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Use of Sequencing Batch Reactors (SBRs) in Treatment of Wood Fiber Wastewater

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ABSTRACT

Wood fiber industries are producing large amounts of wastewater, which are discharged into the environment everyday. This type of wastewater with high pollution potential in suspended solids, COD and color, are required to be treated before entering to the receiving environment. North part of Iran is covered by huge land of forests. Several pulp and paper industries are located in the area. One of these industries is Iran Wood Fiber Company in which many researches have been done in both laboratory and pilot scale by the main author in recent years. One of the studies was to investigate the Sequencing Batch Reactors (SBRs) efficiency for treating the wastewater. Considering parameters such as influent COD, detention time, nutrient concentration, and their effects on COD, turbidity and total solids removal efficiency of the system, four serial SBRs in laboratory scale were investigated. The results of the system with 10 hours detention time, 1000-2500 mg/L COD and 100:5.1:1 C/N/P had the best efficiency with 92, 84, 52 percent removal for COD, turbidity and total solids, respectively. Pilot scale plant studies using SBRs were also done in the company. The results indicated good removal efficiencies that also discussed in this paper.

Keywords: *Aerobic, Biological treatment, Sequencing Batch Reactors (SBRs), Wood fiber, Wastewater*

INTRODUCTION

In the recent years, Sequencing Batch Reactors (SBRs) have been used in many industries. This system has many advantages and has been very successful especially in pharmaceutical, petrochemical and food industries' wastewater treatment. Many researches have been conducted related to wastewater treatment using SBRs.

One of the full scale plant studies for nutrients removal using SBR, has shown 95, 89, 70 and 77 percent removal of Biological Oxygen Demand (BOD_5), Suspended Solids (SS), nitrogen (N) and phosphorous (P), respectively (Rim et al., 1997). In treating of recirculated whitewater at high temperature, removal of 100 percent of resin acids, 96 percent of fatty acids, 76 percent of Soluble Chemical Oxygen Demand (SCOD) and 34 percent of Total Dissolved Solids (TDS) in 20-40^{o}C have been reported (Tardif and Hall, 1997). In treating of cheese factory wastewater using SBRs, it has been shown a removal efficiency of over 90 percent COD, nitrogen and phosphorous (Malaspina et al., 1995).

In investigation of petrochemical wastewater treatment by SBR, the amount of phenol from 950-2000 ppm has been reduced to less than 0.1 ppm (Hsu, 1986). This system had also good performance in BOD_5 removal and nitrification.

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In the removal of nitrogen and organics in a SBR, after acclimatization period, effluent total COD concentrations slightly decreased and the removal efficiency of organics increased to about 90 percent (COD= 70 mg/L) after 60 days and achieved 98 percent (COD= 30 mg/L) at the end of the experiments. The organics reduction seemed to be less affected by shock loading since high organic loads did not affect the removal efficiency. NH_4^+ concentrations in effluent showed almost lower than 1 mg/L and NO_3^- concentrations were high (150 mg/L) during C:N=2. Over 90 percent of total nitrogen removal efficiency (T-N; 16 mg/L) was obtained during the last 20 days of the operation after controlling COD: N=7 (Thuan et al., 2003).

In another research using laboratory scale for treating sanitary wastewater and nitrogen, 82 to 94 percent of nitrogen with organic loading rate of 0.02-0.05 Kg BOD_5/ Kg MLSS has been removed (Irvin et al., 1983).

Many research works have been carried out to choose a proper way for treating of the wastewater from Iran Wood Fiber Company (Ayati, 1998; Ayati 1997; Ganjidoust et al., 2000 & 2001). A new one is the investigation of SBR system in laboratory scale, which is discussed in this paper. Therefore, the objective of this study was to derive data for the removal of COD, turbidity and TS from the wood fiber wastewater using SBR system.

MATERIALS AND METHODS

The wastewater has been obtained from Iran Wood Fiber Company, which is located in kilometer 35 of Rasht-Anzali country road. The wastewater has high amount of COD, SS, color and turbidity with both alkaline and acidic wastewater lines. Some of the important wastewater characteristics are given in Table 1.

Table 1: Wastewater characteristics of Iran Wood Fiber Company

Parameters	Amount
Average COD (mg/L)	6000
Average BOD_5 (mg/L)	600
Average TS (mg/L)	4600
Average SS (mg/L)	2500
Temperature (^oC)	20+/- 2
pH	5.5
Color	Brown

SBRs consisted of four similar cylinders in series with volume of 4 liters for each reactor (Fig. 1). The required sludge was prepared from Zargandeh sanitary wastewater treatment plant in Tehran. Known amount of glucose solution with necessary nutrients (urea, K_2HPO_4, and KH_2PO_4) as substrate were added to the reactors every day and adapted gradually with gradual feeding of low concentrated wastewater from wood fiber industry. After the adaptation process in which the diluted wood fiber wastewater was reached to COD concentration of 2000 mg/l, the sludge was then divided equally into the four SBRs.

