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Using Activated carbon of Date Seeds for the Removal of Methyl Red from aqueous Solutions

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Abstract

In this study, the activated carbon that was obtained from date seeds, after heating at 500 ºC, was used to remove methyl red dye from its aqueous solutions. Different parameters were applied including (the effect of dose, the effect of adsorption time, and the effect of pH value). The extent of dye removal increased with increasing adsorption time. An acidic pH is optimal for enhancing dye adsorption. The Langmuir isotherm was applied to the data obtained, and its constants were calculated at the optimum conditions. According to Langmuir isotherm, the monolayer saturation capacity (q_m) is 0.9 mg/g. The study concluded that date seeds activated carbon (DSAC) has demonstrated effective adsorption results in removing methyl red and suggests its potential for use in other adsorption studies.

Keywords: Date seeds, Carbon, Methyl red, removal

Introduction

The dye manufacturing industry represents a relatively small part of the overall chemical industries. The worldwide, production of dyes is nearly 800,000 tons per year. About 10-15% of synthetic dyes are lost during different processes in the textile industry. There are more than 10,000 dyes used in textile Manufacturing alone nearly 70% being azo dyes which are complex in structure and synthetic in nature [1-5]. A major source of color release into the environment is associated with the incomplete exhaustion of dyes onto textile fiber from an aqueous dyeing process. The need to reduce the amount of residual dye in textile effluent has become a major concern in recent years. [1-5]. Textile industries produce large amounts of liquid waste. These textile effluents contain organic and inorganic compounds [3]. During the dyeing processes, not all dyes that are applied to the fabrics are fixed on them and there is always a portion of these dyes that remains unfixed to the fabrics and gets washed out. These unfixed dyes are found to be in high concentrations in textile effluents [4]. The development of economical dye pretreatment methods for the removal of color from effluents has been a major challenge to the dyestuff production units. The processes for the removal of dyes can either be biological, chemical, or physical in nature; the physical dye removal methods include ion exchange, adsorption, and filtration or coagulation [6].The adsorption of different pollutants using agricultural waste products has been one of the economic and realistic approaches for wastewater decontamination from dyes and heavy metals before discharging into the environment [7] The conversion of waste materials and agriculture by-products, into ACs would add considerable economic value, help reduce the cost of waste disposal, and most importantly provide a potentially inexpensive alternative to the existing commercial activated carbon (CAC) [8]. There are large numbers of palm trees in Libya and thus the amount of dates is largely available, which is an economically viable material for the production of activated carbon (AC) from date seeds (DS).The current study aims to use actited carbon obtained from seed of date for removal methyl red dye.

Materials and Methods

Preparation of Date seed carbon

Date seeds collected from date which collected from local markets, The date palm seeds were washed with deionized water to remove foreign materials and dried in an oven at 105 ^{0}C for 24 h, After that, the date seeds were carbonized in a furnace at 500 °C for 2 h to produce carbon, Then, the produced material was cooled at room temperature for 30 min, before it crushed.

Preparation of dye solution:

The dye used in this study is Methyl Red, Methyl red is a pH indicator; it is red in pH under 4.4, yellow in pH over 6.2, and orange in between. Methyl red is a reddish-brown, crystalline powder, has the chemical structure shown in Fig (1) A stock solution of reagent of 100 ppm was prepared by dissolving 0.01g of reagent in an appropriate amount of water and made up to 100ml mark with distilled water. All the adsorption experiments were carried out at room temperature Figure 1.

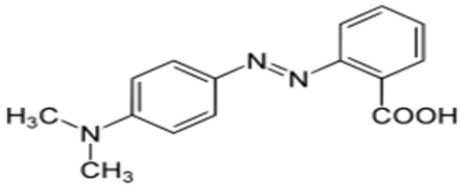

Figure 1. Chemical structure of methyl red

Calibration curve.

Different concentrations ranged from 10- 50 mgL^{-1} of the methyl red was prepared from the stock solution. A calibration curve of absorbance versus concentration was constructed, using a UV-VIS spectrophotometer (Type D-U 800) at a maximum wavelength of 427nm. Figure 2.

