Journal of Water Process Engineering 4 (2014) 74–81

Contents lists available at ScienceDirect

Journal of Water Process Engineering

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

Microbial population in an aerated thermophilic reactor that treats recycled cardboard plant wastewater

Eloisa Pozzi [a], Claudia Regina Megda [a], Victor E.A. Caldas [b], Márcia Damianovic [a], Eduardo Cleto Pires [a,*]

[a] Department of Hydraulics and Sanitary Engineering, Engineering School of São Carlos, University of São Paulo, Av. Trabalhador Sãocarlense 400, 13560-970 São Carlos, SP, Brazil

[b] Institute of Physics of São Carlos, Universidade de São Paulo, Av. Trabalhador Sãocarlense 400, 13566-590 São Carlos, SP, Brazil

ARTICLE INFO

Article history:
Received 1 July 2014
Accepted 14 August 2014
Available online 14 October 2014

Keywords:
Activated sludge
Anaerobic treatment
Paper mill
Thermophilic wastewater treatment
Clone library
16S rRNA

ABSTRACT

Aerated thermophilic reactors may have advantages for treating industrial effluents discharged at high temperatures. In this study, the wastewater from a recycled packaging cardboard plant was treated at 55 °C in a moving bed aerated reactor. It was observed that, although the overall dissolved oxygen was maintained at 2–3 mg L^{-1}, several anaerobic microorganisms are found either in the mixed liquor or in the attached biofilm. This result indicates that both aerobic and anaerobic mechanisms participate in pollutant removal in this reactor, which confers advantages when recalcitrant compounds are found. The median COD removal efficiency of 84% for 36 h of HRT observed in this experiment is expected for non-optimized activated sludge treatment of high temperatures industrial wastewater.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

Wastewater from pulp and paper mills is usually treated in mesophilic activated sludge plants using a cooling step if the discharge temperature is higher than 45 °C. This step demands high energy consumption and is expensive to maintain, being an important motivation for studying thermophilic processes to treat this class of wastewater [1–3].

The treatment of recycled cardboard plant wastewater is a relatively simple process when performed at conventional treatment plants at mesophilic temperature. An extensive literature on this subject was published describing the different plant configurations that are used. These plants can be as simple as aerated ponds or complex, state-of-the-art anaerobic/aerobic plants. For instance the mill from which the wastewater for this experiment came from uses a batch extended aeration activated sludge and the overall efficiency of BOD removal averages 90%.

Aerobic thermophilic treatment is known to better control the excessive sludge production than a mesophilic treatment. This advantage results from the high energetic requirements for microbial maintenance and from the high microbial decay coefficient found in thermophilic operations [4]. In addition, the rates of pollutant degradation and pathogenic microorganism inactivation increase at higher temperatures.

The increased degradation rate reduces the hydraulic retention time (HRT) needed for treatment and, consequently, may compensate for additional costs with aeration at higher temperatures [1].

Considering the comments on the advantages of thermophilic processes and in particular the elimination of the wastewater cooling stage, anaerobic thermophilic processes are an option to consider for the treatment of high strength wastewater discharged at high temperatures, such as paper mill wastewater. However, little is known about the microbial population in these reactors, especially for recalcitrant compound-containing wastewaters, such as recycled paper manufacturing wastewater. Thus, this paper characterizes the microbial community of a moving bed aerobic reactor at thermophilic conditions while treating industrial wastewater from a recycled cardboard industry. Whenever possible the current findings are compared with results obtained from other kinds of reactors and environments.

2. Methods

2.1. Aerated reactor

The aerated moving bed reactor operated in continuous flow and was built of carbon steel with an internal diameter of 145 mm, total height of 0.50 m and reaction volume of 3.6 L (Fig. 1a). A fine

* Corresponding author. Tel.: +55 16 3373 9571; fax: +55 16 3373 9550.
E-mail address: ecpires@sc.usp.br (E.C. Pires).

http://dx.doi.org/10.1016/j.jwpe.2014.08.011
2214-7144/© 2014 Elsevier Ltd. All rights reserved.

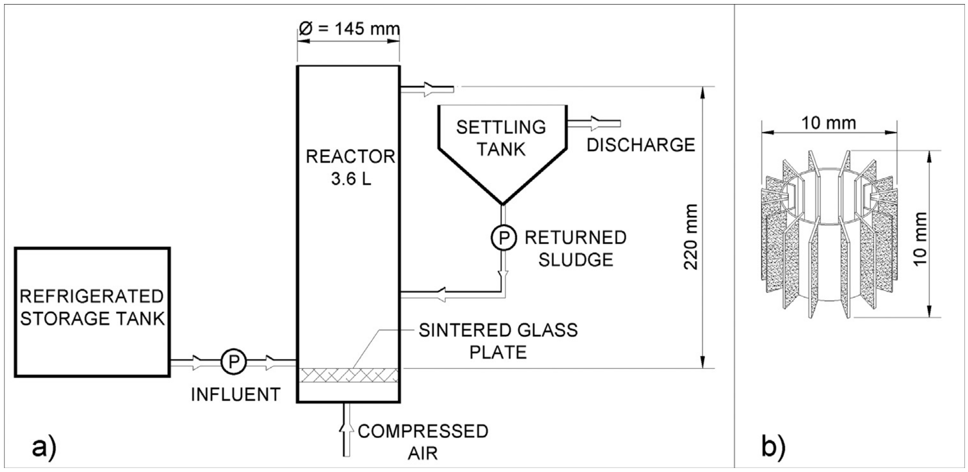

Fig. 1. Thermophilic aerated reactor and biofilm carrier.

