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ORIGINAL PAPER

Biological treatment of red bronze dye through anaerobic process

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Abstract

Industries that are ever increasing are major contributors to environmental pollution due to inappropriate waste handling. Textile wastewater contains mutagenic and carcinogenic chemicals which are harmful to natural phenomenon of receiving water channels. Therefore, textile wastes should be treated before discharging in the environment. Treatment of red bronze dye was investigated in the upflow anaerobic bioreactor. Varying dye concentrations (40~325 mg/L) were treated by adjusting primary pH at neutral. The performance of reactor was judged by conventional process parameters like pH, turbidity, dissolved oxygen (DO), electroconductivity (EC), total dissolve solids (TDS), removal efficiency, and chemical oxygen demand (COD). The maximum removal efficiency occurred at 150 mg/L dye concentration with addition of 50 ml of biomass. The pH of the water remained basic, COD removal ranged between 60 and 91%, and the maximum removal was done at 91%. EC and TDS were also low indicating good dye removal efficiency of the reactor.

Keywords Red bronze dye · COD · UASB · pH · EC · TDS

Introduction

Economic growth is vigorous to nation's development; improper disposal of industrial wastes is the root of environmental damages (Gnanapragasam et al. 2010; Sarayu and Sandhya 2012). Dumping of dye industrial wastes into different environmental compartments badly affects the equilibrium and integrity of ecological systems. The textile industrial wastewaters cause turbidity and affect photosynthetic microbiomes in addition to being genotoxic, mutagenic, and carcinogenic; these dyes are quite damaging to the health of biota (Tahir et al. 2016). Textile industry consumed a large volume of water and producing a vast amount of toxicity to water bodies (Gong 2016). Muda et al. (2013) investigated the characteristics of textile industry wastes which involved the extended sequence of multifaceted actions during the processes from raw materials up to final products. Although these industries increased the economy by creating job opportunities; unfortunately, these also cause enormous water pollution. The techniques used in the treatment of these wastewaters employ toxic chemicals which are hazardous for human and aquatic as well (Muda et al. 2013). Need to discover new techniques, which could be proficient of eliminating the toxicity and decolorization of dye industry's wastewater, are highly desired (De Jager et al. 2014). Wastewaters of dye industry contain sturdy color, high temperature and pH, chemical oxygen demand (COD), and recyclable ingredients. After treating the effluent in upflow anaerobic sludge blanket (UASB) reactor, there was significant reduction of COD and decolorization. The effluent was further treated and showed a final reduction of 92% of COD (Babu et al. 2011). Lu and Liu (2010) described the dyes which contaminated the environment and aquatic life due to improper treatment of its effluents, and they also studied the biodegradation of dyes and its complex

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structure. So it is necessary to remove the dyes (Lu and Liu 2010). Two kinds of bacteria acidogenic and methanogenic play significant role in color removal in textile industries (Sarayu and Sandhya 2012). MTCC 1360 showed 87 % decolorization of the azo dye Rubine GFL (45 mgL^{-1}) within 96 h at 30 °C and pH 7.0 under static circumstances, with a substantial decrease of COD (68 %) and total organic carbon (59 %) (Waghmode et al. 2012). Gnanapragasam et al. (2010) investigated the removal efficiency of COD and dye by using upflow anaerobic sludge blanket for the treatment of wastewater of textile (Gnanapragasam et al. 2010). Senthilkumar et al. (2011) studied the COD and decolorization of textile dyeing industry by varying the concentration with COD ranging from 5200 to 6320 mg/L (Senthilkumar et al. 2011). An efficient and economical, wastewater treatment system was generated for the treatment of textile dye, which should be efficient and cost effective (Venkatesh et al. 2017). Very few information is available on the treatment of textile dyes by biological methods alone. The main objective of this study was to explore suitability of anaerobic treatment for golden dye by calculating the removal efficiency of golden dye using anaerobic treatment method to find low cost removal method of golden dye from wastewater.

