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Calorific Value of Biogas Obtained by *Cavia porcellus* Biomass

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The objective of the investigation is to determine the calorific value of the biogas obtained from the biomass of manure from *Cavia porcellus* (guinea pig), for which a biodigester model Intermediate Bulk Container (IBC) with a capacity of 1 m3 was designed and built. The physicochemical properties and the amount of animal biomass to generate biogas were determined. 459 kg of *Cavia porcellus* manure (guinea pig) was used, the weekly load was 233 L of guinea pig mixture with water in a 30-day retention time. At the end of the process, biogas was obtained with a calorific value of 6 527.3 kcal / m3, corresponding to 72.3% methane with a volume of 1 m3. The method to obtain unconventional energy from biogas produced by animal biomass has environmental advantages and low cost
Keywords: Biodigester, *Cavia porcellus,* animal biomass, methane, biogas, calorific value.

1. Introduction

Organic waste in Peru represents 53.16%, of which 18.64% are non-usable solid waste and 6.83% are recyclable waste (MINAM, 2016). Among the organic waste are those generated by excreta of Cavia porcellus commonly known as guinea pig, curi, where it excretes 50 g for every 200 g of food per day (Chauca, 1997). One way to manage this waste is to use it to generate biogas after an anareobia decomposition process, forming methane gas and carbon dioxide to be used as heat energy or converted into electrical energy (Cusi, 2018).
There is research where animal and plant waste from livestock, fishing and agroindustry activities has been used to obtain heat energy transforming it into electrical energy (Vásquez and Gamio, 2018). Biogas was obtained from organic waste from food and manure market of different animals using Batch model biodigesters (Sallo, 2014). 2x10-4 m3 of cattle dung biogas was obtained in a polyethylene bioreactor (Toala, 2014). Biogas was obtained using animal wastes from livestock activities (sheep, pigs and cattle) in Majes-Caylloma-Peru (Cruz, 2017). Some fermentation accelerators were used such as whey, fat, chickpea, in addition to fat and cow dung obtaining 41.6 L/kg of biogas (Briceño, 2017). Leachates from landfills of solid waste produce nutrients to be used as inoculums in the generation of biogas (Chien, 2018). The temperature is very important in the generation of methanogenic communities and without using inoculum (Achinas et al., 2018), in 30 days biogas is generated with chicken manure and cattle from 0.83 to 6.33 m3 in a reactor obtaining a calorific value of 21,000.00 kJ/m3 (or 5, 019.12 Kcal/m3) (Boysan et al., 2015).
The excreta or manure of Cavia porcellus, known as cuyibaza, is what was used in this investigation. Its composition is: phosphorus (0.7%), nitrogen (1.5%) and potassium (1.7%) (Borrero, 2001). In obtaining biogas from animal biomass the biodigester was used and that generally its shape, size, color would not harm the generation of biogas (Olaya and Gonzales, 2009). The Batch model is the most recommended for volumes larger than 15 m3 (Varnero, 2011, p.98). The Model IBC biodigester with a capacity of 1 m3 was used, with a low rigid structure without agitation mechanism to obtain biogas (Culhane et al, 2015).
The objective of the research was to generate biogas from excreta of Cavia porcellus (guinea pig) and determine its calorific value, as an alternative to obtain energy under criteria of sustainability and renewable energy, taking advantage of the animal biomass of this species in Peru, considered as the world's leading

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producer and exporter with 22 million (FAO, 2018). In this context, the operating parameters are evaluated to optimize the anaerobic process of digestion in the generation of biogas for the control, monitoring and production of biogas (Rego et al, 2018).

2. Materials and methods

2.1 Materials

The Biodigester used was a PVC tank with a capacity of 1 m^3, it has accessories such as: PVC pipes, hoses for the entry of manure and the exit of biogas (Figure 1).
Guinea pig manure was obtained from the small animal farm of the National Agrarian University La Molina, and for use it was mixed with water.

2.2 Procedure for obtaining biogas

Below is the process of obtaining biogas.

