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Elaboration of Bovine Manure Biodigester for Biogas Transformation to Electric Power

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Abstract

This research concerns the design of a biodigester to obtain biogas from organic cattle, which seeks to reduce waste contamination. By describing the descriptive-experimental method and bibliographic collection of previous studies, information was collected where the manure sample of 6 cows for 5 consecutive days obtaining an average of 7.5 Kg per day, Also, two practical biodigesters were built in this study using two 20L drums, pipes and valves, the first called biodigester experimental, which was monitored during the time of stay of the substrate in which temperature data was collected, specimen and flame tests were performed during the biogas generation process. Tubular biodigester design formulas vacuum were applied to project experimental results to a total of 15 cattle heads and thus obtain overall results by which the experimental biodigester was chosen. It was concluded that the production of methane gas is 2.83 m3 per day, which would provide 45% of the total value needed by the Breeding ground to cover activities in which it uses liquefied petroleum gas (LPG). It is recommended to implement the bio digestor since it minimizes the negative impacts caused by organic waste from livestock, these being the ones that will serve as the raw material used to generate products such as biogas and biol, also, studies must be carried out so that this system is implemented according to the climatic zones of the country.

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1 Introduction

The growing demand for energy worldwide based on fossil fuels has caused severe damage to the environment, the use of cattle and pig excreta for biogas generation and electricity collection is a renewable energy option that turns out to be highly attractive in terms of savings that can be obtained on the Federal Electricity Commission's bill for production units (Pérez-Pacheco *et al*., 2014; Venegas *et al*., 2017).

The high financial and environmental cost associated with the use of for oil fuels, together with the propias limitations of the Colombian electricity interconnection network, they have gradually encouraged the use of alternative energies in different productive sectors of the country, especially in the rural sector, where both the unmet need for energy supply and the potential for energy generation from renewable sources (UPME, 2007) meet (Ministry of Mines and Energy, 2006). It can also be contributed by harnessing this type of energy to partially solve the problems of hunger and poverty and to improve health, as mentioned in Doelle (2001). In Colombia, the increase in the use of renewable energy sources has been 1.5% for the last six years (Ministry of Mines and Energy, 2006). This potential for energy generation is represented in a high percentage by biomass, and specifically by forest and agricultural waste (IIT 1983, Ministry of Mines and Energy, 2006). The production of biogas from this raw material is a practice that has in the country for about thirty years. It begins with the massive installation of digesters to process organic animal and plant waste to produce the energy necessary to meet the basic needs of the rural sector such as food cooking and lighting (Fundación Pesenca, 1992; IIT, 1983).

This first stage was not very successful due in part to the need for biogas equipment to require manual feeding of the raw material and its proper operation depending on atmospheric conditions. The biodigesters used at this stage are known as Hind type digesters, and consist of a buried container, constructed of masonry, which on top has a metal mobile hood that allows storing the biogas produced (GTZ; IIT, 1983; Sasse, 1986; Ong *et al*., 2000; Fantozzi & Buratti, 2009). Subsequently, there is a period where the installation of biodigesters slows down and is investigated with new substrates (rice and coffee residues, mainly). Towards the end of the eighties began the implementation of plastic biodigesters, manufactured from a flexible PVC tube, which is economical and easy to install and maintain (An *et al*., 1997; Rutamu, 1999).

This type of digester was born from the initiative of countries such as Colombia, Ethiopia, Tanzania, and Vietnam to promote a low-cost biodigester that uses locally produced materials, and that has a quick and simple installation (Preston & Rodriguez, 2002; Rodriguez & Preston, 19). The development of this initiative has been installed in the country digesters of this type with satisfactory results, which can process different types of organic waste and are located on small farms. Methane has a PCG 25 times greater than CO_2. Methane from the soil of livestock systems can be generated by anaerobic fermentation of organic matter, deposition of manure in pastures, anaerobic treatments of animal waste and biomass burning (Silva *et al*., 2013; Lübken *et al*., 2007; Comino *et al*., 2009). According to FAO, the livestock sector would be responsible for 9% of global CO2 emissions, 35-40% of CH_4, and 65% of N_2O (Steinfeld *et al*., 2006).

Small biodigesters from 6 to 10 installed. If it's hot in the place, the TRH will be lower, but if it's cold, the TRH will be higher. They found that the equation: TRH -44,705 ln(T) + 160,394 models TRH in days for the production of biogas based on ambient temperature (T:2m3 working volume, were promoted C), with an adjustment R-0.924. (Barrena, 2019). In the 1970s and 1980s in Asia and Latin America, to improve sanitary conditions and provide power to single-family homes, running on the manure of few animals (two to five pigs, five to ten cows, 100 chickens, or a combination of these) along with organic housing garbage. These biodigesters help reduce GHG emissions by 23 to 53% compared to homes that do not have biodigesters to produce biogas (Hristov *et al*., 2013; Harikishan & Sung, 2003; Chachkhiani *et al*., 2004). The project presented is focused on the design of a biodigester whose objective is to take advantage of cattle droppings, to obtain biogas, it must be borne in mind that these technologies are not an expense, but an investment that will bring in the medium and long term great economic and environmental benefits, since this is an energy alternative with low cost of implementation.

