Removal Of Methylene Blue Dye Using Carbon Derived From The Bulb Of Zephyranthes Citrina By Adsorption And Kinetic Studies

J. Prakash, S. Vedanayaki and K. Karthick

Abstract: The studies open up an innovative approach and investigate porous, efficient raw carbon from the Zephyranthes citrina (ZC) bulb, which was used as an adsorbent. The well-dried and finely powdered ZC bulb was carbonized at a temperature of 900 °C. The carbonized crude ZC sample was characterized by FT-IR, UV-visible, Scanning Electron Microscopy (SEM), BET and X-ray diffraction techniques, and their adsorption potential to remove the basic methylene blue (MB) dye from an aqueous sample. Adsorption studies comprise both adsorption isotherm and kinetic methods. The processes were carried out with diverse adsorbate concentrations and adsorbent quantities at various time intervals in the batch process. The BET isotherm model has also been used as an adsorption mechanism, which explores the finest adsorption capacity of the synthesized carbon material. Kinetic models of Lagergren first order, pseudo second order and intra particle diffusion were used to assess the kinetics and adsorption mechanism. The results revealed that the adsorption process follows the first order kinetic model of Lagergren. The BET isotherm model confirmed that it has an excellent adsorption capacity in an adsorption process. Based on the results obtained, the maximum removal (81%) of the dye was achieved as a solution containing 50 mg of the 50 ml dye at 3 hours for methylene blue. The results indicated that the bulb of Zephyranthes citrina carbon is a proficient adsorption material and is also used as a cost effective alternative that can absorb dye from an aqueous solution without activation treatment.

Index Terms: Zephyranthes citrina, Adsorption isotherm, kinetics, Spectral characterization, Methylene Blue

1. INTRODUCTION:
Pollution has always been a non-negligible crisis that hampers not only the industrialization process but also the health of people. For example, massive quantities of pollutants are liquefied and hooked on the environment without pretreatment. These pollutants predominantly consist of organic dyes, heavy metal ions, overused antibiotics, different tricky chemicals, etc. [1,2]. The treatment of wastewater from dyeing and finishing processes in the textile industry is one of the imperative environmental problems. Since most synthetic dyes have complex aromatic molecular structures, they are inactive and intricate to biodegrade when detached in an environment. Colored waste is harmful to aquatic organisms in rivers, lakes and seas, where it is disposed of. In addition, the dyes themselves are an extremely toxic to some organisms and therefore disrupt the ecosystem. Dyes may be the source for allergic dermatitis, skin irritation, cancer, mutations, etc. Besides, biodegradation of number of dyes produces aromatic amines that are intensely carcinogenic. The continuing disclosure of workers in the textile industry is associated with an augmented risk of bladder cancer. Dyes are normally stable to light degradation, biodegradation and oxidizing agents, which has led to intensive research on physical or chemical methods of removing the colour of textile wastewater [3-5]. The effluent treatment studies comprise the use of coagulants, ultrafiltration and electrochemical. With these methods it has been discovered that adsorption is an efficient and inexpensive process to remove dyes, pigments and other dyes as well as to control the biochemical oxygen demand [6-10].

