Al-Azhar Bulletin of Science, Section A, Vol. 33, No. 1 (June) 2022, pp. 1-13
http://doi.10.21608/absb.2022.105908.1152

Al-Azhar Bulletin of Science: Section A

BIO-WASTE AS ECO-FRIENDLY ADSORBENT FOR THE REMOVAL OF HAZARDOUS DYES

Fatema Al-Zahra Reda [a,*], Heba M. El Refay [b], Asrar Goma [b], Nagwa Badawy [b], Samia E. Abufarha[b], Abeer E. El-Sayed [b]

[a] PhD Candidate, Physical Chemistry, Faculty of science (Girls), Al-Azhar University, Cairo, Egypt.
[b] Department of Chemistry, Faculty of science (Girls), Al-Azhar University, Cairo, Egypt.
* Corresponding Author: fatemazhra6@gmail.com
Received: 13 Nov 2021; Revised: 03 Jan 2022; Accepted: 09 Jan 2022; Published: 01 Jun 2022

ABSTRACT

In recent years color removal from textile effluents on an industrial scale has received a lot of attention not only because of its potential toxicity but also because of its visibility issue. The current study investigated the use of Banana Peel (BP) as a low-cost adsorbent for Reactive Red 43 (RR43) and Malachite Green (MG) removal from aqueous solution. There are numerous color removal techniques, the most common of which is adsorption. The practical performance evaluation in a batch reactor is carried out due to its feasibility of operation. In our batch system, we looked at variables like initial dye concentration, contact time, adsorbent dose, and solution temperature. Thermodynamic, kinetic, and adsorption isotherm studies have all been evaluated. The adsorbent was characterized using different techniques. The equilibrium data was analyzed by Langmuir and Freundlich isotherm and showed a good fit with the Freundlich isotherm (R^2=0.964 for RR43,0.996 for MG). kinetic data were analyzed using pseudo-first order and pseudo-second order kinetic, the adsorption kinetics data were fitted to pseudo-second order kinetic with a good agreement with the intra-particle diffusion model. The parameters of thermodynamic including enthalpy ΔH°, entropy ΔS° and free energy ΔG° demonstrated that the adsorption process was feasible, spontaneous, and exothermic in nature. The results clarified that optimized conditions were (2.15, 6.3) solution pH for RR43 and MG respectively,10mg/L initial dye concentration, adsorbent dose 0.1 gm/20 ml, and adsorption time 80 min,100 min for RR43 and MG respectively, and (92.82% and 82.52%) of RR43 and MG were removed by BP at experimental optimum conditions. The experimental results show that BP has good potential as a bio-sorbent to remove the colour from textile effluent and as an alternate low-cost adsorbent.

Keywords: Dye color removal; adsorption; Banana Peel; adsorption isotherms; thermodynamics.

1. INTRODUCTION

The textile industry alone accounts for two-thirds of total dye material production. [1,2] The practical performance evaluation in a batch reactor is carried out due to its simplicity of operation, as well as the fact that it involves fewer economic aspects. The practical utility of leaf-based adsorbents for dye removal, as well as their potential applications in the treatment of industrial wastewater, is extensively emphasized [3]. The experimental results show that Banana Peel (BP) has good potential as a bio sorbent to remove the colour from effluent and as an alternate low-cost adsorbent. Dyes can also be toxic to aquatic life, mutagenic, carcinogenic, and dangerous to humans, including kidney, reproductive, liver, brain, and central nervous system dysfunction [4-6]. Because removing dyes from wastewater is regarded as an environmental challenge, there is a constant need for an effective process that can efficiently

remove these dyes. [7]. Conventional methods for removing dyes include adsorption, electrocoagulation, ultrafiltration, reverse osmosis, flocculation, oxidation, ion exchange, etc. [8,9]. Adsorption is an effective dye removal method for the removal of various dyes from water and wastewater [10], and it has a wide range of applications in wastewater treatment [11]. Natural adsorbents, such as agricultural waste, have been the most popular for wastewater treatment due to their availability and low cost [12-14].

The main goal of this paper is aimed at specifying the potentiality of banana peel, (Banana being a native and abundant fruit in Egypt) as bio sorbent for the removal of (RR) and (MG) dyes from a solution. Due to the chemical composition of the banana peel which contained a high amount of cellulose, pectin, hemicellulose, and lignin and contained various polar functional groups, including hydroxyl, carboxylic, and phenolic acid groups, it could serve as an adsorbent for dye removal [15-17]. BP is high in Gallo catechins, making it an excellent food source for preventing heart disease and cancer. [18]. The impact of different reaction conditions, such as the initial dye concentration, dosages, contact time, and adsorption temperature of the formulated adsorbent, as well as the kinetics, thermodynamic, and isothermal adsorption models were investigated to prove their effectiveness. The future of biosorption with respect to how productivity and efficiency can be increased with the advances in modern technology is also discussed.

2. MATERIALS AND METHODS

BP for the study was obtained from agricultural waste, (Egypt), RR43 (C.I. 179125), and MG. (C.I. 42000) dyes were purchased from Sigma Aldrich (USA), Egypt. Distilled water was used throughout the work and all reagents used in our analysis are of analytical grade and high purity.

2.1. Preparation of the Adsorbent

BP were removed and washed under running water to get rid of dirt and surface impurities. The sample was put in air drying for 3 days and then oven-dried for 24 hours at 100°. It was then ground into powdered and sieved using a 75 μm sieve and finally stored in an airtight plastic bottle labeled according to the sizes.

2.2 Preparation of Simulated Wastewater

To avoid interfering with other elements in actual wastewater, the experiments in this study were conducted using simulated synthetic aqueous solutions of various dyes. Simulated dye solutions of 1000 mg/L were prepared by accurately weighing 1.0g dye and dissolving it in 1000 ml distilled water. Following that, whenever another concentration was required, it was prepared by diluting the stock solution. Table 1 summarizes the properties of the two dyes.

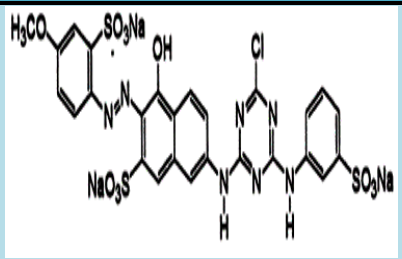
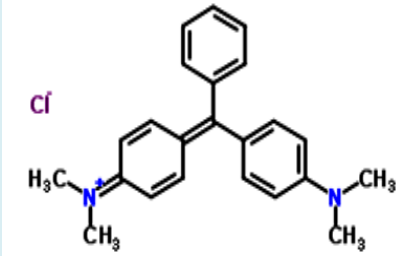
2.3. Characterization of Adsorbent

The adsorbent was characterized using Scanning Electron Microscope (SEM) in conjunction with Energy Dispersive X-ray (EDX) and Fourier-Transform Infrared Spectroscopy (FTIR).

