UNIVERSIDADE ESTADUAL DO MARANHÃO – UEMA
CENTRO DE CIÊNCIAS AGRÁRIAS – CCA
CURSO DE AGRONOMIA BACHARELADO

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FEASIBILITY OF BIOGAS PRODUCTION AND CARBON CREDITS SALE FROM IMPLEMENTATION OF ANAEROBIC MANURE TREATMENT SYSTEMS IN SWINE FARMS

SÃO LUÍS – MA
2024

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Artigo científico apresentado ao Curso de Agronomia da Universidade Estadual do Maranhão, para obtenção do grau de Bacharel em Agronomia.

Orientador(a): Prof. Dra. Alana Gandra Lima de Moura

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Moraes, Thyago Diogo Rocha.

Feasibility of Biogas production and carbon credits sale from implementation of anaerobic manure treatment systems in swine farms. / Thyago Diogo Rocha Moraes, Leonardo Victor Moreira Rodrigues Conceição, Raimundo Calixto Martins, Carla Eloísa Diniz Santos, Alana Gandra Lima de Moura. – São Luís(MA), 2024.

14p.

Trabalho de Conclusão de Curso (Curso de Engenharia Agronomica) Universidade Estadual do Maranhão, 2024.

Orientadora: Profa. PhD. Alana Gandra Lima de Moura

biodigestion. 2. swine manure. 3. biomethane. 4. carbon capture. 5. biofertilizer I. Moraes, Thyago Diogo Rocha [et.al.]. II.Feasibility of Biogas production and carbon credits sale from implementation of anaerobic manure treatment systems in swine farms.

CDU: 631:620.92

Elaborado por Luciana de Araújo - CRB 13/445

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Aprovado em: 08/08/2024

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FEASIBILITY OF BIOGAS PRODUCTION AND CARBON CREDITS SALE FROM IMPLEMENTATION OF ANAEROBIC MANURE TREATMENT SYSTEMS IN SWINE FARMS

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Artigo científico redigido de acordo com as normas da revista International Journal of Greenhouse Gas Control.

RESUMO

Swine farming is an activity that demands high water availability, being a cause for concern due to the current growing need for savings and rational use of water in production chains. The adoption of sustainable technologies that mitigate the impacts caused in the final disposal of solid and liquid waste from swine activities is essential. The present study evaluated the potential for generating biogas and carbon credits from "Oriente", a swine farm at the Maranhão mesoregion, proposing a biodigester model, as well as the costs of its implementation, and the economic analysis of this project. It was evidenced the total of 250 animals generate an average of 5.45 m^3 of manure/day. Followed by Volatile Solids (VS) analysis that resulted in an average 309 gVS/L. The Indian biodigester project applied to swine residues treatment demanded 200 m^3 volume capacity. Furthermore, methanogenic potential (PrM) of the biodigester was estimated as 624 m^3/day based on the mass balance of the organic matter measured using volatile solid analyses, resulting in a 4028 KWh/day energy production potential. The carbon capture potential (Mo) of 510 tonCO_2/year was priced in R$ R$13260.00 at carbon credits market. Assessment of Nitrogen composition of the residue resulted in an average of 5.5 gN/kg of sludge, evidencing suitability to C:N ratio for biodigestion as well as biofertilizer further use. Economic feasibility analyses was done with energy gains and the Payback would take 32 days.

Keywords: biodigestion; swine manure; biomethane; carbon capture; biofertilizer.

