Water Research 39 (2005) 1511–1518

WATER RESEARCH

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Optimum cycle time for intermittent UASB reactors treating dairy wastewater

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Received 5 September 2004; received in revised form 12 January 2005; accepted 25 January 2005
Available online 29 March 2005

Abstract

This work accesses the influence of cycle duration on the intermittent operation of mesophilic UASB reactors inoculated with flocculent sludge and used in dairy wastewater (DWW) treatment. Five cycle lengths ranging from 24 to 144 h were compared for loads between 2.5 and 29.0 g COD/l/d. COD balances are presented which demonstrate the importance of a feedless period in the conversion to methane of the substrates removed during the feed period. The maximum applicable loads determined for the system were higher for the longer cycle times. The higher conversion to methane of the removed COD was obtained for the 96 h cycle (48 h feed + 48 h feedless) resulting in a more stable operation. The 96 h cycle (48 h feed + 48 h feedless) was considered as the optimum for the treatment of dairy effluents in intermittent UASB reactors. Compared to the maximum applicable loads reported in the literature for continuous systems (3–6 g COD/l/d) treating dairy effluents the stable operation loads attained with intermittent operation were considerably higher (22 g COD/l/d).
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Keywords: UASB; Intermittent operation; Dairy wastewater; Optimum cycle time; Flocculent sludge

1. Introduction

The anaerobic treatment of industrial wastewater has grown in acceptance as a perfectly mature technology and it is widely used in many countries. Presently the UASB reactor is the most promising anaerobic high-rate configuration for the treatment of various kinds of liquid wastes (Totzke, 2004). The high-rate anaerobic treatment of dairy wastewater (DWW) and other fat containing effluents has been subjected to extensive studies in the last decades. Recent research done on anaerobic degradation of complex fat containing wastewater showed that the initial removal mechanism is mainly adsorption (Hwu, 1997; Nadais et al., 2001a, 2003; Riffat and Dague, 1995), which occurs very rapidly but is not followed by an immediate biological degradation. It was found that the biological degradation steps are much slower than the adsorption phenomena (Hwu, 1997; Nadais et al., 2001a, 2003, accepted for publication; Sayed, 1987; Sung and Dague, 1992). The visible consequence of this kinetic difference is an accumulation of organic matter in continuous treatment systems which has been reported both at lab-scale (Nadais et al., accepted for publication; Petruy, 1999; Sayed, 1987) and full scale (Totzke, 1992) anaerobic reactors treating complex fat containing substrates.

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0043-1354/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.watres.2005.01.020

Most of the literature data on the anaerobic treatment of DWW in continuous systems are not detailed enough to allow the calculation of the conversion to methane of the removed COD. The results from González et al. (1994); Nadais et al. (accepted for publication) and Strydom et al. (1995) show that the conversion to methane of the removed COD falls abruptly from about 80% to about 60% when the load is raised between 0.5 and 3 g COD/l/d, for hydraulic retention times (HRT) ranging from 12 h to 4.5 d. For HRT under 12 h continuous UASB reactors used for the treatment of DWW presented conversions to methane of the removed COD lower than 30% (Nadais et al., accepted for publication). These results led to the conclusion that in order to obtain conversions to methane of the removed COD above 70% in continuous UASB reactors the maximum load is around 3.0 g COD/l/d and the HRT must be above 12 h (Nadais et al., accepted for publication). This value for the maximum load is in accordance with other previous works on anaerobic treatment of dairy effluents (Borja and Banks, 1994; Cayless et al., 1990; Goodwin et al., 1990; Hawkes et al., 1995; Omil et al, 2003; Shin and Paik, 1990; Strydom et al., 1995). Other works on anaerobic treatment of dairy effluents in continuous reactors have reported a significant decrease in reactor performance or failure due to build up of organic matter inside the reactors (Bull et al., 1982; Córdoba et al., 1984; Filho et al., 1996; González et al., 1994; Morgan et al., 1991; Motta Marques et al., 1990; Shin and Paik, 1990; Strydom et al., 1995) although no numerical data are presented for this accumulation.

As a result of experiments with slaughterhouse wastewaters in UASB reactors demonstrating severe COD accumulation in the sludge bed Sayed (1987) suggested the use of flocculent sludge and intermittent operation for the treatment of complex fat containing effluents. The intermittent feed operating mode was also recommended by Lettinga and Hulshoff-Pol (1991) for complex wastewater, specifically for DWW. The intermittent operation consists of an interruption of the reactor feed during a certain amount of time keeping the same (or a higher) operating temperature as during the feed period. In the feedless period time is allowed for the biological degradation of the adsorbed substrates thus eliminating or reducing the accumulation of organic matter in the sludge bed. This operating mode was successfully tested for slaughterhouse wastewater (Sayed et al., 1993), for domestic wastewater (Sayed and Fergala, 1995) and for DWW (Nadais et al., 2001b). Some results were also published on the intermittent operation of UASB reactors for the treatment of proteic wastewaters (Viñas et al., 1991). In spite of these promising results to date, no specific investigation has been reported in the literature concerning the influence of the operating parameters, namely the cycle duration, in the intermittent operation of UASB reactors for the treatment of complex fat containing effluents.

This work aims to access the performance of intermittent operation of mesophilic UASB reactors inoculated with flocculent sludge for the treatment of DWW and to study the influence of the duration of the intermittent cycle on the performance of the system. This assessment was made in terms of COD removal and its conversion to methane and in terms of the stability of the reactors when operated at the higher loads.

2. Materials and methods

Five lab-scale UASB reactors were operated each with a different intermittent cycle: 24, 48, 72, 96 and 144 h. The reactors were operated in the same conditions in the feed period (Table 1) so that all reactors received the same amount of feed the only difference being the feed distribution in time (Tables 2 and 3). The reactors were

Table 1
Operating conditions common to all reactors

Phase	HRT[a] (h)	Flow[a] (l/h)	Load[a] (g COD/l/d)	CODfeed[a] (g COD/l)	Average load[b] (g COD/l/d)	Days per phase
I	12	0.5	5.0	2.5	2.5	18
II	12	0.5	7.0	3.5	3.5	18
III	12	0.5	9.0	4.5	4.5	18
IV	12	0.5	12.0	6.0	6.0	18
V	12	0.5	15.6	7.8	7.8	18
VI	12	0.5	20.0	10.0	10.0	18
VII	12	0.5	26.0	13.0	13.0	18
VIII	12	0.5	34.0	17.0	17.0	18
IX	12	0.5	44.0	22.0	22.0	18
X	12	0.5	58.0	29.0	29.0	18

[a]Operating conditions in the feed period.
[b]Average load = total load fed during one cycle divided by the number of days in the cycle.

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