SELECTION OF POTENTIAL ABSORBENT FROM LOCALLY AVAILABLE MATERIAL FOR THE REMOVAL OF COLOR FROM INDUSTRIAL WASTEWATER

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ABSTRACT

Removal of colour from industrial effluent is yet to be challenges for the researchers, engineers, environmentalist, concern industrialist and also government. Among the established methods, adsorption has already been proved as effective method. However, the use of suitable low cost adsorbent is steel a challenges for the large scale wastewater treatment which govern the total cost of treatment. This study has been carried out to find out the potential absorbent from locally available low cost material for the removal of colour from industrial wastewater. Four locally abundantly available materials viz. wooden charcoal, banana leaves ash, rice husk ash (white) and rice husk ash (black) have been tested to determine the efficacy for removing color from methylene blue, a basic dye, from aqueous solution. The experimental results show that the banana leaves ash is the most potential adsorbent though other materials are also capable to remove methylene blue. The banana leaves ash with the particle size of 0.053 to 0.075 mm has showed the efficiency to remove about 95.60% colour from aqueous solution of methylene blue. The optimum dose is determined to be of 16 mg/100 ml of aqueous solution.

Keywords: *Wastewater, colour* removal*, banana leaves ash, low cost material, potential adsorbent*

1. INTRODUCTION

The textile industries are the major source for coloured wastewater production through their industrial process. Dyes are used in large quantities in many industries including textile, leather, cosmetics, paper, printing, photographic, plastic, pharmaceuticals, food, etc. to colour their products. Though colour is considered to be very important from the aesthetic point of view but they are toxic in nature. These industries use about 10,000 different commercial dyes and pigments and produce more than 7x105 tones of synthetic dyes annually world-wide (Mohammed et al., 2014). Since most of these dyes are toxic in nature their presence in industrial effluents is of major environmental concern because they are usually very recalcitrant to microbial degradation.

Dyes are organic compounds which have complex aromatic molecular structure that make them toxic and harmful. The combination of the processes and products make the wastewater from textile plant contains many types of pollutants (Lin and Chen, 1997). The textile printing and dyeing industry use large volume of fresh water and equally produce wastewater through the process. It contains various waste chemical pollutants such as sizing agents, wetting agents, complexing agents, dyes, pigments, softening agents, stiffening agents, fluorocarbon, surfactants, oils, wax and many other additives which are used throughout the processes. These pollutants contributes to high suspended solids (SS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), heat, color, acidity, basicity and other soluble substances (Ahn et al., 1999). When these large quantities of wastewater discharge into environment without any treatment may cause problems to all living organism. These dyes can remain in the environment for a long time unless treated (Suteuet et al., 2009; Zaharia et al., 2009). In these dyes highly toxic metals are used as mordents so the removal of these dyes is very essential.

Various methods of dye/color removal such as aerobic and anaerobic microbial degradation, coagulation, and chemical oxidation, membrane separation process, electrochemical, dilution, filtration, flotation, softening, adsorption and reverse osmosis, have been proposed from time to time. However, all of these methods suffered with one or more limitation and none of these were successful in removing color from the wastewater completely. Although biological treatment processes remove biochemical oxygen demand, chemical oxygen demand, and suspended solids to some extent, they are largely ineffective in removing color from wastewater because most of these are toxic to the organisms used in the process. The coagulation process effectively decolorizes insoluble dyes but fails to work well with soluble dyes. Photochemical degradation in aqueous solution is likely to progress slowly because synthetic dyes are in principle designed to possess a high stability to light. Accordingly the removal of dyes from effluent in an economic fashion remains a major problem. The convectional biological treatment process is not very effective in treating a dyes wastewater, due to low biodegradation of dyes. However, these processes were very expensive and could not be effectively used to treat the wide range of dyes waste (Grag et al, 2003).

