ORIGINAL ARTICLE

Determination of Appropriate Anaerobia the Technology of Biodigestion for a System of Poultry Production

Determinación de la tecnología de biodigestión anaerobia adecuada para un sistema de producción avícola

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ABSTRACT: This research is aimed to determine the anaerobic bio-digestion technology suitable for a poultry production system, established at the “El Guayabal” University Farm, belonging to the Agrarian University of Havana considering economic, environmental and energy feasibility. To do this, the animal species existing (Leghorn chickens, white-breasted turkeys and free-range chickens) in the scenario are determined, given that these species will contribute sizing the organic waste to the biodigester, the number of animals is also determined, considering the herd movement, which would make it possible to determine the biomass generated daily for the purpose of establish the of the appropriate biodigester technology and know the behavior of the economic and energy parameters. Among the main results obtained, it was evident that the installation of a tubular polyethylene biodigester is more feasible than the installation of a fixed dome biodigester, meaning an economic saving of 21 418.1 peso due to technology selection; the necessary volume of this technology must be 22 m^3, making it possible to produce 11.6 kg/day of biofertilizers, which represents a daily economic contribution of 145 peso/day (5.8 USD/day), constituting an added value, in addition to the energy and economic benefits to be obtained. Furthermore, with the introduction of the selected anaerobic bio-digestion technology it is possible to generate electrical energy for lighting, heating and the extraction of humid air, which requires the acquisition of a 2 kW biogas generator.

Keywords: renewable energy, anaerobic digestion, energy feasibility, environmental impact.

RESUMEN: La presente investigación tiene como objetivo determinar la tecnología de biodigestión anaerobia adecuada a introducir en un sistema de producción avícola, para producir biogás y biofertilizantes, en la Granja Universitaria “El Guayabal”, perteneciente a la Universidad Agraria de la Habana, teniendo en cuenta la factibilidad económica, ambiental y energética. Para ello se determinan las especies animales existentes (gallinas Leghorn, pavos de pecho blanco y gallinas camperas) en el escenario, dado que estas especies aportarán los residuos orgánicos hacia el biodigestor, también se determina la cantidad de animales, considerándose el movimiento de rebaño, lo cual posibilitaría determinar la biomasa generada diariamente con el propósito de establecer el dimensionamiento de la tecnología de biodigestor adecuada y conocer el comportamiento de los parámetros económicos y energéticos. Entre los principales resultados obtenidos, se evidenció que la instalación de un biodigestor tubular de polietileno resulta más factible que la instalación de un biodigestor de cúpula fija, significando un ahorro económico de 21 418,1 peso por concepto de selección de la tecnología; el volumen necesario de esta tecnología debe ser de 22 m^3, siendo posible producir 11,6 kg/día de biofertilizantes, que representan un aporte económico diario de 145 peso/día (5.8 USD/día) constituyendo un valor agregado, unido a los beneficios energéticos y económicos a obtener. Por otro lado, con la introducción de la tecnología de biodigestión anaerobia seleccionada es posible generar energía eléctrica para luminarias, la calefacción y la extracción de aire húmedo, para lo que se requiere de la adquisición de un generador de biogás de 2 kW de potencia.

Palabras clave: energía renovable, factibilidad energética, impacto ambiental, biodigestor.

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INTRODUCTION

The derived energy of biomass is that that arises starting from the alive beings or its wastes, and it represents an interesting use potential for its conversion in biofuel that cannot mitigate the use of fossil fuels renewable as the petroleum.

American Society for testing and materials standards Biodigesters are facilities in which a certain organic waste is decomposed by the action of populations of anaerobic bacteria, in the absence of oxygen and produce as a result of this process gases with a high percentage of methane and therefore a good capacity for generating (Grundey, 1982; Priddle, 1998; Guardado, 2006; Santos *et al.*, 2011; Frankiewicz, 2015; Rahayu *et al.*, 2015; Suárez *et al.*, 2018).

The biodigester is in fact anthropogenically (taken place by human activity) the technology to highlight in the biotechnical process of digestion anaerobic of biomasses to obtain biogas (Flotats *et al.*, 2001; Sosa, 2017).

