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FEASIBILITY STUDY OF ANIMAL WASTE BIOGAS PRODUCTION

Maurício Zanon Antunes
Juan Galvarino Cerda Balcazar
Mariana Vieira Coronas
Cristiano Frandalozo Maidana
Charles Rech

Universidade Federal de Santa Maria – Campus Cachoeira do Sul
Rod. Taufik Germyear, nº 3013, Bairro Passo D'Areia - Cachoeira do Sul – RS
CEP: 96503-205
eng.mauricioantunes@gmail.com
juan.balcazar@ufsm.br
mariana.coronas@ufsm.br
cristiano.maidana@ufsm.br
charles.rech@ufsm.br

Abstract. *Promoting proper management of waste and effluents generated in production processes is one of the main challenges of today's society. Among the various types of waste and effluents generated, organic material compounds, when not properly treated, become a potential source of soil and water body contamination, vector proliferation and diseases that generate bad odors and gas emissions harmful and greenhouse gases. In this sense, methanization, or anaerobic digestion, is a process with wide applicability for the conversion of waste and effluents used in biogas and biofertilizer, associated with the appropriate treatment for renewable energy generation. The implementation of biodigesters for biogas production can be configured as a viable alternative and assist in the production and consumption cycle, promoting a return of waste and effluents used in the production chain, increasing the sustainability of agroindustrial processes. Biodigesters allow the waste to be treated and transformed into biogas and can later be used in energy production systems, the remaining matter can be converted into biofertilizer and used in crops, contributing to the reduction of the use of chemical fertilizers. Thus, the present work aims to evaluate the potential of cattle and swine manure in biogas generation through anaerobic digestion. For this, a survey was conducted, based on a literature review, of the economic and environmental benefits of production, as well as quantifying the production potential of biogas. From this information, the objective of the present study was to design a biogas production system from animal waste biomass through anaerobic digestion. The biodigester model was developed at the UFSM campus in Cachoeira do Sul. These models evaluated biogas production in the different biomass. There was a reduction of 36.32% and 3.98% of total solids in swine and bovine biomass, respectively. This solids reduction is directly related to the biogas productivity generated in the biodigesters. The lower production of biogas from cattle manure may be related to several factors, such as environmental conditions, humidity and biomass constitution. From this, an Indayn model swine manure biodigester was designed for its use in thermal conversion.*

Keywords: *Sustainability, Anaerobic Digester, Animal Waste, Methanization, Solid Waste*.

1. INTRODUCTION

The potential of biofuels as a vehicle for social and environmental inclusion has been incorporated as a goal of public policies in Brazil, taking into account its role in reducing global emissions of greenhouse gases (GHG), in particular, in the transport sector. In this context, in addition to expanding the role of fuel ethyearl, since the launch of flex-fuel or dual-fuel vehicles, biodiesel, bioelectricity, biogas and biomethane have been included in the national energy matrix in recent decades. Environmental concern also motivates research and development of new biofuels and biomaterials, towards a low carbon economy (MINISTÉRIO DE MINAS E ENERGIA, 2017).

According to Konrad et al. (2016) the use of biomass can be done through several technological options to convert energy from biomass. These conversion technologies can release energy directly, in the form of heat or electricity, or convert it to yearther form, such as liquid biofuel or biogas.

An interesting technological route to improve economic efficiency and reduce the environmental impacts of agro-industrial activities, which generates effluents and waste with a high organic rate, is the energetic use of biogas generated from the anaerobic degradation of organic waste. This process can be applied in the treatment of animal waste, being considered a more sustainable production system, due to the reduction in the use of conventional energies and commercial fertilizers, in addition to providing a highly efficient method for recycling resources and closing the production cycle. (ABBASI; TAUSEEF; ABBASI, 2012).

Due to the majority presence of methane (CH_4) in its composition, biogas is characterized as an energy gas, configuring itself as a biofuel with great potential to expand the share of renewable energies in the Brazilian energy matrix. Biogas can be considered a strategic fuel for the country, and it can become an important tool to overcome economic and infrastructure challenges, while reducing environmental liabilities in waste and effluent management. In addition to the benefits arising from the proper treatment of waste and generation of renewable energy, the organic material resulting from the biodigestion process can be used as a soil conditioner and also as a biofertilizer (FUNDAÇÃO ESTADUAL DO MEIO AMBIENTE, 2015).

