



Mordant Yellow 12 Dye Removal from Wastewater Using Low Cost Modified Sugarcane Bagasse as an Adsorbent

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Abstract

The adsorption behavior of mordant yellow 12 (4-amino phenyl azo salicylic sodium salt) (MY12) from aqueous solutions using low cost adsorbent citric acid or tartaric acid treated Sugarcane bagasse (SCB) was carried out. The experimental results have been investigated according to Langmuir and Freundlich isotherms. The effect of initial concentration of the dye, biosorbent dosage, temperature, contact time and pH were involved in the experiments. It was reported that the maximum removal percentage of MY12 was 95.2 % at pH 2.8 and contact time 40 minutes. The removal percentage decreases, as the concentration of the dye increases. Similar trend was found with the pH factor. The maximum biosorption capacities q_e of MY12 by SCB was 8.2 mg g⁻¹. It was concluded that; bagasse can be used as an efficient adsorbent material for the removal of organic dyes from aqueous solutions.

Keyword: *Adsorption, MY12, Sugarcane Bagasse, Citric and Tartaric acid.*

1. Introduction

Large amounts of pollutant water have been produced by different industries. These industries cause severe water pollution with organic pollutants, acids, bases, heavy metal ions and dyes etc. Dyes have complex aromatic molecular structure and are usually resistant to light, temperature and oxidizers. So it causes bioaccumulation in living organisms, resulting in severe diseases like hypersensitivity ^[1], mutagenic and oncogenic effects ^[2], allergy and asthma ^[3], skin eczema ^[4] and immunosuppression ^[5]. Overall, at present there are more than 100,000 commercial dyes -with a rough estimated production of 7105–

1106 tons per year^[6,7]. It is recorded that, 10–15 % of the used dyes contaminate the environment through wastes^[8]. Dyes are considered a dangerous type of pollutant because they are toxic^[9, 10]. Several methods of dye transmission to human were recorded such as, oral ingestion, inhalation, skin and eye contact, skin sensitization leading to problems as skin irritation and sensitization^[11]. Dyes are the important type of industrial pollutants^[12-14] including textile effluent. Adsorption using activated carbon is the most efficient method for the removal of synthetic dyes from aqueous effluents^[15]. Recently many authors have attempted to use natural waste as adsorbents due to the high cost of activated carbon^[16]. Some of these alternative materials like banana pith, vine, eucalyptus bark, neem leaves, luffa cylindrical fiber, sunflower seed hull, soybean hull, hazelnut shell, neem saw dust, agricultural waste byproducts and teak wood bark were used as adsorbents for the purification of waste water^[17-21]. Various adsorbents have been proposed for the removal of dyes from aqueous solutions^[22-25]. A number of residues are obtained in the sugarcane milling process including bagasse^[26] which is the residue left after crushing the sugarcane stalks for extraction of the sucrose-rich juice and it is a highly promising lignocellulosic feedstock^[27]. Over the years, large amounts of bagasse have accumulated due to the expansion of sugarcane crops^[28]. Hence, sugarcane bagasse (based on lignin) is a suitable and economically attractive alternative for textile effluent and dye extraction. The previous methods for treating dye containing wastewaters are coagulation and flocculation, reverse osmosis and activated carbon adsorption^[29]. Utilization of industrial solid wastes for the treatment of wastewater from another industry could be useful not only to environment in solving the solid waste disposal problem, but also the economy. There is an increasing interest in using low cost, commercially available materials for the adsorption of dye colors. A large variety of low cost materials, such as clay minerals^[30], bagasse pith^[31], wood^[32], maize cob^[33] and

peat^[34], are being tried as viable substitutes for activated carbon to remove dyes from colored effluents. In this study, the adsorption of MY12 from an aqueous solution on modified sugarcane bagasse particles was investigated.

2. Materials and Methods

2.1. Instruments

The instruments used during the study were;

1. UV- visible spectrophotometers (Nicolet Evolution 100)
2. Jenway 3540 pH & Conductivity Meter.
3. Oven dryer (DHG 9030)

2.2. Materials

Stock solutions of 200 ppm of Mordant yellow 12 (MY12) were prepared using double distilled water (0.05 g Mordant yellow 12/250 ml distilled water). Sugarcane bagasse was treated with 4 % citric acid and 4 % tartaric acid. The pH values were adjusted by using 0.1 M sodium hydroxide (NaOH) or 0.1M hydrochloric acid (HCl).

2.2.1. Preparation of Sugarcane Bagasse

Sugarcane bagasse was obtained from Assiut city, Egypt. These samples were washed several times using tap and bidistilled water to eliminate dust, impurities and other unwanted chemicals and then dried at 105 °C for 48 hours. Bagasse was powdered in an agate mortar and sieved through a nylon sieve to obtain the suitable size of fractions for each sample. The average particle size was 0.71 mm, then SCB was treated with 4 % citric acid or 4 % tartaric acid.

