Water Resources and Industry 5 (2014) 1–8

Contents lists available at ScienceDirect

Water Resources and Industry

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

Effect of mixed liquor volatile suspended solids (MLVSS) and hydraulic retention time (HRT) on the performance of activated sludge process during the biotreatment of real textile wastewater

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ARTICLE INFO

Article history:
Received 28 October 2013
Received in revised form
23 December 2013
Accepted 11 January 2014

Keywords:
Textile waste
Mixed culture
Activated sludge process
Organic removal
Continuous operation
Decolourization

ABSTRACT

Adequate information is available on colour and organics removal in batch mode using pure microbial cultures from dye contaminated wastewater. There was a need to develop environment friendly and cost effective treatment technique for actual field conditions. Therefore, the present study was undertaken with an aim to evaluate the potential of acclimatized mixed microbial consortia for the removal of colour and organics from real textile wastewater. Experiments were performed in laboratory scale activated sludge process (ASP) unit under steady state condition, varying mixed liquor volatile suspended solids (MLVSS) (2500, 3500 and 5000 mg/l) and hydraulic retention time (HRT) (18, 24 and 36 h). The results showed that decolourization and chemical oxygen demand (COD) removal increased with increase in MLVSS and HRT. At 18 h HRT, decolourization was found to be 46, 54 and 67%, which increased to 67, 75 and 90% (36 h HRT) at 2500, 3500 and 5000 mg/l MLVSS, respectively. COD removal was found to be 62, 73 and 77% (at 18 h HRT) which increased to 77, 85 and 91% (36 h HRT) at 2000, 3500 and 5000 mg/l MLVSS, respectively. On the basis of the results obtained in this study suitable treatment techniques can be developed for the treatment of wastewater contaminated with variety of dyes in continuous mode of

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http://dx.doi.org/10.1016/j.wri.2014.01.001

operation. This shall have the advantage of treatment of larger quantity of wastewater in shorter duration.

1. Introduction

The wastewater generated from dyeing and textile industries is considered to be very problematic not only for containing high chemical and biological oxygen demands, suspended solids and toxic compounds but also for strong colour which is the first contaminant to be recognized by human eyes [1,2]. Textile finishing wastewater, especially dye house effluents, contain different classes of organic dyes and chemicals and thus they are coloured and have extreme pH, COD, BOD, different salts, surfactants, heavy metals, mineral oils, etc. [3]. The discharge of organic pollutants (either BOD or COD) into the receiving stream can lead to the depletion of dissolved oxygen and thus creates anaerobic condition [4]. Under anaerobic condition foul smelling compounds such as hydrogen sulphides may be produced. This will consequently upset the biological activity in the receiving stream. Government legislation is becoming more stringent in most developing countries regarding the removal of dyes from industrial effluent. Environmental protection in India is promoting prevention of transfer of pollution problems from one part of the environment to another. This means that most of the textile industries are developing on site or in-plant facilities to treat their own effluent prior to discharge [1]. The removal of polluting dyes from effluents is an important problem, particularly for small scale textile industries where working conditions and economic status do not allow them to treat their wastewater before disposal and they have no choice other than discharging the effluents into the main stream of water resources. Most physicochemical methods for dye removal have drawbacks because they are expensive, have limited versatility, are greatly interfered by other wastewater constituents, and/or generate waste products that must be handled [5–10]. Alternatively, biological treatment may present a relatively inexpensive way to remove dyes from wastewater. Microbial process for decolourization and degradation is an environment-friendly and cost-competitive alternative process over chemical decomposition processes [11,12].

