Doctorado en Ingeniería

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SIGNIFICANT VOLATILE FATTY ACIDS PRODUCTION BY USING PRIMARY AND ACTIVATED SLUDGE AS RAW MATERIALS IN ANAEROBIC FERMENTATION

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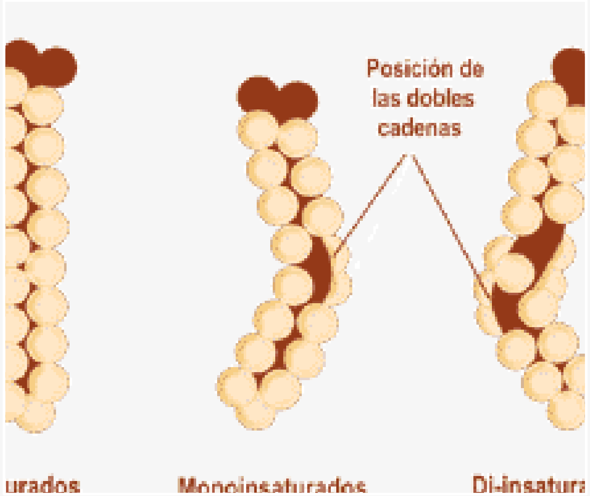
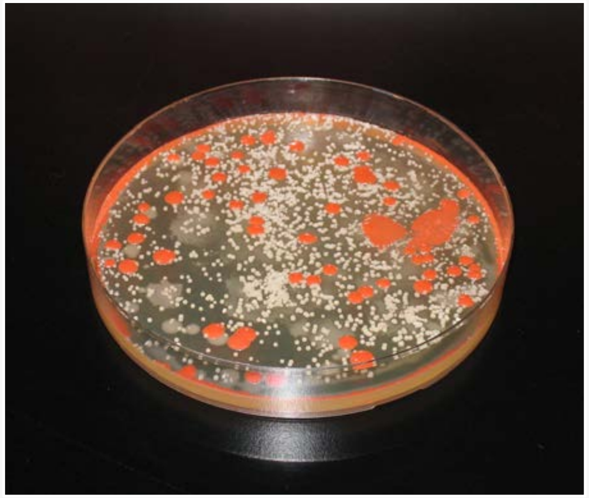
INTRODUCTION

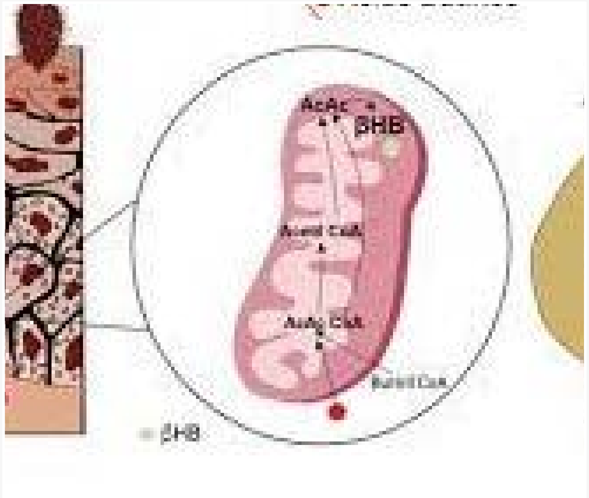


Volatile fatty acids production from waste streams has been studied for the reduction of cost efficiency problems of the current treatments,

also for fuel and materials production, principally, VFAs are considered building blocks for industrial processes and can be used as a carbon source on the production of biopolymers



VFA can be produced by mixed microbial culture anaerobic fermentation of different substrates,



Therefore, the main conditions for the production of VFA are the assessment of: the reaction time; the adjustment of pH values, and temperature

MATERIALS AND METHODS

Inoculum and raw materials characteristics

The primary sludge and digested sludge used for the anaerobic fermentation were collected at El Salitre WWTP, which is the primary sanitation system of Bogotá (Colombia).

The sludge samples were preserved at 4°C to prevent any degradation before the anaerobic fermentation process.