The efficiency of the reactors for an influent wastewater COD of 1000 to 2500 mg/L with C/N/P of 100/4.8/1, total cycle time of 24 h for each reactor with an effective reaction time of 22 h has been considered for five months.

The parameters such as COD, SS, pH and temperature were measured each day. BOD_5 was also measured occasionally. Kinds of available microorganisms and the SVI index were controlled, regularly. The pH was adjusted by lime in the ranges of 6.5 to 7.2 for microorganisms' activities. All experiments were done according to the procedure in the 19th edition of Standard Methods for the Examination of Water and Wastewater (APHA, 1995).

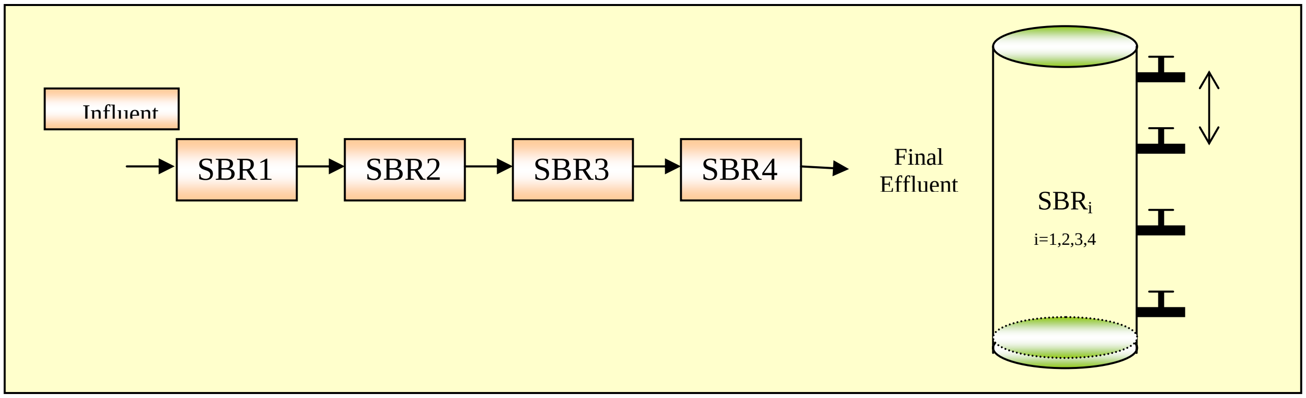

Fig. 1: Lab-scale sequencing batch reactors

RESULTS

The monthly average COD of the SBRs are given in Table 2. The variation in COD data was due to the wastewater received from the factory. It is important to mention that during April, due to shutdown month in the factory, most of the wastewater was diluted. From these data, the percent COD removed for each month has been calculated and the results are shown in Fig. 2. The Figure indicates that COD has been removed from one reactor to the others and overall COD removal efficiency was reached to 90 percent. The figure also shows that as the influent COD decreased to 1000 ppm, the removal efficiency increased in the first two reactors, but the overall COD removed has not been changed. This can be seen from both table and the figure that for an influent concentration less than 1000 mg/L, two reactors are sufficient.

Table 2: Average COD concentration in SBRs (mg/L)

Months	Influent to SBR1	Influent to SBR2	Influent to SBR3	Influent to SBR4	Final effluent from SBRs
February	2350	2200	1100	900	250
March	2200	2100	950	300	200
April	1000	400	100	100	100
May	2250	1750	1350	400	200
June	2100	1500	900	350	150

