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Colour Removal from Textile Dyeing Wastewater Using Different Adsorbents

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Abstract. The ability of different adsorbents/coagulants, such as liquid and solid polymers, ferric chloride, calcium carbonate and coal ash, was investigated for uptake of (reactive dyes, Red - 120, Yellow - 14 and Blue - 4 from textile dyeing waste. Coal ash was used for the colour removal from the textile dyeing wastewater of reactive dyes. Different adsorbents removed the colour from the effluent in different degrees; in some cases the colour was removed 100%. White polymer was ineffective. Calcium carbonate gave excellent results. Liquid polymers were better effective than the solid ones. Coal ash yielded good results without any further treatment.

Keywords: industrial wastes, dyes, colour removal, adsorbents

Introduction

Textile industry requires large amounts of water and generates large quantities of wastewater from various steps of dyeing processes. Textile wastewater is characterized by high content of dyestuff, salts, high COD deriving from additives, suspended solid (SS) and fluctuating pH depending on the process (Balcoiglu and Arslan, 2001; Yeh and Thomas, 1995; Yeh *et al*., 1993). Large amounts of dye chemicals in textile industry effluents create severe water pollution. Dyes impart persistent colour with organic load to the receiving water streams leading to disruption of the total ecological balance impairing the visibility in the recipients. This may significantly affect photosynthetic activity in aquatic environment due to reduced light penetration and may also be toxic to aquatic lives due to metals, chlorides etc., associated with the dyes or the dyeing process. It is, therefore, important to reduce the dye concentration in the wastewater before discharging it into the water bodies. However, it is difficult to remove dyes from effluents since dyes are stable to light, heat and oxidizing agents and are non biodegradable (Hai *et al*., 2003).

Protection of the environment has become a challenge for the chemical industries worldwide and in particular, the water pollution caused by synthetic dyes and chemicals. All over the world, environmental regulations are becoming stricter and are forcing the shift of technology towards less polluting or practically non-polluting areas of technological development (Destaillats *et al*., 2000).

Several physicochemical decolourization techniques have been reported for effluent treatment e.g., adsorption, chemical transformation, incineration, photocatalysis, ozonation or membrane separation, however, few, have been accepted by the textile industries largely due to high cost, low efficiency and inapplicability of the processes to a wide variety of dyes.

The conventional process used to treat textile wastewater is chemical precipitation with alum or ferrous sulphate. Drawbacks of this process are the generation of a large volume of sludge leading to the contamination with the chemical substances of the treated wastewater and associated disposal problems etc. For a more practical application, different processes were developed to treat textile industry wastewater. Filtration process, biological process, adsorption process, electrochemical process (Xiong and Karlson, 2001; Barlas and Akgun, 2000; Sójka-L *et al*., 1998; Banat *et al*., 1996) and ozone process etc., have been investigated for many years in numerous research centres due to their high reactivity but have low selectivity.

In most situations, use of a combination of different methods of treatment is necessary for removal of all the contaminants present in the wastewater (Sójka-L *et al*., 1998). Therefore, adsorption became one of the most effective methods of decolourization of textile wastewater (Vendevivere *et al*., 1998; Naumczyk *et al*., 1996; Venceeslau *et al*., 1994). Activated carbon is, by and large, the most commonly used adsorbent although other materials such as activated clay, wood and different types of cellulose-based materials have also been recently investigated for chemical adsorption (Los and Perkowski, 2003; Ciardelli *et al*., 2001). One important point to be considered when choosing an adsorbent is the possibility of easy regeneration, easy availability of material and the running cost of the treatment.

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Pakistan is one of the major textiles producing countries in cotton products. There are several thousand big dye houses that are operating day and night. The enormous amount of discharge in the form of industrial effluents with un-reacted dyes and electrolytes can be visualized. The industrial effluents are a constant threat for our ecology and environment. There is a pressing need to look into this problem.

The aim of this work is to determine the efficiency of the removal of reactive dyes, namely red, blue and green mono and dichlorotriazine from textile dyeing wastewater, using different materials as adsorbents. Focus was on coal ash in particular, which is locally available and has lower commercial value than other materials already in practice.