The average characteristics of each sludge are as follow:

primary sludge, VS (volatile solids) 39.16±0.06 g/L, TS (Total Solids) 52.35±0.07 g/L, TCOD (Total chemical oxygen demand) 142 g/L; digested sludge, VS 11.40±0.08 g/L, TS 52.35±0.12 g/L, COD 125.5 g/L.

MATERIALS AND METHODS

Inoculum and raw materials characteristics

Moreover, to support the start-up of the fermentation process, an inoculum was used for the experimental setup; the granular sludge was obtained from the sewage plant of Alpina S.A. in Sopo, Cundinamarca (Colombia), before the essays it was pre-treated by thermal shock.

The concentration of VS and TS in the inoculum was 76.07±0.42 and 84.03±0.49 g/L, respectively.

MATERIALS AND METHODS

Batch fermentation experimental set up

Table 1. Experimental design

Combination		1	2	3	4	5	6
OL (gSV/L)	DS	6			4		
Temperature |(°C)		35			35		
pH		9	10	11	9	10	11
Combination		**7**	**8**	**9**	**10**	**11**	**12**
OL (gSV/L)	PS	14			10		
Temperature (°C)		35			35		
pH		9	10	11	9	10	11

The design managed three independent variables, where the organic load (OL) was differentiated for each type of sludge: OL was evaluated in two levels (10gVS/L and 14 gVS/L) for primary sludge (PS) and (6 gVS/L and 4 gVS/L) for digested sludge (DS), pH values of 9.0, 10.0 and 11.0; a temperature around, 35°C for both residues.

The substrate to inoculum ratio was set as 1:1.

MATERIALS AND METHODS

Batch fermentation experimental set up

There were six (6) combinations for each substrate, and the tests were carried out using batch reactors of 250 mL, hermetically sealed, and placed in a thermostated bath. The reactors were filled with the necessary amount of sludge, inoculum, water, and a buffer solution, to guarantee pH conditions; along with an adjustment with NaOH to the required pH value.

Each combination had 12 replicates, monitored by a destructive sampling, set every three days, where the biogas composition was measured using BIOGAS 5000® Landtec and samples were collected for the further quantification of the pH, VFA (mg COD/L), alkalinity (mg $CaCO_3$/L) and COD (mg/L) produced during the reaction time.

MATERIALS AND METHODS

Statistical Methods

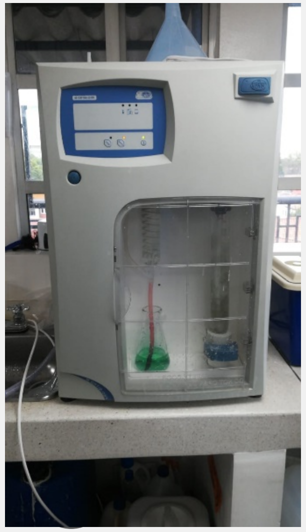
The calculation of the VFA production efficiency results from the total VFA concentration in the effluent per grams of volatile solids (VS) fed (g COD/g VS)

All the analyses were performed by triplicate for each sample.

Analytical Methods

Total Solids (TS), Volatile Solids (VS), pH, Kjeldahl Total Nitrogen (KTN), Volatile fatty acids (VFA) and Alkalinity measurements of the initial substrates and the digestate were determined according to America Society for Testing and Materials (ASTM)

Measurements of pH were determined using a pH meter Edge model HI2002, following the standard test method D 4972-01 of the ASTM.



VFA and Alkalinity where measured according to (APHA, 2005). KTN was determined according to the D1426 of the ASTM.

The Soluble Chemical Demand of Oxygen (SCOD) was measured using commercial vials with a range of 0 to 150 mg/L (HI 93752), samples from bioreactors were centrifuged before the test.

Finally, the gas composition measurements (CO_2, CH_4 and O_2%) was determined by the gas analyzer BIOGAS 5000® Landtec.

