# BIOGAS PRODUCTION THROUGH ANAEROBIC DIGESTION OF INDUSTRIAL EFFLUENTS

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## ABSTRACT

Industrial activities are major generators of solid organic waste and liquid effluents which, due to environmental preservation principles, need to be treated before disposal to avoid pollution. This waste has a high organic matter content, which makes it a potential substrate for biogas production. The aim of this work is to assess the potential for biogas production from a mixture of industrial effluents from different industries, using a batch system. Samples of substrate and inoculum were collected at the Maringaense Wastewater Treatment Company, after which their physical and chemical characteristics were determined. The biogas was quantified by measuring the volume produced each day, and its composition was determined using a gas chromatograph. After the tests, the highest biogas and methane yields were 721.29 NmL $gSV^{-1}$ and 461.69 NmL $gSV^{-1}$, respectively.

**Keywords:** Biochemical Methane Potential; Biological Treatment; Renewable Energy.

## INTRODUCTION

Fossil fuels dominate global energy consumption, with around 85.3 per cent coming from non-renewable sources [1]. The depletion of these sources has fuelled the search for renewable fuels, with biomass standing out as a viable alternative. According to [2], the search for alternative resources that are environmentally sustainable and economically viable is one of the main challenges for the future of the energy sector.

In Brazil, renewable energies account for almost half of the energy matrix, with biomass contributing 24.4 per cent [1]. Biomass is valued as a clean energy source, providing benefits such as reducing greenhouse gas emissions and generating jobs [3].

Industrial effluents, rich in organic matter and other suspended constituents, require appropriate treatment to avoid environmental pollution [4].

In this context, anaerobic digestion is considered an environmentally friendly biological treatment process [5].

This work evaluates the potential for producing biogas from mixtures of industrial effluents in batch systems.

## MATERIALS AND METHODS

In this study, the substrate (S) used to evaluate Biochemical Methane Potential (BMP) is a mixture of effluents from different types of industrial activities, collected at Maringaense Effluent Treatment Company - EMTRE. After collection, the samples were characterised taking into account the recommendations of the VDI 4630 standard [6] and using the analytical methods of APHA [7], all analyses were carried out in triplicate. The physicochemical characteristics of the following parameters were determined: pH, Total Solids (TS), Total Volatile Solids (TVS), Total Fixed Solids (TFS), Total Alkalinity (TA), Total Organic Carbon (TOC), Total Organic Acids (TOA), Chemical Oxygen Demand (COD) and Total Kjeldahl Nitrogen (TNK). Sludge from a full-scale active anaerobic digester was used as inoculum (I) in this study.

The BMP test was carried out based on the criteria recommended by the VDI 4630 standard [6], for an experimental period of 47 days. Amber glass vials with a total volume of 250 mL were used as the reaction medium for the experimental test, which was hermetically sealed to ensure a perfect gas seal. Biogas production was assessed at different substrate and inoculum ratios (SIRs) mixtures, 0.25, 0.5 and 1. Microcrystalline cellulose was used as a positive control.

The volumetric method was used to measure biogas production throughout the tests. The gas produced was removed daily using plastic syringes in order to find out the volume of biogas produced in each reactor. The daily volume was corrected for normal temperature and pressure conditions (CNTP), according to Eq. 1, taking into account the recommendations of VDI 4630 [6].

$$V_N = \frac{V*(p-pw)*T_0}{p_0*T} \qquad \textit{Eq. (1)}$$

$V_N$ - volume of biogas normalised to the Normal Conditions of Temperature and Pressure CNTP (NmL); V - volume of biogas produced (mL); p - biogas pressure at the time of reading (kPa); pw - water vapour pressure as a function of ambient temperature (kPa), $T_0$ - temperature under normalised conditions (273 K); $p_0$ - pressure under normalised conditions (1.031 kPa) and; T - ambient temperature (K).

A gas chromatograph (Model Trace GC Ultra, Thermo Scientific) was used to determine the composition of the biogas produced during the test.

## RESULTS AND DISCUSSION

Physico-chemical characterisation of substrate and inoculum

The results of the physico-chemical characterisation of the substrate and inoculum are shown in **Table 1.** The results of the substrate characterisation showed an average pH of 6.58, which is within the range reported by various authors for anaerobic digestion. [8] carried out a study with slaughterhouse effluent and obtained a pH of 6.50. [9] obtained a pH value of 6.93, similar to that obtained in this study.

For the inoculum, the average pH value measured was 8.13, which is within the range recommended by [10], who stated that in order to be efficient in cumulative methane production, the inoculum must have a pH between 7 - 8.5.