ABSTRACT

A suinocultura é uma atividade que demanda elevada disponibilidade hídrica, sendo motivo de preocupação devido à atual necessidade crescente de economia e uso racional da água nas cadeias produtivas. A adoção de tecnologias sustentáveis que mitiguem os impactos causados na disposição final dos resíduos sólidos e líquidos da atividade suinícola é essencial. O presente estudo avaliou o potencial de geração de biogás e créditos de carbono da Fazenda "Oriente", uma granja de suínos localizada na mesorregião do Maranhão, propondo um modelo de biodigestor, bem como os custos de sua implantação, e a análise econômica deste projeto. Evidenciou-se que um total de 250 animais geram em média 5,45 m^3 de dejetos/dia. Seguido pela análise de Sólidos Voláteis (VS) que resultou em uma média de 309 gVS/L. O projeto indiano de biodigestor aplicado ao tratamento de resíduos suínos exigiu capacidade volumétrica de 200 m^3. Além disso, o potencial metanogênico (PrM) do biodigestor foi estimado em 624 m^3/dia com base no balanço de massa da matéria orgânica medido por meio de análises de sólidos voláteis, resultando em um potencial de produção de energia de 4.028 KWh/dia. O potencial de captura de carbono (Mo) de 510 tonCO2/ano foi precificado em R$ R$ 13.260,00 no mercado de créditos de carbono. A avaliação da composição de nitrogênio do resíduo resultou em uma média de 5,5 gN/kg de lodo, evidenciando adequação à relação C:N para biodigestão, bem como para uso posterior de biofertilizante. Foram feitas análises de viabilidade econômica com ganhos de energia e o Payback levaria 32 dias.

Palavras-chave: biodigestão; esterco de suínos; biometano; captura de carbono; biofertilizante.

1.Introduction

Swine production sector has been growing in Brazilian scenario, currently the country is considered the 4th largest producer of pork in the world, with approximately 41.3 million heads per year (ABPA, 2017, USDA, 2024). During pork production process significant quantities of solid and liquid waste are generated, coming from manure, urine, drinking fountains, scraping, cleaning of stalls, cages and other facilities on the swine farm (DE LUCA and HUSSAR, 2017).

Swine farming is an activity that demands high water availability, being a cause for concern due to growing need for savings and rational use of water in production chains (ITO et al., 2016). It is estimated that the daily consumption of a pig in a full-cycle conventional production system is 72.9 L/animal/day (FATMA, 2014), so the volume of water consumed by the animals has a direct relationship with the amount of waste generated during production. On average, an adult pig produces 0.27 m^3 of waste/month. Sows in the lactation period can generate 18kg/day and produce 27 L of liquid waste/day (FERNANDES, 2012). The waste contains components with high agronomic and polluting potential such as Nitrogen (N), Phosphorus (P) and Heavy Metals such as Zinc (Zn) and Copper (Cu), which, when not properly managed, can damage the environment and human health.

Pig manure contains ammonium carbamate ($H_2NCOONH_4$) which dissociate into gases rich in ammonia (NH_3) and carbon dioxide (CO_2) (LOPES et al., 2016). In addition to these, Nitrous Oxide (N_2O), Nitrogen (N_2) and Ammonia (NH_3) are generated from the decomposition of waste and are among the main gases causing the greenhouse effect (ITO et al., 2016).

In this matter, swine farming waste release causes eutrophication and nitrification of soil, in addition to eutrophication of water. Then, adoption of sustainable technologies that mitigate the impacts caused in the final disposal of solid and liquid waste from swine activities is essential. The implementation of anaerobic biodigesters is a viable and promising alternative to adequate animal waste treatment allied with renewable energy production (ALBUQUERQUE, 2022). It is an easy-to-implement technology, in which waste is subjected to a decomposition process in an environment without oxygen (anaerobiosis), generating a final product composed mainly of methane (CH_4) and carbon dioxide (CO_2), transforming the organic matter generated by animals into alternative energy such as natural gas (biogas) and biofertilizers. Various types of waste can be used in biodigesters: pigs, cattle, goats, poultry, therefore it can attend different types of rural producers (COLDEBELLA et al., 2006).

Furthermore, the adoption of an anaerobic system reduces the emission of methane into the atmosphere, which is considered an extremely polluting gas, being responsible for around 20% of global warming on the planet (CENBIO, 2008). Another positive aspect of this technology is the possibility of generating revenue through the sale of carbon credits resulting from the non-release of greenhouse gases into the atmosphere (MONTEIRO et al., 2015). Therefore, the use of biodigesters on rural properties and its consequent energy production combined with the sale of carbon credits can increase the income of rural producers, promoting greater sustainability in animal production and environmental conservation.

The present study evaluated the potential for generating biogas and carbon credits from a swine farm at the Maranhão mesoregion, proposing a biodigester model, as well as the costs of its implementation, and the economic analysis of this project.

