Removal of Methylene Blue from Effluent by Using Activated Carbon and Water Hyacinth as Adsorbent

Sachin M.Kanawade and R.W.Gaikwad

Abstract—**Activated carbon has been widely used as a good adsorbent. Water hyacinth may be an alternative of activated carbon. This work deals with the study of methylene blue adsorption on activated carbon as well as water hyacinth ash from aqueous solution. Batch kinetic and isotherm studies were carried out at different conditions like, contact time, methylene blue concentration etc for both adsorbents. The Freundlich and Langmuir adsorption models have been mathematical description of adsorption equilibrium and finally it has been that observed that the experimental data fitted more accurate to the Langmuir model for both cases.**

Index Terms—**Adsorption, Activated Carbon, Water Hyacinth Ash, Ethylene Blue, Wastewater**

I. Introduction

Industrial effluents are foremost causes of environmental pollution because effluents discharged from dyeing industries are highly colored with a large amount of suspended organic solid .Presently, more than 10,000 of different commercial dyes and pigments exists and about 7 x 10^5 tones are produced annually world wide(9). Raw disposal of this dyed water into the receiving water body either causes damage to aquatic life. Dyes are widely used in industries such as textile, rubber, paper, plastic, cosmetic etc. Among these various industries, textile ranks first in usage of dyes for coloration of fiber. As a matter of fact, the discharge of such effluents is worrying for both toxicological and environmental reasons. The conventional wastewater treatment, which rely on aerobic biodegradation have low removal efficiency for reactive and other anionic soluble dyes. Due to low biodegradation of dyes, a convectional biological treatment process is not very effective in treating a dyes wastewater. It is usually treated with either by physical or chemical processes. However, these processes are very costly and cannot effectively be used to treat the wide range. The adsorption process is one of the effective methods for removal dyes from the waste sewage(5,6). The process of adsorption has an advantage over the other methods due to its sludge free clean operation and completely removed dyes, even from the diluted solution. Activated carbon (powdered or granular) is the most widely used adsorbents because it has excellent adsorption effectiveness for the organic compound. However commercially available activated carbon is very expensive. Furthermore, regeneration using solution produced small additional effluent while regeneration by refractory technique results in a 10-15% loss of adsorbents and its uptake capacity. This had lead to further studies for cheaper substitutions. Nowadays, there are numerous number of low cost, commercially available adsorbents which had been used to remove the dye. In recent years, there has been growing interest in finding cheap and effective alternatives of activated carbon, such as clay minerals, lignin, fly ash, wood powder , coir pith and peat etc. However, as the adsorption capacities of the above adsorbents are not very large, the new adsorbents which are more economic, easily available and highly effective are still needed.(10)

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Sachin M.Kanawade, is with Pravara Rural Education Society's Sir Visvesvaraya Institute of Technology, Chincholi, Chemical Engineering Department,Pune University, Tal-Sinnar, Dist-Nashik, M.S.India Pin-422101(sachin_kanawade2006@rediffmail.com)

R.W.Gaikwad is with Pravara Rural Education Society's Pravara Rural Engineering College, Loni, Chemical Engineering Department, Tal-Rahata,Dist-A'Nagar,PuneUniversity, M.S.,India.

II. Experimental Programe

Materials

A. Methylene Blue

Methylene blue (MB) supplied by, Merk India Private Limited was used as an adsorbate and was not purified prior to use. Double distilled water was used for preparing all the solutions and regents.

B. Activated Carbon

Powdered activated carbon was supplied by Merk India Private Limited. The adsorbents were used directly without any further grinding and sieving. Following specification are given by the manufacturer: pH value 5-8, loss on drying < 20%, methylene blue adsorption (0.15% solution)>5 mL 0.1 g_1.(11)

C. Water Hyacinth

The water hyacinth was collected from the local ponds. The roots of the collected water hyacinth were separated and cleaned thoroughly with water for several times to eliminate earthy matter and all the soil particles. It was then dehydrated in a muffle furnace supplied by S.B.Scientific Concern at a temperature of 950^{oC} for about 21 hours. The dried roots were then burned for about 2 h. The remaining was then creased, sieved and stored in bottle for use. All dyes and chemicals used were of analytical grades, procured mainly from Merck India. All colour measurements were made with spectrophotometer-169 supplied by Systronics.Absorbance values were recorded at the wavelength for maximum absorbance (λ_{max}) corresponding to each dyes. A calibration curve had been prepared for each dye using known concentration of dye and measuring absorbance in each case. The wavelengths for maximum absorbance of Methylene Blue solution have been found to be 661nm .(12)