The removal of toxic substances, hazardous ions and dyes from industrial wastewater by adsorption is of vast significance for the safety of the environment and human health. Adsorption by solids reduces the toxicity of the wastewater or removes hazardous organic matter from industrial effluents, etc. [11,12]. In this present research work, carbon was derived from bulb of Zephyranthes citrina and used as absorbent for removal of dye from wastewater samples. It belongs to the family Amaryllidaceae. Plants of this family is a small group of monocotyledonous species which comprise about 860 to 1100 species in eighty five genera distributed largely over tropical and subtropical regions. It is a globular plant with green leaves deadly 4mm wide. The flowers were lemon yellow colour with cone shaped from 3.1 to 5 cm green tube. The flowers of this rain lily spring forth in late summer. It grows splendidly in natural grasslands and as well as in precincts after rain fall. Since they often come into bloom after it rains, Zephyranthes citrina is commonly called as citron zephyr lily or yellow rain lily. To the best of our knowledge, awareness and thoughtful, there is no statement on the consumption of carbon derived from bulb of Zephyranthes citrina for removal of dyes. Hence, the main goal of the current study is an effort for the first time to evaluate adsorption efficiency of carbon from the selected plant in the study of removal of dye by absorption method. Methylene blue (MB), a cationic dye, is the nearly everyone generally used dye for colouring amid all other dyes. MB may grounds eye burns and, if swallowed, irritation of the gastrointestinal tract with symptoms of nausea, vomiting and diarrhea. It can also cause methemoglobinemia, cyanosis, seizures and respiratory distress when inhaled [13]. The methylene blue (MB) dye is removed using Zephyranthes citrina carbon by adsorption technique. It is the most important and simplest dye removal technique compared to all other techniques available. Among the accessible adsorbents, the adsorbent derived from plant material is one of the trendiest for both liquid and gaseous purifications because of its unique properties, which consist...
of its porous structure, highly specific surfaces and large sorption capabilities. The texture and surface properties of carbon are inclined by both the ancestor material and the method used to make it. Conversely, the adsorption efficiency of carbon strappingly depends on its specific surface area, the pore size distribution, and the surface functional groups present, and the later influence its performance through polar interaction with polar, non-polar, anionic, and cationic adsorbates [14,15].

2. MATERIALS AND METHODS

2.1 Collection and authentication of Plant material

The plant material was collected from the crowd area of Institution, Paramathi velur, Namakkal District. The plant was renowned and authenticated (Voucher No. BSI/SRC/5/23/2018/Tech/1113) in the BSI (Botanical Survey of India), Department of Botany, Agricultural University, Coimbatore. The globular plant objects were cut into pieces, dried under shade for 15 days, coarsely powdered and stored.

2.2. Preparation of Carbon

Zephyranthes citrina was carbonized by using tubular furnace with inert atmosphere at 900°C for 6 hrs. After cooling down to the room temperature, the biochar was grained as fine particles. As a final point, the samples were stored in an airtight container for future study.

2.3. Experimental Methods

MB was obtained from S.D. Fine Chemicals, Mumbai, India, and used as itself devoid of any additional sanitization. The further whole chemicals were used as to AR quality. A storage solution of 1000 mg/L MB was equipped by dissolving the dye in DD water. Using the above solution, an assortment of concentrations of the solutions was primed and stored in brown glass bottles inorder to prevent deterioration from light. Absorbance measurements were made for MB using a UV-Vis spectrophotometer. During absorbance measurement, the highest absorption at 665 nm for MB was used for monitoring wavelength. Calibration charts were prepared for MB and concentrations were anticipated using calibration charts.

2.4. Instrumental Analysis of Zephyranthes citrina

Crystalline structure and phase recognition of the synthesized taster were studied by X-ray diffraction (XRD) techniques (Rigaku –IVUltima). The morphology and structure were examined by Field Emission Scanning Electron Microscope (FE-SEM) (FEI Quanta-250 FEG microscope). The optical studies were carried out by using UV-Visible spectrophotometer (Jasco V-650).

2.5. Batch Adsorption Experiments

Adsorption experiments for MB dye were performed to examine the consequence of different characters such as initial adsorbate concentration, contact time, adsorbent dose and initial pH. Solutions consist of the preferred concentrations of MB to naturally pH 6.0 and 50 mg g⁻¹. Adsorbent was placed in conical flask (100 ml) and enthused at 200 rpm and 35°C in a WiseCube shaking incubator. Following the encoded intervals of time, the samples were removed and the supernatant alienated from the adsorbents by centrifugation at 2500 rpm for 20 minutes. Then the concentration of lingering dye was dogged as indicated above. The consequence of the pH was in the range of 2.0 to 10.0 by adjusting the pH of the solutions using 1 M hydrochloric acid and 1 M sodium hydroxide solutions through a pH meter.