2. Material and Methods

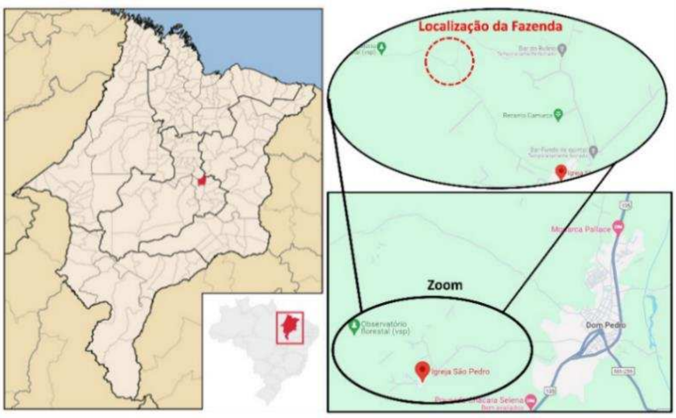
This is an exploratory descriptive study with a quantitative approach and qualitative bias as recommended by SHITSUKA, PARREIRA AND SHITSUKA (2018). The study was developed in six stages:

- Stage I - Indian biodigester project applied to swine residues treatment;
- Stage II - Methanogenic potential of the biodigester was estimated based on the mass balance of the organic matter measured using volatile solid analyses of the Oriente Farm collected samples;
- Stage III – Energy potential was estimated using Stage II method of biogas production;
- Stage IV - Carbon capture potential was priced in the carbon credits market;
- Stage V - Kjeldahl Nitrogen and agronomic potential of biodigester sludge was assessed;
- Stage VI - Economic feasibility analyses was realized.

2.1. Swine farm characterization

The manure samples were collected in the rural establishment Oriente Farm, (5°02'28.7"S 44°29' 3 6.6"W), located in the municipality of Dom Pedro - central mesoregion of Maranhão State - Brazilian northeast (Figure 1).

Figure 1. Oriente Farm locality



The feed offered to the pigs is produced on the property, which has mixers, a corn grain crusher and a threshing machine. Animal feed composition is described in Table 1.

Table 1. 500 kg of Oriente Farm animal feed composition

Component	Quantity (kg)
Corn	360
Soybean meal	50
Babaçu meal	100
Nucleus*	12.5
Salt (NaCl)	1
Supplement**	1

*Combination of highly digestible fat, protein and lactose

**Combination of Mineral, Vitamin and Amino acid

Waste composition used to calculate waste production average value was based on Oliveira 2003 study. The farm has a rotation of 250 animals belonging to the *Pietrain* and *Piau* breed, swine herd is described at Table 2. Piglets are sold at the "*Só Suinos*" local butcher shop and confined production system was adopted by the property. The construction site has two masonry sheds, equipped with pacifiers to animals watering.

Table 2. Average waste in different phases of production on swine farms (Oliveira 2003) applied to Oriente Farm swine herd

Category	Quantity	Waste production (m^3/animal . day)	Waste production (m^3/day)
Swine (25 - 100 kg)	155	0.0270	4.1850
Pregnant sows	30	0.0162	0.4860
Sows and piglets	27	0.0270	0.7290
Nursery piglets	38	0.0014	0.0532
			Total: 5.4532

2.2. Indian biodigester project

According to FONSECA et al. (2009), for the appropriate dimensioning of the biodigester capacity, it is possible to use a practical calculation method (Equation I), as long as the daily load of organic matter placed in the digester and the retention time are considered:

$$VB = VC \times TRH \quad \text{(Equation I)}$$

Where,
VB = biodigester volume (m^3);
VC = daily afluent rate (organic matter + water) (m^3/day),
TRH = hydraulic retention time (days).

The implementation of a continuous flow Indian model biodigester will be proposed, taking into account the large volume of organic matter load from swine activity. The Indian model biodigester can be described as a vertical cylinder, built with bricks and internally coated with waterproofing cement, with a longitudinal wall that divides it into two chambers. In one of these chambers, the biomass inlet tube is connected, and in the other, the outlet tube. This biodigester is characterized by having a floating bell as a gasometer made of steel sheet (NISHIMURA, 2009).

The Indian biodigester has its dome generally made of iron or fiber. The fermentation process is accelerated, as it takes advantage of the soil temperature, which varies little, favoring the action of bacteria. It also takes up little space and, as the construction is underground, it does not require the use of reinforcements, such as concrete straps.

