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Adsorption of Basic Red 2 onto Peanut Shell: Batch and Column Studies

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In this study, peanut shell was utilized as an adsorbent for the adsorption of basic red 2 from aqueous solution. Adsorption experiments were performed as a function of contact time, initial dye concentration, temperature and pH. While the amount of the dye adsorbed onto peanut shell was increasing with increasing contact time, initial dye concentration, it decreased with increasing solution temperature. The most adsorption was observed at pH 5. The maximum adsorptions were between 84.70 and 98.86 % under all the experimental conditions studied such as concentration, pH and temperature. Equilibrium data was consistent with Freundlich isotherm. Adsorption kinetic was in the best agreement with the pseudo-second order model. Furthermore, SEM and FT-IR studies of peanut shell were performed and the results obtained were interpreted. Column adsorption studies were also done. The percentages of basic red 2 adsorbed in column were more than 99 %.

Key Words: Adsorption, Peanut shell, Basic red 2, Isotherm, Kinetics, Column, FTIR, SEM.

INTRODUCTION

Dyes are produced nearly 7×10^5 tons over the world[1] and there are approximately 100 thousand kinds of commercial dyes. Dyes are used commonly in various industries such as textile, dying, food and cosmetic. These dyes are used excessively in textile industry, having toxic and carcinogenic effects. So, before the coloured wastewaters from the industries are released to aquatic environments, it should be required to remove the dyes in wastewaters. For this reason, a lot of methods such as activated carbon adsorption, chemical coagulation, ion exchange, electrolysis, biological treatments, *etc*., have been developed[2,3]. Of these methods, activated carbon adsorption is highly effective for the removal of organic, inorganic and dye pollution from industrial effluents. However, the use of activated carbon is not suitable for developing countries because of its high cost. A large number of low-cost adsorbents such as peat[4], fly ash[5], perlite[6,7], *etc*. have been treated for dye removal. Some researchers have also extensively studied the removal of dyes by various lignocellulosic biomass such as wood[8], orange peel[9], rice husk[10], coir pith[11], sawdust[12],

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recently. For example, Asfour *et al*.[12] have studied the adsorption of basic dye astrazone blue FRR 69 on hardwood (beech) sawdust. Annadurai *et al*.[13] have studied the adsorption of various dyes onto cellulose-based wastes. Liversidge *et al.*[14] have studied the removal of dye basic blue 41 by linseed cake. In this work, the use of peanut shells, low-cost lignocellulosic agriculture wastes, is thought for the adsorption of basic red 2 from aqueous solution.

The amounts of peanut plant produced in the world are 18.54 million tons as an average. The amounts produced in Turkey are 70 thousand tons and the 95 % of peanut grows in the Mediterranean region of Turkey. The shells of peanut plant consist of 35 % of peanut. Hence, the potential amounts of peanut shell are approximately 6.49 million tons over the world and the amounts produced in Turkey are nearly 24.50 thousand tons[15]. Peanut shells are ligno-cellulosic materials with low density which is an agricultural waste. It is known that peanut shells are used in a few fields before. For example, peanut shells are used as fertilizer in the agriculture and as filler for the production of light cement as well as energy[16]. Moreover, they are utilized as a strengthening agent in producing of thermoplastic composite materials and as additive material in the producing of plastic plaque[16]. Furthermore, it was seen that peanut shell has also been used as adsorbent for the adsorption of some dyes and metal ions in literature[17,18]. For instance, the modified peanut shells have been used as a biosorbent for the adsorption of cadmium(II), copper(II), lead(II), nickel(II) and zinc(II) ions[17] and for the adsorption of some cationic and anionic dyes[18].

No work on the adsorption of basic red 2 onto the peanut shell has been done in the literature, so far. Therefore, in this work, peanut shell was used as an adsorbent for the adsorption of basic red 2 from aqueous solution. The effects of contact time, initial dye concentration, solution pH and temperature on adsorption were investigated by using batch and column system. Moreover, the isotherm and kinetic studies of the adsorption process were performed.

EXPERIMENTAL

Peanut shell was provided from Osmaniye province located in the east Mediterranean region of Turkey. It was washed to remove soil and dust and then dried in an oven. Dry peanut shell was crushed into powder. The powdered peanut shell was sieved through a molecular sieve of 100 mesh (Retsch AS-200). Then, it was used as an adsorbent for batch and column adsorption studies without any pretreatment. Elemental analysis of peanut shell was done on a LECO CHNS-932 analyzer and the results obtained were given in Table-1. Moreover, the chemical components[19] of peanut shell are listed in Table-2.

