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Removal of Astrazone Blue from aqueous solutions onto brown peat. Equilibrium and kinetics studies

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Abstract−The aim of this study is to characterize and assess the sorption potential of brown peat, in relation to colored pollutants from the textile industry wastewater. The objectives of this paper were: the physicochemical, morphological, and mineralogical characterization of brown peat, testing the adsorption capacity of natural and chemically treated peat samples for Astrazone Blue, evaluation of adsorption process from equilibrium isotherm and kinetic point of view. The characteristics of the peat samples were investigated using elemental analysis, scanning electron microscopy and X-ray diffractometry. Experimental data indicated that the brown peat tested confirm a high level of adsorption (removal efficiency >93.00%, adsorption capacity reaching up to 24.27 mg/g) of Astrazone Blue from aqueous solution. The Langmuir and Freundlich adsorption isotherm models were used to find the best equation able to describe the adsorption process. Experimental adsorption data were successfully described by the Langmuir equilibrium isotherm model. This fact is supported by the agreement between the q values obtained using the Langmuir equation (26.32 mg/g), and the ones obtained experimentally (24.27 mg/g). The kinetic studies showed that the pseudo-second-order model described Astrazone Blue sorption kinetics, as confirmed by the high values of R^2, which are over 0.99 for the whole investigated concentration range (200 to 800 mg/L). The use of brown peat adsorbent is more advantageous compared with other materials since it does not require a preliminary treatment, is low-cost and is an eco-friendly adsorbent. Hence, this peat appears to be a viable material for the decontamination of effluents containing dyes.

Keywords: Wastewater Treatment, Adsorption, Astrazone Blue, Brown Peat, Isotherms, Kinetics

INTRODUCTION

The textile industry, which plays an important role in the economy of many countries, generates great volumes of wastewater with a high content of dyes [1,2]. The discharge of this wastewater in natural effluents can affect the ecosystem by diminishing the transparency of water and the penetration of solar radiations, which may cause a disruption of aquatic life [3].

Colored wastewaters from the textile industry are difficult to treat by using only conventional treatment methods, because the dyes are stable compounds in the presence of light and oxidizing agents, and are resistant to aerobic digestion [4,5]. Literature shows some treatment methods that can be used for dyes removal, such as advanced oxidation processes, ozonation, photochemical degradation, membrane filtration, electroflotation, electrokinetic coagulation, electrochemical destruction, ion-exchange, and precipitation [6,7]. The most important disadvantages of these methods are represented by the high cost and by the heavy amounts of sludge with obvious disposability problems [7].

Absorption remains today one of the most used methods to remove pollutants from aqueous solutions because of the following advantages: the possibility of using like adsorbents of many materials, of technological steps that are not so expensive, easily to be maintained, requiring no special skills to operate and being locally available [8-10]. The materials used as adsorbents in removal of dyes, heavy metals or organic pollutants are activated carbon, ion exchangers, polyamides, polyurethane foams, inorganic materials, nanoparticles, carbon nanotubes, zeolites and recently the natural lignocellulosic materials, chitin and chitosan [11-14].

Due to their high cost of production, the researches have been redirected toward the cheaper and available materials with adsorptive properties as feasible alternatives [15,16]. Thus, there was studied the use as adsorbents in removal of dyes "non-conventional or "low cost materials including industrial/agricultural/domestic wastes or industrial/agricultural by-products (ash, sludge, sawdust, textile fibbers, mud, bark, straw, de-oiled soya, rice husk etc.) and natural materials (peat, seashell, sepiolite, algae, lignite, wood, etc.) [17-22].

Peat moss represents an available and inexpensive natural material, with a very high specific surface area. Its composition is variable depending on sources and age, the nature of its original vegetation, the regional climate, the acidity of the water, and the degree of metamorphosis [23]. The main components are represented by organic

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chemical species with polar functional groups such as alcohols, aldehydes, carboxylic acids, ketones, and phenolic hydroxides, that may be able to bind pollutant species through different chemical or physical interactions (cation exchange, chelate complexes, hydrogen bonds, or formation of anion - cation bonds) [8,24].

The phenomenon governing the retention or mobility of a substance from the aqueous media to a solid-phase at a constant temperature and pH can be described by the adsorption isotherms [25, 26]. A wide variety of equilibrium isotherm models (Langmuir, Freundlich, Redlich-Peterson, Temkin, Toth, Sips, Hill, Flory-Huggins and Radke-Prausnitz isotherms) have been formulated in terms of three fundamental approaches: kinetic consideration, thermodynamics, characteristic curve. An interesting trend in isotherm modelling is represented by the derivation in more than one approach, thus directing to the difference in the physical interpretation of the model parameters [26].

Kinetic models have been also used to investigate the mechanism of adsorption and potential rate controlling steps, which is helpful for selecting optimum operating conditions for the full-scale batch process. Pseudo-first-order, pseudo-second-order and intraparticle diffusion kinetic models were used [27-31].

