Project and assembly of a biodigester bench

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ABSTRACT

Fuels are known for being significant emitters of pollutants, releasing toxic gases such as SOx and NOx during combustion. As a result, the demand for renewable energy sources is growing. This work aims to design two different types of biodigesters - batch and continuous - for biogas generation as a more sustainable alternative. Furthermore, initial planning, projection, and construction of the purified gas generation system were carried out. As a result, it was possible to build a generation and purification system. Therefore, with this system, it will be possible to generate the gas, which will be purified in its final stage.

Keywords: Renewable energy. Sustainability. Environmental solutions.

1 INTRODUCTION

With the depletion and detrimental environmental effects of non-renewable sources like natural gas (NG), liquefied petroleum gas (LPG), coal, gasoline, and diesel, sustainable energy solutions are becoming increasingly urgent. Fossil fuels, the primary culprits behind greenhouse gas (GHG) emissions and pollution, release significant amounts of CO2 and toxic gases like SOx and NOx upon combustion.

The increase in energy demand is directly linked to the rise in these emissions. Therefore, development focuses on sources such as solar, wind, and hydroelectric to reduce emissions and mitigate climate change (Chen et al., 2020; Pata, 2021).

Biogas shines as a beacon of hope among the myriad of alternative energy options. Derived from the anaerobic decomposition of organic waste in effluents, household, industrial, and agricultural waste, it is emerging as a potent and promising renewable source.

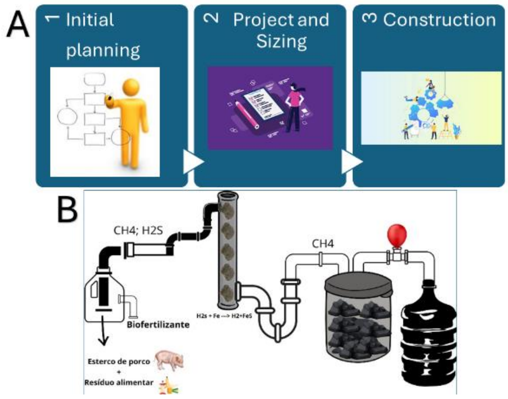
In 2021, global energy generation capacity soared to 21,574 MW, marking a staggering 188.4% increase from 2011, per Irena's (2021) data. Exploring the energy potential of livestock waste, particularly pig and poultry manure, charts a promising path for generating renewable and cost-effective energy. The implementation of anaerobic digesters not only yields biogas but also a high-value biofertilizer for agricultural crops. This system offers significant environmental benefits, notably by curbing the adverse effects of traditional waste management. It's a step towards sustainability and diversity (Hijazi et al., 2016; Sobhi et al., 2019; Gurmessa et al., 2020).

Thus, the aim of this work is to design and assemble a bench of two distinct types of digesters: the batch digester and the continuous flow digester. This experiment will evaluate the efficiency of these systems in biogas production and organic waste degradation, as well as the practical application of these technologies in organic waste treatment contexts and sustainable energy generation.

2 MATERIAL & METHODS

2. 1. Methodology flowchart

Figure 1 – Flowchart



Source: author, 2024.

In the first stage, the purpose of the biodigesters will be defined, whether for educational purposes, research or to test a project. We will establish the budgets and the scale used, which in this case will be on a laboratory scale, and we will identify the resources, materials and equipment necessary for implementation. In the second stage, the biodigester project began, taking into account the assembly of the biogas collection system. Furthermore, the parameters to be analyzed included pressure and temperature. In the last step, the structure will be assembled. Installation of components, such as digestion tanks, biogas collection system, temperature control system, among others, as shown in Figure 1 (A) and (B).

3 RESULTS & DISCUSSION

3.1. Initial Planning

At this stage, the objective of the biodigesters was defined, which will be to test a project of continuous and batch biodigesters on a laboratory scale. The materials used and budgets for assembling the system are shown in Table 1.

Table 1 - Materials used to assemble the system

Material	Quantity (unit)	Usage	Price (R$)
Plastic gallon (5L)	3	Batch and continuous digesters	0,00
PVC pipe (40 mm)	1/2m	Continuous digesters	0,00
Equipo (equipment)	4	Batch and continuous digesters	10,00
Plastic containers	2	Batch and continuous digesters	0,00
Hose	4	Biogas flow from the digester to the filter and gasometer	5,00
Thread sealant	1	Batch and continuous digesters	2,00
Steel wool	1 pack	H_2S removal filter	1,90
Aluminum foil	2 packs	Greenhouse	6,90
Durepox (epoxy adhesive)	2	Batch and continuos digesters	16,00
Charcoal	1 pack	Purification filter	0,00
Bench	1	Support for the biogas system	0,00
		Total cost	41,80

Source: author, 2024.

In implementing the biodigester system, various materials were employed to optimize the system's performance, including equipment, PVC pipes, steel wool, epoxy adhesive, plastic containers, hoses, and 5-liter plastic gallons. The equipment played a role in connectivity and efficient integration between the components. PVC pipes were used as structural elements, providing a solid and resistant base for the system. Steel wool was strategically incorporated to provide biological support, allowing the attachment of microorganisms responsible for the anaerobic decomposition of organic waste, thus facilitating purification. The epoxy adhesive was used as a sealing agent to ensure the system's hermeticity and prevent unwanted leaks. Plastic containers were chosen as temporary reservoirs to store biogas before its use or disposal, providing temporary storage and used to store the organic waste that feeds the system. These containers play an organizational role, facilitating control of the material's input flow and contributing to the overall efficiency of the process. The hose was integrated into the system to conduct the biogas generated during digestion. The 5-liter plastic gallons were used to store the organic waste that feeds the system.

3.2. Project and Sizing and construction

The Biodigester System was constructed using a 5-liter plastic gallon to test the effectiveness of biogas production from organic waste on a pilot scale. The adequately prepared gallon has an opening at the top for the entry of waste connected to a PVC pipe. At the bottom, a second PVC pipe serves as an outlet for biogas, including a valve to control the flow, as shown in Figures 2 (A) and 2 (B).

Figure 2 - Biodigester System

Source: author, 2024.

The process begins with the insertion of waste into the 5-liter gallon. Subsequently, the waste flows through a hose towards a PVC pipe containing steel wool, as shown in Figure 2. Steel wool is a medium to retain microorganisms at this stage, initiating the biogas purification process. After the interaction, the resulting mixture is directed to a filter containing activated charcoal, where impurities are removed, and the gas generated during biodigestion is purified. The charcoal acts as an adsorbent agent, retaining unwanted compounds and contributing to obtaining cleaner biogas. Next, the purified gas is directed to an outlet for testing. This outlet is connected to a balloon, a visual indicator to check for effective biogas production, as shown in Figure 1(B). The gas in the balloon indicates the success of the biodigestion process. Additionally, another outlet is designed to conduct the resulting biogas to a separate container, where the gas is cleaner and can be stored for later use.

4 CONCLUSION

Therefore, it is concluded that the implementation of the biodigester project brings with it a series of benefits, both from an environmental and economic point of view. By optimizing the anaerobic decomposition of organic waste, the system generates purified biogas through the installed filters. As a next step, we intend to carry out experiments with the system in use.

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