III. Experimental Procedures

Aqueous solutions (5 ppm, 10 ppm and 20 ppm respectively) of methylene blue were prepared by adding known amount of dye in de-ionized water. Batch adsorption experiments were carried out by shaking required amount of adsorbent with 20 mL for a period of 8 minutes in a shaker and the mixture is allowed to reach equilibrium for 8-9 hrs. Experimental results were taken for different concentrations, temperature, pH. The pH of dye solutions was adjusted by 1N NaOH/1N HCl solutions. During batch adsorption experiments, temperature was controlled using constant temperature bath and varied at three different temperatures i.e. 8^{0C}, 27^{0C} and 60^{0C}.The adsorbent was removed by centrifugation and the concentration of dye in the supernatant liquid was measured with the help of spectrophotometer and using the calibration curve.(3)

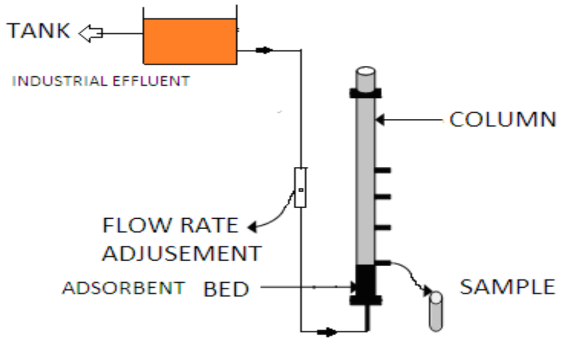

Fig. A. Adsorption Process

IV.. Results & Discussion

A. *Effect of Time and Concentration*

The effects of time on percentage removal of dye have been shown in Fig. 1 and 2. Adsorption of dye from the solution increases with the time and finally attains equilibrium in 80 mins for methylene blue adsorption using activated carbon and 77 mins for methylene blue adsorption using water Hyacinth. Removal of dyes carried out at pH 6.3 when the concentration of dye is increased from 5 to 20 mg/L which indicates that the adsorption of dye depends on its concentration (1).

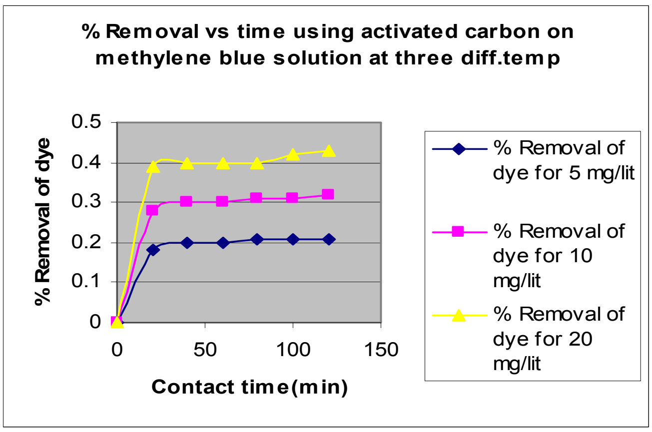

Fig.1 % Removal vs time using activated carbon on methylene blue solution at three different temp

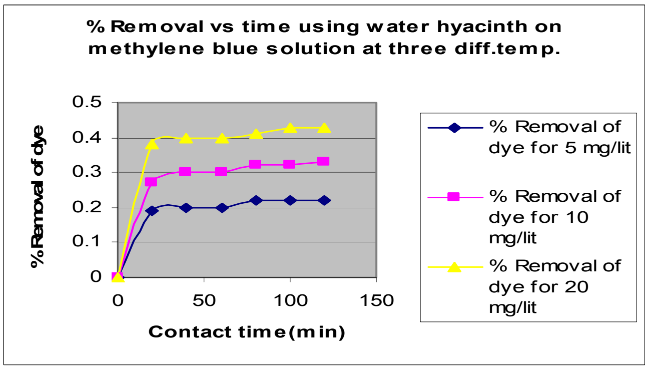

Fig.2 % Removal vs time using water hyacinth on methylene blue solution at three different temp

B. *Adsorption Dynamics*

The rate constant of adsorption ,K_{ad} for removal of methelene blue by activated carbon and water hyacinth at 27 0C determined using the rate expression derived by Lagergren et al.[8]

$$\log(q_e - q) = \log q_e - \frac{K_{ad} t}{2.303} \quad (1)$$

where qe = The amount of dye adsorbed at equilibrium and q= the amount of dye adsorbed at any time t (both in mg/g) From the adsorption dynamics the rate constant K_{ad} at 27^{0C} was found to be 4.39×10^{-2}/min and 5.01×10^{-2} /min for adsorption of methylene blue on activated

