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SOLUTION TO ACHIEVE ZERO LANDFILL: EVALUATION OF THE BIOGAS POTENTIAL FROM THE SLUDGE OF CAPRICÓRNIO TÊXTIL S/A

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Abstract : This work aims to: evaluate the use of sludge from the Denim textile industry to mitigate the socio-environmental impacts caused by the textile sector. The production of solid waste by the textile industries impacts the environment and causes concern for society. This waste is still disposed of in sanitary landfills, and due to the organic matter present, there is great potential for biogas synthesis, which can be used to generate electricity or produce Biomethane. Thus, a study was carried out on a laboratory scale of the potential for biogas generation from the sludge from the ETE of Capricórnio Têxtil S/A, in which the physicochemical variables of the sludge were analyzed, such as dry and organic matter, humidity, macronutrients and the generation of biogas and biomethane. The work showed that it is possible to generate biogas and biomethane from the ETE sludge of Capricórnio Têxtil S/A, but other analyzes in the biodigester are necessary. As gains, we have social and environmental gains, and the other objective of this work is to encourage the chain to seek alternatives for the correct and circular use of its waste.

Keywords : Textile industry, solid waste, biogas, green energy.

INTRODUCTION

The textile sector is considered to have a high polluting potential, due to the generation of a large amount of effluent and solid waste, such as the sludge generated at the Effluent Treatment Station (ETE), which uses a large volume of water and electricity in its processes and high consumption of chemical products (SCHNEIDERS *et al.*, 2018).

The textile sludge has high levels of organic and inorganic compounds, derived from the chemical products used in the process, such as: dyes, starches, sulphides and chlorides. It is also made up of organic matter and cotton fibrils. Due to this variety of compounds, it is considered a complex waste, requiring that its final disposal be adequate and conscious, making the best use of it to reduce environmental and social impacts (VERMOLLEN *et al.*, 2021).

According to NBR 10.004 – Solid Waste – Classification, textile sludge is defined as a Class IIA non-inert material. In view of this, textile sludge is disposed of in landfills, causing a considerable impact on the environment and society, due to the generation of leachate and greenhouse gases, considered the main polluters of the environment, in addition to the consequences for the human health (SILVA *et al.*, 2022).

Sustainability is based on the social, economic and environmental spheres, and when it comes to the social sphere, there is a long way to go to reach acceptable parameters that provide equality, considering the current context of various situations of environmental injustice (FIGUEIREDO; DE BRITO ; CORAZZA, 2019).

Sanitary landfills are places that carry out waste management that is considered adequate, however, they are directly linked to environmental racism, which is defined as a condition that reveals environmental injustice due to socioeconomic inequality (OLIVEIRA; TAGLIAFERRO; OLIVEIRA, 2021).

Economically underprivileged communities are subject to directly suffering the aggravating effects of environmental impacts, a fact that applies, for example, to the location of sanitary landfills, which are areas considered to have low or no real estate appreciation, subject to contamination of natural resources, and with conditions precarious housing, health, education, among other basic aspects of the fundamental right of each individual (BURITY *et al.*, 2019).

This way, there is a greater awareness about the negative effects of solid waste disposal in sanitary landfills. Consequently, interest in generating energy from industrial waste has become recurrent, not only for environmental and social gains, but also to increase the useful life of available energy reserves (Nunes *et al.*, 2018).

Biogas is the product of the decomposition of organic matter carried out by anaerobic microorganisms (without oxygen), basically composed of methane (CH_4) and carbon dioxide (CO_2). Other gases such as nitrogen (N_2), hydrogen sulfide ($H_2 S$) and oxygen (O_2) can be part of the biogas composition, but in smaller amounts. The generated by-products can be used as fertilizers, as there is preservation of nutrients, such as NPK (NEPOMOCENO and PONTAROLO, 2022).