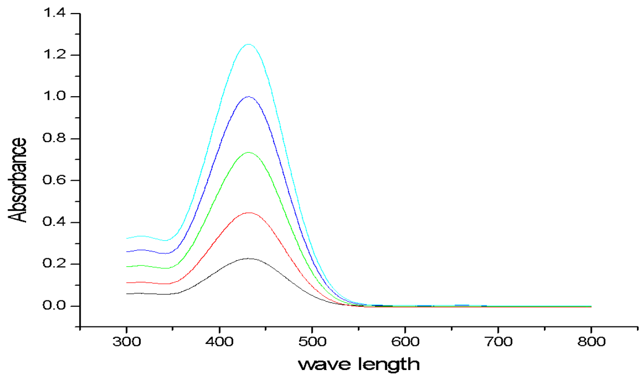

Figure 2. The max wavelength of methyl red (427nm)

Effect of Dosage.

Adsorbent dosage was optimized by performing the experiments at varying adsorbent dosages (0.1, 0.2, 0.3, 0.4, 0.5,0.6,0.7, and 0.8g). with 20ml of dye solution 0f 100 mg/L concentration. The bottles were agitated for 30 min at room temperature then they were filtered. The absorbance of the dye solution was recorded on a UV-VIS spectrometer.

Effect of Contact Time

To establish the effect of time on the absorption, batch equilibrium was carried out at an initial concentration of reagent of 100 mg/L and 0.8g adsorbent dose at (10, 20,30, 40 min) and analyzed by spectrophotometric method. The data obtained were used to plot isotherms which describe the adsorption process**.**

Effect of pH

It is well known that the pH of the aqueous solution is an important controlling parameter in the adsorption process. The pH effect was studied by performing the experiments at different values of pH between 3and12.

Adsorption Studies:

The concentration of unabsorbed dye was obtained by comparing the observed absorbance from a standard curve of the dye**. Figure**

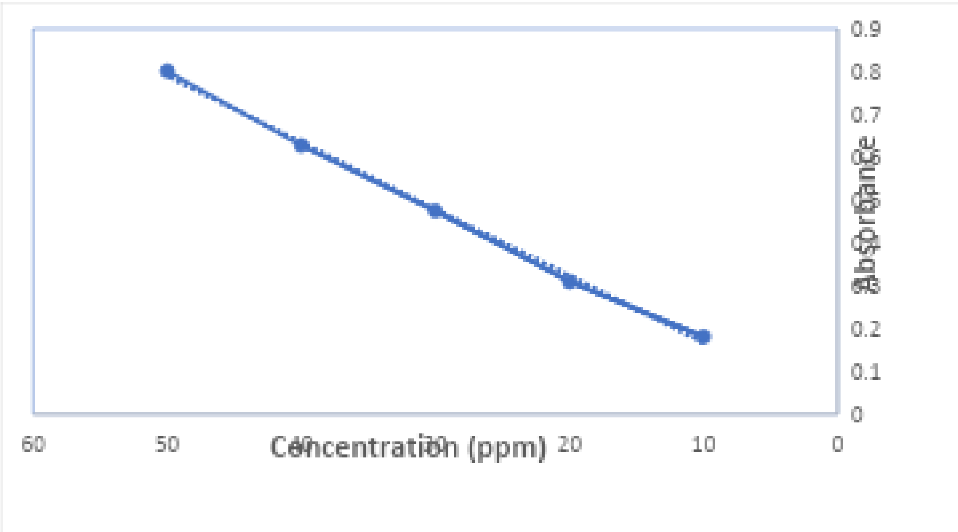

Figure 3. Calibration curve of methyl red before adsorption.

