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REMOVAL OF REACTIVE DYE FROM AQUEOUS SOLUTIONS USING ORANGE AND LEMON PEEL AS BIO- ADSORBENT

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ABSTRACT
The adsorption of Eurozol Navy reactive dye was examined by orange and lemon peel powder considering several parameters as pH, contact time, speed of shaker, temperature and initial dye concentration, single and combined adsorbent dosage. Turbidity and dye extraction parameters also observed. The adsorption obeys both Langmuier and Freundlich isotherm. The removal percentages for orange and lemon peel are 81% and 87% respectively and 91% for combined adsorbent dosages.

Key words: Reactive dye, orange, lemon, adsorption, peel, bio adsorbent, isotherm , desorption.

1. INTRODUCTION
Reactive dyes commonly used in textile industries for dyeing single cotton or cotton blend fabric. Eurozol Navy is a widely used commercial reactive dye. The aqueous solution contains different color of reactive dyes ranges from 200 to 400 Hazen units which are very toxic and harmful for living and aquatic life [1-2]. A number of non-conventional, low-cost adsorbents have been tried for dye removal. Conventional methods for treating dye containing waste water is coagulation and flocculation, reverse osmosis and activated carbon adsorption [3-6]. These technologies do not show significant effectiveness or economic advantage. Low-cost treatment methods have, therefore, been investigated for a long time. A number of non-conventional, low-cost adsorbents have been tried for dye removal [7-9]. These include, wood, china clay, ullers earth and fired clay, flyash, Wollastonite, Fe(III)/Cr(III) sludge, orange and lemon peels for removal direct dye [10-11],Sugarcane bagasse for removal of sulphur dye, Banana peels for removal acid dyes and azoic colour [12-13].This method was successful for removal some textile dyes from aqueous solution but detail study of removal of commercial dyes used in current textile wet processing not done recently[14-15]. Orange and Lemon peels are available and low cost bio adsorbents can be collected from fruit store and juice factories so these adsorbents can be used for removal of reactive dyes very easily. Parameters which affect adsorption of reactive dye such as pH, contact time, speed of shaker, temperature and initial dye concentration, single and combined adsorbent dosage taken under consideration in this study and dye extraction and reduction of turbidity in initial and final condition also measured.
Adsorption isotherm such as langmuier and Freundlich isotherm also plotted according to the experiment result to identify that dye adsorption follows those isotherm or not.

2. MATERIALS AND METHODS
2.1 Preparation of Orange and Lemon peel powder
10 kg of orange and Lemon were washed properly by distilled water after collection and their peels were taken out carefully. Those peels were cut in to small pieces and dried under sunlight for 15 days (Orange) and 22 days (Lemon). After drying the dried peels were crushed and sieved carefully by sieve no. 100 which has size 150 µm so that the surface

area of peel particles become 150 μm. After making orange peel powder the weight of the powder was 250 gm. Finally the powder was collected and kept inside an air tight jar.

2.2 Adsorption Studies

Adsorption experiments were carried out by preparation of 0.5% dye solution of Eurozol Navy reactive dye. Temperature and pH were taken 25^{o}C and 7 respectively. Dye solution was agitated in rotary shaker by Jar test process for 60 minute at 160 rev.min^{-1}. Adsorbent dosage was varied as (200, 400, 1000, 1600 and 2000) mg for orange and lemon peel powder. After that combined dosage of both adsorbent powders at 1:1 ratio was taken for tests and all other parameters were constant. Samples were tested to measure colour removal by spectrophotometer (model DR-2800). Before taking measurement samples were diluted 10 times to ensure the accuracy of result. Then the whole experiment was carried out by varying other parameters such as Speed of shaker (140, 160, 180, 200, and 240) rev.min^{-1}, Contact time (45, 60, 80, 110) minute, Initial dye concentration (0.25%, 0.5%, 1%), Temperature (25, 30, 40, 45, 50)^{o}C, pH (2 to 12). pH was maintained using 0.1N HCL and 0.1N NaOH solution. Initial and final turbidity was measured before and after each test using digital turbidity meter.

