Reactive Dye Removal From Industrial Wastewater On Cotton Dust As A Bio Adsorbent


Abstract: The current study investigates a new, low cost, locally available, eco-friendly bio-adsorbent, cotton (Gossypium herbaceum) dust, to remove reactive dyes from industrial effluent. The cotton dust used in the study was collected from the textile and manufacturing industry, where it was a waste product. Sunfix red, a reactive dye common in textile effluents, was used in the study to check the removal efficiency of the adsorbent. The effects of the variables - contact time, pH of dye solution, adsorbent dosage were investigated, and optimal experimental conditions were ascertained. The highest removal efficiency, 98.5%, was achieved at adsorbent/dye ratio by mass of 1.5:1 at pH 8 in 120 minutes contact time. Raw textile wastewater samples were treated with the adsorbent and it was found that 1.5 g of adsorbent converted 100 mL of deep colored wastewater to transparent water at pH 8. At the same time, the pH, BOD, COD, TS, TDS, TSS of the raw wastewater decreased while the DO level increased.

Index Terms: Adsorption, bio-adsorbent, cotton dust, industrial wastewater, reactive dye, sunfix red.

1 INTRODUCTION

The global yearly production of 10,000 types of commercially available textile dyes has reached approximately 7.10 × 105 metric tons [1]. It is estimated that 2-20% of such dyes are directly released in various environmental constituents as aqueous effluents [2]. The World Bank estimates that 20% of global industrial water pollution comes from the treatment and dyeing of textiles [3]. On average, the textile processing industry requires 50-150 liters of water per kg (L/kg) of textile material processed [4] which is a sharp contrast with the fact that in many regions of the world less than 10 L of water is available per person per day. At present, primary, secondary, and tertiary methods are used worldwide to treat wastewaters. Primary treatment involves screening, sedimentation, flotation and flocculation to remove fibrous debris, insoluble chemicals and particulate matter [4]. Secondary stages are designed to eliminate the organic load and consist of a combination of physico-chemical separation and biological oxidation [4]. Both primary and secondary treatment cannot significantly remove colored materials. Tertiary stages of treatment have become more important but increase treatment costs. Some of these methods involve addition of more chemicals making the processes environmentally unfriendly [5]. Industry owners do not show interest to install these methods due to high running costs and maintenance problems [6]. Ultimately, in many developing countries particularly in India, China, and Bangladesh, the untreated dye-enriched textile wastewaters are discharged directly into various water bodies contributing to environmental degradation, loss of aquatic lives, and harmful human health impacts [7]. In recent years, the uses of natural adsorbents have gained a remarkable importance due to their low cost, environmental friendliness, local availability, and sustainability [8]. In previous studies, Khaleque et al. (2017 & 2018) found that locally available hogla (Typha angustata) leaf and amaran rice (Oryza sativa) husk can remove sunfix yellow reactive dyes from textile wastewater efficiently [9,10]. In this study cotton (Gossypium herbaceum) dust was tested as an adsorbent to remove reactive dyes. Cotton dust possesses granular structure, high chemical stability and high porosity which are very important characteristics for an efficient adsorbent [10]. The cotton dust adsorbent is indigenous, renewable, cost-effective and environmentally friendly.

2 MATERIALS and METHODS

2.1 Materials

The raw cotton dust was collected from textile and manufacturing industry. Sunfix red reactive textile dye was collected from a local textile and garments manufacturing company.

2.2 Methods

Cotton dust was washed with 500 mL of distilled water twice and then it was filtered. Filtered dust was stirred in 500 mL of sodium hydroxide solution (5 g/L) containing 1.5 g of hydrogen peroxide at 90°C for 90 minutes. Filtered dust was then dried at 105°C for 24 hours. 0.1 g of sunfix red dye was added to de-ionized water in a 1 L volumetric flask to make a stock solution. The stock solution was then diluted to 5, 10, 15, 20, 25 and 30 mg/L with the help of de-ionized water. These standard solutions were scanned with a UV-Visible spectrophotometer (DR/4000U, HACH) and the Amax of the dye was obtained at 570 nm. The results were used to draw a calibration curve. The adsorbent and dye solution interaction was done by taking, a specified amount of cotton dust and sunfix red dye solutions in a beaker and stirring with a magnetic stirrer for a specified time. Filtration was used to separate the adsorbent from the aqueous phase. UV-Visible spectrophotometer was used to measure the dye concentration in the filtrate at 570 nm wavelength.