2.3.1. Zero Surface Charges -The Characteristic Analysis of Banana Peel (BP).

The influence on the solution pH on the dye uptake can be explained on the basis of the pH zero-point charge or isoelectric point of the adsorbent. The value of the pH necessary to affect a net zero charge on a solid surface in the absence of specific sorption is called the point of zero charge, $pH_{ZPC.}$ The zero-surface charge of BP was determined by using the solid addition method [19]. The experiment was conducted in a series of 250 mL glass Stoppard flasks. Each flask was filled with 50 mL of different initial pH 0.01N KNO_3 solutions and 0.1 g of mixed nanocomposite. The pH values of the KNO_3 solutions were adjusted between 2 to 10 by adding either 0.1 M HCl or 0.1 M NaOH. The suspensions were then sealed and shaken for 48 h at 150 rpm. The final pH values of the supernatant liquid were noted. The difference between the initial pH (pHo) and final pH (pHf) values ($\Delta pH = pHo - pHf$) was plotted against the values of pHo. The point of

Table (1): Some of the physical properties of C.I. Reactive Red 43 and Malachite Green.

Dye name	Chemical formula	Molecular weight (g/mol)	Wavelength (nm)	Chemical Structure
RR43	$C_{26}H_{17}ClN_7Na_3O_{11}S_3$	804.07	503	
MG	$C_{23}H_{25}ClN_2$	364.9	617	

intersection of the resulting curve with abscissa, gave the pHzpc.

2.4. Batch Adsorption Studies

Batch adsorption experiments were carried out at 25°C to investigate the effect of key parameters such as pH, adsorbent dose, contact time (t), and initial dye concentration (C_o) on the adsorptive removal of RR43and MG dyes. The effect of solution pH was investigated using 0.1 M HCl and 0.1M NaOH solutions within a pH range of 2-10. To look into the effect of adsorbent dose, a dye solution of 20 ml of a known concentration was in contact with varying amounts of adsorbent from 0.05-0.5g/20ml, until equilibrium was reached. To determine the concentrations, various concentrations of each dye ranging 5-60 mg/L were prepared and calibration curves were plotted. At 25°C, all mixtures were agitated at a constant speed of 250 rpm in a temperature-controlled environmental orbital shaker incubator. All samples were centrifuged for 10 minutes before being analyzed for residual dye concentration. The absorbance of the RR43and MG was measured at 503,617 nm, respectively. The adsorption quantities have been evaluated from the modification of the concentration of the solution using the following equation [19]:

Percentage Removal (%R) =

$$\frac{C_0 - C_e}{C_0} x100 \quad (1)$$

The optimum time is calculated by plotting adsorption capacity versus time using the formula:

$$q_t = \frac{(C_0 - C_t)V}{W} \quad (2)$$

the amount of dyes adsorbed at equilibrium time is calculated using the formula:

$$q_e = \frac{(C_0 - C_e)V}{W} \quad (3)$$

C_o, C_t, and C_e represent the initial, time, and equilibrium concentrations of the dye (mg/L), respectively and W is the weight of the adsorbent (g), where V is the volume of dye solution (L). The results have been also analyzed by various adsorption isotherms incorporating Freundlich, Langmuir, and Temkin isotherms and simulated with different kinetic models, including pseudo first- order and pseudo second-order models.

3. RESULTS AND DISCUSSION

3.1. Characterization

The surface morphology of BP was characterized by using SEM before and after adsorption of RR43 and MG as shown in Figure (1). The micrograph revealed variations in the SEM of the raw BP, and the particles were densely packed, with no visible open porous surface. This is because pectin, lignin, and viscous compounds are present. [20]. The result indicated that before adsorption, BP is characterized with an irregular mesoporous compact structure comprising the different number of fine pores as provided in Figure (1a). The pores fill after the adsorption of dyes onto BP adsorbent, which can be observed in SEM image in Figures (1b and 1c) which authenticate the adsorption process.

Elemental analysis of adsorbent was carried out, to determine the percentage weight of chemical compositions available of the BP adsorbent through EDX analysis before and after the adsorption process of RR43 and MG dyes as shown in Figure (2). The highest amounts of carbon and oxygen corresponded to the BP composition, which proves the organic nature of the adsorbent.

FT-IR spectroscopy was used to evaluate the functional group and structural changes in the adsorbent. BP's FT-IR spectra matched the observations [21]. The FT-IR spectra of the dye loaded BP were provided in Figure (3). Because of the presence of acidic hydroxyl (OH) groups, a split band can be seen at 2856 cm^{-1}. In addition, the peaks in the range of 1580 to 1390 cm^{-1} are correlated to stretching vibration of C=O carbonyl group of Ketones & carboxylic acid group and stretching vibration of C=C of the aromatic ring. The peaks at 1033 and 874 cm^{-1} are due to C-O bending vibrations. However, the change in intensity and position of peaks in the FT-IR spectrum after MG and RR43 loading confirms the adsorption process.

3.2. Adsorption Preliminary Studies

To look into the interaction of the operational parameters for MG and RR43 dye removal on BP surface, a batch adsorption study was conducted.

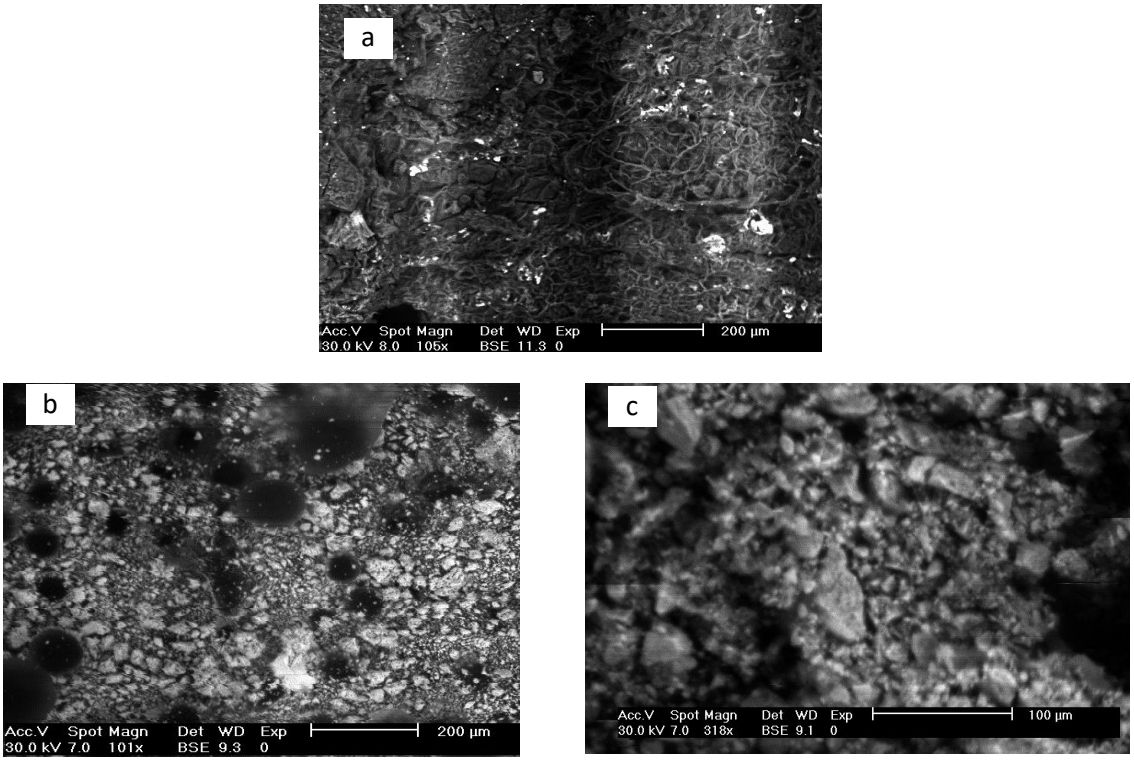


Fig. (1): SEM Images of BP before adsorption (a) and after adsorption process (b) RR43, (c) MG.

