The Effectiveness of Locally Available Charcoal in Removing Dye from Industrial Waste Water

Mahmuda Islam and Md. Masudur Rana

Abstract: *The treatment of industrial effluent has received great attention in the past few years due to increasing environmental awareness and the implementation of ever stricter environmental rules. Adsorption is one of the techniques used for the effective treatment of dyes. However, the efficiency of the adsorption process depends on the choice of a suitable adsorbent. Because of the high cost of some conventional adsorbents, this research has been conducted for seeking alternatives, such as locally available charcoal. To fulfill this aim waste water were collected from Beximco Textile Industry and then experiments were carried out in their laboratory. To remove the dye five doses (20 mg, 40 mg, 60 mg, 80 mg and 100 mg) of charcoal of five different particle size (1-1.8 mm, 0.6-1mm, 0.3-0.6 mm, 0.15-0.3 mm and0.075-0.3 mm) along with five different centrifuging time (3, 6, 9, 12 and 15 minutes at 4000 rpm) are used. From this experiment it is seen that charcoal is very much effective in removing dyes from colored waste water as around 88-100% of color can be removed and 100% efficiency is achieved using 60 mg charcoal in 100 ml sample having particle size 0.3-0.6 mm which was centrifuged for 15 minutes at 4000 rpm.*

Key words: Effluent, dye, adsorbent, charcoal, environment

Introduction

Water is the most vital element among the natural resources which directly contributes to food production and economic development and also critical for the survival of all living organisms including human. In modern world, there are many cities facing an acute shortage of water and nearly 40 percent of the world's food supply is grown under irrigation (FAO, 2011). Having a wide variety of industrial processes depended on water and the world-wide high level of production and use of dyes which generates colored wastewaters depicts the future with more severe shortage of usable water.

It is a very fact for a developing country like Bangladesh where the production rate is growing at a faster pace of 11.04 % per year to meet the ever-increasing demand of fabrics and food for the rapid expanding population. Textile industry is a complicated manufacturing industry which generally requires 100 liters to 1200 liters water for dyeing per square yards of clothes of most of that comes out as wastewater (Hossain, *et al*., 2007) and in case of dying industry, above 30-60 liters of water is consumed by per kg of cloth dyed (Sivraj,*et al*., 2001) and about 16% of the total water consumed are released during processing as effluent. (Namasivayam, *et al*., 1994). Matter of fact that nearly 10-15% of the synthetic textile dyes are lost to waste streams and about 20% of these losses enter the environment per year (Sivraj, *et al*., 2001).

This colored waste water from fabric, textile and dying mills is a serious pollution problem because it is high in color and organic content, temperature, suspended solid content and also high in biological oxygen demand (BOD) and chemical oxygen demand (COD) (Sivraj, *et al*., 2001, Dhas, 2008). Now a days, there are more than 10,000 dyes

Ms. Mahmuda Islam, Lecturer, Department of Environmental Science, Stamford University Bangladesh, Dhanmondi, Dhaka-1209, Bangladesh. email: islam.mahmuda@ymail.com

Md. Masudur Rana, MS student, Department of Environmental Science, Stamford University Bangladesh, Dhanmondi, Dhaka-1209, Bangladesh. email: bongsheebangla@gmail.com

available commercially (Nigam, *et al*., 2000), most of which are not easy to biodegrade because of their stability toward light and oxidation; also these dyes are resistant to aerobic digestion (Gupta *et al*., 2004) due to their complex aromatic molecular structure and synthetic origin (Seshdari, *et al*., 1994). Except changing the quality of the water these dyes cut transmission of sunlight into streams and thereby reduces photosynthetic activity (Namasivayam, *et al*., 2001) and aquatic bio-diversity (Dhas, 2008) with causing allergic dermatitis and skin irritation. Some of dyes are carcinogen or may be transformed into carcinogen (Lee, *et al*., 1999; Pappic, *et al*., 2000). These pollutants also affect ground water system due to leaching (Namasivayam and Sumithra, 2005). The primary concern about effluent color is not only its toxicity but also its undesirable aesthetic impact on receiving waters.