This technology consists on a hermetic reactor with a lateral entrance for the organic matter, an escape in the superior part for where the biogas, and an exit flows for the effluents obtaining with properties bio fertilizers, contributing both products to solve the necessities of the producers and to the development of the organic agriculture, like an economically feasible and ecologically sustainable alternative (Zheng et al., 2012).

The employment of the biomass, by means of a process of digestion anaerobia, is also a source of renewable energy used in some poultry farms. The biomass can be used as fuel to heat the facilities and to provide electricity through the generation of thermal energy. The residuals of the farm, as the manure and the food leftovers, they can be used as biomass for the energy generation.

Besides providing energy, the use of renewable energies in the poultry farms also has other benefits; for example, the use of renewable energies reduces the dependence of the fossil fuels and it contributes to the reduction of emissions of gases of effect hothouse. He/she can also help to the poultry farms to reduce their long term energy costs and to improve their sustainability (Cadena Avícola, 2023).

To these aspects he/she would be necessary to add the high prices of the fuels and the local high rates of the electric power, being factors to consider for the biodigesters introduction or biogas plants that facilitate the energy production starting from the use of the wastes of the agricultural production (Parra *et al.*, 2019).

Being considered the previously described approaches, in the University Farm "Guayabal" belonging to the Agrarian University of Havana (UNAH), located in San José of the Flagstones, of the county Mayabeque, Cuba, was carried out the study of the feasibility of the technology of bio digestion appropriate anaerobia to introduce in a system of poultry production, with the objective of producing biogas and bio fertilizers.

MATERIALS AND METHODS

The University Farm "Guayabal", belonging to the Agrarian University of Havana (UNAH), it is located to the 23°00'12 ,5" North latitude, and 82°09'57 ,9" longitude West in the municipality San José of The Flagstones, county Mayabeque, Cuba. The existent floor in the same one, is classified as Red Typical Ferralitic according to Hernández *et al.* (2015) in all their extension. He/she has a flat relief, height on the sea level of 120 m and annual heatstroke of 1825 kWh/m2. The meteorological variables registered in the Meteorological Station Covered, San José of the Flagstones, during the period January-September/2023, they showed that the maximum temperatures reached in the region overcame the 32 ºC among the months of June to September and the coldest descended like average up to 21,1 ºC in January. The precipitations manifested increments starting from June, and they indicated the values higher means in May and August with 72 and 77 mm, respectively. The relative humidity varied between 47% and (minimum, in March) 84%, (maximum, in September) while the speed of the wind reached a maximum value of 3,6 km / h during the month of August. The behavior of these climatic variables allows to develop poultry production satisfactorily. Inside their facilities he/she is a system of poultry production, which conforms to for three productive areas, one of these areas is dedicated to the production of eggs with the employment egg-laying hens of the race White Leghorn, this area has a maximum capacity of 2 872 animals; another is the area dedicated to the production of turkeys whose capacity varies in function of the time of the year 1 500 animals (summer) and 3 000 animal (winter) and finally the area dedicated to the country hens also dedicated to the production of eggs with a capacity of 700 animals. In the Table 1 the data are shown obtained as for the movement of the animal mass in the system of poultry production, during the period of observation.

In this study it is only considered the technological system dedicated to the production of eggs with hens White Leghorn, since it is the only of the systems settled down in the scenario that offers the possibility to obtain in a direct way you excrete them, because the other species are developed and they manage in floor with zeolita litters and leader of rice what impedes the use of these you excrete in biodigesters.

For the correct sizing of the biodigester of fixed dome the determination of the following parameters is required:

- Quantity of daily generated biomass (Bmd);
- Daily volume of material (it mixes manure and it dilutes) (Vdm);
- Volume of the biodigestor (Vbiodig);
- Volume of the camera of fermentation (Vcf);
- Volume of the cylinder (V1);
- Volume of contention of the biogas (V2);
- Volume of the cone bases (V3);
- Volume of the compensation (Vtc) tank.