The biodigesters allow the manure to be treated and transformed into biogas, and later being able to be used in energy production systems, the rest of the material can be converted into biofertilizer and used in crops, thus contributing to the reduction in the use of chemical fertilizers. Additionally, the capture of methane gas generates carbon credits, with a market value among countries with a higher pollution index, in order to offset the excess emission. Waste management based on energy revaluation is one of the strategies of the Brazilian Federal Law 12.305 / 10, which institutes the National Solid Waste Policy (PNRS), proposing the practice of sustainable consumption habits, providing increased recycling, reuse of solid waste and the environmentally appropriate disposal of tailings (MINISTÉRIO DO MEIO AMBIENTE, 2019).

Southern Brazil is a region with a strong presence in the agro-industry. The use of agro-industrial waste to generate thermal and electrical energy can positively impact production costs. Aiming this, the present work seeks to evaluate the potential of bovine and swine manure, via anaerobic digestion, to obtain biogas. Batch feeding reactors will be used to verify the feasibility of using the energy potential of the waste, which may contribute to cost reduction with the treatment of waste and energy demand.

2. STATE OF ART

According to Konrad *et al.* (2016) the use of biomass can be done through several technological options to convert energy from biomass. These conversion technologies can release energy directly, in the form of heat or electricity, or convert it into yearther form, such as liquid biofuel or biogas.

All plants, animals and living beings in the ecological system constitute biomass. In addition, nutrients, waste and bio-waste are considered biomass. Although biomass is rich in carbon, but it is not considered a fuel fossil. The term biomass refers to a vast field of materials, with varied and infinite purposes, which can be used as a fuel or even as a raw material. As shown in Figure 1, biomass can be obtained from non-woody and woody vegetables, as is the case with wood and its residues, also from organic residues, in which we find agricultural, urban and industrial residues. As well as it is also possible to obtain biomass from biofluids, such as vegetable oils, for example, castor and soy. And so, each source of biomass having its optimal energy conversion process (Figure 1).

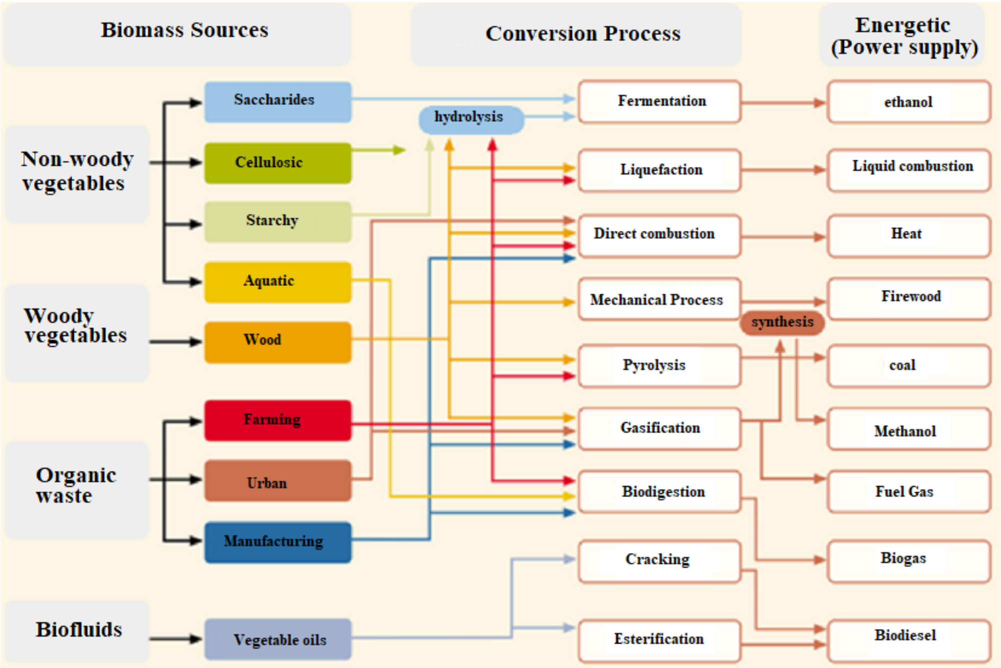

Figure 1 - Schematic diagram of the energy conversion processes of biomass (Aneel, 2005).