Experimental setup

Sludge collection

The sludge sample used in the current study was collected from the anaerobic treatment unit of a local wastewater treatment plant. The mixed culture of anaerobic microorganism used in this experiment was obtained from the Lijiao Wastewater Treatment Plant, Guangzhou, China. The sludge was gray in color, with volatile solids to total solids ratio of 0.7 showing its greater ability of biodegradation of organic compounds.

UASB and synthetic wastewater

A laboratory scale anaerobic UASB (upflow anaerobic sludge blanket) reactor was constructed for treatment process of golden powder. The experimental setup has been shown in Fig. 1.

UASB influent tank connected with peristaltic pump with a pipe, which was further connected with anaerobic sludge reactor. One effluent outlet was connected with recycling peristaltic tank which was used to recycle water into the anaerobic reactor for effluent collection. Seven-liter solution in the influent tank was used, and the 1st peristaltic pump was fixed at 1.7 rpm which pumped only 4 ml of water in 1 min. After getting pumped from sludge bed, water was pumped out by recycle peristaltic pump which was fixed at 5.1 rpm (double the speed from the 1st pump). The concentration was taken as 5 mg/L, 10 mg/L, 15 mg/L, 20 mg/L, and 25 mg/L up to 50 mg/L. Continuous 20-day process was taken to observe its characteristic and treatment capacity through anaerobic reactor. After every 24 h hydraulic retention time (HRT), the samples in triplicate were taken for analytical procedure.

Synthetic wastewater

Commercially obtained red bronze (RB) dye is normally used in printing has been shown in Fig. 2. The pH was adjusted by used 0.1 M H_2SO_4 or KOH.

Analytical procedures

Solvents were purified and dried by the standard methods (Hussain et al. 2017). All the analytical procedures used were the standard methods for water and wastewater analysis prior

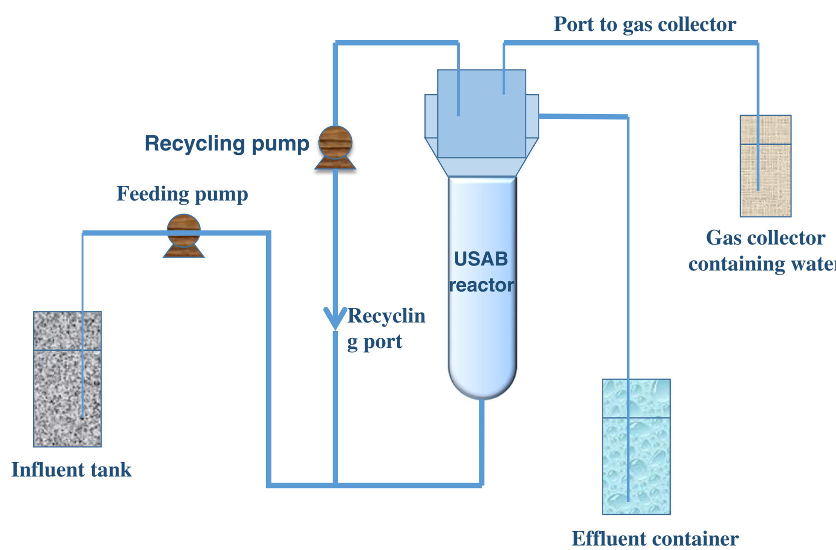


Fig. 1 The schematic diagram of a laboratory scale UASB reactor

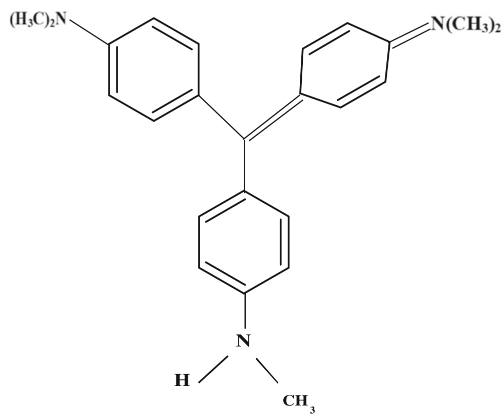


Fig. 2 Structure of red bronze dye

to and after the treatment according to standard procedures (Zhao et al. 2016). The pH of the wastewater was measured with a pH meter (Orion). The dissolved oxygen (DO) was detected by LDOTM portable rapid checking instrument (HACH, USA). Turbidity meter and electroconductivity meter were used to measure the turbidity and EC (electroconductivity) respectively. The model of spectrophotometer (PERSEE TU1810) was used to find out the removal efficacy and COD.

