Application of Wheat Husk in Color Removal of Textile Wastewater

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Abstract- *Adsorption is the most efficient technique used to remove organic pollutants from wastewater. Dyes represent one of the pollutants that may remove by adsorption. The textile industry used dyes for colorization of fibers and always generates a considerable amount of colored wastewater. In present work, the removal of Malachite green (MG) dye pollutant from synthetic wastewater onto mesoporous Wheat husk (WH) was studied in batch adsorption systems. The characterization for the prepared wheat husk was studied by, scanning electron microscopy (SEM), Fourier transforms infrared (FTIR) spectroscopy. The batch experiments were carried out to measure the removal efficiency of MG as a function of contact time, initial concentration (25-135mg/L), pH (2-13) and adsorbent dose (1-7 g/L). The equilibrium was achieved within 8 hours. The equilibrium adsorption data of MG dye on wheat husk adsorbent were analyzed using isotherm models and the adsorption kinetic data were analyzed using pseudo-first and second order. The adsorption isotherm results indicated a better fitting obtained by the Langmuir (R2=0.995) than Freundlich (R2= 0.883) and the adsorption formation of the monolayer could be described. Adsorption Kinetic results were fitted better by Pseudo-second order(0.9886) than Pseudo first order (0.984). The properties obtained make WH an ideal adsorbent for treatment of MG dye from wastewater, besides, to develop some environment-friendly and low-priced material is also the crucial work.*

Keywords- *Adsorption,Dyes,Wheat Husk*

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1. Introduction

Dyes are usually used by several industries like plastics, textile, and paper to color their final products. Large quantities of dyes are released by dying unit every year in their effluents and approximately 10000 types of dyes and pigments are produced annually worldwide,[1]. The dyes damage living beings in water by reduction of light penetration and inhibition of photos syntheses [2]. Also, most of the dyes are stable against photo degradations, bio-degeneration and oxidizing agents [3]. There are numerous procedures that have been used for the removal of different dyes from the wastewater, comprising chemical, physical and biological methods. Among these approaches, adsorption is commonly used for dye removal from wastewater [4] because of their low cost, easy access and efficient in the removal of pollutants, that are not easily biodegradable [5]. Much research has been done on developing more efficient, cheap, regenerated and easily accessible types of adsorbents, particularly from the waste materials, for the removal of dyes from wastewater. A number of low cost and waste materials have been used to remove dye from wastewater, such as; orange peels [6], banana peels [7], gambir [8], rice husk [9], groundnut shell [10] peanut hull [11] and Tamarind seed husk [12].

The aim of the present work is to study the ability to use Iraqi wheat husk (IWH) as the low-cost natural adsorbent to remove dye from wastewater. The effects of factors such as dye concentration, contact time, the mass of adsorbent and pH of the solution on dye removal were examined. The investigational adsorption data were fitted by Langmuir and Freundlich isotherm. Meanwhile, kinetic studies were fitted with pseudo first order and pseudo second models.

2. Adsorption Isotherm Models

The data obtained were fitted by different adsorption models to find a suitable model which can be used to design the adsorption process. Adsorption isotherm data are commonly fitted to the Freundlich model and the Langmuir model.
The Langmuir model can be computed as [13]

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$$q_e = \frac{bq_{max}C_e}{1 + bC_e} \quad (1)$$

Where: qe is the adsorption capacity at equilibrium (mg/g)
qmax is the maximum adsorption capacity (mg/g)
b is a constant related to the affinity of binding sites or bonding energy.
Ce is a concentration of adsorbate at equilibrium (mg/L)
The above equation can be rearranged to the linear form as follows

$$\frac{c_e}{q_e} = \frac{1}{q_{max}b} + \frac{C_e}{q_{max}} \quad (2)$$

From the slope and intercept of the linear plot of Ce/ qe and Ce, the value of qmax and b can be calculated.
The Freundlich model can be expressed as [14]:

$$q_e = kC_e^{\frac{1}{n}} \quad (3)$$

Where: k and n are Freundlich adsorption constants.
The linear form of eq (3) represented by:

$$Ln\, q_e = Lnk + \frac{1}{n}LnC_e \quad (4)$$

Freundlich constants can be calculated from the slope and intercept of eq (4).

