Orange Peel as an Adsorbent for the Removal of Reactive Blue Dye from Textile Waste Water

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Abstract

In this study the capable use of the low cost and eco-friendly material orange peel as a biosorbent for the removal of dichlorotriazine Reactive Blue (RB-Drimarine-K2 RL) dye from aqueous solutions was studied, containing equilibrium and dynamic studies. Experiments were performed on different dye concentrations, particle sizes, adsorbent doses, pH, shaking speed and shaking time. It was revealed that the adsorption capacities of orange peels were comparatively high for the reactive dyes. The adsorption equilibrium data could be best plotted by applying the Langmuir and Freundlich isotherms. The experimental results were labeled by both isotherm. Adsorption results were analyzed using the linear models and the regression results showed that the adsorption was more accurately described by a Lngumuir model.

Key words: Reactive Blue (RB), Dicholortiazine (DCT), Monochlorotriazine (MCT), adsorption.

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INTRODUCTION

The textile industry is one of the largest production industries, having significant role in manufacturing sector global industry. It provides enormous masses of materials for clothing and furnishings, with their specialties and end-uses (Broadbent, 2001). The dyeing procedures may be divided into two major classes of immersion exhaustion (exhaust dyeing) and pad impregnation (pad dyeing) processes (Khatri, 2010). The degree of fixation is variable in different classes of dyes; the reactive dye has 50-80% of fixation, the remaining components are unfixed dyes. The dyeing process produces huge amount of colored wastewater; the amount of color pick up varies from material to material and amount of dye to be hydrolyzed in water. The wet pick up for polyester cotton blends for reactive dyes is 40-45% and it is 60-70% for cotton, cellulosic fibers, the remaining amount of unfixed hydrolyzed disposed in water streams (Broadbent, 2001). The reactive dyes react with hydroxide ions present in the aqueous dyebath under alkaline pH conditions. This produces nonreactive hydrolysed dye which remains in the dyebath as well as in the fiber. In order to obtain the required levels of washing fastness, it is necessary to remove all unreacted and hydrolysed (unfixed) dye from the cotton fiber. This is achieved by 'washing-off'; a series of thorough rinsing and 'soaping' steps. The dye fixation efficiency is typically in the range of 50–80%; i.e. 20 to 50% of the dye of the desired shade of color is discharged to the environment. (Khatri, 2010). Irrespective of the dyeing method and the type of reactive group, almost all of the potentially toxic non biodegradable inorganic electrolyte, alkali and unfixed dye are discharged to dyeing effluent. This creates potential environmental problems from a highly-colored effluent with high levels of dissolved solids and oxygen demand. (Khatri , 2010). There are different conventional methods available for the treatment of such industrial waste; physical, chemical, physico-chemical, biological, and membrane technology are the methods that are widely used for the control of these effluents. Adsorption is one of the best methods for the removal or reduction of dye containing water effluents. Amongst all the sorbent materials proposed, activated carbon is the most popular for the removal of pollutants from wastewater (Derbyshire *et al*., 2003). There are different methods for the removal of colorants such as chemical oxidation, coagulation and reverse osmosis (Ahalya et.al, 2006). The adsorption method has an advantage over the other methods because of sludge free process for the removal of dyes ta a great extent from dissolved solution as compared to other commercial methods and their application in color removal (Ramchandra et.al, 2008).

Though, commercially accessible adsorbent materials are found to be very expensive. the use of low cost adsorbent materials is increasing in the application of the adsorption technology, for the removal of coloring substances and other compounds from waste as well as from underground water (Ramakrishna K.R. and Viraraghavan T., 1997). It has been considered that low-cost and biodegradable alternate materials are obtained from natural resources to remove organic impurities; some of them are sugar-cane bagasse, rice husk, straw, coconut husk, saw dust, and fly ash. By using bio-degradable biosorbent materials the waste can be minimized due to bio-degradable nature of materials (Ramchandra et.al, 2008).

Therefore, orange peels are found to be best adsorbent material and used in this study for the removal of reactive blue dye (Di-Chlorotriazine) from textile effluent. Different working parameters were optimized and used. The following parameters were used: adsorbent dosage, dye concentration, particle size, shaking speed; shaking time and pH to calculate the adsorption capacity of orange peel and removal percentage of adsorbate on adsorbent under these optimized parameters.

MATERIALS AND METHODS

The following chemicals were used for the experimental work: Reactive dye; (H_2SO_4) Sulphuric Acid, Hydrochloric Acid, (HCL) Alkali (NaOH), Sodium bi-carbonate ($NaHCO_3$) and Distilled water were used. The reactive blue dye (Dri-marine K_2-RL) from Clairant was used for this study. The dye has high rate of reactivity and dark color with good fixation properties as compared to other type of reactive dyes such as MCT (Mono choloro-triezene) and Fluorine containing dyes.

Table: 1 shows the general characteristics of Reactive Blue K 2 RL

Dye	Type	Form	Color	Molecular weight(g/mol)	Wave length (λmax) nm	Color Index
Drimarine	Reactive	Granular	Blue	968.52	589	18103

Machinery

Electronic weighing balance of (AFD-300) with range of 0.01-300 grams , Universal pH strips range of 1.0-14.0, Oven dryer (WTB-Binder), Biochrom Lis S-22 Double beam Spectrophotometer, Filter paper(Whatman), Oscillating dyeing machine, Manual cutters, Millers/Manual and Sieves (Tyler manufacturers USA) were used to prepare adsorbent, adsorbent particle sizes.

In this research work the orange peel was collected from local market and used as biosorbent material for the removal of reactive Blue dye from aqueous solution after following process.