The amount of dye adsorbed per gm of adsorbent (qe) was calculated based on the following equation:

$$(q_e) = \frac{(c_\circ - c_e)}{m} \times v \qquad (1)$$

$\mathbf{C_o}$ and $\mathbf{C_e}$ are the initial and equilibrium concentration of adsorbate (here, methyl red dye) respectively; **V** is the volume of dye solution (in liter); **m** is the weight of adsorbent.[9-11]The removal percentage of dye was calculated based on the following equation:

$$Removal\,\% = \frac{c_\circ - c_e}{c_\circ} \times 100 \qquad (2)$$

Langmuir adsorption isotherm:

The most widely used isotherm equation for modeling the equilibrium is the Langmuir equation [9]. The Langmuir linear equation is commonly expressed as follows:

$$\frac{Ce}{qe} = \frac{1}{kl} + (\frac{al}{kl})C_e \qquad (3)$$

A plot of *Ce* versus $\frac{Ce}{qe}$ was linear showing the applicability of Langmuir adsorption isotherm for phenol red and cresol red adsorption. K_L and a_L are the Langmuir constants related to adsorption capacity and rate of adsorption, respectively which are calculated from the slope and intercept of the plot *Ce* versus $\frac{Ce}{qe}$. The fundamental characteristics of the Langmuir adsorption isotherm can be described using a dimensionless constant known as the separation factor or equilibrium parameter 'RL.' This parameter is defined as,

$$\mathbf{R} = \frac{1}{1 + al\,.Ci} \qquad (4)$$

Where, Ci = initial concentration of the dye and al=Langmuir constant. RL>1 Unfavorable, RL=1 Linear, 0<RL<1 Favorable, RL=0 Irreversible, [12 &13]

Results and Discussion

Effect of dosage on adsorption of dyes

According to the removal percentage (%) results for the effect of doses on the adsorption of methyl red, As shown in Figure 4, the adsorption rate of the dye onto the date seed carbon was found to increase with the adsorbent concentration. This was an expected result since a larger surface area is expected at a higher adsorbent concentration. At higher adsorbent concentrations, the adsorption efficiency decreased due to limited surface area increase caused by solvent saturation and subsequent conglomeration of the exchanger particles. It seems from Figures (4 and 5) and Table (1) that the maximum percentage removal (85.38%) occurred when the dose of Date Seed carbon was 0.8g.Table (1) and Figure (4).

Table(1): Effect of adsorbent doses on the adsorption of methyl red.

Dose(g)	q_e (mg/g)	Removal %	Final concentratio (C_e)	Absorbance(Y)
0.1	1.164	8.82	94.18	1.4239
0.2	2.574	25.74	74.26	1.1251
0.3	2.617	39.26	60.74	0.9587
0.4	2.282	45.65	54.35	0.8590
0.5	2.797	69.94	30.06	0.4801
0.6	2.365	70.95	29.05	0.4469
0.7	2.239	78.38	21.62	0.3356
0.8	2.134	85.38	14.62	0.2305
0.9	1.776	79.94	20.06	0.3122

Figure 4. Removal Percentage of methyl red by using different dose of adsorbent.

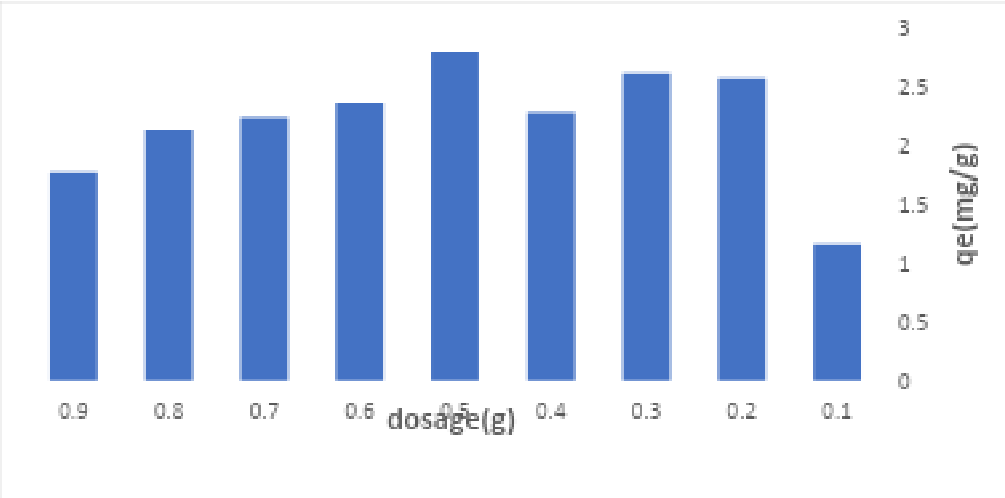

Figure 5. The relationship between q_e and adsorbent doses.

