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Biodigester Carseiros Production of biogas and Biofertilizer

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***Abstract*— *The present work developed a prototype of biodigester in a conventional way. The construction of the prototype used materials that easily access the population, especially PVC materials and reusable scraps that can be found in any community. Furthermore, the prototype was created in order to facilitate the manipulation of this technology by the community in general. To obtain results, the pH parameters, and electrical conductivity (EC) of the organic matter introduced and the final by-product, the biofertilizer, being compared the results between them. The other survey to quantify biogas production was done using the Chen method (1983) perfected by Mito (2018), which resulted in the production of 0.215 m³CH4/ day, the experiment can be used daily as cooking gas, in addition to a second functionality, such as biofertilizer, such as fertilizer in plantations and nutritional control of the soil.*
***Keywords*— Biodigesters; Biofertilizer; Biogas.**

I. INTRODUCTION

When man began to use mineral coal along with petroleum derivatives (diesel oil, butane gas, gasoline, kerosene), as a form of heating and energy production, demand for natural resources began to intensify in a way uncontrolled, natural resources have boosted large corporations around the world for progress, which has caused severe consequences for the health of the population and the ecological balance of the environment, such as the intensification of the through anthropogenic actions that have occurred due to the burning of combustible fuels.

According to Netto (2010) in the second half of the eighteenth century, the industrial revolution reorganized human activities with new techniques and materials, contributing to the development of industries, the expansion of the railway system and the emergence of new forms of power generation, with hydroelectric and petroleum derivatives, initiating greenhouse gas emissions.

In the 1970s when there was the first oil crisis, which hit several countries including Brazil, made them engage in the search for new forms of power generation, and making them more independent. Brazil began to invest in the exploration of new oil reserves and in the development of renewable sources, such as hydroelectric installations and the use of biofuels, starting Proálcool (National Alcohol Program) in 1975, an initiative that aimed to intensify the production of ethanol (fuel from sugarcane), to insert in the automotive sector, as well as Pro-Oil (Plant oil production plan for energy purposes), in order to meet energy demand.

Rural areas began to use biodigesters for biogas production as an alternative with the support of the Ministries of Agriculture and Energy Mines, reaching out to be installed about 8,000 units, using the Chinese and Indian models, as well as models conventional in smaller dimensions, silk built up to 1,900 units functioning properly Andrade (2002). On the other hand, in Brazil cuts of funds for the propagation of biodigesters, caused a lag in the use of this technology in other regions of the country.

Biodigesters also known as Bioreactors, according to (NETO, 2012; FERREIRA, 2013; LEITE, 2017) are hermetically waterproof equipment within which organic material is deposited to ferment for a certain retention time, where the biochemical process called anaerobic biodigestion occurs, resulting in the formation of biogas biofertilizer. Biodigesters used to obtain biogas can be classified in relation to the process used for the production of the by-product, and the batch and the continuous.

As Coelho (2006) and Moura (2014) showed, biogas is a product derived from the decomposition of organic matter, such as animal waste, plant waste and organic products of residential or industrial origin. Its processing takes place through a biochemical process in the absence of oxygen and in adequate conditions of moisture, pH, Temperature. The biogas according to Metz (2013) is formed by a mixture of various gases and consists mostly of methane gas (CH_4).

In addition to the biogas production, biodigesters became a great solution for the disposal of

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effluents from the agricultural sector, which was previously thrown directly into the tributaries impacting the environment began to be used in plantations. For Andrade (2002), the final liquid by-product of anaerobic digestion, derived from the initial and nutrient-rich organic matter, can be used as biofertilizers for fertilization and nutritional control of the soil, and can replace fertilizers chemicals on the other, promoting not only profitability and savings in maintenance and control, but also adds value to products, agricultural crops, which use organic fertilizers being beneficially economical since it is no longer necessary to use of chemical fertilisers.

Due to technological advances, currently the popularization of this technology provided the diversification of the models of biodigesters used and models can be found for various purposes, such as models made of masonry with a large size of biogas production for power generation and or conventional using PVC materials for biogas production to be used in homes such as cooking gas. in addition to a second functionality, such as biofertilizer, used as fertilizer in plantations and nutritional control of the soil.