Results and discussion

In this study, UASB reactor was used with different dye concentrations. The influence of anaerobic sludge in terms of dye and its color removal was calculated. The results were assessed on the bases of pH, turbidity, electric conductivity, and dissolved oxygen, percentage removal efficiency of dye, and COD removal.

Difference in pH of treated and untreated water

The pH of water is not static; it changes with the passage of time, and it even changes many times in a single day with the addition or removal of any pollutant. When there is any change in pH, it affects the ability of anaerobic microbes, so fluctuations in the pH, specifically rapid variations, are very harmful.

In different concentration of dye in wastewater, fraction of changes was noticed in treated water (shown in Fig. 3). pH of the water remained basic even after treating with anaerobic sludge which does not harm or produce toxic compounds that cause damage to soil or living organisms.

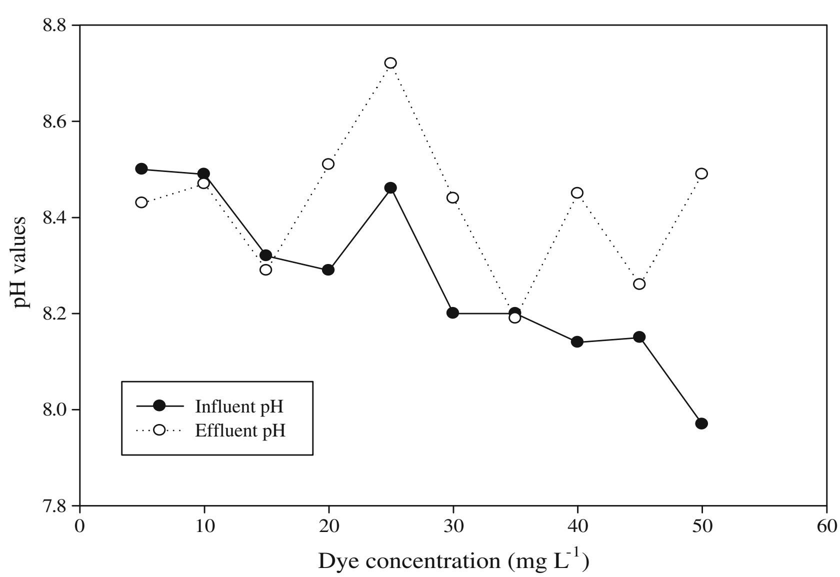
Turbidity of wastewater

Turbidity causes interruption of sunlight into water thus affecting quality of H_2O badly. Wastewater could be comprised of suspended solids, which entails numerous dissimilar sizes of particles. Figure 4 shows influent containing dye concentration had variation in turbidity as the dye quantity has increased turbidity in influent sample. Comparatively effluent contained lesser amount of dye concentration; as a result, the value of turbidity also decreased which indicated better quality of water.

Changes in electric conductivity

The TDS (total dissolve solids) and EC have adjacent association. Higher dissolve solids in the wastewater will increase the rate of the EC. Figure 5 shows relative lesser conductivity value of effluent as compared to influent which showed that the removal efficiency of the dye-caused lowering of EC values.

