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Short Note

Reduction of COD and BOD from Textile Wastewater Using Activated Charcoal

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Abstract: The textile industry, one of the essential and largest sectors, requires fresh water and generates a substantial quantity of effluents containing mineral salts and dyes, both concentrated. To address this problem, the present study deals with the removal of COD and BOD from textile wastewater by activated charcoal. The various adsorbent dosage, contact duration and temperature effects have been studied in this investigation in order to remove COD and BOD. Adsorption isothermal data could be interpreted by the Langmuir and Freundlich equations. The maximum COD and BOD reduction was found to be 97.6% and 93.7 % respectively.

Key words: COD, BOD, activated charcoal, dyeing mill wastewater, adsorption.

Introduction

Environmental pollution and its abatement have drawn keen attention for a long time. The problems of removing the pollutants from water and wastewater have grown with rapid urbanization and industrialization. Control of water pollution has importance for both organisms, which live in the water and those who benefit from water (Amuda and Ibrahim, 2006; Shamim et al., 2005). Textile industry is one of the most common and essential sectors in the world. Textile processes require large volume of fresh water of fairly high purity and discharged equally large volume of wastewater after cloth processing operations. The mills located in cities normally discharge their wastewater into sewers or open nullas. Indian textile industry faces problems of proper wastewater management due to non-availability of adequate land for installation of treatment system (Eremektar et al., 2007; Bal, 1999).

The pollution induced by dyestuff losses and discharge during dying and finishing processes in the textile industry has been a serious environmental problem for years; dyes in the wastewater undergo chemical as well as biological changes, consume dissolved oxygen from the stream, and destroy aquatic life because of their toxicity. It is therefore necessary to treat textile effluents prior to their discharge into the receiving water (Can et al., 2003).

There is an ever-increasing demand of fabrics for the rapid expanding population, which is growing at a rate of 11.04%. Nearly 10-15% of the synthetic textile dyes are lost to waste streams and about 20% of these losses enter the environment through effluent from wastewater treatment plant. The wastewaters discharged from dying processes exhibit high BOD, high COD, are highly coloured, hot, alkaline and contain high amounts of dissolved solids (Raghuvanshi et al., 2004). Textile wastewater includes aqueous discharges from fibre and fabric preparation, de-sizing, scouring, bleaching, dyeing, finishing and other textile-processing stages. Most mills operate their own wastewater treatment or pre-treatment plants to remove chemical oxygen demand (COD), biochemical oxygen demand (BOD) and other contaminants from effluent prior to discharge to receiving

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waters or publicly owned treatment works (Idil et al., 2006).

The use of conventional textile wastewater treatment processes becomes drastically challenged to environmental engineers with increasing more and more restrictive effluent quality by water authorities. Conventional treatment such as biological treatment discharges will no longer be tolerated as 53% of contaminations are identified as non-biodegradable. The important technologies include coagulation/flocculation (Asilian, 2006; Amuda et al., 2006), membrane filtration (Galambos et al., 2004), oxidation process (Aslam et al., 2004), nanofiltration or ultrafiltration (Bes-Pia et al., 2002; Bes-Pia et al., 2003). All of these methods have several disadvantages e.g., coagulant methods discharge lots of solid waste (Pala and Tokat, 2002). Nanotechnology is insufficient quantity of wastewater (Rott and Minke, 1999). Biodegradation is an environmental friendly and cost competitive alternative but the conventional aerobic treatments are ineffective for textile wastewater (Faisal et al., 2003). Some anaerobic microorganisms can biodegrade dyestuffs by azoreductase activity, but highly biotoxic aromatic amines can be formed by reductive fission under anaerobic conditions (Banat and Nigam, 1996).

The present study is designed to investigate treatability of combined textile industry wastewater by adsorbent (activated charcoal). Effects of treatment dose, contact duration and temperature on COD and BOD were explored.

Materials and Method

For treatment of the wastewater samples, the required dosages of activated charcoal (specific surface: 5802.35 cm^2/gm) was added to wastewater sample, stirred well and kept in contact for desired duration at the constant temperature of 300 K under investigation and then filtered. Important physico-chemical characteristics viz. COD and BOD were determined before and after treatment according to the standard methods for examination of water and wastewater (APHA, 1992). To determine the effect of different dosage of adsorbent, the wastewater was treated with 0.2 g/L to 10.0 g/L of activated charcoal at 300 K for 4 hrs.

