Journal of Water Process Engineering 4 (2014) 82–90

Contents lists available at ScienceDirect

Journal of Water Process Engineering

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

Performance evaluation of SBR for the treatment of dyeing wastewater by simultaneous biological and adsorption processes

S. Sathian, M. Rajasimman*, C.S. Rathnasabapathy, C. Karthikeyan

Environmental Engineering Laboratory, Department of Chemical Engineering, Annamalai University, Annamalai Nagar 608002, Tamil Nadu, India

ARTICLE INFO

Article history:
Received 26 February 2014
Received in revised form 20 August 2014
Accepted 14 September 2014
Available online 18 October 2014

Keywords:
Sequencing batch reactor
White rot fungi
Dyeing wastewater
Sorption
Response surface methodology

ABSTRACT

In this work, a combination of physical and biological process was employed for the treatment of dyeing wastewater in a sequencing batch reactor (SBR). Mixed culture comprising of white rot fungus (WRFs), *Pleurotus floridanus*, *Ganoderma lucidum* and *Trametes pubescens*, was used as microorganisms in the reactor. Various sorbents were screened for their ability to decolourize the dyeing wastewater. From the results, tamarind seed was found to be the most efficient sorbent and hence it was used in the SBR along with the microorganisms. Statistical design was employed for the optimization of process variables like air flow rate, sludge retention time (SRT) and sorbent dosage. The effects of these variables on decolourization, chemical oxygen demand (COD) reduction and sludge volume index (SVI) were studied. The optimum conditions were: air flow rate – 13 LPH, SRT – 17 d and sorbent dosage – 11 g/L. At the optimized conditions, the performance of SBR was studied at various organic loading rates by changing the initial substrate concentration and HRT. At an organic loading rate of 0.165 kgCOD/m^3 d, a maximum decolourization and COD reduction of 86.6% and 96% respectively was achieved. SEM analysis confirms the sorption of dye molecules onto the sorbent.

1. Introduction

Sequencing batch reactor (SBR) is an activated sludge process designed to treat a wide range of industrial wastewater. There are several works mentioning the applicability of SBR in wastewater treatment [1–9]. SBR has the advantage of being very flexible in terms of matching reaction and settling times to the strength and treatability characteristics of a particular waste stream. Process is easy to operate, mixed-liquid suspended solids (MLSS) cannot be washed out by hydraulic surges and quiescent settling may produce lower effluent total suspended solids (TSS) concentration.

Dyeing industry wastewater is one of the high strength wastewater which creates problem to the environment and mankind. Previous researches focused on various biological, chemical, and physical techniques for treating synthetic and real dye industry wastewater. It is evident that all three areas have the potential for remediating dye industry wastewater [10–12]. However, chemical treatment is often expensive with limited application, while physical removal can lead to extra solid wastes and increased overheads. But, biological treatment has been effective in reducing dye industry wastewater, and when used properly has a lower operating cost than other remediation processes.

Dyeing industry wastewater contains biodegradable substrates and inhibitory constituents. Thus, biological treatment alone may not be sufficient to remove non-biodegradable substrate. Certain difficulties like the biomass growth and inhibition have been encountered while treating dyeing industry wastewater. Combinations of chemical and biological or physical and biological treatment have also proven to be effective [13,14]. In this work, to enhance the performance of the SBR system in treating the dyeing wastewater, adsorbents have been added. The sorbent addition in SBR involves simultaneous biodegradation and adsorption processes. The benefits of the addition of sorbent over conventional process are: improvement of the removal of COD and biological oxygen demand (BOD), improvement of the stability to shock loads and toxic upsets, enhancement of the removal of toxic substances and priority pollutants, effective colour removal, improvement of sludge settling and dewatering, suppression of stripping of volatile organics and less tendency to foam in aerator [15]. Hence, this study is focused on the combination of physical and biological process for the treatment of dyeing industry wastewater in SBR. No study is reported on the application of response surface methodology (RSM) in simultaneous biological and physical process in SBR.

* Corresponding author. Tel.: +91 9842565098.
E-mail addresses: mrsimman@yahoo.com, mrsimman@gmail.com (M. Rajasimman).

