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RESEARCH ARTICLE

BIOGAS PRODUCTION FROM DIGESTION DAIRY WASTEWATER ANAEROBIC REACTOR IN UASB

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ABSTRACT

Industries dairy, like most other agricultural industries, generates large flows of wastewater resistant, characterized by high biological oxygen demand (BOD) and chemical oxygen demand concentrations (COD). Dairy effluent are considered a major contributor to the pollution caused by these industries. The objective of this work was to study the UASB(UpflowAnaerobicSludgeBlanket)for the treatment of dairy products and biogas effluent.The efficiency of type UASB reactors from the organic loading rate of 6 kg COD m^{-3} d^{-3} and hydraulic retention time (HRT) of 11.8 was studied and its performance was evaluated by monitoring the pH, COD, alkalinity ratio FOS / TAC and biogas production. It was observed COD removal efficiency of 71.3%. The pH of the reactor was observed between 7.0 and 7.3 and the value of FOS / TAC between 0.129 and 0.152. The average biogas production was observed in 85.8 liters per day, and the specific volume of biogas from 0.46 to 0.71 U / g COD per day. The methane content of the biogas produced, observed maximum and minimum value of 56.6% and 40.0%, respectively.

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INTRODUCTION

The production and use of biogas is usually seen as a promising option for clean and sustainable energy generation that can meet global energy needs and providing multiple environmental benefits, such as significant reductions in emissions of gases causing the greenhouse effect. The biogas can be produced from the anaerobic digestion of almost all types of organic materials for the primary agricultural and various industrial and domestic organic waste streams (Agostini *et al*., 2015). Among the industrial activities, the dairy industries stand out as major generators of organic waste. The dairy industry, like most other agricultural industries, generates large flows of resistant wastewater, characterized by high biological oxygen demand (BOD) and chemical demand of oxygen concentrations (COD), representing its high content of organic matter (Demirel *et al*., 2005). During all stages of production are generated industrial wastewater, solid waste and air emissions, without proper control and mitigation, have potential to generate environmental impacts associated with the activity. Net of dairy industry effluents also cover the sewage generated in the toilets, canteen and laundry industry (Fiemg, 2016). The discharge of industrial effluents is considered the main environmental impact of the dairy industry, because besides the high concentration of organic matter, the effluents have high levels of oil and grease, and are characterized by the presence of suspended solids and odor caused by the decomposition of casein. The pH is almost neutral, but tends to acidify due to the use of acid for cleaning operations and the lactic fermentation of waste and its subsequent conversion into lactic acid (Maganha, 2006). Due to high concentrations of residual organic matter, it is considered as an attitude necessary for the implementation of viable treatment systems with greater potential for recovery. In this scenario, the adoption of anaerobic digestion processes in the dairy industry effluent treatment plants stand out as the biological method more suitable for the treatment or pretreatment of generated waste effluents (Rich *et al*., 2015). Anaerobic digestion of applying has increased over the years as a treatment technology that is applicable to high strength

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wastewater without energy consumption, stabilization of the organic matter and the production of biogas which can be used as a renewable source of energy in the industry itself. Among the stories of anaerobic treatments dairy effluents, high rate anaerobic reactors of the UASB type (Upflow Anaerobic Sludge Blanket) are used (Passeggi *et al*., 2012). According Totzke (2004), the UASB reactor is the most promising configuration for the treatment of various waste liquids. UASB type reactors, the microorganisms are mainly grouped into granules and flakes formed by self-aggregation of bacteria and methanogenicarchaeas. The pellets are compact agglomerates that accumulate in large quantities in the reactor have a high specific methanogenic activity and sedimentation. These formations depend very much on the upstream and composition of the waste water (Barros *et al*., 2016). According to Zhao *et al*. (2008), UASB reactors still has positive characteristics, such as their ability to handle high substrate loading and short hydraulic retention times. With that, considered in this work, the application of anaerobic digestion technology in the treatment of liquid waste from a dairy industry using the reactor UASB type.