Preparation of dye solutions: Basic red 2 was provided from dystar and it was used as received without further purification. The chemical structure of the dye is shown in Fig. 1 and its physicochemical characteristic is also given in Table-3. The stock solutions of 500-1000 mg/L of basic red 2 were prepared with distilled

TABLE-1
ELEMENTAL ANALYSIS OF PEANUT SHELL

Component	(%)
C	41.530
H	5.551
N	2.126
S	0.245

TABLE-2
CHEMICAL COMPONENTS OF PEANUT SHELL

Component	(%)
Lignin	32.80
Cellulose	45.30
Hemicellulose	8.10
Protein	4.90
Ash	2.30

TABLE-3
PHYSICOCHEMICAL CHARACTERISTICS OF BASIC RED 2

C.I. name	Basic red 2
C.I. number	50240
Common name	Basic red 2
Other name	Safranin O
Class	Safranin
Ionization	Basic
Aqueous solubility (%)	5.45
Colour	Red
Absorption maximum (nm)	517
Chemical formula	$C_{20}H_{19}N_4Cl$
Formula weight (g/mol)	350.85

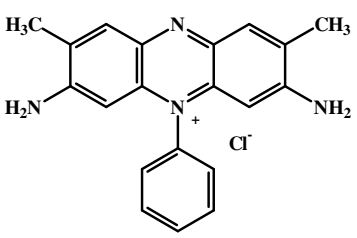

Fig. 1. Structure of basic red 2

water and then they were diluted to the desired concentrations. The pH of the solutions was adjusted with 0.1 N NaOH and HCl solutions using a pH meter (Elmetron pH meter).

Batch adsorption studies: Batch adsorption experiments were performed using 0.25 g of the peanut shell with 50 mL of dye solution in 250 mL Erlenmeyer flasks as functions of concentration, temperature and pH. The samples were shaken

in a temperature-controlled shaking water bath at 130 rpm. After the desired contact time, the samples were taken from shaking bath and they were centrifuged at 5000 rpm for 5 min. Concentrations of dye remained in supernatant were determined using T80 UV/vis spectrometer at a wavelength of 517 nm which is maximum absorbance. The amounts of basic red 2 adsorbed were calculated using the following equation:

$$q_e = (C_0 - C_e)V/W \quad (1)$$

where C_0 is the initial dye concentration of dye (in mg/L), C_e is the concentration of dye remained in solution at equilibrium time (in mg/L), W is the mass of adsorbent (g) and V is the volume of solution (L).

Column adsorption: Column with a diameter of 1 cm and a length of 15 cm was used for continuous adsorption system. Peanut shell particles (dry weight 2 g) were packed between two layers of glass wool in column. Dye solutions with desired concentrations were fed through the top of the column. The flow rate of feed solutions was regulated as 0.35 mL/min (21 mL/h). The system was operated at room temperature (*ca.* 23 °C) and pH 5. The operating conditions are summarized in Table-4. The dye samples passed through column were collected from the bottom of column at specific times. The concentrations of dye unadsorbed within samples in the outlet of the column were determined as described as before.

TABLE-4
COLUMN OPERATING CONDITIONS

Column diameter (cm)	1
Column length (cm)	15
Height of bed (cm)	10
Packing size (mesh)	100
Flow rate (mL/h)	21
Concentration (mg/L)	0-150
Temperature (ºC)	23
pH of solution	5

FT-IR measurements: Peanut shell and dye-impregnated peanut shell samples after adsorption were first dried to the constant weight in an oven at 60 °C for 12 h. Afterward, 1 mg of the dried samples was mixed with 100 mg of KBr to make pellet. The infrared spectra of the pellets were recorded in the wave number range of 4000-650 cm^{-1} using a Perkin Elmer FT-IR spectrometer.

RESULTS AND DISCUSSION

Effect of contact time on adsorption: The effect of contact time on the amount of basic red 2 adsorbed by peanut shell was investigated under all the experiment conditions such as concentration, temperature and pH. A very rapid adsorption occurs between 1-5 min and thereafter the gradual increase in adsorption maintains for 45 min. With the further increment in the time, the amount of dye adsorbed

does not change and even from time to time, very small decreases in the amount of the dye adsorbed are observed, indicating desorption. Therefore, the time of 45 min is accepted as the optimum contact time (equilibrium time) under all conditions studied. A similar result has also been recorded for the adsorption of basic red 2 on bentonite in a work done by Hu *et al.*[20].