The conventional methods of sewage treatment, such as primary and secondary treatment systems are not suitable for the treatment of effluents from textile companies, dye manufacturing industries, paper and pulp mills, tanneries, electroplating factories, distilleries food companies (Amin *et al*., 2008) containing dye molecules because of their very complex nature and stability to heat and light. The methods of color removal from industrial effluents include biological treatment, coagulation, adsorption, oxidation and hyper filtration. Among allof these adsorption is an effective method of lowering the concentration of dissolved dyes in the effluent resulting in color treatment and also due to its sludge free clean operation and complete treatment of dyes and activated carbon is the best option because of its extended surface area, micro pores structure, high adsorption capacity and high degree of reactivity though (Malik, 2003). However, commercially available activated carbons are very expensive for developing countries (Malik, 2003). As a result a wide variety of low cost materials such as agricultural by product (Kadirvelu *et al.*, 2000), waste coir pith (Namasivayam *et al.*, 2001), Indian rosewood sawdust (Garg *et al.*, 2004), pine sawdust (Özacar and Şengil, 2005), banana pith (Namasivayam *et al.*, 1998), rice husk (Lee, *et al.*, 1999), orange peel (Namasivayam *et al.*, 1996) are used as adsorbent. But these materials are not always easily available in Bangladesh. Therefore development of low cost alternative adsorbent which is available in all seasons has been the focus of this research. The present study investigates the efficiency to remove color or dyes from effluent using cheaper source of adsorbent, namely charcoal, which is locally available in Bangladesh along with its efficiency under different conditions.

Aim and Objectives

The aim of this study is to examine color reduction efficiency in selected wastewater by locally available charcoal. Specific objectives include:

- To investigate the efficiency of charcoal in the removal of dyes present in textile effluents.
- To determine the removal performance at different experimental conditions.

Materials and Methods

Charcoal, a final black odorless and tasteless substance made from wood or other materials that have been exposed to very high temperature in an airless environment is very available and cheap in Bangladesh and was collected from Karwan Bazaar (local market). Wastewater samples were collected from three sites (dyeing Section, printing section and finishing section) in the Beximco textile industry according to the instructions of APHA, 1998. After that laboratory test was conducted on five different samples of 100 ml wastewater added with 20 mg, 40 mg, 60 mg, 80 mg and 100 mg charcoal. To achieve the highest efficiency three variables were taken into consideration such as quantity of charcoal, centrifugation time and particle size of charcoal (1-1.8 mm, 0.6-1mm, 0.3-0.6 mm, 0.15-0.3 mm, 0.075-0.3 mm). After resting for 24 hours each of these samples were centrifuged for 3, 6, 9, 12 and 15 minutes respectively at 4000 rpm and then filtered by using filter paper (Whatman no. 1). The filtered water samples were experimented with the help of color test kit (HACH, USA) to assess the removal of color.

Result and Discussion

The effluents from textile or dying industries contain small proportions of dyes which is degrading water quality as well as lowering the aesthetic value. That is why the removal of color from wastewater is often more important than the removal of soluble colorless organic contaminants. Therefore the outcomes of the present experiment are discussed under following subtitles.

Removing Color from Waste Water

Charcoal of five different particle sizes was used as adsorbent of wastewater for aqueous solution. The doses of each charcoal sample were varied as 20 mg, 40 mg, 60 mg, 80 mg and 100 mg each for 100 ml of waste water solution each of which was centrifuged for 3, 6, 9, 12 and 15 minutes. The color removal result in terms of percentage is presented in Table1.

Table 1: Color treatment efficiency (percentage) under different conditions.