Different researches have investigated the dyes adsorption from aqueous solutions and showed that the isotherm and kinetics models can describe the adsorption process [32,33]. In one of these studies [34] dried biomass of Baker's yeast, was used as a sorbent for Astrazone Blue basic dye aqueous solution. The authors reported that the results gained from the study were described by Langmuir isotherm better than Freundlich and Temkin isotherm models. Another paper [35] focused on the removal of Acid Red 14 dye using mixtures of different adsorbents and concluded that the removal process followed pseudo-second-order kinetics.

The present work aims to characterize and assess the adsorption potential of the brown peat, towards the chemical pollutants from the textile industry wastewater. To achieve this goal, researches were conducted in order to attend to three different objectives: i) the physicochemical, morphological, and mineralogical characterization of brown peat from Covasna region in Romania; ii) the investigation of the adsorption capacity of natural and chemically treated peat samples for adsorption of Astrazone Blue dye from aqueous solutions; and iii) processing the obtained experimental data by using adsorption isotherms and kinetic studies.

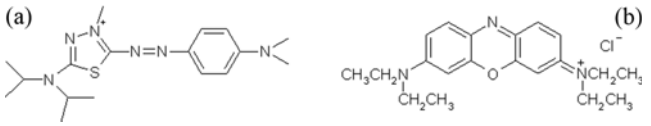
MATERIALS AND METHODS

1. Reagents

All reagents and solvents used were of analytical grade or comparable purity. They were obtained from Sigma Aldrich (Redox Lab Supplies Bucharest, Romania). Standard solutions were prepared by dissolving appropriate amounts of the commercially available pure products in demineralized water or adequate solvents.

2. Adsorbate

The experiments were performed by using the basic dye, Astrazone Blue FGRL (AB), supplied by Dystar Colours Deutschland GmbH (Germany). Blue FGRL consists of two main components: C.I. Basic Blue 159 and C.I. Basic Blue 3. The ratio of the two components is approximately 5 : 1 by weight. Their chemical structures are presented below.



Structure of Astrazone Blue: (a) CI basic blue 159; (b) CI basic blue 3.

The wavelength for maximum absorption (λ max) was initially examined with a Jasco V-550 UV-Vis spectrophotometer (with cell temperature controller) at four pH values: 4, 6, 8, and 10 between 180 and 780 nm. The examination of the recorded spectra showed a maximum absorption at 660 nm. This wavelength was used for further analysis.

3. Adsorbent

As adsorbent was used of brown peat samples collected from Covasna region, Romania. The typical characteristics of the peat (such as pH, density, and moisture content) were determined by conventional methods. A HACH SENSION 156 multiparameter and a KERN MLB 50-3 moisture balance were employed.

A Carlo Erba 1100 elemental analyzer was used to evaluate the elemental composition of the peat samples. The ash content was determined at 750±2 °C, 4 h with a Caloris L 1003 muffle furnace according to the standard procedure 942.05 described in AOAC (1995).

Morphological and mineralogical peat sample characterization was by scanning electron microscopy (SEM) and X-ray diffractometry (XRD) analysis. SEM measurements were performed using Vega Tescan SEM equipment. Detailed mineralogical studies of peat samples were carried out with an X-ray diffractometer (X'PERT PRO MRD) equipped with copper Cu Kα radiation source.

4. Adsorption Experiments

4-1. Batch Mode Adsorption Studies

A stock solution of Astrazone Blue dye with a concentration of 1,000 mg/L was prepared in double distilled water and then diluted to the desired concentrations according to the investigational conditions.

The experiments were conducted by mixing 2 g of dried (dry temp 105 °C, dry time 5 h and final humidity 22.65%) and powdered adsorbent with 100 mL of dye solution in 250 mL glass flasks at fixed temperature (22±1 °C) under constant stirring (150 rpm). After an established certain period of time (15-30 minutes), 2 mL of mixture was collected and centrifuged (5,000 rpm for 5 min). The recovered supernatant was analyzed with a Jasco V-550 UV-Vis spectrophotometer. To quantify the amount of the adsorbed dye on brown peat samples a calibration curve was established using dye solutions with concentrations between 0-100 mg/L.

The dye concentrations in the test sample were calculated using Eq. (1) obtained by plotting the calibration curve,

$$y=0.042308 \cdot x - 0.011500 \quad (R^2=0.999537) \tag{1}$$

where y represents the absorbance and x is the dye concentration in mg/L.

4-2. Brown Peat Chemical Treatment

Three peat samples were used in the experiments: natural brown peat (NBP), brown peat treated with HCl (ATBP) and brown peat treated with HCl and NaOH (ABTBP).

The brown peat acid treatment was performed according to the procedure proposed by Gosset [36]. 10 g of brown peat was mixed with 100 mL HCl (1 mol/L) for 2 hours. The sample was then washed with deionized water until the pH of the filtrate reached 6.0, and subsequently dried at 80 °C for 2 hours.

