TECHINICAL FEASIBILITY OF BIOGAS PRODUCTION BY IMPLEMENTING A BIODIGESTER AT SUPPLY CENTERS OF GOIÁS

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ABSTRACT

This approach is an appealing alternative for energy production in Brazil, which is the largest fruit and vegetable producer worldwide. Parameters such as pH, stirring, temperature, and FOS/TAC ratio were continuously evaluated for process optimization. Results demonstrated that this process could reach a biogas production (60% CH_4) of 1.200 m^3/day, equivalent to 788.4 MWh/year, taking into account an energy conversion factor for biogas with 60% methane adjusted to 1.8 kWh/Nm^3. It encourages the continuity of optimizations for increasing biogas production and, consequently, to continue towards a sustainable energy generation economy.

Keywords: Sustainable Energy Generation, Fruits and Vegetable Waste (FVW), Biogas, CSTR biodigester.

INTRODUCTION

Population growth along with industrialization and urbanization processes are directly connected with the Municipal Solid Waste (MSW) generation worldwide [1]. A valuable manner of treating organic waste is by employing biodigesters' for anaerobic digestion, which occurs through biodegradable transformation of organic matter [2].

The use of renewable biomass sources turns Brazil a recognized power in terms of capacity to generate clean energy [2], [4]. On the other hand, only 53 % of the total MSW is disposed in appropriate landfills [3]. Within this context, the herein

work shows results and prospects of the technical feasibility of implementing a biodigester at the food supply centers of Goiás, CEASA-GO.

MATERIALS AND METHODS

Reactor design and operational conditions

The system was designed comprising four areas for temporary waste storage; a mechanism for pre-selection of organic waste (maximum capacity: 30 tons per day); a CSTR biodigester (1500 m^3); a hydrolysis tank (50 m^3); a batch digester (stabilization lake) (1000 m^3), and flaire system. The industrial system set up is shown in **Fig. *1***.

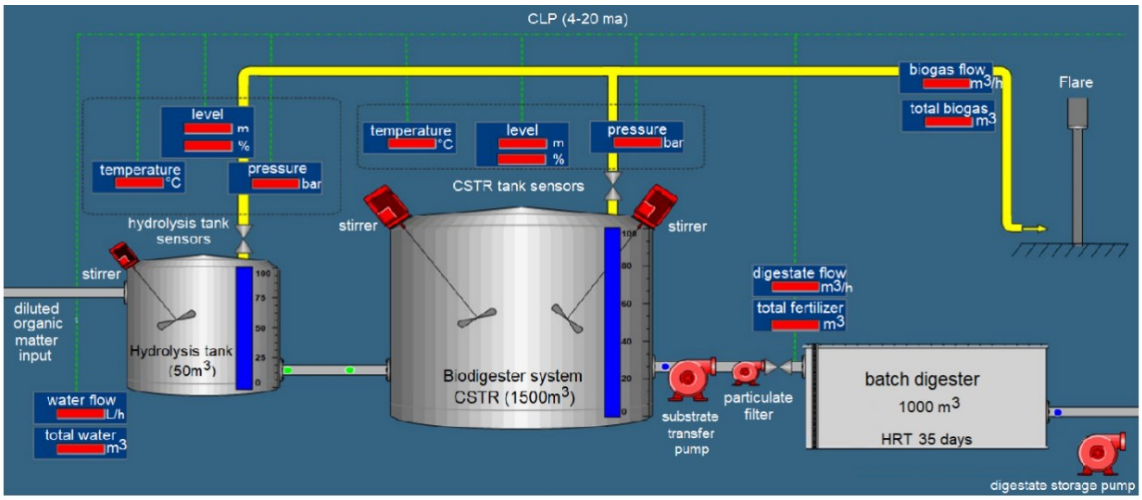

Fig. 1. System set up scheme.

Hydrolysis reactor start-up was carried out with substrate additions following volatile solids proportion of 2:1 (inoculum:substrate). The FVW as substrate was crushed into tiny pieces. Hydrolysis tank was monitored within a period of sixty days, by analysing the biogas, pH, and FOS/TAC ratio. Two weeks after the start-up, semi-quantitative measurements of gases occurred by partial pressure calculations. pH determinations were performed using a properly calibrated pH meter (PH2500 Marte), in a range of 6.5 to 7.5. When needed, corrections were carried out by using NaOH 50%w/w. The volatile organic acids (FOS) and total inorganic carbon (TAC), were determined to obtain the FOS/TAC ratio. TAC was measured by sample “A” titration to pH 5.0, and FOS was determined by continuing

the sample titration "B" from pH 5.0 to 4.4 with a 0.1 N sulphuric acid in mg $CaCO_3$/L, according to Eq. (*1*) and Eq. (*12*).

$$TAC = consumption of A x 250\ [mg/L\ of\ CaCO_3] \quad \text{Eq. (1)}$$

$$FOS = (consumption of B x 1.66 - 0.15) x 500\ [mg/L\ HAc] \quad \text{Eq. (2)}$$

