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REMOVAL OF METHYLENE BLUE FROM WASTE WATER USING BANANA PEEL AS ADSORBENT

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Abstract: The potential feasibility of activated and inactivated Banana peel powder for the removal of Methylene Blue from aqueous solution was investigated. The adsorption studies were carried out under varying conditions of pH, adsorbent dose and contact time. For both the adsorbents, the removal efficiency decreased as the adsorption increased, the percentage removal in activated adsorbent increased from 65% to 90% when the dose of the adsorbent was increased from 0.02 grams to 0.1 grams, and in case of inactivated adsorbent it increased from 55% to 84%. When the contact time was increased from 20 minutes to 120 minutes, maximum percentage removal was obtained at 120 minutes with 94% adsorption in case of activated adsorbent and 90% adsorption in case of inactivated adsorbent.

Keywords: Methylene Blue, Activated banana peel powder, inactivated Banana peel powder, adsorption.

INTRODUCTION

Scarcity of water is the major concern of today's world. The scarcity of water is due to rapid population growth, increased industrialization and decreased amounts of rainfall in the previous decades. Water pollution by untreated synthetic dye effluents released from industries has been identified as one of the consequences of worsening situation of water scarcity in the society[1]. Removal of dyes from wastewater has become concern now-aday[2]**.** Some of the commonly used dye removal methods are Coagulation, flocculation, membrane separation, ion-exchange, oxidation and biomass but all these methods are expensive. Adsorption is an effective and economical method for dye removal due to simple, flexible design and easy operation[3]**.** The dye used in this study is Methylene Blue (MB). MB is a model cationic dye employed by industries such textile industry for a variety of purposes. It is a heterocyclic aromatic chemical compound with a molecular formula $C_{16}H_{18}N_3SCl$[4]. Although MB is used in some medical treatments, and in dying textile, it can cause eye injury, nausea, vomiting, profuse sweating, diarrhoea, gastritis, mental confusion etc. Thus, the removal of MB from industrial effluents has become one of the major environmental concerns[5]. Bananas are used fresh or processed into many products such as chips, puree/pulp,

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powder, jams, juice, bar, biscuits, wine etc. Significant quantities of Banana or plantain peels, equivalent to 40% of the total weight of fresh banana, are generated as a waste product in industries producing Banana based products. At present, these peels are not being used for any other purposes and are mostly dumped as solid waste at large expense. It is thus significant and even essential to find applications for these peels as they can contribute to real environmental problems[6]**.** Hence the use of Banana peels as an adsorbent can reduce the production of waste.

Materials and Methods

The discarded Banana peels were collected from a local fruit stall in Allahabad. The peels were first washed properly with distilled water and then dried in sun for 4-5 days till they became crisp. The peels were then ground to fine powder and thoroughly washed with distilled water till the colour was completely removed and then dried in oven for one day at 60°C to remove moisture completely. The powder was then sieved to a particle size ranging from 350µm-500µm. Half of the inactivated adsorbent was thermally activated at 500ºC in a muffle furnace for 1h in the presence of air. After activation, the ash contents were removed by washing with distilled water and dried in an oven at 110ºC overnight. It was then stored in an air tight container for future use[7]. The stock solution of 1ppm of MB dye was prepared by dissolving 1mg of dye in 1litre of distilled water. The influence of various parameters such as pH (4-12), adsorbent dose (0.02-0.1 g) and contact time (20-120) minutes were studied by keeping the dye solution containing the adsorbent undisturbed for 2 hrs. Then the contents were filtered and readings were taken by single beam uv-vis spectrophotometer at 650nm. In each case, the percentage adsorption and substrate's equilibrium adsorption capacity, *qe* (mg/g) were evaluated using following Equations:

$$\textbf{\% Adsorption =} (Co - Ce / Co) \text{ X } 100$$

$$\textbf{qe =} V\ (Co - Ce\ )/ W$$

Here Co (mg/L) is the initial dye concentration, Ce is the concentration at equilibrium or predetermined time t, V (L) is the volume of dye solution used and W (g) is the weight of the adsorbent. The data obtained were tested against the linear forms of Langmuir, Freundlich isotherms.

RESULTS AND DISCUSSION

Effect of pH: It is observed that as the pH increases the percentage adsorption decreases from 87%-65% (inactivated adsorbent) and 90%-71% (activated adsorbent). This trend is

observed because initially the dye ions easily enter the pores of the adsorbent but as the pH increases the zwitter ion of the dye in water is not able to enter the pores of the adsorbent[8].

Effect of adsorbent dose: It was observed that with the increment of adsorbent dose the adsorption of the dye was found to increase in both the cases. Maximum adsorption was obtained for an adsorbent dose of 0.08 grams for both inactivated adsorbent (84%) and activated adsorbent (90%) and after that there was no change in the percentage adsorption. When the amount of adsorbent increase, a large number of sorption sites become available for adsorption and hence the percentage removal of dye increases with increasing adsorbent dose[9].