2.3 Dye removal Percentage

Dye removal percentages was carried out using the formula

$$(\%) \text{ of dye removal} = \frac{(C_0 - C_e)}{(C_0)} \times 100$$

Here, C_o = initial adsorbate concentration (mg/L), C_e = final concentration at equilibrium (mg/L).

2.4 Adsorption at Equilibrium condition

The amount of adsorption in equilibrium condition q_e (mg/g) was calculated using the formula

$$q_e = \frac{(C_0 - C_e)V}{M}$$

Here, C_o = initial adsorbate concentration (mg/L), C_e = final concentration at equilibrium (mg/L), v = volume of sample, M = mass of adsorbent used.

2.5 Adsorption Isotherm

There are several equations available for analyzing adsorption parameters in equilibrium condition. Among them Langmuier and Freundlich models are most common. The Langmuir isotherm model is based on the assumption that there is a finite number of active sites which are homogeneously distributed over the surface of the adsorbent These active sites have the same affinity for adsorption of a mono molecular layer and there is no interaction between adsorbed molecules.
A well known linear form of the Langmuir equation can be expressed as

$$\frac{1}{q_e} = \frac{1}{q_m K_a} \cdot \frac{1}{C_e} + \frac{1}{q_m}$$

Here, C_e = final steady state concentration, q_e = equilibrium conc. adsorbed/mass C, q_m & K_a = Langmuier constant.
The Freundlich isotherm model applies to adsorption on heterogeneous surfaces with interaction between the adsorbed molecules, and is not restricted to the formation of a monolayer. This model assumes that as the adsorbate concentration increases, the concentration of adsorbate on the adsorbent surface also increases.
The well-known expression for the Freundlich model is given as

$$\log q_e = \log K_f + \frac{1}{n} \log C_e$$

Here, C_e = final steady state concentration, q_e = equilibrium conc. adsorbed/mass C, K = Freundlich Constant, 1/n = heterogeneity factor related to capacity of adsorption

2.6 Dye Extraction

Extraction means the losses of adsorbed dye from adsorbent. It was determined by washing the dye loaded adsorbents with distilled water and agitating 50 ml of washed solution at pH 7 for 30 minute at 140 RPM at room temperature. Finally the value was measured by spectrophotometer (model DR-2800). Before taking measurement samples were diluted 10 times to ensure the accuracy of result.

3. RESULT AND DISCUSSION

Dye removal percentages increases by increasing adsorbent dosages and reaches constant after particular value of dosages. The removal percentages for orange and lemon peel powder are 81% and 87% respectively and 91% for combined adsorbent dosages. The optimum value of adsorbent dosage is 1000 mg or 1 gm for individual and combinedly. After increasing dosages the removal percentages remain almost unchanged. Result is shown in (Figure:1) below

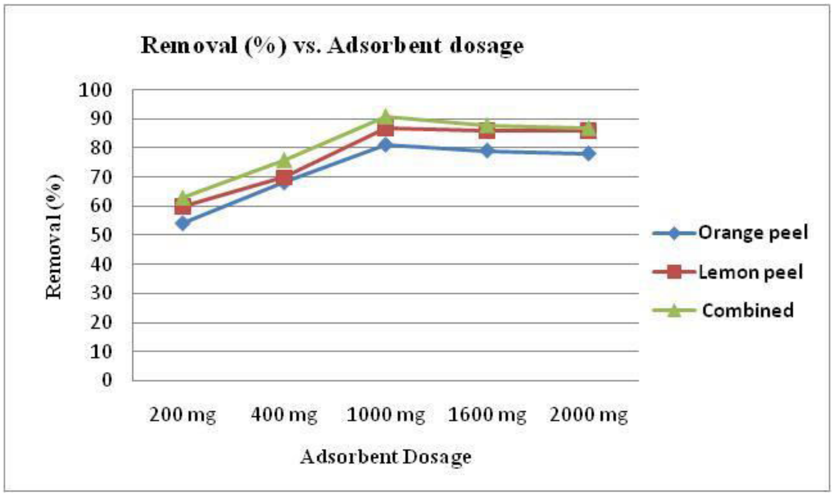

Figure 1: Effect of individual and combined adsorbent dosage

3.2 Effect of initial Dye concentration

Initial dye concentration affects dye removal percentages such a way that removal increases by increasing dye concentration in solution but it remain constant when equilibrium reached. The optimum value of dye concentration is 0.5%. For this concentration equilibrium comes and this value is same for both adsorbents. Further increasing dye concentration in solution the removal percentages remain almost same. Result is shown in (Figure: 2) below