Although the use of biodigesters are still limited in some regions of the country, this research is justified in an attempt to encourage and disseminate the use of this technology, especially in the state of Amazonas, through a prototype of biodigester made in a conventional way, using in particular PVC mateiras and scraps that are available in small community and thus be able to produce biofertilizer and biogas. The present study accounted for biogas production in volume according to parameters of the waste used. And for biofertilizer (effluent) a comparative analysis of the input material (tributary) of the values of hydrogenic potential (pH) and electrical conductivity (EC) highlighting the economic and environmental benefits, after the installation of this technology simple and sustainable.

II. METHODOLOGY

The demonstrative biodigester was developed in order to show the feasibility of simplified construction and use of this technology. Additionally, due to its simple form of assembly allows to use it in the community in general and also, serving as multidisciplinary content for schools. The methodology was based on Metz's work (2013), which perfects biogas production to be used as cooking gas, combustion engine drive and other purposes.

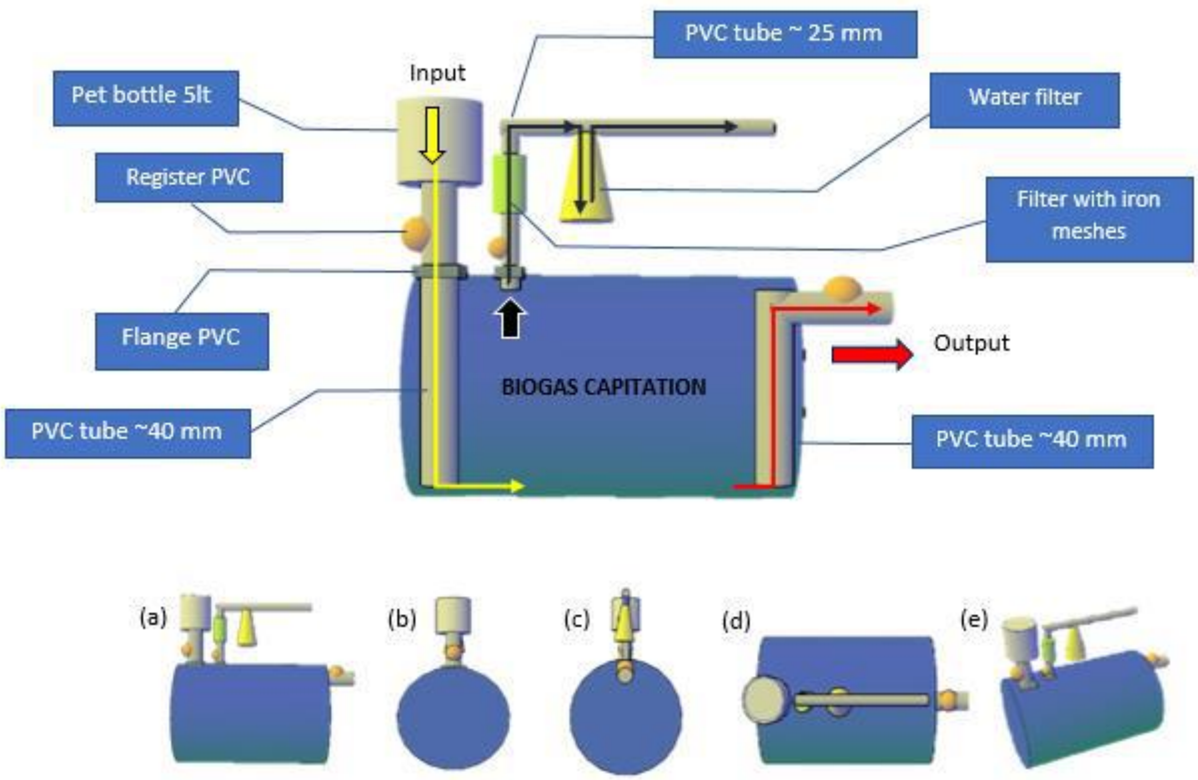

Fig.1: Internal Biodigester scheme: a) Side View; b) Rear View; c) Frontal View; d) Superior View; e) Transverse view

The experiment was developed in a workshop in the municipality of Caapiranga in the interior of the state of Amazonas 153km away from the capital Manaus, whose climate is called Equatorial and average annual temperature of 26°C. During the construction of the biodigester we opted for the use of PVC materials and scraps that can be reused by enabling costs and creating a form of sustainability.