2.6. Desorption studies

The addition of 10 mg L⁻¹ MB dye in a solution was done by using the adsorbent via centrifugation. Using Whatmann filter paper, dye-loaded adsorbent was alienated and tenderly washed with water to eradicate unadsorbed dye. Numerous samples of this type were equipped. Afterward, the spent adsorbent was stirred with 50 ml of distilled water and then washed with ethyl alcohol. The desorbed dye was anticipated as earlier.

3. RESULTS AND DISCUSSIONS

3.1 XRD analysis

Figure 1 shows the XRD spectra of raw carbon material. It shows a idiosyncratic asymmetric broad peak, which is at about 2θ = 25° and is accredited to the reflection (002) of graphite, even though it is enormously disperse in comparison to the ideal graphite, whereas the spiky peak at 2θ = 44° corresponds to the reflection of the crystal phase of (100) graphite. Feeble diffraction peaks at 2θ = 51° associated with the plane (004). Where there are sharp peaks and wide peaks due to the better alignment of the layer and the amorphous structure of the carbon. Therefore carbon belongs to the carbonaceous structure.

3.2. Optical studies
By using FTIR spectroscopy, the natural environment of the functional groups of the adsorbents and chemical bond, without loaded and with MB loaded were monitored. FTIR spectra were noted in granules obtained by pressing a combination of 1 mg of carbon and 100 mg of dry KBr beneath pressure. Figure 2a shows that the FT-IR spectrum of Zephyranthes citrina has feeble and wide peaks in the range of 400 to 4000 cm⁻¹. The FT-IR spectra of carbon indicated that the bands at 3414.07, 2917.88, 2851.02, 1552.49, 1035.95, 604.10 cm⁻¹ corresponds to -OH, -CH₂, C = O, C = C, CO-C, C-OH (twist broad). These outcomes of the results recommend that the presence of oxygen-containing groups, like -COOH and -OH, in Zephyranthes citrina carbon, which probably plays a vital role in the MB dye adsorption owing to electrostatic interactions. The UV absorption spectra of Zephyranthes citrina carbon was recorded using the UV Visible spectrophotometer in the wavelength range about 200-400 nm as exposed in the figure 2b. The peak at 277 nm ascribed to π-π* transition of the carbon. Furthermore, Figure 2c shows a detailed PL investigation with two diverse excitation wavelengths. PL is one of most fascinated features of carbon based fluorescence studies. Hence, The PL spectra of Zephyranthes citrina carbon obtained in the range of 300-500 nm at RT under excitation wavelength of 270 and 290 nm. The maximum emission peaks are obtained in the range of 360-370 nm. No more significant changes in the PL studies and visible light emission are not obtained because of the absorption (carbon size dependent).

3.3. SEM Observations

The scanning electron microscope (SEM) images show a carbon with uniform porosity and surface area. Pores and size of pores increase with increasing carbonization temperature. Pores and high surface area in the material support to increase the proficiency of dye molecule. In carbon, dye molecules were absorbed into the pores of the materials. Figure 4 (a) indicates the SEM micrographs of carbon with a cubic dye molecules presence on the surface. After adsorption, the dye molecules are present inside the pores and sheltered on the outside of the substance. Thus, the SEM and EDAX spectrum confirmed the presence of dye molecules. EDAX spectrum gives the qualitative and quantitative information of element composition present in the sample. The EDAX spectrum [Figure 4 (b)] shows that the confirmation of dye molecule present in the surface as well as pores of the carbon. The efficiency of the sample is increased due to the morphology (porous) of the carbon.