Preparation of adsorbent: The adsorbent material was washed with tap water, followed by chopping, drying under sunlight, distilation washing, oven drying, grinding, and sieving.

Preparation of aqueous solution: The aqueous solution was prepared by mixing different doses of dye 25, 50, 75, 100 and 125 mg/L respectively in distilled water.

Optimization of parameters: Following parameters were optimized to get the maximum sorption of dye on orange peel.

Adsorbent dose

Different doses 10.0, 20.0, 30.0, 40.0 and 50.0 respectively were used and optimized.

Particle size

Different particle sizes of adsorbent were made by sieving the grinded material with 600 µm, 1200 µm, 3.0, 4.0, and 5.0 mm respectively.

Shaking speed
Different shaking speeds 80, 100, 120, 140, and 160 rpm were used and optimized.
Shaking time
Different amount of shaking time i.e 15, 25, 35, 45 and 55 minutes were used and optimized.
pH
Different levels of pH under acidic levels of 2.0, 4.0 and alkaline levels of 8.0, 9.0, 12.0 were used and optimized**.**

Preparation of Adsorbent
Orange peels were collected from the local market and Juice Centers of Hyderabad City and washed several time with tap water to remove the adhering dirt. Further the samples were dried under sunlight for 4-6 days and chopped by manual cutters into small pieces. Later on they were crushed with manual miller to obtain different particle sizes and finally sieved with different mesh sizes ranging from 600um to 1200 um and 3.0 mm, 4.0mm, and 5.0 mm. The mesh sizes again washed with distilled water to remove any acidity or basicity and was oven dried at 80 ^{0}C for 2-4hrs. Oven dryer (WTB-Binder) was used for drying purpose. The chopped peels were further grinded to achieve the different particles size. Finally different mesh sizes of the Sieves were used to obtain the different particle sizes of the grouned material for the experimental work. The mesh sizes of 3.0, 4.0, 5.0, and 600 µm and 1200 µm were used in this study.

Preparation of Aqueous Dye Solution
The Drimarine Reactive Blue dye (DCT) was used for the preparation of aqueous solution. The dye was obtained from Clairant. Aqueous solution of Reactive Blue-(DCT) dye with different concentration was prepared and used in all batch experiments. The dye solution was prepared by dissolving the different amount of reactive blue dye in distilled water at various concentrations. Batch experiments were carried out at concentrations of 25, 50, 75, 100, and 125 mg/l of the dye using the different doses of the adsorbent to attain equilibrium conditions.

Optimization of Parameters
The following parameters were optimized to get maximum removal percentage of reactive blue dye, for further experimental procedure.

pH and Dye Concentration
Dye solutions with different concentrations (25 mg/L, 50 mg/L, 75mg/L, 100 mg/L, and 125 mg/L) were prepared by diluting the stock solution accordingly. Batch biosorption experiments were carried out for each of the dye concentration prepared. The dyes solution was prepared by dissolving these doses in 1000 ml of distilled water to make the aqueous solutions of different concentrations.
The pH value of the samples was adjusted using 2.0 M HCl solution in 1000 ml of dye solution and 2.0 ml of NaOH solution in 1000ml of dye solution for Acid and alkaline ranging from pH 2.0-12.0. The parameters were optimized as minimum dye concentration of 25 mg/L at pH of 8.0-9.0, where maximum dye removal was found and used for further experiments.

Particle Size
Different particle sizes were used to optimize the adsorbent size, 1200 um, 600um, 3.0 mm, 4.0 mm, and 4.0 mm were used to find the particle size. These mesh sizes were used to sieve the material and batch adsorption experiments were conducted. The particle size of 600 um and 1200 um were found to be the best, where maximum adsorption was achieved and used for further experiments.

Adsorbent dose
Different adsorbent doses were used to optimize the adsorbent dose, 10 g/L -50g/L were used and it was found that the increase of adsorbent dose increased the removal percentage more than 85% at initial dye concentration and decreased to 25-35% when dye concentration was increased 25-125mg/L. Therefore maximum adsorbent doses of 40 and 50 g/L were found to be satisfactory and used for further experimental trials.

Shaking time

The different amounts of shaking time were used to obtain the maximum removal of color from the aqueous solution, the shaking time for 15, 25, 35, 45 and 55 minutes were used. The dye removal of 76-92% was obtained with maximum contact time of 55 minutes and was used for further experimental trials.

Shaking Speed

The different shaking speed were used to obtain the maximum removal of color from the aqueous solution, The shaking speed of 80, 100, 120, 140 and 160 rpm were used. It was found that on the maximum shaking speed of 55 rpm, the maximum dye removal of 84-89% was obtained and used for further experimental trials.

The tests were performed in triplicate on lab scale for the removal of color from aqueous solution of reactive blue dye with different dye concentrations on orange peel. The solution was prepared by putting different doses 25, 50, 75, 100, and 125 mg/L of dye into 1000 ml of distilled water. Different experimental parameters were optimized first and used to get the best results of adsorption for reactive blue dye on orange peel. The adsorbent dose of (50 mg/L), size of 600 and 1200 um, shaking time (55 minutes), pH (8.0-9.0), shaking speed (160 rpm) were found to be satisfactory where the adsorption was maximum. The dye solution with pH of 8.0 and 9.0 was poured in to glass flasks. Different particle size and doses of orange peel were used and shaken in with oscillating dyeing machine at different rpm and shaking time; then the samples were taken for color removal analysis.

The solution was filtered with Whatman filter paper to separate the solution and peels. The UV-Light Spectrophotometer (Biochrom-Libra S22) was used to analyze the color removal percentage. The five serum flasks four of them were filled with dye solution after adsorption process and one with initial dye concentration. The obtained results were compared and calculated by Bear-Lambert law; the obtained values were plotted on linear graphs to show the isotherms analysis. The Langumir and Freundlich isotherms were used to show the color removal percentage of reactive blue dye on different parameters.

