Process Safety and Environmental Protection 102 (2016) 385–391

Contents lists available at ScienceDirect

Process Safety and Environmental Protection

journal homepage: www.elsevier.com/locate/psep

Performance of an upflow anaerobic filter in the treatment of cold meat industry wastewater

Elizabeth León-Becerril, Jorge Eduardo García-Camacho, Jorge Del Real-Olvera, Alberto López-López*

Department of Environmental Technology, Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco A.C., Av. Normalistas 800, Colinas de la Normal, 44270 Guadalajara, Jalisco, Mexico

ARTICLE INFO

Article history:
Received 18 December 2014
Received in revised form 3 March 2016
Accepted 16 April 2016
Available online 23 April 2016

Keywords:
Organic load rate
Methane
Cold meat industry wastewater
Upflow anaerobic filter
Nutrients

ABSTRACT

Treatment of cold meat industry wastewater was performed in an upflow anaerobic filter (UAF) analyzing the effect of the physicochemical characteristics of the wastewater, which contains high concentrations of organic matter expressed as total chemical oxygen demand (COD) (3500 mg L^{-1}) and total biochemical oxygen demand (BOD) (2035 mg L^{-1}), fat oil and grease (FOG) (1114 mg L^{-1}), in addition salts (nitrogen and phosphorus), additives, colorings, flavorings and others. The biomass used was previously adapted to the cold meat wastewater in a batch reactor, reducing the total COD and total BOD concentrations by 81% and 87% respectively over a period of 15 days and ensuring to decrease time of staring-up and stabilization of the UAF. Removal efficiencies of total COD and total BOD attained 84% and 88% respectively in the UAF reactor, operating at organic loading rates ranging from 1.17 to 3.5 kg COD m^{-3} day^{-1} at 37 °C and pH 7; methane production yield at operating conditions in the stable period of operation reached 422 mL CH_4 (g $COD_{removed}$)$^{-1}$. Physicochemical characteristics of the wastewater, particularly nutrient concentration was determinant in the biomass adaptation and in the self-generated alkalinity, two parameters that greatly contributed to the performance and stabilization of the reactor.
© 2016 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.

1. Introduction

Cold meat industry generates a large volume of wastewater during the production processes, ranging from 5 to 8 m^3 per tonne of meat processed, depending on the employed processes in each industry. Also physicochemical characteristics of cold meat wastewater depend on the production processes, few literatures are related to cold meat industry wastewater then slaughterhouse wastewater has been taken as reference. Cold meat industry and slaughterhouse wastewaters have some similar physicochemical characteristics, presenting a high content of organic matter as chemical oxygen demand (COD) (meat industry: 2780–6720 mg L^{-1}; slaughterhouse: 4200–8500 mg L^{-1}) and biological oxygen demand (BOD) (meat industry: 1200–3000 mg L^{-1}, slaughterhouse: 1600–3000 mg L^{-1}), implying a high biodegradability, 58% for cold meat wastewater and 54–63% for slaughterhouse wastewater. Also both wastewaters present high content of fats, oils and greases (FOG) (slaughterhouse: 100–200 mg L^{-1}) and high content in total nitrogen (TN) (meat industry: 49–287 mg L^{-1}, slaughterhouse: 114–148 mg L^{-1}), total phosphorus (TP) (meat industry: 15–70 mg L^{-1}, slaughterhouse: 20–30 mg L^{-1}), intense coloration and high conductivity (Johns, 1995; Casani et al., 2005; Cassidy and Belia, 2005; Bohdziewicz and Sroka, 2006; De Sena et al., 2008; Padilla-Gasca et al., 2011; Heponiemi and Lassi, 2012). Nevertheless, cold meat industry wastewater presents a less amount of total suspended solids (TSS) than slaughterhouse wastewater (meat industry: 112–1743 mg L^{-1}, slaughterhouse: 1300–3400 mg L^{-1}), most of the total COD is dissolved, and presents more nitrogen and phosphorus salts;

* *Corresponding author*. Tel.: +52 3333455200; fax: +52 3333455200x1001.
E-mail addresses: alopez103@yahoo.com, allopez@ciatej.mx (A. López-López).
http://dx.doi.org/10.1016/j.psep.2016.04.016
0957-5820/© 2016 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.

differences in color and additive contents are significant (Heponiemi and Lassi, 2012).