First for the construction of the project, a sketch was made of the way the structure was built, using the Autocad program. The idea was to use the bombona horizontally and thus taking advantage of the side dimensions and holes already existing for the construction of the entrance, captaining the biogas output of the biofertilizer, the figures below show the planning and internal scheme of the project.

After planning, the materials for construction were separated (see Table 1). Most of the materials used were scrapped, making the equipment even more sustainable. The main component of the biodigester is a 200lt pump where they were installed as inlet, outlet and capture structures of biogas (see Table 1).

Table 1: Scrap table used for biodigester construction.

Materials	Measures	Quantity
2lt pet bottle	-----	1
5lt pet bottle	----	1
Transparent hose	----	40 cm
Sturdy plastic plate	----	14 x 14 cm
Wood	----	----
Bombona PVC	200 litros	1
Tubo PVC Soldável	40 mm	1
Tubo PVC Soldável	25 mm	1
Flange PVC	40 mm	1
Flange PVC	25mm	1
Registro PVC soldável	40 mm	2
Registro PVC soldável	25 mm	1
Tê PVC soldável	25 mm	1
Joelho 90º PVC soldável	25 mm	1
Joelho 90º PVC soldável	40 mm	2
Junta Líquida Secativa p/PVC	------	-------
Adesivo Plástico p/PVC	------	--------
Fita veda rosca	------	--------
Cola Durepoxi	------	--------

The entry structure of the biodigester was based on Mattos methodology (2011) and improved for the size of the biodigester, at the installation used the due materials, a flange, a register and tubes, both PVC with a diameter of 40mm and a pet bottle of 5lt, which served as a funnel facilitating the entry of organic matter into the system. For the output structure, a 90° knee, a log and pipes, both PVC with 40mm diameter being coupled into the holes already existing in the bombona.

In the process of eliminating odor and other impurities, biogas goes through the filtration process into two dots, the first by the filter produced with iron meshes and the second by the filter with water, where they are able to segregate the gases present inside the biodigester in a significant way and by captaining methane gas (CH4) interesting for use due to the energy potential.

The iron mesh filter aims to prevent a significant portion of the passage of sulfuric gas, responsible for the bad smell produced during the decomposition of organic matter. For the preparation of the filter were necessary; PVC materials, a weldable tube of 50mm diameter with 45 cm long and two reductions from 50mm to 40mm, filled with iron mesh. The filter with water allows the removal of odor, and the decrease of carbon dioxide mixed with methane, increasing efficiency in the biogas capitation process. For the construction of the second filter, the following materials were used, a 90th PVC weldable of 40mm in diameter, 30cm of 1mm hose, 50g Durepoxi glue.

For the survey of biogas production, two methods were used to estimate production and calculations based on Chen methodology (1983) altered by Mito (2018), allowing a stipulation of production from theoretical basis, The methodology addresses important parameters such as volatile solids (SV) and the maximum production capacity of biogas by waste (B0) and, therefore, has been widely used to estimate the theoretical potential of biogas production, calculated through equation 1, the other method for accompanies biogas production will be done through the use of a monometer coupled in the biodigester by pressing accompany ing the through the preção biogas productivity.

Theoretical estimate of biogas production, Equation 1.

$$PdM = \frac{Bo * SV}{TRH} * \left(1 - \frac{K}{THR * \mu m - 1 + k}\right)$$

Onde: ***PdM –*** ($m^3CH4\ m^{-3}$bio day-1) yield in methane m^3 per m^3 of the biodigester per day; Bo - (m^3 CH4. kgSV-1) methane production capacity by the; ***SV*** - (gSV L-1) concentration of volatile solids; ***TRH*** – (days) hydraulic retention time; ***K –*** (Dimensional) kinetic coefficient; ***µm*** - (day-1) maximum speed of specific growth.

Furthermore, for the calculation of the kinetic coefficient, the equation 2 was used

$$k = 0{,}5 + 0{,}0043 * e^{0{,}051 * SV}$$

Where: k dimensional kinetic coefficient; SV (gSV L-1) concentration of volatile solids. Furthermore, for the

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specific growth rate the following equation was used 3:

$$\mu m = 0{,}013 * T - 0{,}0129$$

For the terms of the equation above we highlight: µm (day-1) maximum specific growth speed; T (°C) temperature. Furthermore, it will be necessary to estimate the amount of methane daily, where the Chen method (1983) that presents daily production through equation 4 was used.

$$PrM = PdM * Vbio$$

Where: **PrM** (m^3CH4 day-1) daily methane production; **PdM** (m^3CH4 m^{-3}bio.day-1) methane yield; **Vbio** (m^3) biodigester volume

Table 2: Chen methodology tables (1983) for qualitative parameters.

