Investigation of the efficiency of sequencing batch reactor (SBR) in Cefixime antibiotic removal from aqueous solutions

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Abstract
We investigated the removal of Cefixime (CEF) from synthetic wastewater using sequencing batch reactor (SBR) in the present study. The elimination of antibiotics using activated sludge process before and after biodegradation was measured by the UV spectroscopic method. Antibiotics wastewater contains organic and inorganic matters which are toxic to the ecosystem and difficult biodegradable. The initial concentration of chemical oxygen demand (COD) as optimum parameter for removal of antibiotics using SBR was systematically studied. An aerobic bioreactor is used for antibiotic wastewater treatment. In the biological treatment, MLSS and aeration time have positively related to process efficiency. The experimental results showed that after biological treatment, in various loading conditions, removal rate of COD of synthetic wastewater were 65.2%, 71.42% and 68.6%, respectively.

Keywords: antiobiotic wastewater, biological treatment, activated sludge, COD removal

Introduction
The pharmaceutical industry wastewater consists of pollutants that cause many problems for the environment as well as for humans, and its wastewater treatment is one of the main concerns for the units producing these materials, especially the units producing antibiotics [1, 2]. Cefixime is a semi-synthetic antibiotic, including third-generation cephalosporins. Due to low cost and other non-contamination caused by the use of chemicals, biological wastewater treatment process is more considerable than other conventional chemical methods [3, 4]. But due to the high amounts of organic matter in the pharmaceutical industry wastewater and the high COD/BOD5 ratios, which reduces the possibility of biological treatment by micro-organisms in biological system, this process is not capable of removing completely pollutants from these types of wastewater [5]. But this process can be used as a treatment after a pre-treatment stage and at the end of procedure it could be utilized a post treatment stage to achieved the environmental standards of pharmaceutical wastewater [6]. The performanced of

sequencing batch reactor which is a various configuration of the conventional activated sludge process, is based on five stages: fill, react, settle, draw and idle. During the reaction time, oxygen was nourished into the wastewater samples using diffuser stones installed at the bottom of the reactor. The organic compounants are oxidized by aerobic bacteria in activated sludge systems [7, 8].

In the studies investigated by Jin et. al. [9], Debsarkaret. al. [10] and Bindhu and Madhu [11], sequencing batch reactors fed by synthetic wastewater, were performanced for nitrification, denitrification and organic carbon, and removal efficiencies for nitrification, denitrification and organic carbon were resulted 88-100%, 73-75%, 91-94%, respectively [12].

The present research work is based on evaluation of the sequencing batch reactor (SBR) efficiency for the removal of COD from synthetic solutions of antibiotic (cefixime). These compounds have been treated applying biological process.

Experimental

Figure 1 shows a schematic of laboratory-scale SBR operated in this study. The SBR was a cubic plexiglas column with 150 mm length, 150 mm width, and 300 mm height, and the effective volume was 3 L. The aerobic tank was operated with 24 h cycles divided as follows: 10 min feeding, 22.6 h reaction, 1 h settling and 10 min withdrawal. The reactor operating conditions are summarized in Table 1. Ozonation process was carried out as pretreatment before SBR to enhance removal of organic matter, improvement and mineralization of antibiotics synthetic wastewater biodegradability (COD/BOD_5 ratio). After ozone stage, Antibiotic wastewater was fed to SBR to increace the antibiotics removal efficiency. Compressed air was injected into the wastewater samples using diffuser stones installed at the bottom of the reactor treating the sample of aqueous solution of antibiotic (Cefixime) to supply oxygen for the microorganisms.

The input and effluent of antibiotics wastewater were sampled before and after treatment to analyze the biological oxygen demand (BOD_5) (by means of an Oxitop system, Standard method, 5210 D), the chemical oxygen demand (COD) (Standard method, 1250 D) to follow the biodegradability of the synthetic wastewater and also pH, TSS, NH_4^+-N, NO_3^--N, TKN,TP determined under standard methods [13]. After determination of COD: N: P in the antibiotic wastewater, ammonium chloride (NH_4Cl) and/or potassium dihydrogen phosphate (KH_2PO_4), in the ratio of 100: 5:1 for BOD :N :P, were added to provide the required nitrogen and phosphorus for the biological process. All experiments were performed at ambient temperature (25 ± 2°C).

Cefixime was purchased from Antibiotic Sazi Iran Company. All reagents and reactants were of 98% purity or greater purchased from Merck, Germany.