Biogas energy from anaerobic degradation in animal waste treatment plants is considered a low-cost option, since it can benefit from carbon credits available through the Clean Development Mechanism. The consequence of these investments was reflected in the growth in production, which is around 4% per year, with the States of Santa Catarina, Paraná and Rio Grande do Sul being the main pig producers in the country. However, although the high productivity of pigs and cattle provides economic and social development, it should be noted that this large number of animals produces highly polluting waste. Among the currently viable alternatives, the anaerobic digestion of these residues stands out as a way to promote recycling and energy generation, in addition to the fact that the nature of biological transformations during the digestion process provides the substrate with potential as a final product. use fertilizer.

2.1 Technologies of biodigestors

According to Oliver et al., (2008), a biodigester or bioreactor can be defined as a closed fermentation chamber where organic material is placed for decomposition, this decomposition occurs anaerobically, that is, without the presence of atmospheric air. In this way the microorganisms present inside the chamber degrade organic matter resulting in the formation of gaseous products (biogas) as the main product and biofertilizer as a secondary product. The anaerobic biodigestion process is dependent on the action of bacteria and occurs in three phases: hydrolysis or reduction of the size of the molecules, production of organic acids and production of methane. Methane is the main component of biogas and has no smell or color, but other gases present have a characteristic strong odor (OLIVER et al., 2008).

According to Karlsson (2014), in continuous process biodigesters, the material is pumped continuously into its interior, which allows the flow of raw material throughout the day and, therefore, constant production of biogas. Through the addition of solid-liquid materials it is possible that the material at the entrance of the biodigester is continuous, making it advantageous for microorganisms, as there will be a uniform distribution of material throughout the day. Facilitating the interaction between different groups of microorganisms in the degradation chain, and also reduces the risk of overload, if they are fed with a large amount of material in a single time. The uniform supply of the substrate allows greater stress among microorganisms (KARLSSON et al., 2014).

In the models of batch or batch process biodigesters, all the material is digested at once, always being the same throughout the degradation process. There is no addition of new material, which results in peak biogas production, producing a higher amount of methane at the beginning of the process, and thus decreasing over time. When the material is digested and subsequently removed from the biodigester, a new amount of substrate is added. This system is advantageous from an organic material. Sometimes in this process it can be difficult to achieve high and constant production of biogas, especially if the material has a high solids content (KARLSSON et al., 2014).

2.2 Production of biogas and biofertilizer

According to Persson et al. (2006), biogas is a combustible gas mixture, produced through anaerobic digestion, that is, by the biodegradation of organic matter through the action of bacteria in the absence of oxygen, composed primarily of methane (CH_4) and carbon dioxide (CO_2) , with small amounts of hydrogen sulphide (H_2S) and ammonia (NH_3), traces of hydrogen (H_2), nitrogen (N_2), carbon monoxide (CO), saturated and halogenated carbohydrates and oxygen (O_2) are occasionally present in biogas.

As can be seen in Table 1, the composition and energy content of biogas can vary according to the organic material used and the process by which it was produced. It is a process that can also occur naturally in lakes, rivers, swamps and mangroves, and it is an important part of the carbon biochemical cycle. (PERSSON et al., 2006).

Table 1 - Characteristics and composition of biogas from different sources.

Parameter	**Landfill gas [1]**	**Biogas - anaerobic digestion [2]**
Lower calorific value (MJ/Nm³)	16	23
Methane (% vol.)	35-65	53-70
Carbon dioxide (% vol.)	15-50	30-47
Nitrogen (% vol.)	5-40	-
Sulfuric acid (ppm)	<100	<10000
Ammonia (ppm)	5	<100

1 produced from organic matter and solid waste urbyears in landfills.

2 produced from organic matter and agricultural residues in anaerobic reactors.

source: adaptation by persson et al., (2006, p. 6).