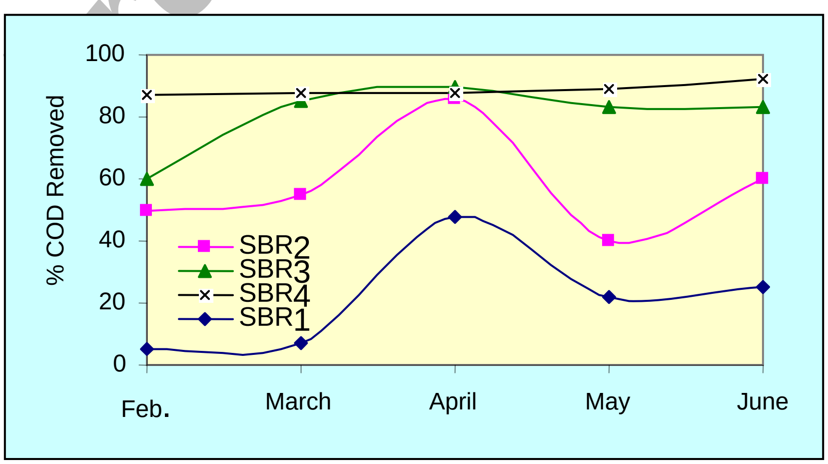

Fig. 2: COD removal efficiency of SBRs in five months

Effect of retention time In this part, the effect of retention time from 2 to 96 h on COD removal was investigated. The results are given in fig. 3. As shown in the figure, COD removal remains almost constant after retention time of 10 h. Therefore, a retention time of 10 h and a cycle time of 12 h have been selected as one of the design parameters in this study. Since control of 10 h reaction time was troublesome, one day detention time was applied for all experiments.

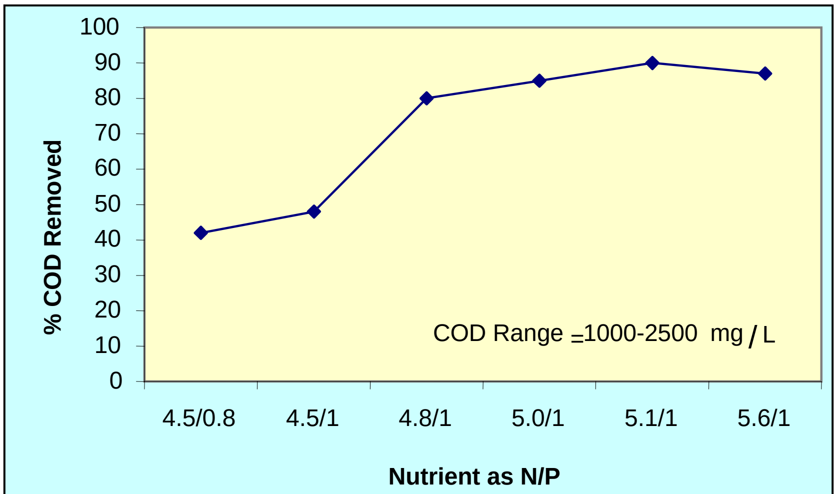

Fig. 4: Effect of nutrient concentration on COD removal

Pilot plant scale studies consisted of four 35 cubic meter SBRs constructed in the plant. The comparison among the results is shown in Fig. 5. As shown in the figure, removal efficiency of the pilot scale plant was almost 90% of the actual laboratory scale one. This 10% lower efficiency could be due to environmental conditions in scale up factor from laboratory to pilot plant scale.

Table 3: Suggested parameters for SBRs

Number of reactors	4
COD range (mg/L)	1000 -2500
Retention time (h)	10
Cycle time (h)	12
C:N:P Ratio	100/5.1/1
COD removed (%)	92
BOD_5 removed (%)	80
Turbidity removed (%)	84
SS removed (%)	52

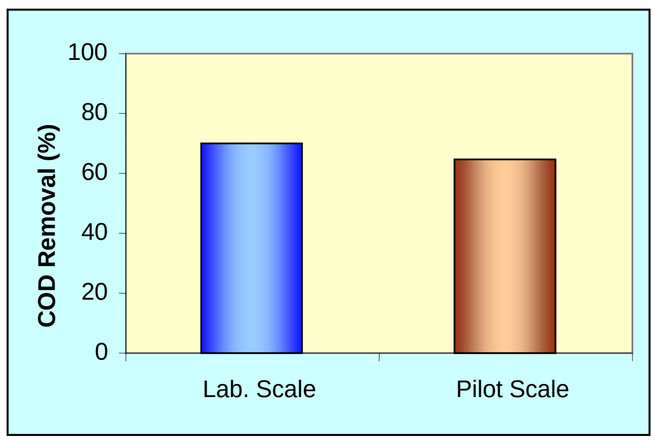

Fig. 5: COD removal rate in the lab and pilot-scale

DISCUSSION

The comparison of COD removal efficiency between SBRs and other previous studies by this university (Ayati, 1997; Ganjidoust et al., 2001) is given in Table 4, which indicates the highest removal efficiency of 92% for SBRs. Almost the same results have been obtained using pilot plant scale studies.This may be compared with another study done by SBR system for pharmaceutical wastewater treatment, in which 90% COD removal has been reported (Ng et al., 1991). Also in slaughterhouse effluent treatment, a percent removal efficiency of 97, 90 and 82.6 for COD, solids and phosphorous has been shown, respectively (Hadjiniculaou, 1998).

Table 4: Comparison of efficiencies in this study and previous ones

Type of treatment	%COD removal
SBRs	92
Anaerobic system	50
Anaerobic-aerobic and sand filter	80
Activated sludge	65

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