Use of organic waste biomass for the design of an electric station

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Abstract. The Colombian countryside is moving forward, among some obstacles is the little use of self-propelled assets in farm activities, the current ones, due to their technical characteristics, don’t adapt to Colombian’s geography, therefore, it’s important to develop technologies that aim to eco-efficiency, taking advantage of Colombia’s great biomass potential. In this way, it’s proposed as an initial part of a macro-project that is developed by the Servicio Nacional de Aprendizaje (SENA) that seeks the incorporation of electric utility vehicles and their charging stations in the sowing and harvesting of cocoa. In this work, a physical-chemical characterization of two types of organic substrates (pigs and chickens manure) is done to obtain the methane energy potential for the design of an electrical station. As a relevant result, the sample obtained from the 1 to 3 proportion of pig manure highlight since it achieves a better production of methane in a retention time of approximately 30 days, achieving a daily load of the batteries in an estimated time of 6 hours, it contributes to the management of slow charge cycles according to its control algorithm and to a complete equalization of the 1.980 cells that make up the 6 modules of batteries.

1. Introduction
Interest in the environment, scarcity of resources, energy saving, and protection of the environment is increasingly a concern worldwide. It is considered that automotive transport is responsible for 40% of carbon dioxide emissions and 70% of other greenhouse gases [1]. Electric vehicles have emerged as a new type of alternative fuel vehicles, compared to conventional internal combustion engine cars, electric vehicles have some notable advantages such as their efficiency in energy consumption and their low impact on the environment, also contribute significantly to the reduction of air pollution and greenhouse emissions [2]. 66% of the Colombian territory has an interconnected system, the remaining 34% is considered a non-interconnected area. The main difficulty faced by non-interconnected areas is when the electric power service is not permanent or even nil. In the areas where the energy service is provided, it is only offered for a few hours per day. In this sense, the Government’s concern has been to generate energy solutions for these areas, which allow the best possible provision of the service in terms of inputs, duration and rates, but which are also viable financially and sustainable in the long term [3].
The realization of the loading station was born from a Technological Supervision realized in the “Tecnoparque Nodo Bucaramanga” strategy of the SENA Regional Santander towards the year 2014 in which the economic sectors of the department are studied and emphasis is placed on the agricultural sector since according to the government plan “Santander Enserio” the technification of the field is of vital importance because it manages to move from an artisanal agriculture to a precision agriculture, saving costs in inputs and making the field more productive [4].

According to the previous proposal, since in the “Department of Santander”, 18.000 tons of cocoa fruit are produced annually (which generates 25.000 jobs for low-income families in rural areas). It is proposed from the SENA to design and implementation of an electric utility vehicle as a solution to the collection and planting of the cocoa seed plantations in hillside crops of the “Aguas Calientes” in the “Playón” town in the “Department of Santander”. In relation to the above and the lack of electricity networks as a rural area and its difficult access plantation lands, it is planned to make a possible solution for the design of an electrical charging station based on biomass, the product of organic waste.

To solve the charging of electric vehicles it is necessary to look for energy alternatives in these areas, for this, the work area is described, the selection of environmental and animal variables in order to perform a physical and chemical characterization of the substrates to be studied. On the other hand, the results obtained in the laboratory are presented and the station is designed according to the load needs of the electric vehicle batteries and the selected biogas generator. Finally, the charging station is designed with its respective instrumentation.

2. Materials and methods

The results are obtained from the laboratory and the methods used for the physical-chemical characterization are described in Table 1.

| Variable                        | Method                          |
|---------------------------------|---------------------------------|
| pH                              | pH meter metrohm 691            |
| Volatile fatty acids            | Analysis by degree              |
| Total acids                     | Analysis by degree              |
| Biochemical potential of methane| Anaerobic biodegradability      |
| Organic chemical demand         | Calorimetric method             |
| Volatile solids                 | Standard method                 |

For the use of the raw material product of the excreta of pigs and chickens, it is necessary to carry out the physical and chemical characterization of both substrates in order to determine the stability of the process through pH and total alkalinity (AT), the conversion of matter organic in terms of chemical oxygen demand (COD) and volatile solids (SV), the concentration of volatile fatty acids (VFA) and the production of biogas through the biochemical potential of methane (PBM).

The physical-chemical characterization is carried out in the Integrated Laboratory Center of the Chemical Physics Faculty of the Industrial University of Santander, following the methodologies proposed by [5-7].

3. Analysis and discussion

According to the availability of animals such as pigs and chickens also the use of waste as raw material for these animals as a substrate for the biodigester, carries out the physical-chemical analysis of each one to determine its behavior and the possible PBM.