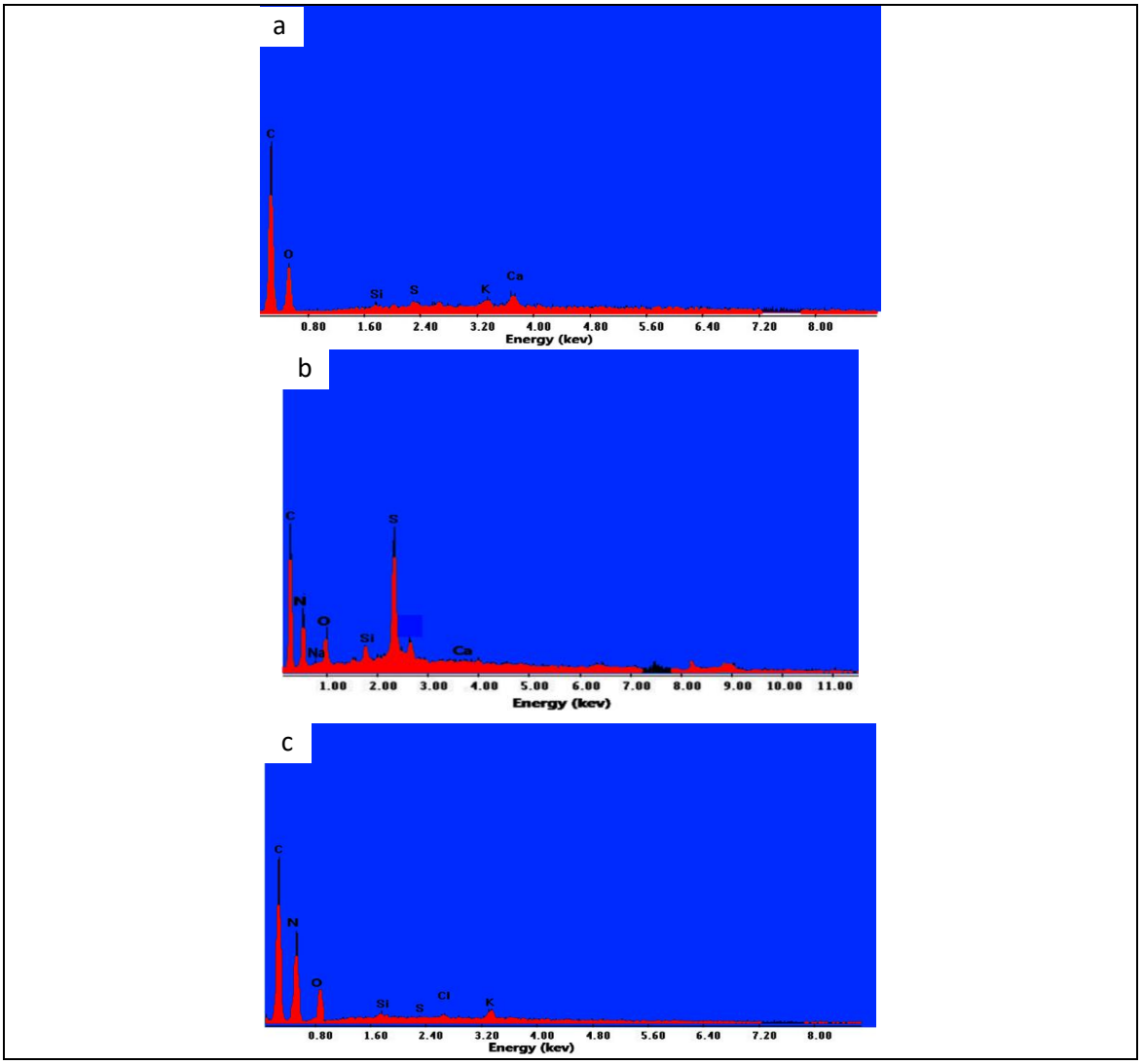


Fig. (2): EDX of (a) BP before adsorption, (b) BP adsorption of RR43, and (c)BP after adsorption of MG.

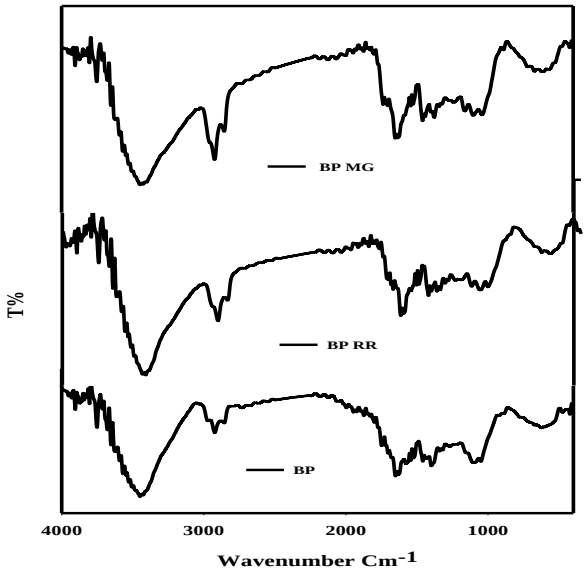


Fig. (3): FTIR spectra of BP adsorbent before and after RR43 and MG adsorption.

3.2.1. Effect of pH on adsorption

Figure (4a), it is clear that the point of zero charges (pHpz) of BP is 5.2. This result demonstrates that at a pH below 5.2, the surface of the BP shows positive charges, while at a pH above 5.2, the surface of the BP has a negative charge**.** When compared to other peels, the pHpzc value and surface pH of BP is closer to neutral pH. As a result, BP can be used to adsorb both cationic and anionic moieties.[22]**.** The effects of different initial solution pH values on the adsorption of RR43 and MG onto BP are shown in Figure (4b) and show that the adsorption of RR43 on BP increases as the solution's pH decreases while the adsorption of MG increase with increase solution's pH [23]. The charge on the adsorbent surface may be affected by the initial pH, altering its adsorption capacity [24]. At low pH (< $pH_{pzc,}$ i.e. <5.2) the