On the other hand, for the determination of the contribution energy potential to obtain in function of the quantity of available animals the determination of the following parameters is required:

- Biogas productivity (AND);
- Daily volume of biogas (G).

In the system of production poultry study object, for their operability, they are used a group of means energy consumers, those that are related in the Table 2.

Methodology for the sizing and installation of biodigesters anaerobes

As Guardado (2007) and Morejón *et al.* (2022), for the calculation of the parameters of design of a biodigester anaerobe, it is necessary to know the entrance data, and those that should be determined (Table 3).

The daily quantity of material (Bmd) is in direct function with the quantity of biomass that is generated, be already domestic, agricultural residuals or of animal origin. Also, he/she should take into account the maximum quantity that one obtains and the plans of productive increments.

TABLE 1. Movement of the poultry in the period of investigation in the Farm "Guayabal" system

Mov. of Flock	Initial Existence	Final Existence	Animals/day	Mass Average kg
Egg-laying hens Leghorn White	2872	2872	2872	1,40
White turkeys of wide chest	3000	1500	2250	6,50
Country hens	700	700	700	2.20

TABLE 2. Means energy consumers installed in the system of poultry production

Means energy consumers (Quantity)	Power, kW	Time of Operation , h	Consumed energy / day , kWh/day
System of production of hens White Leghorn			
Tubes LED 20W (10)	0.20	14	2.80
Tubes LED 40W (18)	0.72	14	10.08
System of production of turkeys of wide chest			
Tubes LED 20W (79)	1.58	14	22.12
Extractor I (1)	0.01	24	0.24
Extractor II (1)	0.02	24	0.48
Heater III (1)	0.01	24	0.24
Heater IV (1)	0.03	24	0.72
	0.06	24	1.44
	0.03	24	0.72
Heater V (1)	0.15	24	3.60
System of production of country hens			
Tubes LED 40W (10)	0.40	14	5.60

TABLE 3. Entrance data and exit required for the design of a biodigester anaerobe

Parameters	Unit
Entrance data	
Quantity of daily generated biomass (Bm_d)	kg day^{-1}
Proportion excrete-water (N)	kg L^{-1}
Biogás yield (Y)	m^3 kg^{-1}
Time of hydraulic retention (TRH)	day
Exit data	
Daily volume of material (it mixes manure and it dilutes) (Vdm)	kg day^{-1}
Volumen del biodigestor, (V_{biodig})	m^3
Volumen diario de biogás producido (G)	m^3 day^{-1}
Daily volume of produced biogas (V_2)	m^3
Volume of the compensation tank (Vtc)	m^3

The quantity of daily generated (Bmd) biomass, is determined through the following expression:

$$Bm_d = Ca \times Ce \times Rp \times Rt, \quad kg\,.day^{-1} \qquad (1)$$

where: Ca - Quantity of animals; Ce-quantity of it excretes for animal, kg / day; Rp - Relationship between the animal population's weight alive average and the equivalent tabulated alive weight; Rt - Fraction among the time of estabulación regarding the duration of the day, h / day

$$Bm_d = Ca \times Ce \times \left(\frac{PVp}{PVe}\right) \times \left(\frac{Te}{24h}\right), \quad kg{\cdot}day^{-1} \qquad (2)$$

where: PVp- Weigh lives the animal population's average, kg; PVe - I Weigh I live equivalent tabulated; You-hours of the day that the animal stabled, h / day remains

The daily volume of material (it mixes manure and it dilutes) (Vdm), is not more than the sum of the residual one and the dilution of the biomass (residual and it dilutes).

$$\text{Vdm} = (1 + N){\cdot}Bmd, \quad m^3{\cdot}day^{-1} \qquad (3)$$

where: N: Proportion excrete-water, kg L^{-1}, it is required to know that the density of the water is: 1000 kg/m^3.

