EVALUATION OF THE BIOGAS OBTAINED BY THE ANAEROBIC DIGESTION OF RURAL BIOMASSES IN ECUADOR

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Abstract - An energy transition is needed that leads to switching fossil fuels to other sources by seeking new alternatives and lower cost. Biogas and biomethane can play an important role in a sustainable energy future. Biogas is a viable alternative that can be obtained from the anaerobic digestion of rural biomass with the possibility of installing biodigesters to take advantage of this source of raw material in gas for household consumption, generate electricity, heat and fertilizer on a large scale to be used in national agriculture. This article evaluates the Biogas produced by the anaerobic digestion of rural biomass in a pilot team formed by a train of biodigesters, whose main objective is to carry out the bibliographic review on the characterization of Biogas produced by the anaerobic digestion of rural biomasses in a pilot team formed by a train of biodigesters, and thus, determine the chemical composition and production parameters of Biogas. A methodology was carried out with a sequence order for the selection of the bibliography that was based on methodological quality and compliance with the criteria of scientific quality investigated, was written with coherence and logic for greater reading analysis. The results obtained from the multiple literatures were scientific information, allowed to analyze the results of the investigations, concluding that all the scientific information developed forms the basis to continue with similar experimental processes in our country.

Keywords - Biogas, Anaerobic Digestion, Rural Biomass, Train of Biodigesters, Biogas Production

I. INTRODUCTION

Loads and more frequent thermal shock than According to the International Energy Organization (2011), the energy demand in the world in 2030 will be able to reach approximately 15,300 million tons of oil annually, implying for developing countries a 62% increase. It also forecasts that by 2025, energy consumption in the developing world will almost double.

"Serious consideration must be given to how to change this unequal distribution of global energy consumption to address the dilemma of providing a dignified life for citizens, as well as protecting the climate and ecosystems" [1]. In Ecuador, there is a high energy dependence on electricity and imported fossil fuels affecting the national trade balance because the country does not have sufficient capacity to refine, consequently, it imports large volumes of derivatives [2].

This research highlights the importance of Biogas as a viable alternative to invest in its production through the anaerobic digestion of rural biomass and the possibility of installing biodigesters to take advantage of this source of raw material in gas for household consumption, generate electricity, heat and fertilizer on a large scale to be used in national agriculture. One of the main problems rooted in the increase of the population in our society is the generation of organic and inorganic waste and the lack of technologies for its respective treatment and final disposal. "Biogas and biomethane can play an important role in a sustainable energy future, but for the moment we are missing this opportunity to reduce waste and emissions" [3], wasting their transformation using thermal and biological methods.

There are few biogas production facilities in Ecuador. According to Pazmiño (2016) two (2) can be cited: in Cotachachi, in San Miguel de Los Bancos one (1), and three (3), are under construction, in Archidona in the community of Cotundo one (1), in Francisco de Orellana in the town of Dayuma two (2). In the province of Guayas in: El Empalme dos (2), in Esmeraldas in the Río Verde canton of the Montalvo parish ten (10), distributed in three communities, in Atuntaqui in the sector known as Natabuela there is one (1) installed and six (6), in construction project in Pact within the community El Paraíso there is one (1), inquinche one (1), in the province of Napo in the town of Cuyuja two (2), and in the province of Cotopaxi one (1). [4]

The characterization of biogas is given by the chemical composition of this in proportions that can vary according to the digested biomass and the control of parameters such as temperature and Ph. The composition of the biogas is a gaseous mixture made up mainly of Carbon Dioxide (CO2) and Methane (CH4) that in theory the latter must be in a concentration higher than 45% so that the biogas can be used in a direct way without any type of previous treatment. There are unconventional methods for the characterization of biogas, one of them is the measurement by displacement columns, using the "Mariotte Principle", which consists of the displacement of a liquid by the action of the pressure exerted by the generated gas. In the event that our biogas has a relatively low concentration of Methane in its composition, the "Mariotte Bottle" is used, equipment that uses 32% Sodium Hydroxide (NaOH); when the biogas is put in contact with the

Sodium Hydroxide solution, the Carbon Dioxide (CO2) becomes Carbonates, leaving only the Methane (CH4) in gaseous form, which will displace its own volume in liquid, which can be measured at the end by weight or by means of a graduated cylinder [5][6] . There are also in the market a variety of equipment both fixed and field or portable that read the chemical composition of the biogas generated, they also provide us with process data such as temperature, Ph and pressure, essential for this type of studies.