2.3 Anaerobic digestion

The anaerobic digestion process involves the degradation and stabilization of organic matter leading to the formation of methane, inorganic products (carbon dioxide) and biofertilizer (stabilized organic matter). The representation of anaerobic digestion can be described by equation (1), (LUSTOSA; MEDEIROS, 2014).

$$\text{Organic Matter} + H_2 \Rightarrow CH_4 + CO_2 + \text{Biomass} + NH_3 + H_2S + \text{Heat} \quad (1)$$

Anaerobic digestion is a biochemical process of stabilization of organic matter that occurs in four phases, through the action of different types of anaerobic microorganisms (in the absence of oxygen), (REIS, 2012).

a) Hydrolysis: phase in which complex organic matter (carbohydrates, proteins and lipids) are fragmented and converted into dissolved compounds of lower molecular weight by means of exoenzymes, enzymes that are excreted by fermentative bacteria, also called hydrolytic bacteria. Proteins are degraded into (poly) peptides, carbohydrates into soluble sugars (mono- and disaccharides) and lipids, into long-chain fatty acids (C15 to C17) and glycerol. In certain situations, the high complexity of the organic material can result in a low rate of hydrolysis, becoming the limiting step of the entire digestion process.
b) Acidogenesis: through optional and mandatory anaerobic bacteria, the compounds produced include short-chain volatile fatty acids (AGV), alcohols, lactic acid, carbon dioxide, hydrogen, ammonia and hydrogen sulfide, in addition to new bacterial cells. Acidogenesis is performed by a large and diverse group of fermentative bacteria, mainly the Clostridium and Bacteroids species.
c) Acetogenesis: the metabolic products from the previous phase serve as a substrate for yearther group of bacteria that transform them into molecules of lower molecular weight. Acetogenic bacteria, in anaerobic digestion, have the main function of producing acetate, CO_2 and H_2, which are then converted by methyeargenic Archeas.
d) Methyeargenesis: understood as the final stage of the global process of anaerobic degradation of organic compounds in methane and carbon dioxide; is carried out by methyeargenic bacteria. Methyeargenic bacteria use only a limited number of substrates, comprising acetic acid, hydrogen, carbon dioxide, formic acid, methyearl, methylamines and carbon monoxide. They are divided into two main groups: the first that forms methane from acetic acid or methyearl, and the second that produces methane from hydrogen and carbon dioxide.

2.4 Operational conditions for biodigesters

The production of biogas from a given volume of the biodigester can vary in relation to several factors, such as ambient temperature, acidity, homogeneity of the substrate, among other factors. Yearther factor that influences production is the biodigester model implemented. These variations make the exact determination of biogas production by a biodigester difficult.

a) temperature: The thousands of bacteria coexisting during biodigestion work at different temperatures from each other. Each group of bacteria has an ideal working temperature where its efficiency is greatest.The microorganisms can then be classified according to their highest thermal efficiency into three main groups: Psychrophilic (T <25°C), Mesophilic (from 37 to 42°C) and Thermophilic (between 50 and 60°C). Most Methyeargenesis bacteria are Mesophilic and work at a temperature of approximately 39°C. Variations in this temperature can even almost completely cancel the production of biogas from a system.
b) Acidity (pH): Acidity follows the same principle as temperature. Each group of bacteria has its ideal acidity point. In the phases of hydrolysis and acidogenesis, the ideal pH is around 5.2 to 6.3. In Acetogenesis and Methyeargenesis, the ideal pH is between 6.5 to 8.
c) Substrate homogeneity: The efficiency in the generation of biogas has its intimate connection with the substrate mixing process. Unmixed substrates tend to form layers according to the density of the mixture in the substrate. Most bacteria accumulate at the bottom of the fermenter, due to the difference in density while most of the substrate is at the top. In this case, due to the decreased contact between the bacteria and the substrate, the biogas generation essentially decreases. Due to a codependency of Acetogenesis and Methyeargenesis bacteria, excessive mixing can be harmful to the anaerobic phase of this process, as these bacteria need to be close to each other.
d) Oxygen concentration: Methyeargenesis bacteria work anaerobically, that is, in the complete absence of oxygen. The lower levels of oxygen concentration can already significantly reduce the action of these bacteria. For this reason, perfect isolation of fermenters is extremely important. If biogas is used to generate electricity, then we add an electric generator coupled to a combustion engine.

3. MATERIAL AND METHODS

The experiments were carried out in the period from October 10th to November 12th , 2019 totaling 40 days. The bioreactors were maintained under natural temperature and environment conditions at the UFSM campus in Cachoeira do

Sul - RS. The purpose of this work was to quantitatively evaluate the potential of bovine and swine manure for biogas generation through anaerobic biodigestion.