3.4. BET analysis

The adsorption ability of the ZC (Zephyranthes citrina) bulb depends on the size, volume, shape and precise surface area of the pore. The specific surface area of ZCC (Zephyranthes citrina carbon) was evaluated from BET analysis and the volume of the micropores (V) was determined by calculating the adsorbate volume. BET method was useful in determining the relationship between the surface area and properties of the material, as well as the influence of activation temperature, activator, and
impregnation ratio on pore formation [16]. In the current research study, ZCC with the largest surface area was prepared by activation at high T. The porous structure of ZCC is based on the fact that the lateral bonds in the molecules are broken and the pore density increases. The S_{BET}, micropore area and average pore diameter of ZC were observed to be 422.16 (m² g⁻¹), 1.93 (m² g⁻¹) and 8.068 (Å), respectively. In support of our findings, IUPAC completed from the results of S_{BET} that the occurrence of a Type I isotherm at high pressure on a horizontal plateau could result in the progress of microporous material dispersed in narrow pores. The results indicated that modify in the fractal dimension was unrelated and the entire progress of pores on the surface area of ZCC [17].

3.5. Batch mode adsorption studies

3.5.1. Effect of pH

The removal of MB (cationic dye) based on the effect of pH is shown in figure 6. The adsorption efficiency of this MB is primarily affected by the surface charge in adsorbent, which in turn is pretentious by pH. The % of dye elimination for Zephyranthes citrina reduced from 92% to 48% as the pH range of diverse concentrations of dye (10 to 50 mg/L) increased from 2.0-10.0. The decrease in the pH of the MB dye solution caused an equivalent increase in adsorption efficiency. At minimum pH, the two SO³⁻ groups present in the dye grounds protonation, and consequently the electrostatic force of attraction among the protonated dye and the positive charge on the adsorbent surface leads to an increase in adsorption [18,19].

3.5.2. Desorption studies

This cram is helpful to determine appropriateness of adsorbent recycling, dye recuperation and also to illuminate the dye adsorption mechanism. The consequence of pH on desorption of MB on Zephyranthes citrina adsorbate-loaded adsorbent at various pH's of 2.0 - 10.0 is shown in figure 7. The smallest and highest desorption was 8.00% and 43.75% at pH 2.0 and 9.0 for 10 mg/L. Desorption studies have proven that ion exchange mechanisms seem to be the main adsorption type for Zephyranthes citrina [20].

![Fig. 7 — Effect of initial pH on desorption of MB onto Zephyranthes citrina](image)

3.5.3. Effect of Agitation Time

A sequence of contact time testing was performed to adsorb MB dye at various primary concentrations (10 to 50 mg/L) at 35°C. The equilibrium time for MB was 120 to 10 mg/L, 140 to 20 mg/L and 160 min for the lingering concentrations. The adsorption delayed at a later time because primarily a huge amount of free surface sites were accessible for adsorption and the residual free surface sites may become tricky to engage after a while owing to the revolving forces among the molecules in the adsorbent and bulk phases. In general, the initial concentration provides an imperative driving force to overcome the overall mass transfer resistance of the dye connecting the aqueous and solid phases. Figure 8 shows the equilibrium adsorption capability of MB at primary dye concentrations of 9.83 to 38.9 mg/L at 10-50 mg/L [21].

![Fig. 8 — Effect of agitation time on adsorption of MB onto Zephyranthes citrina](image)

3.5.4. Effect of adsorbent dose

The amount of adsorbent used is a crucial and economic factor during adsorption processes. Figure 9 shows the elimination of MB by Zephyranthes citrina carbon at various dye doses of the adsorbent (10-50 mg/L). It was found that
the elimination percentage for Zephyranthes citrina was 91.83 to 100%, in doses of 50 to 200 mg. The results in Figure 9 confirmed that by increasing the dose of an adsorbent, the whole number of adsorption sites becomes increased. Hence, percentage of dye removal is increased.

\[
q_i = k_{id} t^{1/2}
\]  

(3)

Where,
- \( q_i \) - The amount adsorbed at time \( t \)
- \( k_{id} \) - The intra-particle diffusion rate constant.