Sample	Centrifugation time (min)	Charcoal Dose (mg/100 ml)				
		20	40	**60**	80	100
Sample-1 (1-1.8 mm)	3	42	35	21	22	18
	6	60	52	47	31	26
	9	64	63	58	51	28
	12	69	82	72	52	45
	15	76	83	88	85	67
Sample-2 (0.6-1mm)	3	15	11	27	21	21
	6	34	20	28	23	43
	9	40	20	63	56	54
	12	47	64	65	57	68
	15	66	65	74	57	81
Sample-3 (0.3-0.6 mm)	3	92	88	93	95	95
	6	93	91	98	97	96
	9	94	94	98	98	98
	12	94	98	99	98	98
	15	99	99	**100**	98	98
Sample-4 (0.15-0.3 mm)	3	68	63	65	64	47
	6	78	64	65	69	48
	9	78	68	67	75	59
	12	72	72	74	76	66
	15	99	72	91	80	73
Sample-5 (0.075-0.15 mm)	3	51	54	47	32	36
	6	52	56	52	56	48
	9	65	57	56	67	64
	12	70	63	82	72	66
	15	76	88	89	73	84

Effect of Centrifugation time

The effect of centrifugation time on color treatment with five charcoal samples of different particle sizes were examined and the results of color treatment are presented in Figure 1 to 5.

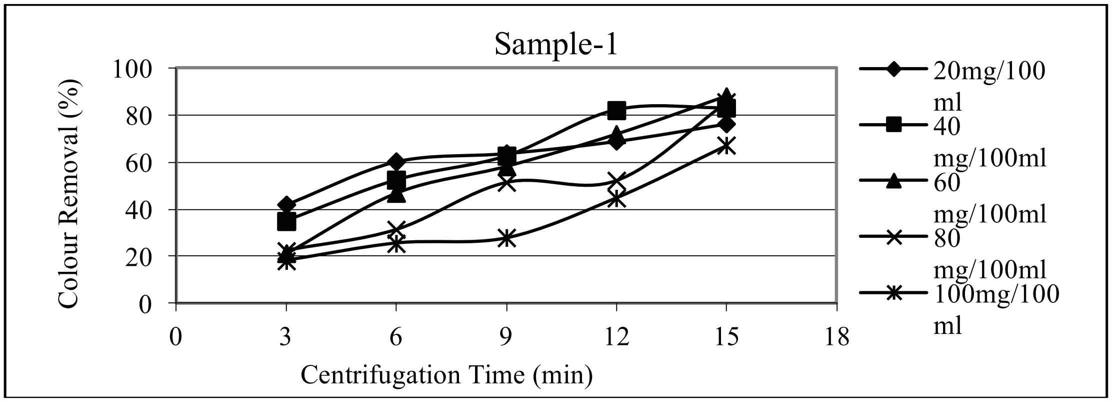

Figure 1. Efficiency of Color Removal with Different Doses of Charcoal with Different Centrifugation Time for Sample-1

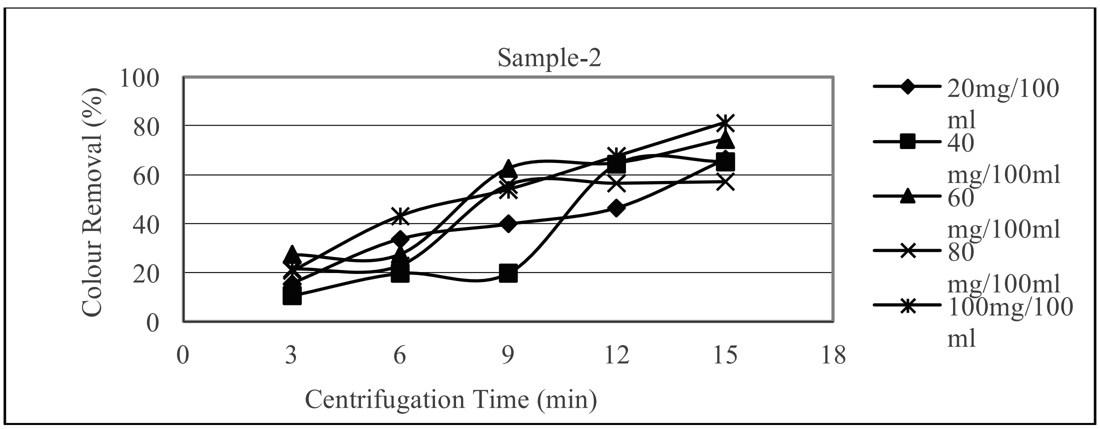

Figure 2. Efficiency of Color Removal with Different Doses of Charcoal with Different Centrifugation Time for Sample-2