The adsorption process is one of the effective methods for removal dyes from the waste effluent. The process of adsorption has an edge over the other methods due to its sludge free clean operation and completely removed dyes even from the diluted solution. The most widely used adsorbent is activated carbon (powdered or granular) which has excellent adsorption efficiency for the organic compound. However, treatment of wastewater with activated carbon is also expensive and searching for alternative low cost material is gaining interest. A wide variety of materials such as Wool Fiber and Cotton Fiber (Rasheed et al, 2005), Banana pith (Namasivayam et al, 1993a, 1993b), Biogas residual slurry (Namasivayam, et al, 1992), Carbonized coir pith (Namasivayam et al, 2001a), Coir pith (Namasivayam et al, 2001b, 2002), Hardwood (Asfour et al, 1985), Mahogany sawdust, rice husk (Namasivayam, et al, 1992b), Partheniumhysterophorus (Rajeshwarisivaraj et al, 2002), Neem (Azadirachta Indica) husk (Alau, et al, 2010), Rice husk (Singh, et al, 2001; Guo et al, 2003), Silk cotton hull, coconut tree sawdust (Kadirvelu et al, 2003), Gypsum (Rauf et al, 2009), Tamarind Fruit Shell (Saha, 2010) are used as low cost alternatives to activated carbon. The development of low cost alternative adsorbent has been the focus of recent research. Therefore, the aim of this study is to find out the potential adsorbent from locally available material for colour removal from wastewater.

2. METHODOLOGY

2.1 Collection of Adsorbent Samples

Locally available material that is considered as possible adsorbent such as Charcoal is collected from kitchen of student hall of RUET, Banana leaves are collected from the local areas of Rajshahi and Rice husk ash samples (black and white) are collected from rice husking mill at BSIC area of Rajshahi.

2.2 Preparation of the Adsorbent

The charcoal and banana leaves are collected and completely dried under the Sun shine. The charcoal is ground into powder form as fine as possible. The banana leaves are burnt to obtain ash in present of oxygen. The ground charcoal, banana leaves ash and rice husk ash are sieved to get the different ranges of particle sizes of each sample (Bari, et al., 2014). The classified samples of different particles size ranges are prepared by sieving as shown in Table 1 are stored in air tight containers.

Table 1: The particle size ranges of different samples

Sample no.	Sieve no.	Particle size
1	200	0.053-0.075 mm
2	100	0.075-0.15 mm
3	40	0.15-0.4 mm
4	30	0.4-0.6 mm
5	16	0.6-1.18 mm

2.3 Preparation of Dye Solution

Methylene blue was purchased from scientific store in Rajshahi. A representative aqueous solution of methylene blue dye is prepared by dissolving the methylene blue in distilled water for experimental analysis.

2.4 Experimental Procedure

A total 20 samples of adsorbent from four materials having five different ranges of particle sizes are used in this experiment. The experiment for the removal of colour from aqueous solution of methylene blue is carried out as the following steps:

1. Methylene blue solution of 100 ml was taken in a beaker. Then 12 mg of adsorbent was added with the solution. The beaker was then kept for 24 hours.
2. The solution was centrifuged for 12 minutes with the help of centrifuge machine.
3. The solution was filtered by using filter paper [Whatman no.1]

4. The optical densities (absorbance) of the treated samples and without treated samples were measured with spectrophotometer at 651 nm wavelength. Distilled water is taken as blank.
5. Removal of color is determined by comparing the optical density of treated samples and without treated samples. Color removal is expressed in percentage.

The potential material and the ranges of particle sizes are determined from the colour removal results. Further experiment is carried out with varying doses of all four adsorbent to observe the removal efficiency with the variation doses. The doses of adsorbents are varied as 4 mg/100 ml, 8 mg/100 ml, 12 mg/100 ml, 16 mg/ml and 20 mg/100 ml of aqueous solution of methylene blue. Finally, the most potential adsorbent is selected and the optimum dose for the maximum removal of colour is determined.