The effect of contact duration was studied by treatment of the wastewater with 2.0 to 8.0 g/L of adsorbent at constant temperature (300 K) and for durations of 30, 60, 90, 120 and 180 min. To determine the effect of temperature, the wastewater was treated with activated charcoal at dosage of 2.0 to 6.0 g/L for temperature of 283, 293, 300, 303 and 313 K for 4 hrs.

Results and Discussion

Effect of Adsorbent Dosage

The effect of different dosage of activated charcoal on COD and BOD adsorption was studied by plotting a graph between percentage reduction and different dosage at 300 K for 4 hrs, presented in Figure 1. It can be seen that there is a large reduction in the COD content, from 30.1% to 80.5% at a dosage of 0.2 to 10.0 g/L of activated charcoal respectively. Also, BOD removal was found to be 12.3% to 76.8% by 0.2 to 10 g/L of activated charcoal respectively. The increasing percentage removal of COD and BOD was found with increasing dosage. Also, the straight line after 9.0 g/L indicates equilibrium attained at 9.0 g/L for COD and BOD.

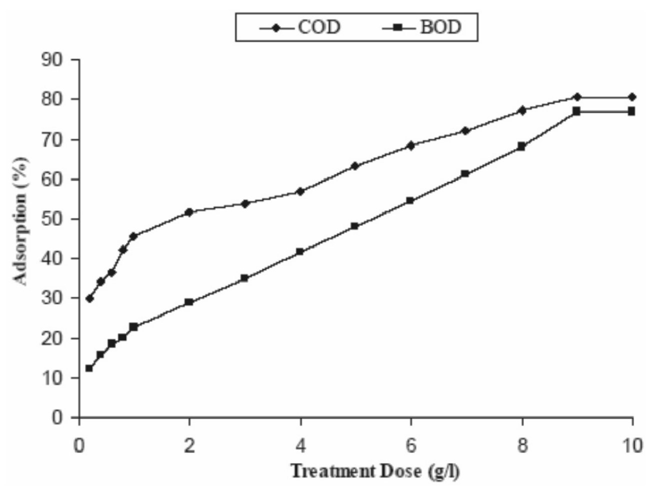

Figure 1: Adsorption of COD and BOD with varying treatment dose of activated charcoal.

Adsorption Isotherms

Freundlich adsorption equation is the most widely used mathematical description of adsorption in an aqueous system, which is shown below:

$$x/m = KC_{eq}^{1/n} \text{ OR } \log x/m = \log K + 1/n \log C_{eq} \quad (1)$$

where x is the amount of the solute adsorbed, m is the weight of the adsorbent, C_{eq} is the solute equilibrium concentration and K and $1/n$ are constant characteristics of the system, which are determined from the log x/m vs. log C_{eq}.

Figures 2 and 3 show Freundlich plot i.e. log x/m vs log C_{eq} for the adsorption of COD and BOD respectively

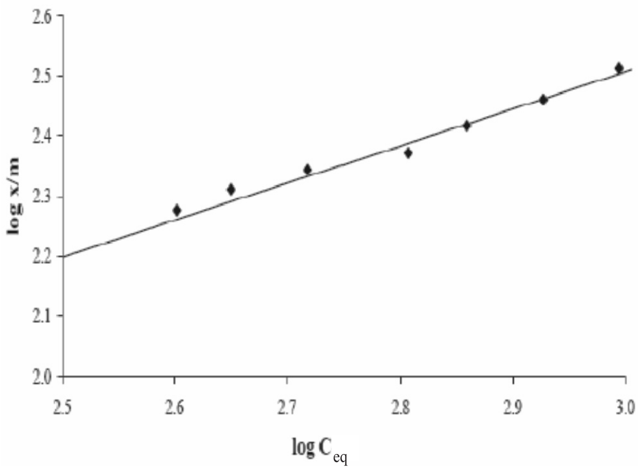

Figure 2: Freundlich adsorption isotherms for the removal of COD by activated charcoal.

