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Isotherm and Thermodynamic Studies of Biosorption of Brilliant Green on Surface of Low Cost Biomass Obtained from *Michelia champaca* Leaf

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The capacity to remove brilliant green from aqueous solutions through biosorption using the *Michelia champaca* leaf powder (MCLP), was examined in batch experiments. Almost 99.00% of brilliant green has been removed from 10 mg L^{-1} brilliant green solution and 93.22% from 50 mg L^{-1} brilliant green solution for 0.8 g L^{-1} biosorbent. The biosorption capacity of *Michelia champaca* leaf powder (MCLP) was independent on the pH of the brilliant green solution. For that reason all the adsorption experiments were done without adjusting the pH value. Langmuir monolayer sorption capacity, q_m decreases from 200 to 55.56 mg g^{-1} (109.63 mg g^{-1}, mean) with increase in MCLP amount from 0.2-1.0 g L^{-1}. The adsorption capacity increases with speed of agitation and most favourable adsorption was achieved at 100 revolution per min (rpm). The extend of adsorption of brilliant green onto MCLP was observed to increase with increase in temperature indicating interaction between MCLP-brilliant green is endothermic in nature. The biosorption of brilliant green on MCLP was studied using Fourier transform infrared spectroscopy (FTIR), which indicates that the presence of brilliant green ions in the biomass, affects the bands correlated with –OH, –CHO, –CO and –CN groups. Complete characterization of parameters indicate MCLP to be an excellent biosorbent for treating wastewaters containing brilliant green.

Keywords: Biosorption, Brilliant green, Langmuir, Freundlich, Temkin, Endothermic, *Michelia champaca* leaf powder.

INTRODUCTION

In last decades, water pollution has become a major problem worldwide. The first pollutant to be identified in fresh water is colour and has to be removed from wastewater before discharging into water bodies. Dyes are extensively used in industries, *viz.* pharmaceutical, textile, paper, plastic, leather, printing, food, cosmetics, *etc.* to colour their concluding product. Almost 10000 types of commercially available dyes with over 700 tons of dyestuff are produced per year worldwide. In textile industries, about 1000 L of water are used for every 1000 kg clothes processed [1].

Disperse dye are synthetic dye intended for polyester and related hydrophobic fibers. Almost 85% of disperse dyes are azo or anthraquinone dyes [2]. Due to their adverse impact on water bodies and growing concern of the dyes, wastewater discharged from textile and dyestuff industries must be treated before discharging it into water bodies. Treatment of dye effluents presents several problems mainly due to the harmful and refractory of dye pigments [3]. A dye not only changes the colour of inherent water but also prevents the sunlight to pass through the stream and as a result decreases photosynthetic activities. Due to immense increase of industries and man's need for colour the usage of dyes has been increased day by day.

A large number of methods and technologies has been developed treating wastewater from textile industries before they get discharged into the water bodies. The treatment of environmental constituents depends on the contaminated matrices, the nature of the pollutants and the subsequent use of the disinfected element [4]. Due to the toxicity and carcinogenicity of dyes, treatment of effluents before discharged has been an urgent challenge to our habitat. For which different separation methods and techniques have been developed to find an economic and efficient way to treat the textile dyeing wastewater, including physico-chemical, biochemical, combined treatment processes and other technologies. Some procedure *viz.* activated charcoal adsorption, chemical oxidation, coagulation, ultra-filtration, electrochemical oxidation, floatation, coagulation, floccution, sedimentation, membrane separation

process, reverse osmosis, nanofiltration, ultrafiltration, microfiltration, ultrasonic technology, Fenton reaction, ozone oxidation, photochemical oxidation, electrochemical oxidation, activated sludge process, *etc*. have been established for treating dye-containing effluents [5].

