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Evaluation of a biogas plant based on environmental aspects

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Highlights:

- Anaerobic biodigestion of waste for biogas generation.
- Clean energy production from domestic sewage sludge and food waste as substrates.
- Annual biogas production of 2,528,846 Nm3, representing about 1.5% of the total produced by plants using domestic sewage sludge.
- The emissions of the Business-as-usual scenario are 39.107,91 tCO2e and for the current scenario correspond to 16.314,65 tCO2e.

Keywords: Biogas; greenhouse gases; clean energy.

INTRODUCTION

Biogas plays a key role in the production of renewable energy and is undergoing increasing technological evolution. The anaerobic digestion technique is used in the formation of biogas, being an alternative route for using organic waste as substrate (SOUZA; RIZZATTO, 2022). According to Araújo et al. (2021), by combining different techniques, the energy produced can be used as thermal and electrical, reducing greenhouse gas emissions and contributing to the circular economy.

Domestic sewage sludge in State of Paraná is mainly destined for landfills and agricultural practice (BITTENCOURT *et al*, 2017). When sewage sludge is sent to landfills, it generates biogas, which is often released into the atmosphere, thus contributing to the worsening of the greenhouse effect. Thus, a viable and efficient alternative for the disposal of domestic sewage sludge is its use as a substrate in anaerobic digestion for the production of biogas to electricity generation in a biogas plant. For the best application of this type of sludge for this purpose, a mixture with food waste is used in order to improve the quality of the substrate and produce more biogas (BUCKER et. al, 2020).

Biogas is composed of methane (CH_4) with a presence percentage between 30 and 70, carbon dioxide (CO_2) and small amounts of adjacent gases, as it varies depending on the organic matter originating.

The gas is obtained by the decomposition of organic waste in a so-called anaerobic environment, that is, without the presence of oxygen in the reaction (COELHO et. al, 2018). Methane contributes approximately thirty times more than carbon dioxide to the greenhouse effect, which makes the biogas process even more significant in reducing such releases (Cassini, 2003).

The present work aims to analyze the environmental sustainability of a biogas plant that uses domestic sewage sludge and food waste as substrates, considering greenhouse gas (GHG) emissions in the current scenario and Business-as-usual scenario (base scenario). The study evaluates environmental aspects such as GHGs that can be avoided with the reuse of waste, as well as the promotion of the circular economy. Thus, one of the main contributions is related to sludge treatment and reuse, as well as biogas management and energy recovery.

METHODOLOGY

Firstly, a survey of biogas plants that use domestic sludge and organic waste as a substrate for biogas generation was carried out. For this purpose, the Biogas Map platform was consulted, which provides a Brazilian overview of biogas generating plants. Thus, a plant located in the State of Paraná was selected to carry out the case study and the unit operations and sources of potential greenhouse gas emissions at the site were listed. Subsequently, two scenarios were considered regarding the destination of the waste used, the current scenario being biogas production and the usual scenario being sent to landfills. Estimates of GHG emissions were carried out using the GHG Protocol calculation tool for both scenarios, and the inventory limits were defined in accordance with ABNT NBR ISO 14064. With the results found for the two surveys, it was possible to compare the emissions avoided from being released and obtain estimates of carbon credits for the plant, the object of the case study.

RESULTS AND CONCLUSIONS

The biogas plants in the state of Paraná were analyzed and it was found that 11 units use sludge from sewage treatment plants or organic waste (CIBIOGÁS, 2024). After technical visits to the plant, a block diagram was generated, as shown in Figure 1. It was found that the process occurs continuously with two pre-treatments of the substrates, one at each inlet. The sludge inlet has dewatering tables and addition of polymers to increase the concentration of total solids. At the organic inlet there is a hammer mill reducing the size of the particles and facilitating the biodigestion of the material. Each inlet has a single 600 m^3 tank and after each of these tanks the reactors are dosed. The reactors are of the CSTR (Continuous Stirred Tank Reactor) type, with continuous agitation and temperature control (approximately 37ºC). The biogas produced is converted into electrical energy and injected directly into the network, in addition to subsidizing the process itself by maintaining a constant temperature and agitation of the medium. The excess gas is burned in a flare. The methane concentration in the biogas is 60.8%. The conversion estimate is 50% of total volatile solids. The annual biogas production was