http://dx.doi.org/10.1016/j.jwpe.2014.09.004
2214-7144/

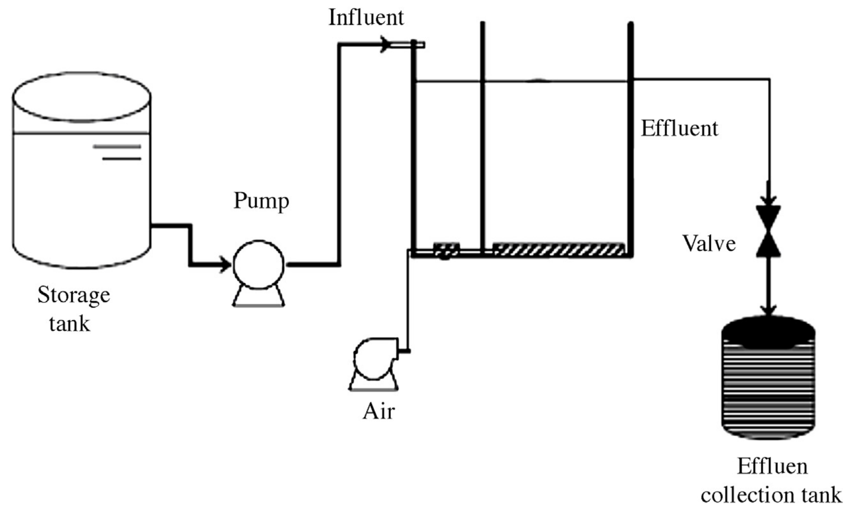

Fig. 1. Schematic diagram of sequential batch reactor set up.

2. Materials and methods

2.1. Materials

Dyeing industry wastewater was collected from a small scale textile dye industry located at Erode in Tamil Nadu, India. The wastewater was stored at 5 °C in a freezer. The wastewater was analyzed in the laboratory and it was reported in our earlier article [16]. The WRFs, *Pleurotus floridanus* (MTCC-6315), *Ganoderma lucidum* (MTCC-1039) and *Trametes pubescens* (MTCC-1813) were obtained from Microbial Type Culture Collection Centre (MTCC), Chandigarh, India. The strains were maintained on solid medium at 4 °C. The medium composition for all the microorganisms were given in Sathian [17]. Experiments were carried out using the mixed culture of the three WRFs (*P. floridanus*, *G. lucidum* and *T. pubescens*).

2.2. Sequencing batch reactor (SBR)

As shown in Fig. 1, a small scale reactor, made up of plexiglass, with a total volume of 3.5 L and a working volume of 2 L was used. Tubes were inserted into the reactor to ensure the filling and withdrawal of the effluent using peristaltic pumps. The reactor was supplied with air by fine bubble air diffuser. The mixing was achieved with a mechanical stirrer at the speed of 170 rpm. Each cycle lasted for 24 h: filling – 1 h, reaction –20 h, settling – 2 h, withdrawal – 0.75 h and idle – 0.25 h.

2.3. Reactor inoculation and start-up

SBR was filled with the dyeing wastewater. The reactor was inoculated with the mixed WRFs (*P. floridanus*, *G. lucidum* and *T. pubescens*). Air was supplied at the rate of 10 LPH and pH was maintained at the optimum value of 6.6. Temperature was maintained at 28 ± 1 °C [17]. During start-up, the reactor was left for 10 days with aeration in order to acclimatize the microorganisms. Then the dyeing wastewater was pumped into the reactor and air was supplied at the same rate.

2.4. Screening of sorbent

In the present study, 18 sorbents were screened for colour removal efficiency from dyeing wastewater. The list of sorbents used is given in Table 1. All the sorbents were sun dried, sieved in a 100 mesh and directly used as sorbents. Experiments were carried out in 250 mL Erlenmeyer flasks. 150 mL of dyeing wastewater was taken and the sorbents were added to it. The best sorbent was selected and it was used in the SBR.

Table 1
Screening of sorbents for the decolourization of textile dye wastewater.

Sorbent code	Sorbents
A	*Sargassumtenerrimum*
B	*Hydrillaverticillata*
C	*Hypneavalentiae*
D	Hardwood sawdust
E	Wheat bran
F	Rice husk
G	Paddy straw
H	Tamarind seed
I	Tea plant leaves
J	*Turbinariaornata*
K	Pressmud
L	*TurninariaConoides*
M	Sugarcane bagasse
N	Coconut shell
O	Bamboo waste
P	Grain sorghum
Q	Tamarind wood
R	*Scenedesmusobliquus*

2.5. Experimental procedure for SBR

The effect of process variables like, air flow rate (10, 15 and 20 LPH), sludge retention time (10, 15 and 20 d) and sorbent dosage (5, 10 and 15 g/L) on decolourization of dyeing wastewater was studied in SBR. These parameters were optimized using RSM. Experiments were performed based on the Box–Behnken design (BBD) as shown in Table 2 in SBR. During the 1st hour, raw dyeing wastewater was fed into the reactor. The aeration was done for the next 20 h (react step: aeration). Aeration was then shut down for 2 h (settle step: sedimentation). After the bio sludge was fully settled, the supernatant had to be removed within 0.75 h (draw step: decant) and the system had to be kept under idle (idle step) for 0.25 h followed by charging of fresh dyeing wastewater into the reactor and the above operation was repeated. The hydraulic retention time (HRT) in the reactor was maintained as 5 d. To control the stable bio sludge concentration in the reactor, the excess bio-sludge was removed from the bottom of the reactor, during the idle step. All the experiments were performed using BBD and the colour removal, sludge volume index (SVI) and COD were analyzed for each condition as per the standard methods of analysis [18].