2.2.2. Treatment of SCB by citric acid and tartaric acid

Chemical modification of SCB by 4 % citric acid or 4 % tartaric acid was done. The biomass was mixed with citric acid 4 % or tartaric acid 4 % in the ratio of 12 g of the acid anhydrous in 300 ml distilled water to 30 g of

SCB, the modified powder was dried at 100 °C overnight. This modification stabilizes the biomass due to insertion and crosslinking of carboxyl groups and increases its dye uptake ability^[35]

2.3. Adsorption measurements

2.3.1. Preparation of solutions

Aqueous stock solutions of 200 ppm of MY12 were prepared using double distilled water by carefully weighting out 0.05 g and it was dissolved in a 250 ml-volumetric flask and completed with distilled water to the mark. Dilution was made to prepare different initial concentrations.

2.3.2. Batch biosorption experiments

2.3.2.1. Calibration curve of Mordant yellow 12

The absorbance of 20 ml of different concentrations (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60 and 80 ppm) of MY12 was recorded at 360 nm.

2.3.2.2. Effect of initial MY12 concentration

20 ml of MY12 solution of different initial concentrations (10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 ppm) was added to 0.2 g of modified biosorbent with 4 % citric acid or 4 % tartaric acid in 250 ml-flat bottom bottle at 25⁰ C and the mixture was stirred on shaker at 300 rpm for 15 min. Then the absorbance was recorded at a wavelength of 360 nm.

2.3.2.3. Effect of pH

At different initial pH values (1-12) biosorption experiments were carried out using 0.1 M sodium hydroxide or 0.1 M hydrochloric acid. Also 20 ml of MY12 solution of initial concentration 50 ppm was added to 0.2 g of biosorbent at 25⁰ C and the mixture was stirred on shaker at 300 rpm for 15 min.

2.3.2.4. Effect of biosorbent dosage

In each biosorption experiment, 20 ml of MY12 solution of initial concentration 50 ppm was added to different dosage of biosorbent (0.02, 0.03, 0.05, 0.07, 0.1, 0.12, 0.15, 0.2 and 0.2 gm) in 250 ml-flat bottom bottle at 25⁰ C and the mixture was stirred on shaker at 300 rpm for 15 min.

2.3.2.5. Effect of contact time and kinetics study analysis

20 ml of MY12 solution of initial concentration (20, 50 and 80 ppm) was added to 0.2 g of the biosorbent in 250 ml-flat bottom bottle at 25⁰ C and the mixture was stirred on shaker at 300 rpm with a contact time (5, 10, 20, 30, 40, 60, 90 and 120) min. The mechanism of the adsorption of MY12 was tested using pseudo first order and pseudo second order kinetic models.

2.3.2.6. Effect of temperature

Effect of temperature on the biosorption of MY12 solution was studied at different temperatures. 20 ml of MY12 solution of initial concentration (20, 50 and 80 ppm) was added to 0.2 g of the biosorbent in 250 ml-flat bottom bottle at different temperatures (25, 30, 40 and 60 ⁰C) and the mixture was stirred on shaker at 300 rpm for 15 min. The mixture was centrifuged after each experiment then the concentration of the filtrate (MY12) was determined using UV spectrophotometer.

2.3.2.7. Calculation of MY12 dye uptake

The MY12 uptake at equilibrium was calculated by the following equation:

$$q_e = V (C_o - C_e) / W \quad (1)$$

Where q_e is MY12 biosorption capacity in mg g⁻¹, V is the volume of the MY12 solution in liters and W is the amount of biosorbent in gram, C_o and

C_e are initial and final (equilibrium) dye concentrations in mg L^{-1} , respectively.

The removal efficiency of the dye was also determined using the following equation:

$$\text{R.E \%} = (C_o - C_e) / C_o * 100 \quad (2)$$

Where R.E % is the percentage of dye removed

2.3.2.8. Adsorption isotherms

Mathematical model equations such as Langmuir isotherm model and Freundlich isotherm model were used to describe the distribution of dye between the liquid and the solid phases. The Langmuir parameters are determined from the linear form Langmuir isotherm following equation.

$$C_e/q_e = 1/(q_m * b) + C_e / q_m \quad (3)$$

Where C_e (mg L^{-1}) sorbate concentration at equilibrium in solution, q_e the amount of dye adsorbed at equilibrium (mg g^{-1} adsorbent). b (L mg^{-1}), q_m is maximum amount of sorbate per unit mass of sorbent when all sites are occupied (mg g^{-1}) where b and q_m are the Langmuir constant related to energy and the adsorption capacity, respectively. $K = b =$ equilibrium adsorption constant related to the affinity of the binding of the sorption.