**Table 1.** Physico-chemical characterisation of the substrate and inoculum

| Parameters | Unit | Substrate | Inoculum |
|---|---|---|---|
| pH | - | 6,58 (±0,01) | 8,34 (±0,02) |
| COD | $mg.L^{-1}$ | 21210,50 (±138,79) | 22789,33 (±39,59) |
| TA | $mg.L^{-1}$ | 7283,33 (±69,28) | 11040,00 (±60) |
| VFA | $mg.L^{-1}$ | 9258 (±20,81) | 1456 (±60,39) |
| TS | $g.L^{-1}$ | 31,76 (±0,37) | 16,84 (±0,12) |
| FS | $g.L^{-1}$ | 10,66 (±0,13) | 9,98 (±0,15) |
| VS | $g.L^{-1}$ | 21,10 (±0,23) | 6,89 (0,04) |
| NTK | % | 1,30 (±0,03) | 0,84 (±0,02) |
| COT | % | 26,18 (±0,02) | 18,31 (±0,22) |

### Cumulative biogas and methane production

The SIRs 0.25 and 0.50 had the highest potential for generating biogas (721.29 $NmL.gSV^{-1}$ and 670.41 $NmL.gSV^{-1}$) and methane (461.69 $NmL.gSV^{-1}$ and 456.18 $NmL.gSV^{-1}$) compared to the other ratios studied **(Fig. 1).**

Lower results were found by [11], when evaluating the production of biogas and methane from pig wastewater, in which they tested the following SIRs: 0.16; 0.33 and 1, and obtained the production of biogas (554 $NmL.gSV^{-1}$, 394 $NmL.gSV^{-1}$ and 466 $NmL.gSV^{-1}$) and methane (382 $NmL.gSV^{-1}$, 241 $NmL.gSV^{-1}$ and 232 NmL.gSV-1) respectively. [12] found higher potential when working with primary sludge, using different SIRs (0.25, 0.50 and 1), obtaining methane generation potential of (660 $NmL.gSV^{-1}$, 790 $NmL.gSV^{-1}$ and 440 $NmL.gSV^{-1}$).

The biogas produced during the experimental period consisted of methane, carbon dioxide and other gases. All the SIRs studied showed average methane production ranging from 57.72 to 59.22 per cent, carbon dioxide production from 17.15 to 23.39 per cent and the concentration of unidentified gases from 16.95 to 24.99 per cent.

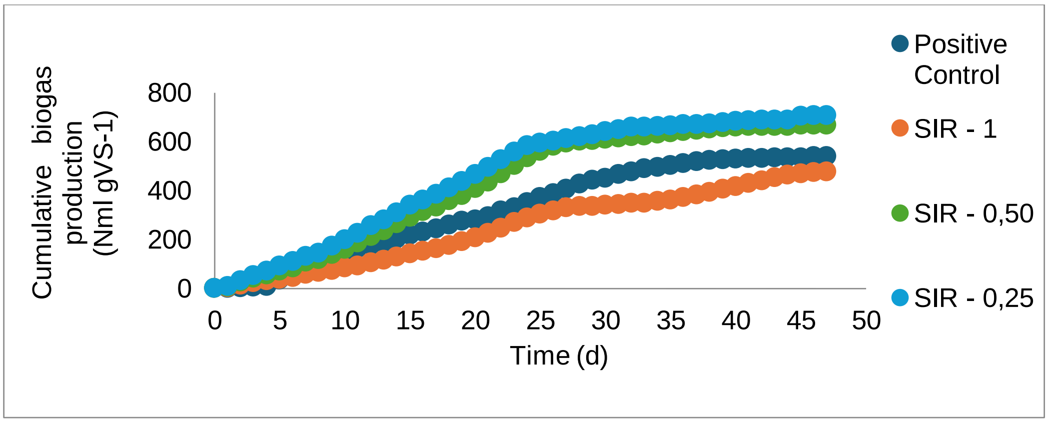


**Figure 1.** Biogas generation potential ($NmL.gSV^{-1}$) for the S/I ratios tested.

## CONCLUSION

The results of this study demonstrate the viability of using industrial effluents as substrates for biogas production in a batch system. The high organic matter content in the tested waste provided favorable conditions for biogas generation, with significant yields of both biogas and methane. The highest recorded yields were 721.29 $NmL.gSV^{-1}$ for biogas and 461.69 $NmL.gSV^{-1}$ for methane, highlighting the potential of industrial waste as a renewable energy source. These findings support the implementation of anaerobic digestion as an environmentally sustainable treatment method, transforming industrial by-products into valuable energy resources while mitigating environmental pollution.

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