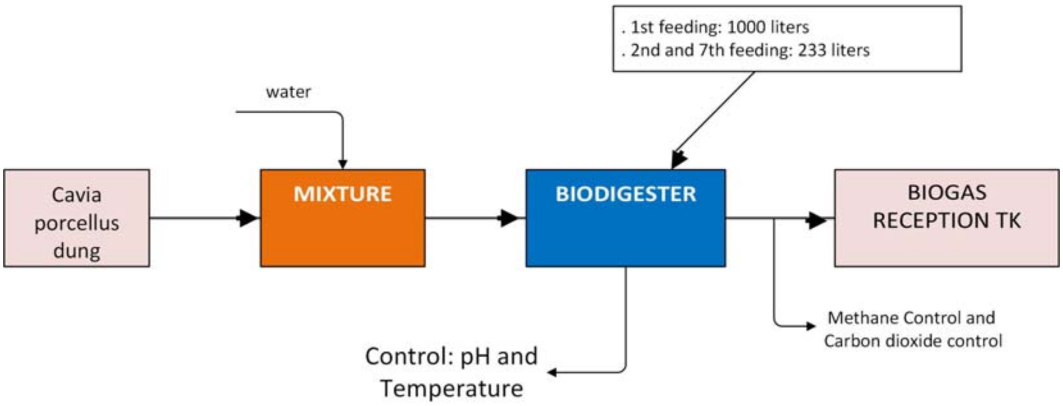

Figure 1: Biogas Obtaining process

Biomass mixture: The first feed to the biodigester was 1000 L of water, then 233 L of manure-water mixture (58.8 Kg of manure and 175 L of water) were recharged, 6 times per week at each feed (Figure 2).

Figure 2: IBC bioreactor

Biogas: On the day 15th, the generation of biogas was evident. The temperature and pH parameters were monitored inter-daily biogas. 4 biogas samples were taken for later analysis. See Figure 3.

Figure 3. Biogas bag and gasometer

3. Results

3.1 Results of the biomass mixture

The values of the initial chemical parameters of the biomass were those presented in Table 1. It was determined that guinea pig manure contains a high percentage of carbon, which is known as an energy source for methanogenic bacteria. According to the Biogas Manual (Varnero, 2011), the optimal ratio is 30 units of carbon per unit of nitrogen, that is, C/N = 30/1.

Table 1: Chemical parameters of Cavia porcellus manure (guinea pig)

% Hd	% MS*	pH	E. C.(dS/m)	%M.O.	%N	% C	C/N	% Cenizas
29.55	0.075	6.9	14.8	81.69	1.97	44.4	23.54	16.69

Likewise, the characteristics of the inoculum used were the biomass of Cavia porcellus biomass indicated in Table 2.

Table 2: Characteristics of the inoculum, manure biol of Cavia porcellus (guinea pig)

E.C. (dS/m)	pH	Suspended solids (g/L)	Organic material (g/L)	N (mg/L)	P(mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)
14.7	7.3	13.54	4.74	920	92.2	2,297.50	230.6	151.2	667.5

For the calculation of the volumes of biomass, inoculum and water, the recommendations of Guevara (1996) were used for the loading of rural anaerobic biodigesters type IBC, with equations (1), (2), (3) and (4).

The concentration of the load: *Cms = Useful volume *% Dry matter* (1)

Cms = 1000 * 0.075 = 75 Kg.

The amount of biomass manure from *Cavia porcellus* (Cec) was: Cec = Cms x * (100%) / (MS%) (2)

Cec = 75 * 100/0.075 = 100,000 Kg

The inoculum volume: inoculum volume = 12% of the useful volume of the biodigester (893.62) (3)

Inoculum volume = 107.23 L

Water volume calculation:

Water vol = Biodigester vol- (guinea pig biomass vol. + Inoculum vol.) (4)

Water volume = 893.62 – (233*0.04 + 107.23) = 786 L.

