Scientific Journal Impact Factor (SJIF) : 1.711
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745
ISSN (PRINT) : 2393 - 8161

REMOVAL OF ACID BLUE-7 DYE FROM AQUEOUS SOLUTION USING WATER HYACINTH AS A ADSORBENT : ADSORPTION EQUILIBRIUM ISOTHERMS

Kapil Malviya[1], Dr. Charu Parashar[2], Dr. Savita Dixit[3]
[1,2,3]*M.A.N.I.T., Bhopal*

Abstract—In this study, the experiments were performed to find the adsorption capacities of locally available Water Hyacinth (W.H.), which are waste for rivers, ponds and lakes. Water creates problems for navigation and recreation also, these we have used Water Hyacinth as adsorbent. This adsorbent is also used to remove the colour of Acid Blue-7 dye, which is used in textile industry. Experiments were conducted with different parameters like adsorbent dosage, pH and contact time using adsorption Isotherms method. The adsorption isotherm of the Acid Blue-7 on the treated adsorbent was determined and correlated with common isotherm equations. The sorption data were then correlated with the Langmuir and the Freundlich adsorption isotherm models. The Freundlich isotherm exhibited a better fit for the adsorption data than the Langmuir isotherm with maximum monolayer adsorption capacity of 1.082 mg g–1.

Keywords –Acid Blue-7, Water Hyacinth, Concentration, pH, Contact Time

I. INTRODUCTION

Textile industry is in the category of the most polluting sectors in terms of wastewater formation and volume of discharge. Dyes are gradually emerging as a class of man-made organic substances [1]. The discharge of highly coloured wastewaters either toxic or carcinogenic and pose a potential health hazard to all forms of life [2]. Even the very low concentrations also present of dyes (less than 1 ppm) in the wastewater is considered unwanted and needs to be removed before the wastewater can be discharged into the environment [3].

Different physical and chemical methods such as adsorption, chemical and photo-oxidations were developed for removal of textile dyestuffs from effluents. Adsorption is usually used to concentrate the dyestuffs on a solid matrix before chemical or biological treatment [4]. Some of the low cost adsorbents that are tested for the dye sorption process are rice husk [5], wood dust [6], tree bark powder [7], peat [8], Adsorption is a surface phenomenon wherein substance adheres to the surface of the other (on an atomic or molecular scale) has been applied for color removal using immobilized aquatic weeds [9]. Water Hyacinth removed nutrients and heavy metals (toxic element) from sewage and sludge ponds which indicate that Water Hyacinth could play a role against environmental pollution [10]. Recently, utilization of Water Hyacinth in the removal of colour from wastewater of textile dyeing processes was studied [11–16]. The aim of this study is to analyse the capability of Water Hyacinth and its aminated derivative to adsorb Acid Blue-7 dye. The rate of dye adsorption process was studied including the influence of the type and amount of Water Hyacinth, pH of the dye, shaking time and dye concentration. Simple kinetics models and equilibrium data for both Freundlich and Langmuir isotherm were determined.

II. METHODS AND MATERIALS

Adsorbent Preparation

The water hyacinth used in this study were obtained from a upper lake Bhopal. The Water Hyacinth was accumulated then take into the laboratory. It was cleaned with water thoroughly to remove any foreign material from surroundings then cut into pieces. The cut material was dried in the shadow for 15 days and afterwards kept for 1 Hour at 80°C temperature in a hot air convection oven. The material was grounded into a powder using 'domestic mixie' and passed through a 300 micron mesh opening size sieve and retained on 150 micron size sieve. After that the material was sealed in plastic bags, and stored in desiccators [17].

Dye Structure

Acid Blue-7 is the sodium salt of 4-Formylbenzene-1, 3-disulfonic acid and N-benzyl-N-ethyl benzenamine (formula: $C_{37}H_{35}N_2NaO_6S_2$; molecular weight: 690.81g/mol) [24] was used and purchased from Chemical Market New Delhi, India as shown in fig. (1).