The essential characteristics of Langmuir isotherm can be expressed in terms of a dimensionless equilibrium parameter (R_L), defined by

$$R_L = 1 / (1 + k C_o) \quad (4)$$

R_L is the separation factor. The value of R_L indicates the type of isotherm to be either unfavorable ($R_L > 1$), linear ($R_L = 1$), favorable ($0.0 < R_L < 1.0$), or irreversible ($R_L = 0.0$).

The Freundlich parameters are determined from the following equation

$$\text{Log } q_e = \text{log } k_f + 1/n \text{ log } C_e \quad (\text{linear}) \quad (5)$$

If $1/n$ is lower than 1.0 the adsorbate is favorably adsorbed on the adsorbent. The type of isotherm can be also irreversible, $1/n = 0.0$ or unfavorable, $1/n > 1$. K_f is adsorption capacity at unit concentration ($L g^{-1}$), related to binding energy.

3. Results and Discussion

3.1. Calibration curve of MY12

The absorbance of different concentrations of MY12 was recorded at 360 nm. (Figure 1). The calibration curve of MY12 is shown in Figure 1.

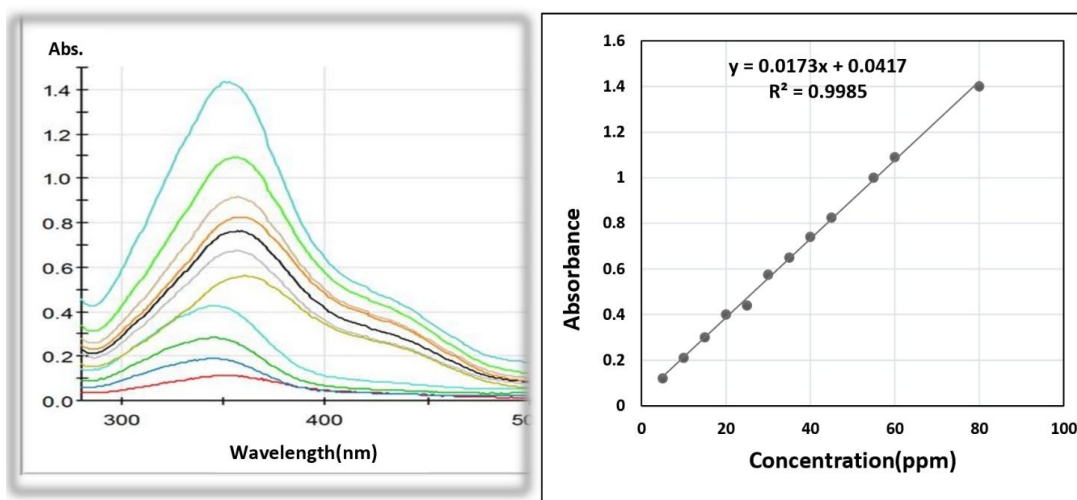


Figure 1. UV-vis spectrum and Calibration curve of MY12

3.2. Adsorption of MY12 onto biosorbent

Adsorption of azo dye from aqueous solution on biosorbent is a process affected by several factors; such as pH, dose, initial concentration, contact time and temperature. The adsorption mechanisms depend on the dye and the type of adsorbent. Most adsorbents interact with the dye species through

binding of it and cellulose /lignin units in the active sites through binding two hydroxyl groups in the cellulose units together [36].

3.2.1. Effect of initial MY12 concentration on its biosorption by SCB

The effect of initial dye concentration on the biosorption of MY12 solution by SCB was illustrated in Figure 2. The maximum biosorption capacity q_e by SCB (modified with 4 % citric acid) was 4.75 mg g^{-1} at initial dye concentration 100 ppm and the maximum removal % efficiency was 83.64 % at initial dye concentrations 10 ppm. (3.88 mg g^{-1} and 95.2 % by SCB modified with 4 % tartaric acid). This showed that the amount of dye adsorbed q_e increases as the initial concentration rises. Also removal % efficiency decreases as initial dye concentration increases. At low concentrations, a greater chance was available for dyes removal.

