Pak. J. Sci. Ind. Res. 2008 **51**(1) 19-23

Peanut Hull as Biosorbent for Removal of Reactive, Acid and Disperse Dyes from Aqueous Solutions

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(received July 3, 2007; revised January 31, 2008; accepted February 7, 2008)

Abstract. In the investigations on peanut hull as a low cost locally available biosorbent for the potential to remove reactive, acid and disperse dyes from aqueous solutions, the acid treated peanut hulls exhibited maximum adsorption efficiency as biosorbent.

Keywords: peanut hull, biosorbent, dye removal, textile dyes

Introduction

Textile factories use various types of dyes. Presently there are more than 10,000 dyes available commercially (Nigam *et al.*, 2000), most of which are difficult to biodegrade due to their complex aromatic molecular structure and synthetic origin (Seshadri *et al.*, 1994). The extensive use of dyes often poses pollution problems in the form of coloured wastewater discharged into the surrounding water. This wastewater contains a variety of organic compounds and toxic substances, which are harmful to fish and other aquatic organisms (Ramakrishna and Viraraghavan, 1996). Such wastewater when get mixed with normal water makes it unacceptable for human consumption. Even small quantity of dye can colour large water bodies, which not only affects esthetics but also reduces light penetration and photosynthesis. Some dyes are even toxic or mutagenic or carcinogenic (Chen *et al.*, 2003). Thus it is desirable to eliminate dyes from textile wastewater before its disposal.

There are many methods of colour removal from textile wastewater which include coagulation and floccation (Panswed and Wongchaisuwan, 1986), oxidation or ozonation (Malik and Saha, 2003; Koch *et al.*, 2002) membrane separation (Ciarderlli *et al.*, 2000) and active carbon sorption (Venkata and Sastray, 1987). Although these methods are highly efficient, they are uneconomical. Thus there is a growing need for some low cost and renewable, locally available materials that can remove dye colours. Some of the low cost agricultural by-products, that have been investigated, include orange peel (Namasivayam *et al.*, 1996), cassava peel (Rajeshwarisivaraj *et al.*, 2001), banana pith (Namasivayam *et al.*, 1998), plum kernels (Juang *et al.*, 2000) apple pomace, wheat straw (Robinson *et al.*, 2002), cotton waste, rice husk, teakwood bark (Mckay *et al.*,1986), sawdust (Garg *et al.*, 2003), bagasse pith, maize cob (Nassar and El-Geundi, 1991) palm fruit bunch (Nassar *et al.*, 1995) etc.

Peanut hull is a low cost agricultural waste residue that is easily available in large quantities. The purpose of this work is to investigate the possibility of using peanut hulls as biosorbent for the removal from aqueous solutions of acid, reactive and disperse dyes which are extensively used by textile units for dyeing cotton, rayon, wool, silk and jute fibres.

Materials and Methods

Dyes. The dyes selected for the study were reactive yellow 1 (RYI), acid orange 2 (AO2) and disperse orange 25 (DO25). The Society of Dyers and Colourists (SDC) has given specific numbers to the dyes. For each dye the number is unique and is called Colour Index Number (C.I.No.). Properties of the dyes used in the present study with their C.I. Nos. and structures are given in Table 1, Fig. 1.

Preparation of peanut hull sorbent. The peanut hull was obtained from local market. The collected biomaterial was extensively washed with tap water to remove soil and dust, sprayed with distilled water and then dried at 80 °C in a hot air convection oven (Memmert-Germany) to a constant weight. Dry biomass was crushed into powder, sieved and preserved in a desiccator for use.

Treatment of crushed peanut hulls. The sieved powder was divided into three parts and given one of the following three different treatments:

1. Powder + distilled water (PH_W)
2. Powder + 37% formaldehyde + 0.2 N sulphuric acid (ratio 1:20) (PH_A)
3. Powder + 0.1 sodium hydroxide (PH_B)

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Table 1. Description of dyes used in the study

Type of dyes	C. I. No.	Formula weight	λ_{max}(nm)
Reactive yellow 1 (anionic azo dye)	18971	744	415
Acid orange 2 (anionic azo dye)	15510	328	486
Disperse orange 25	11227	323	492