Effect of pH on adsorption: The initial pH values of dye solutions affect both the chemistry of a dye molecule and an adsorbent. Herein, to investigate the effect of pH on the adsorption of basic red 2 from aqueous solution by peanut shell, the pHs of initial solution were selected as 3, 5, 7 and 9. For the initial concentration of 75 mg/L at 20 °C, the relationship between the amounts of basic red 2 adsorbed at equilibrium time and the initial solution pH is shown in Fig. 2. As shown in Fig. 2, a very rapid adsorption takes place for the 1st min, at all the pHs and thereafter the gradual increase in adsorption prosecutes up to 45 min, maximum adsorption time. The lowest adsorption occurs at pH 3 and the most adsorption occurs at pH 5. The adsorption values obtained at pH 7 and 9 line between the findings of pH 3 and 5. At pH 3, the adsorption is 13.76 mg/g (91.77 %) and 14.184 mg/g (94.56 %) at 1 min and 45 min, respectively. At pH 5, the adsorption is 14.256 mg/g (95.04 %) and 14.632 mg/g (97.54 %) at 1 and 45 min, respectively. If the values of the adsorption are looked carefully, it is seen that there is approximately 3 % difference between 1 min and 45 min and there is the same difference between the values of maximum adsorption at pH 3 and 5, also. Therefore, the values of adsorption at all the pHs is very closed to each other and the effect of pH on adsorption is less. On the other hand, the fact that a very high adsorption (between 91.77 and 97.54 %) occurs for the 1st min at all the pHs indicates a very high affinity by means of electrostatic interaction between carboxyl groups on the surface of peanut shell and positively charged basic red 2 molecules. Moreover, it is seen that the red colour of basic red 2 turns to colourless within contact time of 1-5 min. This situation indicates also a very high affinity between peanut shell and basic red 2 molecules.

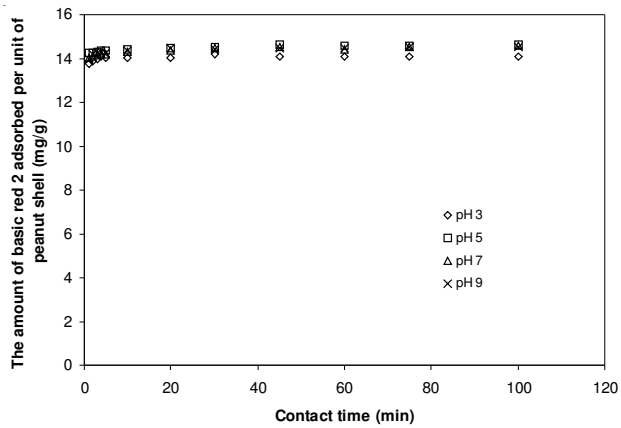

Fig. 2. Effect of initial solution pH on adsorption of basic red 2 by peanut shell

The fact that the most adsorption occurs at pH 5 may be attributed to different ionization degree of the dye basic red 2 at different pHs. Similar results have been recorded for the adsorption of acid blue 25 and direct red 81 onto betacylodextrin polymer by Crini[21]. Therefore, further experiments are performed at pH 5.

Effect of initial dye concentration on adsorption: Effect of initial dye concentration on adsorption was studied at six different concentrations of 10, 20, 50, 75, 100 and 150 mg/L at 20 °C and pH 5. Fig. 3 illustrates the effect of initial dye concentration on the adsorption of basic red 2 by peanut shell. As shown in Fig. 3, a rapid adsorption occurs within the contact time of 1-5 min for all concentrations as in pH effect and thereafter the gradual increase in adsorption maintains to 45 min. While the amounts of basic red 2 adsorbed onto peanut shell are 1.98 mg/g (99.04 %) and 3.671 mg/g (91.78 %) for the concentrations of 10 and 20 mg/L at 1 min, the maximum adsorption is found to be 1.997 mg/g (99.86 %) and 3.997 mg/g (99.31 %) at 10 min, respectively. For the concentrations of 50, 75, 100 and 150 mg/L, while the amounts of basic red 2 adsorbed onto peanut shell are 8.33 mg/g (85.88 %), 12.71 mg/g (84.70 %), 18.22 mg/g (87.41 %), 26.11 mg/g (89.00 %) at 1 min, the maximum adsorption is found to be 9.632 mg/g (99.32 %), 14.588 mg/g (97.25 %), 19.903 mg/g (95.51 %), 27.924 mg/g (93.03 %) at 45 min, respectively. Here, it is seen that the adsorption equilibrium is reached in the shorter time for the low concentrations of dye and in the longer time for the higher concentrations of dye (for the initial concentrations of 10 and 20 mg/L, equilibrium time is 10 min; for the initial concentrations of 50, 75, 100 and 150 mg/L, equilibrium time is 45 min). With increasing initial dye concentration from 10-150 mg/L, while the maximum amount (the amount at equilibrium time) of basic red 2 adsorbed onto peanut shell increases, the per cent adsorption decreases. Similar results have also been recorded for the adsorption of safranin-T by activated carbon and activated rice husks[22].

