Purification of Textile Industry Waste using Coal Char released from Sponge Iron Industry

B.B.Kar, A.Anupama andT.K.Bastia

KIIT University, Bhubaneswar

Abstract

Thepresence of metal complexes in the textile industry effluent makeit highly toxic. Presence of different dyes in these effluent makes their disposal to water sources quite challenging and increases the BOD of the water sources. Coal Char, waste released from iron industry has been proved to be a major pollutant. Due to its half burn texture it can be it can be used as a potential adsorbent. In this paper work has been carried out using textile dyes and coal char. The effect of the amount of coal char used, time of retention, effluent concentration, reaction temperature, pH and % adsorption have been studied and the results obtained are incorporated in the study.

Introduction

Iron being the most vital metal, various iron industries are developing in the country rapidly. During iron ore reduction, the reductant coal is sometimes subjected to half burn and is discarded as a waste material called coal char. In India an appreciable amount of coal char get liberated(1-11). The utilization of coal char has put forward a big demand and has attracted worldwide attention.Coal char is found to be an important feed stock for preparation of activated carbon. This product is slightly porous and attributed to complexity of the process. During activation coal char becomes highly porous and can be served as an adsorbent(12-22). The waste released from dye industry mainly constitute Co and Cr complexes, which are highly toxic and deteriorate the water quality. The presence of this effluent may lead to various bone problems. In the present process an attempt has been made to treat the textile based effluent using coal char concentrate.

Materials and Methods

Physico-chemical Characteristics of Coal char:

Coal char is a half burn coal derived during iron reduction in iron industries. When the iron ore is subjected to smelting mixing with coal and lime stone some amount of unburnt coal lift out produces coal char. The chemical composition of coal char is represents in Table-1.

The coal char is generally black in color, refractory and abrasive in nature. Its specific surface area varies between 3500 and 8900cm^2/gm. The particle size of fly ash varies between 1020μm to 120 μm and specific gravity is between 2.5 to 2.9 with bulk density in the range of 900-1200kg/m^3.

The adsorption capacity of coal char depends on the unburnt substance present within its surface, varies between 24% to 41% by weight. Due to its high adsorption capacity, it can be used during water treatment for the removal of color and other soluble organic pollutants. Being highly settling in character, suspended solids get easily removed and get settled at the bottom of the water surface. The presence of high silica in coal char reduces the eutrophication process of treated water. With the above specific characteristics, coal char can significantly reduce the COD content of water bodies and it also can be used as a good adsorbent for water purification.

Experimental

During the study coal char is used as an adsorbent and methylene blue liquor dye is used as a synthetic effluent to perform the experiments. The raw coal char obtained from the industry is washed with hot distilled water (with 70^0C), filtered and dried. The dried sample is then treated with sulphuric acid (dilute) for 1 hr to get activated. The activated coal char is again washed with distilled water for removal of excessive acid if present and then heated at 140^0C in an oven for 24 hrs to get completely activated. It is then cooled to room temperature and sieved. The sieve analysis is represented in Table-2.

Preparation of Methylene Blue Liquor:

For the preparation of synthetic dye Qualigen grade of chemicals have been used. To prepare the dye solution 1gm of the dye is mixed with 10 drops of soap solution in a beaker and it is diluted using hot distilled water at 70^0C. The solution is mixed to become homogeneous and the volume was made up to 100ml in a volumetric flask.The solution prepared being hydrolyzing in nature is subjected to utilization just after preparation. Adsorption study was carried out by taking 100ml of dye solution in different conical flasks and adsorbents (of differentratio) is added to them. The conical flasks are kept in a shaking thermostat with a speed of 140rpm. At every 10minutes interval of time, samples were drawn out for color estimation. Percentage removal of color is measured using spectrophotometer. During the study, the effect of temperature has been studied using temperatures range of 30^0C to 70^0C with 10^0C variation. Effect of pH, time of adsorption etc. has also been studied during the experiment.