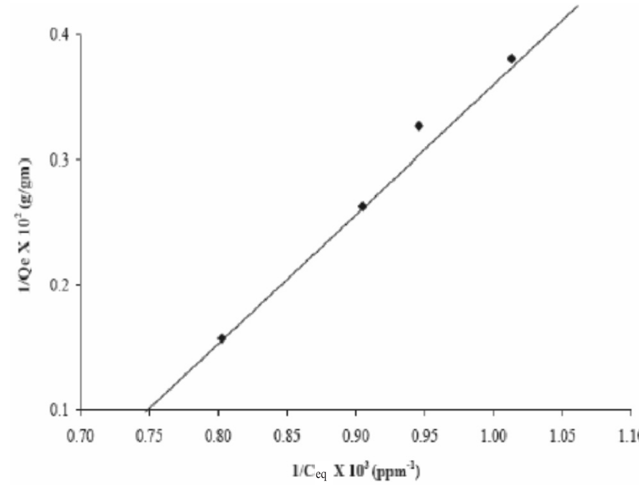

Figure 4: Langmuir adsorption isotherms for the removal of COD by activated charcoal.

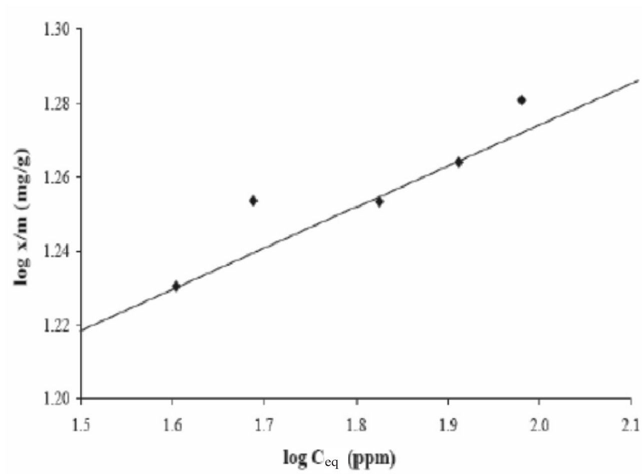

Figure 3: Freundlich adsorption isotherms for the removal of BOD by activated charcoal.

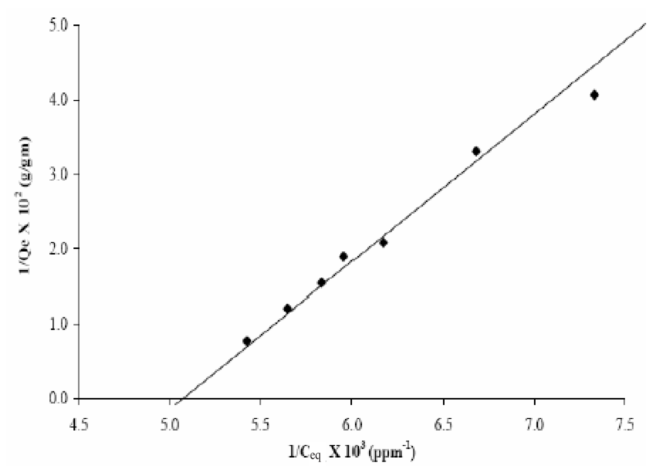

Figure 5: Langmuir adsorption isotherms for the removal of BOD by activated charcoal.

from wastewater by activated charcoal. The value of $1/n$, related to adsorption intensity is 0.586 and 0.110 for COD and BOD respectively. The values of K, related to adsorption capacity were found to be 166.46 and 16.52 for COD and BOD respectively. The observed linearity suggests the applicability of Freundlich adsorption isotherm in both cases and indicates monolayer coverage of the adsorbate on the outer surface of the adsorbent (Bulut et al., 2008).

In addition, the Langmuir adsorption is very useful for predicting adsorption capacities and also interpreting into mass transfer relationship. The isotherm can be written as follows:

$$1/Q_e = 1/\theta b . 1/C_{eq} + 1/\theta \quad (2)$$

where Q_e is the amount of solute adsorbed per unit weight of adsorbent, C_{eq} is the concentration of the adsorption at equilibrium, θ is the Langmuir constant related to capacity of adsorption and b is the Langmuir constant related to energy of adsorption. The values of θ and b are calculated graphically.

