



Treatment of high saline textile wastewater by activated sludge microorganisms

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Abstract

Textile wastewater is a combination of various chemicals and different types of dyes and has a salty nature. In this study, an SBR (sequencing batch reactor) was used to treat synthetic and real textile wastewaters in a 24 h cycle time. Remazol Brilliant Blue R, a reactive dye, was used as the model dye. Dye concentrations ranged from 125 mg/L to 500 mg/L, and TDS (total dissolved solids) concentrations ranged from 1000 mg/L to 10,000 mg/L in synthetic wastewaters. For the highest dye concentration (500 mg/L) with low TDS, an 80.71% COD removal efficiency was obtained; at a TDS concentration of 5000 mg/L, a 59.44% COD removal efficiency was obtained. When the TDS concentration of wastewater was raised to 10,000 mg/L, COD removal decreased to 14.92% and reductions in MLSS (mixed liquor suspended solids) and MLVSS (mixed liquor volatile suspended solids) concentrations were observed. According to the results, increasing the TDS concentration of wastewater up to 5000 mg/L did not affect COD removal efficiency of the activated sludge microorganisms in the treatment system.

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Keywords: Saline wastewater treatment; Sequencing batch reactor; Activated sludge microorganisms

1. Introduction

The textile industry is one of the largest sources of contaminant wastewater, because it uses high volumes of water in dyeing, printing, and finishing processes (Nigam, Banat, Singh, & Marchant, 1996). The most important material consumed by these industries, and thus the most important resulting contaminant, is dye, which is used in large amounts (Nigam et al., 1996). The wastewater from textile and printing industries contain high amount of color and carcinogenic compounds (Quan, Zhang, & Xu, 2015); synthetic dyes are resistant to removal because of their aromatic compounds, Remazol Brilliant Blue R (RBBR) – the model dye – is a synthetic textile dye which is frequently used in producing polymeric dyes. It is toxic and organo-pollutant dye

and has an anthraquinone structure (Javaid, Qazi, & Kawasaki, 2016).

Various chemicals like scattering materials, acids, alkalis, salts, detergents, and oxidations are added during dyeing to improve the dye adsorption and stability of fibers; the most important characteristic of textile wastewater is its salty nature. Cellulosic fibers are the most prevalent textile fibers. When these fibers are placed in water, they are negatively charged because of the ionization of the hydroxyl groups. The most appropriate dyes for these fibers are anionic dyes, such as reactive dyes. An electrical repulsive force between the anionic dye and the fiber causes a reduction in fiber staining (Dodangeh & Gharanjig, 2012). To solve this problem, NaCl is used in the dyeing bath. Salt neutralizes the fiber surface charge and causes increased dye adsorption. The additional amount of dye with high concentrations of salt in wastewater increases environmental contamination (Dodangeh & Gharanjig, 2012). According to different resources, salt range of textile wastewater is varied between 1000 and 10,000 mg/L (Salvadó, Mas, Menéndez, & Gracia, 2001; Yurtsever, Calimlioglu, Görür,

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Çınar, & Sahinkaya, 2016) and the textile industry interns almost 0.2 million tons of salts in the environment per year (Soares et al., 2017).

Wastewater resulting from the dying process is considered the most important contaminant of textile industry wastewater which causes the destruction of organisms, increases BOD concentrations, and decreases the supply of dissolved oxygen in the acceptor water environment (Chaeibakhsh Langroodi & Abedinzadeh, 2004).

Selecting the appropriate treatment method for wastewater with various chemicals and dyes is very important (Nigam et al., 1996). Different methods, including various chemical, physical, and biological treatments, have been applied for treating textile wastewater. Low dye removal efficiency restricts the application of physical methods such as adsorption and filtration methods (Vandevivere, Bianchi, & Verstraete, 1998). Chemical oxidation methods make the destruction and degradation of dyestuff molecules possible, but with these methods, various oxidizing agents such as O_3 , H_2O_2 , and MnO_4 are used. In addition to being unable to completely remove azo dyes from wastewater (because azo dyes are stable and resistant to degradation), these methods are not economical and even produce large quantities of sometimes toxic sludge (Anjaneyulu, Chary, & Raj, 2005).

Biological treatment methods have been selected to remove contamination from textile wastewater that contains salt, because they are cost-effective, non-toxic, sustainable, and environmentally friendly (Banat, Nigam, Singh, & Marchant, 1996; Xiao & Roberts, 2010).