Result and Discussions

Effect of Percentage of Adsorption: During the adsorption study, using coal char, the rate of adsorption of dye from solution increases with increase in time and after a particular time span it appears to be in equilibrium and saturated as represented in Fig.1.

It has been observed that the removal of color is directly proportional to the concentration of adsorbent added. The percentage addition of adsorbent varies between 5gm/litre to 100gm/litre. The percentage of color removal varies from 20-96, when treated up to 80minutes time with an operating temperature of 40^0C.It signifies that color removal is directly dependant on the percentage adsorbent addition and the adsorption shows a constant trend after 80gm/litre adsorbent addition. No significance variation is found which concludes that maximum up to 80gm/litre adsorbent addition can lead to the removal of around 96% of the color imparted by the dye.

Effect of Adsorption Time on Color Removal:

The effect of adsorption time on color removal is studied using 8gms of coal char (activated) in 100ml of 0.2gm/l dye solution. The solutions were drawn at every 10mins internal to study the impact of contact time on color removal. The results obtained are represented in figure-2. It has been observed that with the increase in contact time initially the percentage color removal also increases and reaches the optimum at 80 minutes contact time with 98.8% removal of color.

It had also been observed that, increasing the contact time further, there is no appreciable change in the trend and equilibrium is maintained up to 100mins contact time. This study signifies that 80mins contact time is the ideal time for removal of highest percentage of color from the solution.

Effect of the Dilution of Dye on Color Removal:

The dye under observation, during study was prepared with different concentrations as follows, 0.1gm/l, 0.2gm/l, 0.3gm/l, 0.5gm/l, 0.8gm/l and 1gm/l. These solutions are under study to observe the effect of dilution of dye on percentage of color removal. The operating conditions were kept fixed with pH 7.5, operating temperature 40^0C, 80mins contact time. The results obtained were represented in Fig.3. The data revealed that solution with 0.2gm/l is found to be ideal for adsorption study. When the concentration is increasing above 0.2gm/l the percentage color removal is decreasing drastically.

This can also be explained as with the increase in concentration, the available site of adsorption becomes fewer and hence the percentage removal of dye depends on the initial concentration. The study was also been carried out with varying the contact time and the trend was found to be similar to that of the trend with a fixed time which indicates the formation of monolayer coverage on the outer interface of adsorbent.

Role of Temperature on Color Removal:

For the study the temperature was varied from 30^0C to 70^0C with 10^0C variation with the solution of 0.2 gm/l concentration, 80mins contact time with pH of 7.5. The study revealed that temperature plays a vital role for the removal of color from the solution. It has been observed that with the increase in temperature there is gradual increase in % color removal up to 40^0C, after which the percentage color removal decreases gradually and almost becomes half at 70^0C temperature.The data are represented in Fig.4.This variation in % color removal may be attributed to the fact that at elevated temperature there might be a phase change of the dye sample which might be producing a lesser % color removal with increase in temperature.

Effect of pH of the dye solution on % color removal:

In order to study the impact of pH on % color removal, the pH of the solution has been varied between 3 to 11. The study was conducted at 30^0C temperature with 30mins contact time and 0.1 gm/lt dye concentration. The results obtained were incorporated in Fig.5. It has been observed that with increase in pH the solution, the percentage adsorption increase with increase in percentage of color removal. The result revealed that coal char is a good adsorbent for the removal of dye colors from aqueous solutions at higher pH values. This can be explained with the fact at high pH value the cations present in the dye get associated with the oxidic anions present in the coal char and when the pH decreases the positive charge density increases on reaction surface and adsorption decreases.

Conclusion

The study conducted by using coal char as an adsorbent to remove color from the treated solution has been determined experimentally and it is concluded that adsorption rate is directly proportional to the quantity of adsorbent added and after a particular concentration the adsorption rate becomes equilibrium and constant.The time of contact of the adsorbent with the treated solution increases initially with the increase in time and after that contact time there is no appreciable increase in adsorption.The dilution of the dye solution has equal impact on percentage color adsorption. When dilute solution of a given concentration is used the percentage color removal reaches the optimum and after that there is decrease in the adsorption rate which may be attributed to the fact that increase n concentration decreases the available sites for adsorption.