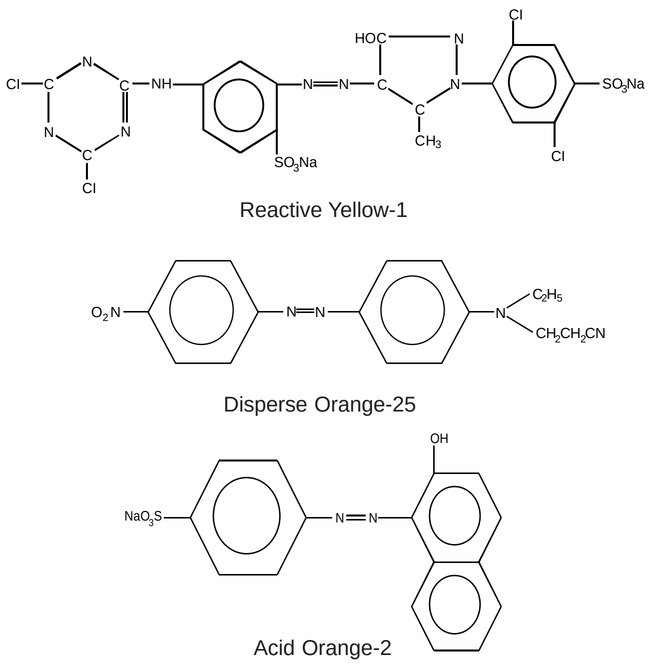

Fig. 1. Structures of dyes used in the study.

The treated samples were filtered and rinsed with distilled water until the pH remained constant at 6-8. The treated material was dried again at 80 °C for 12 h, sealed in plastic bags and stored in desiccator.

Preparation of dye solutions and standard curve. Different initial concentrations of each dye i.e. reactive yellow I (RY-1), acid orange 2 (AO-2) and disperse orange 25 (DO-25) (from 5 ppm-30 ppm) were prepared and their absorbance were noted at their respective lambda max (λ_{max}), (415 nm for RY-1, 486 nm for AO-2 and 492 nm for DO-25) using Unicam Helios Alpha Spectrophotometer (Model Helios α 9423 Spectronic Unicam). The absorbance vs concentration were plotted at the corresponding λ_{max} of each dye. Absorbance obtained against different concentrations of dyes is shown in Table 2.

Table 2. Concentration of dyes and absorbance

Concentration (ppm)	Absorbance		
	RY-1 415 nm	AO-2 486 nm	DO-25 492 nm
5	0.117	0.15	0.044
10	0.234	0.312	0.083
15	0.339	0.455	0.113
20	0.461	0.612	0.144
25	0.571	0.742	0.170
30	0.688	0.902	0.209

Treatment of dyes with peanut hull. Three types of treated peanut hull were used to absorb different dyes. For each type of treated peanut hull and each dye tested, four flasks were used: three contained treated peanut hull and 150 ml of 5 ppm dye solution, and the fourth was control which contained only dye solution. All flasks were shaken at the room temperature at 140 rpm on orbital shaker for 12 h. Six ml of the dye solutions were collected from each flask for assay using a 10 ml syringe. All samples were centrifuged (3000 Centurion, Scientific Ltd.) and the absorbance was measured. Similar process was applied to dye concentrations of 10, 15, 20, 25 and 30 ppm.

Determination of sorption. The concentration of each dye was determined before and after each treatment by measuring absorbance at its respective λ_{max} using spectrophotometer, with the help of calibration curve. The amount of each dye sorbed by the biomass was calculated by the difference in the initial dye concentration (Ci) and the final dye concentration (Ce) in the solution after treatment. The percentage sorption by each type of biomass was calculated as follows:

$$\text{Sorption (\%)} = \frac{Ci - Ce}{Ci} \times 100$$

Results and Discussion

On treating, three types of treated peanut hulls (PH_A, PH_B and PH_W) with the dye reactive yellow 1, it was revealed that among the three biosorbents, the acid treated peanut hull (PH_A) had the highest dye removal efficiency for reactive yellow 1 in dilute solutions, (Table 3, Fig. 2).

The results for the other two dyes i.e. AO-2 and DO-25 are shown in Table 4 and 5 and corresponding Fig. 3 and 4, respectively The results reveal that among the three types of treated biosorbents (PH_A, PH_B and PH_W), the acid treated

Table 3. Sorption of reactive yellow by the treated peanut hull

Ci (ppm)	Absorb before treatment	Absorb. after treatment			Ce (ppm)			% sorption: $\frac{Ci - Ce}{Ci}$ x 100		
		PH_A	PH_B	PH_W	PH_A	PH_B	PH_W	PH_A	PH_B	PH_W
5	0.117	0.098	0.117	0.117	4.19	4.99	4.99	16.19	0.23	0.18
10	0.234	0.192	0.232	0.233	8.20	9.92	9.95	18.11	0.85	0.51
15	0.339	0.271	0.335	0.335	12.01	14.82	14.86	19.92	1.2	0.92
20	0.461	0.368	0.454	0.453	15.98	19.7	19.69	20.11	1.51	1.81
25	0.571	0.450	0.450	0.562	19.7	24.7	24.6	21.29	1.29	1.62
30	0.688	0.521	0.679	0.604	22.7	29.6	29.3	24.22	1.34	2.26

Ci = initial dye concentration (ppm); Ce = equilibrium dye concentration (ppm) in liquid phase