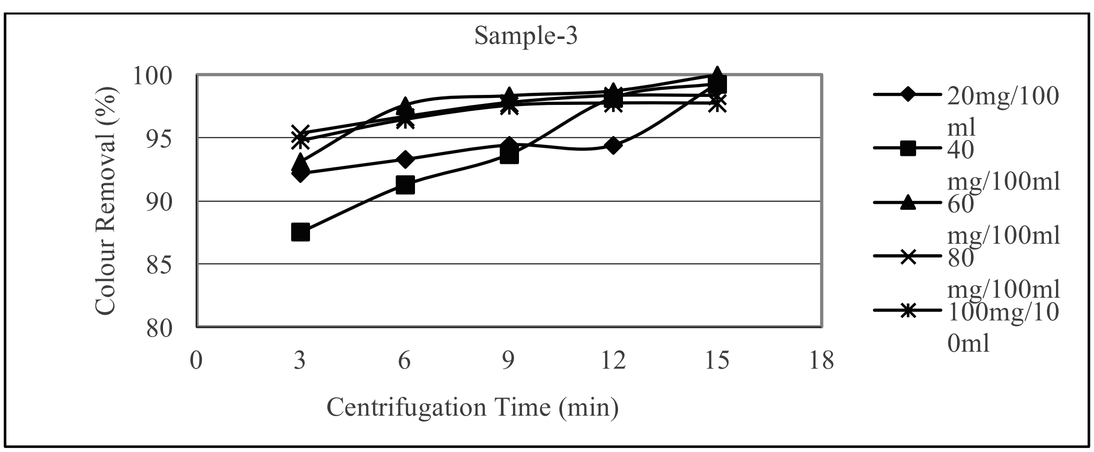

Figure 3. Efficiency of Color Removal with Different Doses of Charcoal with Different Centrifugation Time for Sample-3

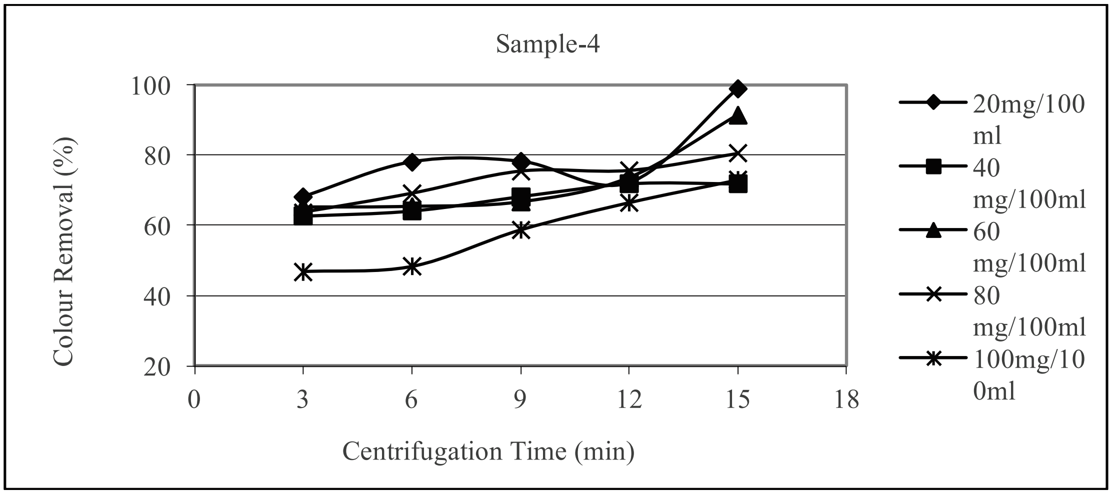

Figure 4. Efficiency of Color Removal with Different Doses of Charcoal with Different Centrifugation Time for Sample-4