For the acid-base treatment 10 g of peat was first treated with 100 mL HCl (1 mol/L) for 1 hour under stirring and then with 100 mL NaOH (1 mol/L), and the stirring process was continued for another hour. The peat was then washed and dried in the same previously described conditions.

4-3. Influence of Astrazone Blue Solution pH

The 2 g of natural brown peat samples without prior chemical treatment was contacted with Astrazone Blue aqueous solutions with an initial concentration of 200 mg/L. The retention kinetics of the dye was monitored at four initial pH values: 2, 4, 7, and 9. The pH of the dye solution was obtained by adding HCl (concentration 1 mol/L) or NaOH solution (concentration 1 mol/L).

4-4. Influence of the Initial Concentration of Astrazone Blue Solution

Astrazone Blue solutions of different concentrations were mixed with 2 g of chemical untreated natural brown peat. The retention of the organic dye on the brown peat adsorbent was monitored at several different concentrations: 200, 300, 400, 500, 600, 700 and 800 mg/L with initial pH=7.

5. Isotherm Experiments

The efficiency of the Astrazone Blue removal from aqueous solution was calculated by using the equation:

$$R_{\%} = \frac{C_0 - C}{C_0} 100\ (\%) \quad (2)$$

where C_0 (mg/L) is the initial concentration of Astrazone Blue and C (mg/L) is the Astrazone Blue concentration after adsorption.

The amount of Astrazone Blue adsorbed onto the peat was calculated by using the following equation:

$$q_e = \frac{C_0 - C_e}{M} V\ (mg/g) \quad (3)$$

where q_e (mg/g, mg of Astrazone Blue per g of dry peat) is the equilibrium adsorption capacity; C_0 and C_e the initial and equilibrium concentrations (mg/L) of dye in solution; V (L) the volume of the Astrazone Blue solution and M (g) is the weight of the peat adsorbent.

6. Kinetic Studies

Experimental data generated from adsorption tests were evaluated to understand the mechanisms and dynamics of the adsorption process.

The dye uptake was calculated with equation:

$$q_t = \frac{C_0 - C_t}{M} V\ (mg/g) \quad (4)$$

where q_t (mg/g, mg of Astrazone Blue per g of dry peat) is the sorption capacity at time t; C_0 and C_t are the initial and time t concentrations (mg/L) of dye in solution, V (L) is the volume of the Astrazone Blue solution and M (g) is the mass of adsorbent used in the experiment.

RESULTS AND DISCUSSION

1. Characterization of Brown Peat

The values obtained from the elemental analysis of brown peat are presented in Table 1.

Table 1. Physical characteristics and elemental analysis of peat sample

Characteristics	Brown peat
pH*	6.62
Apparent density, g/cm^3	0.64
Moisture (%)	75.00
Ash (%)	23.67
C (%)	39.65
H (%)	4.32
N (%)	2.27
Total P_2O_5 (%)	0.20
Organic matter (%)	71.38

*For pH measurements, peat was dissolved in distilled water (1 g/10 mL)

SEM images for brown peat sample are illustrated in Fig. 1. Brown peat sample contains porous granules, but unlike other peat samples it also contains a significant mineral phase. These observations are supported by carbon and dry ash contents. SEM results showed a high level of heterogeneity in terms of particle size and texture (Fig. 1(a)). An agglomeration tendency in compact microportions with varied forms and size is also revealed in Fig. 1(c) and 1(d). This type of peat is fibrous (Fig. 1(b)), with good hydraulic and adsorptive characteristics (hypothesis confirmed by the conducted adsorption experiments). It has a high total pore volume capable of retaining significant quantities of pollutants (Fig. 1(d)).

XRD diffractogram (Fig. 2) analysis and a detailed examination of peat sample mineralogy showed amorphous matter characteristics and revealed the presence of crystalline structures, facts that can be explained by a different content of inorganic and organic matters. SEM and XRD analyses showed that the brown peat sample possessed specific peat characteristics [5].

2. Adsorption Experiments

2-1. The Effect of the Peat Chemical Treatment on the Adsorption Capacity

Based on the results of the adsorption experiments, the Astrazone Blue dye removal efficiency and adsorption capacity of peat were calculated. The adsorption capacity of the three peat samples for Astrazone Blue dye is shown in Fig. 3.

The analysis of the experimental results indicates that the peat (natural and chemically treated) has a good retention capacity of the dye, about 96% after the first 15 minutes. For natural brown peat the removal efficiency (R) reached a maximum of 99.28% in 300 minutes for a dye solution concentration of 200 mg/L. Therefore, only with this type of peat were the experiments conducted.

Chemical treatments are not justified since these reduce (even though not significantly) the peat adsorption capacity from process management point of view.