2.3. Specific biogas production potential using volatile solids analyses

Five samples of swine waste were collected at Oriente Farm to realize solid concentration analyses and determine biogas potential of this specific residues. Samples identifications are described in Table 3.

Table 3. Identification of swine residues samples collected at Oriente Farm

Sample	Identification
1	Collected from pregnant sows
2	Collected from male swine – Pietran breed
3	Collected from general swines category
4	Mixture of samples 1, 2 and 3
5	Collected from old sludge mixture disposed in soil

Estimating the amount of gas from the reduced volatile solids (VS) concentration is a widely used method. The VS concentration varies according to the substrate, whether vegetable or animal, VS content in dairy cattle is 33.17% of fixed solids (Amaral et al., 2004). Thus, one ton of volatile solids is capable of producing an average of 400 m^3 of CH_4 (Bahr et al., 2006). The concentration of total volatile solids in the biodigester influent was measured according to APHA, 2012 and analyses was realized at Soil Laboratory and Maranhao State University (UEMA).

Potential daily biomethane production was estimated using KUNZ AND OLIVEIRA (2006) methodology. Which involves the maximum production capacity of methane and volatile solids (respectively, B_0 and VS) and the volume of waste produced daily, according to Equation II. The values for maximum theoretical methane production capacity used on this study (B0 = 0.37 m^3 of CH_4/kg) was obtained from CIbiogás – ER (2015).

$$PrM = B_0 \times VS \times Q \quad \text{(Equation II)}$$

Where,

PrM = Methane production (m^3/day);

B_0 = Theorical maximum capacity of methane production from swine residues (m^3/kg);

VS = Volatile solids concentration (g/L);

Q = total volume of waste produced (m^3/day).

Additionally, using the conversion parameter of C°≈1,67 it was also possible to estimate the biodigester Biogas Production (PrB) as described in Equation III (KUNZ AND OLIVEIRA, 2006):

$$PrB = PrM \times C^{\circ} \quad \text{(Equation III)}$$

Where,

PrB = biogas production (m^3/day);

PrM = Methane production (m^3/day);

C° = Conversion coefficient (≈1,67).

2.4. Energy generation potential of biogas

Energy generation potential of biogas is approximately 6.45 KWh/m^3 and for treated gases this value rises to 9.50 KWh/m^3 (COLDEBELLA et al., 2008). To obtain the energy potential of biogas Equation IV was used:

$$E = MG \times 6.45 \quad \text{(Equation IV)}$$

Where,

MG = CH_4 generated in the biodigester (m^3/day);
E = Energy generation potential (KWh).

Furthermore, considering the price of KW/h in Maranhao State of R$ 0.56091 (Equatorial, 2019). In this matter, the money saved from energy cost reduction was estimated according to Equation V, as follows:

$$EE = E \times 0.56091 \quad \text{(Equation V)}$$

Where,
EE = Energy saving (R$);
E = Energy produced by biodigester (KWh/m^3).

2.5. Carbon credits sale potential

Carbon credit sales was estimated in accordance with BRAZIL 14590/2023 and the international stock market. In addition to the biodigester, the sale of credits that can be added when using the legal reserve that maintains vegetation in the transition area between Cerrado, Legal Amazon and Caatinga was also calculated.

The new quantitative model to estimate carbon credits in Brazilian swine farming was obtained using simple linear regression techniques and the physical ideal gas model of the Boyle and Gay-Lussac laws, which allowed the temperature and average pressure of the location to be taken into account. Thus, the following equation was obtained as a result, considering the climatic peculiarities of Brazilian northeast region. It is clear that Equation VI incorporates the principle of parsimony, since it use only three decision variables, two of which are related to the region's climatic conditions and easy monitoring (Duarte e Vieira, 2014).

$$Mo = 90.7 \times (Q_e \times P_1/T_1) \quad \text{(Equation VI)}$$

Where,
M_o = Carbon dioxide (ton/year);
Qe = Swine farm waste production (kg/day);
P_1 = Atmospheric pressure (atm);
T_1 = Temperature (K).