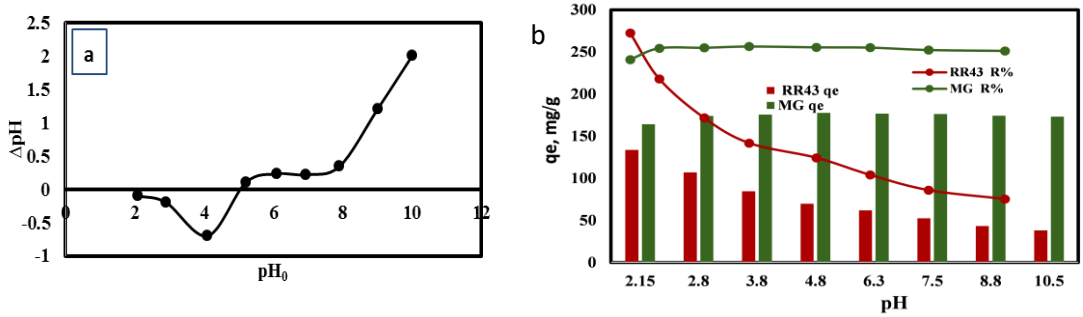


Fig. (4): (a) zero-point charge of BP adsorbents (b) effect of pH on Removal % and adsorption capacity.

adsorbent surface became highly protonated and was suitable for adsorption of anionic dye causing increased removal percentage of dye. Also, at high pH (> $pH_{pzc,}$ i.e. > 5.2) the surface of adsorbent more negative charge so suitable for adsorption of cationic dye as MG. the Incremental dye removal was not observed beyond pH 2.15 and was chosen for further investigation in the case of RR43 dye, but the optimum pH solution for MG dye is 6.3. The foregoing factors, sorption capacity decreased, resulting in a decrease in percentage adsorption., same observations were considered by other researchers [25-27].

3.2.2. Effect of Adsorbent Dose

Figure (5a) shows a plot of the percentage of adsorption versus adsorbent dose mass ranging from 0.05 to 0.5 g/20ml while keeping contact time at 100 minutes, dye concentration at 30 mg/L, and temperature at 25°C, pH 2.15 for RR43 and 6.3 for MG with agitation speed at 250 rpm. The percentage of dye adsorption by BP adsorbent was 31.82-92.8 percent for RR43 and 29 -88.7 percent for MG. Adsorption percentage increased with increasing the amount of adsorbent (g) from (0.05- 0.2g/20ml) due to increased binding site at higher amounts of adsorbent [28]. A gradual increase in the percentage adsorbed occurred as the adsorbent dose increased, and an additional increase in the adsorbent dose had no effect on dye removal. It has been reported elsewhere that as the adsorbent dose increases, the movement of dye ions to the energetic adsorption sites becomes restricted, resulting in decreased adsorption so the optimum adsorbent dose for all dyes is 0.1g/20ml. [28].

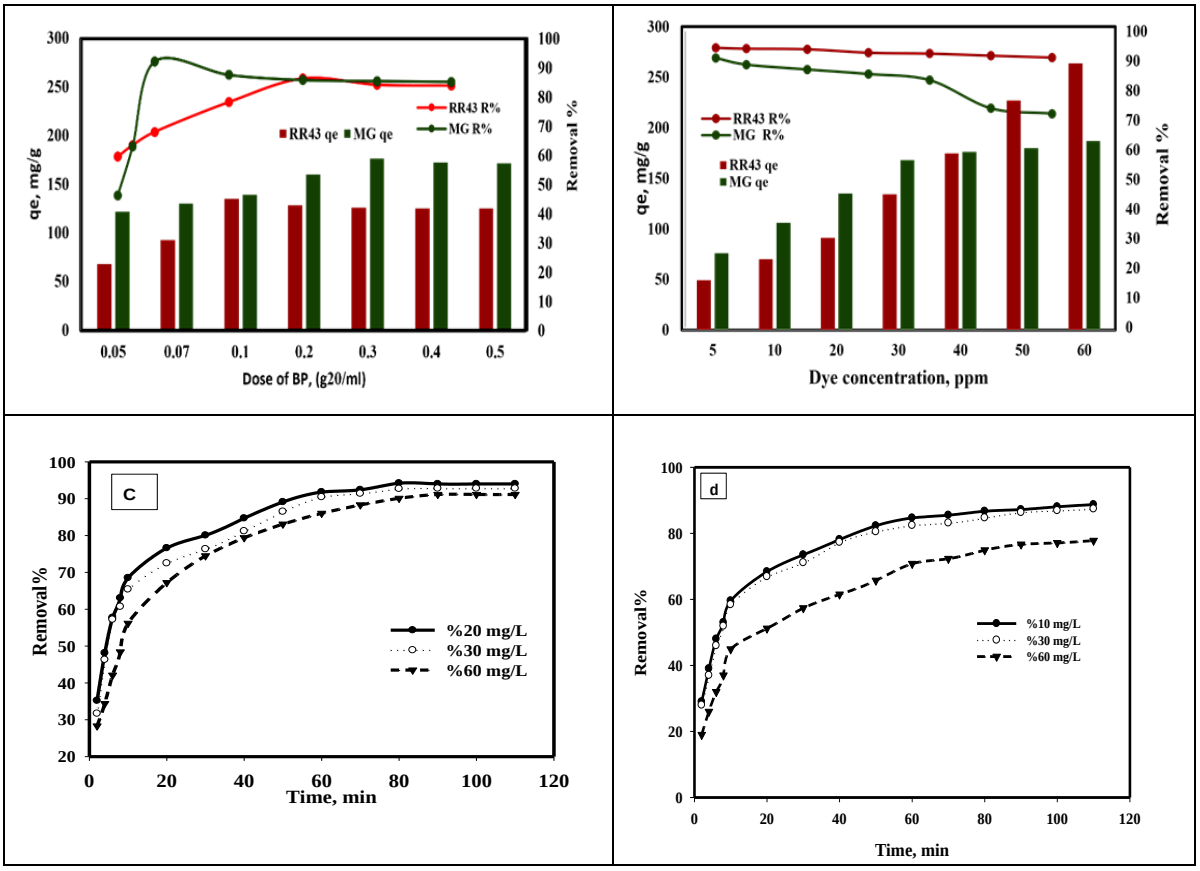
3.2.3. Effect of initial dye concentration. and contact time

From the Figure (5b), it is obvious that the removal percentage decreased with the increase in initial dye concentration. This phenomenon is attributed to the fact that the available sites for adsorption are higher at lower adsorbate concentrations. However, when the concentration is increased, the available sites become fewer [29].

The removal of the aqueous solution effluents is mainly dependent on their contact time with the adsorbent. According to the current research, the influence of time was investigated between 2 to 120 min and different concentrations, 10 to 60 mg/L. Figure (5 c, d) show effect of contact time on removal percentage. Rapid adsorption of dye in the first 20 min, the adsorption rate slowly increases to reach equilibrium in about 80 min for RR43 while 100 min for MG. This can be explained by the fact that the adsorption sites were vacant and easily accessible at the beginning so dye molecules could easily interact with these sites, but after 80, 100 min for RR43 and MG respectively, the removal of dye got constancy due to equilibrium establishment.

