ISSN PRINT 2319 1775 Online 2320 7876

Research paper **UGC CARE Listed (Group -I) Journal Volume 11, Iss 7, 2022**

Sustainable Adsorption Strategies for Textile Effluent Treatment

Anupriya Jain
Assistant Professor
Department of Physics
Gujranwala Guru Nanak Khalsa College, Civil Lines, Ludhiana, India

Abstract

The textile industry is using a wide variety of dyes and is responsible for discharging waste water contaminated with these dyes. The aim of the present study is to evaluate the adsorptive efficiency of sawdust for the removal of the textile dyes from the wastewater. Sawdust was initially subjected to different pre-treatments in order to increase its adsorption efficiency. The activated sawdust prepared was employed for the removal of coloured impurities in different doses. The adsorbent was found to be capable of removing color from wastewater and the color removal capacity of sawdust was approximately 75% at normal pH and temperature.

Keywords: Waste water treatment, textile effluents, sawdust, adsorption technique, adsorbent.

INTRODUCTION

Adsorption is a process of preferential accumulation of one substance on the surface of the other which is called adsorbent. The substance which is accumulated is called adsorbate. Basically it is a surface phenomenon and is widely used in various industrial applications and in research laboratories [1].

One of the most fascinating application of adsorption is the removal of coloured impurities from the waste water [2]. The effluents from textile units are often discharged into water bodies such as, lakes, ponds or rivers. Wherever this contaminated waste water goes it creates a problem to the society as the whole water becomes unfit for drinking and is unusable for other uses because of its toxicity.

In order to solve this problem the industries are forced to equip with treatment plants to remove the toxins from their effluents [3-5]. However, a number of units are still working without any treatment plants or non-operative treatment plants. The hard fact is that water is being polluted every day and every hour. In order to supply clean water to the public, the government of every state needs to setup its own treatments for the treatment of waste water coming from different sources. The research laboratories all over the world are developing more and more techniques and ways to overcome this waste water treatment problem. The main challenge lies in developing a technique which should be simple, cost effective and efficient also [6]. It is interesting to mention that out of the various techniques so far have been developed the cheaper and effective one is 'Adsorption Technique' [7-10]. The most commonly used adsorbent for the textile industries to treat the waste water is the activated carbon also called activated charcoal [11]; and ionizing radiation technique [12]. But these are too expensive. Consequently numerous low cost alternatives have been proposed including vermiculite [13]; wood [14]; water work [15]; and banana pith [16]. But new economical, easily available and highly effective adsorbents are still needed. In the present study a much cheaper and quite effective adsorbent is chosen: saw dust. This adsorbent is cost effective and widely available from local timber industries. A

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 7, 2022

thorough study was carried out using different waste water samples and using activated saw dust as adsorbent. The results are very promising and can open new pathway for the low cost waste water treatment of textile units.

MATERIALS AND METHODS

ADSORBENT

The sawdust is collected from the local saw mills and washed with hot water to remove water soluble impurities and removal of surface adhered particles and then dried at 80°C till a constant weight. The adsorbent was treated with 1N H_2SO_4 at 100°C for 24 hours, then soaked in 1% Sodium bicarbonate solution overnight to remove residual acid. Then the treated material was dried in oven at 80°C for 24 hours. The dried adsorbent was finally powdered into granules, sieved and then preserved in desiccators before use.

ADSORBATE

The wastewater samples were collected from the dying units at Ludhiana, Punjab which contains the wastewater from Textile Industry.

EXPERIMENTAL SETUP

Four sets of clean dry 500 ml beakers were set up.

1) Textile effluents 250 ml + 1.25 g pre activated saw dust.
2) Textile effluents 250 ml + 1.75 g pre activated saw dust.
3) Textile effluents 250 ml + 2.50 g pre activated saw dust.
4) Textile effluents 250 ml + 3.00 g pre activated saw dust.

The removal of coloured impurities from all four mixtures were monitored using UV spectrophotometer at (λ_{max} = 420 nm). All the tests were done in triplicate and the concordant values were recorded for the results.

The removal percentage of dye was calculated by the following equation;

$$R(\%) = \frac{C_0 - C_e}{C_0} \times 100$$

The adsorption capacity (q_e) of dye by sawdust adsorbent (mg/g) was calculated using the following equation;

$$q_e = (C_0 - C_e)V/m$$

where;

C_o: the initial concentration of dye (*mg/L*);

C_e: the equilibrium concentrations of dye in solution (*mg/L*);

V: the volume of solution (*L*);

m: the weight of sawdust (*g*).