2.6. Kjeldahl Nitrogen and agronomic potential of biodigester sludge

The concentration of total Kjeldahl Nitrogen in the biodigester influent was measured according to APHA, 2012 and analyses was realized at Soil Laboratory and Maranhao State University (UEMA).

2.7. Economic feasibility

The economic analysis consisted of all expenses involved in initial investment, operation and maintenance estimation. Payback means return on investment, that is, how long it will take for the initially invested capital to be recovered. Payback was calculated for energy gains as described by Equation VII.

$$PB = II/\Sigma FC_{year} \quad \text{(Equation VII)}$$

Where, II = Initial investment (R$) and FC = cash flow per year (R$).

3. Results and discussion

3.1. Indian biodigester project

In order to dimension the biodigester capacity, the practical calculation method was used (FONSECA et al. 2009), based on the organic matter load placed in the digester of 5.4532 m^3/day (Table 2) multiplied by the retention time hydraulic system for 35 days reaching the required volume of 190,863 m^3. Which, for security reasons, was approximated to a total volume capacity of 200 m^3.

$$VB = VC * TRH = 5.4532\ m^3/day * 35\ days = 190.863\ m^3 \cong 200\ m^3$$

3.2. Specific biogas production potential using volatile solids analyses

The composition of swine manure varies depending on the amount of water used in the facilities, type of food and age of the animals, with the most complete composition of liquid waste being in the growing and finishing phase (Tobias, 2002). The average solids concentration obtained in the samples collected at Oriente Farm are described in Table 5. The percentage of organic matter in total solids of swine manure ranged from 55 to 93%. It is important to highlight that the lower concentration of carbonaceous matter in sample 5 was expected, as it is an old residue that besides partial degradation, also suffered contamination from other sources when disposed in the soil. Furthermore, the highest concentration of carbonaceous matter was obtained in sample 2, collected from breeding male animals. In general, the average of 78% carbonaceous matter of the residue indicates a satisfactory concentration to carry out the biodigestion of this type of substrate (MITO et al., 2018).

Table 5 – Total and Volatile Solids results from swine residues samples collected at Oriente Farm

Sample	Total Solids -TS (g/L)	Volatile Solids – VS (g/L)	Volatile Solids – VS (%)
1	379.67	312.33	82.26
2	418.00	391.00	93.54
3	397.00	286.67	72.21
4	390.67	335.67	85.92
5	401.67	222.00	55.27
Average	397 ± 14	309 ± 62	78 ± 15

Using the average of 309 g/L of VS described on Table 5, average daily production of methane by the Indian biodigester was calculated as follows:

$$PrM = B_0xSVxQ = 0.37\ m^3CH_4/kg\ x\ 309.5\ g/L\ x\ 5.4532\ m^3/day = 624.47\ m^3/day$$

Derived from above estimative and considering that approximately 60% of biogas is composed by biomethane, average biogas production (PrB) was also estimated:

$$PrB = PrM\ x\ C° = 624.47\ m^3/day\ x\ 1.67 = 1042.9\ m^3/day$$

3.3. Energy generation potential of biogas

Biogas has a high calorific value and, as it is a complete combustion process, it releases a large amount of energy. After eliminating all carbon dioxide, its calorific value can reach approximately 12kcal/m^3 (Vieira et al., 2016). According to methane percentage, the average energy generation potential of biogas from swine manure biodigestion is 6.45 KWh/m^3 (COLDEBELLA et al., 2008). On this study, with average Methane production of 624.47 m³/day, potential energy generation would be 4027.83 KWh/day. It is important to notice that more accurate values for electricity production depend on the generator to be installed and the gas consumption for generation (DA SILVA et al., 2021).

$$E = MG \times 6.45 = 624.47 \times 6.45 = 4027.83 \text{ KWh/day}$$

Furthermore, the estimated reduction in energy bills was obtained multiplying the amount of energy produced by the Maranhão KWh price (R$ 0.56091), resulting in an estimated revenue of R$ 2259.26 in electrical energy generated.

$$EE = E \times 0.56091 \text{ R\$/KWh} = 4027.83 \text{ KWh/day} \times 0.56091 \text{ R\$/KWh} = 2259.25 \text{ R\$/day}$$