RESULTS AND DISCUSSION

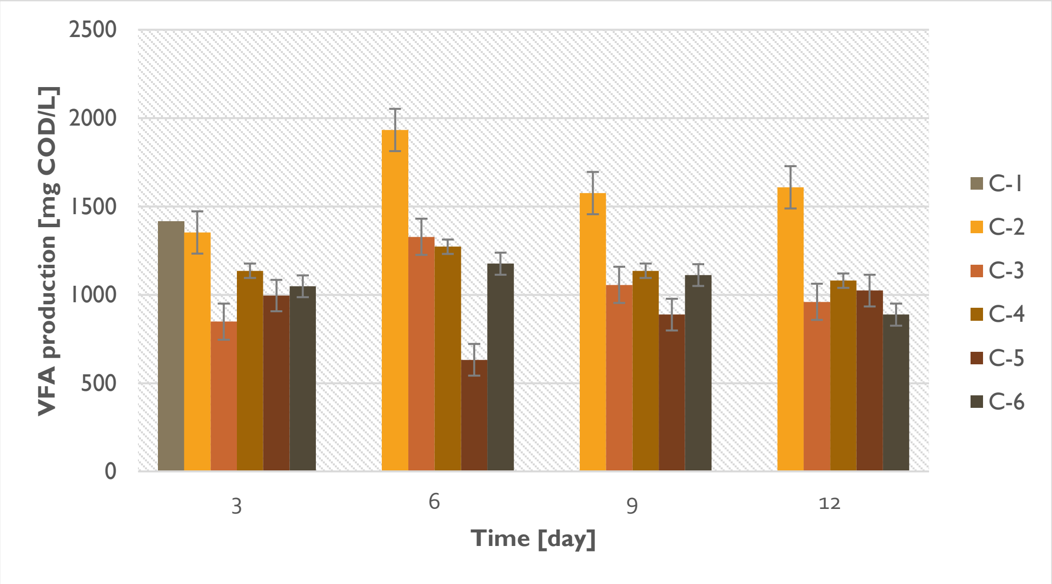


Figure 1a. VFA production by anaerobic fermentation during a digested sludge.

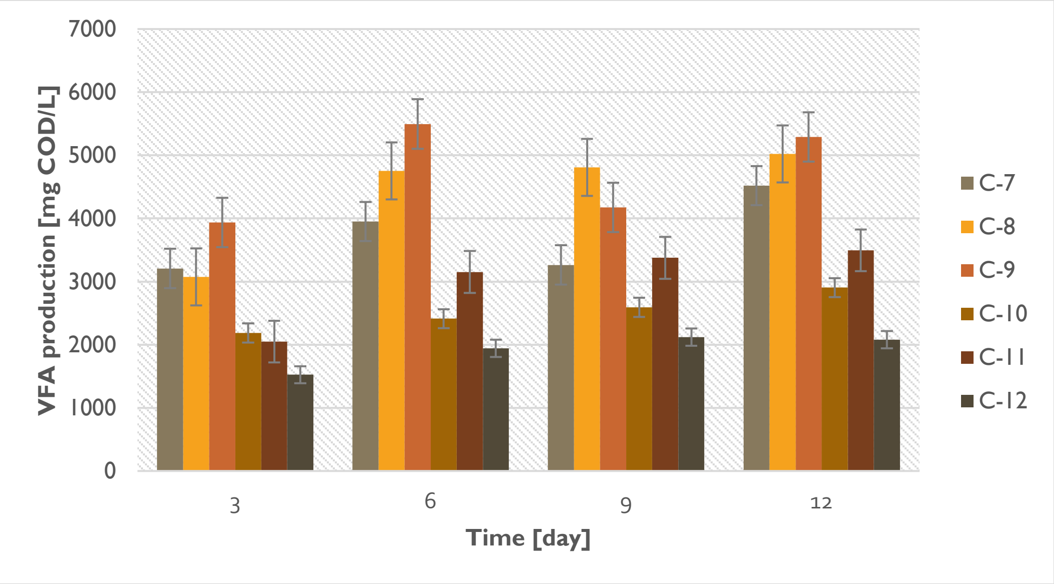
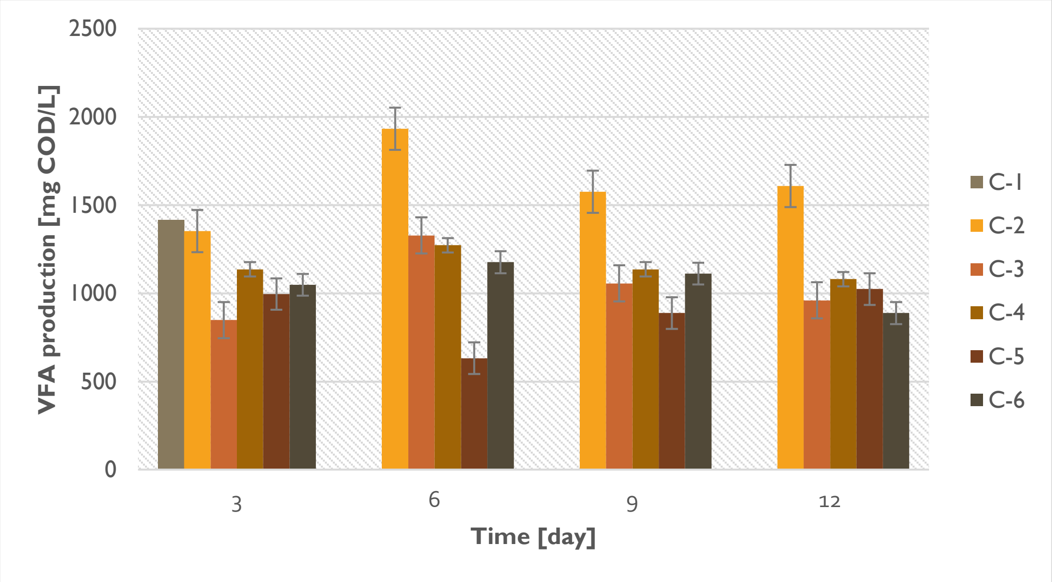