3. RESULTS AND DISCUSSION

The experiment for the removal of colour from aqueous solution is carried out following one-factor-at-a-time (OFAT) method with four different materials of wooden charcoal, banana leaves ash and rice husk ash (white and black). Total 20 adsorbent samples from four materials of five varying particle sizes are used separately. The dose and mixing time is kept constant as 12 mg/100 ml of solution and 12 minutes, respectively. The potential material is selected from this screening experiment. On the next phase, doses of selected material for all five ranges of particle sizes are varied to determine the optimum dose of particular adsorbent with specific ranges of particle sizes. The experimental results are presented and discussed in following sections.

3.1 Colour Removal Performance of Tested Materials

The experiments for the removal of colour from aqueous solution of methylene blue are carried out with four locally available materials with five different ranges of particle sizes. The soaking period is maintained for 24 hours. The percentages of color removal are presented in Table 2.

Table 2: Removal of color from methylene blue aqueous solution with charcoal, banana leaves ash, rice husk ash (black and white)

Adsorbent	Particle size (mm)	Mixing time (min)	Dose (mg/100 ml)	Color removal (%)
Charcoal	0.053-0.075	12	12	59.20
	0.075-0.15	12	12	56.30
	0.15-0.4	12	12	54.84
	0.4-0.6	12	12	50.23
	0.6-1.18	12	12	49.53
Banana leaves ash	0.053-0.075	12	12	89.83
	0.075-0.15	12	12	85.07
	0.15-0.4	12	12	83.23
	0.4-0.6	12	12	66.05
	0.6-1.18	12	12	64.30
Rice husk white ash	0.053-0.075	12	12	50.21
	0.075-0.15	12	12	46.10
	0.15-0.4	12	12	48.70
	0.4-0.6	12	12	42.54
	0.6-1.18	12	12	38.94
Rice husk black ash	0.053-0.075	12	12	43.36
	0.075-0.15	12	12	54.52
	0.15-0.4	12	12	50.16
	0.4-0.6	12	12	51.27
	0.6-1.18	12	12	41.30

The results show that all locally available materials are capable to remove the colour of methylene blue. The removal of colour by using charcoal, banana leaves ash, rice hust white ash and rice husk black ash varying from 4953% to 59.20%, 64.30% to 89.83%, 38.94% to 50.21%, 41.30% to 54.52%, respectively. The colour removal efficiency is almost same for all used materials except banana leaves ash. Banana leaves ash shows the highest 89.83% removal of clour. Therefore, banana leaves ash could be the potential material which can be used as adsorbent for removal of colour from industrial coloured wastewater.

It is well known that the banana leaves ash was used as detergent for washing the cloths by the villages' people in the early days. The history of using banana leaves ash as detergent is very ancient when commercial detergent was not invented. And even during the period of using caustic soda (NaHCO3) as detergent, banana leaves ash was used for washing the cloths specially which was extremely dirty with colour spot on cloth. The ability of removal of colour is already established from the early days. Moreover, the banana leaves ash shows the alkaline nature when it is diluted with water. The better removal capability of banana leaves ash is might be due to this alkaline nature.

3.2 Effect of Particle Size

The effect of particle size of adsorbent on the removal of color is shown in Figure 1. Five different particle size of each adsorbent was used. A graph was plotted for sample size vs. color removal (%). It is evident from the plot that for a fixed adsorbent dose the removal of color is higher for smaller adsorbent size. Further, it is observed that the percentage removal decreases with increasing geometric mean of adsorbent size. This is because adsorption being a surface phenomenon the smaller particle sizes offered comparatively larger surface area and hence higher adsorption occurs at equilibrium. The influence of particle size furnishes important information for achieving optimum utilization of adsorbent.