While, the volume of the biodigester (Vbiodig) is calculated being kept in mind the value of the volume of material (it mixes manure and it dilutes) Vdm that TRH enters at the biodigester and the time of retention.

$$V_{biodig} = \text{Vdm}{\cdot}TRH, \quad m^3 \qquad (4)$$

Later on you proceeds to the calculation of the daily volume of produced biogas (G):

$$G = Y \times B_{md}, \quad m^3{\cdot}day^{-1} \qquad (5)$$

where: Y - biogas Yield, m^3 kg^{-1}

The biogás (Y) yield, is determined by means of the expression:

$$Y = \frac{X}{C_e}, \quad m^3{\cdot}kg^{-1} \qquad (6)$$

where: X - coefficient of energy conversion of it excretes it taken place daily that is to say the daily production of biogas in function of the type of organic residual, m^3/day.

For all the biodigesters types, the volume of the compensation (Vtc) tank is equivalent to the volume of produced gas that is to say it oscillates among 25.30% of the volume of the biodigester.

In the specific case of the calculations for the sizing of a biodigester of fixed dome (characterized by their three parts: conical, cylindrical and spherical cap, represented in the Figure 1), they think about next.

The steps that should be continued for their employment are the following ones:

The total volume of the biodigester (V_{biodig}) is calculated, about the base of the volume of the mixture water-manure and the time of retention, just as it is shown in the expression 4.

The radio of the defaulted (R) volume is calculated.

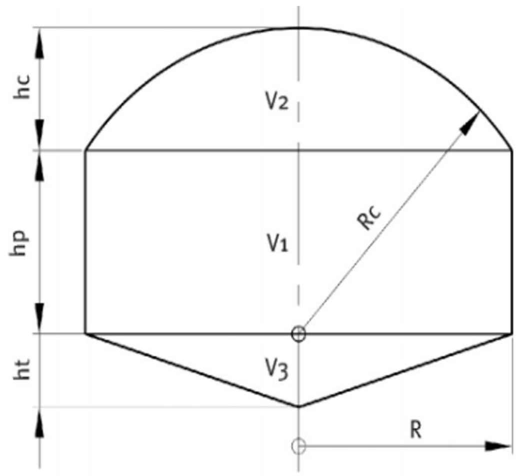


FIGURE 1. Main parts in those that a biodigester of fixed dome is divided. Source: Guardado (2007).

To calculate the radio of the defaulted (R) volume, he/she thinks about the expression:

$$R = \sqrt[3]{\frac{V_{biodig}}{(\pi \times 1{,}121)}} \qquad (7)$$

where: R- radiate basic, m

Being had the radio of the defaulted (R) volume, you proceed to determine the unit in meters (U = R/4).

where: U-Proportional unit

This proportional unit allows to determine the rest of the denominations, substituting U in the following proportions:

$$Rc = 5 \times U \qquad (8)$$

$$D = 8 \times U \qquad (9)$$

$$hc = 2 \times U \qquad (10)$$

$$hp = 3 \times U \qquad (11)$$

$$ht = 0{,}15 \times D \quad (12)$$

where: Rc radiate of the dome, m; D -Diameter, m; hc -Height of the dome, m; $hp-$ Height of the cylinder, m; ht -Height of the cone bases, m

Starting from the determination of the geometric main parameters you proceed to determine the volumes corresponding to the cone it bases, cylinder and spherical segment of the dome:

$$V_1 = Volumen \quad cilindro = R^2 \times hp \times \pi \quad (13)$$

$$V_2 = Volumen \quad cúpula = \frac{\pi \times {h_c}^2}{3}(3R - h_c) \quad (14)$$

$$V_3 = Vcono = R^2 \times \pi \times \left(\frac{ht}{3}\right) \quad (15)$$

RESULTS AND DISCUSSION

Technician-economic valuation of the introduction of a biodigester under the conditions of the system of poultry production of the University Farm "Guayabal"

For the determination of the technology of appropriate biodigester to install under the conditions of the system of poultry production, belonging to the University Farm "Guayabal", one had in consideration the sizing and constructive cost of the technologies of biodigester of fixed and tubular dome of polyethylene, it stops starting from that analysis to determine which of the two technologies it would be of more feasibility on the base of the constructive costs or of acquisition of materials in the market.