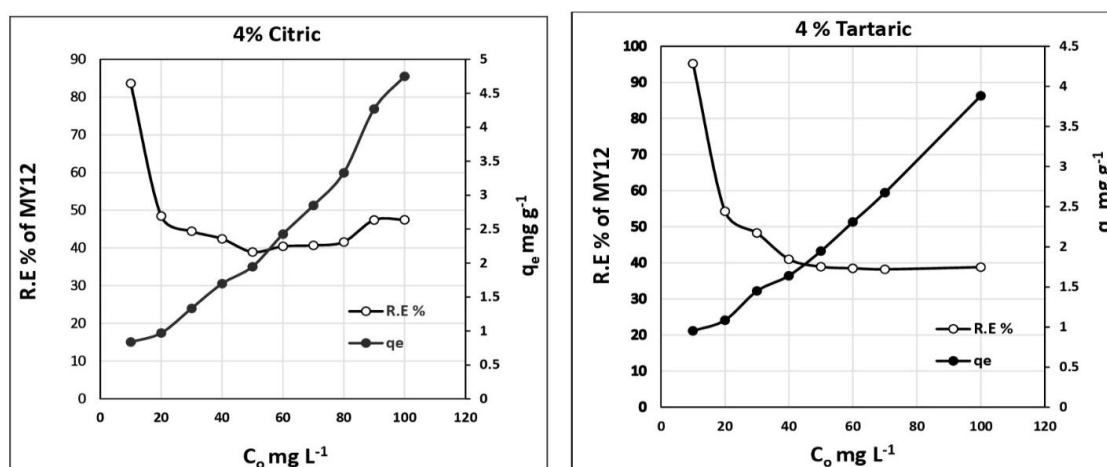


Figure 2. Effect of initial MY12 concentration on the removal efficiency of MY12 and $q_e \text{ mg g}^{-1}$ by modified SCB with 4 % citric acid or 4 % tartaric acid.

3.2.2. Effect of pH on the biosorption of MY12 by SCB

We observed that the highest absorbance at low pH 2.8 and the biosorption decreases as pH increases, as shown in Figure 3. The amount of MY12 removed by SCB modified with 4 % citric acid at pH 2.8 was 4.085 mg g^{-1} and the removal efficiency was 81.699 %. In the case of SCB modified with

4 % tartaric acid was (4.61 mg g⁻¹ and 92.193 %, respectively). This means that there is strong interaction between the dye and the biosorbent in the acidic solution.

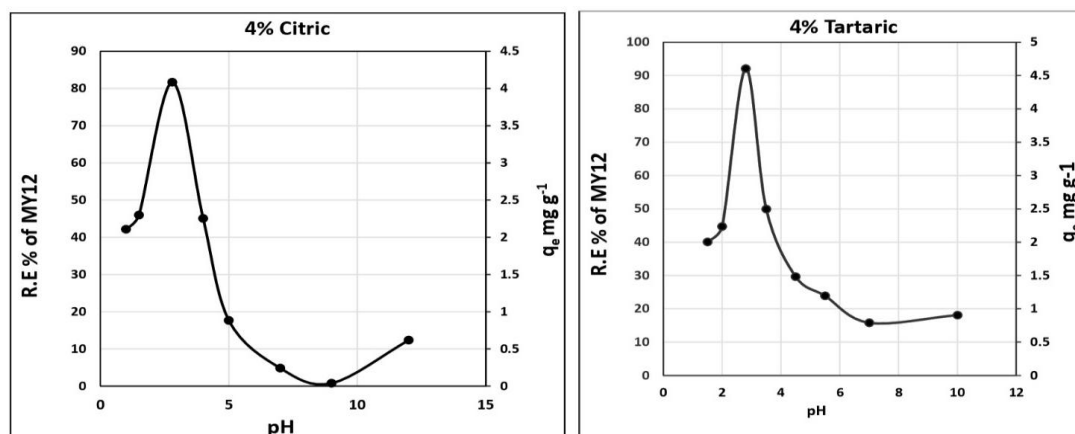


Figure 3. Effect of pH on the MY12 removal efficiency and q_e mg g⁻¹ at initial concentration of MY12 (80 ppm) by modified SCB with 4 % citric acid or 4 % tartaric acid.

3.2.3. Effect of biosorbent dosage on the biosorption of the investigated dye

It was observed that the increase in the biosorbent dosage makes the dye removal efficiency increases as shown in Table.1. The MY12 removal efficiency was the lowest value 10.02 % obtained with 0.02 g of SCB modified with 4% citric acid and the highest value of 95.34 with 1.0 g of SCB modified with 4% tartaric acid. This is due to the increase in surface area and availability of biosorption sites.

Table 1. Effect of biosorbent dosage on the biosorption of the investigated dye

Modified SCB	R.E % at 0.02 gm SCB	R.E % at 1 gm SCB	q_e (mg g ⁻¹) at 0.02 gm SCB	q_e (mg g ⁻¹) at 1 gm SCB
With 4 % tartaric acid	11.2	95.34	5.58	0.95
With 4 % citric acid	10.02	82.86	5.01	0.82

Because of increasing in adsorbent surface area, pores, active sites and number of unsaturated sites it was noted that the increasing in the biosorbent

dosage bringing a decrease in the amount of dye adsorbed per unit weight of biosorbent as shown in Figure 4.