The effect of adsorbent dosage and contact time was studied. The results are as follows.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 7, 2022

RESULT AND DISCUSSION

EFFECT OF ADSORBENT DOSAGE

A number of investigations were carried out by varying the amount of saw dust from 5*g/l* to 12*g/l* at pH of 7 and room temperature of 25±1°C. The effect of adsorbent dosage on the removal of dye was studied and plotted. The figure shows an increase in the removal percentage of dye with increase of adsorbent dose until it asymptotically reaches 70%. This may be due to the increase in the availability of surface active sites with the dose increase.

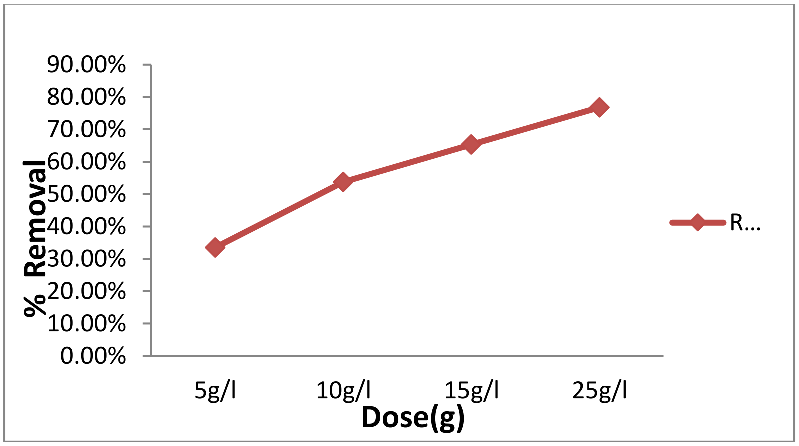
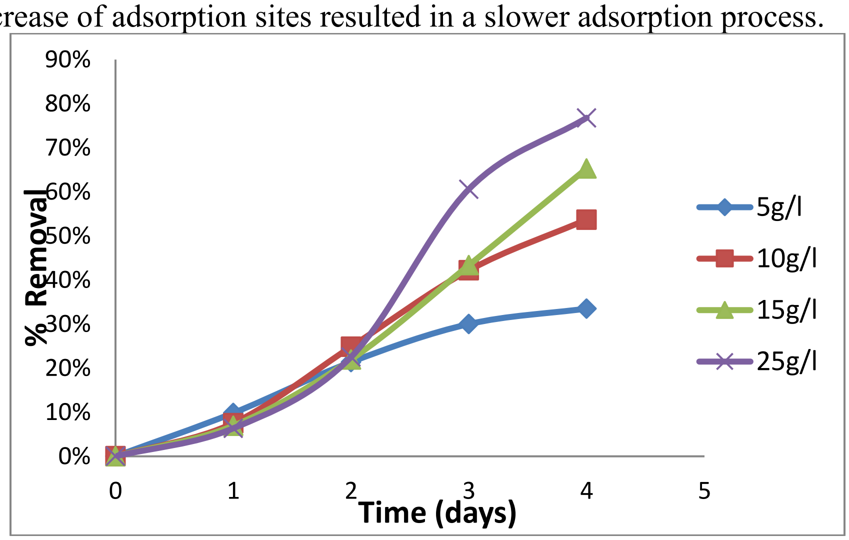


Fig. 1: Change in removal % of dye w.r.t dosage of treated sawdust.

EFFECT OF CONTACT TIME

The results of percentage removal at different time intervals were studied and plotted. The figure indicates that the dye concentration in aqueous solution decreases rapidly in the beginning and becomes almost constant after 4 days, this is attributed to the large surface area of the adsorbent is available in the beginning of adsorption. Also, the faster rate of adsorption in the initial stage of adsorption was primarily due to many active sites available. As the time passes, the progressive decrease of adsorption sites resulted in a slower adsorption process.



ISSN PRINT 2319 1775 Online 2320 7876
Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 7, 2022

Fig. 2: Change in removal % of dye w.r.t contact time.

EQUILLIBRIUM ADSORPTION ISOTHERM

The equilibrium distribution of dye between sawdust surface and the solution can be described using Freundlich and Langmuir adsorption isotherm models. The adsorption data appeared to rise in the adsorption capacity with increasing dye concentration, this is due to the fact that the adsorbate molecules find difficulty in arriving at active sites on the adsorbent surface as all vacant sites are filled.