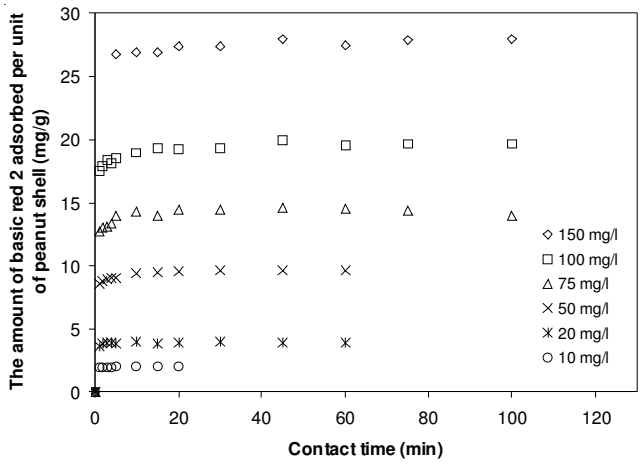

Fig. 3. Effect of initial concentration on adsorption of basic red 2 by peanut shell

Effect of temperature on adsorption: The effect of temperature on adsorption was studied at the temperatures of 20, 30, 40, 50 and 60 °C. The results obtained are illustrated in Fig. 4. As shown in the figure, a rapid adsorption is observed for the 1st min as seen in pH and concentration effects and then the gradual increase in adsorption is continued up to 45 min. While the highest adsorption occurs at 20 °C, the lowest adsorption is resulted at 60 °C. For example, for the initial concentration of 75 mg/L at 20 °C, while the highest adsorption is 14.256 mg/g (95.04 %) at 1 min, the maximum adsorption is 14.632 mg/g (97.54 %) at 45 min. At 60 °C, while the lowest adsorption is 13.80 mg/g (92.02 %) at 1 min, the maximum adsorption is 14.39 mg/g (95.74 %) at 45 min. The fact that the adsorption is the most at low temperature indicates exothermic process. However, the maximum amounts of basic red 2 adsorbed among 20 and 60 °C are highly closed to each other and the temperature has a very small effect on adsorption.

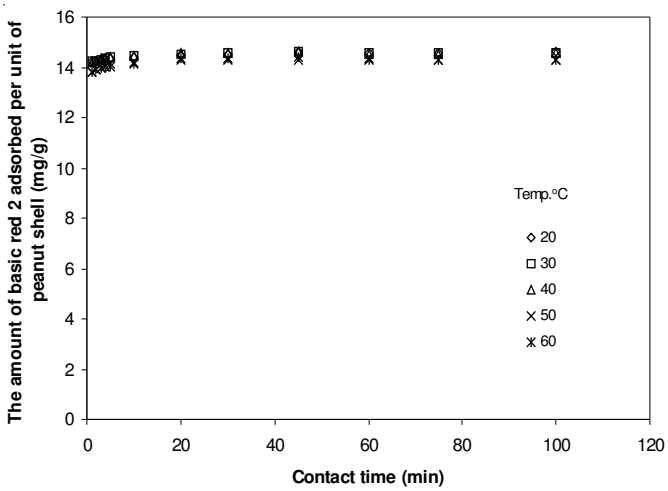

Fig. 4. Effect of solution temperature on adsorption of basic red 2 by peanut shell

Adsorption isotherms: The adsorption equilibrium data were fitted to Langmuir and Freundlich isotherms. The isotherm results indicate that the adsorption of basic red 2 onto peanut shell is consistent with the Freundlich model. Freundlich adsorption isotherm can be expressed as follows:

$$\ln q_e = \ln k + 1/n \ln C_e \quad (2)$$

where q_e is the amount of dye adsorbed at equilibrium time (mg/g), C_e is the equilibrium concentration of the dye in solution (mg/L). k and n are isotherm constants which indicate the capacity and intensity of the adsorption, respectively.

Fig. 5 shows the plot of ln q_e against ln C_e at 20 °C and pH 5. The plots are in harmony with Freundlich model with a correlation coefficient of 0.81. The values of k and n were calculated from the intercept and slope of the plot of ln q_e *versus* ln C_e, respectively. These constants (k and n) obtained from Freundlich isotherms are

found to be 7.089 mg/g and 1.443 g/L, respectively. Here, the value of n is higher than 1. The fact that the value of n obtained according to eqn. 2 are between 1 and 10 indicates that adsorption is favorable[11]. Similar results have been recorded for the adsorption of crystal violet on zeolite MCM-22[23], for removal of various dyes from aqueous solutions by cellulosic waste orange peel[9].