The significance of biosorption over standard wastewater treatment methods incorporate low cost, high efficiency, minimum release of harmful chemicals and lord biological sediments, regeneration of biosorbent and possibility of dye recovery [6]. Biosorbent materials used as an adsorbent for separation of dye ions from wastewater has enormous potential in commercial field and feasibility of biosorption process on new biosorbent products [7]. Few low-cost sorbents such as *Albizia lebbeck* (rattle seed) pod [8]. *Azolla filiculoides* [9], yeast slurry from brewery [10], *Balanites Aegyptiaca* seed husks [11], water hyacinth [12], *etc.* have been used for dye removal. Compared to all the wastewater treatments methods, the biosorption process has been considered to be an effective and economically eficient for the removal of dyes ions from industrial effluent [10]. Bioremediation, biomagnification and biosorption processes are the main technologies used for the removal of dye molecules, heavy metals and organic pollutants from industrial effluents [13,14].

The present work focuses on the feasibility of using *Michelia champaa* leaf powder (MCLP) as biosorbent for the removal of brilliant green dye (BG), the applicability of Langmuir, Freundlich and Temkin isotherm models, kinetic study and temperature dependence on adsorption of brilliant green dye for single component systems.

EXPERIMENTAL

Preparation of biosorbent: Mature *Michelia champaa* leaves were collected from Morigaon district of Assam (India) and washed with fresh water for several times to get rid of sand, dirt and epiphytes. After washing the washed leaves were dried at 100-110 ºC for 3-5 h in hot air oven, the dried leaves were crushed into powder in a mechanical mixer grinder to get the *Michelia champaa* leaves powder (MCLP). The biosorbent was obtained by washing the powdered leaves repeatedly with distilled water to eliminate soluble particles and ultimately dried at 100-110 ºC for 4 h in an hot air oven. The dried MCLP was sieved and the 100-00 mesh fraction was separated. The separated MCLP was preserved in plastic sealed packed for further use as an adsorbent.

Preparation of standards solution of brilliant green: The stock solution of brilliant green was prepared by dissolving 1 g of brilliant green dye in 1 L of deionized distilled water. The required concentration of brilliant green dye sample was prepared by diluting the appropriate amount of the standard solution. A standard calibration curve was drawn by measuring the absorbance at 625 nm λ_{max} for brilliant green spectrophotometrically (Beckmann Coulter 700).

Characterization: The FTIR spectra of *M. champaca* leaf powder (MCLP) was obtained with a Perkin-Elmer spectrometer (Model Spectrum RX I) using 'nujol' method for sample introduction. The MCLP sample was kept for 24 h in an oven at 100-110 ºC, in order to get rid of moisture and cooled to room temperature in a vacuum desiccator and a small amount of the sample was spread on a nujol film between two potassium bromide (KBr) windows. Surface morphologies of MCLP was observed directly with a scanning electron microscope (Type Carl-Zeiss,Σigma-VP). Energy dispersive X-ray spectroscopy (EDS) was also carried out using energy dispersive X-ray analysis (EDX) INCA 4.15 EDS software (Oxford Instruments). The pH of the biosorbent was studied in a 10% slurry of the powdered MCLP (10 g powder in 100 mL double distilled water) with a digital pH-meter (ELICO LI-10). The average specific surface area of MCLP was determined with brilliant green adsorption method [15].

Adsorption experiments: The extend of adsorption on MCLP with respect to brilliant green dye was carried out in a batch adsorption method in a thermostatic water bath shaker at 100 rpm. Each adsorption experiment was carried out in a 150 mL borosilicate Erlenmeyer flask to which a pre-weighed amount of MCLP was added to 50 mL brilliant green dye solution of required initial concentration. The rate of adsorption of brilliant green dye on MCLP was studied under different conditions of time, biosorbent amount, initial dye concentration and temperature to optimize the suitable conditions for biosorption. After shaking the conical flask for fixed interval of time, the mixture was filtered in order to separate the biosorbent from solvent and the unadsorbed dye was determined in the supernatant spectrophotometrically (Beckman Coulter 700) with the help of a standard calibration curve, drawn by measuring the absorbances of the dye solution (λ_{max} of 625 nm) at five different concentrations (10, 20, 30, 40 and 50 mg L^{-1}).