Figure 1b. VFA production by anaerobic fermentation during a primary sludge.

Reflected in the time-course profile of the batch anaerobic fermentation under the conditions established, the highest total VFA production, from all the current evaluated combinations, was achieved using primary sludge, with an OL of 14 gVS/L and a pH of 11 (5496±0.02 mg COD/L at day 6). Also, for the digested sludge, the highest total VFA production was achieved with an OL of 6 gVS/L and a pH of 10 (1932±0.11 mg COD/L at day 6)

RESULTS AND DISCUSSION



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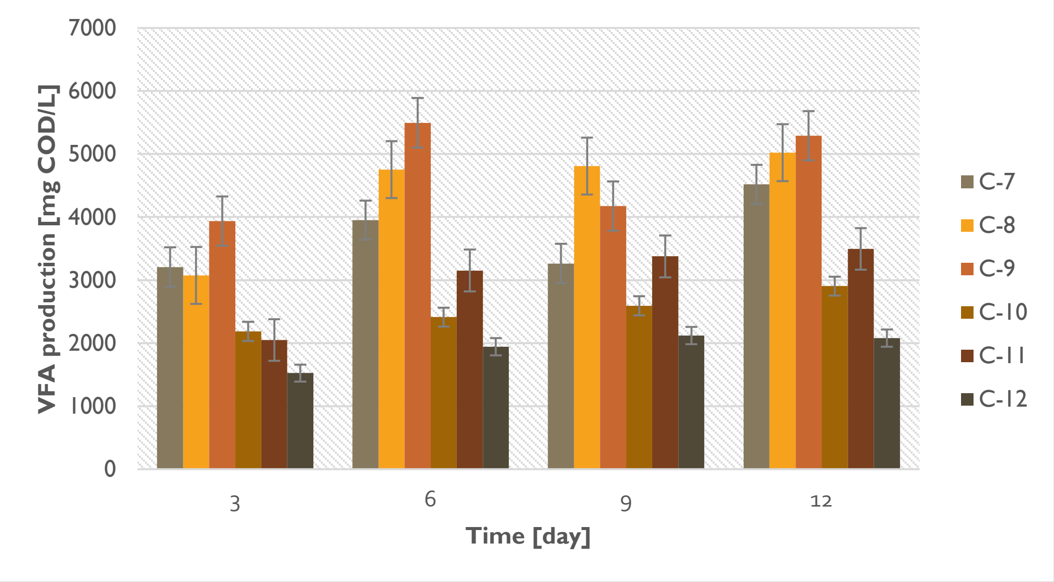


Figure 1b. VFA production by anaerobic fermentation during a primary sludge.