Temperature has a positive impact on the adsorption rate. It has been concluded that with gradual increase in temperature rate of adsorption increases and after reaching an optimum value it gradually decreases, which may be due to the phase changes in the dye sample that decreases the adsorption rate. Similarly, increase in pH of the treated dye solution, rate of adsorption increases which can be explain on the basis that the oxidic anions present in coal char get associated with the positive cations present in dye solution leading to complex formation.The above study concluded that at 80^0C operating temperature, 40 minutes contact time; 0.2 gm/l dye solution with 80 gm/l adsorbent addition and with pH 7.5, activated coal char can be used as a good adsorbent for removal of color from dye solutions.

References

1. Mathur, A and Rupainwar, D.C removal of Lead from polluted water by adsorption of Fly ash, Asian Environment, 10: 19-25(1888)
2. Srinivasn, K, Balsubramanian, N and Ramakrishna, T.V studies on chromium Removal by Rice Husk Carbon, Indian. J.Env.Health. 30 (4): 376-387.(1988).
3. Singh R.D and rawat, S.N., Adsorption and recovery of Zn (II) Ions By. Fly ash in Aqueous Media, Indian. J.Env. Health. 35. (4): 262-267 (1993).
4. Sri Chand, Agarwal, V.K. and Pavankumar, removal of Hexavalent chromium from waste water by Adsorption, Indian J. Env. Health, 36.(3): 151-158(1994).
5. Singaram, P. Removal of Chromium from Tannery Effluent by using water weeds, Indian,J.Env. Health,36 (3): 197-199(1994).
6. Singh,D.K.Saksena. D.K. and Tiwari, D.P. Removal of Chromium(VI) from aqueous Solutions. Indian.Jenv.Health, 36, (4):272-277(1994).
7. Patnaik L.N. and das C.P.Removal of Hexavalent chromium by Balst furnace Flu Dust, Indian,J.Env. Health, 37(i): 19-25 (1995).
8. Fujikawa, Teruo, Reduction of Cr(VI) by activated carbon, Mizu-ShoriGijutsu, 18 (12): 1146-1147(Japanese), (1977).
9. Hasimototu, Seji, reduction of hexavalent chromium, Japan Kokai, 7525:495 (1975).
10. Khannan, n and Vijayaraghavan, A.studied on adsorption and recovery of chromium, from chromium liquor,Indian J Env. Protection 12(1):46-49(1992).

11. Isamu, Saito, Removal of Cr(VI) in aqueous solution by activated carbon Manage Res.Inst.PollutionResource,Environ. Inst. Conf.:663-666(1979).

12. Sarwar, M.etal. removal of barium chromate by activated carbon adsorption and ion- exchange. Pak.J.Sci. Ind. Res 31(9): 660-662(1988).

13. Rao, Padaki,etal, kintic studies on adsorption of chromium by coconut shell carbon from sysntheticeffluents, J.Env. Sci. Health, A 27(8): 2227-2241(1992).

14. Ando, Tetsuya and Toshio. Shimotori, wastewater and waste triting material, Japan Kokai: 7872-7877(1978).

15. Sujatha, K.M.andsurendrakumar Removal of Cr(VI) by activated carbon, Indian J.Env.protection, 18(9): 665-670(1995).

16. Selvaraj,K. chandramohan, VandPattabhi, S, Removal of Cr(VI) from aqueous solution and chromium plating industry waste water using photo film waste sludge, Indian J.Env.Protection, 18(9): 641-646(1998).

17. Bandhopadhya, A and Biswas, M. N. Removal of hexavalent chromium by Synergism Modified Adsorption, Indian J.Env.Protection, 18(9): 662-671(1998).

18. Sumantoraoy ,S, Mohanty, A.K and Mishara, M.Removal of Chromium (VI) by different adsorbents- A Comparative study, Indian.J.Env.Protection, 18(9): 679-682.(1998).