The equilibrium biosorption capacity (q_e) and the percentage removal of the dye were calculated using eqns. 1 and 2, respectively:

$$q_e\ (mg/g) = \left((C_o - C_e) \times \frac{V}{m} \right) \quad (1)$$

$$\text{Dye removal } (\%) = \frac{C_o - C_e}{C_o} \times 100 \quad (2)$$

where, C_o = initial concentration of the dye in solution (mg L^{-1}), C_e = equilibrium concentration of dye in solution (mg L^{-1}) after adsorption, V = volume of solution (L) and m = mass of biosorbent used (g).

In order to describe the equilibrium data for the adsorption of brilliant green dye on MCLP three main adsorption isotherm were used namely, Langmuir, Freundlich and Temkin isotherm models were used:

Langmuir model is represented as:

$$q_e = \frac{q_m b C_e}{1 + b C_e} \quad (3)$$

The linear form of Langmuir adsopption isotherm model is represented as:

$$\frac{C_e}{q_e} = \frac{1}{b q_m} + \frac{C_e}{q_m} \quad (4)$$

where, q_m = amount of the dye adsorbed on unit mass of the adsorbent to form a monolayer (mg g^{-1}), b = Langmuir isotherm

constant = k_a/k_d (k_a and k_d adsorption and desorption rate constants), C_e = equilibrium liquid-phase concentrations of the adsorbate (mg L^{-1}), q_e = equilibrium solid-phase concentration of the adsorbate (mg g^{-1}).

The Freundlich isotherm model mainly describes non-ideal reversible multilayer adsorption onto heterogeneous surfaces. Thus, it has been assumed that once adsorption of dye molecule occurs and occupies all the sites, no further sorption could happen at that site. The Freundlich adsorption isotherm is expressed by the equation as:

$$q_e = K_f C_e^n \quad (5)$$

where, K_f = Freundlich isotherm constant related to adsorption capacity (mg g^{-1}), n = Freundlich isotherm constant related to adsorption intensity, C_e = equilibrium liquid-phase concentration of the adsorbate (mg L^{-1}), q_e = equilibrium solid-phase concentration of the adsorbate (mg g^{-1}).

The linearized form of Freundlich equation is expressed as:

$$\log q_e = \log K_f + n \log C_e \quad (6)$$

The Temkin isotherm model describes the interactions of adsorbents and adsorbate ions and take into account that the heat of adsorption decreases linearly with the sorption and is a function of surface coverage at a particular temperature and a uniform diffusion of binding energies through the exchanging sites on the biosorbent surface [16]. The Temkin model is expressed by the following equation:

$$q_e = \left(\frac{RT}{b} \ln(AC_e) \right) \quad (7)$$

The Temkin isotherm equation in linear form is represented by the following equation [17].

$$q_e = B \ln A + B \ln C_e \quad (8)$$

where, q_e = equilibrium solid-phase concentrations of the dye (mg g^{-1}), C_e = equilibrium liquid-phase concentrations of the dye (mg L^{-1}), B = RT/b = constant related to heat of sorption (J mol^{-1}), A = Temkin isotherm equilibrium binding constant ($Lmin^{-1}$), b = Temkin isotherm constant, B = Temkin isotherm constant, R = universal gas constant (8.314 J mol^{-1} K^{-1}), T = Temperature (K). The values of A and B are obtained from the plot of q_e *versus* ln C_e.

The thermodynamic parameters could be evaluated from the experiments carried out at three different temperatures and are obtained from the following basic thermodynamic relations [18]:

$$\Delta G = -RT \ln K_d \quad (9)$$

$$\Delta G = \Delta H - T\Delta S \quad (10)$$

The classic van't Hoff equation is given by:

$$\ln K_d = \frac{-\Delta H}{RT} + \frac{\Delta S}{R} \quad (11)$$

where, ΔG = Gibb's free energy change (kJ mol^{-1}), ΔH = enthalpy change (kJ mol^{-1}), ΔS = entropy change (JK^{-1} mol^{-1}), $K_d = q_e/C_e$, adsorbate distribution coefficient (L g^{-1}), T = temperature in Kelvin (K), R = Molar gas constant (8.314 J K^{-1} mol^{-1}).