Fig. 3 The effect of pH on the treatment of dye in the anaerobic reactor



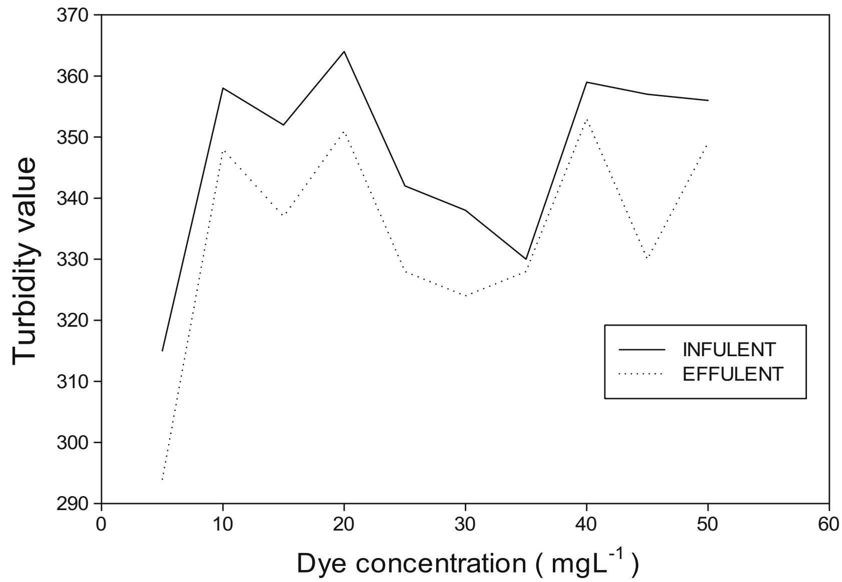


Fig. 4 Effect of turbity on treatment of dye by using anaerobic reactor

Removal efficiency of dye from wastewater

The influent and effluent dye concentrations of anaerobic bioreactors reactors were measured using UV-V spectrometer (Gnanapragasam et al. 2010). The removal efficacy was in the range of 75–94% at 24 h HRT for several ratios of waste reprocess. Figure 6 shows that dye removal efficiency after treatment. At low concentration, value was at its maximum and dye removal decreased by increasing concentration, but overall removal treatment efficiency is appreciable.

COD removal from wastewater

The removal of COD in UASB under anaerobic conditions (HRT 24 h) for 20 days was presented in Fig. 7. It was evident that very high-rate COD removal occurred in the UASB. Considering low strength of municipal wastewater, influent COD was fed around 250 mg/L. The effluent COD after anaerobic treatment was in the range of 30 to 45 mg/L. The removal efficiency (RE) remained always was very high (90%) throughout the treatment process. The enactment of the reactor was recorded based on the COD removal efficacy. Differences of