3.2.4. Effect of Temperature

We investigated the impact of temperature in this work on the adsorbed amount of RR43 and MG on BP between 30 and 50°C Figure (5e). This Figure shows that the amount of dye that has been adsorbed decreased slightly from 92.82 to 90.2 $mg.g^{-1}$ RR43 and from 87.52 to 82.9 $mg.g^{-1}$ for MG by increasing the temperature from 30 to 50°C. The adsorption capacity of BP decreases by increasing the temperature of the range studied, revealing that the adsorption of RR43 and MG on the BS is exothermic in nature.



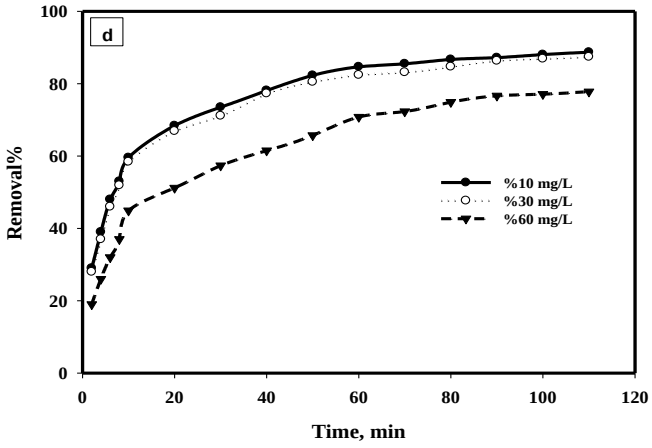


Fig. (5): Effects of different variables of (a) BP dose (b) dye concentration, (c. d) contact time on Removal % of (RR43, MG), and (e) temperature on adsorption efficiency.

3.2.5. Adsorption Kinetics

The kinetics of adsorption of different initial concentrations of RR43 and MG solutions were studied using pseudo-first-order, pseudo-second-order, and intra-particle diffusion models [30].

$$ln(q_e - q_t) = lnq_e - k_1 t \quad (4)$$

$$\frac{t}{q_t} = \left(\frac{t}{q_e}\right) + \left(\frac{1}{k_2 q_e^2}\right) \quad (5)$$

$$q_t = k_p t^{1/2} + C \quad (6)$$

where q_e ($mg.g^{-1}$) is equilibrium amount of RR43 and MG adsorbed; q_t ($mg.g^{-1}$) is the amount of RR43 and MG adsorbed at time t; k_1 (min^{-1}), k_2 ($g.(mg.\ min)^{-1}$), and k_{int} ($mg.(g.min^{0.5})^{-1}$) are the rate constants of the pseudo first-order, pseudo-second-order and intra-particle diffusion models, respectively, Figure (6) depicts the kinetic curves of RR43 and MG adsorption onto BP, Table (2) contains the parameters also confirm that the pseudo-second order kinetic model better fits the adsorption, the results of the intra-particle diffusion model $R^2 < 0.71$ and $C \neq 0$, indicating that intra-particle diffusion was not the only rate-limiting step [31].

3.2.6. Adsorption Isotherm

Equilibrium data, also known as adsorption isotherms, are essential for the design of adsorption systems. These data provide information on the adsorbent's capacity, or the amount needed to remove a unit mass of pollutant under system conditions. Langmuir, Freundlich and Temkin's equations were employed to study the adsorption isotherms of the dye**.**

Therefore, the Langmuir isotherm model was chosen for estimation of the maximum adsorption capacity corresponding to complete mono-layer coverage on BP surfaces. The experimental data are analyzed according to the linear form of the Langmuir isotherm equation.

Langmuir isotherm: can be obtained by following equations [32-34].

$$q_e = \frac{Q_0 b C_e}{(1+bC_e)} \quad (7)$$

$$\frac{1}{q_e} = \frac{1}{Q_0} + \frac{1}{b} Q_0 C_e \quad (8)$$

Where qe is the amount of dye adsorbed per unit weight of adsorbents. Ce denotes the adsorbate concentration at equilibrium (mg/L). Langmuir constants, Qo and b, to maximum adsorption capacity and energy of adsorption, respectively. When m/x or 1/qe is plotted against 1/Ce, a straight line with slope 1/b Qo and intercept 1/Qo is obtained. The fundamental properties of a Langmuir isotherm can be expressed in terms of a dimensionless separation factor, R, which describes the type of isotherm and is defined as the following equation:

$$R_L = \frac{1}{(1 + bC_0)} \quad (9)$$

Freundlich isotherm: can be obtained by following equations [31].

$$Q = K_f C_e \left(\frac{1}{n}\right) \quad (10)$$

$$logq_e = logK_f + \frac{1}{n} logC_e \quad (11)$$

where K_f and n are the Freundlich constants related to adsorption capacity and intensity, respectively. A value of n between 1 and 10, indicates favorable and good adsorption. as shown in Table 3.

Temkin Isotherm: It is based on the heat of adsorption in which all layers of molecules decrease linearly when the lowest and highest concentration values

$$q_e = BlnAT + Bln\,C_e \quad (12)$$

where A is the Temkin equilibrium binding constant ($L\ g^{-1}$) and B is the Temkin isotherm constants B = RT/b, and T denotes temperature (K).

The Langmuir, Freundlich and Temkin were also an important relationship describing the sorption of solutes from a liquid to a solid surface. The calculated constants of each method and the results of correlation coefficients R^2predicted from these models for the removal of RR43 and MG dyes by BP were collected in Table 3. The correlation coefficients reported in the table showed strong positive evidence on the adsorption of the dye onto the adsorbent follows the Freundlich isotherm represents the best fit of experimental data.