With the results obtained in the laboratory, it can be determined that the regulation of the process is due to factors such as pH and alkalinity. The pH is responsible for determining the production of biogas in anaerobic digestion and its optimum range is 6.5 to 8 [8, 9]. The value obtained for the case of the pig substrate is 8.18 and for the case of the hen substrate is 7.79. In addition, it is important to
evaluate the volatile fatty acids with the total acids (AGV/AT) ratio which should be in a range between 0.2 and 0.6 [10] in order to avoid the acidification of the biodigester. The substrate of pigs is between the established range with a value of 0.45 which maintains the pH whereas the substrate of hens presents a higher relation with a value of 0.87, which can produce a decrease in the pH, and decrease the production of acid and likewise, stop the methanogen activity.

The methane production analysis is performed for 1 to 3 and 1 to 5 ratios in hen substrate and 1 to 3 in pig’s substrate. Figure 1 shows the daily behavior of the process and it can be established that the best relationship for the case of hens in a time not longer than 30 days is 1 to 5 where after having a fall after 20 days a stability can be achieved. In the case of pigs, maximum production is achieved after 15 days and the process continues to be maintained, these similar values were reported by [11].

![Figure 1. Daily behavior of methane generation for each sample.](image1)

On the other hand, in Figure 2 it can be seen that the best methane production slope is made by the pig substrate (EP2) and it can also be confirmed that with the 1 to 5 mixture of the hen substrate it has a better behavior.

![Figure 2. Methane production for each sample.](image2)

The analysis of PBM is done by the anaerobic biodegradability method, for a 1 to 3 mixture of pig manure and a 1 to 5 mixture of chicken manure. In our experiment, the values of volatile solids were observed after one month and their minimum values were estimated: 0.101 m³kg⁻¹SV manure from pigs and 0.057 m³kg⁻¹SV manure from chicken.
To obtain volatile solids, it is carried out using the standard method. The values for each type of substrate are: 250.24 gsv kg⁻¹ sample pig’s manure and 461.3 gsv kg⁻¹ sample chicken manure.

With the above values a daily manure production is determined, where for the case of pigs it is of 346.59 kgmanure day⁻¹ and for the hens of 333.15 kgmanure day⁻¹ it is important to maintain that the minimum consumption of the generator is 1.46 m³ biogas purified h⁻¹ and according to the manufacturer your daily work should be about 6 hours [12]. To determine the hydraulic retention time (HRT) the average temperature of the beach is estimated which is 25 °C and for each characteristic region due to its temperature a HRT value of 25 days is contemplated.

The mixture of water and manure corresponding to each substrate is: 1 to 3 for porcine manure and 1 to 5 for chicken manure. With this proportion for each substrate the calculations of daily load, liquid volume of the digester, volume of biogas and total volume are made, as shown in Table 2.

| Substrate     | Daily manure production | Liquid volume biodigester | Volume of biogas | Total volume |
|---------------|-------------------------|---------------------------|------------------|--------------|
| Pig waste     | 346.59 kg day⁻¹         | 1.39 m³                   | 11.55 m³         | 46.21 m³     |
| Chicken waste | 333.15 kg day⁻¹         | 2.00 m³                   | 16.66 m³         | 66.63 m³     |

With the previous results obtained, the design of the loading station is carried out. Because the biogas generator needs a purified biogas pressure of 6000 Pa at its inlet, it is necessary to incorporate a blower. For large quantities of biogas, a side channel blower is required, which has the function of increasing the pressure of the purified biogas aspirated by generating swirls in the peripheral toroidal channel due to the centrifugal thrust of the rotor.

A card is selected that uses an infrared gas sensor, designed to facilitate the integration of gas detection systems that require high quality, accurate and reliable measurement of carbon monoxide (CO), carbon dioxide (CO₂) and methane (CH₄) concentrations. In addition, it includes temperature measurement and atmospheric pressure correction. It uses an RS232 communication with the TCP/IP communication protocol option.

PLC selection is made according to the analog and digital inputs and outputs required by the system. For the case study, two analog inputs and four digital outputs are needed. The selected PLC is a LOGO12/24RC. Figure 3 describes the general scheme of the control and instrumentation stage designed for the operation of the charging station.

![Figure 3. Piping and instrumentation diagram of the loading station.](image-url)
4. Summary and conclusions
When studying the results of the physical-chemical characterization, it can be noted that the pH for the case of the hen substrate is optimal. As a solution to improve the AGV/AT ratio, it is considered to use alkalizing bovine manure which, due to its alkalinity, can counteract the volatile fatty acids and control the pH; In addition, it is a biomass waste, it is available at the place of study and it has microorganisms that can help the process without requiring chemicals that could inhibit the process at some point. The analysis is also carried out to determine the input chemical oxygen demand (COD) value, but it is suggested to take COD shots at the output in order to find the removal efficiency of contaminating loads which can determine better retention times and a greater generation of methanogen bacteria in the biodigester. In the analysis of PBM it can be observed that the production of methane for the case of pig manure has its highest production at day 15 of the trial and achieves stability 15 days later. In the same period of time for the case of the 1 to 5 mixture of chicken manure begins to have its methane production and manages to reach its peak production at 19 days and a stability 4 days later. In addition, taking into account the study of methane accumulation the slope of maximum production is experienced by pig manure which has a better performance compared to the chicken dung mixtures studied.

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