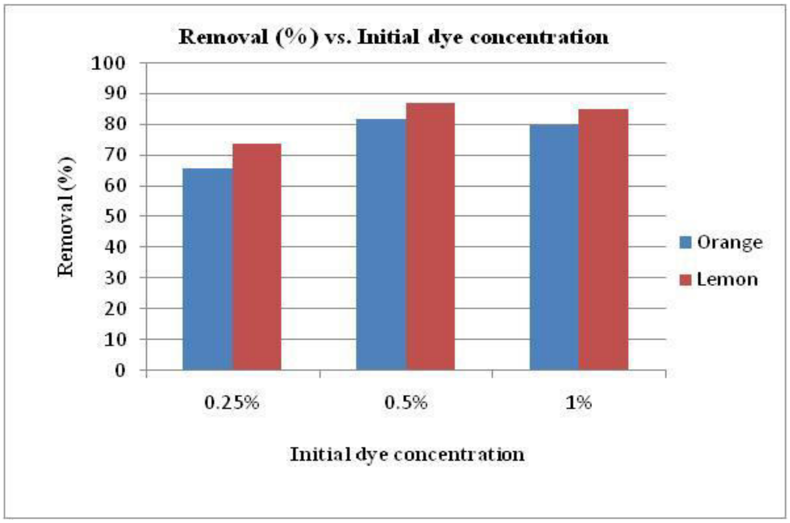

Figure 2: Effect of initial dye concentration

3.3 Effect of contact time

Removal percentages increase by increasing contact time until the equilibrium reached. The optimum value of contact time is 60 minute for both adsorbents and reactive dye. Dye removal percentages increases rapidly at first but after reaching to equilibrium further increasing contact time the removal percentages remain almost unchanged.
Result is shown in (Figure:3) below

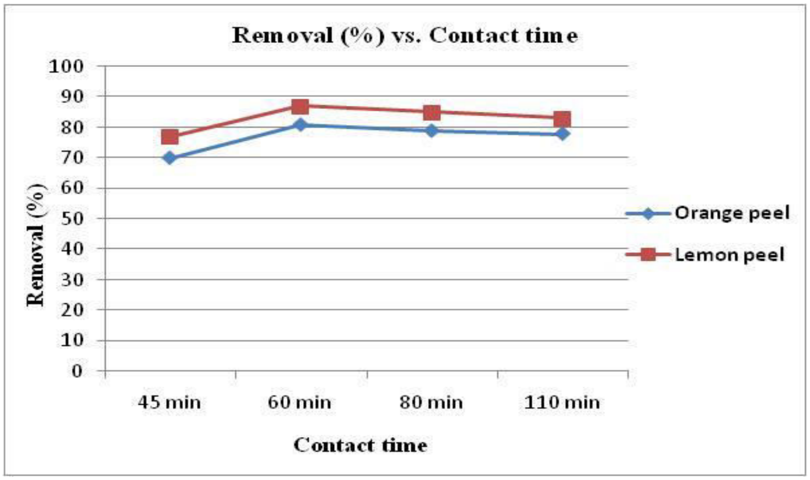

Figure 3: Effect of contact time

3.4 Effect of speed of shaker

Dye removes rapidly by increasing speed of shaker initially but after reaching equilibrium the removal percentages remain unchanged. The optimum value of speed of shaker is 160 R.P.M. Further increasing Speed of shaker the removal of dye remains almost unchanged. Result is shown in (Figure:4) below