II. DETAILS EXPERIMENTAL

2.1. Materials and Procedures

In order to meet the proposed objective, a quantitative, exploratory, descriptive, probabilistic sample methodological process was used, based on five stages: definition of the objectives of the bibliographic review, search for information, bibliographic selection criteria, organization of information and the writing of doctoral research, scientific articles, methodologies and procedures applied by different authors. The same that was very useful and timely in addressing the review, identifying theories that were developed with quality evidence that applies to the topic and other theories with moderate or limited empirical support that suggested the use of potentially essential variables that also served for the research problem.

2.2. Biogas

Definition of Biogas, Fao (2013) defines it as a gas produced by bacteria during the biodegradation of organic material under anaerobic conditions. For its production any manure can be used: cow, pig, goat, poultry and even human waste [7]. As a derivative of biomassic anaerobic fermentation, it is colorless, flammable, composed of: 60% methane, 40% carbon dioxide, nitrogen, hydrogen, and hydrogen sulfide; calorific value: 4400 Kcal/m3 [8].

2.3 Advantages of Biogas

•Its obtaining is renewable.•Production determines a lower pollutant carbon balance than fossil fuel.•It meets the requirements of the EPA (Environmental Protection Agency) as biodiesel.•It can be used pure or mixed with hydrocarbons. It does not have sulfur, nor does it generate emanation of this element.•Produces better combustion, reduces smoke.•Its spill into the waters is less polluting and lethal to the ecosystem.• It is biodegradable, degrades faster than petrofuels • During combustion it diffuses fewer harmful elements thus reducing the chances of producing cancer.•It causes less irritation to the epidermis.•It prolongs the expiration of the engines by acting as a lubricant.•Its transport and storage is safer compared to fossil oil because it has a higher ignition point [9][8]

2.4 Biomass

It is any type of organic matter originated in a biological process [10], for example: wood, agricultural waste and animal manure; they can be converted into energy by biochemical or thermochemical processes [4][11][12]. They are classified into: natural, spontaneously produced; forests, thickets, grasslands, among others; residual, obtained from agricultural, livestock, forestry, energy plantations or energy crops such as sugar cane, corn, palm to produce fuels [6].

2.5 Anaerobic digestion

It converts organic matter into methane and other gases, depending on the matter selected, amount added to the system and psychometric conditions of the internal air; it has been experimentally established that using highly biodegradable elements it is possible to obtain 0.5 m3 per Kg of mass, with 70% in CH4 [8].Anaerobic fermentation occurs when bacteria ferment organic material in the absence of air and produce biogas [13][8].You have three phases: the first, hydrolysis, where fermentative or acidogenic bacteria hydrolyze polymers into soluble organic acids; second, acidification, acetogenic bacteria cause a metabolization of organic acids into acetates (CH3COOH), Dihydrogens (H2) and Carbon Dioxide (CO2); and the third, methanization, proteins, carbohydrates and fat, amino acids, alcohols and fatty acids previously formed, generate methane, carbon dioxide and ammonia. It is here that the fermented material becomes more liquid [14].

2.6 Anaerobic process conditions

The following features are required [15][16]•pH: Determines the inhibition or toxicity of methanogenic bacteria, when it is less than 6.0. The appropriate one is between 6.5 and 7.5.•Temperature: There are three anaerobic environments. The following ranges are recommended: 0 – 20 ºC (psychrophilic); 20 – 45 ºC; (mesophilic); and 45 – 97 ºC (thermophilic).•Retention time (Tr): It is the period that organic matter remains within the system to degrade. It is directly related to the ambient temperature and in optimal conditions, at 30 ºC, it is 20 days.•C/N ratio: Must be between 20:1 and 30:1. •Ammonia: Its optimal level is less than 2000 mg/l.