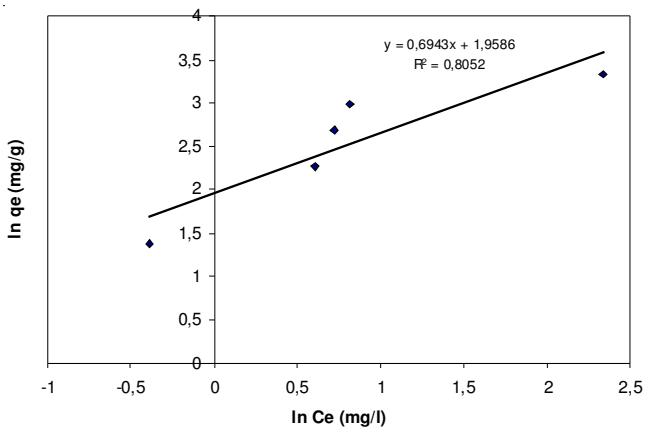

Fig. 5. Freundlich isotherm of adsorption of basic red 2 by peanut shell

On the other hand, a harmony with Langmuir isotherm has not been observed. The fact that the adsorption obey only Freundlich isotherm suggests that the surface of the peanut shell has some heterogeneity and adsorption is local. This situation is attributed to the fact that that various active sites on peanut shell has different affinities to basic red 2 molecules.

The SEM photographs of peanut shell (Figs. 6a and 6b) show SEM images before and after adsorption of peanut shell respectively. It is evident from Fig. 6a that the pores within the particles of the peanut shell are highly heterogeneous. After dye adsorption, the particles are remarkably covered by dye basic red 2 molecules, indicating a local adsorption due to heterogeneous surfaces. Furthermore, as noticed in the Fig. 6b, it can be suggested that dye basic red 2 molecules penetrate to the pores of the peanut shell, also. This situation is confirmed by intra-particle kinetic model, also.

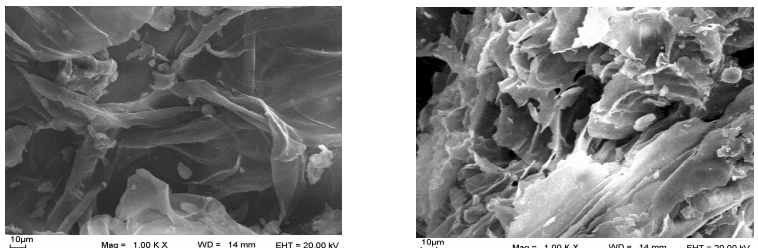

Fig. 6. SEM photographs of peanut shell: (a) before adsorption; (b) after adsorption

Adsorption kinetics: Several models have been proposed to express the adsorption mechanism of solute molecules onto an adsorbent: (a) Pseudo-first order kinetic model, (b) pseudo-second order kinetic model and (c) intra-particle diffusion model.

A pseudo-first order kinetic model of Lagergren[24] is given as

$$\log(q_e - q_t) = \log q_e - \frac{k_1}{2.303}t \quad (3)$$

a pseudo-second order kinetic model of Ho is as follows[4,8]:

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e}t \quad (4)$$

and an intra-particle diffusion model of Weber and Morris[25,26] is shown as

$$q_t = k_i \cdot t^{1/2} + C \quad (5)$$

where, k_1 is rate constant for pseudo-first-order model, k_2 is rate constant for pseudo-second-order model and k_i is intra-particle diffusion rate constant. Moreover, a constant value, C, for intra-particle diffusion in eqn. 5 has been described by Kannan and Sundaram. C is boundary layer thickness between adsorbate and adsorbent. q_e and q_t are the amount adsorbed of solute per unit adsorbent at equilibrium and any time, respectively. In eqn. 4, the initial adsorption rate is $h = k_2 q_e^2$.

The adsorption of basic red 2 on peanut shell in the present study was investigated in terms of the above-mentioned kinetics models for understanding the adsorption kinetics.

Firstly, the plots of log (q_e - q_t) *versus* t for the pseudo-first-order model given in eqn. 3 are drawn for all initial concentrations at 20 °C and pH 5. The plots obtained for the pseudo first-order kinetic models are demonstrated in Fig. 7. From linear regression analysis obtained, it is determined that the values of correlation coefficients, r^2, obtained are 0.911, 0.405, 0.989, 0.849, 0.787 and 0.819 for the initial concentrations of 10, 20, 50, 75, 100 and 150 mg/L, respectively.

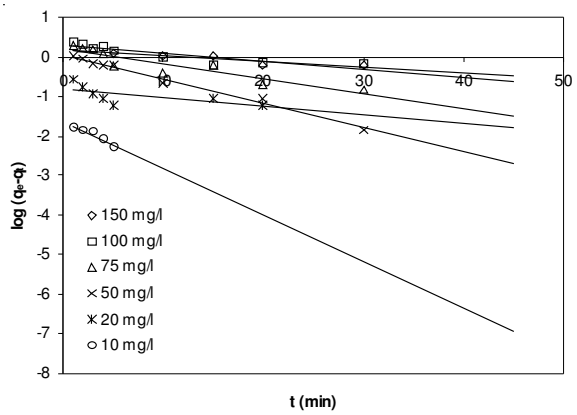

Fig. 7. Pseudo first-order kinetics of basic red 2 adsorption on peanut shell at diffrent concentration