19. Nag, Gupta, N. and Biswas, M.N. removal of chromium (VI) and Arsenic (III) by chemical teated Saw Dust, Indian ,J.Env. Protection, 19(1): 25-29(1999).

20. Rai,A.K. and Surendrakumar, Treatment of chromium Bearing wastewater by Adsorption on Brick Kiln Ash And Flyash, Indian J.Env. Health, 41 (1): 65-73(1999).

21. Samanata, A.K.Basu, J.K. and Kundu, G.,Removal of Hexavalent chromium from Aqueous solution by using low-cost adsorbent , Indian J.Env. Protection,20(10) : 754-760(2000)

22. Rajkumar, M., Nagendran, N.AndSashikumar,S.S, Removal of Trivelent Chromium from wastewater using Red mud, Indian, J.Env. Protection,21(2) : 97-100(2001).

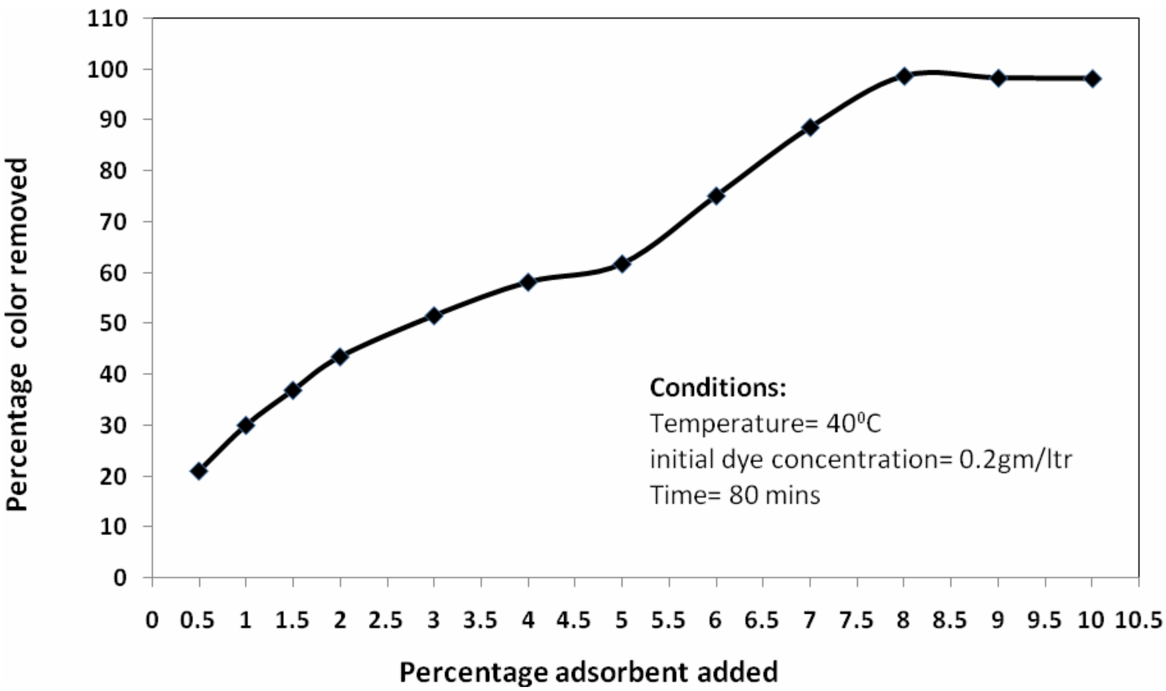

Figure-1 Effect of amount of adsorbent addition on percentage color removal

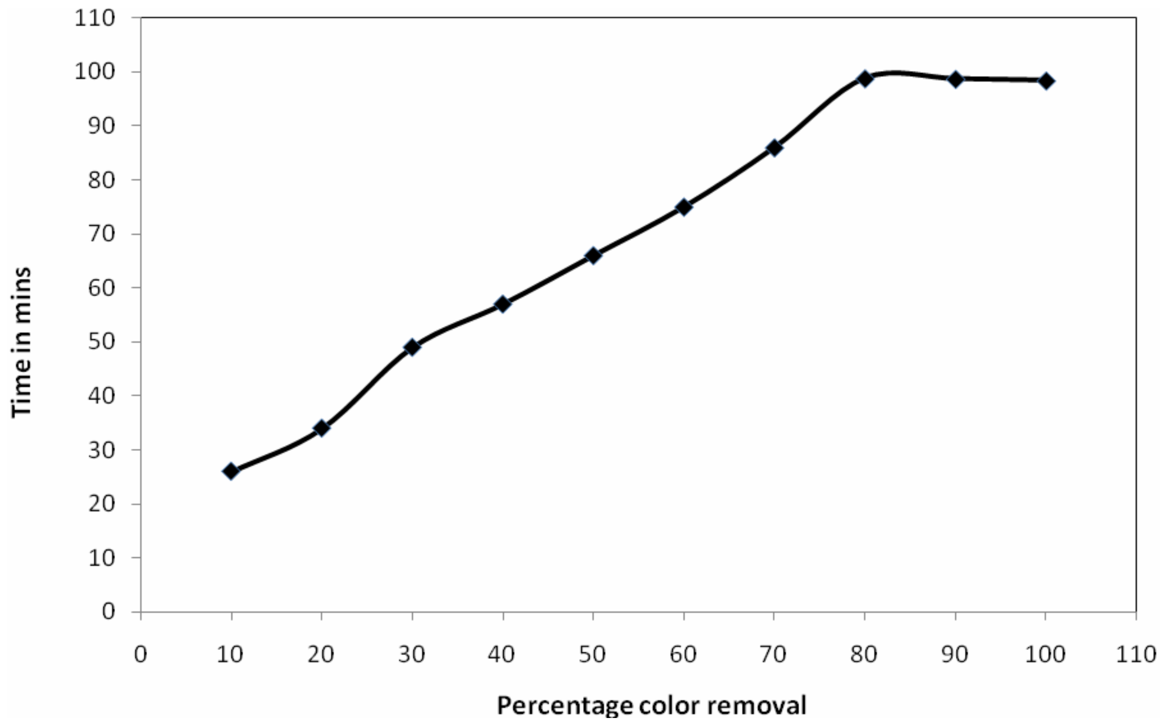

Figure-2 Effect time on percentage color removal

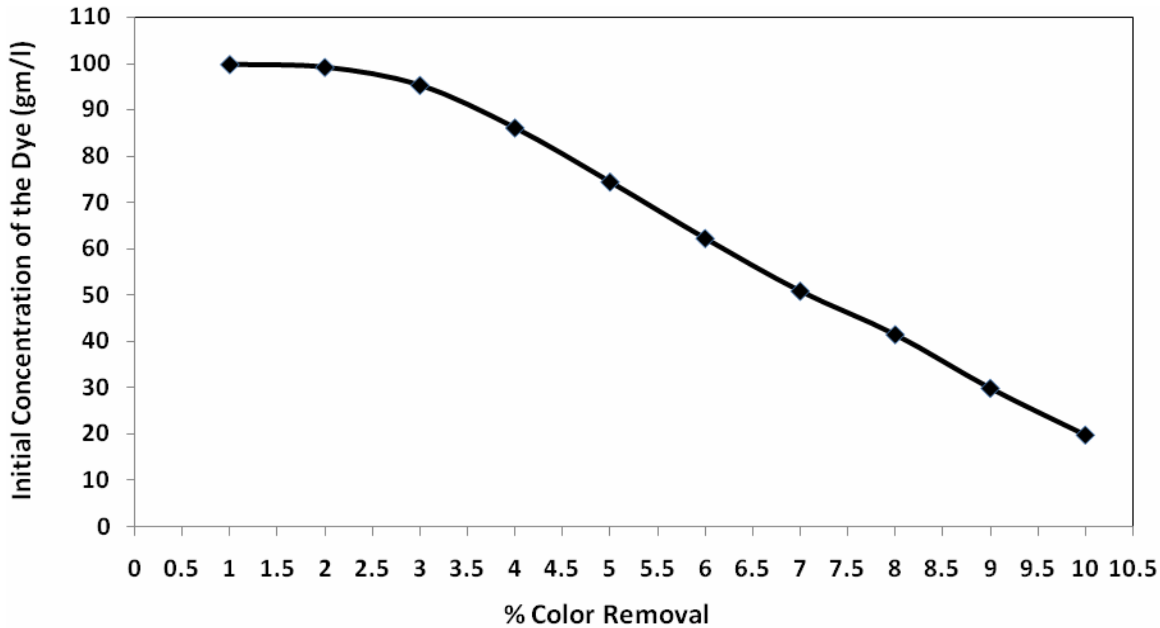