3.4. Carbon credits sale potential

Swine farm waste production in kg/year (Qe) was estimated using total waste production of 5.4532 m³/day described in Table 2 multiplied by VS average concentration described on Table 5 of 309.5 g/L = 309500 g/m³. Therefore,

$$Qe = 5.4532 \text{ m}^3\text{/day} \times 309500 \text{ g/m}^3 = 1687765 \text{ g/day} \cong 1689 \text{ kg/day} \quad \text{(Equation VIII)}$$

The Brazilian National Institute of Meterology (INMET) database was used to collect information such as annual average temperature and atmospheric pressure in the city of Dom Pedro-Maranhao-Brazil (Table 6). The amount of carbon dioxide not released to atmosphere was 186108 tonCO_2/year as follows:

$$Mo = 90.7 \times (Q_e \times P_1/T_1) = 90.7 \times (1689 \times 0.999753/300.15) \cong 510 \text{ tCO}_2\text{/year}$$

Table 6: INMET environmental parameters and volume of carbon dioxide not released to atmosphere

Swines (Units)	Waste (kg/day)	Anual Average Temperature (K)	Pressure (atm)	Mo (tCO_2/year)
250	1689	300.15	0.999753	510

Currently, the average value of a ton of carbon credit according to the Brazilian Carbon and Methane Credit Association (Abcarbon) is US$5, around R$26.00 and can vary between US$1.20 - 40, in specific circumstances. Therefore, based on the estimated values for Mo of 510 tonCO2/year, it amounts to an equivalent R$13260.00 in credits annually.

3.5. Kjeldahl Nitrogen and agronomic potential of biodigester sludge

Nitrogen composition of swine residues was evaluated for two reasons: (a) as it influences on biodigestion efficiency such is a macronutrient and (b) the sludge generated after decomposition is a potential biological fertilizer to replace synthetic products. Table 7 describes values obtained for Nitrogen concentration on swine residues samples collected at Oriente farm. The production of manure per day for the Oriente farm was evaluated at ~1690 kg/day (Equation VIII), taking into account that for 1 kg of sludge would contain ~5.5 g of Nitrogen, the total waste per day would be approximately 9 kg of Nitrogen.

Table 7: Nitrogen concentration on swine residues samples collected at Oriente Farm

Sample	Nitrogen (g/kg)
1	5.33
2	5.89
3	5.39
4	5.25
5	0.93

Swine manure presents 40 to 70% of the total Nitrogen in the ammonium form (Scherer et al., 1996). Samples 1,2,3,4, being collected directly from swine bays, present high N availability (average 5.5g/kg). A factor associated with higher N values is the volume of plant residues that are not digested by the animals, promoting higher levels of organic carbon, which in turn imply greater availability of Nitrogen (DORTZBACH, et al. 2013).

In sample 5, where the manure was collected directly from the soil, Nitrogen concentration value was lower (0.93g/kg) when compared to the other four samples (5.25-5.89 g/kg). Probably, the Nitrogen, in its ammonia form, was easily lost through ammonia volatilization. Furthemore, as an "old" residue, it was susceptible to microbial transformations of nitrification and immobilization, increasing possible losses through leaching. The volatilization of NH_3 has several negative effects on the environment, with emphasis on soil and water acidification, eutrophication of water sources and indirect emission of nitrous oxide (MORAES et al., 2014).

The biofertilizer quality is determined by the amount of organic and inorganic matter contained in substrates. Anaerobic microorganisms consume only organic matter in the biodigestion process. Inorganic matter, such as nitrogen, becomes available in the biodigester, and is converted into ammonium and nitrates, which remain in the biodigester until the end of the biodigestion process. Therefore, the biofertilizer has ammonium and nitrogen compounds directly available, providing a better rate of nitrogen fixation by some soil microorganisms and solubilized nutrients for absorption by plants (MUKHUBA et al., 2018).

Noteworthy, anaerobic biodigestion effluents as biofertilizer in agricultural areas will only be appropriate and/or accepted if health safety is guaranteed. In general, the application of biofertilizer must follow the established fundamental principles of fertilizer management and soil fertility, for a significant reduction of pathogens, such as resolution no. 375/2006 of the National Environmental Council - CONAMA.