C. *Adsorption Isotherms*

The adsorption isotherms of the Methylene Blue using the Activated Carbon and Water hyacinth at 9, 28 and 61^{0C} have been verified. According to experimental results, the Langmuir isotherm model has been found more accurate compared to the Freundlich isotherm. The adsorption data was investigated with the help of the following linear forms of Freundlich and Langmuir isotherms:

$$\text{Langmuir Isotherm}: \frac{C_e}{q_e} = \frac{1}{Q_0 b} + \frac{C_e}{Qo} \quad (2)$$

$$\text{Freundlich Isotherm}: \log q_e = \log K_f + (1/n) \log C_e \quad (3)$$

The Langmuir parameters, Q_0 and b have been estimated from the slopes and intercepts of the straight lines of plot of (Ce/qe) vs. Ce, while the values of Freundlich constants, i.e. K_f and n have been estimated from the plots of log qe against log Ce. Langmuir constants Q_O and b related to absorption capacity and energy of adsorption, respectively, while Freundlich's constants K_f indicates the adsorption capacity and $1/n$ is indicative of the intensity of reaction. Parameters of the Langmuir and Freundlich isotherms are tabulated in Table 1 and Table 2.The linear regression was used for estimating the parameters and R^2 value was obtained in each case. For methylene blue adsorption R^2 value lies between 0.935 -0.999 (close to unity) suggesting that the adsorption can be well fitted to both Langmuir and Freundlich isotherms. The experimental data for adsorption of methylene blue on activated carbon have been fitted to both Langmuir and Freundlich model (8).

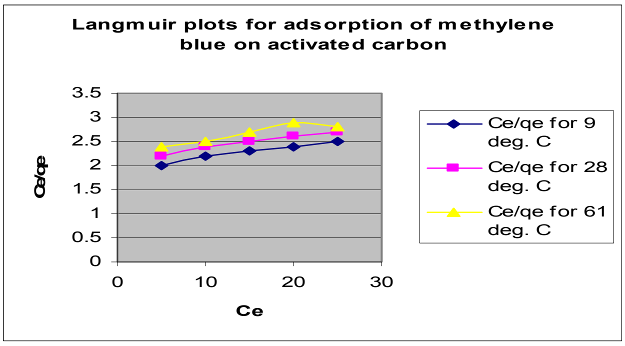

Fig.3 Langmuir plots for adsorption of methylene blue on activated carbon

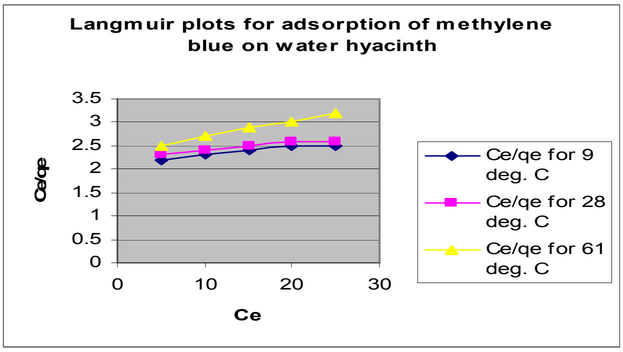

Fig.4 Langmuir plots for adsorption of methylene blue on water hyacinth

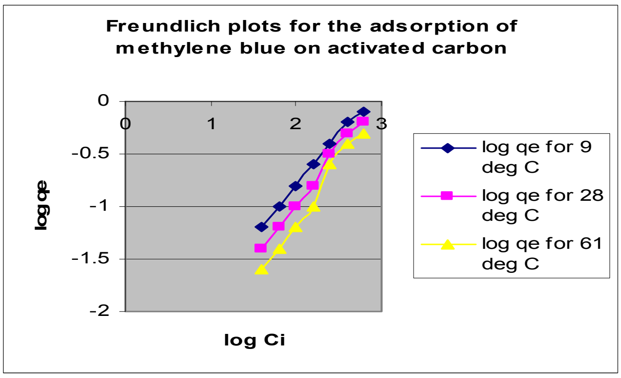

Fig.5 Freundlich plots for adsorption of methylene blue on activated carbon

TABLE 1 LANGMUIR CONSTANTS (FOR ADSORPTION OF METHYLENE BLUE ON ACTIVATED CARBON)

Parameters	Value at $9^{O}C$	Value at $28^{O}C$	Value at $61^{O}C$
Qo	2.15	1.8	1.6
b	2.6	3.2	3
R^2	1	1	1

TABLE 2 FREUNDLICH CONSTANTS (FOR ADSORPTION OF METHYLENE BLUE ON ACTIVATED CARBON)

Parameters	Value at $9^{O}C$	Value at $28^{O}C$	Value at $61^{O}C$
n	0.9	0.9	0.90
Kf	0.07	0.071	0.62
R^2	1	0.99	0.99

TABLE 3 LANGMUIR CONSTANTS (FOR ADSORPTION OF METHYLENE BLUE ON WATER HYACINTH)

Parameters	Value at $9^{O}C$	Value at $28^{O}C$	Value at $61^{O}C$
Qo	2.7	2.3	1.3
b	1.9	2.2	3.4
R^2	0.99	0.99	0.993

V. CONCLUSION

In the present work, it was found that adsorption of methylene blue using activated carbon is explained well by Langmuir and Freundlich isotherm models, but adsorption of methylene blue onto water hyacinth follow Langmuir model. It is also observed that using activated carbon, methylene blue solution attained an equilibrium in 80 min at 27^{0C} for each of three different concentration (5, 10 and 20ppm) .(10)

VI. ACKNOWLEDGEMENTS

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