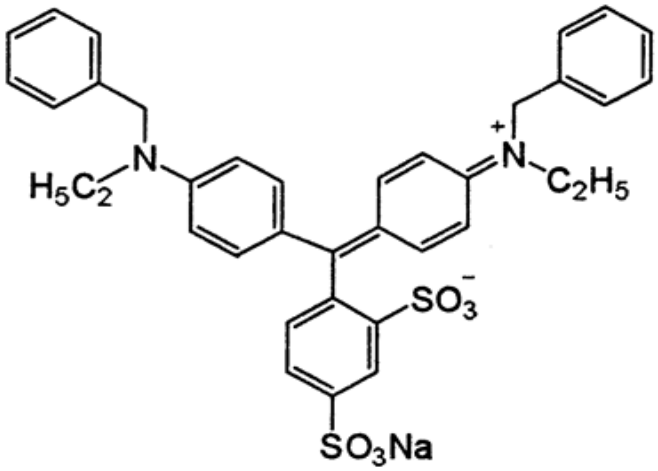

Fig. (1) Acid Blue-7 dye structure [24]

Preparation of dye solution

Acid Blue-7 used without any purification. A calculated amount of dye was dissolved in 500 ml distilled water solution, this solution is the stock solution. The λ_{max} of these dye is 637 nm.

Effect of Contact Time

A 1 ml of Acid Blue-7 dye gives concentration of 10 mg/L was taken in conical flasks and treated with 800 mg of Water Hyacinth (adsorbent) at several times (30, 60, 90, 120, 150 and 180 minutes). The variation in percent removal of dye with the time is shown in figure 2. The equilibrium concentrations was found in 150 minutes, due to saturation of active sites which do not allow further adsorption to take place.

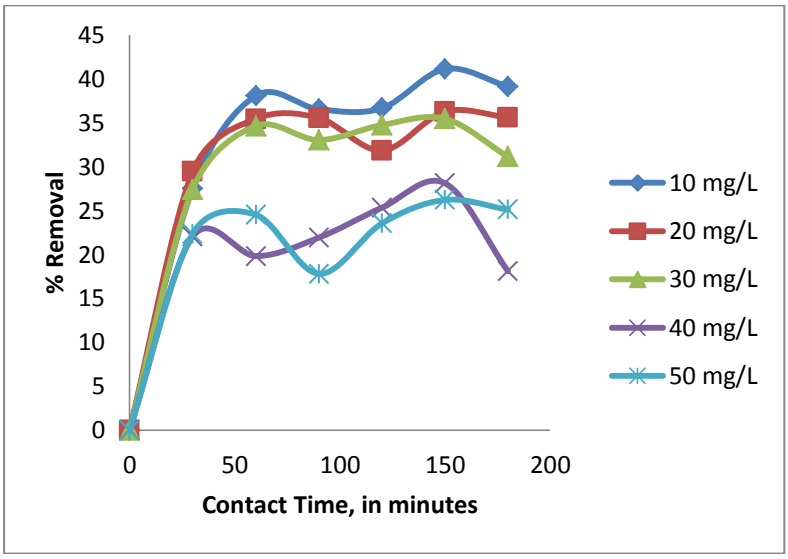

Fig. (2) Effect of Contact Time

Effect of pH

For adjustment of pH of Dye using NaOH and HCL acids. Fig. 3 shows that the pH plays a good role in the rate colour adsorption. It seems that the rate of colour removal is better in their self mode (pH = 4.78) because if NaOH or HCl is added it does not gives better consistency.

