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Investigation on ecological parameters and COD minimization of textile effluent generated after dyeing with mono and bi-functional reactive dyes

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HIGHLIGHTS

- Analysis of DO, BOD, pH and minimization of COD about 95% of reactive dye containing effluent after two stage- dyeing and dyeing to fixing.
- Reactive dyes having different reactive groups in their structure responsible for different effects on environmental parameters.

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ABSTRACT

This research work designates for the assessment of effluent variables after dyeing of 100% cotton fabric with synthesized reactive dyes namely, Reactive Blue 19 (mono functional), Reactive Black 5 (homo bi-functional), and Reactive Red 195 and Reactive Yellow 145 (hetero bi-functional) dyes under four individual dye concentration 0.5%, 2.5%, 4.5% and 6.5%, respectively. Textile effluents were collected from two stages, after dyeing without and with additional fixing treatment mainly for the determination of DO, BOD, pH and minimization of COD values. Result exposed an overall COD reduction of about 95% for the effluent generated from both stages with all dye concentrations. Here most DO, BOD, pH values were obtained from textile effluents after dyeing stage whereas comparatively least values were revealed for the effluents collected after dyeing–fixing stage; and minimized COD values were found for both stages. In addition to this, the effluents containing mono functional Reactive Black 5 and hetero bi-functional Reactive Yellow 145 dyes shows the most and the least environmental parameters, respectively for all dye concentrations.

1. Introduction

A huge volume of wastewater from different steps of textile wet processing, including pretreatment, dyeing and finishing processes has discharged every year from textile sectors. Discharging of polluted wastewater without or with partial treatment is one of the major causes of environmental degradation at developed countries where little or no treatment is carried out before the discharge from industrial sources. This situation becomes day by day an existent cause of pollution in several developing countries (Sala et al., 2014; Sivakumar et al., 2011; Popa et al., 2012). Worldwide annually about 700,000 tons of approximately 10,000 types of colorants are produced, of which about 20% are assumed to be discharged

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as industrial effluent during the textile dyeing processes (Muhammad et al., 2008; Li et al., 2013). Chemical pollutants present in textile wastewater are dyes containing various chemical substances such as carcinogenic amines, toxic heavy metals, pentachlorophenol, chlorine-bleaching, halogen carriers, free formaldehyde, biocides, softeners and other auxiliaries (Popa et al., 2012; Islam et al., 2015; Dos Santos et al., 2007). Dyes containing effluent can obstruct the entrance of daylight and oxygen which is actually the key of the survival of different segments and can seriously hamper some oxygen related environmental parameters like DO, BOD and COD (Li et al., 2013; Dos Santos et al., 2007). One of most burning demand of the consumers of developed countries is biodegradable and ecologically friendly textiles (Chavan, 2001). Cotton fibers are ecological friendly but problem occurs when 80,000 tons of reactive dyes are consumed each year and about 50% of cotton products are dyed with reactive dyes (Babu et al., 2007). Reactive dyes are popular for cotton dyeing because this is the only class of dyes which make strong covalent bond with the cotton fiber (Ghalwa et al., 2016) and also provide superior fastness properties on cotton. Yet again at the same time reactive dyes take part on hydrolysis reaction with water as a result washing fastness hamper and huge amount of dyes become unable to make bond with fiber. The rate of hydrolysis decreases with the use of bi or multifunctional reactive dyes, but the pollution problem still exists due to containing gigantic amount of color, less DO, more BOD and COD in waste water (Ojstršek et al., 2008). Most of the dye used are complex structure of polymer and some of are highly carcinogenic (Kamat and Kamat, 2015). To control pollution recycling and reducing pollution has become necessary; pollution can be reduced by using effluent treatment plant, less polluting technologies and recycling wastes before discharge (Hangargekar and Takpere, 2015; Sultana et al., 2013; Ashtekar et al., 2014). In this research work four different types of reactive dyes were selected to dye cotton fabrics at different shade percentages to produce different level of textile effluents and the related core aim is the determination of environmental parameters like pH, DO, BOD and minimization of COD.

A published research work indicates greater values of BOD and COD in the effluents and suggests using low impact dyes for the reduction of COD, BOD and pH values in effluent considerably (Kumar and Selvadass, 2012; Khan et al., 2014). Another, the use of cationic pretreatment agent in cotton fabric considerably reduces 80% of the BOD and COD levels (Anandhan et al., 2018). The wastewater from a typical cotton textile industry is characterized by high values of BOD, COD, color, and pH (ISPCH, 1995). Because of the high BOD, the untreated textile wastewater can cause rapid depletion of dissolved oxygen if it is directly discharged into the surface water sources. The effluents with high levels of COD are toxic to biological life (Gowri et al., 2014). Also revealed higher pH, BOD and COD with directs chemical and physical treatment processes to minimize the demand of oxygen (Nazih et al., 2008). There are high alkalinities and traces of chromium employed in dyes adversely affect the aquatic life and also interfere with the biological treatment process. The high color renders the water unfit for use at the downstream of the disposal point (Klemola et al., 2007). High levels of COD are expected from dyeing section due to the nature of chemicals employed in the operation (Mohan, 2016). In this research, effluent parameters like DO, BOD, pH and COD minimization are investigated after dyeing and dyeing–fixing stage of cotton fabric with various classes of reactive dyes.

2. Experimental details

2.1. Material specification

Pretreated (scoured, bleached and bio-polished) 100% single jersey cotton knitted fabric was selected for the research work which was specified as yarn count of 37's, and GSM (gram per square meter) of 150. Dyeing auxiliaries and chemical required for after-treatment like glauber's salt ($Na_2SO_4 \cdot 10\ H_2O$), soda ash (Na_2CO_3), caustic soda (NaOH), acetic acid (CH_3COOH), manganese sulfate ($MnSO_4$), potassium iodide (KI), sodium thiosulphate ($Na_2S_2O_3 \cdot 5H_2O$), sulphuric acid (H_2SO_4), starch solution, potassium permanganate ($KMnO_4$) and ammonium oxalate ($C_2H_8N_2O_4$) were purchased from Merck (Germany), soaping agent Dekol SN were purchased from associated chemical corporation (India), sequestering agent Complexant-P-H/C and wetting agent Dynotex-MH_1D were from Dycin (Bangladesh), and fixing agent Finofix PBCT were purchased from Finotex Chemical Ltd. (India).

2.2. Dye structure and molecular formula

For this research purpose four different types of dyes named Reactive Yellow 145, Reactive Red 195, Reactive Blue 19, and Reactive Black 5 were selected. These dyes contain three altered reactive groups in its chemical structures, respectively consist of hetero bi-functional monochlorotriazine-vinyl sulphone, mono functional vinyl sulphone and homo bi-functional vinyl sulphone structure in it. Dyes were purchased from Hangzhou Tiankun Chem Co. Ltd. (China). Related dye structures and molecular formula of four different reactive dyes are given in Figs. 1–4.

2.3. Dyeing and after-treatment process

Dyeing of knitted fabric was done with selected four different kind of reactive dyes at a concentration of 0.5%, 2.5%, 4.5% and 6.5%. Here, dyeing of cotton fabric was carried out at boiling water bath to produce colored samples. Dyeing and related after treatment was carried out according to the recipe and sequence specified in Table 1.