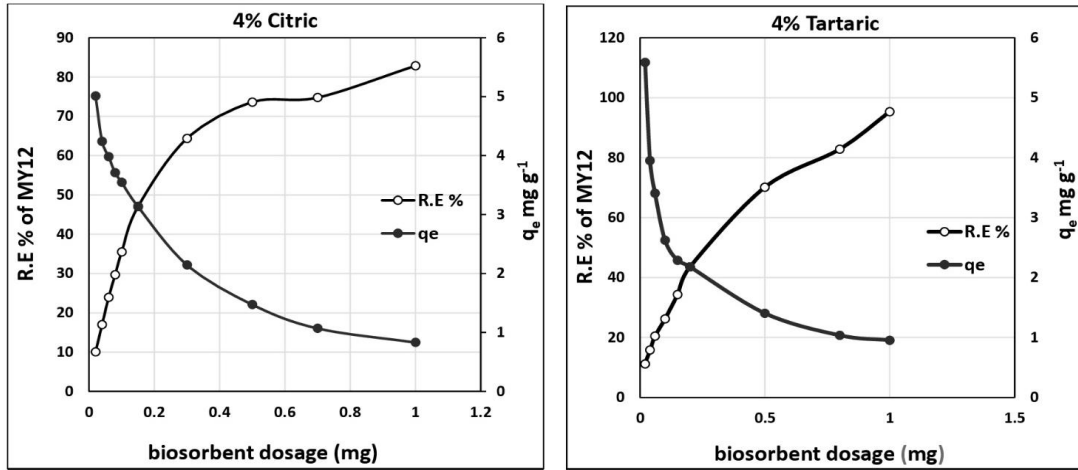


Figure 4. Effect of biosorbent dosage on removal efficiency of the MY12 and q_e mg g^{-1} at initial concentration of MY12 (50 ppm) by modified SCB with 4 % citric acid or 4 % tartaric acid.

3.2.4. Effect of contact time on the biosorption of the investigated dye

The effect of contact time on the biosorption of the MY12 by SCB modified with 4 % citric acid or 4 % tartaric acid at 25⁰ C was shown in Figure 5. It was noted that the increase in the contact time increases the amount of dye adsorbed up to 40 minutes. The removal of MY12 was rapid at first and decreased slightly until the equilibrium is reached.

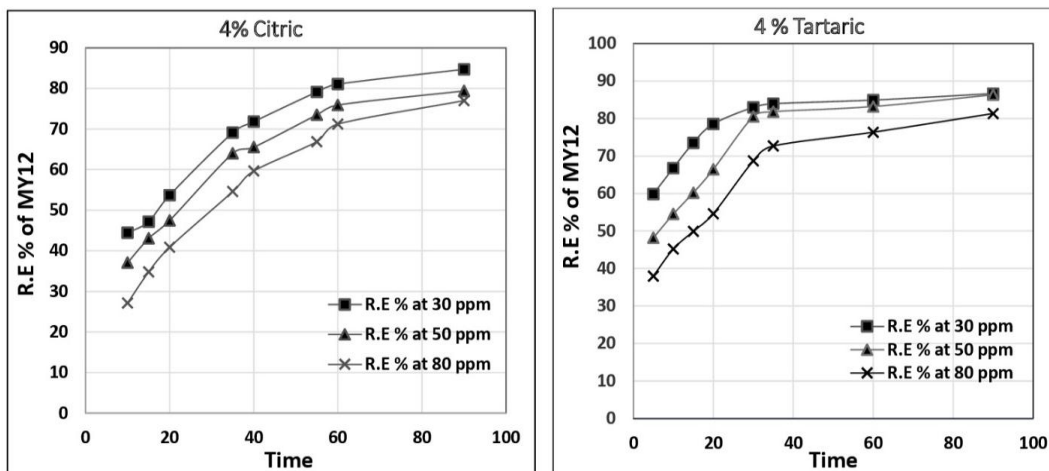


Figure 5. Effect of contact time on MY12 removal efficiency R.E. % and q_e mg g^{-1} at different initial concentrations of MY12 (30, 50, 80 ppm) by modified SCB with 4 % citric acid and 4 % tartaric acid.

3.2.5. Effect of temperature on the biosorption of MY12 by SCB

The effect of temperature on the biosorption of the MY12 was determined using UV spectrophotometer as shown in Figure 6. It was noted that the MY12 removal efficiency and q_e at different initial concentrations (30, 50 and 80 ppm) by modified SCB increases as temperature increases until around 40 °C. Because of the presence of the active site as the temperature increases the adsorption capacity will increase. This means that the rising of the temperature encourages the biosorption due to increase in the movement of the dye at higher temperatures.