This is observed in VFA production reported for day 3 (1352±0.06 mg COD/L for C-2 and 3936±0.03 mg COD/L for C-9).

RESULTS AND DISCUSSION

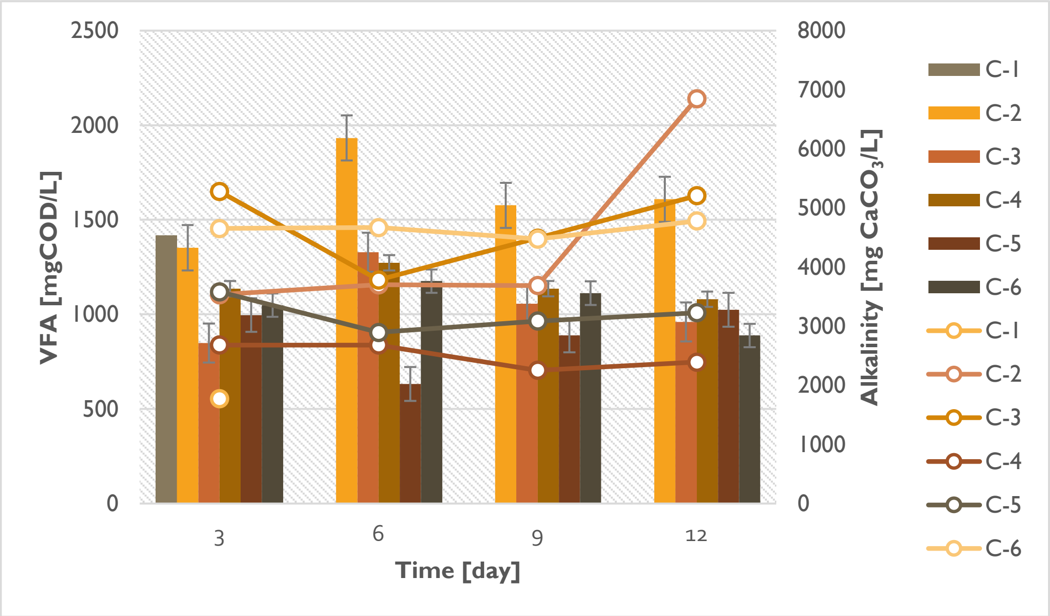


Figure 2a. VFA vs alkalinity performance during the anaerobic fermentation for a reaction time of 12 days; digested sludge.