Type	SV (gSV L-1)	B0 (m^3CH4 kgSV -1)
Pigs	31,50	0,50
Cattle	64,70	0,20
Confined cattle	------	0,35
Other cattle.	------	0,25

Source: alterada de Mito (2018).

The use of the monometer directly enables the monitoring of biogas production, which results in a better production survey and can be compared the two productivity parameters. The monometer to be used measured the measurements in the following units of pretion, Kg/cm² and LB/in² and can be converted by converting unit into kg/m³.

For the analysis of the levels of degradation of organic matter, the following stops, electrical conductivity (EC) and hydrogen potential (Ph) were verified, through the use of electronic devices capable of generating results related to the observed parameters. The conductivity apparatus capable of indicating electrical conductivity through dissolved solids, allows an analysis of the levels of nutrients dissolved in the tributary/effluent (biofertilizers), while the pHmetro, makes it possible to evaluate acidity levels and compare the results of the effluent/effluent of the biodigester.

Fig.2: Instruments for data collection a) conduitmeter; b) hm-1072 model pHmetro.

Figure 2 shows the conductivity and pHmetro, used respectively to obtain electrical conductivity (EC), measured in µS/cm (micro Siemens per centimeter) Factory pre-calibrated with European Conformity Seal (EC); and the second, an HM-1072 model meter, with European Conformity Seal (EC), used to identify the levels hydrogen potential (pH), evaluates acidity on a scale from zero to 14.

The operation of the biodigester was the following way, a 35kg amount of bovine manure was added within a reservoir of 100lt that occupied about 40lt of the reservoir volume, and which was diluted with 60lt of water, forming an aqueous mixture to be inserted within the biodigester, where I pass a 60-day retention theme to evaluate the results, until the introduction of a new load of organic matter.

III. RESULTS AND DISCUSSIONS

One of the objectives of the construction of the demonstrative biodigester was to verify the feasibility of biogas production for family and small properties. This is due to the practicality, compact design and low cost which would enable its use by producers: what does not require great technical knowledge but requires installation guidance by people specialized in the installation of the system.

With the system already installed, some characteristics inherent to biomass used were observed. For methane production; time, type, temperature, and also biofertilizer; pH and electrical conductivity.

Previous examples as in Metz (2013), show that the lack of procedures interferes with the quality of the gas produced, the exhaled odor and that climate conditions of the environment are directly proportional. As previously mentioned in the experiment conducted by Metz (2013), where there was no filtration of the biogas causing the odor malodor and low inflammation of the gas. And from these observations we sought to improve the system by adding new parameters and procedures, which resulted in the

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success of the burning of the biogas produced. These are the following actions taken in improving:

To build an improved system, the filter construction was carried out in two stages inspired by the Junior method (2018), providing not only the elimination of the evil odor, but also increased the efficiency of biogas burning. On the other hand, the segregation of gases removes impurities that decrease or prevent inflammation of the biogas. Thus, the filtered biogas was stored inside the gasmeter, where it passes through gas pipes and then be manipulated for burning as kitchen gas.

The use of records for inlet and exit control made the biodigester operation easier, as it allowed the removal of the fertilizer in the main manner safely controlling the amount that allows removal.

Fig.3: Adaptations made; a) two-step filter; b) gasometer; c) input; d) output; e) Complete biodigester.

To evaluate the feasibility of using biogas as cooking gas, burning time was quantified through a two-mouth stove adapted in the system. Thus, it was possible to obtain better results, such as: a quantified output a time of 38 min and for the two linked outputs were quantified 20 min. It is worth mentioning that this time is proportionally related to the size of the gasometer, and becomes feasible to use for such purpose.