Before proceeding to the mentioned determinations, one should know the flock movement in the productive system that propitiates to obtain in a direct way the excrement, which is reflected in the Table 4.

The obtained results of each one of these sizing parameters are represented in the Table 5, these values are obtained starting from the movement of the lot of birds, conceived by the address of the farm during the period January-September/2023, represented in the previous chart.

Taking in consideration the basics settled down by Morejón *et al.* (2022), that for each 1,4 kg of bird, 0,18 kg is obtained of it excretes, being generated 0,11 m^3 biogas / day, with a proportion of 1:1-8 of excrete-water (taking a proportion of 1:1) and with a time of advisable retention of 30 days, then it is possible to determine the sizing of the biodigester of fixed dome for that species and quantity of animals.

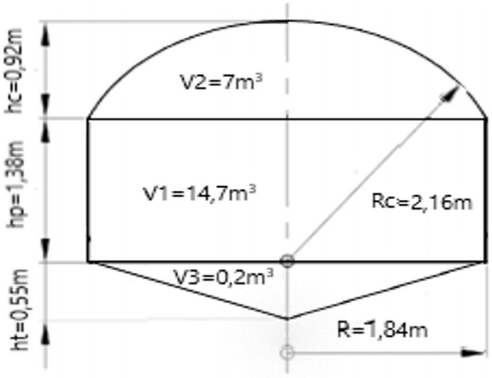


FIGURE 2. Main dimensions of the proposed biodigestor of fixed dome.

Starting from the values obtained in the sizing of the biodigester of fixed dome, he/she intends that this biodigester possesses a volume of 22 m^3, with the purpose of facilitating the installation process and acquisition of the necessary materials.

For the determination of the energy contribution, it is considered the quantity of biomass generated daily, the biogas yield and the daily volume of biogas (Table 6).

As it is represented in the Table 6, the biogas yield to obtain according to the species is of 0,61 m^3/kg and for that quantity of animal stabled it is possible to obtain a daily volume of biogas of 220,76 m^3/day.

To have a dear of the cost of the constructive process and of installation of the system of biodigester of fixed (without considering the manpower) dome, in the Table 7, they are related the materials required for the construction and installation of the technology.

TABLE 4. Flock movement in the productive system of egg-laying Hens Leghorn White during the period of investigation

Mov. of Flock	Initial Existence	Existence Final	Animals/day	Animals / day, kg
Egg-laying hens Leghorn White	2872	2872	2872	1,40

TABLE 5. Sizing of the biodigester of fixed dome

Matter source prevails	Animal / day	Mass Average , kg	Bm, kg/día	Vdm, m^3/d	V_{biodig}, m^3	V_1, m^3	V_2, m^3	V_3, m^3	V_{cf}, m^3	V_{tc}, m^3
Egg-laying hens Leghorn White	2 872	1,4	361,872	0,70	22	14,70	7	0,20	7,00	7,00

TABLE 6. Contribute energy of the animal population

Matter source prevails	Animal/day	Mass Average, kg	Bmd, kg/day	Y, m^3/kg	G, m^3/día
Egg-laying hens Leghorn White	2 872	1,40	361,90	0,61	220,76

TABLE 7. Listing of materials for the construction and installation of the biodigester of fixed dome of 22 m^3 proposed to install and cost

Materials	UM	Quantity	Price unitary **, peso/u	Cost, peso*
Cement	Bags	99	183	18117
Sand	m^3	6,60	160	1056
Gravel (38 mm)	m^3	7,70	200	1540
Block 15 cm	u	528	10	5280
Solid bricks	u	715	8	5720
Steel 3/8	kg	178,20	10	1782
Steel ¼	kg	26,40	12.50	330
Narrow lace edgings	kg	3,30	50	165
Wire of tying cabillas	kg	5,50	25	137.50
Wood for encofrar	m^3	0,33	120	39.6
Excavation	m^3	41,80	25	1045
Filler	m^3	19,80	20	396
Pipes for reception and biogas conduction	Accessories: Unions, elbows, cleaner and paste PVC, closing valves (the quantity varies in function of the distance until the ships)		1 550	1 550
Pipes for supply of it excretes	Tubes of 110 mm (4") (2): 5m/cu		300	300
Total				**37 458.10**