The general properties of all graphs are: (i) the initial curved part is ascribed to the mass diffusion effect (ii) the linear part of the intraparticle diffusion effect and (iii) the equilibrium plateau. The absorption rate could be limited by the size, adsorbate concentration, its affinity for the adsorbent, diffusion coefficient and pore size distribution of the adsorbent. Due to the disparity in size of the inner pores and a different approach for entire sorption period, the mechanism may be changed [23]. Based on equation 3, the slopes of the linear parts of the graphs of \( q_t \) versus \( t^{1/2} \) indicate the values of \( k_{id} \) as represented in Table 1. As can be seen in figure 10, the graphs were non-linear over the entire time domain, which implies that more than one process was pretentious by adsorption. The multiplicity of these graphs could be enlightened by the diffusion of the boundary layer, which gave the first part, and the intraparticle diffusion, which gave an additional linear part. If intraparticle diffusion was the only speed control step, the plot would pass through the origin; otherwise, diffusion of the boundary layer controlled the adsorption to some degree [24]. This oblique that the dye molecule intraparticle diffusion in the mesopores was the rate restricted step in the adsorption process of Zephyranthes citrina, especially during long contact times.

\[\text{Table 1: Evaluation of first order, second order and intraparticle diffusion kinetic data for adsorption of MB dye onto Zephyranthes citrina}\]

<table>
<thead>
<tr>
<th>Kinetic Model</th>
<th>Conc. (mg/L)</th>
<th>( q_e ) exp. (mg/g)</th>
<th>( k_1 ) (min(^{-1}))</th>
<th>( q_e ) cal (mg/g)</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>First order</td>
<td>10</td>
<td>9.83</td>
<td>0.051</td>
<td>10.05</td>
<td>0.978</td>
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<tr>
<td></td>
<td>20</td>
<td>19.59</td>
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<td>17.22</td>
<td>0.996</td>
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<tr>
<td></td>
<td>30</td>
<td>28.64</td>
<td>0.018</td>
<td>27.54</td>
<td>0.989</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>34.54</td>
<td>0.018</td>
<td>34.83</td>
<td>0.958</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>38.9</td>
<td>0.021</td>
<td>40.74</td>
<td>0.943</td>
</tr>
<tr>
<td>Second Order</td>
<td>10</td>
<td>9.83</td>
<td>0.0058</td>
<td>11.36</td>
<td>0.996</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>19.59</td>
<td>0.0015</td>
<td>23.26</td>
<td>0.988</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>28.64</td>
<td>0.0006</td>
<td>35.71</td>
<td>0.980</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>34.54</td>
<td>0.0005</td>
<td>41.67</td>
<td>0.969</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>38.9</td>
<td>0.0005</td>
<td>47.62</td>
<td>0.966</td>
</tr>
<tr>
<td>Intraparticle diffusion</td>
<td>10</td>
<td>9.83</td>
<td>0.566</td>
<td>3.713</td>
<td>0.773</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>19.59</td>
<td>1.395</td>
<td>3.261</td>
<td>0.949</td>
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<tr>
<td></td>
<td>30</td>
<td>28.64</td>
<td>2.223</td>
<td>1.229</td>
<td>0.982</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>34.54</td>
<td>2.697</td>
<td>0.662</td>
<td>0.993</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>38.9</td>
<td>3.059</td>
<td>0.674</td>
<td>0.992</td>
</tr>
</tbody>
</table>

**Fig. 9—Effect of adsorbent dose on adsorption of MB onto Zephyranthes citrina**

3.5.5. Adsorption Kinetics

The Lagergren equation is one of the most commonly used adsorption rate equation for calculating adsorbate adsorption from an aqueous solution. The Lagergren of the first-order rate equation may be represented as follows,

\[
\log (q_e - q) = \log q_e - \frac{k_1 t}{2.303}
\]  

(1)

Where,
- \( q_e \) and \( q \) - The amounts of dye adsorbed (mg/g) at equilibrium and at time \( t \) (min).
- \( k_1 \) - Lagergren rate constant for first-order adsorption (per min).