RESULTS AND DISCUSSION

The project was designed taking into account paramount aspects like the waste generation of CEASA-GO (average of 26.33 tons per day). Its waste co-digestion was considered appropriated as the biomass composition variation throughout the year possess no significant interference in the system's operation. To accomplish optimal performance of an anaerobic biodigester, hydrolysis tank was monitored by pH determination and its changes associated to substrate feeding (**Fig. 2** (a)), and FOS/TAC ratio (**Fig. 2** (b)). pH must be kept in the neutral range (6-8) whereas FOS/TAC ratio must range from 0.2 to 0.5 (ideal value: 0.3). It can be seen that both pH and FOS/TAC ratio varied when substrate feeding was started.

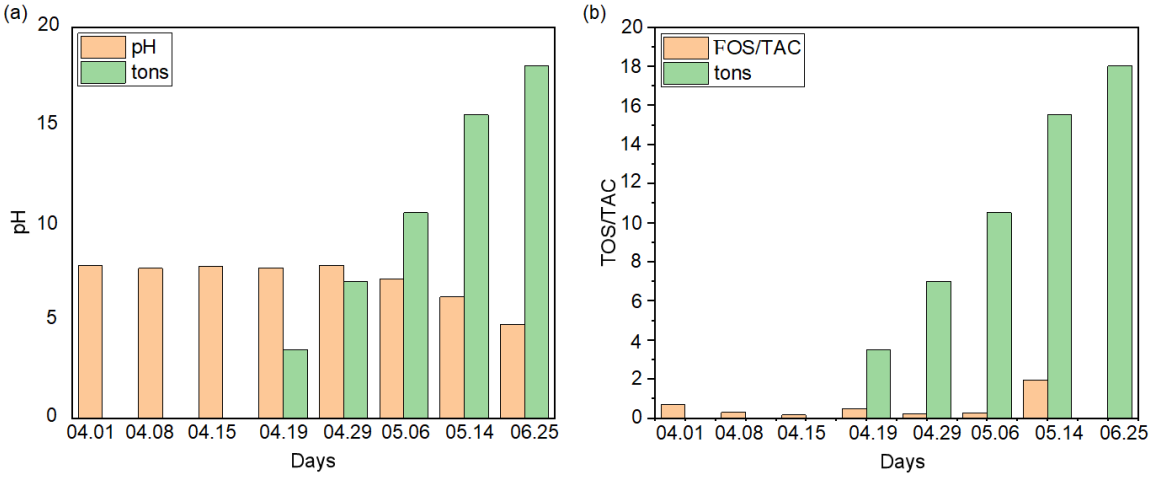

Fig. 2 pH and FOS/TAS ratio changes during process start-up.

Regarding biogas composition (Table *1*), methane production range in biogas is 50 to 75%Vol. Due to the low hydrolyzer pH, a low methane concentration (33.73%Vol) was expected. It should be highlighted that the biodigester sample collected in 25th June showed methane concentration of 63.72%. It also had a low concentration of H_2S (20.0 ppmVol) and NH_3^+ (14 ppmVol), meaning that their retention filters provide corrosive gases free-biogas.

As for 20th August sample, a concentration well below the CH_4 production range in biogas production was obtained (32.97%Vol) in the biodigester. The H_2S and NH_3^+ concentrations were >150 ppmVol and 95 ppmVol, respectively. Low CH_4 concentration was expected, as the CSTR tank required maintenance, and hence, approximately 270 m^3 of digestate and all gases were empty. Such effect is seen by reduction in biodigester's FOS/TAC ratio from 0.1 to 0.09.

Table 1. Biogas composition determination.

Compound	Biodigester sample (%Vol) – 06.25.24	Hydrolyzer sample (%Vol) – 06.25.24	Biodigester sample (%Vol) – 08.20.24
Ethane	<0.01	<0.01	<0.01
Carbon dioxide	33.67	34.02	53.62
Hydrogen	0.07	6.44	7.48
Methane	63.72	33.73	32.97
Nitrogen	2.54	25.81	4.82
Carbon monoxide	<1 (ppmV)	<1 (ppmV)	<1 (ppmV)
Hydrogen sulfide	20 (ppmV)	<1 (ppmV)	>150 (ppmV)
Ammonia	14 (ppmV)	<1 (ppmV)	95 (ppmV)

The annual average temperature in Goiânia provide satisfactorily meets the requirement of optimum temperature for biogas production (25 and 37 °C) [5]. Based on presented data, it is estimated that biogas production (60% CH_4) is 1.200 m^3/day, equivalent to 788.4 MWh/year, considering an energy conversion factor for biogas with 60% methane adjusted to 1.8 kWh/Nm^3 [4].

CONCLUSION

The biodigester implementation at CEASA displays promising capacity for energy generation, although improvements are still required to reach a high and stable methane production.

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