Figure-3 Effect of initial concentration of the dye on percentage color removal

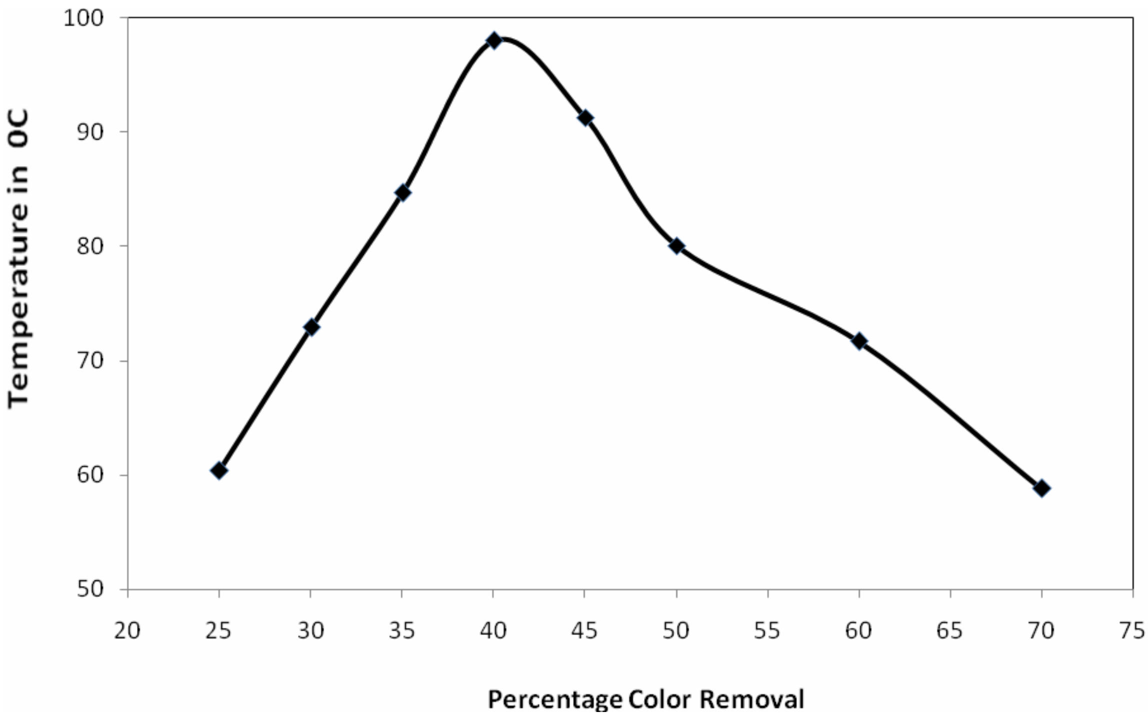

Figure-4 Effect of Temperature on percentage color removal

Table-1 Chemical

Composition of Coal Char

Components	Composition
Volatile	2-3%
Fixed Carbon	27%
SiO_2 (Silica)	48%
Alumina (H_2O_3)	11%
Fe_2O_3	6%
MgO	1.8%
TiO_2	1.2%
Alkali metals	2%

Table-2 Sieve analysis of the activated carbon

Sieve Size	Percentage
-500+250	1.2%
-250+150	2.3%
-150+75	2.8%
-75+25	3.1%
-25	90.4%