Secondly, the linear plots of t/q_t against t for the pseudo-second-order model in eqn. 4 were obtained for all initial concentrations at 20 °C and pH 5. The plots obtained for the second order models are shown in Fig. 8. The values of r^2 obtained from the linear plots of t/q_t *versus* t are found to be 1, 0.9998, 0.9999, 0.9999, 0.9996 and 0.9998 for the initial concentrations of 10, 20, 50, 75, 100 and 150 mg/L, respectively. Correlation coefficients from the pseudo-second-order models have very high values. Correlation coefficients (r^2) obtained from the pseudo-first-order is low. Moreover, the values of q_e from pseudo-first order kinetics model is not in agreement with experimental data, q_e (exp), but the values of q_e from the pseudo-second order kinetic model are in harmony with experimental data, q_e (exp) (Table-5). Therefore the adsorption obeys the pseudo-second order kinetics. This situation may be attributed to a chemical activation between basic red 2 molecules with the functional groups of peanut shell.

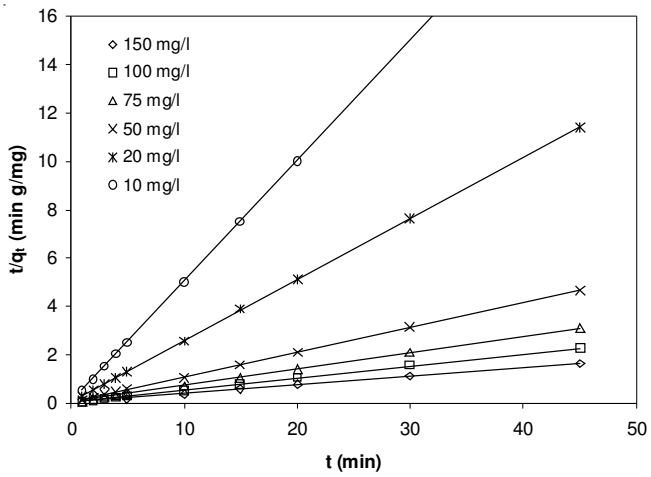

Fig. 8. Pseudo second-order kinetics of basic red 2 adsorption on peanut shell at different concentrations

Finally, due to mass transfer effects, the plots of q_t *versus* $t^{1/2}$ for intra-particle diffusion model given in eqn. 5 were obtained for all initial dye concentrations at 20 °C and pH 5. The plots for intra-particle diffusion model are demonstrated in Fig. 9. The values of r^2 obtained from the plots in the figure were found to be 0.8699, 0.6401, 0.8616, 0.7963, 0.9001 and 0.9262 for the initial concentrations of 10, 20, 50, 75, 100 and 150 mg/L, respectively. According to the value of r^2, it may be understood that the diffusion of basic red 2 occurs partially within the pores of the peanut shell. And therefore, the intra-particle diffusion of basic red 2 within the particles of the peanut shell is found to be rate controlling in the adsorption process as well as pseudo-second order kinetics. Furthermore, the values of boundary layer thickness between peanut shell and basic red 2 molecules, C, increase with increasing initial concentration from 10 to 150 mg/L. For example, while the value C is 1.9773

for the initial concentration of 10 mg/L, it is 26.038 for the initial concentration of 150 mg/L (Table-5). A similar result has been recorded for the adsorption of methyl violet by perlite[2].

TABLE -5
KINETIC PARAMETERS FOR BASIC RED 2 ADSORPTION BY PEANUT SHELL AT DIFFERENT INITIAL DYE CONCENTRATION

C_o [a]	q_e [b]	q_2 [c]	k_2 [d]	h [e]	r_2^2 [f]	q_1 [g]	k_1 [h]	r_1^2 [i]	k_i [j]	C [k]	r_i [l]
10	1.97	1.99	30.880	122.28	1.0000	0.024	0.2708	0.911	0.0052	1.9773	0.8699
20	3.94	3.92	3.090	47.48	0.9998	0.149	0.0488	0.405	0.0345	3.7658	0.6401
50	9.63	9.69	0.473	44.41	0.9999	1.210	0.1407	0.989	0.1845	8.6084	0.8616
75	14.58	14.64	0.209	44.79	0.9999	1.549	0.0861	0.849	0.3180	12.760	0.7963
100	19.90	19.84	0.137	53.92	0.9996	1.927	0.0472	0.787	0.3783	12.434	0.9001
150	27.92	28.09	0.072	56.81	0.9998	1.416	0.0310	0.819	0.2634	26.038	0.9162

[a]Initial dye concentration (mg/L). [b]Equilibrium adsorption capacity obtained as experimental (mg/g). [c]Equilibrium adsorption capacity obtained from pseudo-second-order equation (mg/g). [d]The rate constant of pseudo-second-order reaction (g/mg min). [e]The initial adsorption rate from pseudo-second-order kinetics (mg/g min). [f]Correlation coefficient from pseudo-second-order equation. [g]Equilibrium adsorption capacity obtained from pseudo-first-order equation (mg/g). [h]The rate constant of pseudo-first-order reaction (min^{-1}). [i]Correlation coefficient from pseudo-first-order equation. [j]Intra-particle diffusion rate constant (mg/g $min^{1/2}$). [k]Intercept from intra-particle diffusion equation. [l]Correlation coefficient from intra-particle diffusion equation.