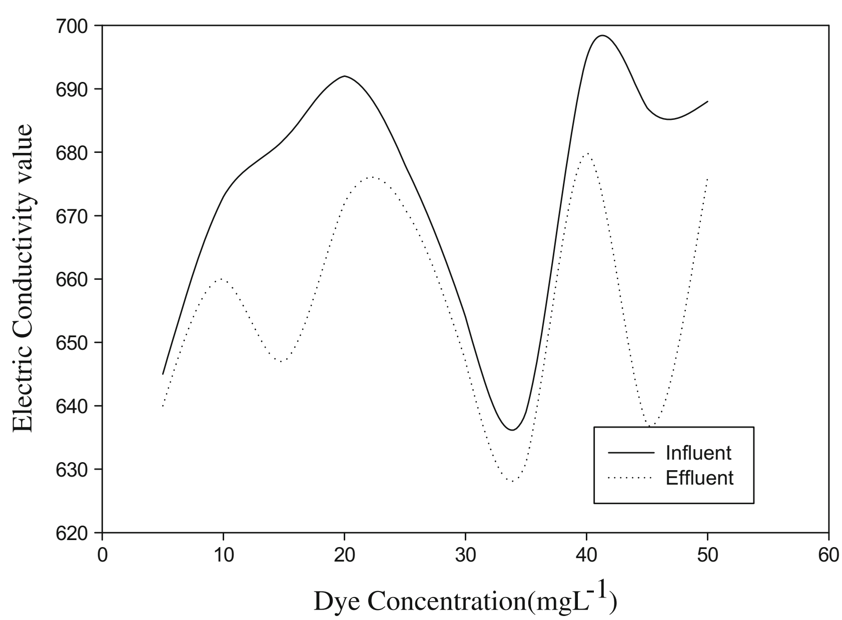


Fig. 5 Effect of electroconductivity on treatment of dye in anaerobic sludge

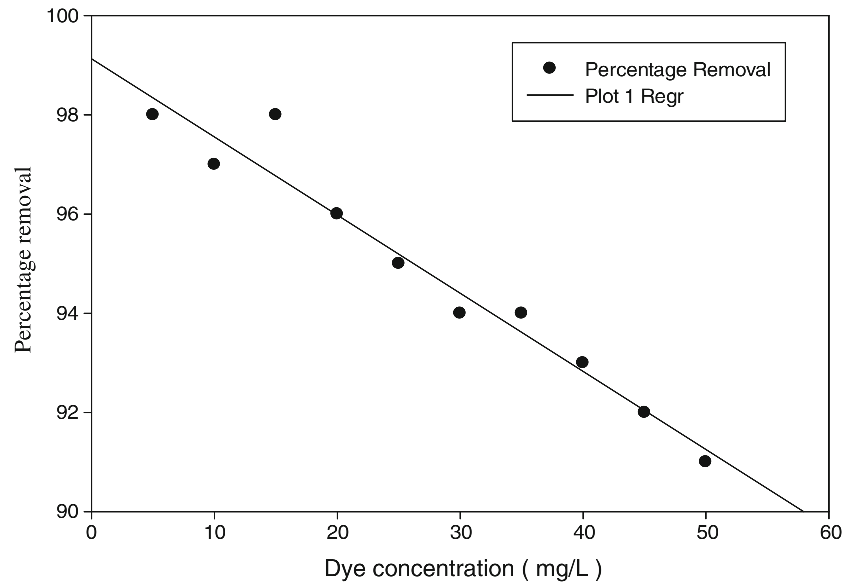


Fig. 6 Percentage removal of dye in effluent

COD concentration were recorded during initial and final phases; during phase one, the removal efficiency of COD was 40 to 50 mgL^{-1}, while final last phase effluent COD concentration was noticeably high as compared with the first phase and attributed to the alteration of microbes to the textile wastewater.

Discussion

This work involved the golden dye treatment by anaerobic biological process using UASB reactor. Dye treatment by biological technique is cost effective with maximum dye removal is environment friendly as compared with other physical and chemical methods. Treatment through UASB reactor is not well established although this technique is progressing day by day. UASB reactor shows effective results for dye removal; removal efficiency at low concentration was maximum up to 98%, as the concentration increases removal efficiency decreases up to 92%. Many researchers compared the aerobic and anaerobic treatment of azo dyes (Pandey et al. 2007; Barathi and Indra 2015). Mixed cultures of the potential strains effectively decolorized the dye contaminated effluent time period of 24–48 h (Palani et al. 2012). Haidera et al. (2018) introduced diverse intermittent phases during the continuous operation of UASB reactor and COD and color removal rates of 67.0% and 77.8% were achieved (Haidera et al. 2018). The application of mesophilic anaerobic systems to color removal of sulphonated mono- and di-azo dyes with