A lot of work has been done on the decolourization of dyes by using pure cultures under growing condition in batch and continuous modes of operation [13–15]. Single bacterial and fungal strains are effective in the treatment of textile wastewater, especially for colour removal. However, difficultly in maintaining the purity of single cultures in the field and the inability of these cultures to degrade all different dyes present in the effluent are the drawbacks with respect to their commercial application [16,17]. The use of mixed cultures seems to be more promising for large scale application at the field level. The syntrophic interactions present in the mixed communities lead to complete mineralization of dyes [18]. Further, most of the studies have been conducted in batch mode for the decolourization/degradation of dyes using synthetic dye solutions and scattered information is available on the treatment of dye contaminated wastewater in continuous mode with actual textile wastewater. A continuous mode of operation shall have the advantage of treating a large quantity of wastewater in shorter duration as compared to batch treatment. Many parameters like MLVSS and HRT affect the performance of activated sludge process; therefore, the present study was undertaken for the treatment of real textile wastewater at different MLVSS and HRTs.

2. Materials and methods

2.1. Textile effluent

Actual industrial effluent (untreated wastewater) was procured from a local textile industry situated near Delhi, the capital city of India. The effluent was stored at 4 °C in a cold room. The characteristics of the effluent are shown in Table 1.

Table 1
Characteristics of the textile industry effluent.

Sr. no	Parameters	Values
1	pH	8–10
2	Temperature (°C)	38–40
3	TSS	180–200
4	TDS	3700–3900
5	COD	1400–1600
6	Trace elements (Fe, Zn, Cu, Ni, and Mn)	15–20

Note: All values are expressed in mg/l, except pH and temperature.

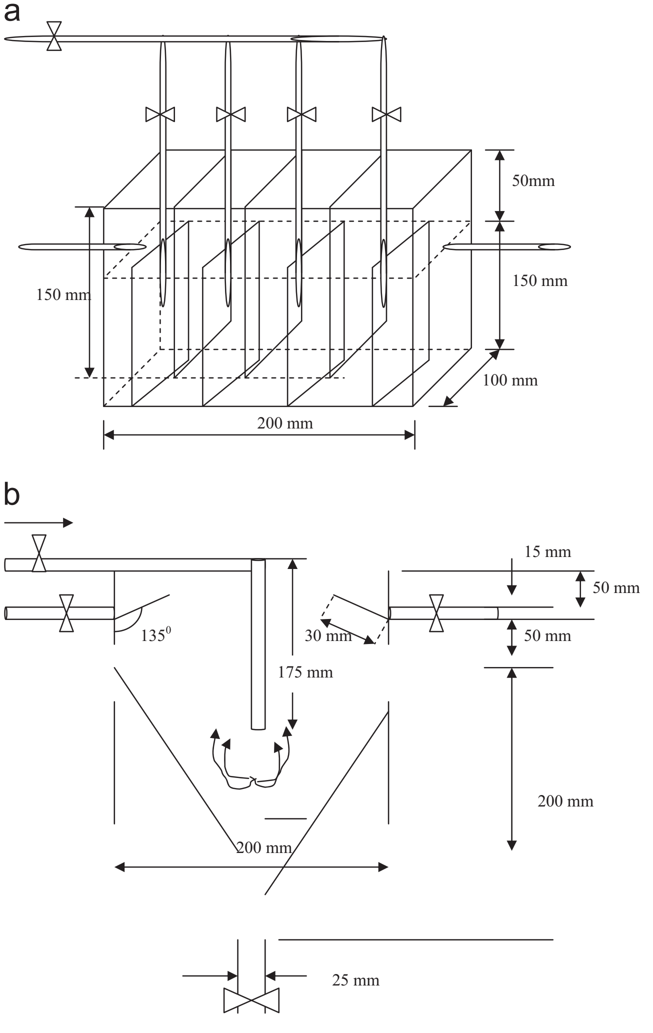

Fig. 1. Schematic diagrams of the aeration tank (a) and clarifier unit (b) in activated sludge process.

2.2. Experimental detail

A bench scale continuous flow activated sludge reactor was used in this study. The reactor volume was 3.4 L. The clarifier volume was 4.5 L. The reactor was operated at room temperature (30 °C). Air

Table 2
Glucose media composition.