According to international data, the author [17] [18] designed a biodigester to generate energy from cattle manure in a rural house in the CC.PP. Las Canteras del Distrito de Pátapo – Chiclayo – Lambayeque. Its general objective was to design a biogas production system for home use. The sample was the amount of excrement produced by 10 cows. Obtained a daily production = 314.0 kg /day; PH=7.3; dry matter = 6% and potential = 0.55 m3/day. It concludes that with this procedure it managed to reuse the waste and compensate for the energy needs of electricity

reflected in the consumption 1.10 kW-h / day and for cooking of 0.30 m3 / day.

(Reyes, 2016) researched on the production of biogas from Biomass. The purpose was to evaluate their obtaining from the star grass Cynodonplectostachyus K. Schum, according to characteristic parameters of operation by uncontrolled anaerobic digestion and the method of balance by drying in ovens. [19]

According to national data, Mendieta(2020) evaluated the production of biogas from rice husk with different concentrations (10, 30, 50, 75, 100, 150) mg/L of zinc. It was performed on a laboratory scale, using bovine manure as an inoculum that matured for 3 months at 35 ºC. The substrate was subjected to a particle size reduction to values ≤ 150µm, in an adsorption process from ZnCl2 to add Zn+2 to the substrate with different concentrations. The inoculum-substrate ratio was 3:1, incubated at 39 ºC in a water bath for 63 days. The results indicate that the zinc-free rice husk presents the best methanogenic process, obtaining 15.52 L/g SV of biogas. Methanogenesis is affected by concentrations above 70 mg/L. Inhibitions occurred when it had concentrations of 100 and 150 mg/L of zinc at day 58 and 51, respectively. [20]
Guamanquispe and Perdomo, (2018) made a technological proposal on the Implementation of a biodigester to generate biogas from chicken excrement in the Poultry farm Aves del Cotopaxi. To do this, they carried out an information survey on its potential in shed number 5, the same one that is divided into 4 warehouses that house 2000 hens each, of which 1kg was selected, for its respective characterization, obtaining in its composition a 33.66% of total solids and a ratio of C / N of 23: 1, which allowed to establish a quantification of 25 kg of hen daily to supply the flexible biodigester, tubular type, 1.50 m in diameter and 5.50 m in length with a total volume equal to 9.72 m3. [21]

With the data obtained in the gas meter and through the analysis of equations, a daily production volume of 2.65m3 of biogas is obtained, to be adapted to the heating system, in the breeding shed number 4, it should be noted that the biogas produced has a higher calorific value = 7719.57 [kcal/m3], and a lower calorific value = 2623.29 [kcal/m3], at a temperature of 20°C, the analysis was with a gas chromatograph under the ASTMD 1945-03 (2010) standard, in this way a better treatment of the excreta and a good disposition of the biomass in the Poultry farm Aves del Cotopaxi is obtained.

(Pazmiño, 2016) study on Biodigesters, an energy solution for the rural population. Use of biogas in a case study. To do this, he turned to academic and bibliographic sources on the installation and use of biodigesters in the region and other countries that served as support to abstract the experiences with the use of biodigesters to obtain biogas, which is the fuel that is transformed into thermal energy and allows the cooking of food. It was evident that the use of biodigesters in the Peñaherrera Parish allowed the opportunity to diversify the local energy supply. In addition, it should be noted that although its applicability is punctual and oriented to a very small sector, the level of satisfaction and usefulness of biogas contributed to improving the social, environmental and economic situation of the locality. [15][14]

III. RESULTS AND DISCUSSION

Paucar and Quispe, 2015 "Production and evaluation of biogas quality in a biodigester using farm quail manure v.a.Velebit S.ac, in their study characterized the composition of the biogas by a Gas meter by extraction Model Gem 500 (CH4, CO2, H2S, 02), maintaining standard process parameters obtaining acceptable results and agree with statistical analysis CH4 (44.6 – 40%), CO2 (26.6 – 20%). [22]