After going through a treatment step to remove sulfur, the biogas can be used in motor generators to generate electricity or it can go to a purification unit, resulting in a stream rich in methane - called biomethane - and another rich in $CO_{2,}$ which can be captured for the production of renewable fuels, food industry or CCS (*carbon capture storage*). Biomethane is a gaseous fuel with a high methane content (minimum of 90% $CH_{4,}$ according to ANP) in its composition. This fuel has characteristics that make it interchangeable with natural gas in all its applications, and can even replace diesel and LPG.

Thus, biogas has the potential to reduce particulate emissions by up to 97% and CO_2 emissions by up to 95% when compared to diesel, being an important ally in meeting decarbonization targets.

Brazil is the country with the greatest biogas production potential in the world. According to Abiogás, there are more than 84 billion Nm^3 of biogas that can be produced annually in the country from waste from the sugar-energy sector, agricultural production, animal protein and sanitation.

As the event of COP26, the participating countries, including Brazil, accelerated their green agendas and highlighted biogas as a strong ally to achieve the established goals. With a global commitment to reduce its emissions by 30% by 2030, Brazil recently signed the Decree establishing the Federal Strategy to Incentive the Sustainable Use of Biogas and Biomethane, with the aim of promoting programs and actions to reduce methane emissions and encourage the use of biogas and biomethane as renewable sources of energy and fuel. As a result, the expectation is to take full advantage of our country's biogas production potential, which today is less than 4% of what it could be. In 2021 alone, 2.35 billion Nm^3 of biogas were produced by 755 plants in operation, generating a 10% increase in production compared to 2020 (2.14 bi Nm^3/year), that is: an increase in decarbonization of the Brazilian sustainable ecosystem based on waste management.

Thus, the objective of this work is to carry out an analysis of the potential for biogas generation from the textile sludge of the ETE of Capricórnio Têxtil S/A, showing the economic and socio-environmental benefits of this technology.

METHODOLOGY

The potential for biogas generation from ETE sludge at Capricórnio Têxtil was evaluated by the Geo Research Center Biogas & Tech as a possible partnership for the disposal of sludge for biogas generation in a partner unit, in the conceptual phase.

The pressed sludge, from the ETE filter press, was collected in samples of 300 g each, at 9 equidistant points of the sludge pile, to ensure maximum representativeness. The collection was made in the 3 shifts of operation during 6 days.

The samples were submitted to triplicate analysis of dry matter, organic matter, total protein, lipids, cellulose and lignin, in order to result in the preliminary theoretical potential of biogas and methane content. For confirmation of the potential and sequence in the elaboration of basic and detailed design assumptions, further laboratory tests of methanogenic potential must be performed.

All the analyzes mentioned follow the methodology referenced in the *Standard Methods for the examination of water and wastewater*, 22nd edition, authored by Eugene W. Rice *et. al.* and edition of the *American Public Health Association.*

RESULTS AND DISCUSSIONS

Figure 1 shows the results of the analysis of the ETE sludge from Capricórnio Têxtil according to the previously mentioned methodologies.

Each analyzed sample represents one day of collection in Capricórnio's industrial process and the result represents the percentage of the "fresh" sample. A small variation can be observed in the presented results due to normal variations of the industrial process, implying more or less humid samples. The lower the humidity, consequently, the higher the dry and organic matter, and the higher the biogas productivity.

The result observed for the ETE sludge from Capricórnio Têxtil is 117 Nm^3biogas/ $t_{fresh\ matter}$ or 692 Nm^3biogas/ $t_{organic\ matter}$, which corresponds to 384 Nm^3CH4/ $t_{organic\ matter.}$ Biogas can be used in motor generators to produce clean energy - it is possible to generate approximately 0.270 MWh/t and a gross revenue of up to around R$ 130.00/t - or be used to produce biomethane, which represents, approximately, 67.3 Nm^3biomethane/t and a gross revenue that