3.6. Economic feasibility

Table 8 – Indian biodigester implementation costs according to total volume (Source: CALZA et al. 2015)

Capacity (m³)	Cost (R$)
20	5065.70
40	7099.30
60	9440.20
80	11047.90
100	12486.30
120	14178.60

Considering total capacity of 200m³ required by Oriente Farm swine residues, as described in item 3.1, the implementation of two Indian biodigesters with a capacity of 100 m³ will be suggested, which has an approximate cost of 2*12,486.30 = 24972.60 ~R$25000.00.

According to the biogas generation capacity, it was proposed to use a diesel cycle motor generator for electrical generation, due to its robustness, lower maintenance costs and ease of adaptation to feed with biogas.

To calculate the depreciation of this biodigestion and energy generating plant, a rate of 10% p.a was applied, in accordance with SRF° Normative instruction no. 162, of December 31, 1998. (RECEITA FEDERAL DO BRASIL, 2012). For energy gains, according to Simple PayBack, the initial investment for the biodigester and motor generator plant takes 32 days. Besides, for discounted PayBack, 35 days.

4. Conclusion

The results obtained highlight that investment in anaerobic biodigestion treatment systems for swine waste generates important opportunities for generating revenue and increasing the income of rural producers together with the treatment of polluting waste through environmental and social benefits.

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ANEXOS

International Journal of Greenhouse Gas Control

FEASIBILITY OF BIOGAS PRODUCTION AND CARBON CREDITS SALE FROM IMPLEMENTATION OF ANAEROBIC MANURE TREATMENT SYSTEMS IN SWINE FARMS

--Manuscript Draft--

Manuscript Number:	
Article Type:	Full Length Article
Keywords:	biodigestion; swine manure; biomethane; carbon capture; biofertilizer
Corresponding Author:	Alana Moura Federal University of Maranhao BRAZIL
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	Carla Eloísa Diniz Santos
Abstract:	Swine farming is an activity that demands high water availability, being a cause for concern due to the current growing need for savings and rational use of water in production chains. The adoption of sustainable technologies that mitigate the impacts caused in the final disposal of solid and liquid waste from swine activities is essential. The present study evaluated the potential for generating biogas and carbon credits from “Oriente”, a swine farm at the Maranhão mesoregion, proposing a biodigester model, as well as the costs of its implementation, and the economic analysis of this project. It was evidenced the total of 250 animals generate an average of 5.45 m3 of manure/day. Followed by Volatile Solids (VS) analysis that resulted in an average 309 gVS/L. The Indian biodigester project applied to swine residues treatment demanded 200 m3 volume capacity. Furthermore, methanogenic potential (PrM) of the biodigester was estimated as 624 m3/day based on the mass balance of the organic matter measured using volatile solid analyses, resulting in a 4028 KWh/day energy production potential. The carbon capture potential (Mo) of 510 tonCO2/year was priced in R$ R$13260.00 at carbon credits market. Assessment of Nitrogen composition of the residue resulted in an average of 5.5 gN/kg of sludge, evidencing suitability to C:N ratio for biodigestion as well as biofertilizer further use. Economic feasibility analyses was done with energy gains and the Payback would take 32 days.
Suggested Reviewers:	Euloglio Galiano University of Jaén ecastro@ujaen.es Dr. Euloglio Castro Galiano could be considered referee of this article because he works, among other areas, with anaerobic digestion, one of the issues researched in this paper.
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Dear Editor,

Please find attached the original research paper entitled: " FEASIBILITY OF BIOGAS PRODUCTION AND CARBON CREDITS SALE FROM IMPLEMENTATION OF ANAEROBIC MANURE TREATMENT SYSTEMS IN SWINE FARMS", which we are submitting for publication in the International Journal of Greenhouse Gas Control. The reasons why we believe it deserves to be published are derived from the following features:

i) To our knowledge, this manuscript is the first report that numerically evidences how carbon credits sale allied to biogas production would modify swine farms economic reality;

ii) Volatile solids composition of old swine residues demonstrated how the implementation of manure treatment systems must happen as quickly as possible

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The graphical abstract should summarize the contents of your article in a concise, pictorial form which is designed to capture the attention of a wide readership. A graphical abstract will help draw more attention to your online article and support readers in digesting your research. Some guidelines:

- Submit your graphical abstract as a separate file in the online submission system.
- Ensure the image is a minimum of 531 x 1328 pixels (h x w) or proportionally more and is readable at a size of 5 x 13 cm using a regular screen resolution of 96 dpi.
- Our preferred file types for graphical abstracts are TIFF, EPS, PDF or MS Office files.