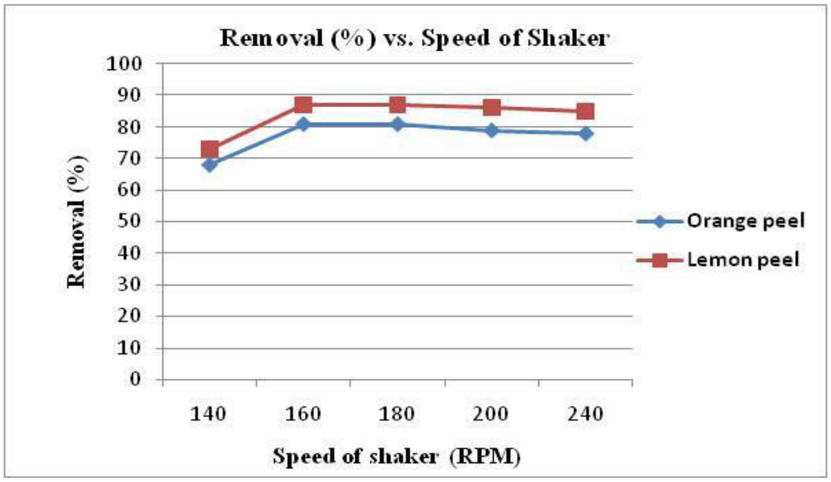

Figure 4: Effect of Speed of Shaker

3.5 Effect of temperature

Dye removal percentages become maximum in 25^{o}C to 30^{o}C temperature. Further increasing temperature removal percentages remain almost same. Eurozol navy is cold brand reactive dye and cold brand dyes becomes more active in low temperature and fixation of these dyes occurs in low temperature normally 25^{o}C to 35^{o}C so normally this temperature range is suitable for adsorption. Further increasing temperature dye removal percentages decreases gradually. Result is shown in (Figure:5) below

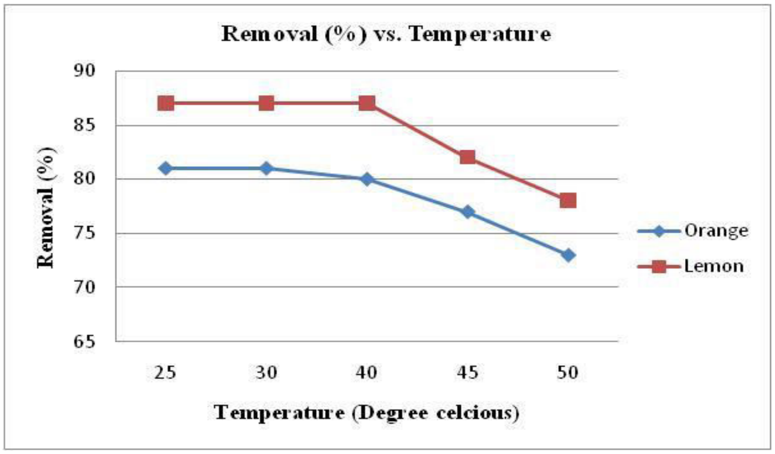

Figure 5: Effect of Speed of Shaker.

3.6 Effect of pH

Reactive dye removes maximum amount in pH 7 to 8. Eurozol Navy reactive dye is anionic in nature and the activity increases in neutral to alkaline condition so in this pH value the removal percentages becomes maximum for both adsorbents but further increasing pH value dye removal percentages decreases gradually. Result is shown in (Figure:6) below