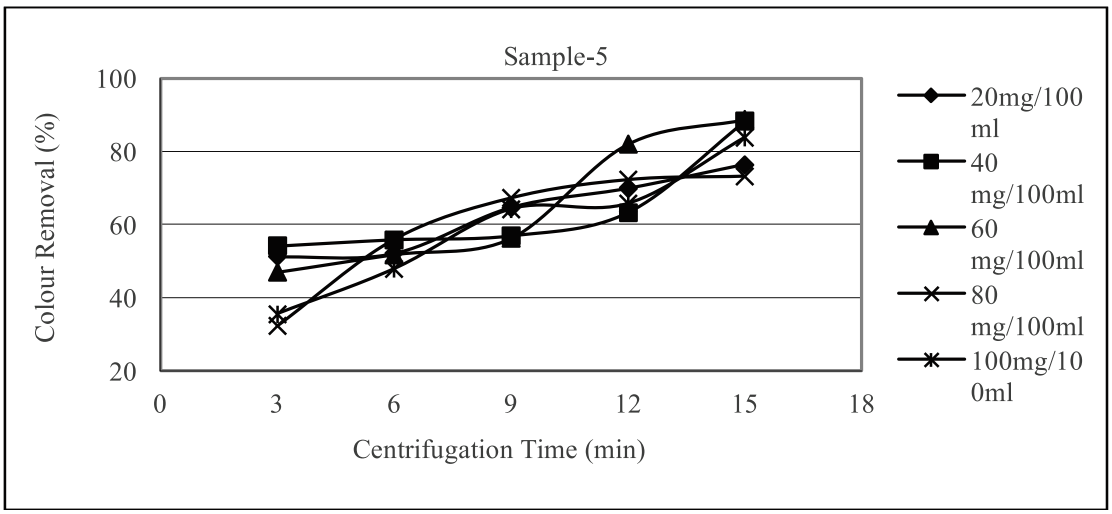

Figure 5. Efficiency of Color Removal with Different Doses of Charcoal with Different Centrifugation Time for Sample-5

Figure 1 to 5 shows a similar trend of color removal with respect to centrifugation time. The fractions of removal increased with the increasing time of centrifugation. The highest frequency of removal for all the samples was achieved at 15 minutes centrifugation time and for sample-3 the success rate is 100%.

Effect of Charcoal Particle Size

Five charcoal particle sizes; Sample-1(1 to 1.8 mm), Sample-2(0.6 to 1 mm) Sample-3(0.3 to 0.6 mm) Sample-4(0.15 to 0.3 mm) and sample-5(0.075 to 0.15 mm) were used as adsorbent of five various doses. As maximum treatment was obtained at the centrifugation time of 15 minutes, the effect of particle size of charcoal on color removal is presented only for that duration in figure 6. The highest removal of color was obtained for the Sample-3(0.3 to 0.6 mm sized charcoal powder).