RESULTS AND DISCUSSION

Effect of pH and Dye Concentration

Table: 2 Shows the effect of pH and dye concentration on dye removal

pH	25mg/L	50mg/L	75mg/L	100mg/L	125mg/L
2.0	12.4	14.9	16.2	19.3	22.4
4.0	19.3	20.2	24.9	28.4	32.3
8.0	84.4	74.2	66.3	58.7	43.2
9.0	90.7	88.4	71.8	64.2	57.7
12.0	14.4	16.8	26.5	30.7	36.6

The effect of pH on the adsorption percentage of dye by orange peels was examined over a range of pH values from 2.0 –12.0, as the results showed that the amount of adsorption decreases when the pH is decreased to 2.0-4.0, as shown in in Graph.1. With initial dye concentration of 25mg/L adsorption was maximum and decreased when the dye concentration was increased to 100 and 125mg/L. The dye removal was maximum at pH of 8.0 to 9.0 and decreased as the pH increased to alkaline pH of 9.0-12.0 at initial concentration of 25 mg/L.

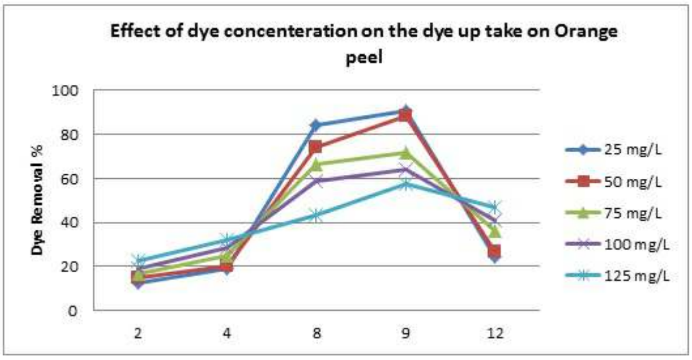


Figure: 1 shows the percentage of dye removal at different concentrations

On observing the effect of dye concentration, it was found that the maximum dye concentration gave slow adsorption on orange peel. Because after a definite time the dye concentration came to equilibrium level, where further adsorption was minimum or zero. The results showed that maximum adsorption of 91.7% and 84.4% of adsorption were obtained at 25 and 50 mg/L respectively.

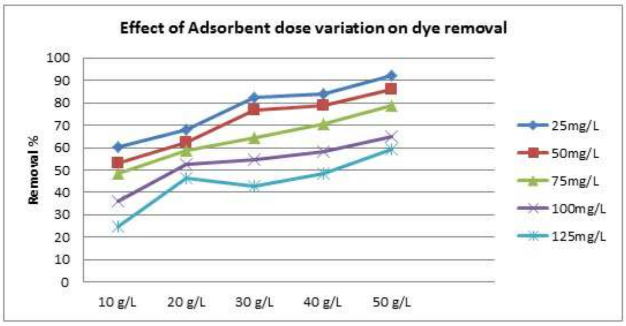
Effect of adsorbent dose

From experimental results it was found that the increase of adsorbent dose from 10-50 g/L increased the adsorption at optimized pH levels of 8.0 –9.0, with mesh size of 600 um and 1200 um respectively, at the shaking speed of 160 rpm and contact time of 55 minutes. Furthermore it was found that the maximum adsorption capacity was 84.6%-92.2% at 40g/Liter and 50 g/L of adsorbent dose with 600 um and 1200 um mesh sizes at initial dye concentration of 25mg/L.

Table: 3 Shows the effect of adsorbent dose on percentage of dye removal

Adsorbent Dose g/L	25mg/L	50 mg/L	75 mg/L	100 mg/L	125 mg/L
10	60.7	52.9	48.6	36.3	24.9
20	68.3	62.2	58.6	52.4	46.3
30	82.4	76.8	64.5	54.7	42.6
40	84.6	78.7	70.6	58.2	48.4
50	92.2	86.2	78.9	64.7	59.2

Figure:: 2 Shows the percentage of dye removal at different doses



Maximum color removal was obtained at 25 mg/L of dye concentration; the 60% color was removed at 10g/L as initial adsorbent dose and removal percentage was increased as dose increased up to 50 g/L on which color removal was found to be 90-92%. It is clear from the above results that the increase in adsorbent dose increased the adsorption and decrease in color removal when adsorbent dose eas reduced.

Effect of particle size

The particle size also plays a major role in adsorption due to the surface of the adsorbent material, higher the surface area higher the adsorption, lower the surface area lower the adsorption. Particle sizes were varied from (600-1200 um) and (3.0-5.0 Mesh sizes) microns. For different particle sizes, the removal percentages of dye on orange peel were measured; the values are given Table.2 Shows the results for maximum color removal of dyes at different particle sizes.

