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DOG WASTE IN BIOGAS PRODUCTION

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Abstract: In Brazil, there is an increase in the number of pets, among which dogs are the most sought after. The increase in the number of pets also contributes to the increase in waste generation. The anaerobic biodigestion of these wastes is an alternative for obtaining biogas and environmental protection. Adequate environmental management and established guidelines for the disposal of animal waste are necessary for sustainable development and improved quality of life. The objective of this work was to carry out the anaerobic co-digestion of mixed breed dog waste (SRD) with cattle waste, in batch biodigesters to obtain biogas. After 7 days of operation of the biodigesters, biogas production was observed, but this subsequently ceased, indicating some inhibition that needs to be studied in future work.
Keywords: Solid Waste. Methane. Animal Waste. Environment. Health.

INTRODUCTION AND BIBLIOGRAPHIC REVIEW

In Brazil, there has been an increase in the number of pets, driven mainly by the need for companionship during the pandemic. In 2022, the pet market, involving medical care and food, generated approximately 42 billion reais in revenue in Brazil. And among pets, dogs stand out, with an estimated population of 67.8 million in 2022 (ABINPET, 2023).

The advantages of having a pet are well established through scientific studies. The presence of a dog helps reduce levels of loneliness, stress, anxiety and blood pressure, as well as promoting social contact and physical activity (MD SAÚDE, 2023).

Despite these benefits, dogs, like other animals, present a risk of zoonoses, especially for people with weakened immune systems (MD SAÚDE, 2023). The increase in the number of pets also contributes to the increase in waste generation. For example, a single dog can produce an average of 140 g to 340 g of waste per day, depending on the size of the animal (MARTÍNEZ-SABATER et al., 2019).

After reviewing the literature, it was observed that there are no programs or actions to use dog waste and few studies are focused on the area of environmental impacts and sustainability when it comes to managing dog waste in Brazil. Typically, dog and cat waste in cities is discarded with household waste or abandoned in the environment and can cause environmental impacts and risks to public health (DINIZ, 2021). But there are already some applications for producing biogas from dog waste, such as the parks in the city of Cambridge, Massachusetts, which are already equipped with anaerobic digestion technology, and the methane generated keeps the park lights up. lit (PARK SPARK, 2023)

Dog waste contains an average of 0.7% nitrogen, 0.25% P2O5 and 0.02% K2O (based on fresh mass). The percentage of the composition of solid cow excrement is equal to 83.2% water, 14% organic matter, 0.3% nitrogen, 0.17% phosphorus, 0.1% potassium and 0.1 % calcium. At 50% humidity, the average Carbon (mass)/Nitrogen (mass) ratio of cattle manure is approximately 12. According to (Campos 1997), the amounts of NPK nutrients (nitrogen, phosphorus and potassium) vary from 4.6 at 5.10 kg per cubic meter, for cattle waste. In comparison, fresh cattle manure contains 40% more nitrogen, the same amount of P2O5 and 1/20th the amount of K2O. Dog waste has an excess of total nitrogen (NT) in relation to total organic carbon so that aerobic or anaerobic self-degradation will not occur autonomously and it is necessary to mix it with other waste rich in carbon (MARTÍNEZ-SABATER et al., 2019). The food the dog consumes has a strong influence on the characteristics of the feces it produces. Therefore, owners seek to provide dogs with quality food, which in addition to nourishing, promotes health and results in less bulky, more consistent and less fetid feces (FÉLIX, 2009).

Until then, the exposed ways of disposing of dog and cat waste do not present an environmentally and sanitary acceptable option in Brazil, and may present potential major polluters depending on the animals' hygiene and health habits, as well as food. However, there are treatments for this waste that mitigate the problems generated, and even add value to the waste, as opposed to what happens when it is allocated to a landfill. These treatments are anaerobic co-digestion and composting (DINIZ, 2021).

Therefore, the objective of this work was to carry out the anaerobic co-digestion of mixed breed dog waste (SRD) with cattle waste, in batch biodigesters to obtain biogas.

REVIEW OF LITERATURE

DOG WASTE

The unbridled increase in the number of these pets in urban centers, especially dogs and cats that are multiparous species, as well as their causes and consequences, has not been followed, with due attention, by the population or even by public authorities (LOPES JÚNIOR, 2016). According to Van der Wel (1995) cited by LOPES JÚNIOR (2016), one gram of dog feces contains 23 million fecal coliform bacteria, almost double those found in human feces.

The waste generated by dogs and cats can be very varied, depending on the owners' choices. There are basically 3 destinations for waste generated by domestic animals (DINIZ, 2021):

1) Leave it outdoors: in the backyard, street corner, park, among others;

2) Sewage: When waste is deposited in the toilet or wastewater originating from cleaning toilet rugs;

3) Trash: In the vast majority of Brazilian municipalities, landfills are destined for landfills.