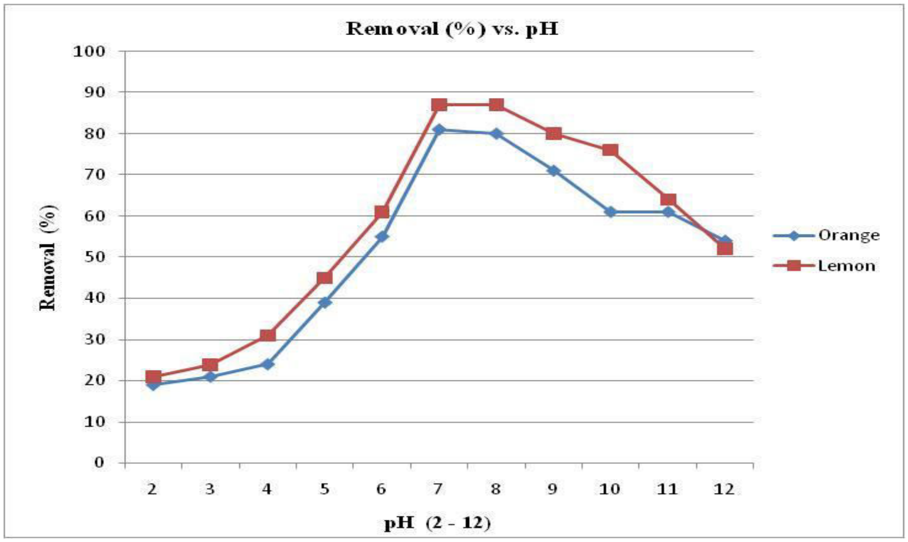

Figure 6: Effect of pH

3.7 Turbidity

Turbidity of initial dye solution reduces due to removal of dye particles. Initial dye solution shows turbidity 182 NTU and the final turbidity is 35 NTU after adsorption for orange peel and 24 NTU for lemon peel. It is clear that as dye particles adsorbed in to the surface of the adsorbents and when adsorbent separated from dye solution turbidity reduces proportionally with dye removal and in a constant way. so reduction of turbidity is constantly proportional with dye removal. Result is shown in (Figure:7) below

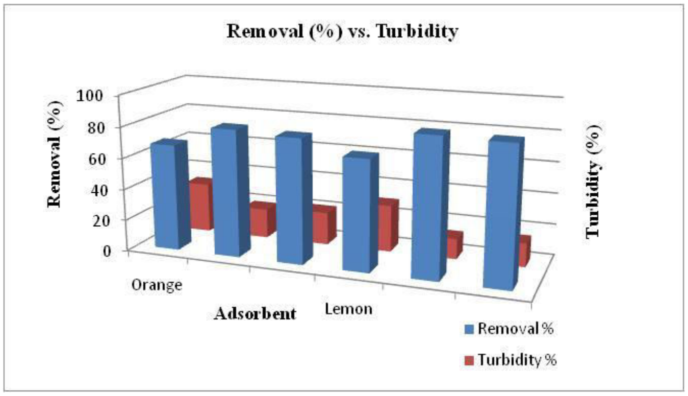

Figure 7: Reduction of turbidity with increasing removal percentages of dye.

3.8 Dye extraction

Higher adsorption of dye particles by adsorbent also can cause higher dye extraction. The detachment of dye particles from adsorbent occurs due to weak force by which dye and adsorbent are held together. Extractions of dye normally known as desorption also and it is a reverse process of adsorption. For orange peel amount of maximum desorption is 30% and for lemon peel maximum desorption is 40%. As reactive dye adsorbed more by lemon peel instead of orange peel so the desorption is of reactive dye is quite higher for lemon peel. Result is shown in (Figure:8) below

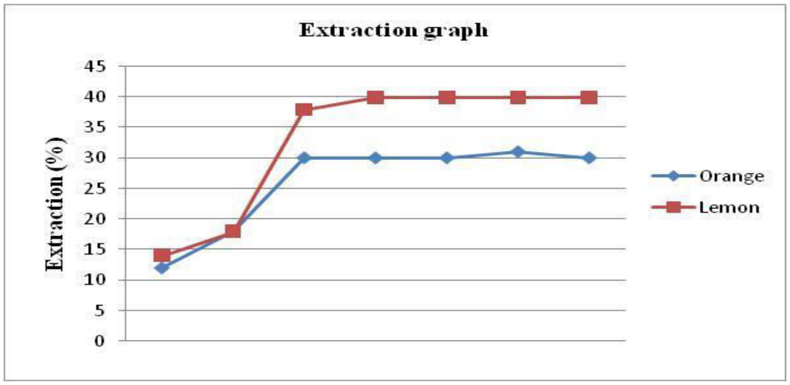

Figure 8: Extraction of reactive dye for orange and lemon peel

3.9 Adsorption Isotherm

Adsorption isotherm of reactive dye removal for orange and lemon peel was plotted by calculating Ce (mg/l) and q_e (mg/g) and a graph ($q_{e\ \text{Vs. Ce}}$) was drawn. The shape of the graph shows that adsorption of dyes by orange and lemon peel follows both langmuier and freundlich Isotherm. Result is shown in (Figure:9 & 10) below