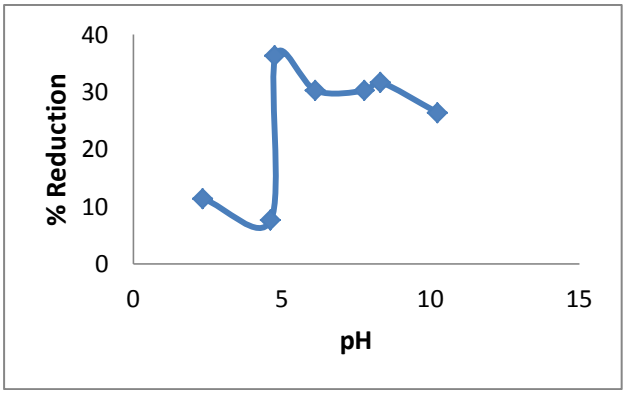

Fig. (3) Effect of pH

Adsorption isotherm

Langmuir isotherm [18] is represented by the following equation below:

$$C_e/q_e = 1/q_{max} K_L + (1/q_{max}) C_e$$

Where q_e is the amount of adsorbate in the adsorbent at equilibrium (mg/g), C_e is the equilibrium concentration (mg/l) and q_{max} and K_L are the Langmuir isotherm constants related to free energy. The above equation can be linearized to get the maximum capacity, q_{max} by plotting a graph of C_e/q_e Vs C_e.

Freundlich isotherm [19]

$$q_e = K_f C_e^{\frac{1}{n}}$$

On rearranging this equation we get

$$\log q_e = \log K_f + 1/n \log C_e$$

where K_f and 1/n are Freundlich isotherm constants related to adsorption capacity and adsorption intensity respectively. A plot of log q_e vs log C_e yields a straight line with a slope of 1/n and intercept log K_f. The Langmuir and Freundlich adsorption isotherms of Acid Blue-7 on Water Hyacinth are shown in figure 4 and 5. Table 1 gives the values of parameters and correlation coefficient of the Langmuir and Freundlich equations. The experimental results indicated that the adsorption isotherms of Acid Blue-7 adsorption on Water Hyacinth followed both Langmuir and Freundlich models.

Conformation of the experimental data into the Langmuir and Freundlich isotherm models indicates the homogeneous nature of the wastewater treated with water hyacinth, i.e. each dye molecule/ water hyacinth adsorption has equal adsorption energy. The results also demonstrate the formation of monolayer coverage of dye molecule at the outer surface of water hyacinth.

Table 1: The values of parameters and correlation coefficient of Langmuir and Freundlich equations

Langmuir				Freundlich		
q_{max}	K_L	R^2	R_L	K_f	1/n	R^2
1.082	**0.041**	**0.960**	**0.708**	**0.916**	**0.631**	**0.965**

The essential characteristics of the Langmuir isotherm can be expressed in terms of a dimensionless equilibrium parameter (R_L) [20, 21], which is defined by:

$$R_L = 1/ (1 + K_L C_o) \text{ [22]}$$

where K_L is the Langmuir constant and C_o the highest dye concentration (mg/l). The value of R_L indicates the type of the isotherm to be either unfavorable ($R_L > 1$), linear ($R_L = 1$), favorable ($0 < R_L < 1$) or irreversible ($R_L = 0$) [22]. The value of R_L was found to be 0.708 and it confirmed that the treated water hyacinth is favorable for adsorption of the Acid Blue-7 dye under conditions used in this study.