2 Materials and Methods

Materials used: 20L capacity plastic jerry can, ½ inch PVC pipe, 1 ¼ inch PVC pipe, ½ inch elbow, ½ inch union, ½ inch ball wrench, thermometer, jar, Teflon, glue for PVC joints. For the installation of the pipe, first, the end of the PVC pipe of 1 1/4 inches is placed to the biomass inlet of the experimental biodigester, the Teflon necessary for the

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joint to be firm is placed, at the other end is continued with 10 or 15 cm of pipe. Then with the help of the *tarraja* the top section of the pipe is taken and threaded, to place the reduction from 1 1/4 to 1/2 inches since with this pipe it will be more manageable to work and make the rest of connections. A 1/2-inch elbow is attached so that at the end of the pipe the ball wrench is placed through which the biogas can exit in a controlled manner and perform the measurements. We proceed to check all the joints to ensure that they are tight, then sealant was placed and allowed to dry, all in order to avoid any leakage.

Once the connections are completed, a hole was made at the top of the biodigestor, in which the thermometer was inserted, Teflon and sealant is placed to hold firm. This is the instrument with which temperature measurements were performed. Once the construction of the biodigestor was finished he moved it to the selected place where it remained at room temperature as no additional adaptations were made and only several aspects such as the one that should not be under trees are taken into account, since with wind and other factors the branches could cause some kind of damage. The biodigestor must be installed at an intermediate point between the kitchen and the stable as this is the place where the fresh manure is worked with and thus it is easier to pick it up every morning.

The recommended distance between the biodigestor and the kitchen should not be greater than 25 m, for the costs of the pipes used for the conduction of biogas and so that the pressure does not decrease. The chosen site should not interrupt the path of animals or people. It must be located in a sunny area to take advantage of the solar radiation that will help heat the biodigester and the surrounding terrain, in Figure 1, the channel for manure collection is shown.

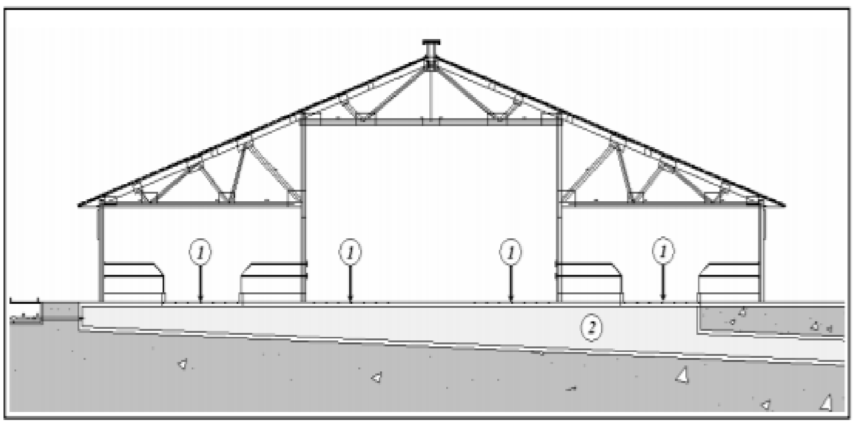

Figure 1. Manure collection channel

It is observed that it is located between two stables, its function is to collect the manure that has been transported through the concrete channel thanks to a jet of water under pressure (brought from a river employing a pump and filtered to remove impurities), which supplies an exact amount of water to that required by the digester (1,500 gallons/day approximately (Duke *et al.*, 2006; NRCSS, 1999).

3 Results and Discussion

Equation (1) was used to calculate the daily load. Daily Load: the amount of substrate or daily charge (Cd) that enters the biodigester is determined by the relationship between the substrate (S) and water (H_2O), for the design the ratio is 1: 1, that is, equal parts. For which the Equation is used. Daily Charge: the amount of substrate or daily load (Cd) that enters the bio digestor is determined by the relationship between the substrate (S) and water (H_2O), for the design the ratio is 1:1 or be, equal parts. For which the Equation is used:

$$Cd = S\,(kg) + H2O\,(kg) \qquad (1)$$

Where:
Cd→ Carga daily
S→Substrate
H_2Or→Water

Liquid Volume: the liquid volume is calculated with equation (2). The retention time (Tr) is considered to define the volume of the biodigester, in this case, 49 days the time in which the greatest amount of biogas was increased. For the calculation of the Liquid Volume (Vl: Equation is used:

$$Vl = Cd\,.Tr \qquad (2)$$

Gaseous Volume: the biodigester in its total volume (Vt) stores 75% liquid part and 25% gas phase. Calculation of the Gaseous Volume (Vg) with Equation (3).

$$V_g = \frac{0{,}25}{0{,}75} \cdot V_l \qquad (3)$$

Total Volume: For the calculation of Total Volume (Vtd) it is done using equation (4).

$$V_{ts} = V_{L*} + V_G \qquad (4)$$

Finally, you get the biodigester shown in Figure 2.

Figure 2. Experimental Biodigester

This experiment allowed us to obtain biogas that can be used to take advantage of the residual and convert it into different forms of energy, either heat or electric energy that can be used for isolated homes that today have no energy service and that have cattle rearing.

4 Conclusions

The design of the biodigester was feasible in the study carried out thanks to the availability of organic matter, from which biogas was obtained under the climatic conditions of the area, Also, the average of the experimental method was managed to check the homogeneity of biogas generation in the two biodigesters in different installed areas, so it is concluded that the temperature in the two areas did not significantly influence the generation; obtaining an average production of 3,080 L and 3,010L.

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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