2-2. The pH Effect of the Astrazone Blue Solution on the Peat Adsorption Capacity

The effect of initial solution pH on the adsorption of dyes onto peat was examined and the results are presented in Fig. 4. A good retention capacity of organic dye on the entire investigated pH range was noted. The lowest removal efficiency was at pH=9, respectively, 98.21%, while the maximum of 99.28% removal was recorded at

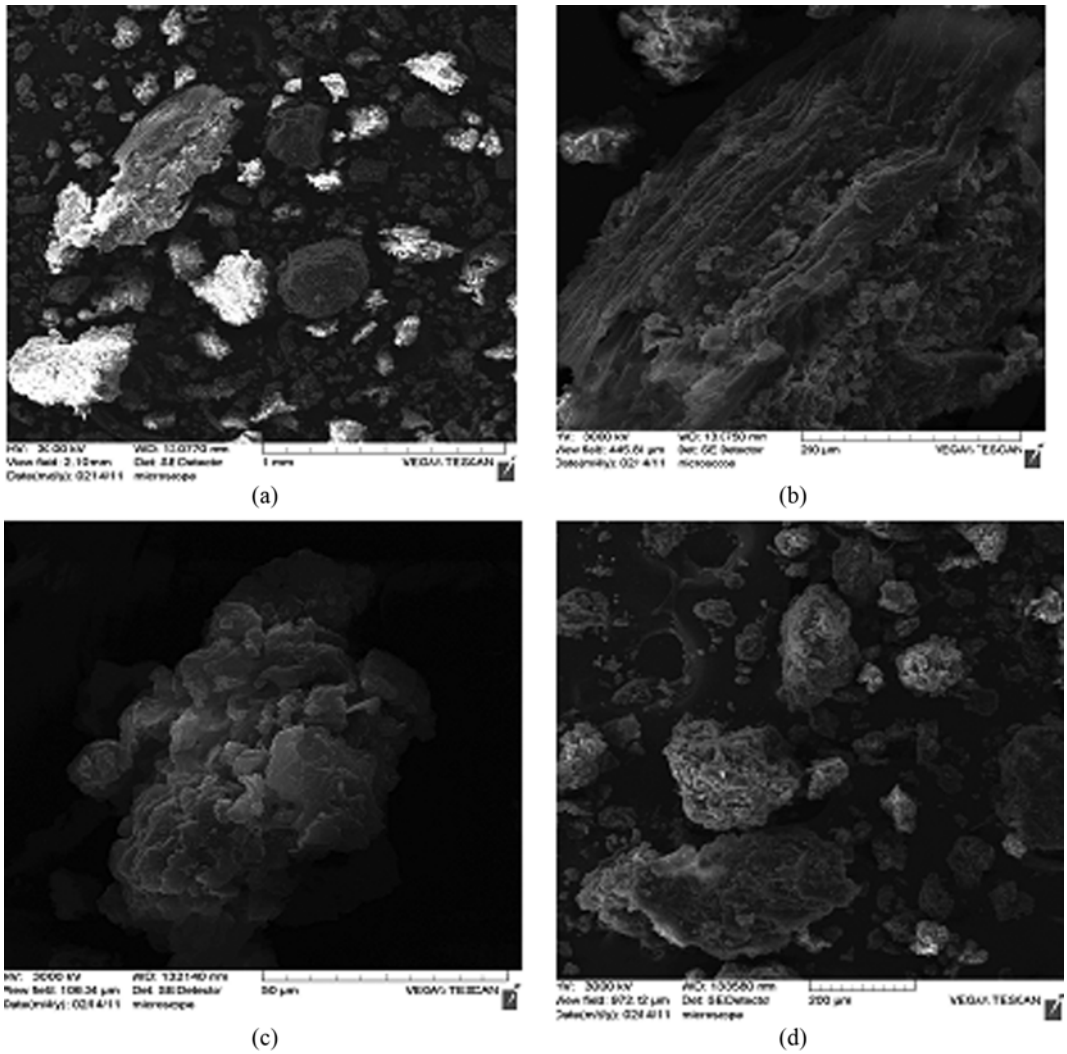


Fig. 1. Scanning electronic microscopy images for brown peat.

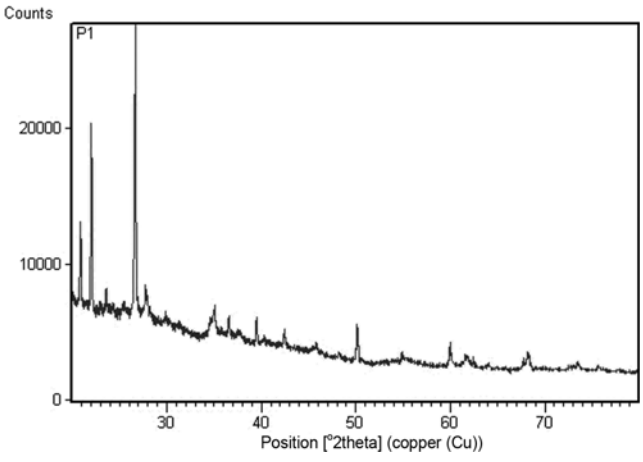


Fig. 2. X-ray diffractogram of brown peat sample.

pH=7. The dye cationic structure justifies the obtained results.