3. Adsorption Kinetics

The two simple kinetic models: the pseudo first order and pseudo second order are the most used to analyze the rate of adsorption. These kinetic models are computed by eq (5) and eq(6).[15,16]

$$Ln(q_e - q_t) = ln\, q_e - k_1 t \quad (5)$$

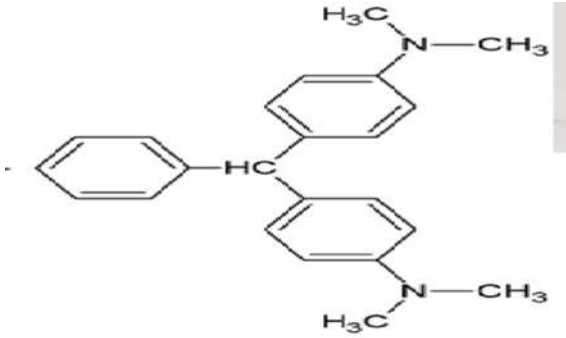
$$\frac{1}{q_t} = \frac{1}{k_2 q_e^2 t} + \frac{1}{q_e} \quad (6)$$

Where qt is the adsorption capacity at time t, k1 is the rate constant of the first order model in min-1 and K2 is the rate constant of the second-order model in g/mg min.

4. Experimental Work

I. Preparation of adsorbent

Iraqi wheat husk was used as precursor material of adsorbent. The material was rinsed several times with distilled water and dried in the oven at 105 Co for overnight. The wheat husk was crushed, milled and sieved by 200 mesh sieves. The dye used in this work was Malachite green (basic green 4) which is commonly used in textile industries. Malachite green dye has a maximum absorption wavelength of 620nm, molecular formula of C23H25N2Cl and has the following structure feature:



All chemicals were analytical grade.
The surface morphology of WH sample was obtained by scanning electronic microscope (VEGA 3 TESCAN (SEM)).FTIR spectra of wheat husk were documented in the region of 4000-400 cm-1 on a perkin-Emler spectrometer.

II. Batch Adsorption Experiments

The effect of pH, adsorbent dosage, contact time and initial concentration of dye solution on the removal of dye from textile waste water were studied. A known quantity of adsorbent (WH) was added to 200 ml solution with different concentration of dye. The flasks were kept in a shaker with 150 r.p.m.at room temperature. The solution pH was adjusted using 0.1 N HCl and 0.1 N NaOH solutions. Then the content was filtered and dye concentration was determined by UV – spectra photometer (Cary 60, Agilent Technology Germany). The experiments were carried out as shown in Table 1.

Table 1: Experimental details for dye removal using Wheat husk

Adsorbent dose	(1- 13) gm
Time	(0.5 -24) hr.
PH	(2 -12)
Dye Concentration	(25-135ppm)

The removal efficiency of the MG dye by WH was determined by [17]:

$$R\% = \frac{C0-Cf}{C0} x\, 100\% \quad (7)$$

Where R is the removal efficiency and C0 is the concentration (mg/l) at the begining and Cf is the concentration(mg/l) at t time.

5. Results and Discussion

I. Scanning electron microscope analysis

The surface morphology of WH surface was shown in Figure 1. The sample reveals a dense sheet of original natural wheat husk structure with a dense number of original fibers bundle

(Cellulose fibers) collects within the bulk of the structure bound by lignin to form a natural composite structure [18]. The pores around and between the fibers and the fiber surface may be responsible for large amounts of active sites available on the surface of WH adsorbent. Dense bundles of fibers also offer a high surface area for dye removal from aqueous solution.

II. FTIR result

The FT-IR spectra of Iraqi wheat husk(WH) were shown in Figure 2. The band at 1075cm-1 and 1237cm-1 are from the vibration of Si-O-Si, the band at 3291cm-1 is a characteristic band of Si-OH and water molecules adsorbed. The bands at 1415cm-1,2854cm-1and 2923cm-1 correspond to characteristics of alkanes groups