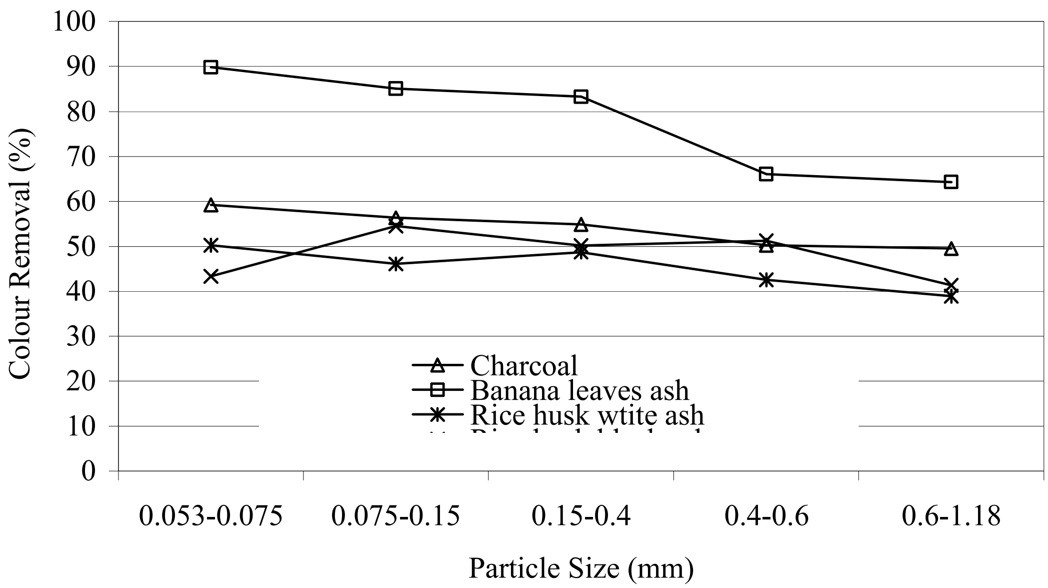

Figure 1: Removal of colour with locally available adsorbents

3.3 Effect of Adsorbent Dose

From the analysis of above graph it is observed that banana leaves is more effective for removal of color from methylene blue solution. Various experiments were conducted to determine the most effective dose at constant mixing time. The effect of adsorbent dose on the removal of color is shown in Table 3.

Table 3: Color removal for variation of doses

Adsorbent	Particle size	Color removal(%)				
		4mg/100ml	8mg/100ml	12mg/100ml	16mg/100ml	20mg/100ml
Banana	1	68.44	75.52	89.83	95.60	93.30
Leaves ash	2	65.40	80.73	85.07	91.40	78.93
	3	65.80	70.65	83.23	92.20	91.47
	4	51.90	55.42	66.05	79.66	81.40
	5	40.10	42.56	64.30	67.70	58.76

The results are graphically presented in Figure 2 for the better understanding of variations. It is observed that the removal of color per unit weight of adsorbent mostly increases with increasing adsorbent load. The percent removal increases from 40% to 96% with increasing adsorbent load limited from 4 mg/100ml to 16 mg/100ml. The percent removal decreases with increasing dose after 16 mg/100 ml. It is found that the reduction in color increases with an increase in dose of banana leaves ash and slightly decreasing with further increase in adsorbent dose except adsorbent with particle sizes of 0.4-0.6 mm.