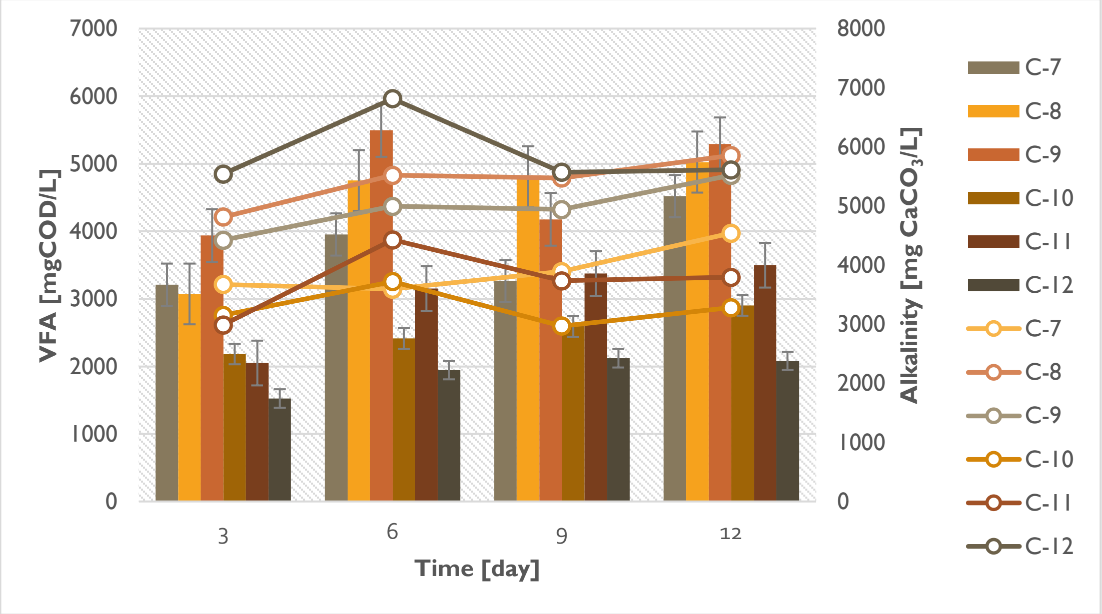


Figure 2b. VFA vs alkalinity performance during the anaerobic fermentation for a reaction time of 12 days; primary sludge.

Regarding the alkalinity, Figure 2. shows the effect of alkalinity on VFA production. As the initial alkali pH was set to 9, 10 and 11 with no pH control during the experiments, the result showed that the initial pH favoured the hydrolysis of the substrates until pH drops to neutral level, while VFA accumulation was higher.

RESULTS AND DISCUSSION

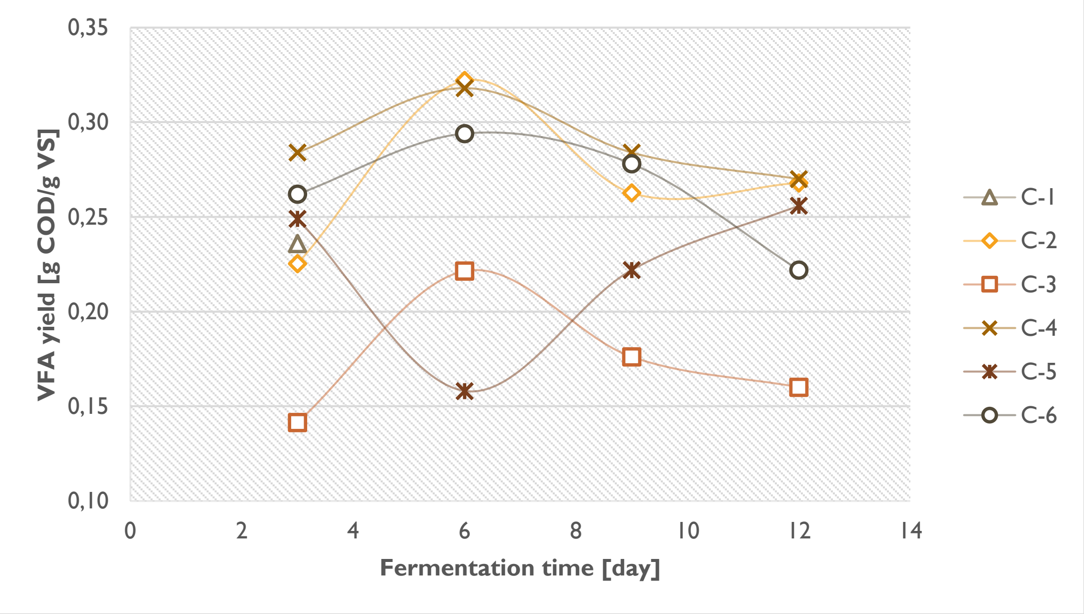


Figure 3a. Anaerobic fermentation performance of primary sludge in terms of the VFA production efficiency for a reaction time of 12 days; (a) C-1, C-2, and C-3 were evaluated for 6 gVS while C-4, C-5, and C-6 were evaluated for 4 gVS.