Component	Concentration (g/l)
Glucose	10
Yeast extract	0.340
NH_4Cl	0.840
KH_2PO_4	0.134
K_2HPO_4	0.234
$MgCl_2 \cdot 6H_2O$	0.084

Table 3
Specifications of aeration tank.

Shape of the reactor	Rectangular cross section
Material of construction	Stainless steel
Size of the reactor	0.2 m × 0.2 m × 0.2 m
Inlet	2 nos.
Outlet	2 nos.
Total volume	4.5 l
Working volume	3.4 l

Table 4
Specifications of clarifier unit.

Shape of the clarifier	Conical
Material of construction	Stainless steel
Diameter	0.2 m (top); 0.025 m (bottom)
Height	0.25 m
Inlet	1 no.
Outlet	3 nos.
Sampling ports	2 nos.
Total volume	6.1 l
Working volume	4.5 l

was continuously sparged through the diffuser to maintain the desired oxygen concentration in the aerator. Fig. 1 shows the whole experimental set-up. It was started with 1% (w/v) synthetic glucose media in batch mode. The medium was inoculated with acclimatized aerobic culture. After the reactor was stabilized continuous feeding was started. Untreated textile wastewater fed as influent to the reactor was brought from a textile industry near Delhi, India. The untreated wastewater mixed with 1% (w/v) glucose media was fed to the aeration tank through a peristaltic pump of variable capacity, which was calibrated before the start-up of the experiment as well as occasionally during the start up of the reactor. The composition of synthetic glucose media is given in Table 2. Details of the experimental set-up are given in Tables 3 and 4.

The reactor was operated at different MLVSS concentrations and HRTs. The settled sludge from the clarifier was removed from the beaker daily and the desired concentration of MLVSS was maintained inside the aeration tank manually. A DO level of around 2 mg/l was maintained inside the aeration tank throughout the study. The two chosen operating parameters, i.e. MLVSS concentration and HRT were varied during the course of the study keeping into consideration the generally applied range in activated sludge process for industrial effluent treatment. The reactor was operated for MLVSS concentrations of 2500, 3500 and 5000 mg/l and HRT value of 18, 24 and 36, respectively. All the connections were made with silicon tubes.

2.3. *Analytical methods*

At different time intervals, the samples were withdrawn from the reactor centrifuged at 5000 rpm for 10 min to precipitate suspended biomass using a Hitech model centrifuge. The colour removal was measured using a UV–Vis spectrophotometer 117. Chemical oxygen demand and other analytical determinations were made according to standard methods [19].

3. Results and discussion

Experiments were performed on actual textile industry wastewater in continuous mode using an activated sludge process (ASP) at different HRTs (18, 24 and 36 h) and mixed liquor volatile suspended solids (MLVSS) of 2500, 3500 and 5000 mg/l concentrations. The removal of colour and COD was studied at different MLSS concentrations and HRTs.

3.1. *Effect of MLVSS on colour and COD removal at 18 h HRT*

Figs. 2 and 3 show the effect of MLVSS concentration (2500, 3500 and 5000 mg/l) on decolourization and COD removal with time at 18 h HRT using textile industry wastewater under steady state condition. The results of the studies showed that percentage colour and COD removal increased with increase in MLVSS. At 18 h HRT, colour removal was found to be 46, 54 and 67% at 2500, 3500 and 5000 mg/l MLVSS, respectively under steady state condition. Increasing trend for COD removal was also observed with increase in MLVSS concentration. At 18 h HRT the removal in COD was found to be 62, 73 and 77% at 2500, 3500 and 5000 mg/l MLVSS, respectively under steady state condition. The reason for higher decolourization and COD removal at higher MLVSS is due to higher number of microorganisms present in the aeration tank. Similar kinds of results have also been reported already [20].