LANGMUIR ISOTHERM

The most important monolayer adsorption isotherm for homogeneous surfaces is the Langmuir adsorption isotherm, where each the adsorbate molecules on the surface has similar sorption activation energy and independent of surface coverage. The Langmuir isotherm equation is

$$\frac{C_e}{q_e} = \frac{1}{Q_{max} \times K_L} + \frac{C_e}{Q_{max}}$$

where, C_e is the equilibrium concentration of adsorbate (*mg/l*), q_e is the amount of the dye adsorbed (*mg/g*) on treated sawdust. Q_{max} (*mg/g*) and K_L (*l/mg*) are the Langmuir constants related to the adsorption capacity and energy of adsorption, respectively. Q_{max} represents a maximum adsorption capacity.
When C_e/q_e was plotted against C_e, a straight line with the slope of $1/Q_{max}$ was obtained. Q_{max} and K_L were determined from the slope and intercept of the plot and are presented.
R^2 = 0.9884 indicates the applicability of the Langmuir model [17].

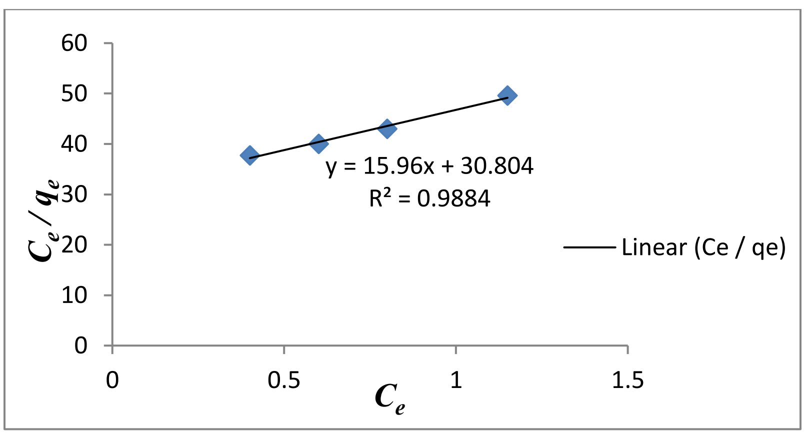


Fig. 3: Langmuir adsorption plot of Dye onto treated sawdust at 303 K.

Adsorbent	Q_{max} **(mg/g)**	K_L **(l/mg)**	R^2
Treated sawdust	0.0626	0.5181	0.9884

Table 1: Langmuir constants of effluent treated with sawdust at 303 K.

IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 7, 2022

Freundlich Isotherm

The Freundlich isotherm assumes that the uptake of dyes occurs on a heterogeneous surface by multilayer adsorption. The Freundlich equation which is given by:

$$log q_e = log K_F + \frac{1}{n} log C_e$$

where q_e is the amount of adsorbate adsorbed per unit weight (*mg/g*) of adsorbent, C_e is the equilibrium concentration (*mg/l*), and K_F (*mg/g*) and n are Freundlich constants related to the capacity of adsorption and favorability of adsorption, respectively [18].

Linear plots of $log\ q_e$ versus $log\ C_e$ give a straight line, the slope and intercept of which correspond to *1/n* and log K_F, respectively.

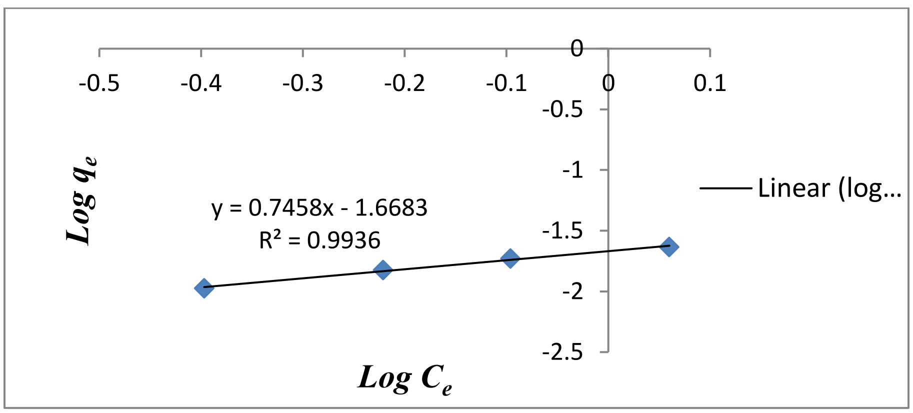


Fig. 4: Freundlich adsorption plot of Dye onto treated sawdust at 303 K.

Adsorbent	K_F (mg/g)	*n*	Correlation coefficient (R^2)
Sawdust	46.59	1.3408	0.9936

Table 2: Freundlich constants of effluents treated with sawdust at 303 K

The value of correlation coefficient fits well in both Langmuir & Freundlich isotherm.