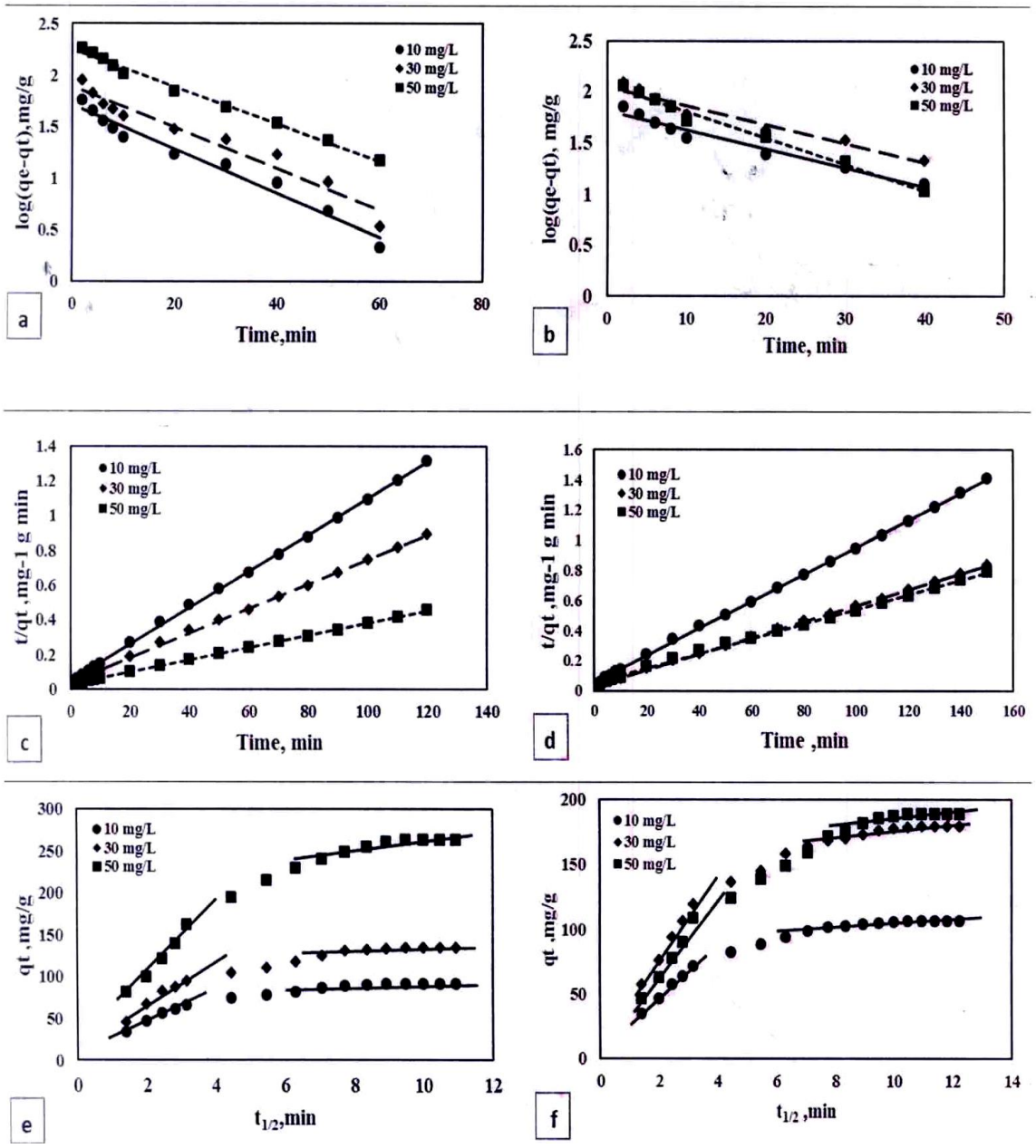


Fig. (6): (a, b) Pseudo-First-order kinetic, (c, d) Pseudo-Second-order kinetic, and (e, f) Intraparticle Diffusion of RR43 and MG respectively for adsorption of the RR43 and MG onto BP. at concentration 10 mg/L, 30 mg/L and 50 mg/L.

Table (2): Kinetic parameters for the adsorption of RR43 and MG onto BP.

Parameters / Dye	Conc. mg/L	Pseudo- First- order			Pseudo-Second- order						Intraparticle diffusion model					
		k_1 min^{-1}	$q_{e\,(cal)}$ $mg.g^{-1}$	R^2	k_2 min^{-1}	$q_{e\,(exp.)}$ $mg.g^{-1}$	$q_{e\,(cal.)}$ $mg.g^{-1}$	H	NSD	R^2	k_1	C_1	R^2	k_2	C_2	R^2
RR43	10	0.049	50.79	0.872	$2.24x10^{-3}$	91.37	95.24	20.32	0.58	0.999	18.51	9.11	0.992	2.69	65.26	0.856
	30	0.046	78.09	0.851	$1.32x10^{-3}$	134.19	140.85	26.19	0.66	0.998	27.88	9.47	0.969	4.72	88.14	0.585
	50	0.042	176.81	0.891	$4.45x10^{-4}$	263.61	285.71	14.81	0.92	0.999	45.91	12.26	0.980	10.48	160.30	0.898
MG	10	0.041	109.92	0.871	$8.26x10^{-4}$	106.15	185.19	18.52	68.09	0.999	20.80	0.11	0.997	5.12	120.70	0.840
	30	0.041	110.92	0.882	$8.34x10^{-4}$	179.00	188.68	29.69	71.87	0.999	35.70	5.85	0.998	5.15	123.00	0.861
	50	0.040	98.67	0.892	$1.01x10^{-3}$	188.86	196.06	19.20	109.70	0.999	34.73	14.47	0.996	4.60	138.64	0.854

3.2.7. Adsorption Thermodynamics

The following equations can be used to calculate thermodynamic parameters such as Gibbs free energy ΔG^{o}, enthalpy ΔH^{o} and entropy $\Delta S°$ at different temperatures, 30, 40 and 50 °C.

$$\ln K_d = \Delta S° R - \Delta H° RT \quad (13)$$

$$\ln G° = \Delta H° - T\Delta S° \quad (14)$$

where Kd = q_e/C_e is the distribution coefficient, R is the universal gas constant and T is the temperature in (*K*) [19]. The values of $\Delta G°$, $\Delta H°$, and $\Delta S°$ were calculated by plotting the Figure (8) and are listed in Table (4). This result indicated that the magnitudes of Gibbs free energy practically remained constant during the

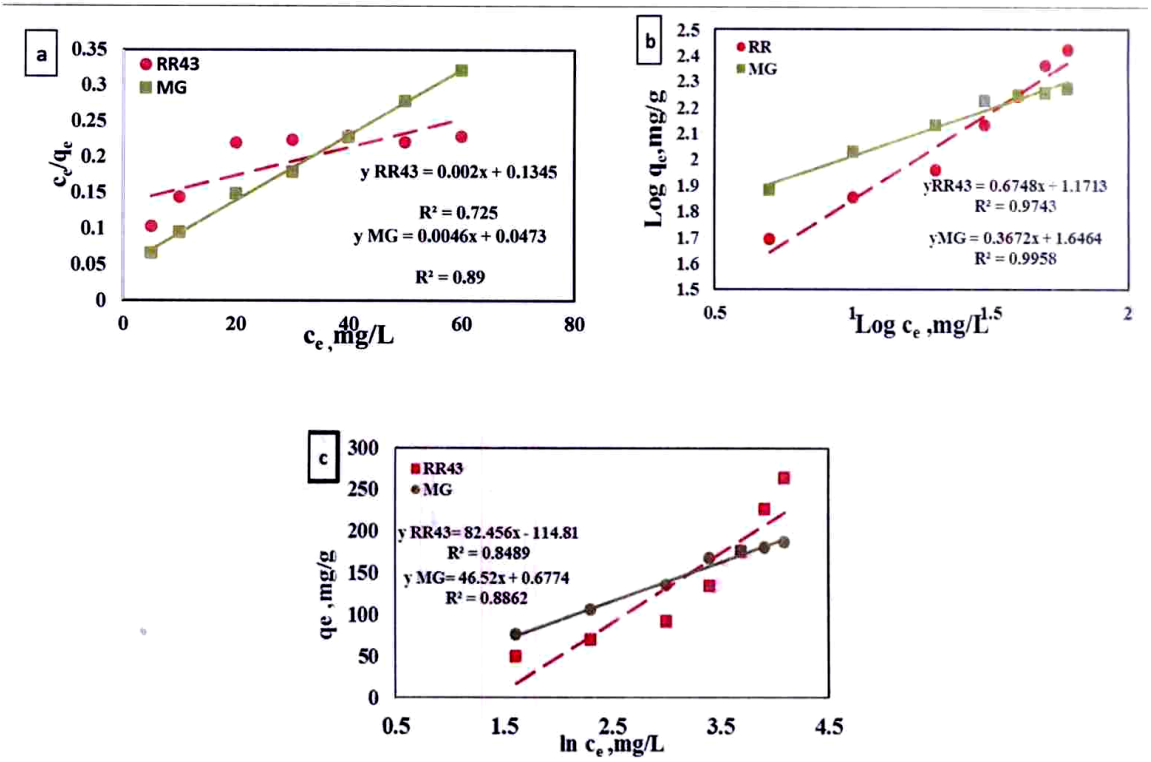


Fig. (7): (a) The Langmuir, (b) Freundlich and (c) Temkin isotherm model by BP.