The sequencing batch reactor is an effective activated sludge process used for treating saline wastewater (Mesquita, Amaral, Ferreira, & Coelho, 2009). This biological treatment method involves a strong system, simple function, and high flexibility in procedures (Mohan, Rao, Prasad, Madhavi, & Sharma, 2005).

Equalization, aeration, and clarification can all be achieved using a single batch reactor (SBR). The SBR is appropriate for wastewater treatment applications characterized by low or intermittent flow conditions. Different effluents such as municipal, domestic, hypersaline, tannery, brewery, dairy wastewaters, and landfill leachates can be treated using this biological system (Mace & Mata-Alvarez, 2002).

SBR is considered a biological system for decolorizing the textile dye including Blue Bezactive 150, a reactive dye; according to the results, decolourisation rates were obtained in the range of 88–97% for different volumetric dye loading rates (3–15 g dye/m³ d) (Khouni, Marrot, & Amar, 2012).

The color removal efficiency of the SBR system increased when mixed liquor suspended solids (MLSS) were increased. The color removal efficiency of disperse dye treatments (Disperse Blue 60 and Disperse Red 60) was over 98% at an MLSS of 4000 mg/L; COD and BOD₅ removal efficiencies were also quite high (Sirianuntapiboon & Maneewon, 2012).

According to different studies, high loads of salt (0.5–5%) decreases the efficiency of biological treatment in wastewater treatment plant (Salvadó et al., 2001); because saline loads reduce the metabolic functions of activated sludge microorganisms (Mahmoud & Davis, 1979; Woolard & Irvine, 1995) but, gradually adapting the microorganisms to high saline conditions

can help minimizing the effect caused by salt (Bassin, Dezotti, & Sant'Anna, 2011). A gradual increase in the salt concentration (from 0 to 30 g NaCl/L) has less impact on the COD removal in the aerobic system with salt-adapted microorganisms rather than the one with non-adapted biomass (Bassin et al., 2012).

With regard to the salty nature of textile wastewater, SBR was selected as the treatment system in the present study, the main purpose of which was to investigate the ability of the aerobic microorganisms of the activated sludge to remove dye from textile wastewater containing a high concentration of salts. So far, few studies have been done on treating wastewater containing dye under high saline conditions using the same treatment system.

2. Materials and methods

2.1. Dye, sludge, and synthetic textile wastewater

Remazol Brilliant Blue R ($C_{22}H_{16}N_2Na_2O_{11}S_3$) obtained from Iran Poplin textile factory was used as the model dye for all experiments. This is a reactive dye frequently used in the textile industry.

Activated sludge was obtained from the treatment plant of the pharmaceutical company Sobhan Darou Co. in Rasht, Iran because activated sludge microorganisms from the pharmaceutical factory were adapted with dyes and organic compounds.

At first, the synthetic wastewaters were made without adding salt to achieve basic adaptations with different concentrations of dye in microorganisms; synthetic wastewaters were made with dye concentrations of 125, 250, and 500 mg/L. Then, after evaluating the COD removal efficiency of the first three synthetic wastewater treatments, synthetic wastewater samples with TDS concentrations of 1000, 5000, and 10,000 mg/L were made with a dye concentration of 125 mg/L. NH_4Cl and KH_2PO_4 were added as supplementary nutrients based on a COD/N/P ratio of approximately 100/5/1 for all samples.

2.2. Equipment

A magnetic stirrer set (Taksan Co., Iran), a 2000-mL beaker, and an air pump were used for the SBR treatment system. Other equipment used in this study included a BOD measuring device (Aqualytic Co., Germany), a digital scale with the precision of 0/0001 g (Sartorius Co., Germany) for measuring the dye and salt, an oven (DENA Co., Iran), an electrical furnace (Iran Khodasaz Co.) for MLSS and MLVSS tests, a spectrophotometer (WPA, S2100 Diode Array model, USA) for measuring absorption at a maximum visible wavelength of 570 nm, and a portable device for measuring pH and TDS (ESICO Co., model 7200, USA).

All experiments were performed based on the standard methods for examining water and wastewater (APHA, 2005).

2.3. SBR treatment process

Based on the Sequencing Batch Reactor system, the treatment process was as follows:

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