

Biological Treatment of Dairy Wastewater by Sequencing Batch Reactor

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ABSTRACT

A bench scale aerobic Sequencing Batch Reactor (SBR) was investigated to treat the wastewater from an industrial milk factory. The reactor was constructed from plexi glass material and its volume was 22.5 L. The reactor was supplied with oxygen by fine bubble air diffuser. The reactor was fed with milk factory and synthetic wastewater under different operational conditions. The COD removal efficiency was achieved more than 90%, whereas COD concentration varied from 400 to 2500 mg/l. The optimum dissolved oxygen in the reactor was 2 to 3 mg/l and MLVSS was around 3000 mg/l. Easy operation, low cost and minimal sludge bulking condition make the SBR system an interesting option for the biological medium strength industrial wastewater treatment. The study demonstrated the capability of aerobic SBR for COD removal from dairy industrial wastewater.

Keywords: Sequencing Batch Reactor (SBR), COD removal, Dairy wastewater

INTRODUCTION

Wastewaters from dairy industries are characterised by their high COD content. Most of the dairy industries in Iran use the typical activated sludge for their effluent treatment. The typical activated sludge treatment is characterised by the relatively high energy consumption and biomass production, leading to a relatively high operation costs and problem with the disposal of large amounts of sludge. Biological processes based upon Suspended Sequencing Batch Reactor (SBR) are effective for organic carbon removal in domestic and industrial wastewater. SBR is often operated with higher TS concentrations compared with conventional wastewater

treatment plants, which makes a reduction of the reactor volume possible, thus decreasing investment costs for the treatment plant (Loo and Liao, 1990). In SBR operation, each reactor in the system has five basic operating modes or periods. The periods are Fill, React, Settle, Draw and Idle.

SBR technology has gained more and more importance in wastewater treatment plants (Schiegl et al., 1996; Franta et al., 1997). The main advantages are easy operation, low cost, handling hydraulic fluctuation, no need for settling tank and sludge recycling as well as organic load without any significant variation in removal efficiency (Kolb and Wildere, 1997; Keudel and Dichtl, 2000).

This study was conducted to determine the treatability of dairy wastewater by SBR and to

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evaluate the effect of oxygen and MLSS concentrations on COD removal efficiency.

MATERIALS AND METHODS

A bench scale sequencing batch reactor (SBR) was fed by wastewater from milk factory. The reactor was constructed from plexi glass with a volume of 22.5 L. The reactor was supplied with oxygen by fine bubble air diffuser. In the first phase, the reactor was operated with total cycle time of 7 hrs. The second phase of the experiments was run under different dissolved oxygen concentrations of 3, 5, 6.5, and 7.5 mg/L. In the third phase the reactor was conducted at different COD concentrations of 1000, 1500, 2000, and 2500 mg/L. All analyses were performed according to the procedures outlined in Standard Methods (APHA, AWWA, WEF, 1995).

RESULTS

In order to determine the COD removal efficiency by SBR, the reactor was operated at 8 hrs cycle time and influent COD varied from 410 to 480 mg/L. The performance of reactor in this phase under these conditions is shown in Table 1 which demonstrates that, more than 90% COD removal efficiency was achieved in the reactor with mean influent and effluent COD concentrations of 445 and 42 mg/L, respectively.

In the second phase, the reactor was operated at

different aeration times to evaluate oxygen effect on the removal efficiency and settling of sludge.

Fig. 1 shows the effect of aeration time on COD removal, based on which, the optimum aeration time was 6 hrs. As shown in Fig. 1, COD removal efficiency increased with rising aeration time up to 6 hrs. No significant COD removal efficiency was observed when aeration was applied more than 6 hrs.

Fig. 2 illustrates the sludge settling under different dissolved oxygen concentrations. From this Figure, the optimum dissolved oxygen concentration for best sludge settling was 3 mg/L. Increasing dissolved oxygen more than 3 mg/L resulted poor sludge settling conditions.