Effect of contact time: It was observed that on increasing the contact time the removal efficiency increased. The maximum adsorption efficiency in case of inactivated banana peel powder was 90% and in case of activated banana peel powder it was 94%. It is observed that when the dye and the adsorbent comes in contact , initially the removal occurs rapidly but after that easily available adsorption sites become blocked and the dye requires more time to bind with the other available adsorption sites. Therefore, the removal efficiency increases steadily with the passage of time[10].

Adsorption Isotherms

Langmuir Isotherm: This isotherm is applicable for monolayer adsorption on the surface having a limited number of identical sites. It describes the formation of a monolayer adsorbate on the surface of the adsorbent. The Langmuir equation is as follows:

$$ce/qe = 1/bQm + ce/Qm$$

here, qe is the amount of dye adsorbed ,ce is the dye concentration at equilibrium, b is equilibrium constant, Qm is adsorption capacity. Essential characteristics of the Langmuir isotherm can be expressed in terms of dimensionless equilibrium parameter *RL.*

$$RL = 1/1+bCo$$

Where Co is initial concentration of the solution. The value of *RL* indicates the type of the isotherm to be either unfavorable *(RL* >1), linear *(RL* =1), favorable (0< *RL* <1) or irreversible (*RL* =0).

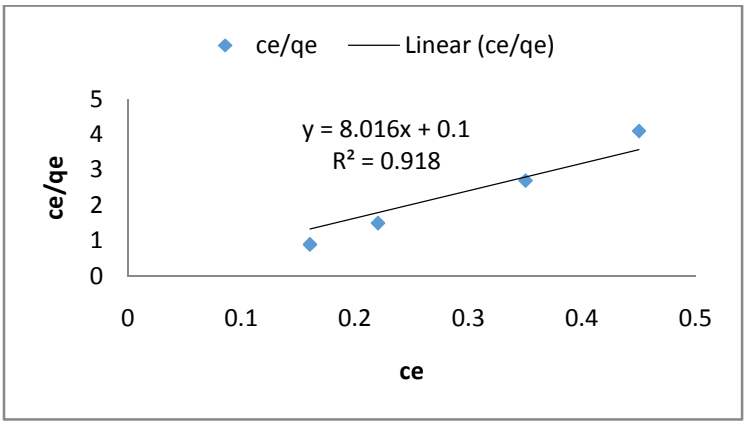

Figure 1: Langmuir isotherm for adsorption of Methylene Blue onto inactivated banana peel powder at pH 4, contact time 2 hours, and adsorbent dose 0.02g – 0.1g.

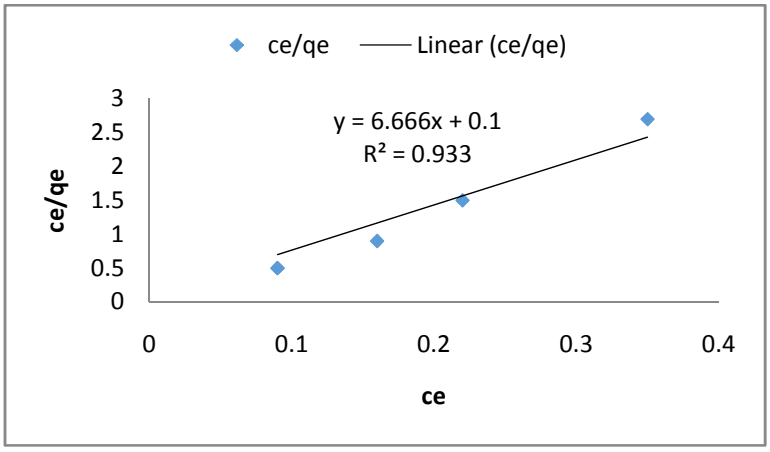

Figure 2: Langmuir isotherm for adsorption of Methylene Blue onto activated Banana peel powder at pH 4, contact time 2 hours and adsorbent dose 0.02g-0.1g.

Table 1: Langmuir Isotherm constants for adsorption of methylene blue onto inactivated and activated banana peel powder

Inactivated adsorbent				Activated adsorbent			
Q_m (mg/g)	b (L/mg)	R^2	R_L	Q_m (mg/g)	b (L/mg)	R^2	R_L
0.124	80.6	0.918	0.012	0.15	66.6	0.933	0.014

According to the isotherm curves in figure 1 and 2, the Langmuir isotherm parameters are calculated and listed in table 1. The R^2 values for MB dye adsorption are 0.918 and 0.933, Suggesting that the adsorption follows Langmuir model and the values of RL for both the adsorbent lies between 0 and 1 indicating favourable adsorption of the dye onto the adsorbents. Similar results were obtained by (Mohammad *et al.,* 2015) when they used

activated carbon derived from Egyptian Banana peels for removal of cadmium from water. The value of RL reported by them was 0.0008 which indicates favourable adsorption.