Table 1
Summary of the operational conditions and COD removal efficiency.

Phase	Time (days)	Influent COD ($mg\,O_2\,L^{-1}$)	Range (median) COD removal efficiency (%)
Acclimation* HRT: 48 h Black-liquor		Variable, Range: 340–1040 Median: 590	0–20 (–)
Phase I HRT: 48 h Industrial wastewater	1–3	350	16–38 (–)
	4–14	880	38–73 (70)
	15–20	1970	82–72 (–)
	21–37	2630	55–75 (73)
	38–47	4060	68–82 (78)
	48–65	4060	60–86 (84)
Phase II HRT: 36 h Industrial wastewater	66–75	4060	78–84 (82)
	76–79	4930	85–86 (–)
	80–96	4500	81–83 (82)
	97–118	4680	84–86 (86)

* 46 days of continuous operation.

Table 2
Composition of the black liquor used to prepare the synthetic wastewater.

Parameter	Value ($mg\,L^{-1}$)	Parameter	Value ($mg\,L^{-1}$)
pH	13	Pb	0.29
COD	243,000	Cd	0.20
BOD	81,455	Ni	0.77
Ratio COD/BOD	2.98	Fe	1.56
Sulfide	n.d.	Mn	1.80
TOC	55,110	Cu	1.40
Zn	0.74	Cr	n.d.

135 mm in diameter sintered glass plate, assembled at the bottom of the reactor, allows air injection. The oxygen concentration was monitored by an oximeter using a specially designed circuit to cool the mixed liquor before measurement and reheating the mixed liquor prior to its return to the reactor (circuit not shown in Fig. 1a). The dissolved oxygen concentration was maintained between 2 and 3 $mg\,L^{-1}$ by means of manual adjustment of the air flow rate. An electronic circuit using the oximeter was also installed to assure that the dissolved oxygen stayed between 1 $mg\,L^{-1}$ and 4 $mg\,L^{-1}$. This circuit worked turning on and off the air pump but was rarely needed. The reactor, settling tank and return sludge pump were assembled in a temperature-controlled cabinet at $55 \pm 1\,^{\circ}C$. Fifty percent of the reactor was filled with a 1 cm × 1 cm (external diameter × height) conventional polyethylene biofilm carrier for biomass immobilization (Fig. 1b). The reactor was inoculated with mesophilic sludge collected at the wastewater treatment plant from Indústria de Papel São Carlos S/A – Papel e Reciclagem (Paper Industry of São Carlos S/A – Paper and Recycling) located in the municipality of São Carlos, state of São Paulo, Brazil. This same industry provided the industrial wastewater for this study. Biomass development at the aerobic thermophilic reactor followed the protocols of Jahren et al. [4] and Suvilampi et al. [2].

The experiment was divided into three phases: reactor acclimation, Phase I and Phase II (Table 1). The sludge acclimation phase lasted 46 days at 48 h HRT using a synthetic wastewater prepared with black liquor from a pulping plant as its main substrate. The acclimation was performed at (55 °C) reproducing extreme conditions of operation: high temperatures and a substrate containing toxic compounds. The authors experience indicates that this protocol results in a sludge able to stand most substrates and requires a relatively short period. Phase I began after 46 days of sludge acclimation, when diluted wastewater from the recycled packaging cardboard plant replaced the diluted black liquor. The HRT was maintained at 48 h as used during acclimation.

After 64 days, the HRT was decreased to 36 h, and Phase II started. The influent COD was increased in irregular steps in Phases I and II from a minimum of 880 $mg\,O_2\,L^{-1}$ to a maximum of 4930 $mg\,O_2\,L^{-1}$. All wastewater measurements followed standard procedures [5] (Table 1).

2.2. Synthetic and industrial wastewaters

The synthetic wastewater used for biomass acclimation was prepared using weak black liquor from an unbleached eucalyptus kraft cellulose pulp mill (Table 2). This substrate was supplemented with macronutrients (nitrogen and phosphorus) and micronutrients. Subsequently, the mixture was diluted with tap water to keep the influent COD at 500 $mg\,O_2\,L^{-1}$, and the pH was adjusted to 7.0 with sulfuric acid.

The industrial wastewater (Table 3) fed at Phases I and II was collected from the paper machine discharge pipe before mixing with other plant wastewaters. Three samples were collected and maintained below 4 °C, numbered 1, 2 and 3 in Table 3. The natural degradation under cold storage was monitored and less than 10% COD decay occurred in 30 days, which is a small loss considering that the wastewater was diluted and the COD was adjusted before use. Samples for other works also provided data for interpretation of the current results and their characteristics are also listed in Table 3.

Download English Version:

https://daneshyari.com/en/article/232543

Download Persian Version:

https://daneshyari.com/article/232543

Daneshyari.com