RESULTS AND DISCUSSION

Characterization of MCLP

pH of 10% slurry of MCLP: The pH of slurry of MCLP (10%) with water was found to be 6.24 (nearly neutral).

Specific surface area (SSA): The average monolayer capacity for brilliant green sorption on MCLP was calculated to be 90.91 mg g^{-1}, as the cross-sectional area of the brilliant green molecule is 1.30×10^{-18} m^2. Therefore, the specific surface area of the MCLP biosorbent was found to be 190.37 m^2 g^{-1}.

SEM study of MCLP before and after adsorption: The SEM micrographs of the MCLP surface particle before adsorption (MCLP a) and after adsorption (MCLP b) of brilliant green is shown in Fig. 1. The surface topography of MCLP before adsorption as seen from the SEM micrographs revealed that highly heterogeneous surface with lots of irregular intercellular spaces, voids and rough surface like broken egg's shells. The presence of these intercellular spaces and voids are considered to be responsible dye adsorption on MCLP surface. After adsorption the SEM micrographs MCLP (b) have clearly shown the difference in surface morphology brought in by dyes adsorption. The SEM images have clearly shown that after adsorption, a slight change in the surface morphology of MCLP is visible and this may be due to the deposition of brilliant green dye molecules over the biosorbent (MCLP) surface.

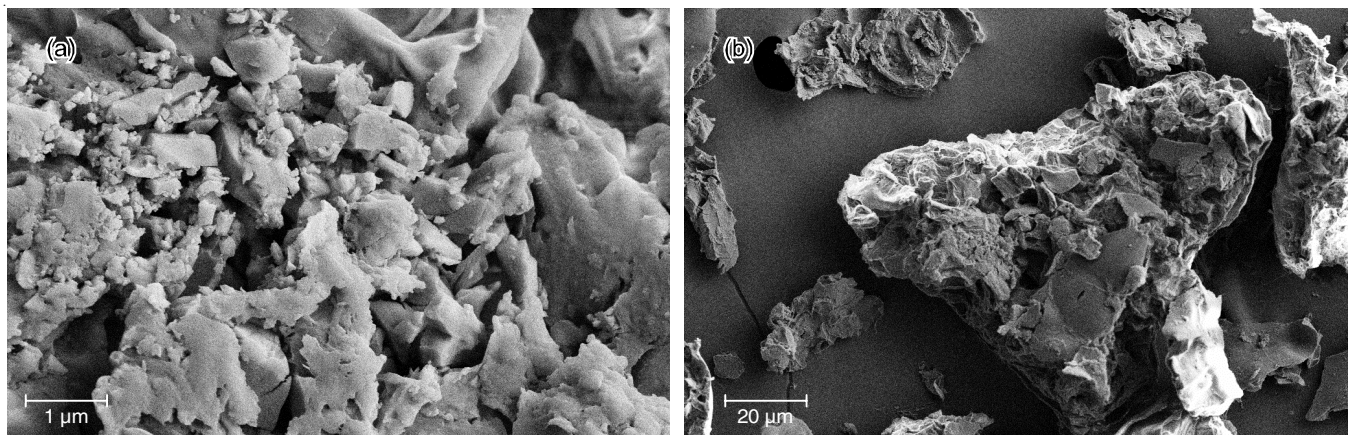

Fig. 1. Scanning electron microscope (SEM) image of MCLP before adsorption (a) and after adsorption of brilliant green (b)

EDX studies: The energy dispersive spectra (EDX) of MCLP before adsorption and after adsorption of brilliant green are shown in Fig. 2. The spectrum of EDX analysis confirmed the presence of four major elements, *i.e.* carbon, oxygen, calcium and silicon before dye adsorption (Fig. 2a). After adsorption of brilliant green (Fig. 2b), the amount of carbon increased which may be attributed due to adsorption of dye as brilliant green possesses a carbon-based structure. Complete disappearance of Si and minor changes in other elements indicates adsorption of brilliant green from aqueous solution onto MCLP surface and their interaction with adsorbent.