Materials and Methods

Dyes used in the study were the most common dyes used in the textile industry, red, blue and green belonging to the reactive class, from the group of mono and dichlorotriazine namely Indian Reactive Red-120, Reactive Yellow-14 and Reactive Blue-4.

The materials used for colour removal were ferrous chloride, calcium hydroxide, white solid polymer (Imp orient 20 PWG), liquid polymer (Imp orient A-100), Imp orient WWT-50, coal ash-1 (without any treatment), coal ash-2 (first regeneration) and coal ash-3 (second regeneration), coal ash-4 (third regeneration). Reactor of 300 mL was used for adsorption purpose.

The effluent samples were collected and their pH was measured at site. Absorbance of samples was taken in the laboratory before treatment at 480 nm using spectrophotometer, Model Bush and Lomb, USA. After treating the wastewater samples with adsorbents, the absorbance was again measured at the same wavelength of 480 nm; the wavelength was selected so as to obtain the maximum absorbance for each dyestuff used. pH of solutions varied between 1-8.

Effects of contact time on the removal of colour were studied by adding 5.00 g of adsorbent to 100 mL of double distilled water containing 50 ppm of dyestuff at constant temperature. Laboratory scale batch reactors (200 mL) were stirred at a controlled speed. After regular intervals of time, the slurry solution was filtrated and concentration of the dye was determined (Kang *et al*., 2000; Shimoda *et al*., 1997).

Results and Discussion

The factors that affect the adsorption of reactive dyes namely, Indian Reactive Red-120, Reactive Yellow-14 and Reactive Blue-4 in aqueous solution were studied using different liquid and solid materials. Colour concentration and absorbance graph of the dyes is given in Fig. 1. The samples were collected in 30 L plastic containers and their pH was measured at the site. Then each sample was divided into small portions which in turn were treated with different materials/coagulants.

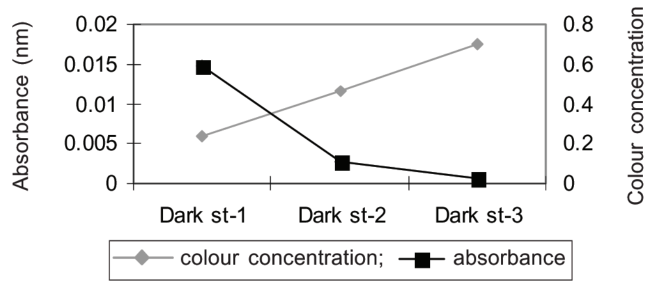
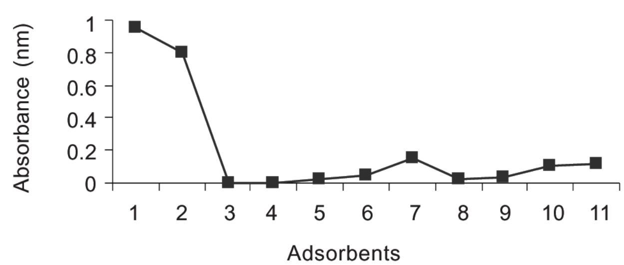


Fig. 1. Absorbance of known colour standards.

The results of effluent treated with different materials are presented in the graphic form (Fig. 2). In this study the coal ash was used four times, once in the original form and three times after regeneration. Solid and liquid polymers were imported items and showed good results. However, these are organic materials which may create soil problem after disposal and also increase the pressure on foreign exchange. Different concentrations of the liquid polymer showed good results but poorer than the solid polymer. Coal ash, used to treat the wastewater, showed the results comparable with the solid polymer giving the absorbance 0.02 at the 480 nm. Coal ash is available free of cost and can be regenerated many times.



1: Treatment; 2: untreated effluent; 3: ferrous chloride; 4: calcium hydroxide; 5: imp orient 20 PWG; 6: imp orient A-100; 7: imp orient WWT-50; 8: coal ash 1(untreated); 9: coal ash 2(1st regenerated); 10: coal ash 3(2nd regenerated); 11: coal ash 4(3rd regenerated).

Fig. 2. Colour removal with different materials.