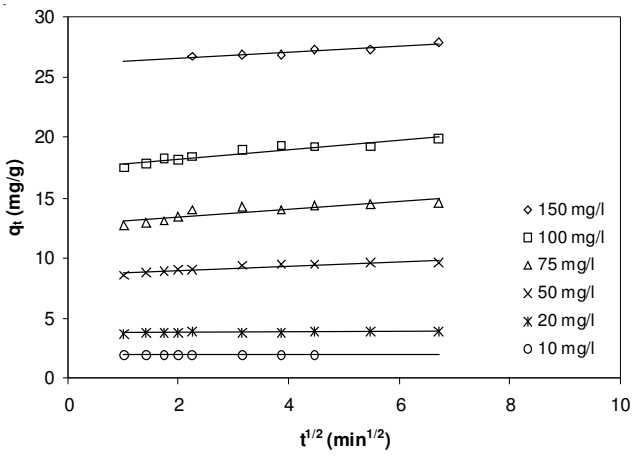

Fig. 9. Intra-particle diffusion kinetics of basic red 2 adsorption on peanut shell at diffirent concentrations

Column adsorption: The percentage of dye calculated from the analysis of the samples at the outlet of the column is shown Fig. 10. As shown from this figure, a very high adsorption (rather than 99 %) occurs for all initial concentrations in each time. Furthermore, it is observed that all the outlet samples are colourless and cleared off the red colour of basic red 2. This situation indicates that a very high adsorption occurs as a result of a high affinity between the functional groups of

basic red 2 molecules and peanut shell packed in column. Column exhaustion time is determined as 2.5 h.

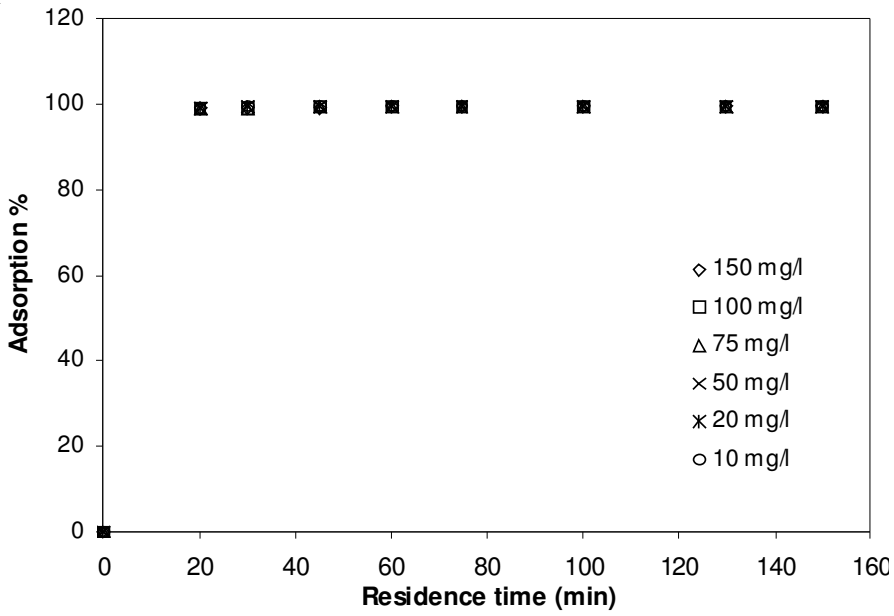

Fig. 10. Effect of concentration on the column adsorption of basic red 2

FT-IR study of adsorption: Before and after adsorption, FT-IR spectra of peanut shell are shown in Figs. 11a and 11b, respectively. The broad band at 3294 cm^{-1} indicates the existences of -OH groups of glucose and -NH groups of proteins. After the adsorption of the dye, this band is shifted to 3329 cm^{-1}. The strong absorption bonds at 2919 and 1737 cm^{-1} can be assigned to -CH stretching of carboxyl groups. These peaks, after the adsorption of the dye, are slightly shifted to 2925 and 1734 cm^{-1}, respectively. The absorption peaks at 1634 and 1511 cm^{-1} can be attributed to the amide I and amide II bands of protein peptide bonds. After the adsorption of the dye, the peak at 1511 cm^{-1} is slightly shifted to 1508 cm^{-1} and its intensity is increased. The absorption peaks at around 1200-1000 cm^{-1} indicate the existence of C-O single bond in carboxylic acids, alcohols, phenols and esters. Herein, very strong absorption peak at 1027 cm^{-1} can be assigned to C-O bond in carboxylic and phenolic groups. This band is reduced and slightly shifted to 1019 cm^{-1}, after adsorption. The strong peaks at around 1650, 1400 and 1240 cm^{-1} are caused by the C=O stretching band of carboxylic groups. The peaks in 3500-3200 cm^{-1} region and 1540 cm^{-1} represent the stretching vibrations of amino groups. The peak found at 1000 cm^{-1} is finger print zone resulted from phosphate and sulphur. FT-IR result indicates that the peanut shell has characteristic bands of proteins, phenolic and carboxylic groups, polymeric compounds which are able to react with positively charged basic red 2 molecules in aqueous solution.