MATERIALS AND METHODS

The anaerobic system for the treatment and biogas production from liquid of a dairy wastewater was implemented in Bioenergy Laboratory for waste management and bio-energy at the University of Rostock, Germany. The duration of the experiment was 51 days. The dairy liquid waste used as substrate for this study was provided by the dairy industry, located in Upahl (Mecklenburg-Vorpommern, Germany). This dairy industry manufactures a variety of dairy products such as yoghurts, butter, cheese, milk and others. The milk residues were transported to the laboratory and stored at 4 ° C until use. Before being used for the anaerobic reactor total feed, this substrate samples were subjected to analysis and physico-chemical characteristics are shown in Table 1.

Table 1. Physical and chemical properties of the milk substrate used in this study

Parameters	Unit	Values
DQO	(mg/ L)	65000
P tot.	(mg/ L)	842
NO_3-N	(mg/ L)	5,24
NH_4-N	(mg/ L)	67
N tot.	(mg/ L)	786
pH	(mg/ L)	4,53
Ca	(mg/ L)	1680
Cl	(mg/ L)	932
MS	(% bymass)	5,30
SV	(% bymass)	4,50
SV	(total MS%)	83,70
LacticAcid	(mg/ L)	12000
Ethanol	(mg/ L)	31,40
ÁceticAcid	(mg/ L)	1165,5
ButyricAcid	(mg/ L)	21,33

Notes: COD, chemical oxygen demand; DM, dry matter; SSV, volatile solids.

For this study it was used a cylindrical UASB reactor with a diameter of 0.3 m, cross-sectional area of 0, 0707 m^2 and a useful working volume of about 85 liters, built from glass and covered with a three-phase separator. The UASB basically consists of three main parts in its upward column: sludge bed; settling zone; and the three-phase separator which is a device placed at the top of the reactor. The gas-liquid-solid separator is a device whose purpose is to divide the digestion zone, where the sludge blanket responsible for anaerobic digestion and settling zone (Hamerski, 2012). The sludge from an industrial anaerobic reactor used in the treatment of residues of a potato was used as inoculum for this study. After inoculation, the reactor feed was held by the lower part of the reactor via a peristaltic pump and the effluent left the reactor through an outlet pipe at the top of the reactor. The feed system consisted of a 10 L plastic container, which was supplied daily with the effluent maintained under refrigeration at 4 °C. This feed vessel was maintained at room temperature on a magnetic stirrer to avoid any sedimentation of solids. The UASB reactor was fed in an intermittent operation mode with 12 periods per day meal and feed pump operating time of 1 minute for each period. The UASB reactor was operated with a hydraulic retention time of 11.8 days 7 flow rate of 85 L d^{-1}, the organic loading rate of 6 kg COD m $^{-3}$ d^{-3} and the temperature maintained in the range of mesophilic 28 to 30 °C by means of heated water around the reactor and insulating foam. The amount of biogas generated in the UASB reactor was measured by means of a biogas measuring device installed adjacent to the top of the reactor to measure the production of biogas daily. Biogas volume was quantified every 30 minutes per day. For the biogas storage, metallized material bags were made that were connected to the biogas flow meter. The reading of the biogas composition was performed using the software (method) Visit 3. The stability of the anaerobic process regarding the alkalinity of the medium can be evaluated either by the knowledge of the individual volatile organic acids and buffering capacity or through the relationship between these parameters parameters (MEZES *et al*., 2011). In this study, we applied the FOS / TAC method, the ratio of volatile fatty acids (FOS) and buffer capacity (TAC) according to Nordmann method (1977). Other parameters analyzed during the experiment were pH, temperature and COD (DIN 38409-H41-1, 1980). The volume of produced biogas and biogas methane content were determined daily. They were the pH, temperature and COD (DIN 38409-H 41-1, 1980). The volume of produced biogas and biogas methane content were determined daily.