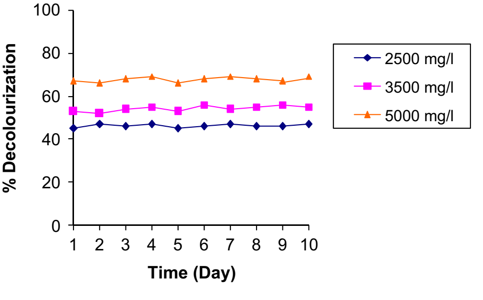

Fig. 2. Effect of MLVSS concentrations on decolourization of textile industry wastewater at 18 h HRT.

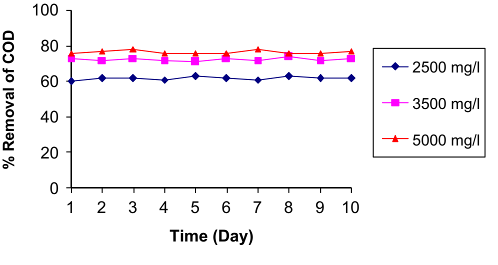

Fig. 3. Effect of MLVSS concentrations on COD removal from textile industry wastewater at 18 h HRT.

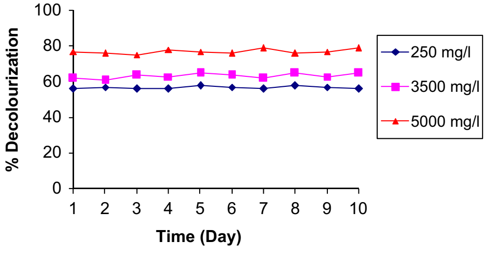

Fig. 4. Effect of MLVSS concentrations on decolourization of textile industry wastewater at 24 h HRT.

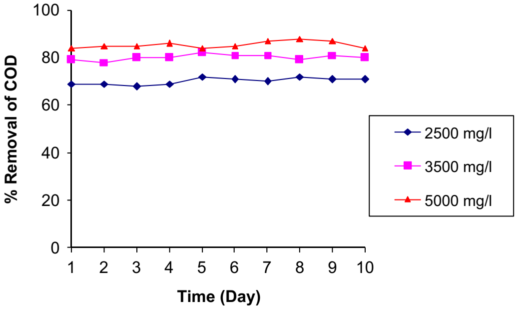

Fig. 5. Effect of MLVSS concentrations on COD removal from textile industry wastewater at 24 h HRT.

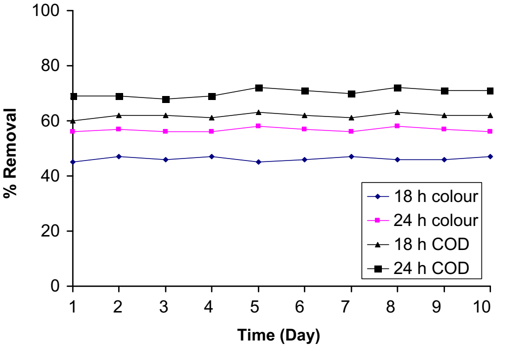

Fig. 6. Removal of colour and COD from textile industry wastewater with time at 2500 mg/l MLVSS and different HRTs.

3.2. Effect of MLVSS concentration on colour and COD removal at 24 h HRT

Effect of MLVSS concentration on decolourization and COD removal with time at 24 h HRT is shown in Figs. 4 and 5. It is clear from the figures that percentage decolourization and COD removal increased with increase in HRT (18 h to 24 h). Maximum decolourization was 77% at 5000 mg/l MLVSS followed by 63% and 56% at 3500 and 2500 mg /l MLVSS. Similar kind of increasing trend of COD removal with increase in MLVSS concentration and HRT was also found. Increased COD removal was observed at 24 h HRT as compared to what was observed at 18 h HRT. Removal of COD was 84, 80 and 71% at 5000, 3500 and 2500 mg/l MLVSS, respectively. Similar kinds of results have been reported in literature [21]. Fig. 6 shows the percentage decolourization and COD removal with time at 2500 mg/l MLVSS concentration and different HRTs. It can be seen from the figure that percentage decolourization and COD removal are higher at 24 h HRT in comparison to results obtained at 18 h HRT using the same MLVSS concentration (mg/l) under similar experimental conditions.