Figures 4 and 5 indicate Langmuir adsorption isotherm for adsorption of COD and BOD respectively on activated charcoal i.e. $1/Q_e$ versus $1/C_{eq}$. The Langmuir constant related to adsorption capacity, θ, in mg/g and the average Langmuir constant related to adsorption energy, $b \times 10^3$ L/gm of activated charcoal for COD exerting components is found to be 50.429 and 0.751 respectively; BOD exerting components, the values are found to be 1.758 and 4.931 respectively; The observed linearity suggests the applicability of this isotherm model in both cases and further confirms the monolayer formation (Bulut et al., 2008).

Effect of Contact Duration

Figure 6 represents the graph of equilibrium concentration (C_{eq}) vs. contact duration for adsorption of COD and BOD at different dosages of activated charcoal at constant temperature of 300 K, in which the C_{eq} values are

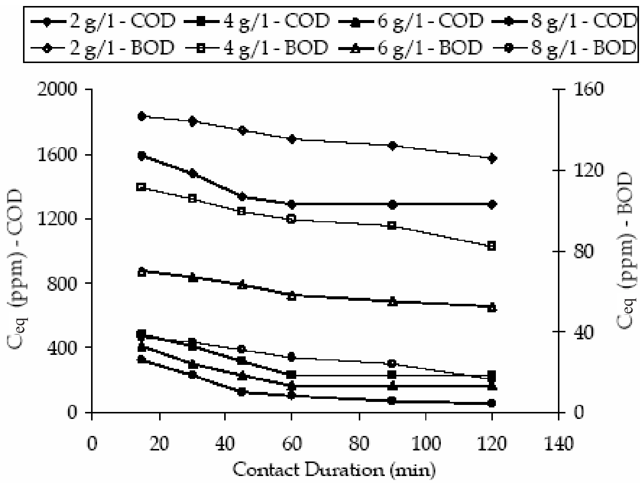

Figure 6: Variation in equilibrium concentration of COD and BOD with time-use of activated charcoal at 300 K.

continuously decreasing with increasing contact duration for BOD, while for COD the values of C_{eq} decrease upto 60 min. So, equilibrium is found at 690 min and after that the value of C_{eq} remains almost constant for an increase of time. Most of the data for COD and BOD gives a straight line. Also, the doses of absorbent increase the reduction of COD and BOD observed.

Effect of Temperature

The effect of temperature on adsorption of COD and BOD on activated charcoal was studied by changing the temperature of the system from 283 K to 313 K at 4 hrs and results are shown in Figure 7. It can be seen from the figure that the equilibrium concentration decreases with an increase in temperature of system. The straight line after 303 K indicates equilibrium attained at 303 K for COD and BOD.

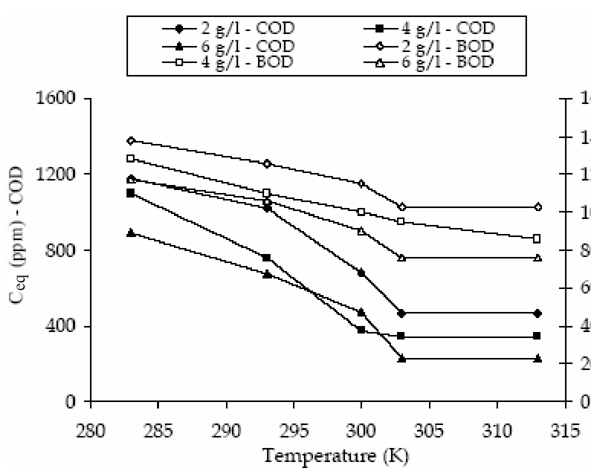

Figure 7: Effect of temperature on equilibrium concentration of COD and BOD at contact duration of four hours.

Conclusion

- Activated charcoal was found to be very effective in the removal of contaminants contributing to the COD and BOD of the wastewater at all doses studied.
- Freundlich and Langmuir adsorption isotherms are found to be applicable for the removal of components contributing to COD and BOD from the wastewater by adsorption onto activated charcoal.
- The maximum percentage removal of COD and BOD was found to be 97.6 and 92.1 respectively which occur at activated charcoal dosage of 8 g/L at contact duration of 120 min and temperature of 303 K.

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