3 RESULTS and DISCUSSION

3.1 Calibration curve for sunfix red dye

A calibration curve (Figure 1) was drawn using the standard solutions of the dye of concentrations ranging from 5-25 mg/L and measuring their absorbances at 570 nm. The correlation coefficient (R2) was found to be 0.9997 which indicate statistical validity of the measurements (Fig. 1).
3.2 Interaction of sunfix red dye with adsorbents and calculation of removal efficiency
In a typical experiment, 1.5 g of cotton dust was interacted with 100 mL dye solution of 10000 mg/L concentration. After interaction the dye concentration was determined from the calibration curve using the absorbance obtained. The removal efficiency of dye was calculated by using the formula

Removal Efficiency (%) = \( \frac{(C_0 - C_e)}{C_0} \times 100 \)

Where,
- \( C_0 \) = initial concentration of dye solution
- \( C_e \) = final concentration of dye solution

3.3 Effect of adsorbent dosage
Effect of amount of adsorbent was studied to find out adsorbent/dye ratio that can result in quantitative adsorption with complete removal of dye from aqueous phase. The dosage of the adsorbent tested ranged from 0.5 to 4 g, added to dye solutions of fixed volume and concentration. Cotton dust shows almost quantitative adsorption (98.5% removal efficiency) at adsorbent/dye ratio of 1.5:1 by mass (Fig. 2).

3.4 Effect of pH on adsorption
Adsorption of sunfix red on cotton dust was tested in pH range 4-12. It was observed that removal efficiency increases with pH, reaching maximum (98.5%) at around pH 8 (Fig. 3). This is because of the fact that in acid medium bridging group present in dye is destabilized [11]

3.5 Effect of initial dye concentration on adsorption
Contact time and adsorbent concentration used to test the effect of initial sunfix red reactive dye concentration on adsorption on cotton dust was 120 minutes and 10000 mg/L respectively (Fig. 4). As initial dye concentration increased, adsorption capacity decreased because with increasing concentration, number of dye molecules increases in aqueous phase leading to lower removal efficiency.

3.6 Effect of contact time on adsorption
Effect of contact time for adsorption of sunfix red on cotton dust was studied for a period ranging from 30-150 minutes while all other parameters remained constant. As observed in Fig. 5, removal efficiency gradually increases with time and reaches maximum (98.5%) in 120 mins. At 98.5% efficiency, it is considered that surface of the adsorbent becomes saturated. After that removal efficiency gradually decreases due to possible desorption of dye molecules from surface of adsorbent.
3.7 Interaction of the adsorbent with the raw wastewater

The effect of treatment by cotton dust adsorbent on selected physical parameters of wastewater was also conducted. The raw wastewater, collected from a leading textile and manufacturing industry, was characterized by measuring pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total solids (TS), total dissolved solids (TDS), and total suspended solids (TSS) to establish pretreatment a baseline. After the baseline values are established the wastewater was allowed to interact with the cotton dust adsorbent. The values of the parameters before and after treatment are presented in table 1:

**TABLE 1 CHARACTERISTICS OF RAW EXTILE WASTEWATER BEFORE AND AFTER TREATMENT**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Before Treatment</th>
<th>After Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/L)</td>
<td>6.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Biological Oxygen Demand (mg/L)</td>
<td>98</td>
<td>40.2</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (mg/L)</td>
<td>992</td>
<td>310</td>
</tr>
<tr>
<td>Total Solids (mg/L)</td>
<td>3444</td>
<td>2150</td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/L)</td>
<td>3224</td>
<td>2010</td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td>220</td>
<td>120</td>
</tr>
</tbody>
</table>

After interaction with the cotton dust adsorbent, pH of wastewater decreased from 11 to 8. This is because of the adjustment made to gain the optimum pH for this adsorption system. DO level was found to increase approximately 10% after interaction. Significant decreases were observed in BOD (60%) and COD (69%) after treatment as well. The TS, TDS and TSS decreased by 38%, 38%, 45.5% respectively due to adsorption. Visual evaluation confirmed that after treating with the adsorbent, the color of the wastewater was completely removed proving that the adsorbent is capable in removing reactive dyes from wastewater.

4 CONCLUSIONS

Cotton dust, a waste product of textile and manufacturing, was successfully used as a bio adsorbent for removal of reactive dyes from wastewater. The peak removal efficiency was found to be 98.5% at pH 8 in 120 minutes contact time. The optimum adsorption/dye ratio of the system is 1.5:1 by mass. The variables pH, COD, BOD, TS, TDS and TSS of wastewater decreased and DO level increased after treatment with the adsorbent. Initially although a single reactive dye, sunfix red was used, it is concluded that the present adsorbent could be an effective, economical and environment friendly alternative for the removal of dyes from industrial effluents.

REFERENCES


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