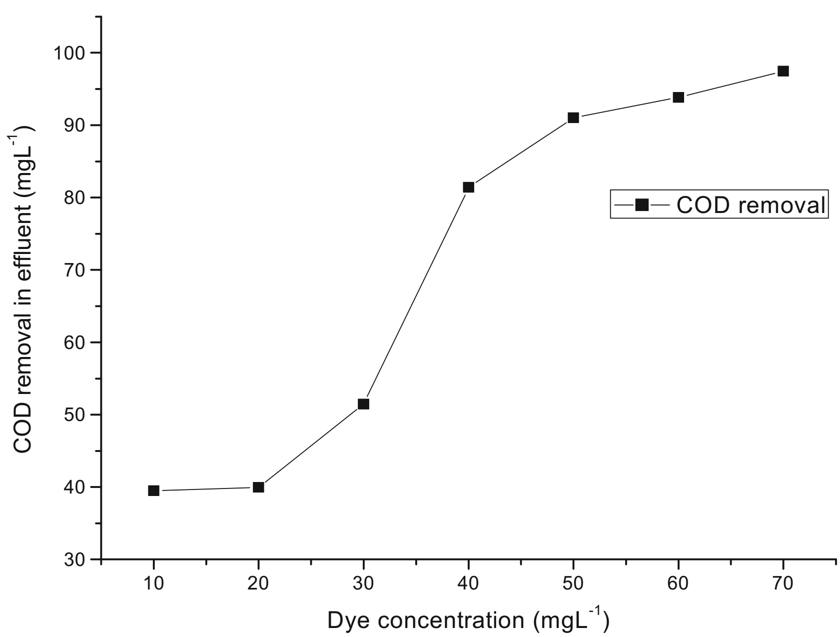


Fig. 7 COD removal of dye effluent during UASB treatment

ethanol as electron donor was investigated (da Silva et al. 2013). Couras et al. (2014) examined stability period, which involved the disruption of continuous operation of reactor in same operation condition under different time during the continuous (feeding) period (Couras et al. 2014). Higher stability of the biological process presented good prospect for application to decolorization of dye.

Amaral et al. (2014) conducted a research on UASB to remove color and chemical oxygen demand (COD) from actual textile wastewater. The experiment was done for 335 days and divided into three phases with total HRT varying from 21 to 14 h. This showed high sulfate levels diminish the dye reduction. Removal efficiencies of 30% and 96% for the UASB and the reactor system were recorded respectively (Amaral et al. 2014).

Ong et al. (2005) evaluated the decolorization of methylene blue (MB) by an upflow anaerobic sludge blanket (UASB) reactor. The reactor was operated under batch condition with total treatment volume of 3 l and operation time of 24 h per batch. They concluded that the color of MB disappeared within a few minutes after entering into the UASB reactor due to reduction by anaerobic biomass (Ong et al. 2005).

UASB reactor is time effective biological technique by which treated effluent was collected within 24 h, and the removal efficiency is also under acceptable range. Although the pH of the stock influent and effluent was basic at small concentration (5 mg/L), as the concentration increases (50 mg/L), influent become acidic which can be harmful, but after treatment, it becomes basic. UASB reactor shows possible result of the removal of suspended solids, turbidity, and decolorization of the solution. The mechanism of the dye removal should be investigated further; however, it is speculated that anaerobic microbial consortia in the UASB might have degraded dye during hydrolysis process and subsequently stabilized in methanogenesis.

The experiment showed the decolorization of basic, reactive, and direct dyes by pre-treated *Typha angustifolia* Linn, a narrow-leaved cattail. By doing the treatment from this plant, pH of the dye solution has little influence on the elimination of active dyes and the efficiency range from 96 to 98% over the range of pH used. The removal efficiency of reactive and direct dyes was affected by pH, which was highest at pH 3 for 98% for direct dyes and 95% for reactive dyes (Inthorn et al. 2004).

Different methods have variant results and analytical parameter, but the major concern is agricultural lands as these influents damp directly into the water reservoir that is feed to the agriculture sector which then cause many problems to crops and the people who eat them. UASB is an effective technique, which can remove these type of solids in less timing more effectively.

Conclusion

The result of this study showed that synthetic wastewater containing red bronze dye could be effectively treated by UASB reactor at different concentration varying from 10 to 60 mg/L. It investigated the removal efficiency at low concentration is maximum up to 98%, as the concentration increases removal efficiency decreases up to 92%. In UASB reactor, the decrease of chemical oxygen demand (COD) and color removal were 60% and 85% respectively. A final reduction of COD of 91% was observed. UASB reactor is time effective biological technique by which treated effluent was collected within 24 h, and the removal efficiency is also under acceptable range.

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