The pseudo second-order kinetic may be written as

\[
\frac{t}{q} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e}
\]  

(2)

Where,
- \( k_2 \) - Equilibrium rate constant for adsorption of pseudo second-order (g mg\(^{-1}\) min\(^{-1}\))

The calculated results from the first and second order kinetic models together with the experimental \( q_e \) values are shown in Table 1. In general, the deliberate \( q_e \) values of the first-order kinetics of Lagergren are closer to the experimental \( q_e \) values, compared with the values of \( q_e \) deliberate from the second-order kinetics for MB in Zephyranthes citrina. As a result, the adsorption follows the first-order Lagergren kinetic model for MB dye [22].

3.5.5.1. Intraparticle Diffusion

The present study also includes the intraparticle diffusion model based on the kinetic data measured and expressed by Weber–Morris equation.
3.6. Adsorption Isotherms

The adsorption isotherm is significant from a theoretical as well as a practical point of view. So as to optimize the sketch of an adsorption system for the removal of dyes, it is imperative to determine the most essential correlations of the equilibrium data of each system. The data collected from the various replica offer significant information on sorption mechanisms, surface properties and adsorbent affinities. This equilibrium of adsorption could be articulated by the isotherms of Langmuir, Freundlich and D-R [25].

3.6.1. Langmuir Isotherm

The Langmuir adsorption isotherm model imagine that the intermolecular force of attraction between the adsorbed molecules are negligible and once the surface sites in the adsorbent are completely engaged, no possibility for further adsorption to occurs [26]. The equilibrium adsorption isotherm is an essential for telling the interaction performance among adsorbate and adsorbent and also plays a vital role in the design of adsorption systems. The linear form of Langmuir adsorption isotherm equation is represented as, [27],

\[
\frac{C_e}{q_e} = \frac{1}{Q_0b} + \frac{C_e}{Q_0}
\]

(4)

Where,

\(C_e\) - Equilibrium concentration (mg/L)

\(q_e\) - Amount adsorbed at equilibrium (mg/g)

\(Q_0\) - Amount of dye adsorbed at complete monolayer coverage

b - Langmuir adsorption constant

The linear graphs of \(Ce/qe\) against \(Ce\) propose the acceptability of Langmuir adsorption isotherm. The \(Q_0\) and b values were calculated from the slope and intercept of the curves (Table 2). The adsorption capacity of Langmuir (\(Q_0\)) was 41.67 mg/g at pH (6.0). Equation 4 illustrates the process of adsorption very well fitted with the values of \(r^2\) (0.998). The \(qe\) values of the Langmuir isotherm are in very good agreement with the experimental data for MB on Zephyranthes citrina carbon, may be because of the homogeneous adsorption of the same energy location. In addition, the separation factor (RL) was calculated to authenticate the favorable adsorption process.

\[
R_L = \frac{1}{(1 + b C_0)}
\]

(5)

The \(R_L\) values were obtained between 0 and 1 (0.55 to 0.12) (Table 2). This occurrence states that the adsorption process is authenticated [28].

3.6.2. Freundlich Isotherm

Freundlich’s adsorption isotherm provides a term that encircling the exponential allocation of the active sites and their energies. This type of isotherm can be used for heterogeneous systems that have interactions flanked by adsorbed molecules. The equation represents a logarithmic form of the Freundlich model is expressed as below,

\[
\log q_e = \log k_f + \frac{\log C_e}{n}
\]

(6)

Where, 

\(k_f\) and \(n\)-Constants (Factors affecting the adsorption capacity and intensity of adsorption).

The values of \(k_f\) and \(n\) were calculated from the linear graphs of \(\log q_e\) versus \(\log C_e\) for MB dye on Zephyranthes citrina and \(n\) ranging from 1.0 to 10.0 indicated that, it follows an excellent adsorption process (Table 2). A higher value of \(k_f\) shows a possibility of larger adsorption capacity. The relatively high value of \(n\) designates that adsorption is superior over the series concentration studied [21].