Table: 4 Shows the effect of particle size on percentage of dye removal

Dye Concentration	600 um	1200 µm	3.0 mm	4.0 mm	5.0 mm
25 mg/L	92.4	89.9	86.6	84.3	82.4
50 mg/L	78.3	70.2	64.9	58.4	52.3
75 mg/L	64.4	52.2	46.3	38.7	32.2
100 mg/L	50.7	42.4	31.8	24.2	17.7
125 mg/L	40.2	34.8	26.5	20.7	14.6

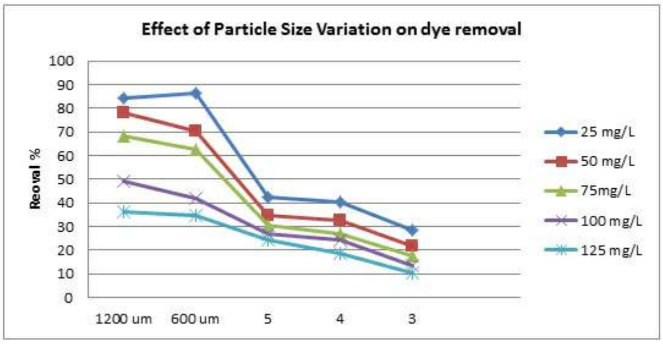


Figure: 3 Shows the percentage of dye removal on different particle sizes

The results clearly showed that the maximum adsorption was obtained at a concentration of 25 mg/L with particle size of 600 um and 1200 um. As the concentration of dye increased in the adsorption of dye on the orange peel decreased and when the dye concentration was reduced to 25mg/L, the maximum color removal 82-88% was obtained.

Increase in particle size gave the lower adsorption due to the low surface area and decrease in particle size gave the higher adsorption due to the more surface area. It was concluded from the observation that the mesh size of 600-1200 um were found to be best for adsorption.

Effect of shaking time

Shaking time or contact time was used from 15-55 minutes; the shaking time was varied to analyze the maximum adsorption for optimization of contact time.

Table: 5 Shows the effect of shaking time on percentage of dye removal

Shaking Time min	25mg/L	50mg/L	75mg/L	100mg/L	125mg/L
15	44.8	35.3	28.6	21.9	16.4
25	48.3	38.6	42.4	34.2	29.2
35	67.1	56.5	62.7	51.5	46.3
45	89.4	84.6	86.2	76.3	74.6
55	92.6	85.9	88.7	79.2	76.4

The effect of shaking time on adsorption was conducted on various contact time and the results show in Graph.4, that the adsorption increased with the increase of contact time and decreased with the decrease of time, caused by the diffusion of dye molecules towards the surface of orange peel. In some cases it was found that more contact time gives reversible reaction of dye diffusion from orange peel surface to solution, so the maximum time of best adsorption results was found to be 45-55 minutes, where 89.4%-92.6% dye was removed and adjusted for further experiments.

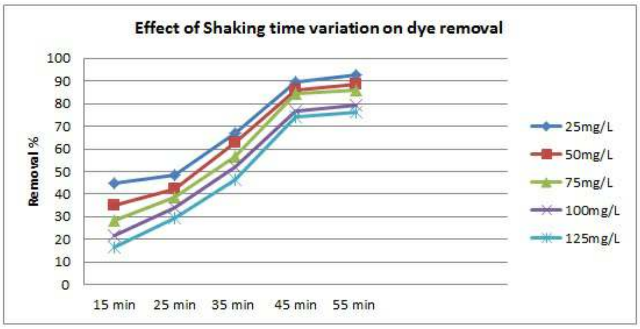


Figure: :4 Shows the percentage of dye removal on different shaking time

Effect of shaking speed

Different Shaking speeds ranging from 80-160 rpm were used and optimized to find the maximum color removal of reactive dye. The other parameters such as pH, adsorbent dose, dye concentrations, and shaking time were kept constant after optimizing. It was found that the maximum color removal was obtained on maximum contact time of 55 minutes. The color removal percentage was found 83-86% on 140-160 rpm.

Table: 6 Shows the effect of shaking speed on percentage of dye removal

Shaking Rpm	25mg/L	50mg/L	75mg/L	100mg/L	125mg/L
80	68.4	62.9	58.6	46.3	40.4
100	73.7	69.2	65.6	60.4	56.3
120	79.4	74.8	70.5	68.7	62.1
140	83.8	80.3	75.6	70.2	66.4
160	86.4	84.2	82.9	79.7	72.6

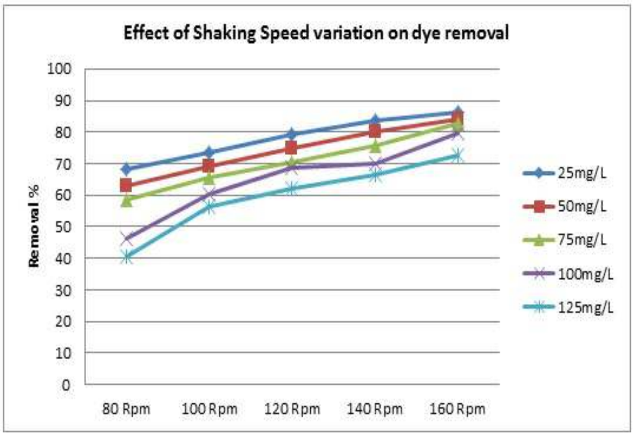


Figure: : 5 Shows the percentage of dye removal on different shaking speed

Adsorption Isotherms Analysis

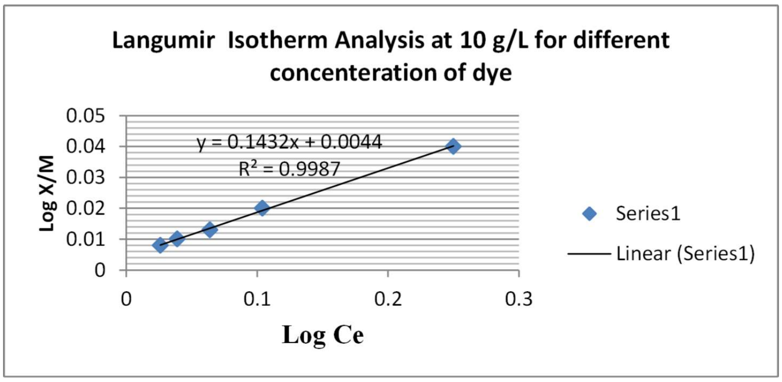
The dye removal percentage was studied on different dye concentrations at optimized parameters adsorbent dose of 50 g/L, particle size of 1200 um, pH of 8.0-9.0, with shaking speed of 160 rpm and contact time of 55 minutes and plotted on Langumir and Freundlich isotherms. The initial and final concentrations were measured and obtained results were plotted. It was found that Langumir and Freundlich isotherms fit the obtained results. Isotherm constants and coefficient of correlation of both are given in table 6. The adsorption kinetics showed that the adsorption was maximum at initial dye concentration of 25 mg/L.