Regarding legislation, there are several initiatives from municipalities, seeking to regulate mainly the collection of waste produced by dogs and cats, on public roads. For example, the municipality of Florianópolis, through Complementary Law 094/2001 which provides for the control and protection of animal populations, in Article 14 indicates that it is the responsibility of the owners to maintain the animals in perfect housing and feeding conditions, health and well-being, as well as the measures relevant to the removal of waste left by them on public roads. The same occurs in the municipality of São Paulo, where in Law Number 13,131, May 18, 2001, which indicates in Article 16, that the driver of an animal is obliged to collect the fecal waste eliminated by the same on public roads and places.

Global pollution prevention objectives, as well as important issues related to human and animal health and food safety, require increasingly sustainable solutions for the treatment and recycling of animal manure and organic waste.

The large quantities of animal manure and slurry currently produced by the livestock sector, as well as wet organic waste streams, represent a constant risk of pollution with a potential negative impact on the environment if not managed optimally. To prevent greenhouse gas (GHG) emissions and the leaching of nutrients and organic matter into the natural environment, it is necessary to close the cycles from production to use through optimized recycling measures. Therefore, anaerobic digestion can be an alternative for energy production, for example.

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ANAEROBIC DIGESTION

The anaerobic digestion process in biodigesters is an alternative for the production of biogas, which can be converted into thermal or electrical energy through the thermal oxidation of methane (CH4).

Anaerobic digestion is a biological stabilization process in which different types of microorganisms, in the absence of molecular oxygen, promote the transformation of complex organic compounds into simpler products such as methane and carbon dioxide. All microorganisms involved in anaerobic digestion are specialized and each group acts in specific reactions (CHERNICHARO, 2007).

Anaerobic digestion (AD) has the stages of hydrolysis, acidogenesis, acetogenesis and metagenesis, as described by Chernicharo (2007) (Figure 1).

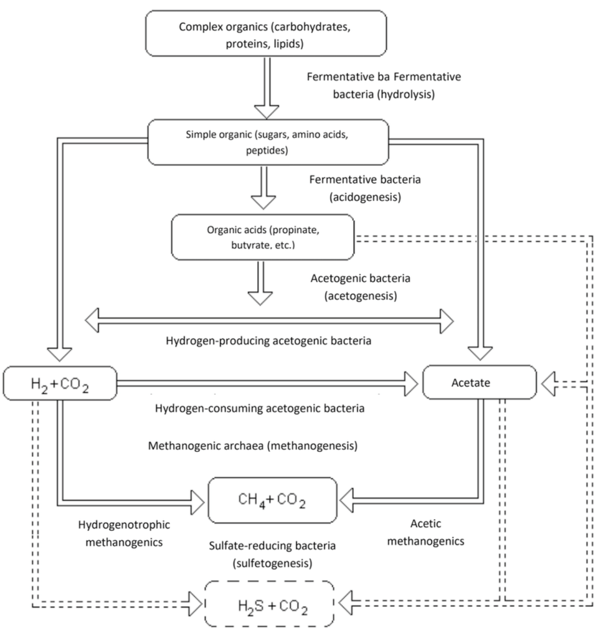

FIGURE 1: Sequence of processes in the anaerobic digestion of complex macromolecules (Source: Adapted CHERNICHARO, 2007)

Biogas can be produced from almost all types of biological raw materials, including those from primary agricultural sectors and various organic waste streams from society in general. The largest resource is represented by manure and animal slurry from cattle and pig production units, as well as poultry, etc. (MENZI, 2002). It is possible to correlate chemical oxygen demand (COD) with biochemical oxygen demand (BOD). This is advantageous, as the COD is determined in just three hours, whereas the BOD determination takes five days.

BRAILE & CAVALCANTI (1993) consider a residue to be easily biodegradable, when its chemical and biochemical oxygen demands present a COD/BOD ratio < 2 (BRANCO & HESS, 1975; CENTURIÓN & GUNTHER, 1976; SCHROEDER, 1977).

In this case, the biogas obtained from the anaerobic decomposition of organic matter is considered a renewable biofuel, consisting mainly of methane (CH4) and carbon dioxide (CO2). Methane, the main gas present in biogas, is a gaseous fuel with a high calorific value of around 50 to 80% (FREITAS, 2019).

The use of biogas for energy use has a great impact on the local economy, as there is the decentralization of energy generation, which must be measured in kilowatt hours, on environmental health and local microeconomic development (BLEY JUNIOR, 2009).

KUCZMAN et al. (2011) also highlights that biogas systems lead to environmental gains due to the indirect benefit of soil management and product manipulation.

In the first step, complex organic substances that cannot be directly used by bacteria are broken down into soluble monomers with the help of extracellular enzymes from hydrolytic bacteria. In acidogenesis, fermentative bacteria convert soluble monomers into terminal products, such as volatile fatty acids (VFA), accompanied by the production of biomass. In the third step, hydrogen-producing acetogenic microorganisms metabolize the hydrolyzed byproducts into acetic acid with the yield of hydrogen and carbohydrate. Finally, acidification products (such as acetic acid, formic acid, CO2/H2, etc.) are transformed into methane by strictly anaerobic methanogenic microorganisms.