FTIR studies: The FTIR exhibits that the MCLP surface contains a large number of functional groups, comparatively –OH at 3500-3300 cm^{-1}, -CHO at 2900-2800 cm^{-1}, C=C (alkene) at 1680-1600 cm^{-1}, -C=O (amide) at 1680-1630 cm^{-1} and C-N (amine) at 1350-1000 cm^{-1} (Fig. 3a) and these functional groups of MCLP binds to the dye cations on the adsorbent surface.

The FTIR spectrum of MCLP after adsorption of brilliant green is shown in Fig. 3b. Comparing the FTIR results of MCLP before and after adsorption of dye showed a significant change in intensity or shift of the present functional groups intensity in MCLP and this may be due to interactions formed between the functional groups present in MCLP and dye ions. After adsorption the shift in the intensity of the peaks clearly indicates the involvement of these groups in the dyes adsorption process by MCLP.

Batch adsorption studies

Effect of pH: The pH of aqueous solution of brilliant green was found to be approximately ~ 6.5, which doesn't change much with further dilution. The aqueous solution of brilliant green dye solution is pH sensitive. At lower pH, the solution becomes turbid due to precipitation and it changes colour with increase in pH. Due to which all the experiments were done without adjusting the pH of dye solution.

Effect of agitation time: The results of agitation time on adsorption of brilliant green dye on MCLP was investigated within a time interval of 10 to 100 min, with dye concentration, which varies from 10-50 mg L^{-1} at 0.8 g L^{-1} MCLP amount (Fig. 4). For 10 mg L^{-1} of brilliant green dye solution, the extent of adsorption q_t (mg g^{-1}) increases from 12.04 to 12.38 mg g^{-1} with increase in contact time from 10 to 100 min. The increasing contact time increased the brilliant green adsorption and after attaining the equilibrium time of 100 min it remains constant. The rapid extent of adsorption of brilliant green dye of each concentration (10 to 50 mg L^{-1}) within 20 min of agitation time was found to be in the range from 12.31 to 57.03 mg g^{-1} and it is due to the larger surface area of the MCLP (0.8 g L^{-1}) being available at beginning for the adsorption. At 100 min, the extent of adsorption of brilliant green was found to be in the range of 12.38 to 60.56 mg g^{-1} as the dye concentration increases from 10 to 50 mg L^{-1}. The relatively short equilibrium time 100 min for brilliant green dye sorption on MCLP indicates that the biosorbent possessed a high degree of affinity for the dye ion. Chaghaby *et al.* [19] reported a similar short equilibrium time (120 min) for adsorption of brilliant green from aqueous solution onto rice straw ash (RSA).

Effect of MCLP amount and brilliant green concentration: The effect of MCLP amount and brilliant green concentrations on the removal of brilliant green was performed for

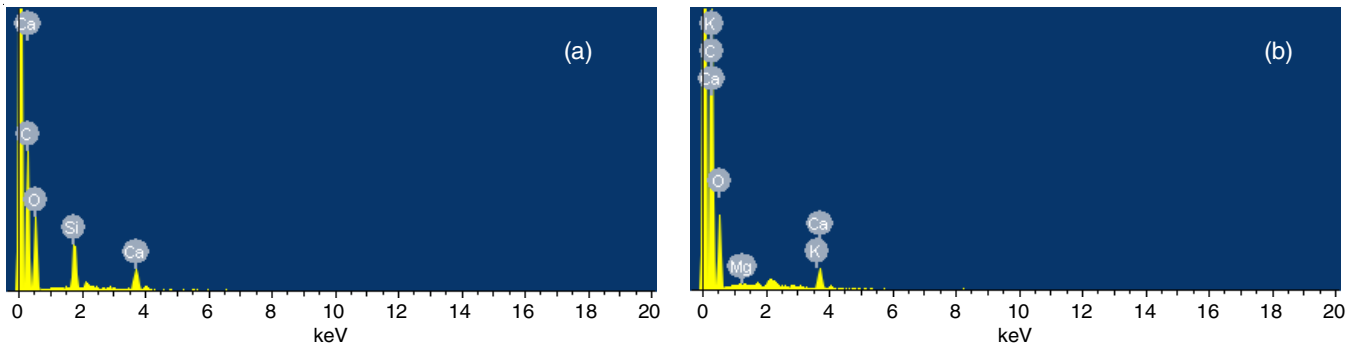

Fig. 2. EDX spectra of MCLP before adsorption (a) and after adsorption of brilliant green (b)