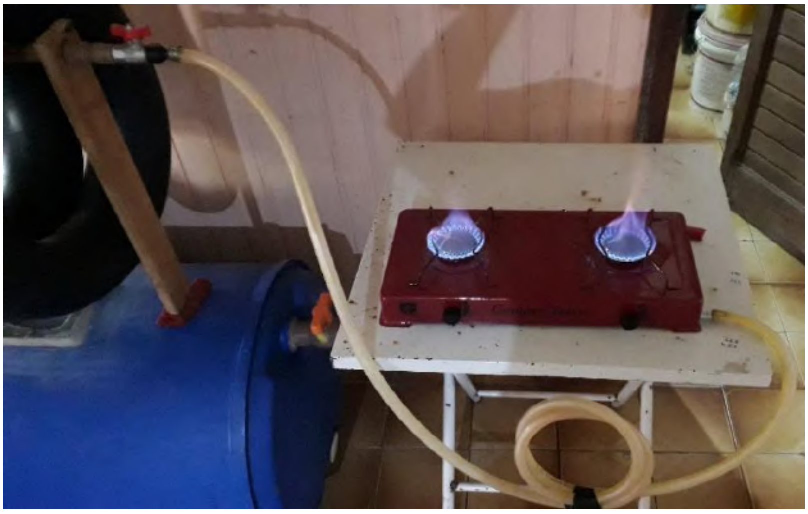

Fig.4: Prototype of the equipment during the process of burning biogas;

The calculation of biogas production generated by the prototype was performed using the Chen (1983) method perfected by Mito (2018), which totaled a volume of 0.215 m³CH4/ day, in a retention time of 60 days in the chamber, using bovine waste as raw material. Unfortunately, in the survey through the monometer it was not possible to obtain results, due to the pressure was not enough for the monometer pointer to mark measurement able values. However, even without measurements by the monometer, the burning itself on the stove and the filling of the gasmeter identifies the pressure formation within the system.

After the 60 days of retention, the analysis of biofertilizer (effluent) by means of a pHmetro shows the significant results for comparison with the added organic material (affluent), and an increase in the pH level can be identified after biodigestion. At the same time, Matos (2017) and Queiroz (2018) showed that the occurrence of acid pH occurs due to the gasification process of organic matter being basically composed of fatty acids, neutralizing the pH of the biodigester load, and thus, the environment is more susceptible to the action of metnogenic bacteria. At the same time, Santos (2016) states that for increased gas volume productivity the ideal range for pH would be between 6.5 and 7.5, while for Metiz (2013), the appropriate pH is in the range between 6 and 8.

Table 4: Values of pH, EC parameters for comparison between tributary and effluent.

Analyzed Material	pH	Electric conductivity
affluent	5,3	523X10 µS/cm
effluent	6,2	375X10 µS/cm

For the use of effluent as biofertilizer the ideal pH, according to the Ministry of Agriculture (2009) : class D effluents, organic fertilizer that, in its production, uses any amount of raw material from the treatment of sanitary dumps, resulting in a safe use product in agriculture, as is the case, must have a minimum pH of 6.0. On the other hand, for resolution CONAMA 375/06, which defines criteria and procedures for sewage sludge generated in effluent treatment plants in agriculture, for the application of the product, the criteria for effluent and soil analyses should be met, where soil-effluent mixture does not exceed the neutral pH limit (7,0).

Electrical conductivity (EC), measured through the pocket digital conductivity, is able to measure ec from the dissolved sais through the ions present in the mixture, made it possible to compare the levels of dissolved nutrients between the tributary and effluent. Matos (2017) in his study points out that EC is related to mineral salt levels from anaerobic biodigestion in biofertilizer, and the decrease in values in his experiment was due to a decrease in the amount of salts dissolved during the process of anaerobic digestion. In the study developed by Junior (2018) the increase in EC levels after digestion indicates what in the degradation process occurred the transformation of the most complex substances into simpler by-products, thus increasing dissolved sais and consequently the increase in EC. On the other hand, if we compare the results of this study to those of Junior (2018) and Queiroz (2018), it is verified that pH and EC are inversely proportional.

IV. FINAL CONSIDERATIONS

With the results analyzed, it was possible to conclude that the application of the experiment is of great viability in environmental issues. Because the use of this provides a control of organic waste, minimizing impacts and increasing environmental safety. Furthermore, the tests and results with the prototype presented previously presents an economic bias, because it uses the by-products of anaerobic digestion such as biogas. The biogas produced in this experiment can be used daily as cooking gas, in addition to a second functionality, such as biofertilizer, such as fertilizer in plantations and nutritional control of the soil.

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