Effect of pH on the adsorption of dye

The pH of the dye solution is an important influencing factor for the adsorption of methyl red on date seed carbon. The maximum MR removal was observed at pH 9.58, where the removal percentage was 99.24% as shown in Table (2) and Figures. (6 and 7) Then the efficiency of adsorption decreased as pH increased. While in an acidic medium, the solutions do not exhibit any absorbance values.

Table (2): Effect of pH on adsorption of methyl red.

PH	q_e (mg/g)	Removal %	Final concentration (C_e)	Absorbance(Y)
9.58	2.481	99.24	0.7533	0.0225
9.18	2.37	94.8	5.20	0.0893
10.59	2.19	86.97	13.026	0.2066
11.3	1.48	59.57	40.433	0.6177

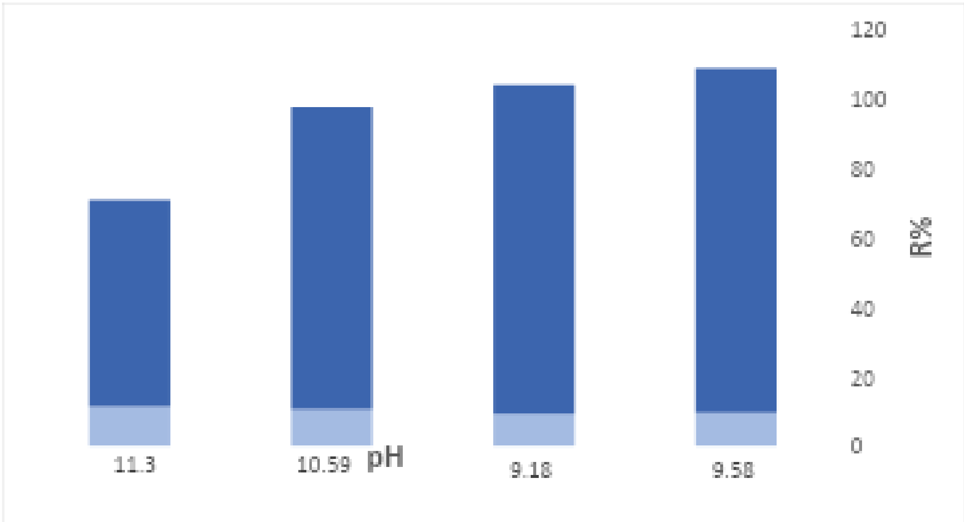

Figure 6. Removal Percentage of methyl red by using solutions with different pH. values

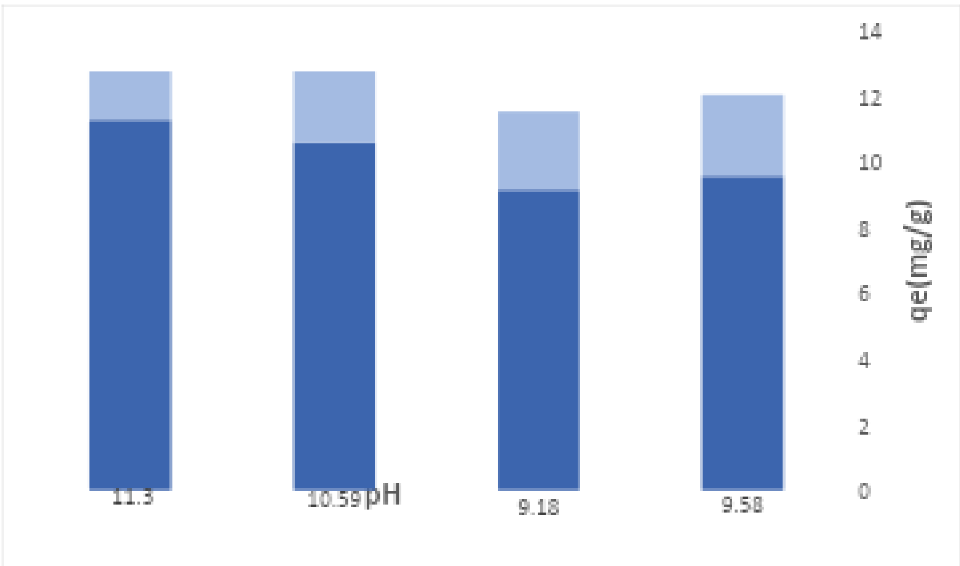

Figure (7) : The relationship between q_e and pH values.