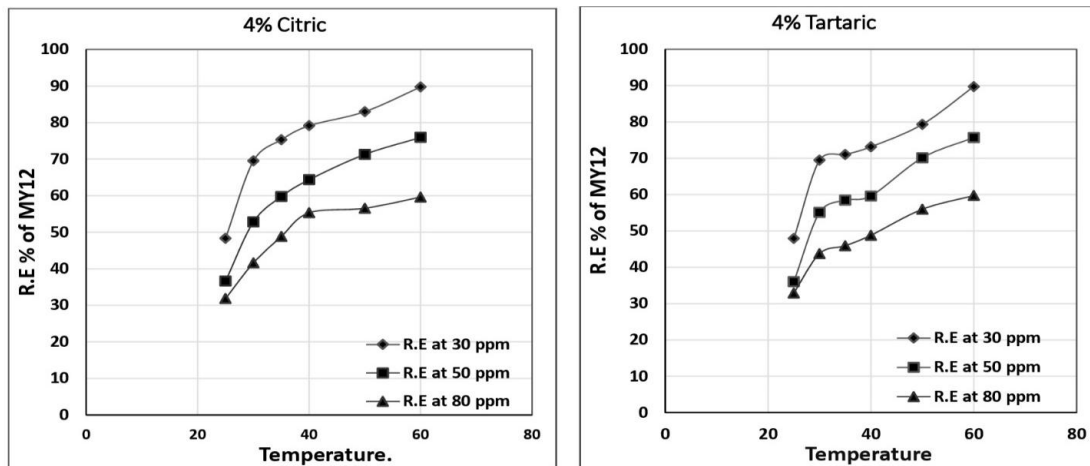


Figure 6. Effect of temperature on MY12 removal efficiency R.E % and q_e mg g⁻¹ at different initial concentrations of MY12 (30, 50, 80 ppm) by modified SCB with 4 % citric acid and 4 % tartaric acid.

3.2.6. Adsorption isotherm of MY12 onto SCB

Mathematical model equations such as Langmuir isotherm model and the Freundlich isotherm model described the distribution of dye between the liquid and the solid phases. These isotherm models have an ability to describe experimental results in a wide range of concentrations. They describe the equilibrium between dye adsorbed onto adsorbent and dye in solution. Langmuir and Freundlich isotherms and its parameters of dye biosorption onto modified SCB were shown in Tables 2, 3. It was

observed that the amount of dye adsorbed per unit mass of biosorbent increased with the initial concentration of dye.

Table 2. Isotherm constants of MY12 biosorption onto SCB modified with 4 % citric acid

Temp.	Langmiur			Friendlich		
	q_m (mg g ⁻¹)	b (L mg ⁻¹)	R ²	N	K _f	R ²
303	5.1151	0.0437	0.8606	3.5	1.1	0.9988
308	7.4404	0.0284	0.907	3.14	1.18	0.9874
313	7.3964	0.0304	0.8979	2.838	1.22	0.99
323	6.8213	0.0522	0.8869	3.201	1.51	0.9998
333	7.1023	0.0351	0.9484	4.103	2.05	0.9986

Table 3. Isotherm constants of MY12 biosorption onto SCB modified with 4 % tartaric acid

Temp.	Langmiur			Friendlich		
	q_m (mg g ⁻¹)	b (L mg ⁻¹)	R ²	N	K _f	R ²
303	4.52	0.08	0.9113	3.1	1.01	0.9978
308	4.8	0.071	0.9607	2.94	1.03	0.9932
313	5.2	0.067	0.9439	2.83	1.04	0.9866
323	6.1	0.064	0.9208	2.74	1.25	0.9725
333	6.1	0.1	0.9335	4.1	2.05	0.9905

The dimensionless equilibrium parameter (R_L) is a dimensionless constant separator factor, which indicates the type of isotherm. From the experiment using 4 % citric SCB R_L values varied from 0.19 to 0.54 for different MY12 concentrations (30, 50, 80) ppm at different temperatures (Table 4). From the experiment onto 4 % tartaric SCB R_L values varied from

0.11 to 0.34 for different MY12 concentrations (30, 50, 80) ppm at different temperature (Table 5). The results show that the values of R_L ranged between 0.0 and 1.0, indicating a favorable dye biosorption onto modified SCB

Table 4. A dimensionless constants separator factor for (R_L) MY12 biosorption onto SCB modified with 4 % citric acid using Langmuir type.

$C_o(mgL^{-1})$	R_L at 30° C	R_L at 35° C	R_L at 40° C	R_L at 50° C	R_L at 60° C
30	0.432713	0.539957	0.523013	0.389712	0.487092
50	0.313972	0.413223	0.396825	0.277008	0.362976
80	0.22242	0.305623	0.291375	0.193199	0.262605

Table 5. A dimensionless constants separator factor (R_L) for MY12 biosorption onto SCB modified with 4 % tartaric acid using Langmuir type

$C_o(mgL^{-1})$	R_L at 30° C	R_L at 35° C	R_L at 40° C	R_L at 50° C	R_L at 60° C
30	0.294118	0.319489	0.332226	0.342466	0.25
50	0.2	0.21978	0.229885	0.238095	0.166667
80	0.135135	0.149701	0.157233	0.163399	0.111111

It was observed that the value of Freundlich exponent n indicates better biosorption mechanism and formation of relatively stronger bond between adsorbate and biosorbent as n values were greater than 1. (cf. Tables 3, 4). $1/n$ values of MY12 biosorption onto sugarcane bagasse modified with 4 % citric were found in the range of 0.6 - 0.67 and 0.48 – 0.74 with 4% tartaric at temperature from 298 to 333 K, thus $1/n$ values were between 0.0 and 1 that means the MY12 biosorption onto modified SCB are favorable under the studied

conditions. Freundlich model has a better fitting model according to linearity coefficient R^2 0.9998 but Langmuir model R^2 0.8869 for MY12 biosorption onto modified SCB with 4 % citric (Table3) and 0.9978, 0.9113 for MY12 biosorption onto modified SCB with 4 % tartaric (Table 4) respectively.