The high retention throughout all pH range suggests that the molecular interaction (favored by the large size and structure of dye molecule) is the determinant elementary process (ion exchange, electro-

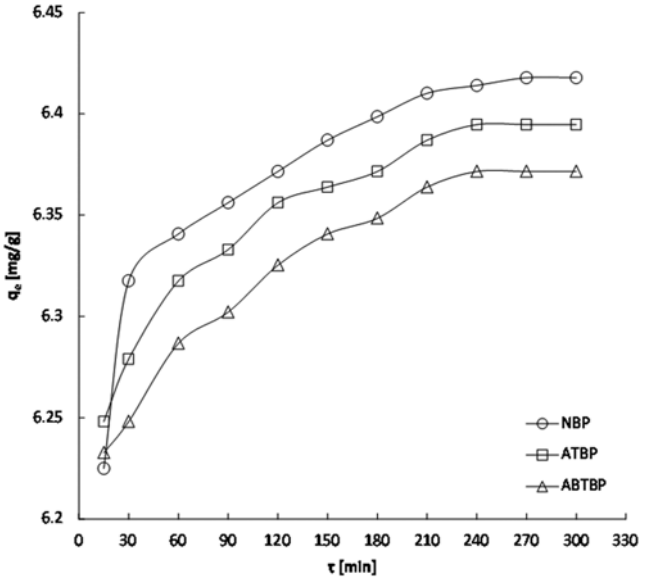


Fig. 3. Adsorption capacity of three peat samples: NBP (natural brown peat), ATBP (brown peat treated with HCl), and ABTBP (brown peat treated with HCl and NaOH).

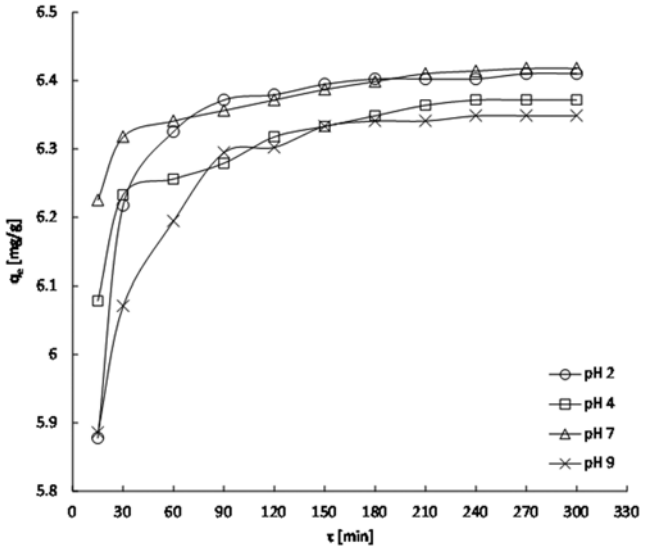


Fig. 4. pH influence on peat adsorption capacity.

static attraction, and van der Waals interaction) that compose the overall retention. Consequently, the experiments were conducted at initial solution pH=7.

This behavior may be correlated with the variation of the peat surface charge in function of the solution pH. The value of pH_{PZC} (pH of zero charge) for peat, determined by method proposed by Nouri and Haghseresht [37], was of 3.7. At values of $pH<pH_{PZC}$ the peat surface is positively charged (fenolic hydroxide groups are protonated) and susceptible to electrostatic interactions with polar portions of anionic dye molecule. At $pH>pH_{PZC}$ values, the adsorbent surface is negatively charged due to dissociation of the -COOH functional groups and is capable to electrostatic interactions with cationic dye molecules of Astrazone Blue.

2-3. The Effect of the Initial Concentration of Astrazone Blue Solution on the Peat Adsorption Capacity

The influence of initial concentration of dye solution on the adsorption capacity of natural brown peat is presented in Fig. 5. The obtained results revealed a good adsorption capacity for peat for the whole investigated concentration range (200-800 mg/L), reaching up to 24.27 mg/g for an initial solution concentration of 800 mg/L. The removal efficiency of Astrazone Blue dye from aqueous solutions was over 93% for the seven tested concentrations.