The samples were collected in the city of Santa Maria, central region of Rio Grande do Sul. The bovine manure was collected on property that has the activities of agriculture and dairy cattle. This property has a total herd of 85 animals in a semi-confined regime, with 50 lactating cows, facilities for milking and storage of milk. About 35 liters of waste were collected after the milking procedure, where the environment is cleaned. The pig manure was collected in the pig sector of the Zootechnics department at UFSM, where there are 3 sows with an average of 7 piglets each. The waste generated is taken to a central reservoir, where it is stored and from where approximately 40 liters were collected (Figure 2).

The work was carried out on a small scale at the UFSM campus Cachoeira do Sul, with two models of biodigestors being developed, one being operated by batch and a second being operated by continuous flow (Figure 2).

Figure 2 - Swine manure samples(1) and batch digester (2) and continuous form (3) models.

3.1 Production of biogas and biofertilizer

The present work was based on two main methodologies for estimating the production potential of methane and biogas developed or adapted by the Intergovernmental Panel on Climate Change - IPCC (2006) and by the International Center for Renewable Energies - CIBiogás - ER (2009). In this work, the original methodology was used and the only adaptation was the equivalence of the final result of methane to biogas, considering that methane represents 60% of biogas.

Intergovernmental Panel on Climate Change - IPCC (2006): This methodology measures CH4 emissions, which are a potential greenhouse gas, in the atmosphere from biological treatments for waste. For this work, the methodology for the calculation of emissions from anaerobic digestion was used. The equation used is equation 2 and 3 presented below, Calculation of methane emission factor:

$$FEM = SV * 365 * \beta o * 0{,}67 * \frac{FCM}{100} * SM \quad (2)$$

Where:

FEM	kg_{CH4} $head^{-1}$ $year^{-1}$	methane emission factor by population / category
SV	kg_{SV} $head^{-1}$ day^{-1}	volatile solids
βo	$m^3_{CH4}.kg_{SV}^{-1}$	methane production capacity by manure
0,67	dimensionless	conversion of m3 of methane to kg of methane
FCM	%	conversion factor according to the management
SM	dimensionless	factor of the waste management system

Calculation of methane emissions:

$$CH_{4\ waste} = \sum FEM * N \quad (3)$$

Where:

$CH_{4\ waste}$	Kg_{CH4} $year^{-1}$	methane emission during manure management
FEM	kg_{CH4} $head^{-1}$ $year^{-1}$	methane emission factor by population / category
N	integer	number of animals in the category in question

International Renewable Energy Center - CIBiogás - ER (2009). This methodology developed by CIBiogás - ER (2009) estimates the production of biogas and was developed based on the methodology and parameters described in the IPCC (2006). It should be noted that, in the methodology developed by CIBiogás - ER, data were added regarding the weight of the animals and the annual fraction of stay (pigs) and the daily confinement fraction (cattle), in addition to equations to calculate the production of manure, as equations 4, 5, 6, 7 and 8 and table 9 that describes the values of qualitative parameters of methodology.

Calculation of daily and annual production of pig manure:

$$PDDS = \sum(N^{\circ} * PE) \quad (4)$$

Where

PDDS	m^3_{waste} day^{-1}	daily production of swine waste from the animal category
Nº		absolute number number of heads belonging to the animal category
PE	m^3_{waste} $head^{-1}$ day^{-1}	specific production of swine waste by category

$$PADS = \sum(PDDS * 365 * FAP) \tag{5}$$

where:

PADS	m^3_{waste} $year^{-1}$	annual production of pig waste from the animal category
PDDS	m^3_{waste} day^{-1}	daily production of swine waste from the animal category
FAP	dimensionless	Annual fraction of stay (between 0 and 1)

Calculation of daily and annual production of bovine manure:

$$PDDB = \sum(N° * TC * PE) \tag{6}$$

where:

PDDB	m^3_{waste} day^{-1}	daily production of bovine waste from the animal category
Nº		absolute number number of heads belonging to the animal category
TC	confinement time	hours of confinement per day
PE	m^3_{waste} cab^{-1} $hora^{-1}$	specific production of bovine waste by category

$$PADB = \sum(PDDB * FAC) \tag{7}$$

where:

PADB	m^3_{waste} $year^{-1}$	annual production of bovine waste
PDDS	m^3_{waste} day^{-1}	daily production of swine waste from the animal category
FAC	dimensionless	Annual fraction of confinement (between 0 e 1)