Table 6: Shows the Isotherms constant and coefficient of correlation of Langumir and Freundlich

S.No	Adsorbent dose mg/250 mL	Langumir isotherm constants			Freundlich isotherm constants		
		Q_m (mg/g)	K_a (l mg^{-1})	R^2	K_f (mg/g)	1/n	R^2
1.	2.5	17.52	0.12	0.997	7.23	0.146	0.995
2.	5.0	20.67	0.18	0.999	8.04	0.259	0.983
3.	7.3	24.26	0.24	0.996	6.53	0.275	0.971
4.	10.0	32.58	0.32	0.994	4.21	0.384	0.964
5.	12.7	38.72	0.39	0.995	2.82	0.553	0.952

Table 7: Shows the removal percentage of color at 2.5 g/250 ml

S.No	M.AC (g/250 ml)	Initial C_o (mg/L)	Final C_f (mg/L)	X= C_o - C_f (mg/L)	Removal %	X/M mg/g	1/C mg/L
1.	2.5	25.0	15.0	10.0	60.0	0.25	0.04
2.	2.5	50.0	24.0	26.0	52.2	0.091	0.02
3.	2.5	75.0	38.5	36.5	48.7	0.068	0.013
4.	2.5	100.0	61.4	38.6	38.6	0.064	0.01
5.	2.5	125.0	94.5	30.5	24.4	0.081	0.008



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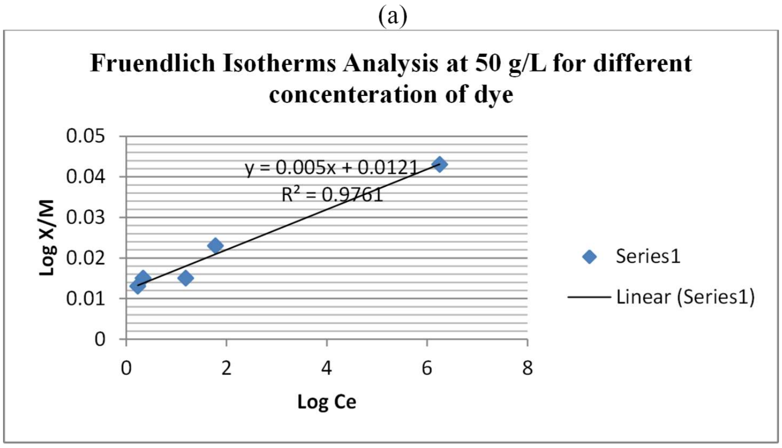
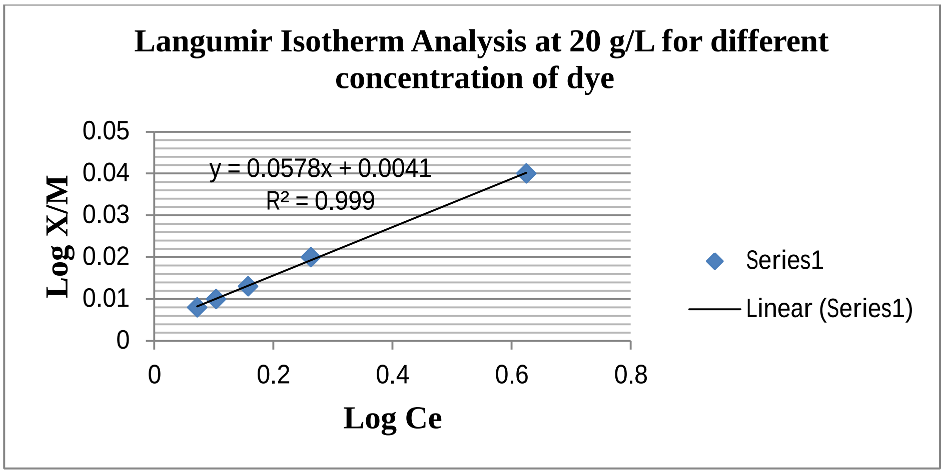


Figure:: 6 Shows the (a) Langumir and (b) Freundlich Isotherm analysis of adsorbate removal (X/M) mg/g on adsorbent at different concentration **for RB (C_0**= 25, 50, 75, 100, 125& 150 mg/L; M_{Ac}= 10 g/L; particle size: 600-1200µm; Shaking speed = 80-160 rpm; initial pH~8.0-9.0; Shaking time = 15-55 min.