Table 2. Adsorption isotherms models

Isotherm	Nonlinear form	Linear form	Plot
Langmuir 1	$q_e=\frac{Q_o bC_e}{1+bC_e}$	$\frac{C_e}{q_e}=\frac{1}{bQ_o}+\frac{C_e}{Q_o}$	$\frac{C_e}{q_e}$ vs C_e
Langmuir 2		$\frac{1}{q_e}=\frac{1}{Q_o}+\frac{1}{bQ_oC_e}$	$\frac{1}{q_e}$ vs $\frac{1}{C_e}$
Langmuir 3		$q_e=Q_o-\frac{q_e}{bC_e}$	q_e vs $\frac{q_e}{bC_e}$
Langmuir 4		$\frac{q_e}{C_e}=bQ_o-bq_e$	$\frac{q_e}{C_e}$ vs q_e
Freundlich	$q_e=K_FC_e^{1/n}$	$\log q_e=\log K_F+\frac{1}{n}\log C_e$	$\log q_e$ vs $\log C_e$

3. Adsorption Isotherms

The literature [25-27,32,33] describes a wide variety of equilibrium isotherm models such as Langmuir, Freundlich, Brunauer-Emmett-Teller, Redlich-Peterson, Temkin, Dubinin-Radushkevich, Toth, Koble-Corrigan, Sips, and Hill isotherm. Two of these adsorption isotherms models were tested to verify the adequacy to our experiments. Their mathematical expressions are presented in Table 2.

3-1. Langmuir Isotherm Model

The Langmuir model (empirical form) is one of the most well-known models for surface adsorption up to monolayer coverage with the major assumptions that adsorption takes place only at specific localized sites on a homogeneous surface and there is no interaction between adjacent adsorbed molecules [26].

The Langmuir adsorption isotherm, originally developed to describe gas-solid-phase adsorption onto activated carbon, has traditionally been used to quantify and contrast the performance of different bio-sorbents [5,29,32]. In its derivation, the Langmuir isotherm refers to homogeneous adsorption with no transmigration of

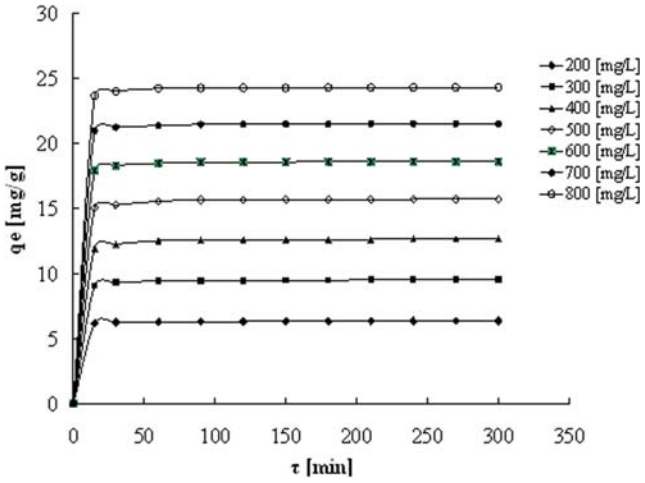


Fig. 5. Influence of Astrazone Blue solution concentration (pH 7) on peat adsorption capacity.

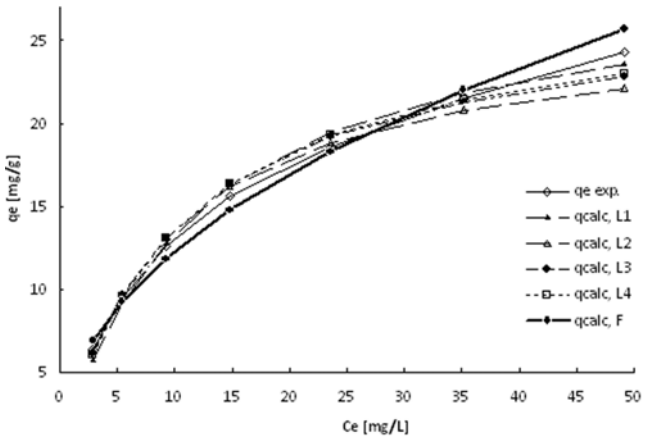


Fig. 6. Isotherm models and experimental obtained values plots for Astrazone Blue adsorption (peat dosage 20 g/L; pH 7, temperature 22±1 °C).

Table 3. Isotherm parameters summary for Astrazone Blue sorption onto brown peat

Isotherms model		Parameters		
Langmuir		Q_0 (mg/g)	b (dm^3/mg)	R^2
	Model 1	29.4117	0.0831	0.9944
	Model 2	26.3158	0.1077	0.9959
	Model 3	27.5420	0.098	0.9705
	Model 4	27.9180	0.0951	0.9705
Freundlich		n	K_F (mg/g, [dm^3/g]^n)	R^2
		2.155	4.2332	0.9854

the adsorbate in the plane of the surface. The graphical form is characterized by a plateau, an equilibrium saturation point where once a molecule occupies a site, no further adsorption can take place [26]. Linear plots (C_e/q_e vs. C_e in case of 1st Langmuir form, $1/q_e$ versus $1/C_e$ for the 2nd form, q_e vs. q_e/bC_e and q_e/C_e vs. q_e for 3rd and respectively 4th form) show that the Astrazone Blue adsorption onto brown peat obeys the Langmuir isotherm model for all (Fig. 6). The values of Q_0 and b were determined from the slopes and intercepts of the Langmuir plots and represented in Table 3.