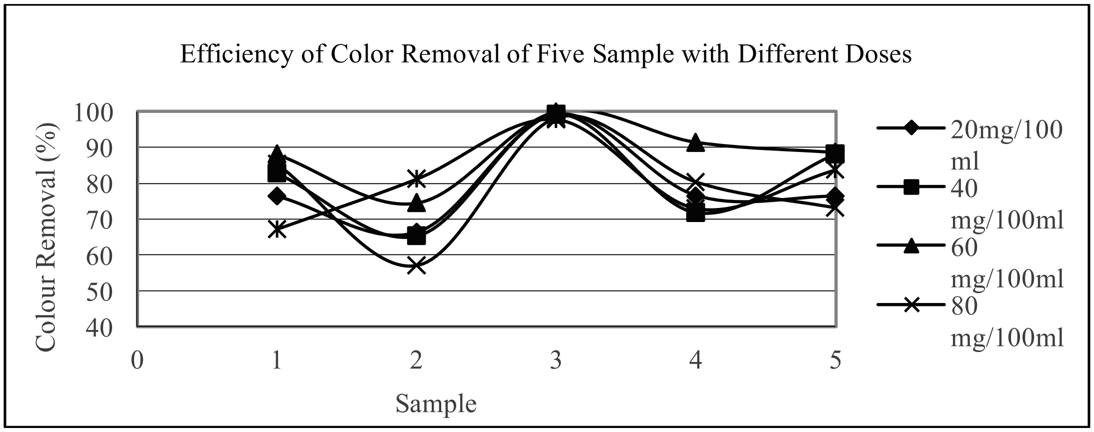

Figure 6. The Effect of Particle Size of Charcoal on Color Removal

Effect of Adsorbent Dose

The highest removal from wastewater solution was obtained against the charcoal dose of 60 mg/100 ml for all samples except Sample-2. The highest percentage of removal was obtained for Sample-3 with any doses of charcoal compared to the other samples.

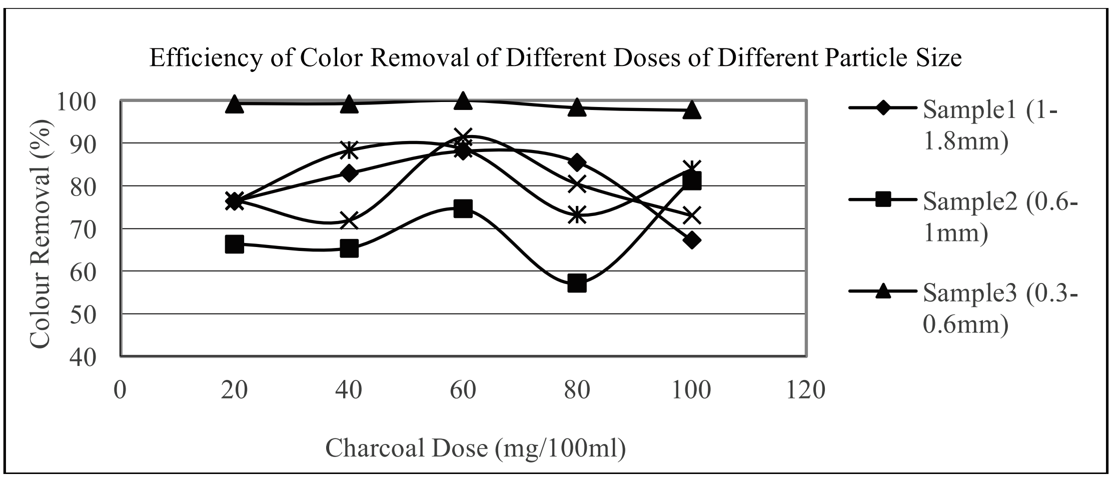

Figure 7. The Effect of Particle Size of Charcoal on Color Removal

Conclusion

The conflict between the development and environment is one of the greatest concern in today's world and this is gaining more attention due to the need for more production to meet the ever-increasing demand of the rapidly increasing population, basically in developing countries. Hence to ensure sustainable development, it is a matter of concern that the effluents from the production industries especially fabric and textile contain dye which changes the temperature, pH, COD and BOD values of the water bodies must be treated properly. But the authority is not interested to run ETP regularly due to high cost. Therefore, it is an urgent call to go for a cheaper source of adsorbent to get relief of dyes. With this aim, this work has found that locally available charcoal is very efficient since 100% efficiency is achieved with the use of 60 mg dose of charcoal per 100 ml waste water, grounded at particle size of 0.3-0.6 mm along with centrifugation for 15 minutes at

4000 rpm. Therefore if the charcoals can also work to standardize the pH, BOD and COD of the effluents, it will encourage the authority to run the ETP on a regular basis due to its low cost and round the year availability which in turn will ensure safer and greener environment for the coming future.

Acknowledgement

The authors would like to acknowledge Professor Dr. Ahmad Kamruzzaman Majumder, chairman of Department of Environmental Science in Stamford University Bangladesh for his continuous support and encouragement in completion of this research.

Reference

Amin, N. K.. (2008) Treatment of reactive dye from aqueous solutions by adsorption activated carbons prepared from sugarcane bagasse pith, *Desalination*, 223, pp. 152-161.