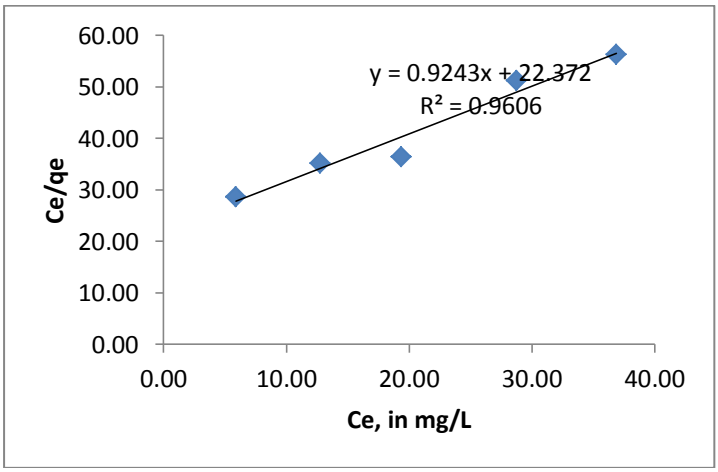

Fig. (4) The Langmuir adsorption isotherms

Conformation of the experimental data into the Langmuir isotherm model indicates the homogeneous nature of the wastewater treated with water hyacinth, i.e. each dye molecule/ water hyacinth adsorption has equal adsorption energy. The results also demonstrate the formation of monolayer coverage of dye molecule at the outer surface of water hyacinth.

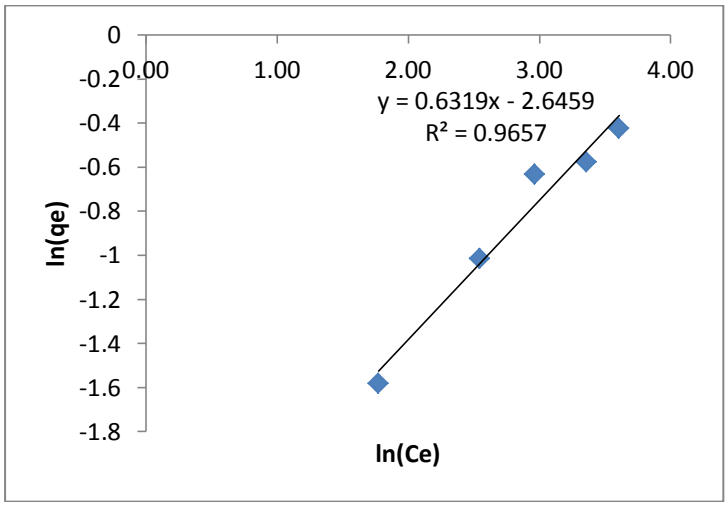

Fig. (5) The Freundlich adsorption isotherms

Table 1 shows the values of the parameters of the two isotherms and the related correlation coefficients. As seen from Table 1, the Langmuir model yields a somewhat not better fit (R^2 = 0.960) than the Freundlich model (R^2 = 0.965). As also illustrated in Table 1, the value of 1/*n* is 0.631, which indicates favorable adsorption [23]. This work has shown that utilization of water hyacinth will be useful in the treatment of AB-7 dyes. it will also eliminate various ecological problems that these waste effluents could cause.

III. CONCLUSION

The Water Hyacinth has good sorption capacity of Acid Blue-7 dye from aqueous solution as shown in the results for different parameters such as concentration of adsorbent, contact time and pH. The experimented results shows that adsorbent have moderate capacity for removal of dye molecules.