parameter / Dye	Langmuir Isotherm				Freundlich Isotherm			Temkin		
	b (L/mg)	Q_0 (mg .g^{-1})	R_L	R^2	K_f (L/mg)	n	R^2	A	B	R^2
RR43	0.001	5000	0.995-0.997	0.725	4.920	1.028	0.964	4.020	30.55	0.849
MG	0.997	217.4	0.771-0.894	0.897	44.30	2.720	0.996	1.020	53.31	0.886

Table (4): Thermodynamic Parameters of RR43 and MG onto BP at different temperatures

Temp.°C / Adsorbents	30	40	50	ΔH° (kJ/mol)	ΔS° (kJ/mol)
RR43	ΔG° (kJ/mol)				
	-19.798	-20.158	-20.518	-8.89	0.036
MG	-15.25	-15.43	-15.55	-11.65	0.0121

adsorption process. The negative $\Delta G°$ values show that the RR43 and MG adsorption processes on BP are feasible and spontaneous. The negative value of $\Delta H°$ suggests that the adsorption process is exothermic and chemical in character, involving significant forces of attraction between RR43 or MG molecules and BP. The positive $\Delta S°$ value indicates the increased randomness at the solid- liquid interface during the fixation of the RR43 and MG on the active sites of the studied adsorbent.

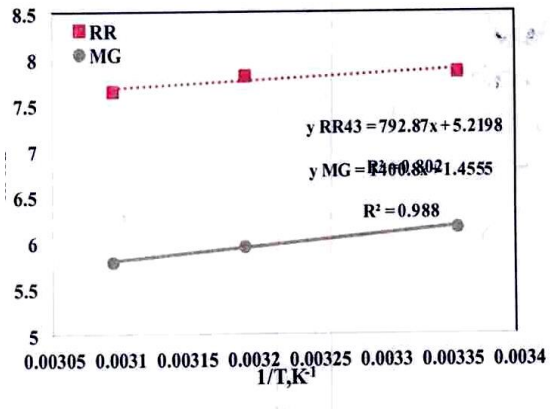


Fig. (8): Thermodynamic of RR43 and MG onto BP

4. CONCLUSION

In this study MG and RR43 were removed from simulated wastewater using BP. The adsorption process was strongly pH dependent, as the higher removal percentage at pH=2.15 for RR43 dye, and 6.3. for MG dye. The effect of contact time shows rapid adsorption of dye in the first, followed by a gradual increase in adsorption rate to reach equilibrium in about 90 minutes. According to the thermodynamic parameters, the adsorption process was feasible, spontaneous, and exothermic, with increasing order at the adsorbent–solution interface. According to this study, the adsorption process of color is suited to the Freundlich model rather than the Langmuir model. Furthermore, adsorption kinetic of the color showed that pseudo-second order fit better than pseudo first-order kinetic model. From the obtained data we concluded that BP can be used as a good low-cost naturally adsorbent material for many anionic and cationic dyes.

REFERENCES

[1] Azhar SS, Liew AG, Suhardy D, Hafiz KF, Hatim MDI. Dye removal from aqueous solution by using adsorption on treated sugarcane bagasse. Appl. Sci.2005; 23:21-26.

[2] Garg VK, Kumar R, Gupta R. Removal of malachite green dye from aqueous solution by adsorption using agro-industry waste: a case study of Prosopis cineraria. Dyes Pigm.2004; 62:1-9.

[3] Karthik V, Saravanan K, Bharathi P, Dharanya V, Meiaraj C. An overview of treatments for the removal of textile dyes. Chem. Pharma. Sci.2014; 7: 301-307.

[4] Kadirvelu K, Kavipriya M, Karthika C, Radhika M, Vennilamani N, Pattabhi S. Utilization of various agricultural wastes for activated carbon preparation and application for the removal of dyes and metal ions from aqueous solutions. Biores. Technol.2003; 87: 129-132.

[5] Dinçer AR, Günes Y, Karakaya N, Günes E. Comparison of activated carbon and bottom ash for removal of reactive dye from aqueous solution. Biores. Technol.2007; 98: 834-839.

[6] Shen D, Fan J, Zhou W, Gao B, Yue Q, Kang Q. Adsorption kinetics and isotherm of anionic dyes onto organo-bentonite from single and multisolute systems. Hazard. Mater.2009; 172: 99-107.

[7] Lee JW, Choi S P, Thiruvenkatachari R, Shim WG, Moon H. Evaluation of the performance of adsorption and coagulation processes for the maximum removal of reactive dyes. Dyes Pig.2006; 69: 196-203.

[8] Elkony AM, Ibrahim AG, Abu El-Farah MH, Abdel-Hai F. Synthesis and characterization of (AAm-co-AHPS)/MMT hydrogel composites for the efficient capture of methylene blue from aqueous solution. Al-Azhar Bulletin of Science. 2020; 31: 31-36.

[9] Basri Senturk H, Ozdes D, Duran C. Biosorption of Rhodamine 6G from Aqueous Solutions onto Almond Shell (Prunus dulcis) as a Low Cost Biosorbent. Desalination. 2010; 252: 81-87.

[10] Daneshvar E, Sohrabi MS, Kousha M, Bhatnagar A, Aliakbarian B, Converti A, Norrstrom AC. Shrimp shell as an efficient bio sorbent for Acid Blue 25 dye removal from aqueous solution. Taiwan Inst Chem. 2015; 45: 2926-2934.

[11] upta VK, Suhas A. Application of low–cost adsorbents for dye removal – A review. Environ Manag.2009; 90:2313-2342.

[12] Nahali L, Miyah Y, Assila O, El Badraoui A, El Khazzan B, Zerrouq F. Kinetic and

thermodynamic study of the adsorption of two dyes brilliant green and eriochrome black T using a natural adsorbent sugarcane bagasse. Mor. Chem.2019; 7: 715-726.

[13] Thai AN, Vinh TN, Thi T, Hieu T, Thi QNL, Nhat HN Batch and column adsorption of reactive dyes by eggshell powder–chitosan gel core-shell material. Mor. Chem.2021; 9: 18-27.

[14] El maguana Y, Elhadiri N, Benchanaa M, Chikri R. Adsorption Thermodynamic and Kinetic Studies of Methyl Orange onto Sugar Scum Powder as a Low-Cost Inorganic Adsorbent. Hinda. Chem.2020; 2020: 10 pages

[15] Someya K, Yoshiki S, Okubo Y. Antioxidant compounds from bananas (Musa Cavendish). Food Chem.2002; 79: 351–354.