Fig. 3 shows the effect of different MLSS concentrations on the COD removal efficiency. Apparently, no significant COD removal efficiency was achieved with the increase of MLSS concentrations. The MLSS concentrations of the SBR reactor varied from 3000 to 9000 mg/L during the study.

In the third phase the flexibility of the reactor to high COD concentration was evaluated. The reactor was operated under different COD concentrations in the range of 1000 to 2500 mg/L, whereas dissolved oxygen, time of aeration and MLSS were kept constant and equal to 2-3 mg/L, 6 hrs and 3000 mg/L, respectively. The results of this phase are shown in Fig. 4. It shows that the COD removal efficiency achieved was 80 to 90% for influent COD concentration of 2500 and 1000 mg/L, respectively.

Table 1: Performance of reactor in first phase

Parameters	Range of concentration	Mean of concentration	Number of observations
Influent COD (mg/L)	410-480	445	15
Influent BOD (mg/L)	336-394	365	8
MLSS (mg/L)	2950-3200	3050	12
MLVSS (mg/L)	2655-2880	2745	12
Effluent COD (mg/L)	38-46	42	15
COD removal (%)	90-92	91	15

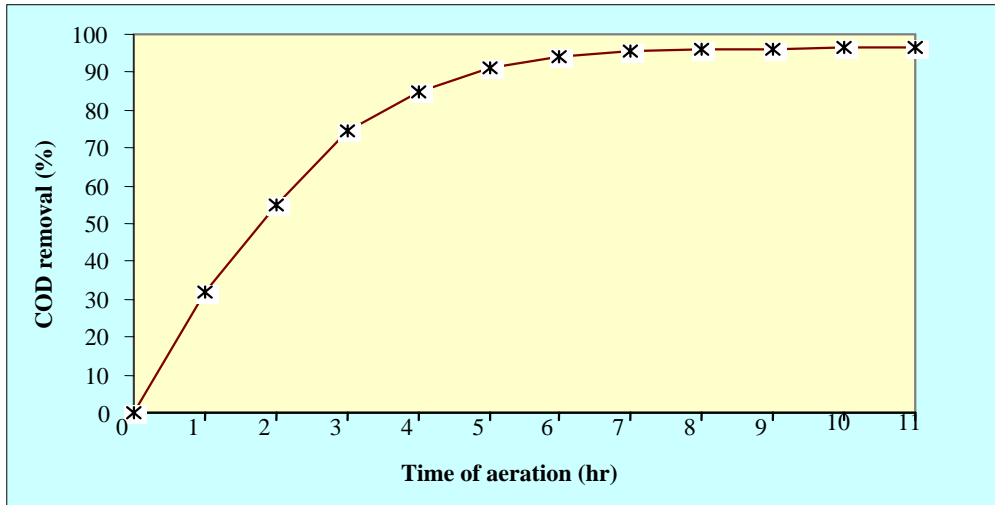


Fig. 1: The effect of aeration time on the COD removal efficiency

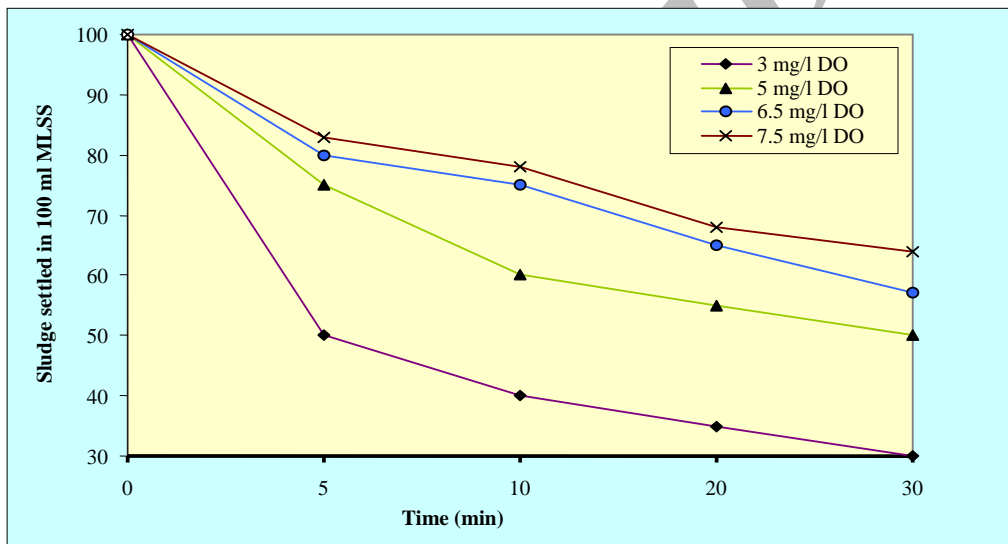


Fig. 2: Sludge settlability versus different times under different concentrations of dissolved oxygen

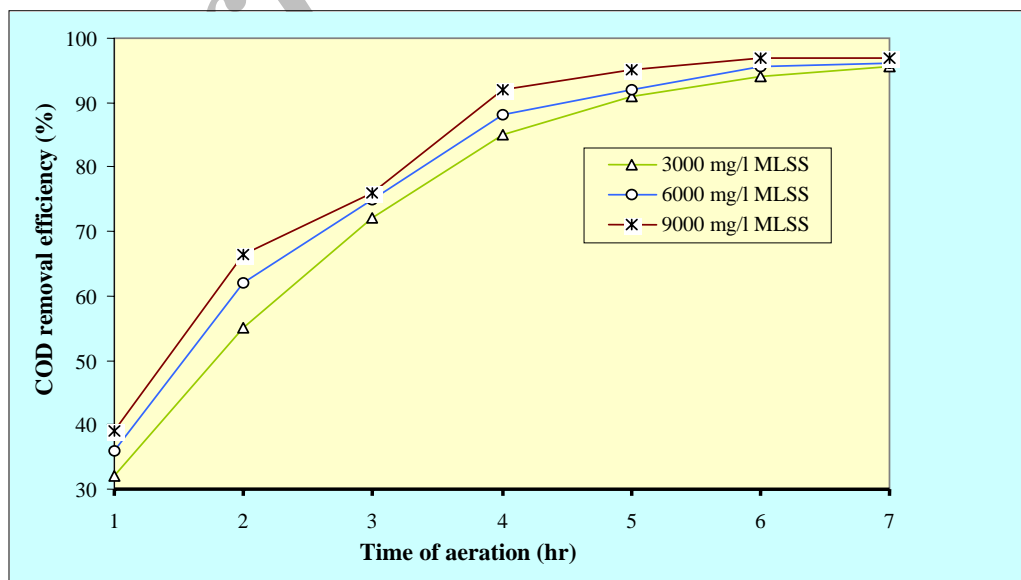


Fig. 3: COD removal versus different aeration time under different concentrations of MLSS