We encourage you to view example graphical abstracts and read about the benefits of including them.

Units, classifications codes and nomenclature

This journal requires you to use the international system of units (SI) which follows internationally accepted rules and conventions. If other units are mentioned within your article, you should provide the equivalent unit in SI.

Tables

Tables must be submitted as editable text, not as images. Some guidelines:

- Place tables next to the relevant text or on a separate page(s) at the end of your article.
- Cite all tables in the manuscript text.
- Number tables consecutively according to their appearance in the text.
- Please provide captions along with the tables.
- Place any table notes below the table body.
- Avoid vertical rules and shading within table cells.

We recommend that you use tables sparingly, ensuring that any data presented in tables is not duplicating results described elsewhere in the article.

Figures, images and artwork

Figures, images, artwork, diagrams and other graphical media must be supplied as separate files along with the manuscript. We recommend that you read our detailed artwork and media instructions. Some excerpts:

When submitting artwork:

- Cite all images in the manuscript text.
- Number images according to the sequence they appear within your article.
- Submit each image as a separate file using a logical naming convention for your files (for example, Figure_1, Figure_2 etc).
- Please provide captions for all figures, images, and artwork.
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Artwork formats

When your artwork is finalized, "save as" or convert your electronic artwork to the formats listed below taking into account the given resolution requirements for line drawings, halftones, and line/halftone combinations:

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To foster transparency, you are required to state the availability of any data at submission.

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Please provide definitions of field-specific terms used in your article, in a separate list.

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We ask you to use the following format for appendices:

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References

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Any references cited within your article should also be present in your reference list and vice versa. Some guidelines:

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- Use of DOIs is recommended.

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Citations can be made directly (or parenthetically). Groups of references can be listed either first alphabetically, then chronologically, or vice versa. Examples: "as demonstrated (Allan, 2020a, 2020b; Allan and Jones, 2019)" or "as demonstrated (Jones, 2019; Allan, 2020). Kramer et al. (2023) have recently shown".

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Abbreviate journal names according to the List of Title Word Abbreviations (LTWA).

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Van der Geer, J., Handgraaf, T., Lupton, R.A., 2020. The art of writing a scientific article. J. Sci. Commun. 163, 51–59. https://doi.org/10.1016/j.sc.2020.00372.

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Van der Geer, J., Handgraaf, T., Lupton, R.A., 2022. The art of writing a scientific article. Heliyon. 19, e00205. https://doi.org/10.1016/j.heliyon.2022.e00205.

Reference to a book:

Strunk Jr., W., White, E.B., 2000. The Elements of Style, fourth ed. Longman, New York.

Reference to a chapter in a book:

Mettam, G.R., Adams, L.B., 2023. How to prepare an electronic version of your article, in: Jones, B.S., Smith, R.Z. (Eds.), Introduction to the Electronic Age. E-Publishing Inc., New York, pp. 281–304.

Reference to a website:

Cancer Research UK, 2023. Cancer statistics reports for the UK. http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/ (accessed 13 March 2023).

Reference to a dataset:

Oguro, M., Imahiro, S., Saito, S., Nakashizuka, T., 2015. Mortality data for Japanese oak wilt disease and surrounding forest compositions [dataset]. Mendeley Data, v1. https://doi.org/10.17632/xwj98nb39r.1.

Reference to software:

Coon, E., Berndt, M., Jan, A., Svyatsky, D., Atchley, A., Kikinzon, E., Harp, D., Manzini, G., Shelef, E., Lipnikov, K., Garimella, R., Xu, C., Moulton, D., Karra, S., Painter, S., Jafarov, E., & Molins, S., 2020. Advanced Terrestrial Simulator (ATS) v0.88 (Version 0.88) [software]. Zenodo. https://doi.org/10.5281/zenodo.3727209.

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- All references in the article text are cited in the reference list and vice versa.
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