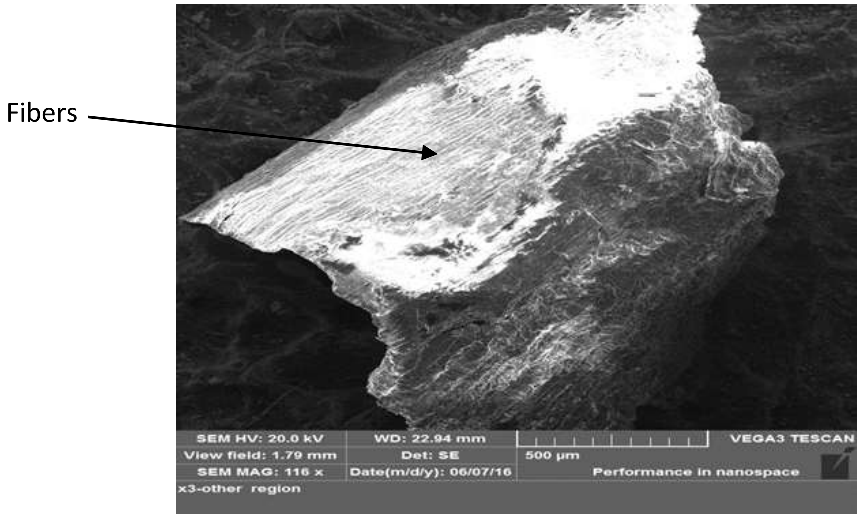


Figure 1: SEM image of WH sample

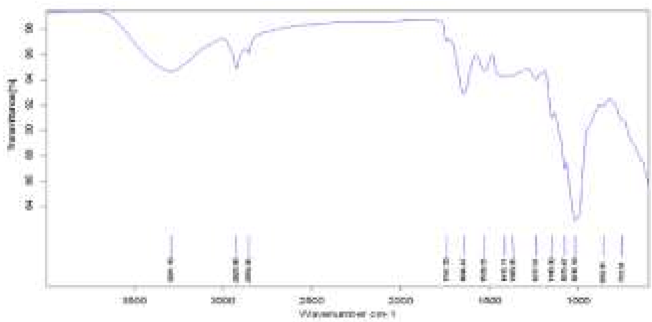


Figure 2: FT-IR for wheat husk

a. Effect of PH

The removal efficiency of dyes with pH ranging from 2 to 12 is studied and the results are depicted in Figure 3. From the figure, it can be seen that the best pH value for removal was 5.5. The removal efficiency increased when pH increase up to pH=5.5 then decreases; this is because of a reduction in the force of attraction between adsorbent (WH) and adsorbate (Malachite green dye).

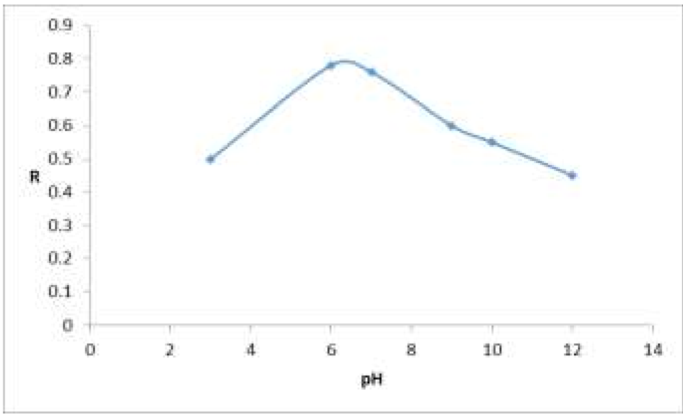


Figure 3: Removal efficiency (%R) of dye vs. pH [Co=50ppm, dose=5 gm., time=24 hr.]

b. WH dose effect

The amount of WH is important to obtain the quantity uptake of dye. Figure 4 shows the effect of WH dosages on the removal efficiency of dye from wastewater. It can be seen that the removal efficiency increased with increasing the dose of adsorbent from 1.0 – 7.0 gm and then relatively remain constant. However, the percentage of removal efficiency increased from 25% to 80% this may be attributed to the increasing of WH surface area and more free binding sites are available.

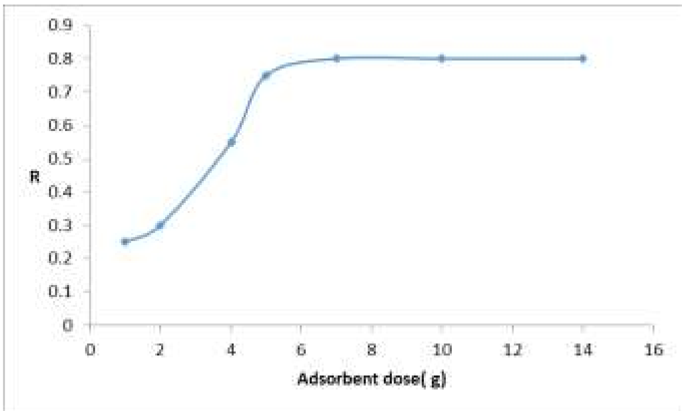


Figure 4: Removal efficiency of dye (%R) at different dose of adsorbent [Co=50ppm, pH=5.5, time=24 hr.]

c. Effect of contact time

The contact time effect on the dye adsorption is illustrated in Figure 5. It revealed that the removal efficiency increased with increasing of contact time. The equilibrium condition was roughly attained within the first eight hours, then increase in contact time after that time had a negligible effect on the removal percentage because the surface adsorbent sites become exhausted. So the contact time of 8hr. was taken for the next experiments as an equilibrium time.