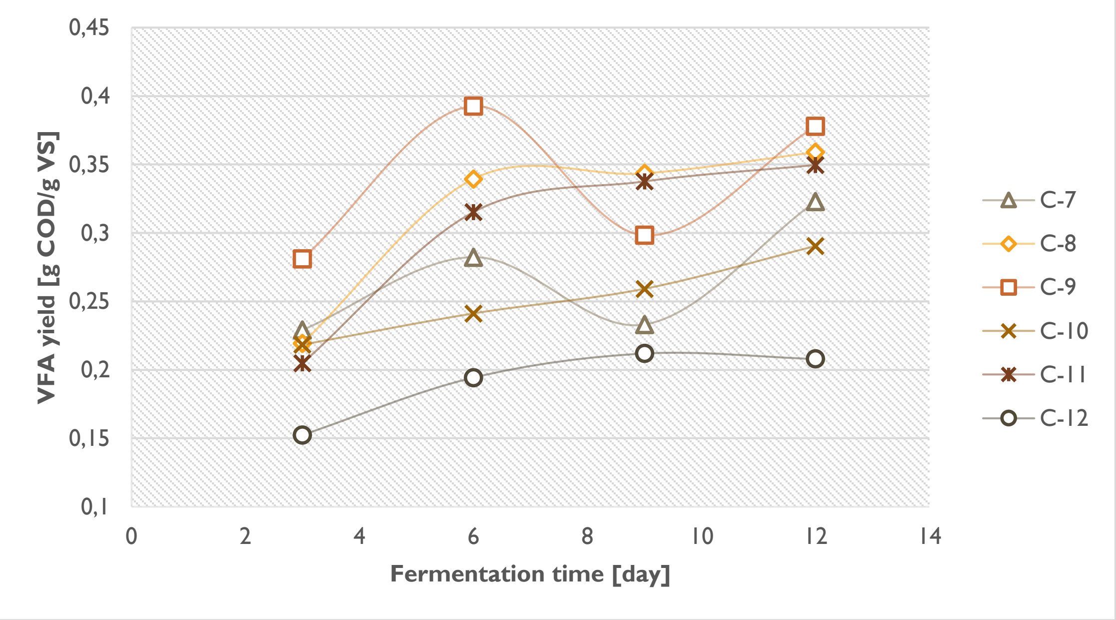
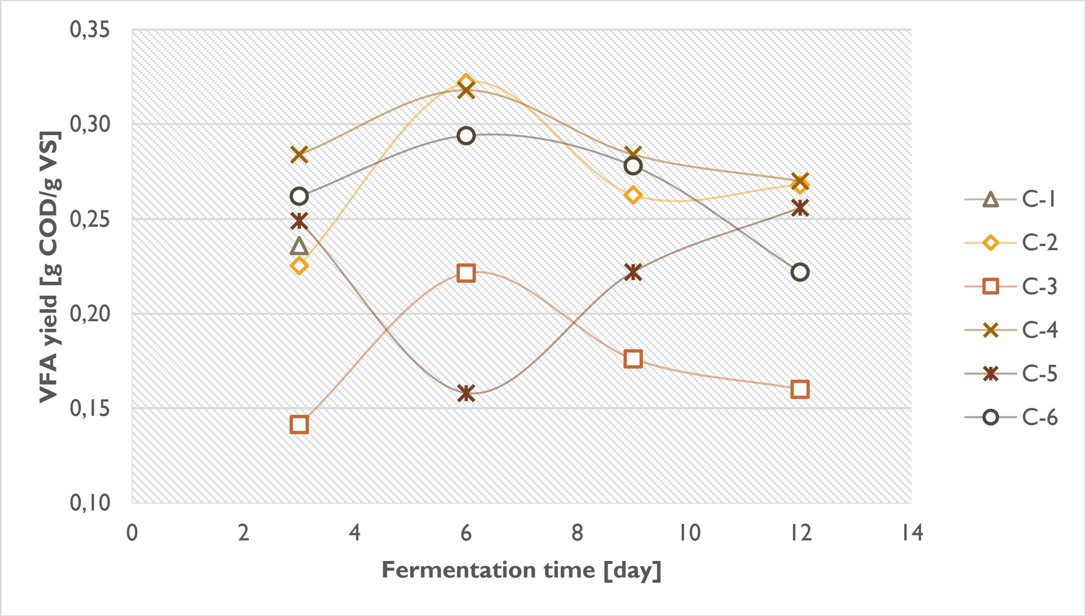


Figure 3b. Anaerobic fermentation performance of primary sludge in terms of the VFA production efficiency for a reaction time of 12 days; C-7, C-8, and C-9 were evaluated for 14 gVS while C-10, C-11, and C-12 were evaluated for 10 gVS.