Freundlich Isotherm: It describes the adsorption characteristics for heterogeneous surface. The Freundlich equation is as follows:

$$\text{Log } q_e = \log K_f + 1/n \log c_e$$

n = equilibrium constant

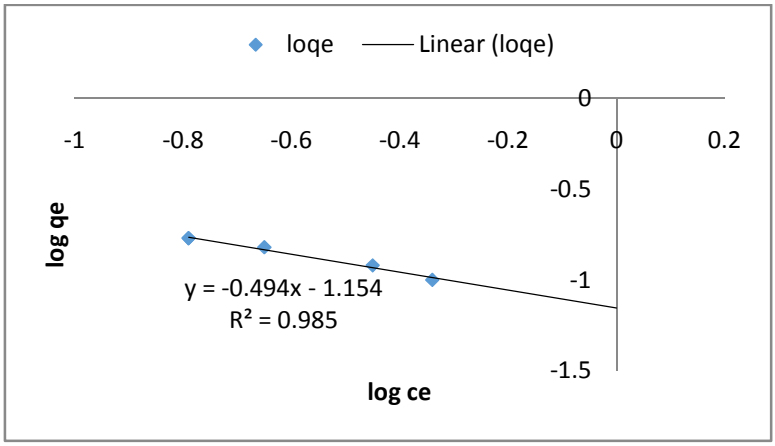

Figure 3: Freundlich Isotherm for adsorption of Methylene Blue onto inactivated banana peel powder at pH 4, contact time 2 hours and adsorbent dose 0.02g-0.1g.

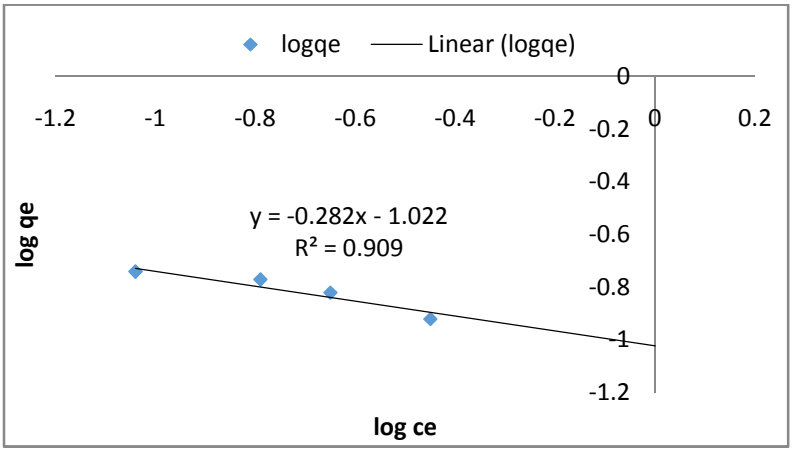

Figure 4: Freundlich Isotherm for adsorption of Methylene Blue onto activated banana peel powder at pH 4, contact time 2 hours and adsorbent dose 0.02g – 0.1g.

Table 2: Freundlich isotherm constants for adsorption of MB dye onto inactivated and activated banana peel powder

Inactivated adsorbent			Activated adsorbent		
K_f (mg/g)	n	R^2	K_f (mg/g)	n	R^2
0.07	-2.02	0.9859	0.09	-3.53	0.9092

According to the isotherm curves in figure 3 and 4, the Freundlich isotherm parameters are calculated and listed in table 2. The Freundlich isotherm constant can be used to explore the favourability of adsorption process. The adsorption process is said to be favourable when the value of n satisfies the condition $1< n <10$, otherwise it is unfavourable. While the n values for adsorption of MB in both the cases are negative indicating unfavourable adsorption process. Similar results were obtained by (Ibrahim and sani, 2014) when they plotted the Freundlich isotherm for adsorption of Congo red dye onto Water Melon rinds. The regression coefficient value reported by them was 0.9913 demonstrating that the experimental data fitted well with Freundlich isotherm but the value of *n* reported by them was 10.13 which did not satisfy the condition $1< n <10$ indicating unfavourable adsorption process.

Conclusion

A linear plot for Langmuir isotherm and Freundlich isotherm was obtained in both the cases. The negative values of freundlich constant n indicates unfavourable adsorption,

but the value of RL in case of Langmuir isotherms lies between 0 and 1 indicating favourable adsorption. From these values it can be concluded that the adsorption of MB on the Banana peel adsorbent followed Langmuir model or the monolayer phenomena. Even though the removal efficiency of Banana peels in inactivated state is not much higher than other bio-adsorbents, it is cheaply available. With this cheap and environment friendly adsorbent considerable dye removal can be achieved. So it can be substitute other expensive bio-adsorbents.

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