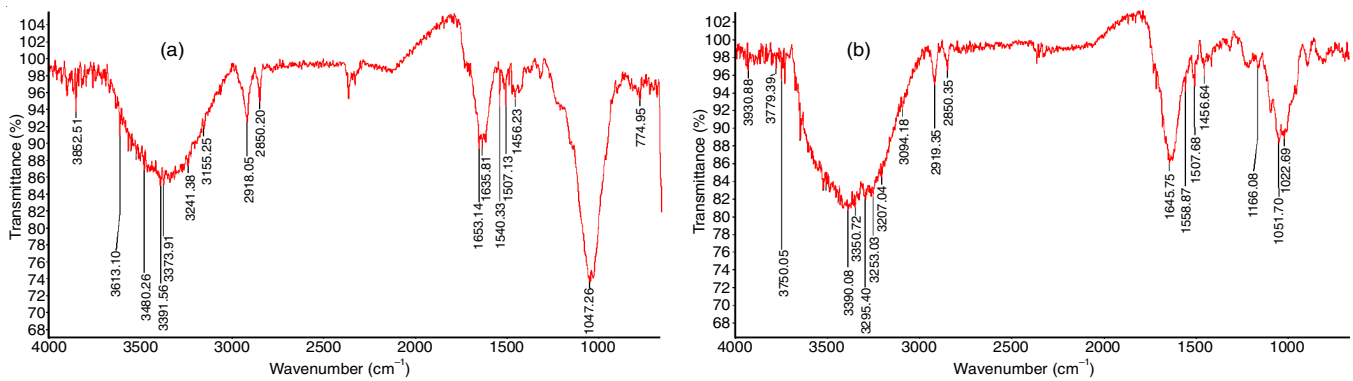

Fig. 3. FTIR spectra of MCLP (a) before adsorption and (b) after adsorption of 30 mg L^{-1} brilliant green

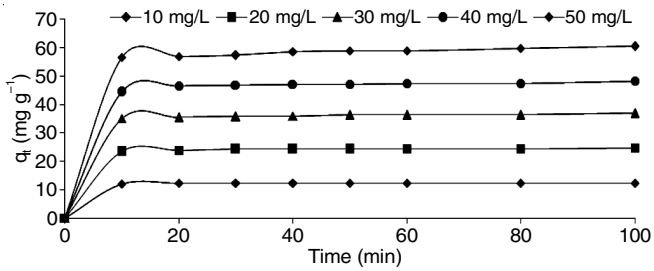

Fig. 4. Effects of agitation time on brilliant green (10-50 mg L^{-1}) adsorption by 0.8 g L^{-1} MCLP at 303 K

five different dye concentration (10-50 mg L^{-1}) solution by varying the adsorbent amount from 0.2 to 1.0 g L^{-1} at 303 K. The results revealed that as the MCLP amount increases, the percentage of brilliant green dye removal increases from 75.86% to 96.5% for a constant brilliant green concentration 50 mg L^{-1}.

Moreover, for fixed biosorbent amount (MCLP 0.8 g L^{-1}) the extend of adsorption of dye decreases from 99% to 93.22% with increase in brilliant green concentration from 10 to 50 mg L^{-1}. Similar decrease in extend of adsorption of dye with increase in concentration of dye, have been reported by Mazaheri *et al.* [20] for sorption of brilliant green onto the commercial activated carbon (CAC) and kaolin.