The total VFA yield for the digested sludge, fluctuated from 0.14 to 0.27 (g COD/g VS) for the conditions with 6gVS and from 0.22 to 0.32 (g COD/g VS) for conditions with 4gVS, while; for primary sludge, fluctuated from 0.21 to 0.39 (g COD/g VS) for the conditions with 14gVS and from 0.15 to 0.34 (g COD/g VS) for conditions with 10gVS

RESULTS AND DISCUSSION



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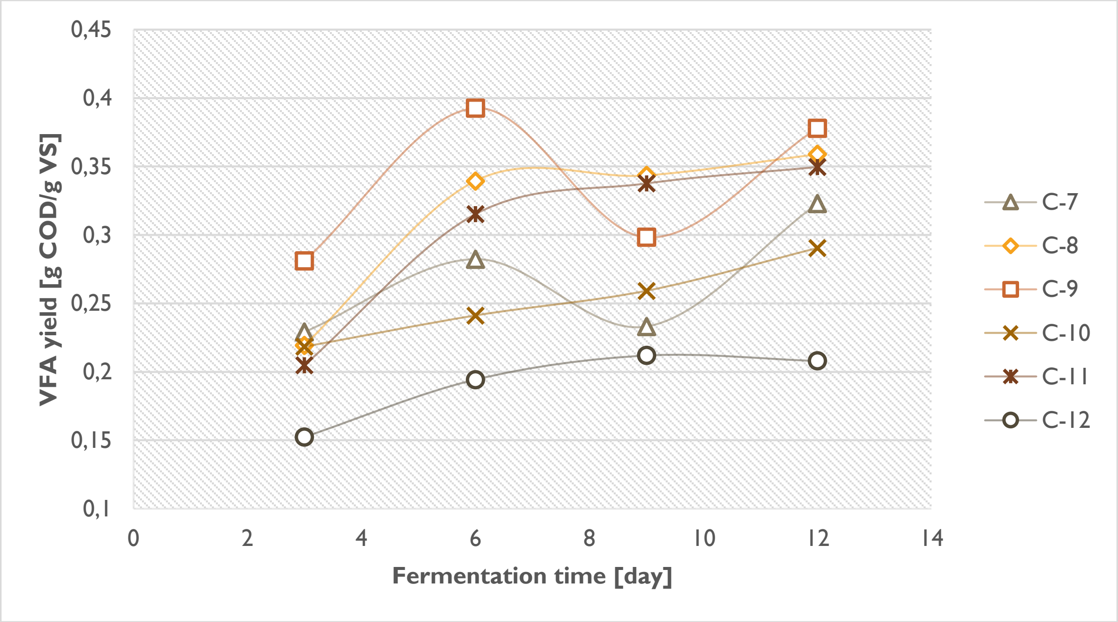

Figure 3b. Anaerobic fermentation performance of primary sludge in terms of the VFA production efficiency for a reaction time of 12 days; C-7, C-8, and C-9 were evaluated for 14 gVS while C-10, C-11, and C-12 were evaluated for 10 gVS.

As the best yields resulted from the tests with pH 10 at day 12 and 11 at day 6, an enhance on hydrolysis along with a high SCOD was identified (49.6g SCOD/L for C-2 and 67.65g SCOD/L for C-9, at day 3).

CONCLUSIONS

The results obtained allow the implementation of the most suitable anaerobic fermentation conditions to produce VFA for the further production of renewable value-added products. The highest yield was produced from the fermentation of primary sludge, under an OL of 14 g VS/L, at 35°C and a pH of 11, where the methanogens were inhibited. Likewise, the high content of proteins and the OL of the essays performed with PS resulted in significant production of VFA, strongly differenced from the DS assays.

Following this, the results of this research will be the basis for future research on the production of sustainable-based polyhydroxyalkanoates, through the recovery of municipal wastewater, using VFAs as a substrate.

THANK YOU!

Questions and Comments:

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