3-2. Freundlich Isotherm Model

Similar to the Langmuir isotherm model, the Freundlich model has also been widely employed in sorption research [26,32,33], describing the non-ideal and reversible adsorption, not restricted to the formation of monolayer. This empirical model can be applied to multilayer adsorption, with non-uniform distribution of adsorption heat and affinities over the heterogeneous surface [34]. Linear plots of log(q_e) versus log(C_e) show that the adsorption follows Freundlich isotherm model. K_F and n were calculated from the intercept and slope of the plot. The constants K_F and n for Astrazone Blue adsorption onto brown peat are presented in Table 3. The values of n lie between 1 and 10 indicate a favorable adsorption comparable with other researches [8,25]. The fitted value of g for brown peat is 0.5694, meaning that is well fitted with the Langmuir isotherm, and does not follow Henry's law.

4. Adsorption Kinetic

The adsorption kinetic studies are important in predicting the mechanisms (chemical reaction or mass-transport process) that control the rate of the dye removal and retention time of adsorbed species at the solid-liquid interface. That information is also important in the design of appropriate adsorption treatment plants.

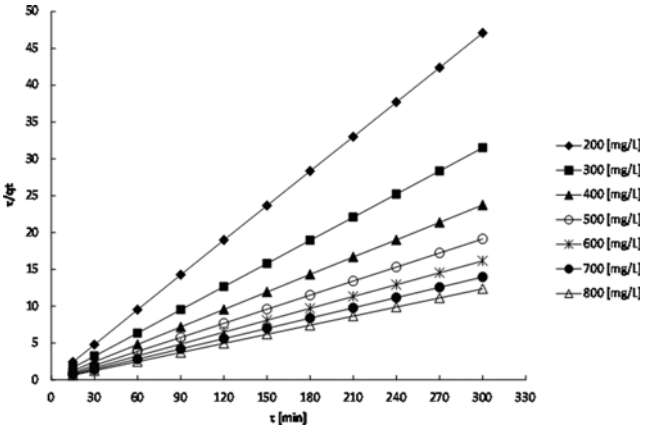


Fig. 7. Pseudo-second-order kinetics for Astrazone Blue adsorption onto brown peat (conditions: peat dosage 20 g/L; pH 7, temperature 22±1 ºC).

The operational parameter effects (adsorbent type, initial Astrazone Blue concentration, contact time, pH) were analyzed from the kinetic point of view. Using the untreated brown peat, the preliminary tests on the adsorption rate show that the amount adsorbed increased with increased Astrazone Blue concentration. In the first 180 minutes, approximately 98% of the amount of Astrazone Blue was adsorbed and thereafter the adsorption proceeded at a slower rate until equilibrium was reached. The equilibrium times were established between 240 and 280 minutes for the initial Astrazone Blue concentration range studied.

The experimental kinetics data for Astrazone Blue adsorption by peat were processed using two of the most knowing kinetic models: pseudo-first-order and pseudo-second-order models. The kinetic parameters related to each model, calculated from the intercepts and slopes of the corresponding linear plots (Fig. 7), are presented in Table 4. The fitting of each model to the experimental data was estimated using the linear regression correlation coefficient, R^2.

4-1. Pseudo-first-order Kinetic Model

The pseudo first-order Lagergren model is usually expressed as [27]:

$$\log(q_e - q_t) = \log(q_e) - \frac{k_1}{2.303}t \quad (5)$$

where k_1 (min^{-1}) is the first-order adsorption rate constant, q_e is the amount of Astrazone Blue adsorbed at equilibrium and q_t is the amount adsorbed at time t.

Table 4. The pseudo-first and pseudo-second-order rate constant value at different initial concentration of Astrazone Blue sorption onto peat

Concentration [mg/L]	Pseudo-first-order			Pseudo-second-order		
	q_{exp} [mg/g]	k_1 [min^{-1}]	R^2	q_e [mg/g]	k_2 [g/mg min]	R^2
200	6.37	0.0154	0.9533	6.3854	0.1881	0.9998
300	9.52	0.0184	0.9671	9.5453	0.1344	0.9997
400	12.63	0.0128	0.8498	12.6699	0.0754	0.9983
500	15.68	0.0191	0.9105	15.7226	0.0824	0.9987
600	18.57	0.0166	0.8625	18.6084	0.0995	0.9988
700	21.49	0.0208	0.9799	21.5242	0.1054	0.9998
800	24.27	0.0198	0.9514	24.3029	0.1095	0.9997

Plot of $\log(q_e - q_t)$ versus "time at different adsorbate concentrations deviated considerably from the data. The calculated slopes were used to determine the rate constant k_1. Its values and those of the regression coefficient are presented in Table 4.

The first-order equation did not apply throughout all the contact times in this work. The model was applicable over all the initial concentrations between 15 and 240 minute sorption period except 400 and 600 mg/L where the limit of time was 210 minutes.

