Evaluation of microorganisms responsible for the production of biogas in an anaerobic reactor that treats agro-industrial waste

Summary

Agro-industrial effluents are composed of food waste and chemical compounds, discharged from industry with a high organic load, pH outside neutrality, with high COD and BOD, and with a high solids. If not treated, the agro-industrial effluent can cause serious damage to the river and the environment. Biological treatment, both aerobic and anaerobic, is widely used in the treatment of agro-industrial effluents. The objective of this work was to evaluate the communities of microorganisms in the anaerobic reactor treatment of agro-industrial effluent, investigating the efficiency of the system in the transformation of organic matter into biogas. All operating parameters of a full-scale anaerobic IC reactor of an agroindustry were monitored. The preliminary results showed that the organic load, pH, redox potential, temperature influence the performance of the reactor and consequently the generation of biogas. In relation to the biological sludge, the alkalinity was between 660 and 940, values that allow a good buffering of the medium, the volatile fatty acids were between 96 and 162 avoiding the acidification of the reactor, the temperature of 29 and 34ºC favored anaerobic digestion. The macronutrient analysis showed that the influent to the reactor had total nitrogen between 34.6 and 58.5 mg/L, P between 7.86 and 17mg/L and ammonia nitrogen between 9.34 and 12.5 mg/L, well meeting the need of anaerobic microorganisms. The volatile solids were between 58 and 85%, optimal values for biodegradability, with all these parameters well monitored, a COD removal between 72 and 84% was observed and the generation of biogas at an average of 1072 m³/d. It is concluded that for a good performance of an anaerobic reactor and efficiency in anaerobic digestion and biogas generation, it is necessary that the physicochemical parameters are well monitored.

Keywords: agro-industrial effluents, anaerobic reactor, anaerobic digestion and biogas.

Introduction

Agro-industrial waste is waste generated in agricultural activities and in the food processing industry. They are the result of operations carried out by the farmer when the waste is no longer useful and needs to dispose of it, and also the result of food processing in the industry. Proper management of agro-industrial waste is essential to minimize negative effects on the environment. The development of research aimed at treating the waste from the agroindustry has grown due to the concern with the potential that these residues have to degrade the environment. In order to minimize damage to the environment, the use of this waste in a sustainable way has been a viable alternative, thus avoiding the disposal of these materials inappropriately (Malafaia et al., 2015).

Most of the time, this waste leaves the agroindustry in the form of effluent (water with food waste and chemicals). There are several technologies used for the recovery and maintenance of the physical, chemical and biological integrity of water. In Brazil, effluent treatment with anaerobic reactors such as the sludge blanket reactor (UASB), fluidized flow and internal circulation reactor (IC) is widely used. Also aerobic processes, such as aeration ponds, activated sludge followed by polishing pond and flotators as aftertreatment (Costa et al., 2018).

The internal circulation reactor is widely used in industry to carry out a variety of processes. In this type of reactor there are two distinct zones, the lower zone contains the granular sludge in an expanded form and the complete mixing zone (Sereno Filho, 2013).

Anaerobic digestion in an internal circulation reactor is a process that involves the decomposition of organic matter by anaerobic microorganisms, this digestion is efficient in mass transfer and ability to handle different types of substrates. However, the design and operating conditions of the reactor, such as temperature, pH, feed rate of substrates must be carefully adjusted to ensure efficient and stable performance of the system (Castro et al., 2015).

Anaerobic microorganisms play an essential role in digestion in anaerobic reactors. These microorganisms are mainly bacteria and archaea that decompose organic matter in the absence of oxygen, generating biogas (Rodrigues et al., 2021).

Biogas is a mixture of gases produced by the anaerobic digestion of organic matter by microorganisms under oxygen-free conditions. The composition of biogas can vary depending on the source of the organic matter and the digestion conditions, but it is generally composed of methane, carbon dioxide, and nitrogen (Cavalcanti et al., 2023).

General objective

To evaluate the communities of microorganisms in the anaerobic treatment of agro-industrial effluent, in order to investigate the efficiency of the system in the transformation of organic matter into biogas, with a view to the energy use of the biogas produced.

Methodology

The study was carried out at the industrial effluent treatment plant (ETE) of a food company in the metropolitan region of Goiânia - Goiás. The treatment plant treats 350m3/h of effluent, in the harvest this volume reaches 450 m3/h. The station has two types of biological effluent treatment simultaneously, anaerobic and aerobic treatment. The treated effluent is discharged into the Capivara River, or used as reuse by farmers in the region and also by the industry itself.

The effluent from the industry contains a high organic load with tomato, pea, carrot, corn and ingredients that are used in the manufacture of mayonnaise. Physicochemical analyses of the influent and effluent to the biological reactor were carried out, such as pH, temperature, chemical oxygen demand (COD), biochemical oxygen demand (BOD), alkalinity, redox potential, macronutrients. The characterization of the biological sludge (pH,, total solids (TS), volatile solids (SV), fixed solids (SF), temperature, alkalinity, volatile acidity and redox potential was also carried out. The physicochemical analyses were carried out according to APHA (2012).

Findings

The preliminary results showed that the organic load, pH, redox potential and temperature influenced the performance of the reactor and consequently the generation of biogas. In relation to the biological sludge, the alkalinity was between 660 and 940 mg$CaCO^3$/L, values that allow a good buffering of the medium; the volatile fatty acids were between 96 and 162 mgHC/L, avoiding the acidification of the reactor, and the temperature of 29 and 34ºC favored anaerobic digestion. The macronutrient analysis showed that the tributary to the reactor had total nitrogen between 34.6 and 58.5 mg/L, phosphorus between 7.86 and 17 mg/L and ammonia nitrogen between 9.34 and 12.5 mg/L, well meeting the needs of anaerobic microorganisms.

The volatile solids were between 58 and 85%, optimal values for biodegradability. Considering these monitored parameters, it was observed a COD removal between 72 and 84% and the generation of biogas at an average of 1072 m^3/d. It is concluded that, for a good performance of an anaerobic reactor and efficiency in anaerobic digestion and biogas generation, it is necessary that the physicochemical parameters are adequately monitored.

Conclusion

Through the preliminary results obtained, it is concluded that the IC anaerobic reactor used in agro-industrial effluent treatment with adequate monitoring of the physicochemical parameters and knowledge of the metabolism of anaerobic microorganisms, can produce biogas on a large scale.

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