Effect of time contact on the adsorption of methyl red:

The effects of contact time on the removal of green dye by the prepared activated carbon are shown in Table (3) and Fig. 8&9. The removal efficiency was observed to increase with the contact time. The highest removal percentage was 94.8% at 40 min. according to this result, all adsorption processes have been carried out by employing a shaking time of at 40 min.

Table(3): Effect of time on the adsorption of methyl red.

Time (min)	Absorbance (Y)	nal concentration ((C_e	% Removal	(q_e (mg/g
10	0.9515	62.68	37.32	0.933
20	0.5733	37.47	62.53	1.563
30	0.2305	14.62	85.38	2.134
40	0.0893	5.20	94.80	2.370

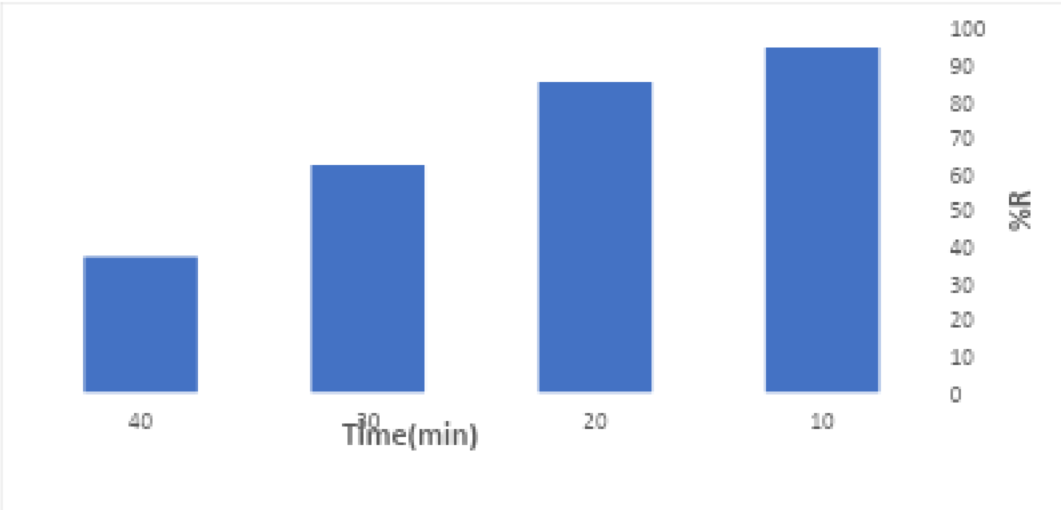

Figure 8. The effect of time on the removal percentage of methyl red

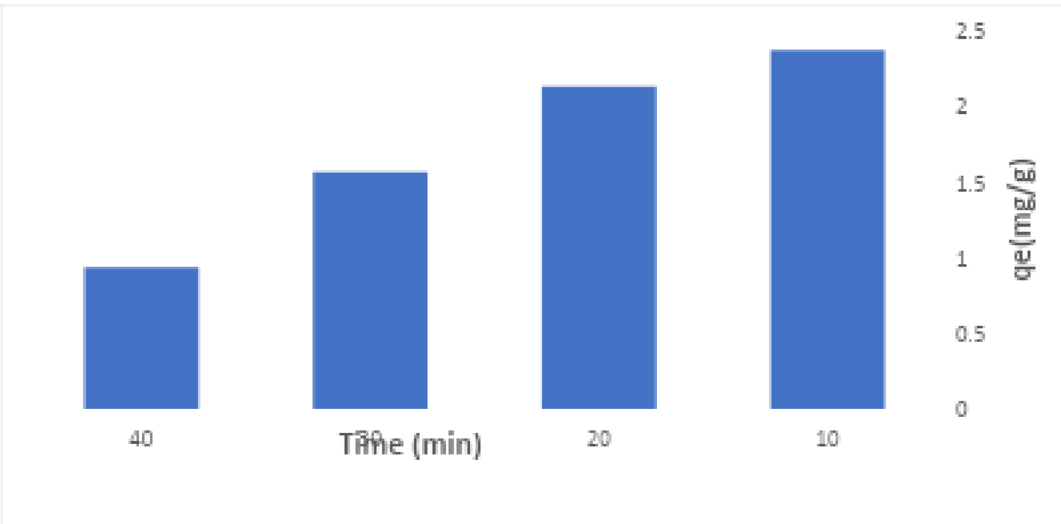

Figure 9. The relationship between q_e and contact time.

Adsorption Isotherm (Langmuir Isotherm):

The data for sorption of the studied indicators onto date seed carbon were fitted to the Langmuir model r^2 = 0.944, indicating the monolayer coverage of dyes on the outer surface of the sorbent. It has been observed that the sorption capacity (q_m) was found to be 0.9 mg/g (Table 5). Also, the value of R is (0.071) This value was higher than zero ($0 < R_L < 1$), indicating the favorable adsorption for the date seed carbon on methyl red.