Calculation of daily biogas production:

$$PDB = N° \left(\frac{PM}{PP}\right) * FDC * SVpadrão * \left(\frac{FCM * B_0 * fb}{CH4}\right) \tag{8}$$

Where:

PDB	m^3 day^{-1}	daily biogas production
Nº		absolute number of animals
PM	kg	average weight
PP	kg	standard weight
FDC	dimensionless	Daily fraction of confinement (between 0 e 1)
SV	kg_{SV} cab^{-1} $year^{-1}$	daily production of bovine waste from the animal category
FCM	dimensionless	conversion factor from metyear to system baseline
β_o	$m^3_{CH4}.kg_{SV}^{-1}$	metyear production capacity by manure
f_b	dimensionless	uncertainty correction factor
CH_4	%	percentage of metyear in biogas

3.2 Sizing the biodigestor

To dimension a biodigester, it is initially necessary to choose which model of biodigester will be used. There are several types of biodigesters, each of which has its particularities and is specific to the reality of the place where it will be built, as already discussed in item 2.3.1. For property 2 where the pigs are found, it was decided to use the Indian model continuous flow biodigester according to the amount of waste produced, and the calculations were based on the article by Araújo et al. (2018). The volume of the biodigester (Vb) can be obtained through the product of the hydraulic retention time (HRT) by the daily load (VC), according to the equation below:

$$Vb = VC * TRH \tag{9}$$

The diameter of the digestion tank (DTank) is calculated using the equation below, where h is the height of the biodigester:

$$DTank = \sqrt{\frac{(Vb)*4}{h*\pi}} \tag{10}$$

The dimensions of the inbox (D load) must be sufficient for its volume to support the daily load volume, with an increase of 20%. Therefore, the volume of the feed tank will be calculated by the following equation:

$$DLoad = \sqrt{\frac{(PDDS*2)*1{,}20*4}{hc*\pi}} \tag{11}$$

The cargo box must be built with the floor 20 cm high above the level of the edge of the digestion tank. Unlike the digestion tank and the cargo box, which are cylindrical in shape, the box and discharge has a rectangular shape and will be divided into two compartments. According to Oliver et al., (2008), it must be dimensioned with at least three times the volume of the daily load to allow the storage of the biofertilizer. So that:

$$Vdischarge \geq 3 * Vload \tag{12}$$

$$Vdischarge = H * L * C \tag{13}$$

$$C = \frac{Vdischarce}{H*L} \tag{14}$$

3.3 Estimate of biogas production

To estimate the volume of gas produced, equations 15 and 16 were used:

$$V = \pi * h * (Re^2 * Ri^2) \tag{15}$$

Where:

V	m^3	Volume of biogas produced
h	m	Tread width (camera height)
Re m		External camera radius
Ri	m	Internal camera radius

To estimate the volume of atmospheric pressure that occupies this volume, the gas law is used, keeping temperature and gas quantity constant:

$$P1 * V1 = P2 * V2 \tag{16}$$

4. MAIN RESULTS

4.1 Caracteristics and condicion of biomass

Data on average air temperature and other climatological factors were obtained using the iMETOS 3.3 automatic meteorological station, model IMT300. The average and average temperature of the maximum and minimum daily of the 40 days of operation of the digesters are shown in fig. 3.

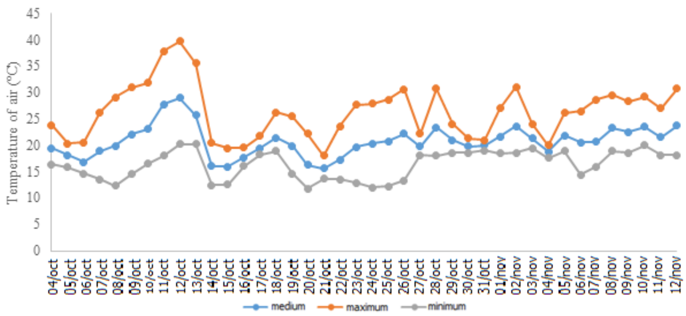

Figure 3 - Daily air temperature averages on the days of operation of the digesters.