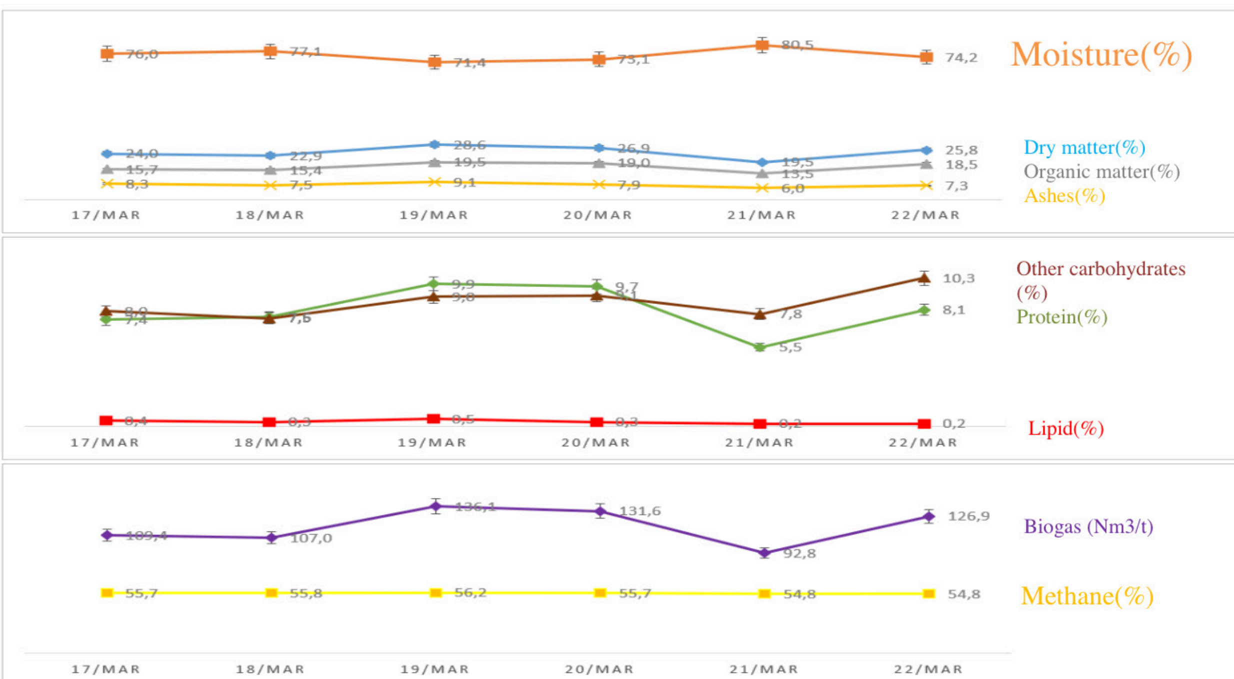

Figure 1: Results of analyzes of sludge samples from Capricórnio Têxteis ETE: moisture, dry matter, organic matter, ash, carbohydrates, protein, lipid, biogas and methane.

can be around R$ 168.30/t depending on the natural gas tariff. A mix of electricity and biomethane is also possible. In addition, when producing biomethane it is possible to count on CBios revenue, which are decarbonization credits, in which each CBio corresponds to 1 ton of CO_2 that is no longer emitted into the atmosphere.

There are not many works available in the literature that evaluate the theoretical potential of biogas production from sludge from the textile industry. However, some works carry out tests in pilot reactors, evaluating different reaction conditions with a focus on waste treatment and not on the maximum efficiency of gas production. One of them is Dias (2020), who evaluated in his master's thesis the production of biogas and removal of color from textile industry effluent, obtaining as a result a gas production of 160 mLCH4/ gCOD, which is equivalent to 250 Nm^3CH4/ t.

CONCLUSION

Given this, biogas appears as a solution aligned with the tripod of sustainability, since it takes advantage of the energy potential of organic waste, avoiding the emission of greenhouse gases; fosters regional development; and monetizes the gas that would otherwise be emitted into the atmosphere, contributing to increased pollution.