Isotherm studies: The adsorption data of brilliant green dye adsorption on MCLP at a fixed temperature (303 K) were investigated with respect to the applicability of three common adsorption isotherms *viz.* Langmuir, Freundlich and Temkin isotherms. The Langmuir isotherm was applied for brilliant green (10 to 50 mg L^{-1}) adsorption on MCLP (0.2 to 1.0 g L^{-1}) by plotting C_e/q_e *versus* C_e. The Langmuir coefficients, q_m and b, are obtained from the slope and the intercept of the curves, are shown in Table-1. The linearity of the plots are quite good with a mean regression coefficients value of 0.95 (mean). The monolayer adsorption capacity (q_m) decreases from 200 to 55.56 mg g^{-1} (109.63 mg g^{-1}, mean) with increase in MCLP amount from 0.2 to 1.0 g L^{-1}. The large value of q_m signifies that MCLP has a good affinity for brilliant green adsorption. The dimensionless separation factor (R_L) varies from 0.91 to 0.97 with an average mean value of 0.95, which fulfill the requirement for a favourable sorption process *i.e.* $0 < R_L < 1$, indicating effective absorption of brilliant green dye on MCLP. The value of Langmuir constant 'b' varies from 0.63 to 3 with a mean value of 1.53. Similar results of q_m (156.35 mg g^{-1}), R_L (0.033) and regression coefficient R (0.99) was also reported for adsorption of malachite green on Eucalyptus wood fiber (EWBC) was reported by Singh *et al.* [21]. These values are similar to the ones obtained in this work.

The Freundlich isotherm model is obtained by the plotting a graph between log q_e *vs.* log C_e, which gave straight lines with good regression coefficients value 0.95 (mean). Both the Freundlich coefficients n and K_f are obtained from the slope and the intercept of the plots are given in Table-1. The adsorption affinity (n) vary from 0.32 and 0.53 (mean = 0.42), fulfilling the condition *i.e.* $0 < n < 1$ indicates that a favourable type of adsorption has taken place between brilliant green and MCLP. The adsorption capacity (K_f) values remained between 4.86-6.45 L mg^{-1} (mean 5.40 L mg^{-1}). The Freundlich coefficients values are shown in Table-1. Brillant green adsorption on the shrimp shell yielded very similar values of K_f (2.02) and n (0.36) [22].

The Temkin isotherm plots were obtained by plotting q_e *vs.* ln C_e, which gives straight lines and the Temkin coefficients, A_T and b is calculated from the slope and intercepts of the plots and are also listed in Table-1. The regression coefficients (R) had values in the range 0.89-0.99 (mean value 0.96), indicated the applicability of this model for adsorption of brillant green on MCLP. The Temkin coefficients (A_T) had values in the range from 13.49 to 33.11 L g^{-1} (mean 21.86 L g^{-1}) and b from 45.87 to 98.37 J mol^{-1} (mean 65.64 J mol^{-1}).

Thermodynamic parameters: The experimental data obtained by adsorption of brillant green on 0.8 g L^{-1} MCLP at 30, 40 and 50 ºC and five different brillant green concentrations (10 to 50 mg L^{-1}) were applied in determining the Gibb's free energy change (ΔG), the enthalpy change (ΔH) and entropy change (ΔS). The thermodynamic values were computed from the slope and intercept of the plots of log q_e/C_e *versus* 1/T. The values of the parameters, ΔH, ΔS and ΔG are listed in Table-2. The negative ΔG values; -9.00 KJ mol^{-1} to -10.92 KJ mol^{-1}, at 303 K to 323 K obtained suggested the spontaneity of adsorption of brillant green dye onto MCLP. With the increase in