The pH estimate and the ST determination carried out in the swine and bovine manure biomasses before and after the 40 days in the biodigester are shown in Table 2. It was possible to observe a reduction of 36.32% and 3.98% of ST in the biomasses swine and cattle, respectively. While a trend of increasing pH was observed in swine manure, the opposite was observed for cattle. The pH change during the anaerobic degradation process occurs due to the different phases with specific action of different microorganisms, since there is an ideal pH range for each one (FERREIRA et al. 2017). The gas production has an excellent speed with pHs between 7 and 8, and temperature around 35 ° C (TURDERA; YURA, 2006). At pHs less than 7, gas generation can be compromised, as a decrease in pH can reduce the activities of methyeargenic bacteria (CASTRO; CORTEZ, 1998; FERREIRA et al. 2017).

Table 2. pH values and percentage of total solids present in the waste evaluated on the first and last day of the experiment.

	Waste	***pH***	***Massa inicial (g)***	***Massa final (g)***	***Sólidos Totais (%)***
Antes	Suínos	7.0	24.989	0.501	2.01
	Bovinos	7.0	29.047	1.856	6.53
Depois	Suínos	7.0-8.0	28.392	0.363	1.28
	Bovinos	6.0-7.0	33.379	2.243	6.27

4.2 Assembly of the biodigestor and production of biogas

In the pig manure biodigester one day after the system was installed, on October 8, a $4.7x10^{-3}$ m^3 chamber was removed. The next day, a new bicycle chamber burs and a motorcycle was placed, which burst in two days (11 October). The same day, a car was installed, which was removed on October 18. From that last date, two were collected by bicycle until November 12, 2019. In the bovine biodigesters you can hear the collection of three chambers with a volume of biogas of approximately $1.9x10^{-3}$ m^3. There is no overflow of chambers in these biodigesters. The total biogas collected is described in Table 3.

Table 3 - Estimated biogas production.

Waste	Biogas produced
Total pig volume	0.032327 m^3
Total bovine volume	$1.9x10^{-3}m^3$

These same authors did not observe the effect of temperature on the production of biogas and indicate the viability of the biogas production process from bovine manure in a tropical climate. The decrease in pH in bovine manure in the present study may indicate a reduction in communities of methyeargenic bacteria, which directly compromises the production of biogas. , evaluating the physical-chemical factors in the biogas production of a bioreactor fed with organic residues from a cafeteria, observed an almost zero production of biogas at the beginning of the process when there was a drop in pH, and, subsequently, as the pH approached neutrality, methane production was increasing. This temperature variation greater than 5°C occurred in 31 of the 40 days of the experiment, which may have compromised the production of biogas in the biodigester with bovine manure.

The best performances in experiments evaluating the production of biogas from animal waste under temperature control conditions are observed at temperatures above 35°C. The ambient temperature and its range of variation were not so harmful to the production of biogas from swine manure, as these, in addition to having a higher initial humidity, also present differences in composition depending on the diet when compared to cattle. The fibers present in bovine manure are the main element for the production of biogas, although its natural content is rich in cellulose and hemicellulose, after digestion in the gastrointestinal tract the remaining fibers are more lignified and resistant to the fermentation processes, making it difficult to produce biogas.

4.3 Production estimate of waste and biogas

To estimate the amount of methane gas produced from the degradability content of the substrate by the Intergovernmental Panel on Climate Change method - IPCC (2006), the data in Table 8 was taken into account, where:

To estimate the amount of waste produced and methane gas generated by the International Renewable Energy Center - CIBiogás - ER (2009) method, the data in Table 4 was taken into account together with the literature data, where according to Kunz et al., (2005) the production of female manure with piglets (in lactation) is 0.027 m^3 / day and piglets in a nursery 0.014 m^3 / day.

Table 4 - Tabulated values of the CIBiogás-ER methodology for qualitative parameters

Category	**SV (kg cab^{-1} day^{-1})**	**βo (m^3_{CH4}.kg_{SV}^{-1})**	**FCM (%)**	**SM**	**F_b**	**%CH_4**
Pigs	0.3	0.29	0.78	1	0.94	60
Dairy cows	4.0	0.18	0.78	1	0.94	60
Other cattle	2.5	0.10	0.78	1	0.94	60

The total production of manure in swine farms is highly variable, depending mainly on the cleaning management adopted in each farm, determining the greater or lesser amount of water used. Either way, water will always be present, diluting and taking part in the generation of final waste, which gives pig waste, in most systems, the characteristic of liquid effluent.According to Santos and Nogueira (2012), an animal with approximately 450 kg in weight generates 0.037 m3dejects / day, so from equation (6) we have the calculation of the daily amount of bovine manure produced: Equation (8), proposed by CIbiogás-ER (2009), which also used parameters from the IPCC model (2006), in addition to the average weight (PM) which corresponded to 115 kg (animal exit weight) and the standard weight (PP), by swine category, being 198 kg (IPCC, 2006). The production properties of pigs and cattle from which the manure was collected for the present study produce 0.79 and 0.375 m^3 of cattle and pig manure, respectively, per day (Table 5). These wastes emit, by the IPCC estimation methodology, more than 65 kg of methane per year, showing the importance of treating wastes in reducing the emission of greenhouse gases.