Dhas, J. A. A/L. A., (2008), Study on Treatment of COD and color from textile wastewater using limestone and activated carbon, MSc Thesis, University Sains Malaysia.

FAO (2011) *The State Of The World's Land And Water Resources For Food And Agriculture: Managing systems at Risk*, Earth Scan, Abingdon, UK.

Garg, V.K., Amita, M., Kumar, R. and Gupta, R. (2004) Basic Dye (Methylene Blue) Removal from Simulated Wastewater by Adsorption Using Indian Rosewood Sawdust: A Timber Industry Waste, *Dyes and Pigments,* 63 (3), pp. 243- 250.

Gupta, V.K., Singh, P. and Rahman, N. (2004) Adsorption behavior of Hg(II), Pb(II), and Cd(II) from aqueous solution on Duolite C-433: a synthetic resin. *Journal of Colloid and Interface Science*, 275 (2), pp. 398-402.

Hossain, S. M., Ahmed, I. and Parvez, M. (2007), Study of Textile Dye Decolonization by a Fixed Bed of Activated Carbon, BSc Thesis, BUET, Dhaka.

Kadirvelu, K., Faur-Brasquet, C. and Cloirec P. L. (2000) Removal of Cu(II), Pb(II), and Ni(II) by Adsorption onto Activated Carbon Cloths, *Langmuir*, 16 (22), pp. 8404-8409.

Lee, C.K., Low, K.S., and Gan, P.Y. (1999), Treatment of some organic dyes by Acid Treated Spent Bleaching Earth, *Environmental.Technology*, 20 (1) , pp. 99-104.

Malik, P.K. (2003) Oxidation of direct dyes with hydrogen peroxide using ferrous ion as catalyst, *Separation and Purification Technology*, 31 (3), pp. 241-250.

Namasivayam, C. and Kadirvelu, K. (1994) Coir pith as an agricultural waste by product, for the treatment of dyeing wastewater. *Bioresource Technology*, 48 (1), pp. 79-81.

Namasivayam, C., Muniasamy, N., Gayatri K., Rani, M. and Ranganathan, K. (1996) Treatment of dyes from aqueous solution by cellulosic waste orange peel, *Bioresource Technology*, 57 (1), pp. 37-43.

Namasivayam, C., Prabha, D. and Kumutha, M. (1998) Treatment of Direct Red and Acid Brilliant Blue by Adsorption on to Banana Pith, *Bioresource Technology* 64 (1), pp. 77-79.

Namasivayam, C., Kumar, M.D., Selvi, K., Begum, R.A., Vanathi, T. and Yamuna, R.T. (2001) Waste coir pith- a potential biomass for the treatment of dyeing wastewater, *Biomass and Bioenergy*, 21 (6), pp. 477-483.

Namasivayam, C. and Sumithra, S. (2005) Treatment of direct red 12B and methylene blue from water by adsorption onto Fe(III)/Cr(III) hydroxide, an industrial solid waste, *Journal of Environmental Management*, 74 (3), pp. 207–215.

Nigam, P. G., Armour, I.M. and Banat, D. (2000) Physical Treatment of textile dyes and solid-state fermentation of dye-adsorbed agricultural residues, *Bioresource Technology,* 72 (3), pp. 219–226.

Özacar, M. and Şengil, A. (2005), Adsorption of metal complex dyes from aqueous solutions by pine sawdust, *Bioresource Technology*, 96 (7), pp. 791-795.

Pappic, S., Koprivanac, N. and Bozic, A. L. (2000) Removal of reactive dyes from wastewater using Fe(III) coagulant, *Coloration Technology*, 116 (11), pp. 352-358.

Seshadri, S., Bishop P.L. and Agha, A.M. (1994) Anaerobic/aerobic treatment of selected azo dyes in wastewater. *Waste Management*, 14 (2), pp. 127-137.

Sivraj, R, Namasivayam, C and Kadirvelu, K (2001) Orange peel as an adsorbent in the removal of Acid violet 17 (acid dye) from aqueous solutions, *Waste Management*, 21(1), pp. 105-110.