3.2.7. Kinetic studies on the biosorption of the investigated dye on biosorbent

The mechanism of the adsorption of MY12 was tested using pseudo first order and pseudo second order kinetic models (equations 6 and 7)

$$\ln (q_e - q_t) = \ln q_e - k_1 t \quad (6)$$

$$(t/q_t) = 1 / (k_2 q_e^2) + (t / q_e) \quad (7)$$

Where, q_t is the MY 12 uptake in mg g^{-1} at time t , q_e is the MY12 uptake in mg g^{-1} at equilibrium and k_1 is the rate constant of pseudo- first order. k_2 is the rate constant of pseudo- second order.

From experimental data obtained of sorption time investigation the adsorption kinetic of the removed MY12 from aqueous solution was studied. The pseudo-second- order model is the best fitting model according to linearity coefficients as shown in Figures 7, 8. The experimental q_e close to the calculated q_e determined from the plot of the pseudo- second order model as shown in Tables 6, 7.

Table 6. Kinetic parameters of MY12 biosorption onto modified SCB with 4% citric acid.

Concentration	Pseudo- first- order			Pseudo- second- order			Observed q_e mg g^{-1}
	K_1 (1min^{-1})	q_e (mg g^{-1})	R^2	K_2 ($\text{gmg}^{-1}.\text{min}^{-1}$)	q_e (mg g^{-1})	R^2	
At C_0 30 ppm	0.07	3.51	0.9101	0.03	2.99	0.9966	2.5
At C_0 50 ppm	0.098	9.67	0.7968	0.01	4.8	0.9966	3.97
At C_0 80 ppm	0.08	12.33	0.7832	0.004	8.2	0.9973	6.1

Table 7. Kinetic parameters of MY12 biosorption onto modified SCB with 4% tartaric acid.

Concentration	Pseudo- first- order			Pseudo- second- order			Observed q_e mg g ⁻¹
	K_1 (1min ⁻¹)	q_e (mg g ⁻¹)	R^2	K_2 (mg ⁻¹ .min ⁻¹)	q_e (mg g ⁻¹)	R^2	
At $C_0 = 30$ ppm	0.024	0.67	0.8177	0.1	2.68	0.9998	2.6
At $C_0 = 50$ ppm	0.037	1.976	0.6811	0.04	4.6	0.9974	4.3
At $C_0 = 80$ ppm	0.042	4.48	0.9784	0.014	7.2	0.9954	6.5

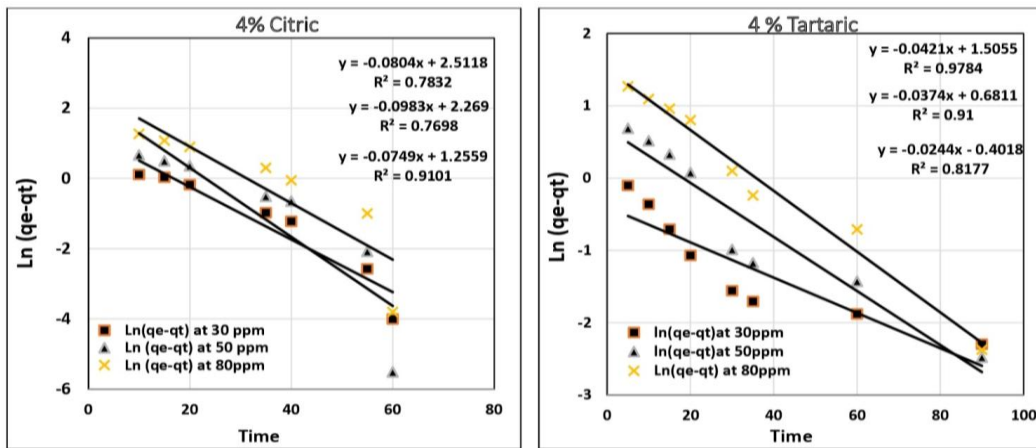


Figure 7. pseudo- first- order for biosorption of MY12 by modified SCB with 4 % citric acid or 4% tartaric acid.