2,528,846 Nm3, representing approximately 1.5% of the total produced by all plants using sewage sludge (CIBIOGAS, 2024). Considering the PBGHG and the current scenario, the results for scope 1 of the biogas plant were 3,245 tCO2e, for scope 2 it was 224.31 tCO2e and, finally, for scope 3 it returned 16,087,100 tCO2e. Considering the Business-as-usual scenario, in which organic waste is sent to landfills, the estimated greenhouse gas emissions resulted in 26,086.93 tCO2e for sewage sludge, 1,697.33 tCO2e for fish waste and 11,323.65 tCO2e for organic waste, totaling 39,107.91 tCO2e.

It is worth noting that the plant uses large quantities of waste to form biogas, contributing significantly to environmental sustainability. Another important factor is transportation, since domestic sewage sludge is sent through pipelines directly to the biogas plant. Therefore, no vehicle fumes are generated for the transfer of the sludge. Comparing the emissions from the Business-as-usual scenario with the current scenario, it can be concluded that the biogas plant reduces GHG from 39,107.91 tCO2e to 16,314.65 tCO2e, resulting in a reduction of 58.28%.

Considering the difference in emissions calculated for the biogas plant and the waste sent to the landfill and in consultation with the stock exchange on June 21, 2024, the estimated monetary amount of carbon credits amounts to 1,551,081.34 euros, which is an additional attraction for the project. In order to effectively commercialize such credits, the base project must be approved by accredited organizations in the market and follow the steps indicated in ABNT NBR 15948:2011, being valid from the receipt of the certificate and being able to be converted into assets.

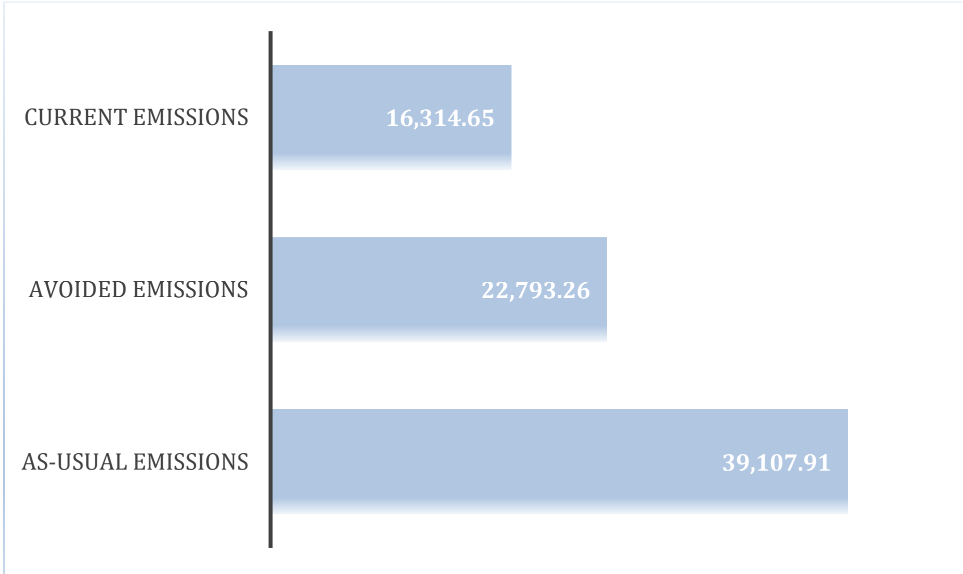

FIGURE 1 – COMPARISON OF EMISSIONS CONSIDERING THE USUAL AND CURRENT SCENARIOS

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