Where 0.04 m^3/kg is the specific biogas production (Hernandez, 2014)

3.2 Results of Biogas Production

Methane

The percentage of methane production (CH_4) in the biodigester is shown in Table 3. The samples were analyzed with a gas analyzer (OEM Evaluation Kit Type OEM - 1). It is observed that methane production is increasing up to sample 3 (average 72.30%) over time according to the biogas manual (FAO, 2011) where it indicates that the production should range between 55 to 70%, in case the biogas It has a methane content greater than 45% is flammable, which means it can be converted into energy.

Table 3: Percentage of Methane in the biogas produced

	% Methane (CH_4)			
	Sample 1	Sample 2	Sample 3	Sample 4
R1	31.80	52.50	72.50	64.20
R2	32.60	53.30	71.80	63.80
R3	32.10	53.50	72.50	63.50
Average	32.20	53.10	72.30	63.83

Carbon dioxide

The biogas in its composition also had carbon dioxide (CO_2), over time as indicated in Table 4. It is observed that the production of CO_2 decreases over time.

Table 4: Percentage of Carbon dioxide (CO_2) in biogas

	% Carbon dioxide (CO_2)			
	Sample 1	Sample 2	Sample 3	Sample 4
R1	68.30	74.50	27.50	35.80
R2	67.40	46.70	28.20	36.20
R3	67.90	46.50	27.50	36.50
Average	67.90	46.90	27.70	36.1

pH

During the 72 days of biodigestion the pH ranged between 6.5 and 7. According to the scientific literature in the process of fermentation and digestion (6 to 8 is the ideal pH). With low pH values, lower volumes of methane are obtained.

Temperature

The temperature monitored in the biogas process was maintained between 26 and 28.2 °C. The seasonal climatic conditions of the city of Lima in the investigation period in terms of temperature were between 25 and 35 °C, which is the range that also developed the biodigester process.

Calorific value of *Cavia Porcellus* biomass biogas

Having the data of percentages of methane and the higher calorific value (HCV), the calorific value of the biogas shown in Table 5 was calculated, using the following relationship:

$$PCI = \%\, CH_4 * PCS \quad (5)$$

The value recommended by Guardado (2006) where biogas is composed of about 60% methane gas was taken into account.

To be considered a biogas with adequate calorific value, this value must be between 4,500 to 6,500 Kcal/m^3, so it can be seen that the majority of sample results were in the range (Tellez C., 2008).

In Vega's research (2015) a calorific value of 5,100 Kcal/m^3 was found from guinea pig and rabbit manure biomass. This research found a calorific value of 6,427.3 kcal/m^3 on average using *Cavia Porcellus* manure biomass (guinea pig).

Table 5: Biogas calorific value

	Calorific value (Kcal/m^3)		
	Sample 1	Sample 2	Sample 3
R1	2,844.7	4,6687.2	6,445.1
R2	2,933.6	4,738.3	6,882.9
R3	2,853.6	4,756.0	6,445.1
Average	2,862.5	4,720.5	6,427.3

4. Conclusions

Biogas was obtained from biomass manure from *Cavia Porcellus* (guinea pig) with characteristics of good calorific value due to the significant percentage of methane containing 72.3% on average and carbon dioxide by 27.7%. Similarly the pH is neutral. This product was achieved using biomass with a Carbon/Nitrogen (C/N) composition of 23.54, with a 16.69% ash content. This anaerobic digestion technology turns out to be very advantageous to obtain a potentially energetic product that can be used in the generation of electrical and heat energy with environmental advantages. It is present that the characteristics of animal biomass must be taken into account since it is not always homogeneous, that is, the result depends on the biomass to be used.
Regarding the calorific value of biogas, it was found within the range considering biogas with adequate calorific value, that is, the amount had the characteristics of producing heat energy that allows the property of flammability is, it can be converted into energy. In this way it is verified that the biogas of animal biomass is a viable alternative to improve the energy matrix from renewable and sustainable sources, especially in countries that have these resources.

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