Table 8: Shows the removal percentage of color at 5.0 g/250 ml

S.No	M.AC (g/250 ml)	Initial C_o (mg/L)	Final C_f (mg/L)	X= C_o - C_f (mg/L)	Elimination %	X/M	1/C
1.	5.0	25.0	19.8	5.15	79.4	0.970	0.04
2.	5.0	50.0	30.8	19.2	61.6	0.260	0.02
3.	5.0	75.0	42.2	32.7	56.3	0.152	0.013
4.	5.0	100.0	52.9	47.1	52.9	0.106	0.01
5.	5.0	125.0	71.0	54.0	56.8	0.092	0.008



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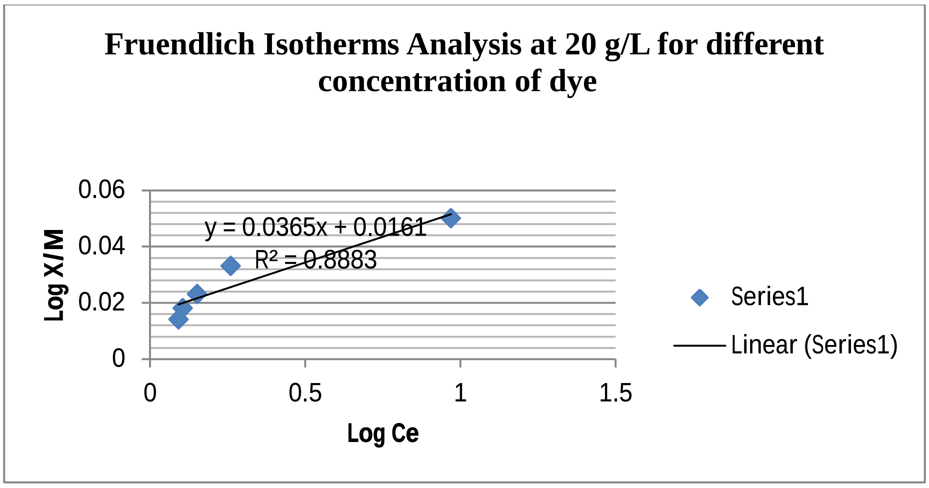
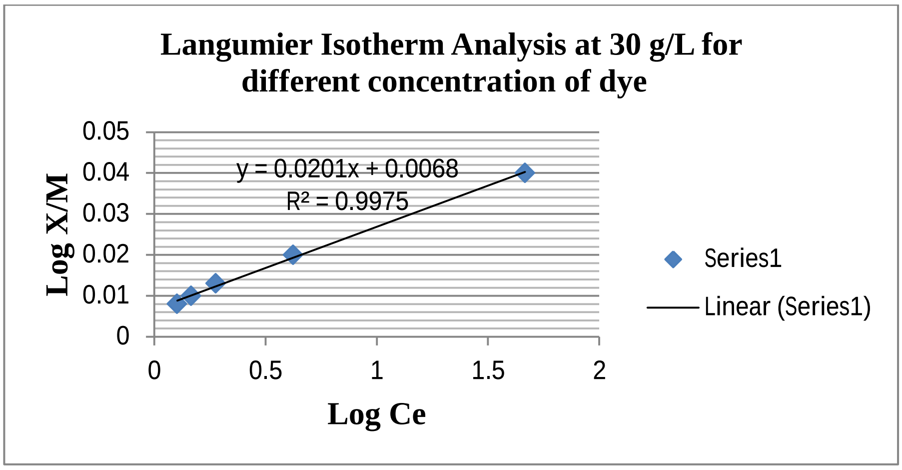


(b)

Figure: 7 Shows the (a) Langumir and (b) Freundlich Isotherm analysis of adsorbate (dye) removal (X/M) mg/g, on adsorbent at different concentration **of RB (C_0**= 25, 50, 75, 100, 125& 150 mg/L; M_{Ac}= 20 g/L; particle size: 600-1200μm; Shaking speed = 80-160 rp m; initial pH~8.0-9.0; Shaking time = 15-55 min.

Table 9: Shows the removal percentage of color at 7.3 g/250 ml

S.No	M.AC (g/250 ml)	Initial C_o (mg/L)	Final C_f (mg/L)	X= C_o - C_f (mg/L)	Elimination %	X/M	1/C
1.	7.3	25.0	20.5	4.5	82	0.622	0.04
2.	7.3	50.0	39.0	11.0	78	0.663	0.02
3.	7.3	75.0	46.5	28.5	62	0.265	0.013
4.	7.3	100.0	54.0	44.0	54	0.165	0.01
5.	7.3	125.0	52.5	72.5	42	0.100	0.008



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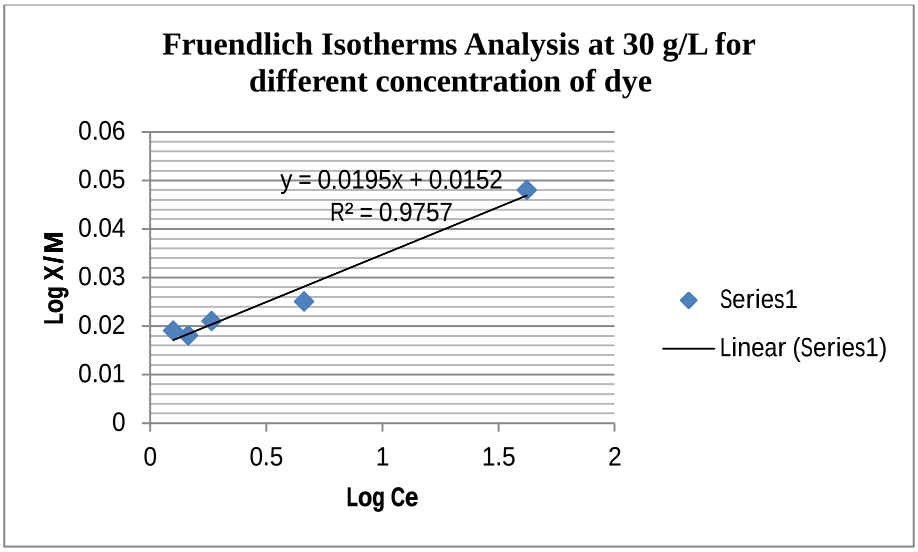