3.6.3. Dubinin- Radushkevich Isotherm (D-R isotherm)

In order to differentiate among the physical and chemical adsorption, D-R isotherm was applied and it is represented as [29].

\[
\ln q_e = \ln q_m - \beta \xi^2
\]

(7)

where,

\(\beta\) - Constant (related to the mean free energy of adsorption)

\(q_m\) - Theoretical saturation capacity

\(\xi\) - Polyanion potential

The value of \(\xi\) can be calculated as follows,

\[
\xi = RT \ln (1 + \frac{1}{C_e})
\]

(8)

The slope of the graph of \(\ln q_e\) vs \(\xi^2\) confers the value of \(\beta\) and the intercept gives the ability of adsorption (figures not shown). The mean free energy of adsorption (E) (KJ/mol) is determined from the below mentioned equation 9,

\[
E = \frac{1}{\sqrt{2\beta}}
\]

(9)

The value of E provides information of type of adsorption. If E < 8 KJ/mol, it is physisorption, E is between 8 to 16 KJ/mol, it is an ion exchange and E > 40 KJ/mol then it is chemisorption. From the experimental result, value of E for MB was observed as 15.81 KJ/mol on Zephyranthes citrina. Therefore, the adsorption is found to be an ion exchange mechanism[30]. Figure 11 represents various adsorption isotherms together with the investigation data for adsorption of MB dye on Zephyranthes citrina. By using equation 10, \(\Delta q\)
The lower values of $\Delta q$ (%) achieved from the isotherm models designate the highest appropriate with adsorption data. In the current research, the values of $\Delta q$ (%) received for MB dye on Zephyranthes citrina (Table 2) are in the order as, Langmuir < Freundlich < D-R. Therefore, the Langmuir adsorption isotherm rather corresponds to the equilibrium experimental adsorption data for MB on Zephyranthes citrina. As far as we know, this is the first report to record adsorption for dye removal using carbon derived from the bulb of Zephyranthes citrina, which has proven to be an efficient carbon. The comparison of the adsorption capacity with some other adsorbent was shown in Table 3.

### Table 3: Comparative assessment of Langmuir adsorption capacity over various adsorbent from literature

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Adsorbent</th>
<th>$Q_e$ (mg/g)</th>
<th>$\beta$ (mol/L)x10^3</th>
<th>$R^2$</th>
<th>$\Delta q$ (%)</th>
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<tbody>
<tr>
<td>1</td>
<td>Mansonia wood sawdust/299K</td>
<td>17.7</td>
<td></td>
<td>0.902</td>
<td>30.12</td>
</tr>
<tr>
<td>2</td>
<td>Sugarcane dust</td>
<td>3.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Neem sawdust</td>
<td>3.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pinus bark powder</td>
<td>32.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Wood apple</td>
<td>19.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Banana pith</td>
<td>5.92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Wheat Bran</td>
<td>6.410</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Almond shell</td>
<td>11.95</td>
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</tr>
<tr>
<td>9</td>
<td>Aloe Vera plant ash</td>
<td>29.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Zephyranthes citrina carbon</td>
<td>41.67</td>
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</table>

### 4. CONCLUSIONS

The adsorption of methylene blue dye from an aqueous solution using carbon derived from the bulb of Zephyranthes citrina has been successfully investigated. Batch mode adsorption studies were performed to appraise the effect of diverse stricture such as initial concentration of dye, pH, adsorbent dose, agitation time and desorption for the MB dye removal by Zephyranthes citrina. The chemical properties of both the adsorbate and adsorbent in an aqueous solution would affected by pH. It was found that the maximum removal of dye for adsorbent was pH 9.0. The results revealed that the adsorption goes behind the first order kinetics of Lagergren. Adsorption equilibrium data were inducences by isotherm equations of Langmuir, Freundlich and D-R. The experimental data showed an excellent agreement with the Langmuir isotherm model. With increasing the concentration, desorption of adsorbed MB also increased, suggesting that the adsorption mechanism occurs through ion exchange. Hence, it can be used as a low cost material and environmental benign for the recovery of dyes from an aqueous solution and the possibility of reusing carbon.

### 5 REFERENCES