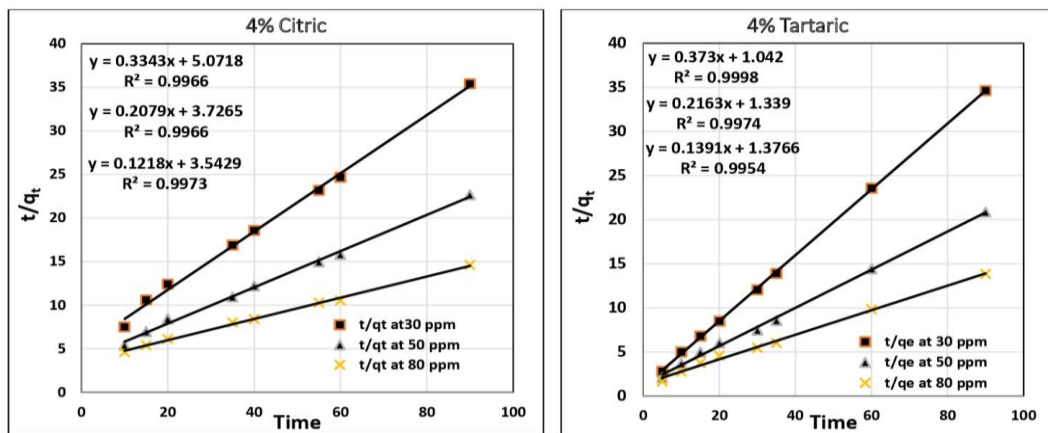


Figure 8. pseudo- second- order for biosorption of MY12 by modified SCB with 4 % citric acid or 4% tartaric acid.

4. Conclusion

Removal of poisonous MY12 from solutions using selected adsorbents modified SCB was the most effective for which the removal efficiency reached more than 95 % for MY12 at concentration of 80 ppm and at pH 2.8. Increase in the dose of adsorbent, decrease in the initial concentration of MY12 and increase in the contact time up to 40 minutes are favorable for all increase the adsorption of MY12. The kinetic of the MY12 adsorption on sugarcane bagasse was found to follow pseudo- second order mechanism. The adsorption data can be satisfactorily explained by Freundlich isotherm. Higher sorption capacity of this sorbent indicates that modified SCB can be used for the treatment of MY12 effluent.

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□ الملخص العربي



إزالة صبغة المورديانت الأصفر (12) من مياه الصرف الصناعي باستخدام مصاصة قصب السكر المعالج كمادة مازة

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يعتبر الصرف الصناعي والزراعي والمبيدات الحشرية التي تصرف في المياه من اهم العوامل التي تؤدي الى مشكلة تلوث المياه بالصبغات وغيرها مما ينتج عنه العديد من التأثيرات الضارة والسامة للكائنات الحية (نبات وحيوان وانسان). فأصبح من الضروري التخلص من تلك الملوثات من مياه الصرف قبل ان تصل الى البيئة. وهناك عدة طرق كيميائية للتخلص من تلك الملوثات لكن لها كثير من العيوب مثل استهلاك الكثير من المواد الكيميائية والطاقة والتكلفة. وتقدم هذه الدراسة استخدام بقايا بعض النباتات الطبيعية مثل مصاصة قصب السكر والذي يوجد بوفرة في مصر وقد يسبب في حد ذاته تلوث للبيئة حيث كان الحرق في الهواء الطلق هو السبيل الوحيد للتخلص منه وبذلك ترتفع القيمة الاقتصادية له . وتشير النتائج الى ان النسبة المئوية لإزالة صبغة المورديانت الأصفر 12 الممتازة من المحاليل المائية تزداد مع زيادة كمية مسحوق مصاصة قصب السكر المعالج بواسطة تركيزات مختلفة من حمض الستريك وحمض الطرطريك المضافة ونقص التركيز الابتدائي للصبغة كما ان اعلى معدل امتزاز عند قيمة الرقم الهيدروجيني 2.8 والزمن الامثل لامتزاز 40 دقيقة علاوة على ذلك فان كفاءة ازالة الصبغة تزداد بزيادة درجة الحرارة . فكانت اعلى نسبة مئوية لازالة الصبغة على سطح مصاصة القصب تساوى 95.2 % كما وجد ان الامتزاز يتبع معادلة الرتبة الثانية الظاهرية اكثر من الرتبة الاولى. وأشارت العمليات الحسابية ان قيم معامل التصحيح تترواح بين الصفر والواحد الصحيح مما يشير ان عملية الامتزاز عملية مفضلة. وكذلك قيم اس فرويندليش اكبر من الواحد الصحيح اي ان الامتزاز يتبع فرويندليش ايزوثيرم واكثر ملائمة مقارنة بلاثيرم ايزوثيرم مما يدل على ان عملية الامتزاز هي افضل ميكانيكية لتفسير ما يحدث بين الصبغة وسطح مصاصة قصب السكر كبقايا نباتية متاحة ورخيصة وصديقة للبيئة.