Table 4. Sorption of acid orange dy by peanut hull

Ci (ppm)	Absorb. before treatment	Absorb. after treatment			Ce (ppm)			% sorption: $\frac{Ci - Ce}{Ci}$ x 100		
		PH_A	PH_B	PH_W	PH_A	PH_B	PH_W	PH_A	PH_B	PH_W
5	0.15	0.047	0.146	0.124	1.56	4.85	4.14	68.81	3.00	17.10
210	0.312	0.096	0.302	0.258	3.07	9.68	8.27	69.23	3.24	17.21
15	0.455	0.139	0.437	0.373	4.48	14.40	12.29	70.11	3.88	18.11
20	0.612	0.166	0.581	0.610	5.43	19.00	16.15	72.83	4.53	19.21
25	0.742	0.172	0.696	0.592	5.79	23.44	19.94	76.81	6.23	20.21
30	0.902	0.198	0.828	0.770	6.57	27.54	23.15	78.11	8.19	22.82

Ci = initial dye concentration (ppm); Ce = equilibrium dye concentration (ppm) in liquid phase

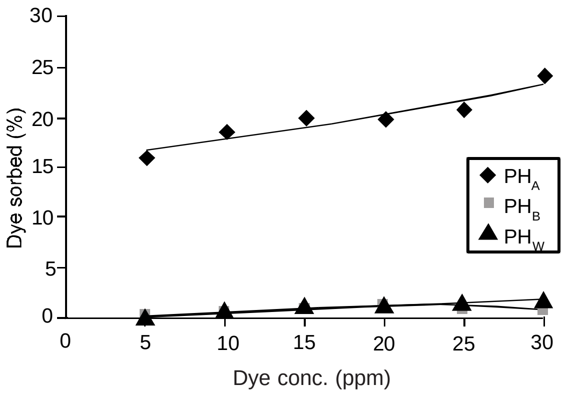

Fig. 2. Sorption of reactive yellow on treated peanut hull.

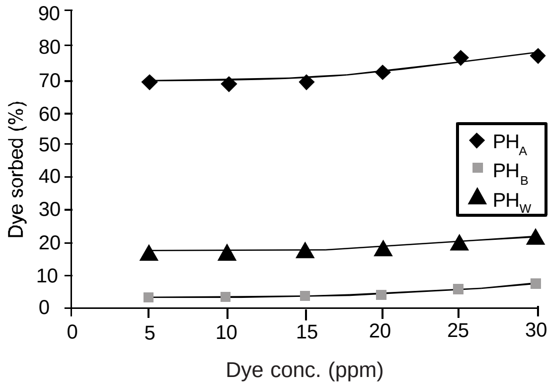

Fig. 3. Sorption of acid orange on treated peanut hull.

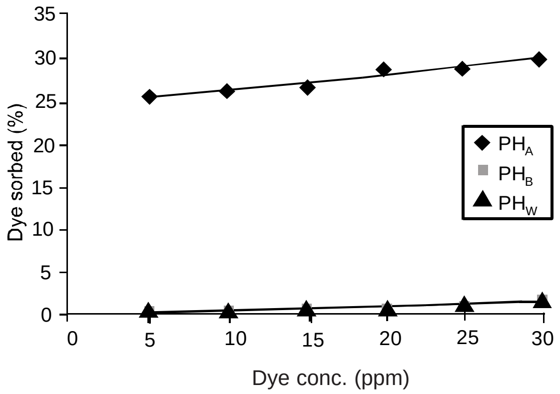

Fig. 4. Sorption of disperse orange 25 on treated peanut hull.

peanut hull (PH_A) had the highest dye removal efficiency for the other two dyes used in this study, as well.

Conclusion

In the study on determination of the potential of low-cost biosorbents for removing dyes from aqueous solutions, the sorption efficiency of peanut hull was increased by three types of treatment i.e., acid, base and water. The acid treated peanut hulls showed maximum dye removal efficiency. Peanut hull is an economicaly and easily available biosorbent which has

Table 5. Sorption of disperse orange 25 by peanut hull

Ci (ppm)	Absorb. before treatment	Absorb. after treatment			Ce (ppm)			% sorption: $\frac{Ci - Ce}{Ci} \times 100$		
		PH_A	PH_B	PH_W	PH_A	PH_B	PH_W	PH_A	PH_B	PH_W
5	0.044	0.034	0.044	0.044	3.88	4.98	4.99	22.41	0.28	0.11
10	0.083	0.064	0.083	0.083	7.75	9.97	9.98	22.49	0.29	0.13
15	0.113	0.087	0.113	0.113	11.62	14.95	14.98	22.51	0.30	0.13
20	0.144	0.111	0.193	0.143	15.46	19.94	19.97	22.67	0.30	0.14
25	0.170	0.131	0.169	0.169	19.28	24.92	24.97	22.88	0.30	0.15
30	0.209	0.157	0.208	0.208	22.85	29.82	29.91	24.82	0.61	0.31

Ci = initial dye concentration (ppm); Ce = equilibrium dye concentration (ppm) in liquid phase

been found to be the most effective adsorbent for the removal of dyes and phenols from their aqueous solutions.

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