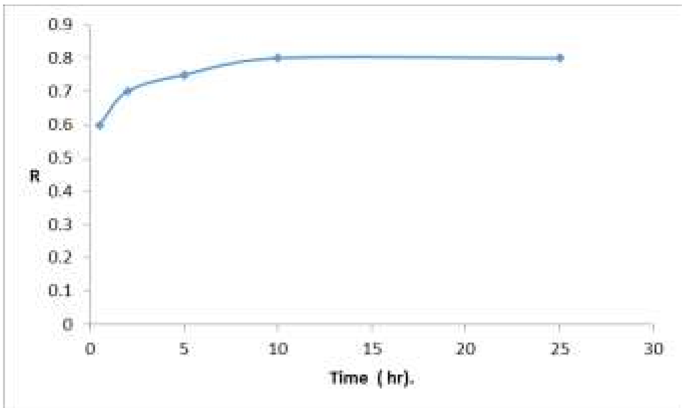


Figure 5: Removal efficiency (%R) of dye as a function of time [C0=50ppm, dose=7g, pH=5.5]

d. Effect of the initial concentration of dye

Removal of dye by 7 gm WH dosage was investigated using different concentration (25-135 mg /L) of dye solution at 8 hrs contact time and PH 5.5, the result is displayed in Figure 6. However, it can be seen that the dye removal percent decrease from 80% to 40% with increasing the initial concentration of dye solution from 25 -135 mg/L. This is because of saturated active sites of adsorbent(WH) after a definite concentration of dye.

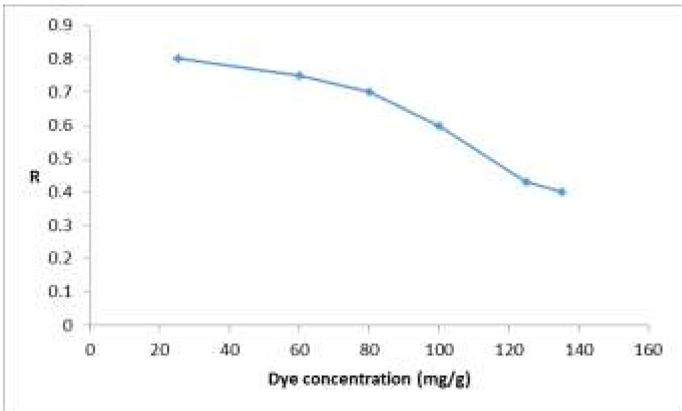


Figure 6: Removal efficiency of dye as a function of different initial concentration [dose=7.0 gm. pH=5.5, time=8h]

d. *Adsorption isotherm*

The b,q,n,k parameters and the regression correlation coefficients (R^2) for Langmuir and Freundlich isotherm are given in Table 2. The correlation coefficients indicate that adsorption data [Figure 7 and 8] was fitted better by the Langmuir (R^2 =0.99) than the Freundlich model (R^2=0.78). Therefore the adsorption product formed a monolayer coverage of dye on the WH surface.

Table 2: Isotherm model parameters for adsorption of dye on the wheat husk

Model	Constant.	Value
Langmuir model.	q_{max}(mg/g)	2.344
	b(L/mg)	6.365
	R^2	0.995
Freundlich model	K.	0.58
	n	3.044
	R^2	0.78