Gomez, Julius and Rosenfeldt, 2015 with the theme characterization of biogas generated in the treatment of domestic effluents in uasb reactors in Brazil, The quality of biogas is good considering that the percentage of methane did not exceed 50% during experimentation, this could be due to the fact that biodigesters have 17% of total solids, the low biogas generation capacity of the inoculum, the anaerobic fermentation temperature or the presence of oxygen that results in the biodigestion process being slowed down, finally the presence of oxygen must be considered, which is an inhibitor in the elaboration of Biogas.
Condor, 2019 with the production of biogas in batch biodigesters from agricultural residues pre-treated with the bokashi technique, the following results were obtained from the composition of the biogas (64.2 – 55% CH4, 34.2 -30.1% CO2, 3.5 - 2.5% 02) the duration of the trial was 61 days. [16]

Carvajal, Tafur, Villavicencio, Gutiérrez, 2018 with the theme Characterization of the calorific value of the residual biomass of cocoa ccn51 through anaerobic and thermochemical gasification processes of the National Polytechnic Institute, characterized the biogas obtained from the anaerobic digestion of waste from cocoa plantations, working experimentally with the following variables to be taken into account: ph 7; temperature 37°c, particle size between 2-3 mm, atmospheric pressure of 0.740 atm.

According to Ortega (2010) the formation of the mud was a mixture of cocoa biomass, cattle manure and water. [2]The results obtained in the gas chromatograph of the Faculty of Chemical

Engineering of the Central University of Ecuador were the following in the following table:

Chemical composition	Percentage
H_2	0.13%
O_2	11.79%
CO	34.66%
CH_4	20.09%
CO_2	25.82%
H_2S	0.12%
Carbon	3.37%
PCS	17.24 KJ/KG
PCI	16.11 KJ/KG

Table 1 Biogas Results obtained in the gas chromatograph

In this study with the results presented it can be found that the percentage of methane (CH4) obtained in this test is relatively low (20.09%), compared to the 45% that should be taken into account of CH4 so that the biogas is flammable and can be used directly.

In arango's study (2018) with the theme of obtaining biogas through anaerobic digestion of disposable diapers, whose general objective was to determine the quantity and quality of biogas generated from the anaerobic digestion of disposable diapers. Being part of the material of disposable diapers cellulose, it can be estimated that, if there was digestion of these wastes in a biodigester, working in tests of 10l, 1l, 100 ml, they managed to obtain the following results: The cellulose was degraded by 20%, the ph was always maintained between 7 and 8 throughout the process, with reduction of between 30% and 50% of organic material mixture of grass, diaper with plastic and other mixture of grass and diaper without plastic, [23] as detailed in the following tables:

Volume	% CO_2	%CH_4
1L	70.56	18.46
10L	76.5	16.02

Table 2 Analysis mixture of Grass – Diaperwithplastic

Volume	% CO_2	%CH_4
1L	70.24	17.87
10L	76.61	11.70

Table 3 Analysisofgrass mixture – Diaperwithoutplastic
Source:(1)

According to Cóndor (2019), the best results were obtained by mixing manure with cartridge Zantedeschia aethiopica) giving a considerable concentration of Methane (64.2% – 55%), compared to the work carried out by Arango 2018, in which he treated disposable diapers with plastic and without plastic in biodigesters in order to obtain biogas for subsequent energy use, reflecting relatively low methane concentration values for direct use (11.70% – 18.46%).

IV. CONCLUSION

Reviewing the articles and analyzing their contents, it was possible to observe the different methods of biogas characterization, among which the laboratory type ones stand out, which were carried out in gas chromatographs and also by the characterization with portable field equipment that measures or focuses more on the concentrations of Carbon Dioxide (CO_2) and Methane (CH_4).

1. Almost all the authors highlight the mixture of biomasses of different origins (vegetable and / or animal), to optimize the production of Biogas, but do not guarantee a high percentage of Methane (CH_4) in the generation.
2. This work will serve as a guide to give rise to the subsequent implementation of many experiments, which will provide data of vital importance for the respective treatment and energy use of different types of rural waste.
3. We must consider as the "Mariotte Principle" as the main method of measuring methane in biogas product of the anaerobic digestion of rural biomasses. In all cases, the initial cracks were initiated at the edge/corner of the square specimens.

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