*peso: he/she refers to the national (MN) currency, it is considered the rate of change 25 MN = 1 USD
** Prices of the materials of the construction settled down by the Ministry of Trade Interior (MINCIN) in Cuba

In the case of the variant of the tubular biodigester of polyethylene they are related the materials required for the construction and installation of the technology, in the Table 8, to have a dear of the cost of the constructive process and of installation (without considering the manpower), to have bigger accuracy in the economic values, the main dimensions were determined for a biodigester of 22 m^3, these they are reflected in the Figure 3.

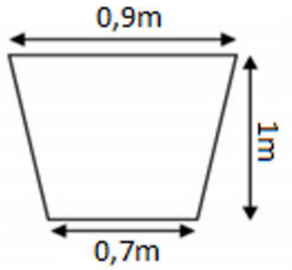
As you it can appreciate in the Table 7 and 8, the cost of these technologies is not high, although they are appreciated difference among both, to achieve a better understanding of the aspects related with the sizing of both technologies, as well as the energy contribution to obtain with the biogas taken place by the introduction of these technological variants, in the Table 9, summary these so much values of design, as energy.

In the case of the biodigester of fixed dome, if it is considered the investment required by concept of materials of the construction, which ascends at a cost of 37 458.10 peso and if this is analyzed in function of the energy saving to be obtained, for example, for concept of gasoline with an equivalent daily production of 176,60 L, starting from the price of this fuel that is equal to 25 peso, one would have a saving of 4 daily 415.20 peso, therefore in one year (being considered 365 days) this saving would be equal to 1 611 548 peso, what evidences that in so single 8,5 days of operation he/she recovers the investment for concept of materials required for the construction and a gain of 1 574 is obtained 018.80. peso in what subtracts of year.

Of equal it forms if he/she is carried out the same analysis, but being considered the electric power saving, starting from potential generation to obtain with the employment of the biogas that ascends daily to 397,36 kWh and taking the rate settled down by the Electric Company in Cuba:

- From 0 kWh up to 100 kWh: 0,33;
- From 101 kWh up to 150 kWh: 1,07;
- From 151 kWh up to 200 kWh: 1,43;
- From 201 kWh up to 250 kWh: 2,46;
- More than 250 kWh: 3,12 for each kWh.

Then one would have a saving monthly average of 37 170 peso, what means an annual equivalent saving to 446 400 peso, being evidenced that in so alone approximately a month and half of operation he/she recovers the investment for concept of materials required for the construction, so 19,8 years of gain they would be had, being kept in mind that the lifespan of a biodigester of fixed dome ascends to the 20 years. These elements demonstrate the economic feasibility of the analyzed proposal.



Dimensions/Wide of the Roll (A_R), m	2
a, m	0,90
b, m	1
p, m	0,70
Long biodigester, m	7

FIGURE 3. Main dimensions of the gutter and the biodigester of tubular of proposed polyethylene.

TABLA 8. Lists of costs of the installation of the tubular biodigester of polyethylene

Materials	UM	Quantity	Price unitary, peso/u	Cost, peso
Polyethylene module	m^3	22	6 250 (for each 10 m^3)	13 750
Excavation	m^3	5,60	25	140
Pipes for reception and biogas conduction	Accessories: Unions, elbows, cleaner and paste PVC, closing valves (the quantity varies in function of the distance until the ships)		1 550	1 550
Pipes for supply of it excretes	Tubes of 110 mm (4") (2): 5m/cu		300	600
Total				**16 040**

TABLE 9. Sizing and energy contribution of the biogás to obtain with the installation of the biodigestion technology