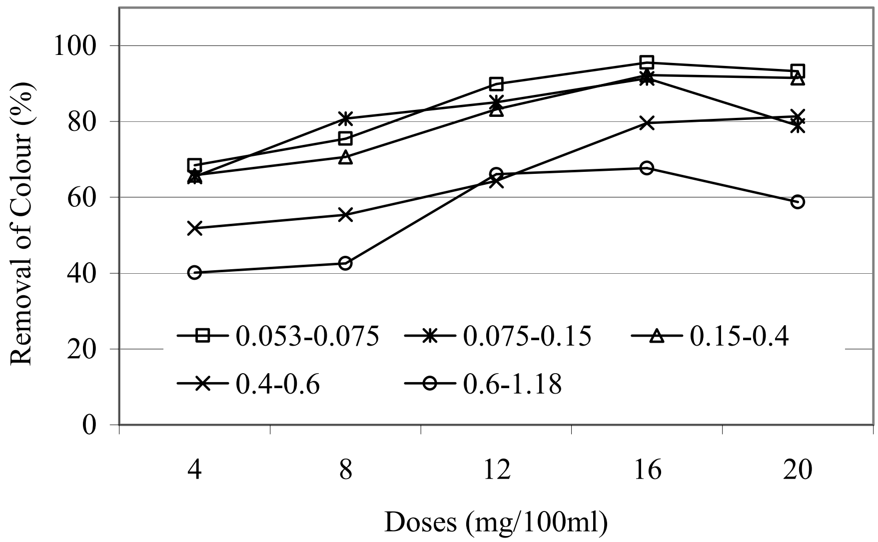

Figure 2: Color removal for banana leaves sample 1 (Particle size 0.053-0.075 mm)

3.4 Summary of Results

The experimental results show that banana leaves ash is most effective to use as adsorbent. The efficiency of color removal is higher at sample 1 having particle sizes of 0.053-0.075 mm. Therefore, the effective particle size of banana leaves ash for using as adsorbent is varying from 0.053-0.075 mm. For the maximum removal of color the required dose to be 16 mg/100 ml. However, the mixing time could also be varied to observe the effect of it which is considered constant in this experiment.

4. CONCLUSIONS

Based on the literature reviewed so far, it is evident that recently there has been an increase in production and utilization of dyes, resulting in an increase in environmental pollution. Dye wastewater effluents are major contributors to a variety of water pollution problems**.** Various techniques have been utilized in the removal of dyes. The adsorbent used in the present study have proved to be very efficient for removing coloring compounds from textile dyeing and printing industrial wastewater. The substrate raw materials employed are widely available and inexpensive. The color removal capacity of that adsorbent is appreciably good (95.6%). Thus, it can be concluded that, this banana leaves ash with particle size of 0.053 to 0.075 mm as alternative adsorbent seems to offer a very cheap and useful products for effective treatment of wastewater contaminated with methylene blue.

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REFERENCES

Ahn, D.H., W.S. Chang and T.I. Yoon. (1999). Dyestuff wastewater treatment using chemical oxidation, physical adsorption and fixed bed biofilmprocess. Process Biochem. 34: 429–439.

Alau, K.K., Gimba, C.E., Kagbu, J.A. (2010). "Removal of Dye from Aqueous Solution using Neem (Azadirachta Indica) Husk as Activated Carbon.: Archives of Applied Science Research, 2(5), 456-461.

Asfour, H.M., Fadali, O.A., Nassar, M.M., El-Geundi, M.S. (1985). "Equilibrium studies on adsorption of basic dyes on hardwood." Journal of Chemical Technology and Biotechnology, 35(1), 21-27.

Garg, V.K., Gupta, R., Yadav, A.B., Kumar, R., (2003). Dye removal from aqueous solution by adsorption on treated sawdust. Biore-source Technology 89(2), 121–124.

Guo, Y., Yang, S., Fu, W., Qi, J., Li, R., Wang, Z. (2003). “Adsorption of malachite green on micro and mesoporous rice husk based activated carbon.” Dyes and Pigments, 56(3), 219-229.

Kadirvelu, K., Kavipriya, M., Karthika, C., Radhika, M., Vennilamani, N., Pattabhi, S. (2003). “Utilization of various agricultural wastes for activated carbon preparation and application for the removal of dyes and metals ions from aqueous solutions.” Bioresource Technology, 87(1), 129-132.

Lin SH, Chen AL (1997) Treatment of textile waste water by chemical me-thods for reuse. Water Research 31, 868-876

Md. Niamul Bari, Mst. Sulekha Khatun, H. M. Rasel and Fatema Khatun (2014). Removal of Colour from Wastewater using Locally Available Charcoal. Proceedings of the 2nd International Conference on Civil Engineering for Sustainable Development (ICCESD-2014), 14~16 February 2014, KUET, Khulna, Bangladesh (ISBN: 978-984-33-6372-5).