RESEARCH METHODOLOGY

Four biodigesters were assembled (B1, B2, B3 and B4), with volumes of 2.8 L, as illustrated in Figures 3 and 4. Biodigesters B1 and B2 received only dog waste and in biodigesters B3 and B4, the co-digestion of dog waste and livestock waste.

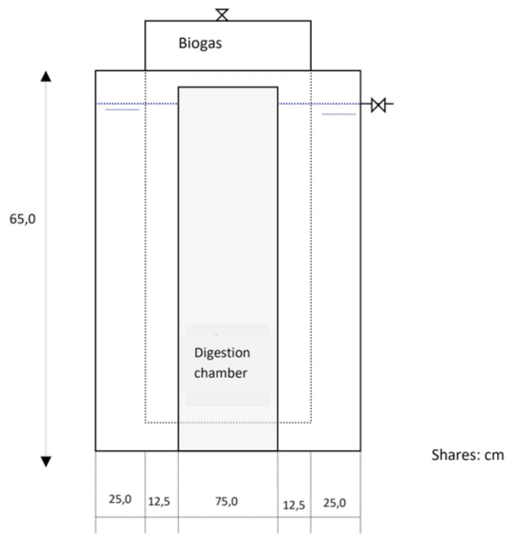

Figure 3. Scheme of biodigesters used for the production of biogas from dog waste and co-digestion of dog waste and cattle waste.

To carry out this experiment, waste was collected from adult dogs that lived in a kennel in the city of Ribeirão Preto and ate only food. Cattle waste was collected in the milking parlor at Unesp in Jaboticabal. The cattle were kept on pasture and during milking they received feed.

Biodigesters B1 and B2 received a mixture of 440 grams of dog waste and 1900 ml of water. Dog waste was mixed with water before being introduced into the biodigesters.

Biodigesters B3 and B4 received a mixture of 440 grams of dog waste and 350 grams of cattle waste dissolved in 1550 ml of water.

In the influent mixtures, before introducing into the biodigesters, total solids were determined, using the APWA (2005) methodology.

The experiment was set up at the Fatec Jaboticabal Laboratory, on March 13, 2023 and the biodigesters were kept at room temperature.

Figure 4. Illustrative photo of the biodigesters used for the production of biogas from dog waste (B1 and Be) and co-digestion of dog waste and cattle waste (B3 and B4).

RESULTS AND DISCUSSION

Total solids (TS) values in the influent of biodigesters B1, B2 were 509 mg L^{-1} and biodigesters B3 and B4 were 633 mg gL^{-1}.

Seven days after the start of operation of the biodigesters, a volume of 188 and 200 ml of biogas was observed in biodigesters B1 and B2 and 588 ml of biogas in biodigesters B3 and B4.

After this period, biogas production was no longer observed. This may have occurred due to the starting of the biodigesters without the use of inoculum. In biodigesters B3 and B4, higher volumes of biogas were observed, compared to biodigesters B1 and B2. This was already expected, as dog waste has an excess of total nitrogen (NT) in relation to total organic carbon, so that aerobic or anaerobic self-degradation will not occur autonomously and it is necessary to mix it with other residues rich in carbon (MARTÍNEZ-SABATER et al., 2019).

However, in biodigesters B3 and B4, continuous biogas production was expected, which did not occur and further studies will be necessary to verify possible disturbances and inhibition. The suggestion would be to place an inoculum, which would probably greatly improve biogas production. Also identify pH, temperature and nutrients, with the aim of identifying to accelerate fermentation and improve biogas production.

CONCLUSIONS

It is concluded that the production of biogas in anaerobic biodigesters using the co-digestion of dog waste and cattle waste can be an alternative for the management of these wastes, but future studies are needed to identify more completely the possible disturbances that may occur. in the stages of hydrolysis, acidogenesis, acetogenesis and metagenesis, which led to the stoppage of biogas production in biodigesters.

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APPENDIX A – ORIGINALITY TERM

TERM OF ORIGINALITY

I, **ROSILDA FERREIRA OLIVEIRA LEITE,** student regularly enrolled in **Higher Biofuels Technology Course,** of: ``Faculdade de Tecnologia Nilo De Stéfani de Jaboticabal`` (Fatec-JB), I declare that my graduation work titled: **DOG WASTE IN BIOGAS PRODUCTION IS ORIGINAL.**

I declare that I received guidance on the standards of the Brazilian Association of Technical Standards (ABNT), that I am aware of the Fatec-JB Undergraduate Work Standards and that I was advised on the issue of plagiarism.

Therefore, I am aware of the legal consequences applicable in the event of PLAGIARISM being detected (Federal Law Number 9,610, of February 19, 1998, which amends, updates and consolidates copyright legislation, published in the D.O.U. of February 20, 1998, Section I, page 3) and I fully assume any type of consequences, in any scope, arising from my Undergraduate Work, subject of this term of originality.

Jaboticabal/SP, [insert day, month and year].

[Student's signature]
[Full name of student]