Natural material used in this study showed promising adsorption capacities without any chemical treatment. The high internal mass transfer resistance impairs its satisfactory application as adsorbent for continuous removal of direct and reactive dyestuff from the textile dyeing waste-water (Kang *et al*., 2000; Shimoda *et al*., 1997). In the treatment of wastewater, total colour removal occurs due to the breakage of bonds between the dye molecules by treatment; in the case where dye is not completely removed from wastewater by treatment, excess amount of dye is removed by absorbing the treatment material. The results of treated wastewater samples with different materials are presented in Fig. 2. The residual colour concentration with variation in pH is given in Fig. 3. Absorbance and colour concentration of known colour standards are given in Fig. 1. Known and unknown samples with wavelength are given in Fig. 4. Fig. 5 shows the absorbance and percentage of colour removal.

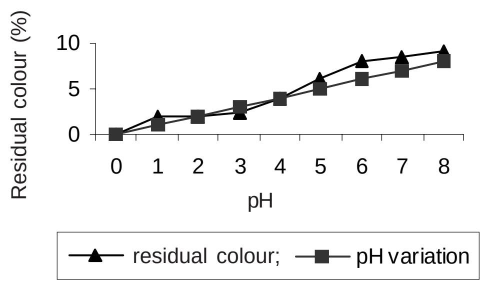


Fig. 3. Residual colour with variations in pH.

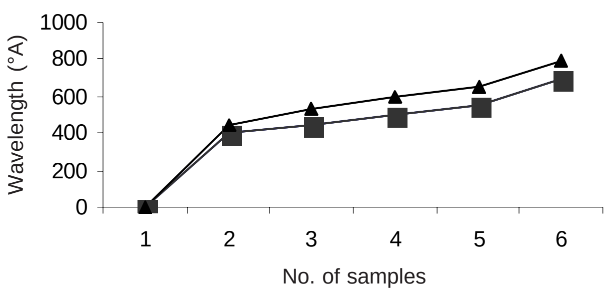


Fig. 4. Colour removal by known and unknown samples (%).

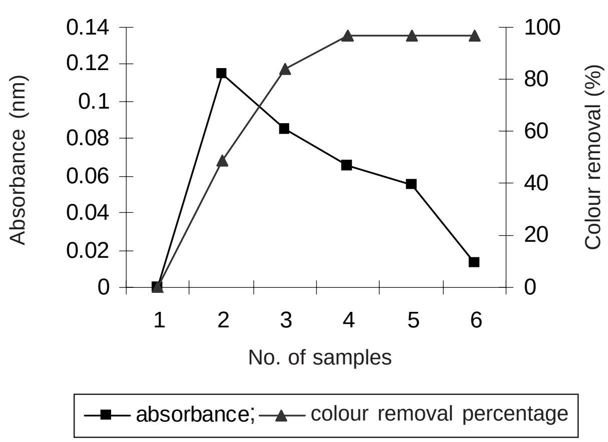


Fig. 5. Colour removal (%) by samples.

The dyes used in this work represent the most commonly used dyes in the textile industry and belong to the reactive class. The red, blue, green dyes from the group of mono and dichlorotriazine were used.

Wastewater sample was decolourized when treated with ferrous chloride, but the latter imparted its own slight yellow colour to the decolourized wastewater which is objectionable. In the second batch, the effluent sample was treated with the calcium carbonate which also absorbed the dye from the wastewater. Solid calcium carbonate showed very excellent results regarding the colour removal but it increased the total dissolved solids in the treated sample making it turbid. In the same way 6 different materials were used for the treatment. White polymer did not show any effect on the colour of the wastewater. Liquid polymer showed excellent result comparable with the ferrous chloride and calcium carbonate. These polymers are organic based and their long term use in bulk may create problems; the large quantity of such treated wastewater on disposal will affect the land quality and fertility. Finally, coal ash was used for the treatment. Coal ash also yielded good results. It is a cheaper material and can be used several times after its regeneration. There was 10% loss during its regeneration. Hence the coal ash is recommended for the treatment of textile dyeing wastewater.

Conclusion

Coal ash used in this study showed promising adsorption capacities without chemical treatment. The high internal mass transfer resistance impairs its satisfactory application as adsorbent due to the continuous removal of reactive dyestuffs from the textile dyeing wastewater.

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