CONCLUSION

In the present work, attempts have been made for studying the colour removal efficiency of low cost adsorbent prepared from sawdust in place of activated charcoal. From the experimental finding it has been observed that saw dust can be used successfully for the removal of colour.

IJFANS International Journal of Food And Nutritional Sciences
Official Publication of International Association of Food and Nutrition Scientists

ISSN PRINT 2319 1775 Online 2320 7876

The maximum colour removal efficiency was observed upto 75% using treated sawdust. It was found that colour removal efficiency was achieved maximum at the dose of 25*g/l* with the retention time of 4 days.

The adsorption data of treated sawdust fits well into Langmuir & Freundlich isotherms.

References

[1] D. B. Singh, G. Prasad, D. C. Rupainwar, Adsorption technique for the treatment of As(V)-rich effluents, Colloids and Surfaces A: Physicochemical and Engineering Aspects, 111, 49-56 (1996).

[2] H. M. Asfour, M. M. Nassar, O. A. Fadali, M. S. EI-Geundi, Colour removal from textile effluents using hardwood sawdust as an adsorbent, Journal of Chemical Technology and Biotechnology, 35(1), 28-35 (1985).

[3] E. IIoms, O. O. Ololade, H. J. O. Ogola, R. Selvarajan, Investigating Industrial Effluent Impact on Municipal Wastewater Treatment Plant in Vaal, South Africa, International Journal of Environmental Research Public Health 17(3), 1096 (2020).

[4] R. S. Asiwal, S. K. Sar, S. Singh, M. Sahu, Wastewater treatment by effluent treatment plants, SSRG International Journal of Civil Engineering, 3 (12), 29-35 (2016).

[5] G. Jallan, Natural Products Contaminated by Pollutants, Journal of Emerging Technologies and Innovative Research, 1(1), 876-878 (2016).

[6] W. R. Abma, W. Driessen, R. Haarhuis, M. C. M. Van Loosdrecht, Upgrading of sewage treatment plant by sustainable and cost-effective separate treatment of industrial wastewater, Water Science & Technology 61 (7), 1715–1722 (2010).

[7] A. Dąbrowski, Adsorption-from theory to practice, Advances in Colloid and Interface Science, 93(1-3), 135-224 (2001).

[8] H. A. Hegazi, Removal of heavy metals from wastewater using agricultural and industrial wastes as adsorbents, HBRC Journal, 9 (2013) 276-282.

[9] M. J. Luján-Facundo, M. I. Iborra-Clar, J. A. Mendoza-Roca, M. I. Alcaina-Miranda, Pharmaceutical compunds removal by adsorption with commercial and reused carbon coming from a drinking water treatment plant, Journal of Cleaner Production, 238, 117866 (2019).

[10] J. Fito, S. Abrham and K. Angassa, Adsorption of Methylene Blue from Textile Industrial Wastewater onto Activated Carbon of Parthenium hysterophorus, International Journal of Environmental Research, 14, 501-511 (2020).

[11] E. I. Ugwu and J. C. Agunwamba, A review on the applicability of activated carbon derived from plant biomass in adsorption of chromium, copper, and zinc from industrial wastewater, Environmental Monitoring and Assessment, 192 (2020) article number 240.

[12] A. Jain, Wastewater treatment using ionizing radiation technology: A Review, Journal of Emerging Technologies and Innovative Research, 6(4), 545-547 (2019).

[13] Y. S. Choi, J. H. Cho, Colour removal from dye wastewater using vermiculite, Environmental Technology, 17(11), 1169–1180 (1996).

[14] V. J. P Poots, G. McKay, J. J. Healy, The removal of acid dye from effluent using natural adsorbents-II wood, Water Research, 10(12), 1067–1070 (1976).

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group -I) Journal Volume 11, Iss 7, 2022

[15] G. Jallan, Water work waste as low cost adsorbent, Journal of Emerging Technologies and Innovative Research, 1(2), 25-27 (2014).
[16] C. Namasivayam, D. Prabha, M. Kumutha, Removal of direct red and acid brilliant blue by adsorption on to banana pith, Bioresource Technolology, 64(1), 77–79 (1998).
[17] Langmuir I 1916 Part 1, The Research Laboratory of The General Electric Company 2221; Langmuir I 1918 Part 2, The Research Laboratory of The General Electric Company 1848.
[18] H. M. F. Freundlich, The Journal of Physical Chemistry, 57, 1906, 385-471.