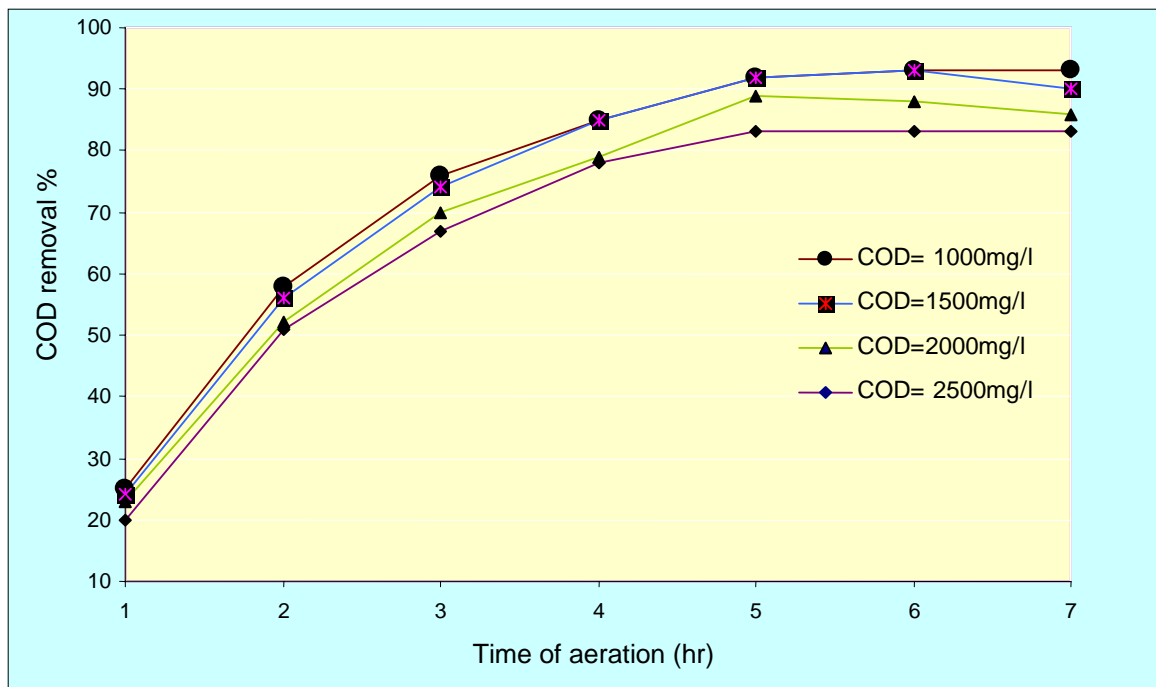


Fig. 4: Performance of the reactor under different COD concentrations

DISCUSSION

The results of aerobic bench scale SBR confirmed the capability of the reactor for dairy wastewater treatment. It showed to be an efficient biological process, producing low COD effluent under optimum aeration and cycle configurations.

From the results obtained, it was evident that the SBR was a suitable alternative for industrial wastewater treatment. The highest COD removal efficiency was more than (90%) and the best sludge settling properties for the milk factory wastewater were obtained at high sludge age (20 days) and aerated period of 6 hrs, showing a good concordance with the results presented by the study of Flapper and Ashbolt (1999). Application of SBR technology revealed that, COD removal efficiency of 95% is obtainable with influent COD concentration of about 2000 mg/L. The SBR configuration has been found to be an appropriate technology for treating this type of wastewater. The study of

COD removal from dairy wastewater (Garrido et al., 2000) indicated that, COD removal efficiency was achieved between 80 to 90%, similar to our study with an influent COD concentration between 1000 and 7000 mg/l. The laboratory scale SBR has been operating from October 1997 to April 1999 with influent average COD concentration about 6500 mg/l (Flapper et al., 2000). Average COD removal was achieved 70% in this study. The best satiability sludge was obtained in 3 mg/L dissolved oxygen conditions. No bulking sludge was observed under concentration of dissolved oxygen kept between 2 to 3 mg/L. Increasing dissolved oxygen in the reactor may cause eliminated biological floc and result disturbance settling sludge in the settling phase and high turbidity in effluent. The settling of sludge is one of the main parameters which should be studied for the dimensioning of sequencing batch reactors. Hydraulic dimensioning results in the number of reactors, the cycle time for biological reaction, as well as the settling process influence and the achievable concentration

of MLSS in the effluent (Keudel and Dichtl, 2000).

As shown in Fig 3, the elimination of COD increases with the time of aeration up to 6 hrs. More than 90% COD removal efficiency was achieved in the reactor with influent COD concentration ranging from 410- 480 mg/L.

The results from this study proved the SBR flexibility and excellent performance for treating domestic and easily biodegradable wastewater such as dairy wastewater.

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