The ETE sludge from Capricórnio Têxtil analyzed by Geo presents a gas generation potential greater than the mentioned literature, being comparable to the potential of the filter cake, waste from the sugar-energy segment and with biogas production already proven in 3 biogas plants in operation at the Geo Biogás & Tech.

It is noteworthy that more analyzes must be carried out in order to prove and certify the performance of the waste evaluated in this article and to assist in the preparation of the project, such as minerals, which are of fundamental importance for the evaluation of possible substances that may harm biodigestion.

REFERENCES

BURITY, Natália *et al*. Resíduos sólidos e racismo ambiental: o caso de Jardim Gramacho, Duque de Caxias/RJ. *In:* XIII ENANPEGE – A geografia brasileira na ciência-mundo: produção, circulação e apropriação do conhecimento, 2019. **Anais do VIII Encontro Nacional de Pós-Graduação e Pesquisa em Geografia.** São Paulo: 2019, 13 p.

FIGUEIREDO, Aline Campos; DE BRITO, Marcelino Vitor; CORAZZA, Rosana Icassatti. Breve histórico e elementos para análise da injustiça e racismo ambiental no caso do Aterro Sanitário de Macaúbas de Sabará, Minas Gerais, Brasil. **Anais do III Simpósio Internacional de Geografia do Conhecimento e da Inovação**, p. 126-141, 2019.

INTERNATIONAL RENEWABLE ENERGY AGENCY (IRENA): Biogas For Road Vehicles, 2018. (IRENA, 2018).

NEPOMOCENO, Taiane Aparecida Ribeiro; PONTAROLO, Edimar Lia. Panorama brasileiro do aproveitamento energético dos resíduos sólidos urbanos para a geração de biogás em áreas de aterro sanitário. **International Journal of Environmental Resilience Research and Science-IJERRS**, v. 4, n. 2, p. 1-12, março, 2022.

NUNES, Leonel *et al*. Economic and environmental benefits of using textile waste for the **production of thermal energy. Journal of Cleaner Production, v. 171, p. 1353-1360,** janeiro, 2018.

OLIVEIRA, Izabela; TAGLIAFERRO, Evandro; OLIVEIRA, Adauto. Gerenciamento dos resíduos sólidos domiciliares no município de Jales–SP e sua relação para com a política nacional de resíduos sólidos (PNRS). **Brazilian Journal of Development**, v. 7, n. 1, p. 11475-11499, 2021.

SILVA, Elisângela Maria da *et al*. **Ecotoxicidade de resíduos sólidos urbanos e de lixiviado gerado em aterro sanitário.** Tese (Doutorado em Engenharia Civil e Ambiental) – Universidade Federal de Campina Grande, Campina Grande, 2022.

SCHNEIDERS, Danieli *et al*. Tratamento de lodo da indústria têxtil e produção de biogás em reator UASB. **Revista AIDIS de Ingeniería y Ciencias Ambientales. Investigación, desarrollo y práctica**, v. 11, n. 2, p. 182-201, agosto, 2018.

VERMOLLEN, Aturiê Felipe Melo *et al*. **Avaliação da influência da adição de lodo têxtil em propriedades de resistência de um solo tratado com cimento.** Trabalho de Conclusão de Curso (Engenharia Civil) - Universidade Federal de Santa Catarina, Joinville, 2021.

DIAS, Heitor Róger Alvez e *et al*. **Co-digestão anaeróbica de efluente têxtil com levedura residual oriunda do processo de fermentação alcoólica visando remoção de cor e produção de biogás.** Dissertação (Mestrado em Hidráulica e Saneamento) – Escola de Engenharia de São Carlos, São Carlos, 2020. Disponível em:https://www.teses.usp.br/teses/disponiveis/18/18138/tde-16122020-185638/en.php.

RICE, Eugene W. *Standard Methods for the examination of water and wastewater*. 22ª edição. ISBN: 9780875530130. Editora American Public Heath Association, 2012.