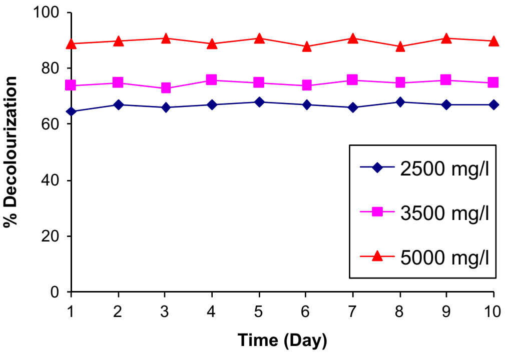

Fig. 7. Effect of MLVSS concentrations on decolourization of textile industry wastewater at 36 h HRT.

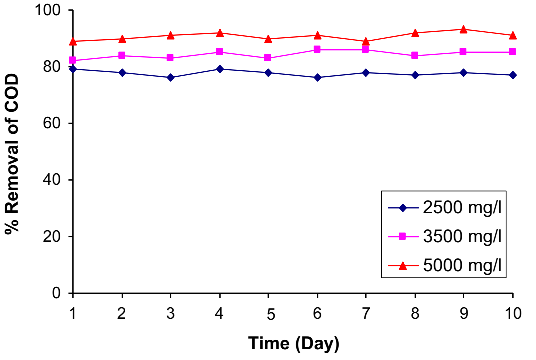

Fig. 8. Effect of MLVSS concentrations on COD removal from textile industry wastewater at 36 h HRT.

3.3. Effect of MLVSS concentration on colour and COD removal at 36 h HRT

The results of the study conducted at 36 h HRT at different MLVSS concentrations under steady state condition are shown in Figs. 7 and 8 for decolourization and COD removal, respectively. The results clearly indicate that percentage decolourization and COD removal increased with increase in HRT at all the concentrations of MLVSS. The maximum decolourization was 90% at 5000 mg/l MLVSS which decreased to 75% and 67% at 3500 and 2500 mg/l MLVSS, respectively. Removal of COD also increased with increase in HRT and MLVSS. The COD removal was observed to be 77%, 85% and 91% at 2500, 3500 and 5000 mg/l MLVSS, respectively. Removal of COD was higher at 36 h HRT in comparison to the results obtained at 18 h HRT and 24 h HRT. At 18 h HRT the COD removal was 62%, 73% and 77% at 2000, 3500 and 5000 mg/l MLVSS, respectively which increased to 71%, 80% and 84% at similar MLVSS concentration and at an HRT of 24 h. The higher decolourization and removal in COD at higher HRT are due to the higher concentration of microorganisms. In another study “biomass growth in the activated sludge stage was limited by carbon source” noting that the MLSS decreased from approximately 4000 to 1000 mg/l when the feed concentration of starch was decreased from 3.8 to 1.9 mg/l; MLSS then increased after the starch concentration was again increased to 3.8 mg/l [22].

4. Conclusions

The results of the above study clearly reveal that activated sludge process is efficient to remove colour and COD from real textile wastewater. Moreover, hydraulic retention time (HRT) and mixed liquor volatile suspended solids (MLVSS) affect the performance of the activated sludge process. Removal of colour and COD was increased with increase in HRT and MLVSS. Maximum colour removal was found to be 90, 75 and 67% at 5000, 3500 and 2500 mg/l MLVSS, respectively at 36 h HRT. The COD removal was observed to be 77, 85 and 91% at 2500, 3500 and 5000 mg/l MLVSS, respectively at 36 h HRT. Removal of colour and COD was higher at 36 h HRT in comparison to the results obtained at 18 h HRT and 24 h HRT. On the basis of the present study, suitable treatment technology can be developed for the treatment of textile wastewater in continuous mode of operation which shall have advantage to treat large quantity of effluent in shorter duration.

Conflict of Interest

There is no conflict of interest.

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