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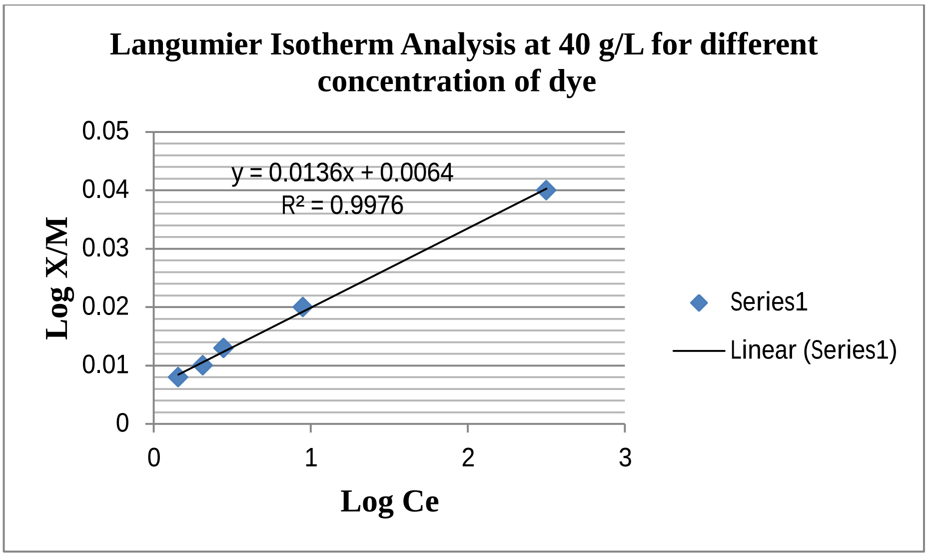
Figure: :8 Shows the (a) Langumir and (b) Freundlich Isotherm analysis of adsorbate removal (X/M) on adsorbent at different concentration **for RB (C_0**= 25, 50, 75, 100, 125& 150 mg/L; M_{Ac}= 30 g/L; particle size: 600-1200µm; Shaking speed = 80-160 rpm; initial p H~8.0-9.0; Shaking time = 15-55 min.

Table 10: Shows the removal percentage of color at 10.0 g/250 ml

S.No	M.AC (g/250 ml)	Initial C_o (mg/L)	Final C_f (mg/L)	$X= C_o - C_f$ (mg/L)	Elimination %	X/M	1/C
2.	10.0	50.0	10.5	39.5	79.0	0.25	0.02
4.	10.0	100.0	41.0	59.0	59.0	0.16	0.01
5.	10.0	125.0	65.0	60.0	48.0	0.16	0.008



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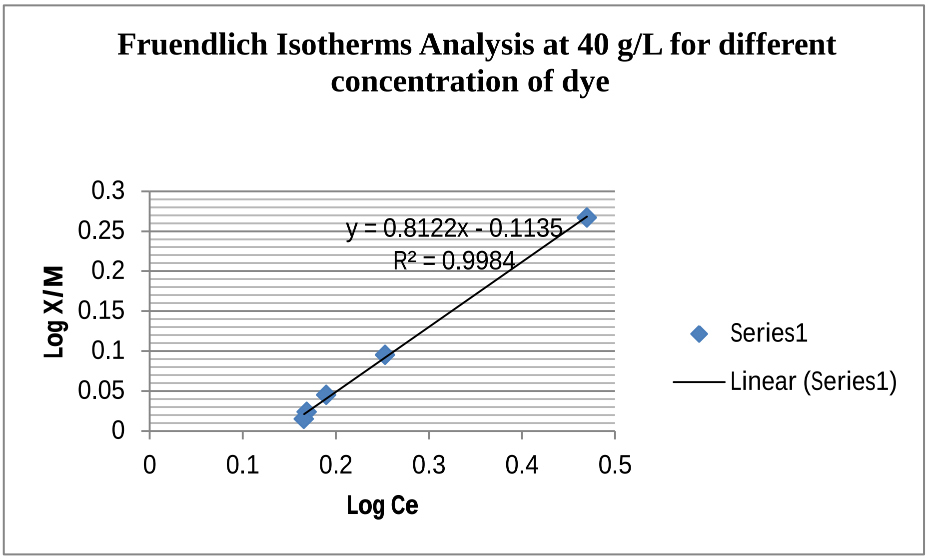
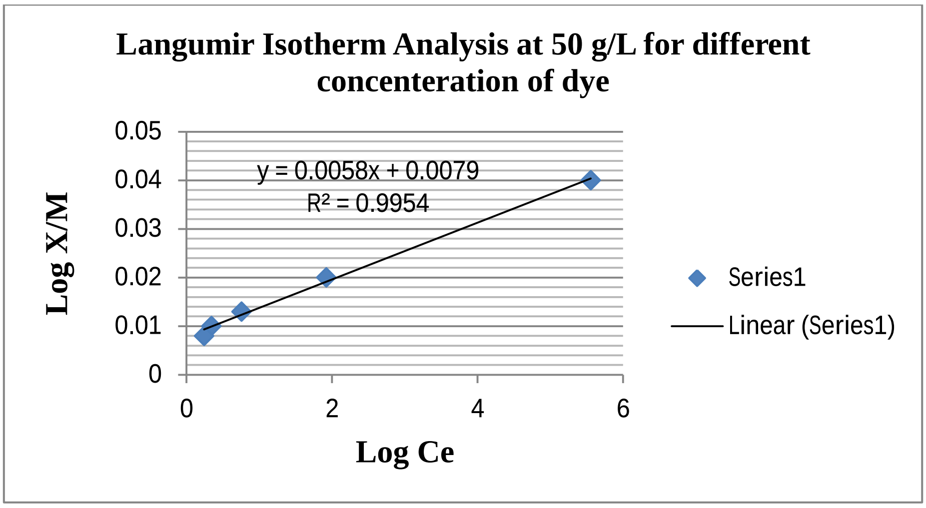