Mohammed M.A., Shitu A. and Ibrahim A. (2014). Removal of Methylene Blue Using Low Cost Adsorbent: A Review. Res. J. Chem. Sci. Vol. 4(1), 91-102,

Muhammad Rauf, A., Shehadeh, I., Amal Ahmed, Ahmed Al-Zamly. (2009). “Removal of Methylene Blue from Aqueous Solution by using Gypsum as a Low Cost Adsorbent.” World Academy of Science, Engineering and technology, 55.

Namasivayam, C. and Kavitha, D. (2002). “Removal of Congo Red from water by adsorption on to activated carbon prepared from coir pith, an agricultural solid waste.” Dyes Pigments, 54(1), 47-58.

Namasivayam, C. and Yamuna, R.T. (1992a). “Removal of Rhodamine-B by biomass slurry from aqueous solution.” Water Air and Soil pollution, 65(1-2), 133-139.

Namasivayam, C. and Yamuna, R.T. (1992b). “Removal of Congo Red from aqueous solution by biomass slurry.” Journal of Chemical Technology and Biotechnology, 53(2), 153-157.

Namasivayam, C., and Kanchana, N. (1993a). “Removal of Congo red from aqeous solution by waste banana pith.” Journal of Science and Technology, 1(1), 33-42.

Namasivayam, C., Dinesh Kumar, M., Selvi, K., Ashruffunissa Begum, R., T. Vanathi, T., Yamuna, R.T. (2001b). “Waste coir pith-a potential biomass for the treatment of dyeing wastewaters.” Biomass and Bioenergy, 21(6), 477-483.

Namasivayam, C., Kanchana, N., Yamuna, R.C. (1993b). “Waste banana pith as adsorbent for the removal of Rhodamine-B from aqueous solution.” Waste Management, 13(1), 89-95.

Namasivayam, C., Radhika, R., Subba, S. (2001a). “Uptake of dyes by a promising locally available agricultural solid waste: coir pith.” Waste Management, 21(4), 381-387.

Papita Saha, (2010). “Assessmentonthe Removal of Methylene Blue Dye using Tamarind Fruit Shell as Biosorbent.” SpringerScience+BusinessMediaB.V., 213, 287–299.

Rajeshwarisivaraj, Subburam, V. 2002. “Activated parthenium carbon as an adsorbent for the removal of syes and heavy metal ions from aqueous solution.” Bioresource Technology, 85(2), 205-206.

Rasheed Khan, A., Hajira Tahir., Fahim,U. and Uzma, H. (2005). “Adsorptionof Methylene Blue from aqueous Solutiononthe Surface of Wool Fiber and Cotton Fiber.” Journal of Applied Science and Environment Management ,9(2),29 –35.

Rauf M.A., Shehadeh I., Ahmed A. and Al-zamly A., Removal of Methylene Blue from Aqueous Solution by Using Gypsum as a Low Cost Adsorbent, World Acad. Sci. Eng. Technol., 31,604–609 (2009)

Singh, D.K., Srivastava, N. (2001). “basic dye removal from wastewater by adsorption on rice husk carbon.” Indian Journal of Chemical Technology, 8(2), 133-139.

Suteu, D., Zaharia, C., Muresan, A., Muresan, R., and Popescu, A. (2009). “Using of industrial waste materials for textile wastewater treatment,”Environ. Eng. Manage. J.8(5), 1097-1102.

Zaharia, C.; Suteu, D.; Muresan, A.; Muresan, R. & Popescu, A. (2009). Textile wastewater treatment by homogenous oxidation with hydrogen peroxide. Environmental Engineering and Management Journal, Vol.8, No.6, pp.1359-1369