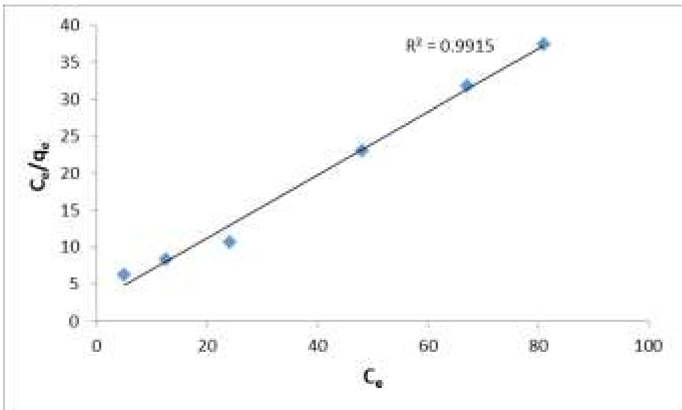


Figure 7: Langmuir isotherm model of dye onto the wheat husk

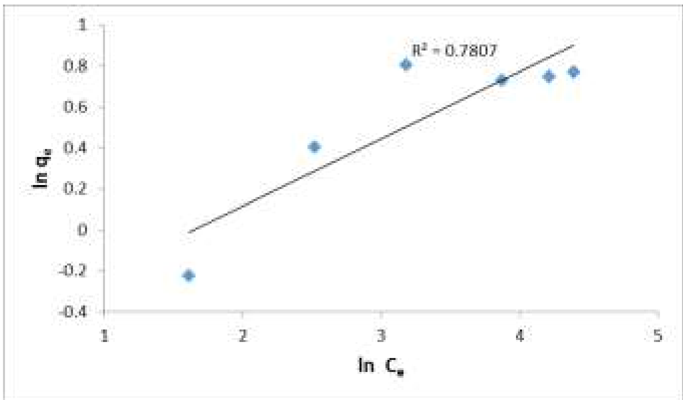


Figure 8: Freundlich isotherm model of dye onto the wheat husk

e. Adsorption kinetic

The results of kinetic models are in the Table 3. The correlation coefficients indicate that the kinetic data of the adsorbent [Figure 9 and 10] was fitted better to the pseudo-second-order kinetic model (R^2=0.9886) than the pseudo-first-order model (R^2=0.9844)

Table 3: Kinetic model parameters

Model	Parameters	Value
Pseudo-first order model	q_e(mg/g).	1.393
	K_1 (min).	0.444071
	R^2	0.9844
Pseudo-second order model	q_e(mg/g)	1.64
	K_2	1.67
	R^2	0.9886

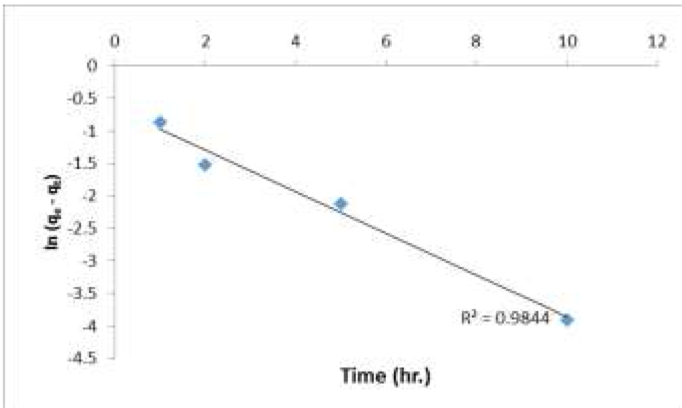


Figure 9: The Pseudo first-order kinetics plot for the adsorption of dye on the wheat husk

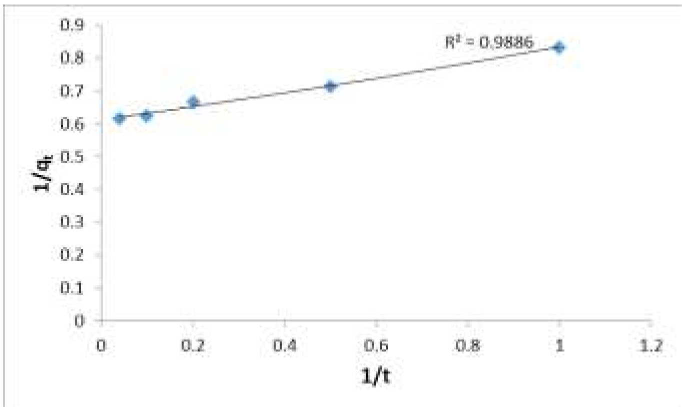


Figure 10: The Pseudo-second order kinetics for the adsorption of dye onto the wheat husk

6. Conclusions

This study demonstrates how sorbent prepared from wheat husk can remove the color from synthetic wastewater. It was found that color removal efficiency was achieved the maximum of a dose of 7.0 gm in 8 hr. The result of the PH study shows that the optimum pH value of the color removal from synthetic wastewater was pH 5.5. The adsorption isotherm data were explained well by Langmuir model (R^2=0.99). The kinetic of dye adsorption on to wheat husk reveals that dye adsorption data fitted well with pseudo-second model. These properties of WH make them ideal adsorbent for treatment of MG dye from wastewater, besides, to develop some environment-friendly and low-cost material is also the key work.

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