Therefore, cold meat wastewater represents an important problem if it is discharged without an adequate treatment to the environment, specifically to rivers or sewer systems. Physicochemical and biological processes have been applied for the treatment of slaughterhouse wastewater (Johns, 1995; Mittal, 2006; López López et al., 2008; Heponiemi and Lassi, 2012; Harris and McCabe, 2015). In particular, for biological treatments, aerobic process showed removal performances of COD, ammonia and phosphate of 95.1%, 99.3% and 83.5%, respectively using aerobic granular sludge at laboratory scale (Liu et al., 2015). However aerobic processes require energy to supply oxygen to microorganisms, especially when wastewater presents high concentrations of nitrogen and FOG (Johns, 1995). Therefore anaerobic processes have been proposed as an alternative for the treatment of wastewaters with high organic loads, being suitable for the treatment of effluents from agro-industries (Johns, 1995; Del Real Olvera and López-López, 2012). These processes present advantages such as high production of biogas rich in methane, low generation of sludge, no aeration costs and elimination of pathogens due to the low energy requirements and rate resistance to dynamic changes in organic matter concentration (Buendía et al., 2008; Khanal, 2008). Several studies show the viability of the anaerobic process for the treatment of slaughterhouse wastewaters; an upflow anaerobic sludge blanket (UASB) operated at organic loading rates (OLR) from 1 to 6 kg COD m^{-3} day^{-1}, in mesophilic range, could attaint removal efficiencies from 66% to 90% for COD in stabilization periods of 300–410 days (Ruiz et al., 1997). Upflow anaerobic filters (UAF) at 23.6–37 °C can obtain 66–90% of COD removal, for OLRs ranging from 1 to 6.5 kg COD m^{-3} day^{-1} and hydraulic residence time (HRT) from 0.8 to 4.9 days, with a starting-up reactor period of 60 days and more than 300 days for stabilization (Ruiz et al., 1997; Mittal, 2006; Padilla-Gasca and López-López, 2010; Padilla-Gasca et al., 2011; Martinez et al., 2014). Also combined processes (anaerobic–aerobic) such as an UAF operating at 24 h of HRT and at 11 kg COD m^{-3} day^{-1} of OLR with a sequencing batch reactor (SBR) with 9 h for aeration time, can reach COD removal efficiencies around 95% (Borja, 1995; López-López et al., 2010). The combination of the activated sludge process with reverse osmosis has attaint removal efficiencies of 98% for COD and BOD, at 0.15 g COD g^{-1} TS day^{-1}, aeration intensity 800 L h^{-1} and HRT 12 h; the reverse osmosis operated at 0.1–0.3 MPa with a flux of water of $1.0–2.78 \times 10^{-6}$ m^3 m^{-2} s^{-1} (Bohdziewicz and Sroka, 2006).

Hence, anaerobic process represents an opportunity for the treatment of cold meat industry wastewater, in specifically the UAF; it is less sensitive to variations in pH, temperature and OLR, the upstream hydrodynamic ensures better contact between the immobilized biomass and water substrate, therefore it can operate at high organic loads and with different substrates. The UAF is stable in the presence of toxic substances such as fats and oils and colorants; also its operation is simple; therefore UAF is an adequate option for the cold meat industry wastewater treatment (Mittal, 2006; López-López et al., 2010; Padilla-Gasca and López-López, 2010; Padilla-Gasca et al., 2011; Martinez et al., 2014).

Despite of the advantages of anaerobic processes for treating slaughterhouse and similar wastewaters, there are still technical problems, particularly long periods for staring-up and stabilization of the reactor due to the high concentration of toxic compounds present in wastewater and the low concentration of nutrients with respect to the high concentration of carbon, organic matter that is measured as COD. Nutrients and trace metals provide suitable biochemical resources for the optimum growth of microorganisms. It is important to note that if the wastewater to be treated does not have one or more of the important nutrients and trace elements, then the biological treatment process is severely affected; this is because of the inability of microbial cell to grow at optimum rate and to produce new cells (Johns, 1995; Khanal, 2008; Padilla-Gasca et al., 2011).

The aim of this work was to evaluate the effect of the physicochemical characteristics of the cold meat wastewater and the adaptation of biomass in a batch reactor on the performance of an anaerobic upflow filter. The presence of nutrients in the wastewater will avoid the addition of external chemicals to maintain the stability and performance of the biological process; and the previous adaptation of biomass will permit the reduction of time in the start-up and stabilization periods of the UAF.

2. Materials and methods

2.1. *Wastewater*

Samples of wastewater were taken every 3 h over 2 days from a cold meat industry in Mexico, to obtain a composite sample; wastewater was maintained at 4 °C until it was used for the experiments. Before feeding the cold meat wastewater to the UAF reactor, pH was adjusted at 7. Standard Methods were used to determine total COD (COD), total BOD (BOD), FOG, TSS, TN, TP, turbidity, color and conductivity; in the particular case of the species SO_4^{2-}, Ca^{2+}, Na^+, Cl^- they were determined by ion chromatography using an apparatus Metrohm, model 861 with conductivity detector (Clesceri et al., 1998).

2.2. *Adaptation of biomass in a batch reactor*

Granular sludge from a stabilized anaerobic process for the treatment of vinasse was used as inoculum; an Erlenmeyer flask glass of 2 L with constant stirring was used for the adaptation and growth of biomass before to be feeding to the UAF reactor. The reactor operated in batch mode at 37 ± 2 °C, and pH from 6.8 to 7, adjusted with NaOH, with a volume of wastewater of 1.6 L. A sludge volume of 20% (v/v) with respect to the reactor volume reaction was used with a volatile suspended solids (VSS) concentration of 8500 mg VSS L^{-1}. The reactor was initially fed with a COD concentration of 350 mg L^{-1}, corresponding to 10% of the wastewater COD concentration; then COD concentration was gradually increased in 10%, until reaching the COD concentration of the effluent (3500 mg L^{-1}); by replacing the equivalent volume of wastewater with the required COD concentration. Each load lasted 48 h; this time assures the organic matter degradation greater than 50% and in consequence biogas production.

Biogas (methane and carbon dioxide) generated during the anaerobic process passed through a solution 3 M NaOH for capturing the CO_2 present in the biogas to Na_2CO_3, then methane gas was measured by displacement of water in a column; methyl orange was used as indicator of the saturation of NaOH solution. During the batch experiments, the volume of methane was measured as a function of time; samples of

Download English Version:

https://daneshyari.com/en/article/588092

Download Persian Version:

https://daneshyari.com/article/588092

Daneshyari.com