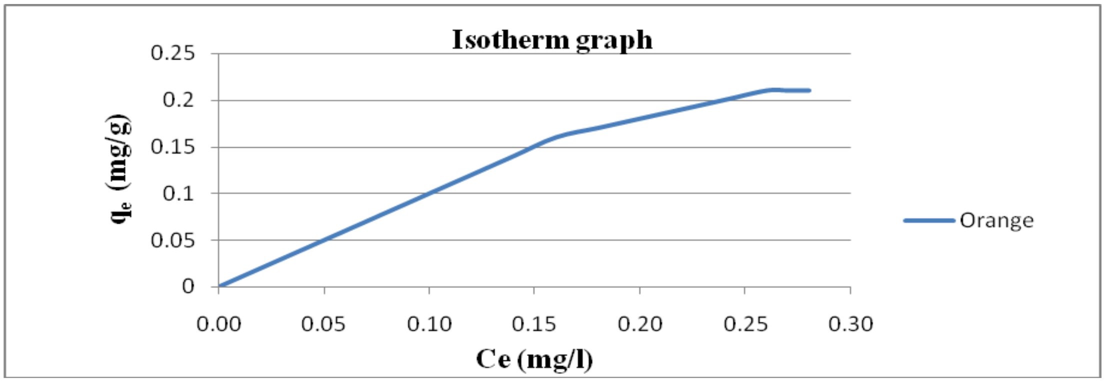

Figure 9: Isotherm model for adsorption of reactive dye by orange peel

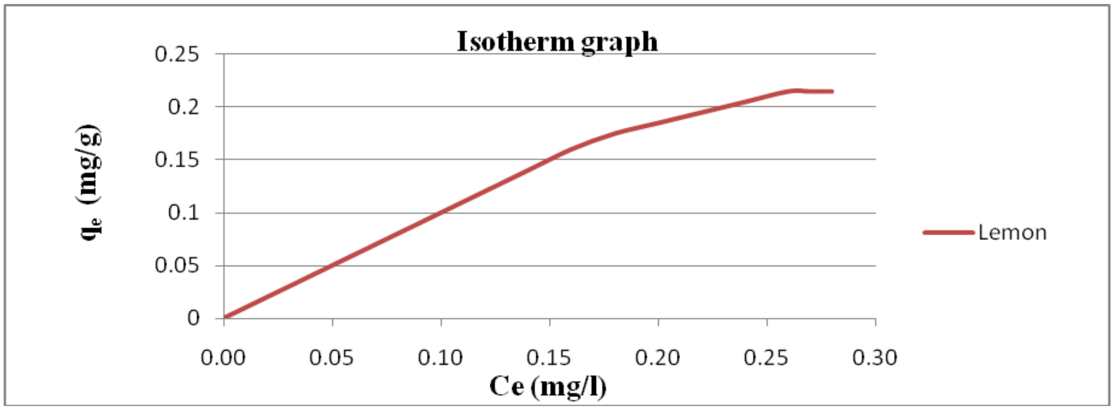

Figure 10: Isotherm model for adsorption of reactive dye by lemon peel

4. FINDINGS

The present study shows that orange and lemon peel adsorbs reactive dye effectively. Both adsorption follows langmuier and freundlich isotherm. The adsorption capacity of orange and lemon peel respectively 0.162 mg/g and 0,174 mg/g. The optimum adsorbent dosage for individual and combinedly is 1000 mg, contact time 60 minute, Speed of shaker, pH (7-9). Removal of dye was maximum for these parameters. Increasing adsorbent dosage rapidly increases dye adsorption due to increasing more surface area of adsorbents but after reaching equilibrium it becomes almost constant. Eurozol Navy reactive dye is anionic in nature more effective in alkaline condition in pH 7-9 so it shows higher adsorption but after further increasing pH adsorption falls a little. The Turbidity decreases constantly with increasing dye adsorption as the amount of circulated dye particles inside the solution reduces. Dye extraction increases quite higher as increasing of adsorption as adsorbents adsorbs more dye then the extraction or desorption of dyes becomes more.

CONCLUSION

From the present study it can be concluded that orange and lemon peel are very effective bio-adsorbent for removal of reactive dye from aqueous solution. Their adsorption capacity under considered parameter shows that they can be used as effective adsorbent for removal of reactive dyes in large scale also. Further studies can be done to evaluate the effectiveness of orange and lemon peel for removal of other textile dyes like acid, disperse, azoic colour etc.

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