[16] Sulaiman A, Yusoff SF, Eldeen NAM, Seow IM, Sajak EM, Ooi KL. Correlation between total phenolic and mineral contents with antioxidant activity of eight Malaysian bananas (Musa sp.). Food Compos. Anal.2011; 24: 1–10.

[17] Emaga M, Robert TH, Ronkart C, SWathelet N, Paquot B. Dietary fiber components and pectin chemical features of peels during ripening in banana and plantain varieties. Bio. Reso. Technol.2008; 99: 4346–4354.

[18] Someya S, Yoshiki Y, Okubo K. Antioxidant compounds from bananas (Musa Cavendish). Food Chem.2002; 79: 351–354.

[19] Abeer AE, Mohamed AA. Removal of some advanced dyes from aqueous solution using modified kaolinite clay. Al-Azhar Bulletin of Science.2020; 31: 59-68.

[20] Ali A, Saeed K, Mabood F. Removal of chromium (VI) from aqueous medium using chemically modified banana peels as efficient low-cost adsorbent. Alexandria Eng.2016; 55: 2933–2942.

[21] Memon JR, Memon SQ, Bhanger MI, Memon GZ, El-Turki A, Allen GC. Characterization of banana peel by scanning electron microscopy and FT-IR spectroscopy and its use for cadmium removal. Colloids Surf.2008; 66: 260–265.

[22] Pranav DP, Sachin AM, Bhaskar DK. Fruit peel waste: characterization and its potential uses. Current Science.2017; 113: 3-9.

[23] Mckay G, Otterburn MS and Sweeney AG. The removal of colour from effluent using various adsorbents Silica: Equilibri and column studies. Water Res.1980; 14: 21-27.

[24] Annadurai G, Juang RS, Lee DJ. Use of cellulose-based wastes for adsorption of dyes from aqueous solutions. Hazard Mater. 2002; 92: 263-274.

[25] Abbas FS. Dyes removal from wastewater using agricultural waste. Adv. Enviro. Bio.2013; 28: 1019-1027.

[26] Elmoubarki R, Mahjoubi FZ, Tounsadi H, Moustadraf J, Abdennouri M, Zouhri A, El Albani A, Barka N. Adsorption of textile dyes on raw and decanted Moroccan clays: Kinetics, equilibrium and thermodynamics. Water Reso. Indus.2015; 9: 16-29.

[27] Fytianos K, Voudrias E, Kokkalis E. Sorption–desorption behavior of 2,4–dichlorophenol by marine sediments. Chemosphere.2000; 40: 3-6.

[28] Abdur Rahman FB, Akter M, Zainal AM. Dyes removal from textile wastewater using orange peels. Int. Sci. Technol. Res.2013; 2: 47–50.

[29] Khan S, Ali TA, Singh I, Sharma VV. Utilization of Fly Ash as Low-Cost Adsorbent for the Removal of Methylene Blue, Malachite Green, and Rhodamine B Dyes from Textile Wastewater. Environ. Prot. Sci.2009; 3: 11–22.

[30] Saucier C, Karthickeyan P, Ranjithkumar V. Efficient removal of amoxicillin and paracetamol from aqueous solutions using magnetic activated carbon. Enviro. Sci. Poll. Rese.2017; 24: 5918–5932.

[31] Wu FC, Tseng RL, Juang RS. Characteristics of Elovich equation used for the analysis of adsorption kinetics in dye-chitosan systems. Chem. Engine.2003; 150: 366–373

[32] Rachakornkij M, Ruangchuay S, Teachakulwiroj S. Removal of reactive dyes from aqueous solution using bagasse fly ash. Chem. Engine.2004; 26: 13-24.

[33] Shahbeig H, Bagheri N, Ghorbaman SA, Hallajisani A, Poorkarimi S. A new adsorption isotherm model of aqueous solution of granular activated carbon. Mod Sim .2013; 9: 243-254.

[34] Panahi HA, Shakerin N, Zolriasatain F, Panahyab A, Moniri E. Adsorption of brilliant green by poly (ethylene terephthalate) grafted acrylic acid/acrylamide fiber-isotherm study. Eur. Exp Bio.2013; 3: 215- 220.

طريقة جديدة لتطبيق النفايات الحيوية كممتزات صديقة للبيئة لإزالة الصبغة الخطرة من المرحلة المائية.

فاطمة الزهراء رضا [1] ، هبة الرفاعي [2] ، اسرار جمعة [2] ،
نجوي بدوي [2] ، سامية الحسيني ابو فرحة [2] ، عبير إمام السيد [2]

1. باحثة دكتوراه، كيمياء فيزيائية، قسم الكيمياء، كلية العلوم فرع البنات، جامعة الأزهر، القاهرة، مصر
2. قسم الكيمياء كلية العلوم فرع البنات جامعة الأزهر، القاهرة، مصر

الملخص:

اليوم، أصبحت إزالة اللون من مياه الصرف الصحي مصدر قلق، سواء من الناحية الجمالية أو من وجهة النظر الصحية. لقد حظي اللون الذي تمت إزالته من مخلفات النسيج السائلة على نطاق صناعي مستمر باهتمام كبير في السنوات القليلة الماضية، ليس فقط بسبب سميته المحتملة ولكن أيضًا بسبب مشكلة الرؤية بشكل أساسي. في هذه الدراسة، فإن استخدام الممتزات منخفضة التكلفة، والمتوفرة بكثرة، وذات الكفاءة العالية، والصديقة للبيئة، قابلية تطبيق قشر الموز (BP) كممتاز منخفض التكلفة لإزالة الملكيت الأخضر الموجب (MG) والأحمر التفاعلي 43 تمت دراسة (RR43) من محلول مائي. هناك العديد من تقنيات إزالة اللون التي تحظى بشعبية عملية الامتزاز. تم تطبيق العديد من تقنيات الإزالة. لكن عملية الامتزاز غير مكلفة ومتاحة بسهولة للتحكم في الملوثات المختلفة من المياه ومياه الصرف. يتم إجراء تقييم الأداء العملي في المفاعل الدفعي بسبب جدواه وبساطته في العمل، كما يتضمن جوانب اقتصادية أقل. في تجاربنا، تم تحليل معلمات مختلفة مثل تركيز الصبغة الأولي، ووقت التلامس، وجرعة الممتزات ودرجة حرارة المحلول في نظام دفعي، وبالمثل، تم تقييم دراسات الديناميكا الحرارية، والحركية، ومتساو الامتصاص. تم إجراء توصيف المادة الماصة باستخدام (SEM) إلى جانب تقنيات EDX و .(FTIR) تم تسليط الضوء بشكل كبير على الفائدة العملية للممتصات القائمة على الأوراق لإزالة الصبغة، واستخداماتها المحتملة في معالجة مياه الصرف الصناعي. تظهر النتيجة التجريبية أن (BP) كمادة ماصة حيوية لديها إمكانية جيدة لإزالة اللون من النفايات السائلة وإمكانية جيدة كممتاز بديل منخفض التكلفة.

.