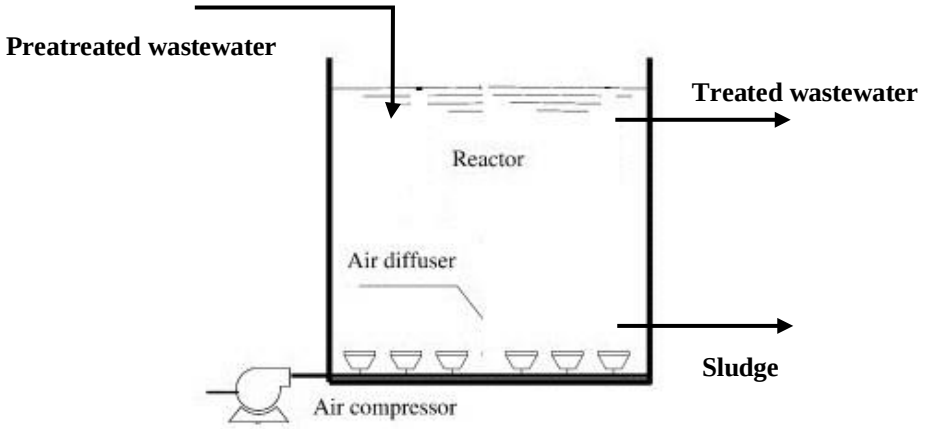

Fig. 1. Schematic structure of sequencing batch reactor (SBR).

Table 1. Operation conditions of the SBR system during experiment

Parameter	Values
Inlet COD (mg/L)	2500, 3500 and 4500
Inlet BOD (mg/L)	1000- 2500
Time (day)	50
HRT (hr)	24
MLSS (mg/L)	3000- 6000
F/M (kg BOD/ kg MLSS/ d)	0.2
Organic loading rate (kg COD/ m^3.d)	0.833, 1.167 and 1.5

Results and discussion

The antibiotic wastewater investigated in this research was synthetic wastewater containing cefixime dissolved in distilled water.

The concentrations of MLSS in SBR are shown in Figure 2. It is shown, that in the initial days, there is not a remarkable variation in MLSS concentration. Maybe, it is because of the conformity of microorganisms by antibiotics. This research represents CEF is a biodegradable antibiotic and it eliminates after 5 days, in activated sludge system with MLSS of 4000 mg/L. In addition, COD reduced in this period.

Figure 3 summarize the performance of SBR in terms of COD removal under three various loading conditions, 0.83, 1.167 and 1.5 kg COD/m^3 day. The influent was determined by varyious COD concentrations (2500, 3500 and 4500 mg/L). The effluent COD concentrations were between 870, 1000 and 1350 resulting in a COD removal efficiency between 65- 72%. The highest removal efficiencies above 70% were obtained in the periods of organic loading rate 1.167 kg COD/m^3 day. Comparably, the lowest removal efficiency (65.20%) was resulted at the lowest COD feed concentration. Over the time, the low reduction of COD concentration indicated the presence of chemical compounds in the antibiotic wastewater that were resistant

to biodegradation. These results agree well with those reported by Andereottola, Hudson and Venkata [14-16] who achieved the high COD removal efficiency in SBR [7]. However the removal efficiency are lower than other similar studies ,these results are reasonable according to authors and cited references. Radjenović et al., [17, 18] reported the high removal efficiency of SMZ and OLF that might be cuased of wide-range input antibiotic concentrations.
The sludge age in the SBR treating antibiotics wastewater exceeded 90 days. The elimination of CEF in the SBR is based on adsorption of the compounds on the activated sludge system and biodegradation. The experimental results demonstrated that the most effective parameters that affect on removal of CEF are: COD and MLSS. Further, aeration and mixing have not a obvious effect on CEF removal.
The results show that increasing MLSS concentration improved the SBR performance in terms of the elimination of COD due to higher biomass concentration [19].
Considering that the COD concentration in the SBR effluent is higher than the target value of Standards for Discharge of Effluent into. Water or on Land, Utilizing an advanced posttreatment technology is recomamnded after SBR process.