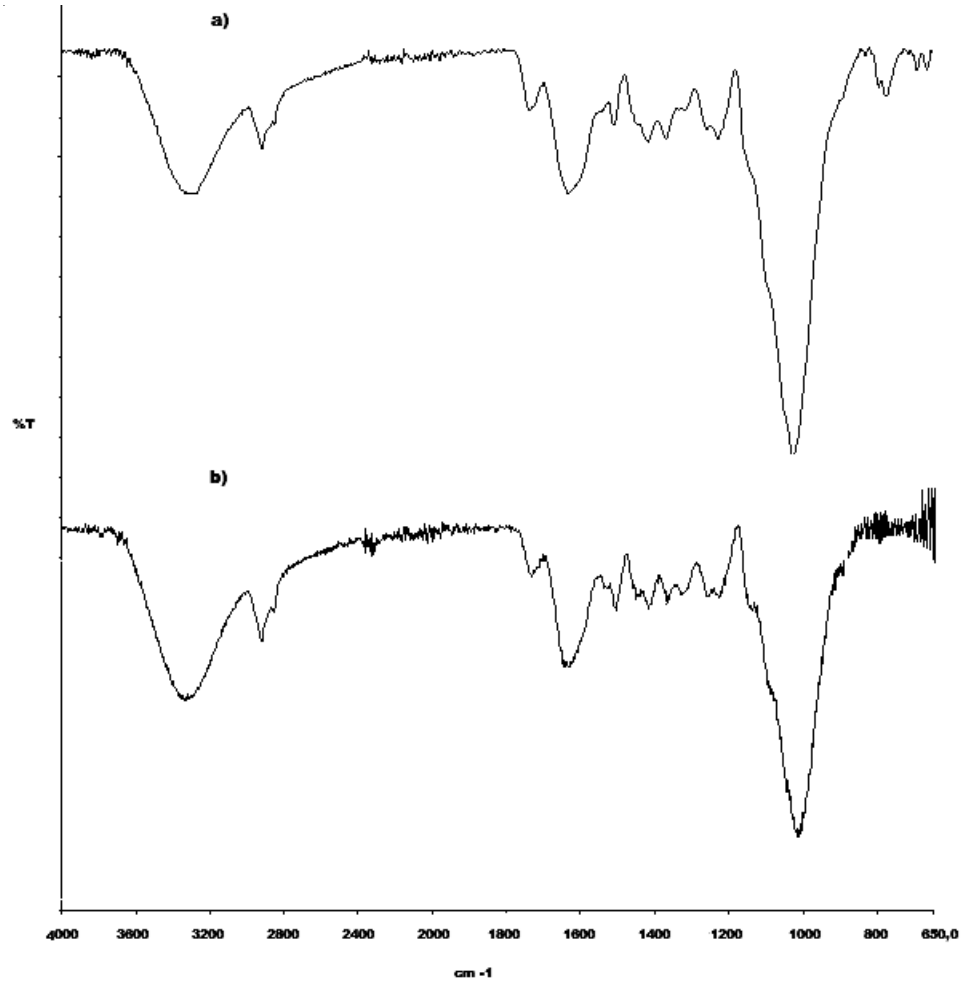

Fig. 11. FT IR spectra of peanut shell: (a) before adsorption; (b) after adsorption

Conclusion

Peanut shell, an agricultural waste, was used as an adsorbent for the removal of basic red 2 from aqueous solution by batch and column adsorption. The adsorption of basic red 2 was investigated as a function of initial dye concentration, pH and temperature. It was determined that the maximum adsorptions were between 84.70 and 98.86 % under all the experimental conditions studied. The values of adsorption obtained from column experiments were more than 99 %. Adsorption isotherm was consistent with Freundlich model. The kinetics of adsorption followed the pseudo second-order model and it was partially consistent with intra-particle diffusion models, also. From the results of the adsorption experiments, it could be concluded that low-cost peanut shell acted as a potential adsorbent for the removal of basic red 2 from wastewater.

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