TABLE-1
ADSORPTION ISOTHERM PARAMETERS FOR BG-MCLP INTERACTIONS AT 303 K

MCLP (g L^{-1})	0.2	0.4	0.6	0.8	1.0	Mean
Langmuir coefficient						
R	0.97	0.97	0.99	0.98	0.99	0.98
q_m (mg g^{-1})	200	125	90.91	76.92	55.56	109.68
b (Lmg^{-1})	0.63	0.80	1.22	2.00	3.00	1.53
R_L	0.97	0.95	0.96	0.95	0.91	0.95
Freundlich coefficient						
R	0.99	0.98	0.99	0.98	0.99	0.99
K_f (L mg^{-1})	6.45	5.37	5.02	5.32	4.86	5.40
n	0.32	0.39	0.42	0.53	0.46	0.42
Temkin coefficient						
R	0.89	0.97	0.95	0.98	0.99	0.96
A_T (Lg^{-1})	25.88	19.05	13.49	17.78	33.11	21.86
B	54.92	41.05	43.89	38.64	25.61	40.82
b ($Jmol^{-1}$)	45.87	61.37	57.39	65.19	98.37	65.64

temperature, the Gibbs free energy (ΔG) decreases, resulting favourable interactions between MCLP-brillant green dye, which corresponds to the increase in the extent of adsorption [23]. The positive enthalpy change ΔH values, varied from 10.73 to 33.35 KJ mol^{-1} (mean 25.31 KJ mol^{-1}) indicates that brillant green dye sorption process on MCLP was endothermic in nature. The entropy of the system *i.e.* ΔS increases from 61.21 J K^{-1} mol^{-1} to 137.49 J K^{-1} mol^{-1} (mean value 91.86 J K^{-1} mol^{-1}). The positive value of entropy indicates the high degree of disorderness at the solid-liquid interface during the sorption of brillant green ions on MCLP biosorbent. Similar type of adsorption has been reported for the sorption of BG dye onto *Calotropis procera* leaf powder (CPLP) adsorbent having –ΔG (3.99 KJ mol^{-1}), ΔH (8.15 kJ mol^{-1}) and ΔS (39.97 J K^{-1} mol^{-1}) by Shah *et al.* [24] and reactive yellow dye adsorption on malt bagasse adsorbent having –ΔG (5390.08 KJ mol^{-1}), ΔH (13.38 kJ mol^{-1}) and ΔS (0.062 J K^{-1} mol^{-1}) has been reported by Silva *et al.* [25].

TABLE-2
THERMODYNAMIC PARAMETERS FOR ADSORPTION OF BRILLIANT GREEN ON MCLP

BG (mg L^{-1})	ΔH (kJ mol^{-1})	ΔS (J mol^{-1} K^{-1})	–ΔG (kJ mol^{-1}) at temperature		
			303 K	313 K	323 K
10	13.77	80.39	10.59	11.39	12.19
20	20.89	103.57	10.49	11.53	12.56
30	33.35	137.49	8.31	9.68	11.06
40	10.73	61.21	7.82	8.43	9.44
50	15.41	76.65	7.81	8.58	9.35
Mean	18.83	91.86	9.00	9.92	10.92

Conclusion

The present work mainly aimed at evaluating the sorption of brilliant green dye using the biosorbent *Michelia champaca* leaf powder (MCLP). Equilibrium time of the adsorption process was attained at 100 min of contact time. The effect of parameters such as pH, nature of biosorbent, contact time, initial dye concentration, temperature and biosorbent amount was investigated by batch adsorption process. The Freundlich, Langmuir and Temkin isotherm models mainly explains the mechanisms of the sorption process using the correlation coefficient values. The adsorption process of brilliant green on MCLP is best applied into Freundlich model, which indicates that multilayer adsorption has taken place on the bisorbent. Based on thermodynamic parameters, indicates favourable interactions between MCLP-brilliant green dye, which corresponds to the increase in the extent of adsorption with increase in temperature *i.e.* endothermic, as spontaneous and high degree of disorderness at the solid-liquid interface during the sorption of brilliant green dye on MCLP. The results of FTIR, EDX and SEM analyses indicated that the functional groups on the surface of MCLP had played an important part in biosorption of brilliant green dye. Maximum percentage of the dye removal rate was found the highest as 99% comparing the results of other studies about dye biosorption by MCLP. It is concluded that *Michelia champaca* leaf powder (MCLP) is an effective, low cost and environment friendly biosorbent for treating dye containing wastewater from textile effluents.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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