(b)

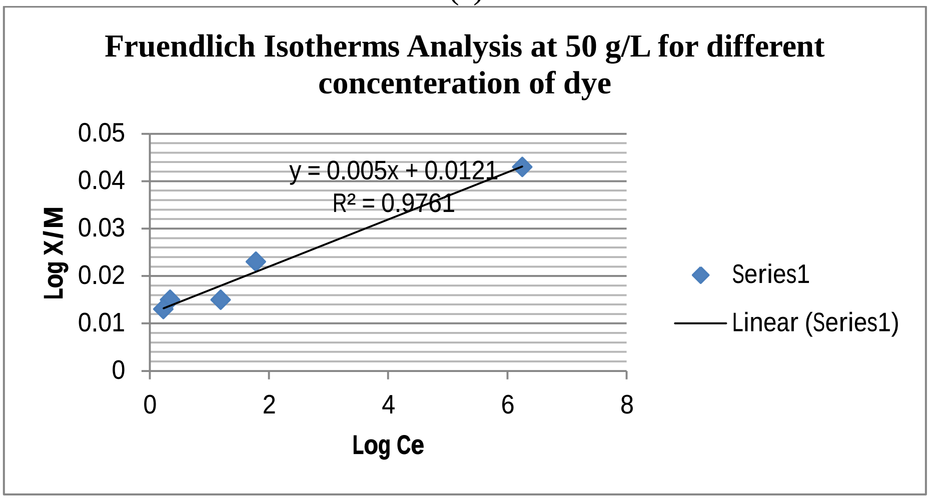
Figure: :9 Shows the (a) Langumir and (b) Freundlich Isotherm analysis of adsorbate Re moval (X/M) mg/g on Adsorbent at different concentration of RB (C_0= 25, 50, 75, 100, 125& 15 0 mg/L; M_{AC}= 40 g/L; particle size: 600-1200μm; Shaking speed = 80-160 rpm; initial pH~8.0-9.0; Shaking time = 15-55 min.

Table 11: Shows the removal percentage of color at 12.5 g/250 ml

S.No	M.AC (g/250 ml)	Initial C_o (mg/L)	Final C_f (mg/L)	$X= C_o - C_f$ (mg/L)	Removal %	X/M	1/C
1.	12.5	25.0	23.0	2.0	92	2	0.04
2.	12.5	50.0	43.0	7.0	86	4	0.02
3.	12.5	75.0	64.5	10.5	78	6	0.013
4.	12.5	100.0	64.0	36.0	64	8	0.01
5.	12.5	125.0	72.5	52.5	58	10	0.008



(a)



(b)

Figure: 10. Shows the (a) Langumir and (b) Freundlich Isotherm analysis of adsorbate removal (X/M) on adsorbent at different concentration for RB (C_0= 25, 50, 75, 100, 125& 150 mg/L; M A.c = 50 g/L; particle size: 600-1200µm; Shaking speed = 80-160 rpm; initial pH~8.0-9.0; Shaking. time= 15-55 minutes. The most common isotherms used for the design and study of adsorption are Freundlich and Langumir isotherms. These two isotherms are based on the analysis of monolayer formation of adsorbate over the surface of adsorbent.

It was found from the above plotted linear graphs of Langumir and Freundlich isotherms for the different dye concentrations of 25, 50, 75,100 and 125 mg/L at different doses of adsorbent 10,20,30,40, and 50 g/L, that the maximum adsorption was found on 25 mg/L on adsorbent dose of 50 g/L. The Langumir isotherms show more linear graphs as compared to the Freundlich isotherms, the isotherms constant and coefficient of correlation are tabulated in Table .6. The coefficient of correlation was found ($R^2 \geq 0.99$) and the value of K_f decreased with the increase of concentration from 25-125 mg/L in aqueous solution. The adsorption isotherm kinetics show that the maximum, easy and well in time adsorption of reactive blue dye on orange peel was achieved on 25 mg/L.

CONCLUSION

The use of orange peel as bio- serpents for the removal of reactive blue dyes from aqueous solution was studied; the following results were obtained after batch experiments. The amount of adsorption increased when the pH was increased to 8.0-9.0, at the adsorbent dose 50 g/ L; at 160 rpm of shaker for initial time of 55 minutes, with particle sizes 1200 µm of mesh size; with initial dye concentration of 25mg/L. Further it was found that the optimized pH of 8.0, and 9.0 were ideal to obtain maximum sorption of dye from the solution, the maximum adsorption was 92.35% and 86.64%. It is clear from the obtained results that the dye concentration is inversely proportional to adsorption and removal percentage, As dye concentration was increased from 25 mg/L to 125 mg/L, the maximum color removal was found at 25 mg/L that is 90-92%. On the other hand when dye concentration reached 125 mg/L the color removal percentage was reduced to about 30-38%. Whereas, the adsorbent dose is directly proportional to adsorption and removal percentage; when the adsorbent dose was 10g/L the minimum percentage of dye removal was found, as the adsorbent dose increased up to 50 g/L the maximum adsorption was established. Further the optimized shaking speed 160 rpm, and optimized particle size found to be 1200 µm, and maximum contact time of 55 minutes were found to be satisfactory to get the maximum results. The adsorption percentage decreased with the increase of particle size, Smaller the particle size, the greater was the contact surface area for adsorption. The results showed that the adsorption isotherms fits both the Fruendlich and Langumir isotherms. The isotherm analysis graph shows the linear slope that best fits the Langumir for the removal of reactive blue dye on orange peel.

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