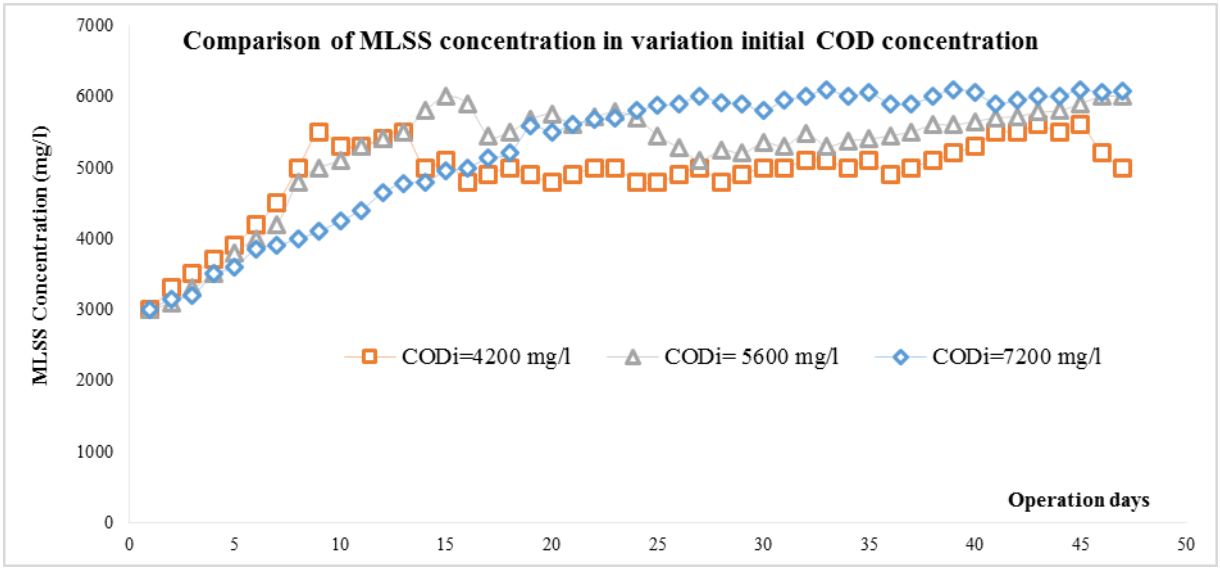

Fig. 2. Variation of MLSS concentrations against operation days in the SBR system

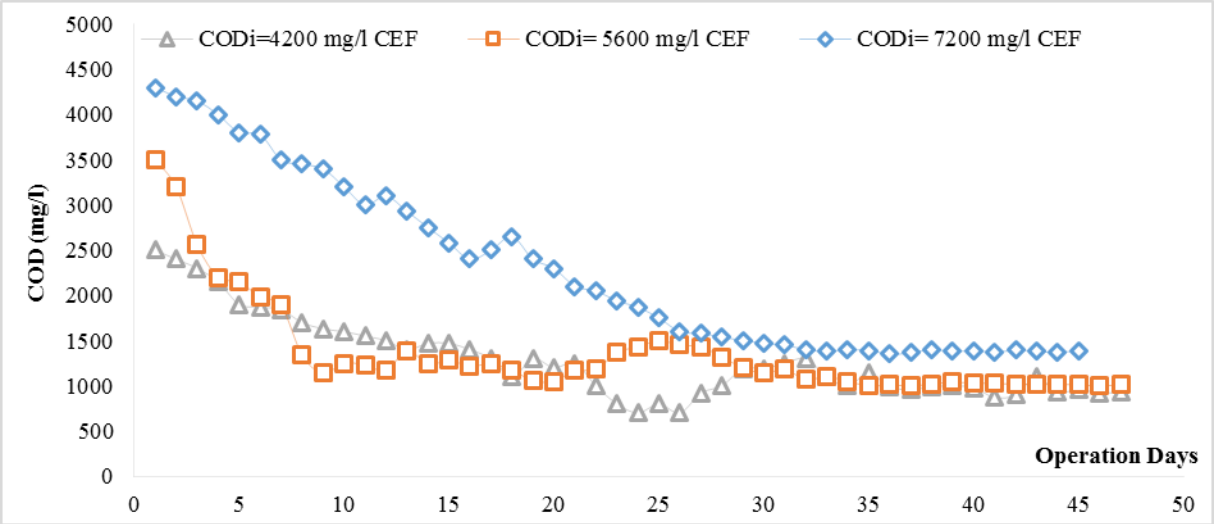

Fig. 3. COD removal in the SBR system.

Conclusions

A SBR process was indicated on a pilot scale for the treatment of synthetic pharmaceutical wastewater. The biological system included a batch reactor. Using a sequencing batch reactor, the antibiotic wastewater could be treated, with an acclimated biomass, providing sufficiently high biodegradation of COD that the treated effluent could be released to the next stage for further treatment. Effective biodegradation may be dependent on the combination of the antibiotic wastewater that was variable from batch to batch and may have caused the problems in the biodegradation process. Because of the complexity of the antibiotic wastewater, High OLRs effected The treatment efficiency of the bioreactor. The presence of complex and toxic compounds in real antibiotic wastewater may have effected on COD biodegradation efficiency, thus long HRT in the sequencing batch reactor can reduce these effects. Almost all the COD was eliminated by the SBR system, leaving a COD of around 1000 mg/L in the SBR effluent and the pH of the SBR effluent was found in a narrow range of 7–7.8. As demonstrated by an overall COD removal efficiency of more than 65%, it is concluded that the SBR system is utilizable to the treatment of antibiotic wastewater.

Further research is required to achieve a better understanding of the antibiotic biotreatment.

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