Table 4. The values of q_e and C_e/ q_e

Time (min)	ıal Concentration C_e	(q_e (mg/g	C_e/ q_e
10	62.68	0.933	0.0671
20	37.47	1.563	0.0239
30	14.62	2.134	0.0068
40	5.20	2.370	0.0022

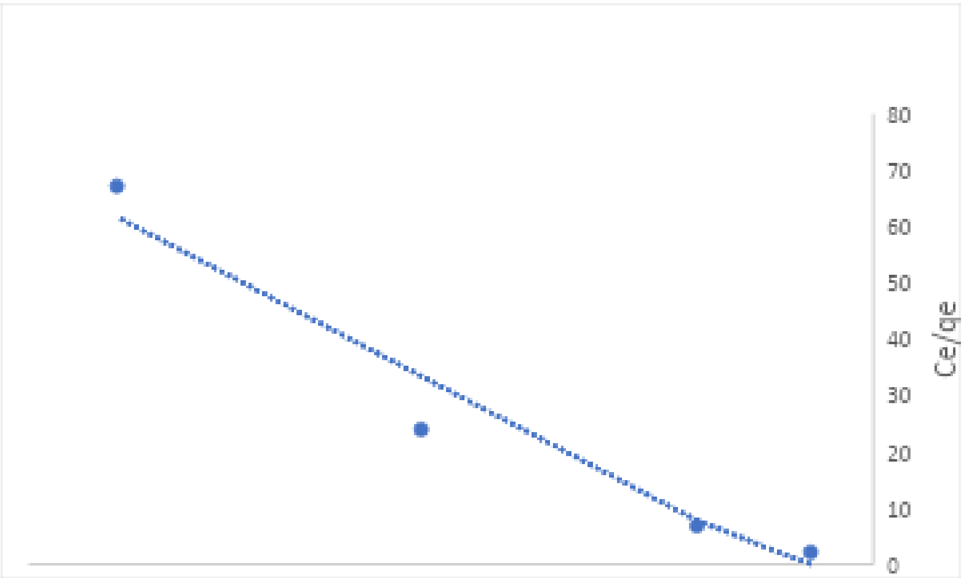

Figure 10. Langmuir Isotherm of methyl red on date seed carbon.

Table 5. Langmuir Isotherm Constants.

Constants	q_m	K_L	a_L	R_L
Values	**0.9**	**0.116**	**0.131**	**0.071**

CONCLUSION

This study which was carried out on the removal of methyl red dye from aqueous solutions by using date seed, showed successful adsorption without activation. The outcome of this study showed that Date Seed Carbon could be used as an adsorbent for the removal of methyl red dye from the solution. The results also showed that the Langmuir isotherm equation provided the best fit for the experimental data. Finally, the use of Date Seed Carbon for the removal of methyl red dye showed a high removal efficiency of 99.28% and could be considered for industrial wastewater treatment.

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