition of manure and reducing the use of synthetic nitrogen fertilizers. In relation to this investigative work, we can say that we also seek to design a technology that offers a comprehensive solution for the generation of renewable energy, the management of organic waste and the improvement of the quality of life of the community, in this way reduce environmental pollution.

Durazno, (2018) carried out a comparison study where he reported that pig manure has a 6% higher biodigestion percentage compared to cow manure at an average temperature of 14.4 °C. Regarding the study, the type of livestock that the majority of the population of Tayacaja or the study place itself has must be taken into consideration. In that sense, it is considered convenient to carry out the biodigester with bovine manure; furthermore, the difference in biodigestion does not vary by a large percentage.

Regarding the efficiency of biogas and liquefied petroleum gas (LPG or domestic gas), Jiménez, (2016) mentions that LPG has a lower combustion rate than biogas in a traditional burner, so its efficiency was 69 % in energy value. Similarly, Barrena et al., (2019), installed a biogas and biofertilizer production system consisting of a tubular or horizontal PVC geomembrane biodigester that was fed with water in a ratio of 1:5; at an average ambient temperature of 14.4 °C. The biodigester produced was 1.27 meters in diameter and 6.70 meters long, which generated a working volume of 6.37 cubic meters. These dimensions of the biodigester allowed a peasant family to prepare their food and be illuminated for around 5 continuous hours. In this sense, biogas presents a high effectiveness in relation to costs and benefits, traditional domestic gas in Peru of 10 kg ranges in price approximately 40 soles, which is a considerable amount for low-income livestock families in the region. province of Tayacaja.

The degree of danger of gas cylinders is another determining factor to establish optimal viability between the production of biogas and the use of traditional gas. In relation to this, in just 6 months of 2020, four 4,906 gas leak events were recorded in the cities of Lima and the constitutional province of Callao (ASPEC, 2020). The biodigesters, for their part, ensure effective safety against possible explosion risks, thanks to the relief valve that works in the event of a pressure overload in the biodigester (ECLAC, 2019).

Cortéz, (2019) mentions that the production of biogas as a source of energy will be very viable, mainly the horizontal model, due to the ease of its construction, since they are made of plastic covers, where the gas that will be formed will be located in the elevated part of the balloon, with the pressure that will depend on the space. Furthermore, Moreira (2014) states that obtaining biogas will depend on the compatibility of the manure with water, where the biodigester must be constantly monitored. The biodigester that Moreira applied had a Horizontal model, because it is characterized by containing the elongated digestion chamber and it helps that the load cannot mix with the effluent.

The current scenario of the ecosystem is destined for total collapse, unless man completely changes his worldview through sustainable business practice, causing a change of values and orientation in his operating systems, compromising the idea of sustainable development and preservation of the environment. atmosphere (Zanin, Bagatini and Pessatto, 2009). Therefore, it is necessary to promote alternative energy such as the biodigester. The subversive effects of manure, as previously mentioned, are greatly underestimated; however, it is a main emitting agent of greenhouse gases. Given this, it can be stated that cattle manure is not only viable for the operation of the biodigester, but also for reducing greenhouse gases and global warming.

CONCLUSIONS

The feasibility analysis of the cattle manure *(Bos taurus)* biodigester as a renewable energy source for the Ahuaycha district, in the year 2023, reveals the promise and potential of this technology to address a series of local challenges and promote further development. sustainable and equitable in the community. This technology offers a comprehensive solution for the creation of renewable energy, the management of organic waste and the improvement of the quality of life of the community. However, the importance of a collaborative approach involving the community, local authorities and other stakeholders is highlighted to ensure the success, as well as the long-term sustainability of this project.

The implementation of the cattle manure biodigester is viable, since when the comparison of content and

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performance of domestic gas with biogas was carried out, it resulted that domestic gas is 0.01 m3 with a performance of 2 weeks, on the contrary, The biogas content is 230.4 m3 with a yield of 1 month. In comparison, it was stated that biogas performs better than domestic gas due to its high concentration of methane, therefore, the viability of the biodigester is attributed for providing us with biogas. Likewise, it is important to mention that it has a low cost and is a viable option for obtaining thermal energy for cooking food for families with limited resources in rural areas. Furthermore, biodigesters are an advantage as a tool to promote profound changes in the management of organic waste, because the systems not only process said waste, but also help recover nutrients through the fertilizer produced, and provide energy through its capture and exploitation.

Adding to the above, the biodigester is a less expensive way to produce gas, which will help the population, especially those who have livestock, to be able to implement it, since the materials used are not so expensive, in the same way supporting the care of the environment. On the other hand, the expected costs for 10 years of the polyethylene biodigester will initially be an investment for the implementation of the biodigester, but it will bring benefits over the years, in turn helping to combat pollution.

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