Table 5 - Summary of waste production estimates (m³ / day), biogas and methane at the waste collection sites (properties).

	m³waste/day	*m³biogas/day*	*kgCH$_4$/ year*
Cattle - Property 1	0.79	17.14	61.91
Pigs - Property 2	0.375	1.48	4.03

4.4 Sizin the biodigestor model

For the present work, due to the low production of biogas from bovine manure, it was decided to design only one biodigestion system for pig manure, fig.4. From equation (9) we obtain the volume of the biodigester (Vb), the daily load (VC) consists of the sum of the waste volume (PDDS) plus the water that will be inserted in the biodigester, which must be mixed in the proportion of 1 : 1 in volume, according to Faustino et al, (2009). The hydraulic retention time (HRT) adopted was 40 days (AMARAL et al., 2004), according to the equation below: From these equations (9), it can be estimated that an Indayn biodigester with a load box of 0.9 m3, a biodigestion chamber of 36 m^3 and 2.7 m^3 (Figure 19) will be sufficient to meet the demand for the production of swine manure from the Zootechnics department at UFSM, where there are 3 sows with an average of 7 piglets each (property 2). This biodigester, in addition to treating waste, with a high potential for contamination, will produce 1.48 m^3 of biogas per day and biofertilizer. The biogas produced, as it is in small quantities, can be used for the heating system of the maternity floor, which according to Kunz and Oliveira (2006) the transformation of biogas into electrical energy has a yield close to 25% against 65% if transformed in thermal energy, thus seeking a better conversion efficiency.

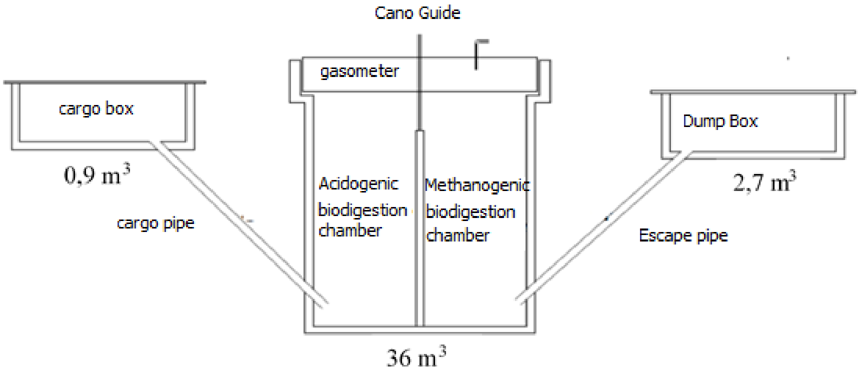

Figure 4 - Scheme for sizing biodigester for property 2 (pig manure)

5. CONCLUSION

The methodologies for estimating the theoretical potential of biogas production show different results, but it is considered that the IPCC methodology may be a viable option for adaptations that take into account the particularities of management in the region / country. The energetic potential of the residual biomass of swine manure cannot be ignored and for it to become production plants, it is important to advance in research and public policies to make it viable and representative in the Brazilian energy matrix. Although energy conversion is not feasible in small properties, thermal exploitation or organization in producer cooperatives can be alternatives for the viability of the biodigester.

The biodigester can meet the waste treatment requirements, greatly reducing the possible environmental impacts on the region's soil, water and air. The production of biogas and biofertilizer through the biodigestion system adds value to the rural property, be it due to the financial factor, as well as by the integration to the most varied activities that are developed in the rural environment, bringing renewable energy generation, recycling of nutrients for the plants and sanitation environmental.

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7. RESPONSIBILITY NOTICE

Juan Galvarino Cerda Balcazar, Mariana Vieira Coronas are the only responsible for the printed material included in this paper.

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