Sizing parameters	Biodigester Fixed Dome	Tubular Biodigester of Polyethylene
V_{biodig}, m^3	22,00	22,00
V_{cf}, m^3	7,00	-
V_{tc}, m^3	7,00	7,00
V_{gas}, m^3	7,00	7,00
Wide of the roll (polyethylene), m	-	2,00
Long of the roll (polyethylene), m	-	7,00
Base superior it settles, m	-	0,90
Base inferior it settles, m	-	0,70
Height of the Gutter, m	-	1,00
Parameters of energy		
Y, m^3/kg	0,61	
G, m^3/day	220,76	
Save Energy Potential starting from the Energy Potential of 1 m^3 of methane (CH_4)		
Electric power, kWh	397,36	
Natural gas, m^3	132,45	
Vegetable coal, kg	66,22	
Wood, kg	596,05	
Gasoline, L	176,60	
Alcohol, L	264,91	
Oil fuel, L	154,53	
Biofertilizers Production, kg/día	11,60	

For the tubular biodigester of polyethylene, the investment required by concept of materials of the construction ascends at a cost of 16 040 peso and if this is analyzed in function of the energy saving to be obtained, alone for concept of gasoline with an equivalent daily production of 176,60 L, starting from the price of this fuel that is equal to 25 peso, one would have a saving of 4 daily 415.20 peso, therefore in one year (being considered 365 days) this saving would be equal to 1 611 548 peso, what evidences that in so single 4 days of operation he/she recovers the investment for concept of materials required for the construction and a gain of 1 595 508 peso is obtained in what subtracts of year; this element demonstrates the economic feasibility of the proposal.

Of equal it forms if he/she is carried out the same analysis, but being considered the electric power saving, starting from potential generation to obtain with the employment of the biogas that ascends daily to 397,36 kWh and taking the rate settled down by the Electric Company in Cuba:

- From 0 kWh up to 100 kWh: 0.33;
- From 101 kWh up to 150 kWh: 1.07;
- From 151 kWh up to 200 kWh: 1.43;
- From 201 kWh up to 250 kWh: 2.46;
- More than 250 kWh: 3.12 for each kWh.

Then one would have a saving monthly average of 37 200 peso, what means an annual equivalent saving to 446 400 peso, being evidenced that he/she recovers the investment for concept of materials required for the construction in so single two weeks of operation, so they would be been approximately 5 years of gain old, being kept in mind that the lifespan of a tubular biodigester of polyethylene ascends to the 5 years. These elements demonstrate the economic feasibility of the analyzed proposal.

It is valid to point out that the correct sizing of this type of technologies propitiates the maximum use of the wastes obtained in the productive scenarios.

As it is evidenced in the Table 9, the biodigesters installation in poultry units constitutes an option energetically viable, to that which he/she would be necessary to add the contribution to the conservation and care of the environment.

So to adopt the biodigestion technology in the system poultry study object it is advisable from the economic point of view the introduction of a tubular biodigester of polyethylene.

With the introduction of this technology it would be possible:

- To generate electric power for the supply and working of: stars, heating and extraction of humid air, for what is required of the acquisition of a generator of biogas of 2 kW of power,
- According to the company China Shenzhen Teenwin Environment Co, the price of these biogas generators oscillates among 550. 1250 USD (13 750.31 250 peso MN)
- Also, it is possible to obtain 11,6 kg / day of biofertilizer that represent a contribution economic newspaper of 145 peso/day (5.8 USD/day), starting from the price of the biofertilizer in the international market that reaches a value of 500 USD/t (12 500 peso/t).

CONCLUSIONS

- To cover the energy demand of the system of poultry production settled down in the Farm "Guayabal" he/she intends the installation of a tubular biodigester of polyethylene due to their low installation costs.
- With the installation of a tubular biodigester of polyethylene of 22 m^3 it is possible to take place 11.60 kg/day of biofertilizers that represent a contribution economic newspaper of 145 peso/day (5.80 USD/day) that constitute an added value.
- With the introduction of the technology of biodigestion proposed anaerobia it is possible to generate electric power for the supply and working of: stars, heating and extraction of humid air.
- The total investment of the proposed technology recovers in a maximum period of 14 days without considering the acquisition of the generator of biogas of 2 kW of power and if it is considered the acquisition of this team, the period of recovery of the investment it would ascend to 32 days.

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