The pseudo-first-order kinetic model fits well for the first 30 min and thereafter the data deviate from the theoretical plot. A similar behavior was also reported by other researches [4] where the proposed model fits well the initial stages where rapid adsorption occurs but cannot be applied for the entire adsorption process.

4-2. Pseudo-second-order Kinetic Model

The amount of Astrazone Blue on the adsorbent's surface and the amount of dye adsorbed at equilibrium greatly influenced the pseudo-second-order model. Between the rate and the number of active surface sites is a relation of direct proportionality [22,35].

The pseudo-second order model (Ho model) is expressed by

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

where k_2 (g/mg·min) is the pseudo-second-order rate constant, q_e the amount adsorbed at equilibrium and q_t is the amount of metal adsorbed at time "t".

The second-order sorption rate constant (k_2) and q_e values (Table 4) were calculated from the slopes and intercepts obtained by plotting t/q_t against t at different adsorbate concentrations (Fig. 7).

The q_e calculated values from the obtained equations (characterized by regression coefficients near to 0.99) are close to the experimental values (Table 4), which confirms that the model can be applied for the entire adsorption process.

CONCLUSIONS

The aim of this study was to characterize the brown peat and assess its sorption potential in relation to the colored pollutants from the textile industry wastewater. The adsorbent physicochemical, morphological, and mineralogical characteristics were investigated using elemental analysis, scanning electron microscopy (SEM), and X-ray diffractometry (XRD). The SEM results indicate that the brown peat presents a high level of heterogeneity in terms of particle size and texture and reveal that it is a fibrous material which contains porous granules with good hydraulic and adsorptive characteristics. The XRD analysis showed the presence of crystalline structures and characteristics of amorphous matter.

The use of a chemically treated peat in the dye adsorption processes is not justified because natural peat has a very good retention capacity reaching up to 99.28% in 300 minutes for a dye solutions concentration of 200 mg/L.

Peat has a good retention capacity of organic dye on the entire investigated pH range (2 to 9) and it can be used to remove organic dyes from wastewater with pH values in both alkaline and acid fields.

Peat has a good adsorption capacity for the whole investigated concentration range (200 to 800 mg/L) reaching up to 24.27 mg/g for an initial solution concentration of 800 mg/L.

The removal efficiency of Astrazone Blue dye from aqueous solutions was over 93% for the seven tested concentrations.

Experimental adsorption data were successfully described by the Langmuir equilibrium isotherm model, which may indicate that the number of adsorption sites available for dye on brown peat is limited, and that an adsorbate monolayer was established at saturation.

This conclusion is supported by the agreement between the q values obtained using the Langmuir equation (26.32 mg/g), and the ones obtained experimentally (24.27 mg/g).

Pseudo-first-order and pseudo-second-order kinetic models were used for evaluations of sorption process kinetics. The pseudo-second-order model described Astrazone Blue sorption kinetics, this fact being confirmed by the high values of R^2, which are over 0.99 for the whole investigated concentration range (200 to 800 mg/L).

This study revealed that the brown peat can be successfully employed as low-cost adsorbent for colored aqueous effluents decontamination. The maximum capacity for sorption (q) of Astrazone Blue using the brown peat (NBP) was 24.27 mg/g. This value was compared with other adsorbents reported in literature. It can be observed that the adsorption capacity of the brown peat to remove Astrazone Blue from aqueous solution is higher compared with that obtained for commercial granular activated carbon (18.5 mg/g at pH= 7 and 30 °C).

The use of the brown peat adsorbent is more advantageous compared with other materials since it does not require a preliminary treatment, it has a low-cost and it can be an eco-friendly adsorbent. Hence, this peat appears to be a viable material for the decontamination of effluents containing organic dyes.

ABBREVIATIONS

b : Langmuir isotherm constant [dm^3/mg]
C : concentration after adsorption [mg/L]
C_e : equilibrium concentration [mg/L]
C_t : concentration at time "t" [mg/L]
C_0 : adsorbate initial concentration [mg/L]
C_s : adsorbate monolayer saturation concentration [mg/L]
k_1 : first-order adsorption rate constant [min^{-1}]
k_2 : second-order sorption rate constant [g/mg min]
K_F : Freundlich isotherm constant (mg/g) (dm^3/g)^n related to adsorption capacity
K_L : Langmuir isotherm constant [L/mg]
M : adsorbent weight [g]
n : adsorption intensity
q_{exp} : experimental amount of adsorbate in the adsorbent at equilibrium [mg/g]
q_e : amount of adsorbate in the adsorbent at equilibrium [mg/g]
q_s : theoretical isotherm saturation capacity [mg/g]
Q_0 : maximum monolayer coverage capacities [mg/g]
R : universal gas constant [8.314 J/mol K]
R% : efficiency removal [%]
R^2 : correlation coefficient
t : time [min]
T : temperature [K]

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