REFERENCES

[1] Yadav and Vasanti G. (1998). Dyes for the next millennium. Colourage, Vol. 45, pp 53–56.
[2] Reife, A. and Freeman, H.S. (1994). Environmental Chemistry of Dyes and Pigments. Wiley, New York, pp 265.
[3] Vandevivere, P.C., Bianchi and R., Verstraete, W. (1998). Treatment and reuse of wastewater from the textile wetprocessing industry: review of emerging technologies, J. Chem. Technol. Biotechnol., Vol. 72, pp 289–302.
[4] Rozada, F., Calvo, L.F., Garcia, A.I., Martin-V, J. and Otero, M. (2003). Dye adsorption by sewage sludge-based activated carbons in batch and fixed-bed systems. Bioresource Technol., Vol. 87, pp 221–230.
[5] Reddy, M. K., Mahammadunnisa, P., Ramaraju, S., Sreedhar, B., and Subrahmanyam, B. (2013). Low-cost adsorbents from bio-waste for the removal of dyes from aqueous solution. Environ. Sci. Pollut., Vol. 20(6), pp 4111–4124.
[6] Garg, V.K., Amita, M., and Kumar, R., (2004). Basic dye (methylene blue) removal from simulated waste water by adsorption using Indian rose-wood saw dust: a timber industry waste. Dyes Pigments, Vol.63, pp 243–250.
[7] Egwuonwu, P., and D.I.M. (2013). Adsorption of methyl red and methyl orange using different tree bark powder. Acad. Vol. 4 (1), pp 34.
[8] Fernandes, A.N., Almeida, C.A., Menezes, C.T., Debacher, N.A., and Sierra, M.M. (2006). Removal of methylene blue from aqueous solution by peat. J. Hazard. Mater., Vol.144 (1–2), pp 412–419.
[9] Shah, R. A., Kumawat, D.M., Singh, N., and Wani, K. A. (2010). Water hyacinth (eichhornia crassipes) as a remediation tool for dye-effluent pollution. International journal of science and nature., pp 172-178.
[10] Araujo, R.S. and Senner, R. (1979) Eichhornia Crassipes, a pollution remover. An Assoc Bras Quim., Vol.30(3–4), pp 111–2.

[11] El Zawahry, M.M., (1995). Utilization of some carbohydrate derivatives in dye adsorption to minimize dyestuff pollution. Ph.D. thesis, Facultyof Science, Cairo University,.
[12] El Zawahry, M.M., (1998). Decolorization of anionic dye solutions using water hyacinth derivatives. Bull NRC Egypt., Vol. 23(1), pp 11–22.
[13] Richardson, M.L.J., (1983). Dyes—the aquatic environment and the mess made bymetabolite s. J Soc Dyers Colorists., Vol. 99, pp 198–201.
[14] Shaoning, L., Zhenhong, L., Tianhua, S., Huang, L., Suxiang, X., Zhengli, Z., and Henian, L., (1990). Study on hyacinth oxidation pond for purifing dyeing waste water. Shanghai Huanjing Kexue., Vol. 9(7), pp 10–3.
[15] Shaoning, L., Tianhua, S., Zhenhong, L., and Suxiang, X., (1991). Current status in dyeing waste water treatment in water hyacinth pond. Fungzhi Xuebao, Vol. 12(5), pp 226–9.
[16] Tianhua, S., Zhenghong, L., and Shaoning, L., (1990). Function of the root microecosystem in the dyeing waste water treatment by the water hyacinth. Huanjing Kexue, Vol. 11(3), pp 24–27, 57.
[17] Rajamohan, N., (2009). Equilibrium studies on sorption of an anionic dye onto acid activated water hyacinth roots, African Journal of Environmental Science and Technology, Vol. 3 (11), pp 399-404.
[18] Langmuir, I., (1916). The constitution and fundamental properties of solids and liquids, J. of American chemical Society, Vol. 38 (11), pp 2221–2295.
[19] Freundlich, H.M.F., (1906). over the adsorption in solution, Journal of. Phys. Chem., Vol. 57, pp 385–470.
[20] Nakbanpote, W., Thiravavetyan P. and Kalambaheti C., (2002). Mineral Eng., Vol. 13, pp 391-552.
[21] Hall, K. R., Eagleton, L. C., Acrivos A. and Vermeulen, T., (1966). Pore and solid diffusion kinetics in fixed bed adsorption under constant pattern conditions. Industrial and Engineering Chemistry Fundamentals, Vol. 5 (2), pp 212–223.
[22] Adamson, A. W., (2001). Physical Chemistry of Surfaces, 5th ed., Wiley, New York, 1990. Pigments, Vol. 51, pp 25–40.
[23] Chen, B., Hui, C. W., and McKay, G., (2001). Pore-surface diffusion modeling for dyes from effluent on pith. Langmuir, Vol.17, pp 740–748.
[24] http://www.worlddyevariety.com/acid-dyes/acid-blue-7.html