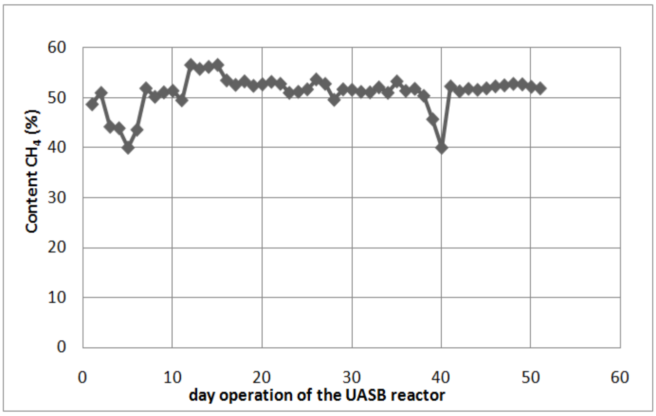

Figure 1. CH_4 content in the biogas produced from dairy effluents

RESULTS AND DISCUSSION

The anaerobic digestion process can be greatly influenced by various environmental factors such as temperature, pH and alkalinity. Thus, it is important to provide favorable environmental conditions for microbial populations within the anaerobic reactors to ensure the digestion process to occur in a stable manner. The temperature remained in the mesophilic range set at the beginning of the experiment, with no fluctuations outside this range. According Powar *et al*. (2013). The organic material degradation rate is enhanced at mesophilic temperatures. According Lettinga and Haandel (1993), the early stages of anaerobic digestion can take place over a wide range of pH values, while methanogenesis proceed only when the pH is neutral. The pH value recorded during the experiment remained in the range of 7.0-7.3. These values are in accordance with the pH values observed in other studies for the treatment of dairy wastewater in UASB reactors (Kavitha *et al*., 2013; Tawfik, 2008). For pH values outside the 6.5-7.5 range, the methane production rate is lower (Mes *et al*., 2003). The alkalinity ratio control system degradation is extremely important, since increased too much organic acids and low buffering capacity can cause a breakdown in the anaerobic digestion process. Applying FOS / TAC method the stability of the anaerobic degradation process was determined easily.

The value of FOS / TAC in this study was observed between 0.129 to 0.152. This value is in agreement with the results E. Voss *et al*. (2009), which determined optimal range between 0.15 and 0.45. According Drosg (2012), alkalinity ratio below 0.3 is generally considered as an indicator of stable processes. The test chemical demand of oxygen (COD) was used to quantitate the amount of organic matter in the dairy substrate and predict the biogas potential. The COD of input wastewater in UASB reactor was 68900 mg / l, and the COD after leaving the reactor varied between values of 10500-16600 mg / L during the experiment. The efficiency of the UASB reactor operated in this study in terms of COD removal was 71.3%. Kavitha *et al*. (2013) in his study on the performance evaluation and biological treatment of dairy wastewater in UASB reactor, verified the reactor performance efficiency by 76.9%. Already, Gotmare *et al*. (2013) studied the "Biomethanation of UASB in dairy effluents in the mesophilic temperature range," and noted that the reactor efficiency of COD was 87, 06%. Throughout this time there was studied the average value of biogas production from dairy effluents in 85.8 liters per day. The specific volume of biogas produced ranged from .46 to 0.71 U / g COD per day. Regarding the methane content in biogas, the observed maximum and minimum value of 56.6% and 40%, respectively (Figure 1).

In this study, the anaerobic digestion of waste water in the dairy UASB reactor has been reported. The results showed good performance of UASB for this type of waste, achieving a COD removal efficiency of 71.3%. The specific volume of biogas was observed in the range of 0.46 to 0.71 U / g COD per day with the methane content of around 40% and 56.6 in biogas. The pH and temperature values remained stable throughout the experiment, not operating outside the optimal range for this type of process in UASB. The value of FOS / TAC in this study was between 0.129 to 0.152. This value is in agreement with the values shown in the literature, confirming process stability. Based on the results, the UASB reactor had a satisfactory performance for the treatment and biogas production. Thus, this biological treatment process can be considered as an important tool for the treatment of polluted waste water, and consequently in the production of renewable energy.

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