

ANAEROBIC DIGESTION OF WASTEWATER TOWARDS BUTANOL AND ETHANOL PRODUCTION

Ariovaldo José da Silva

School of Agricultural Engineering / University of Campinas (UNICAMP)

FAPESP Process 2012/09785-8 | Term: Sep 2012 to Feb 2015

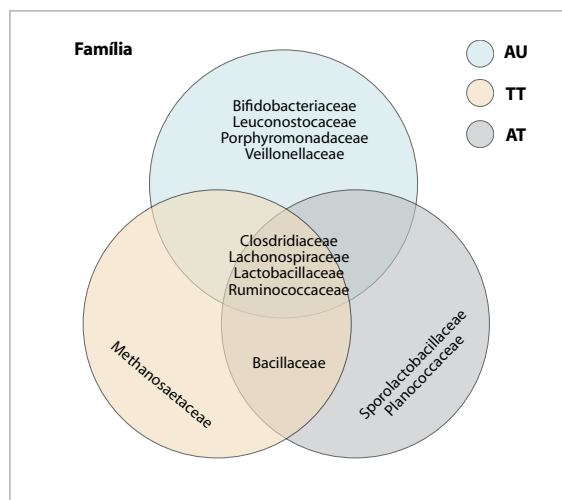


Figure 1. Venn's Diagram of families classified among the bacterial communities present in the reactors were the inoculum was treated with AT, TT and AU

The recovery of energy from wastewaters can be a feasible alternative for butanol and ethanol production via ABE fermentation, a biological biphasic process conducted by *Clostridium* genus bacteria. The ethanol or butanol production in the anaerobic digestion of wastewater depends of the wastes characteristics and operational conditions. In this context two projects were done at laboratory scale aiming to define and evaluate the operational parameters that could lead the metabolism in anaerobic digestion to ethanol or butanol pathway and verify the possible generation of these alcohols from vinasse.

Performance of fixed bed anaerobic reactors coupled in series for ethanol and butanol production from wastewater

This work was conducted in two fixed bed anaerobic reactors (FBR) inoculated with fermentative biomass obtained by natural auto-fermentation of sucrose-based synthetic wastewater. The reactors were operated in acidogenic and solventogenic conditions using hydraulic retention time (HRT) of 2, 4 and 12 hours and organic matter concentration expressed in COD of 500 mg L⁻¹, at 1000 mg L⁻¹, 4000 mg L⁻¹ and 12000 mg L⁻¹. Furthermore, experiments were conducted at variable temperature of 25 °C and 30 °C and controlled temperature of 35 °C.

Effect of vinasse in the biological production of alcohols and volatile organic acids by microbial consortium

In this work, the potential of vinasse as source of feedstock and nutrient for alcohols and volatile organic acids (AVT) production was evaluated by batch fermentation using a microbial consortium from anaerobic reactor treating cattle production wastewater. The sludge was exposed to thermic (TT) and acid-thermic (AT) treatment in order to select bacteria of *Clostridium* genus. The inoculum treated was incubated in two distinct medium one containing only sucrose as organic substrate and another containing sucrose plus vinasse in three different percentages, 33%, 50% and 66%.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Performance of fixed bed anaerobic reactors coupled in series for ethanol and butanol production from wastewater

The mean values of influent and effluent pH were 8.0 ± 0.9 e 4.6 ± 0.2 , respectively. The stability of pH in the reactors for control of solventogenesis was obtained by adding sodium bicarbonate in the influent and permitting the driving of anaerobic digestion process of synthetic wastewater to ABE fermentation. The variations of the HRT and the organic loading rates (OLR) in the feed and operational conditions resulted in increase of AVT concentrations, mainly acetic and butyric acid. The maximum concentration of this acid at variable temperature, HRT of 4 h and OLR of $24 \text{ g COD m}^{-3}\text{d}^{-1}$ were 0.61 g L^{-1} and 0.52 g L^{-1} , respectively. The maximum concentration of ethanol detected was 0.92 g L^{-1} when the temperature was controlled at $35 \text{ }^\circ\text{C}$, HRT of 4 h and OLR of $24 \text{ g COD m}^{-3}\text{d}^{-1}$.

Effect of vinasse in biological production of alcohols and volatile organic acids by microbial consortium

The highest productivity of butyric ($44.2 \pm 2.3 \text{ mg L h}^{-1}$), and acetic ($9.3 \pm 0.2 \text{ mg L h}^{-1}$) acids occurred in the reactors were the inoculum was treated by AT and with vinasse. We observed highest productivity of ethanol ($8.4 \pm 0.1 \text{ mg L h}^{-1}$) when the inoculums was treated by TT in presence of vinasse. The yield of ethanol production and AVT in relation to total carbohydrates (g.g^{-1}) was the highest in the reactor that received 66% of vinasse, with values of 0.26; 0.69; 0.28; 0.14 g^{-1} , respectively.

The microbiological characterization done by pyrosequencing technic revealed the occurrence in large quantity of bacteria of *Clostridium* genus, mainly in the consortium were autoclaved sludge was used at $120 \text{ }^\circ\text{C}$ during 10 min, at 1 kgf/cm^2 (AU) of pressure. At this conditions, the *C. pasteurianum*, a butanol specie producer bacteria of *Lactobacillus* genus was found in consortium treated with TT and AT.

The addition of vinasse improved significantly the production of butyric acid, being an excellent source of nutrients for butyric fermentation. Butyric acid is the main precursor for butanol production, because high concentrations of butyric acid were produced as the main product of the fermentation process.

MAIN PUBLICATIONS

Silva DB, Silva AJ. Effect of Biogas Recirculation with Sodium Bicarbonate Supplementation for Alcohol Production in Wastewater Treatment. Applied Biochemical and Biotechnology (*submitted*).

Santos GM, Silva AJ. Cofermentation of vinasse and molasses of sugar cane for production of butyric acid. Brazilian Journal of Agricultural and Environmental Engineering (*submitted*).

Santos GM, Moraes BS, Silva AJ. Biological alcohols production from sucrose and vinasse medium by anaerobic mixed culture. Annals of XIV Talyer y Simposium Latin-American of Anaerobic Digestion, Havana. November 2014.

Silva DB, Silva AJ. Influence of biogas recirculation in the stability of anaerobic reactors operating in acidogenic condition. Annals of XIV Talyer y Simposium Latin-American of Anaerobic Digestion, Havana. November 2014.

Pinheiro MI, Tarraf ABJ, Brota GA, Silva AJ. Effect of the organic loading rate on anaerobic digestion of wastewater aiming butanol production. Annals of XIV Talyer y Simposium Latin-American of Anaerobic Digestion, Havana. November 2014.

Silva AJ, Silva DB. Ethanol production by organic matter anaerobic digestion in uncontrolled pH condition. Annals of XIV World Congress on Anaerobic Digestion, Viña del Mar. November 2015.

Silva DB, Silva AJ. Anaerobic fermentation of wastewater in two stages, for the production of volatile acids and alcohols Annals of XIV World Congress on Anaerobic Digestion, Viña del Mar. November 2015.

Ariovaldo José da Silva

Faculdade de Engenharia Agrícola
Universidade Estadual de Campinas (Unicamp)
Avenida Cândido Rondon, 501 – Barão Geraldo
CEP 13083-875 – Campinas/SP – Brasil

+55-19-3521-1025
ariovaldo.silva@feagri.unicamp.br