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Comparison of Natural Materials for Colour Removal from Textile Effluent

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The comparative studies of three natural materials *i.e.* bentolite, zeolite and fuller's earth for colour removal from textile waste water has been investigated, in which zeolite is found to be most effective among these natural materials. Various parameters like adsorbent dosage, temperature, contact duration and agitator speed have been considered in this studies. The Freundlich and Langmuir isotherm are used to analyze the data. The total decolourization was found at zeolite dosage of 50 g/L at temperature of 310 K and contact duration of 4 h.

Key Words: Natural materials, Colour removal, Process parameters, Isotherm models.

INTRODUCTION

Population explosion, haphazard rapid urbanization, industrial and technological, energy utilization and waste generation from domestic and industrial sources have rendered many waters unwholesome and hazardous to man and other resources[1]. A large variety of dyestuffs can be found in real effluents such as acid, basic, reactive, direct, *etc*. It has been estimated that about 9 % of the total amount (450000 tons) of dyestuffs produce in the world are discharged in textile wastewater[2]. In textile industry, the variety of raw materials, chemicals, processes and also technologic variations applied to the processes cause complex and dynamic structure of environmental impact of textile industry for each raw material like wool, cotton, *etc.*, on which dying is to be applied. The chemicals include different types of enzymes, detergents, dyes, acids, sodas and salts. These dynamic structure not affect the characterization and quantity of wastewater and the applied purification technologies but also make it being impossible to focus on a typical kind of wastewater and a standard purification technology[3].

The textile industry generally has difficulty in meeting wastewater discharge limits, particularly with regard to dissolved solids, ionic salts, pH, COD, colour and sometimes, heavy metals[4]. Colour can be considered as the earliest pollutant to be detected in polluted water. The presence of very small amounts of dyes in water (less than 1 ppm for some dyes) is highly visible and affects the quality of waterbodies. Colour may significantly affect photosynthetic activity in aquatic life reducing light penetration and may also be toxic to some aquatic life[5]. There are several methods for colour removal like adsorption[6], coagulation/flocculation/precipitation[7], polyelectrolyte[8] and biological process[9], ionizing/γ radiation[10], in which adsorption using natural materials have been, used comprehensively[11].

In this study, the comparison of natural materials *viz*. bentolite, zeolite and fuller's earth for colour removal has been conducted. Also, process parameters like adsorbent dosage, temperature, contact duration and agitator speed were also analyzed. The adsorbent behaviour can be explained on the basis of Freundlich and Langmuir adsorption isotherm model.

EXPERIMENTAL

The natural materials like bentolite, zeolite and fuller's earth were purchased from Fisher Sci. Comp. USA, Enli Mining Corporation, Turkey and HRP Industries, India, respectively. The textile wastewater samples periodically were withdrawn from Pandesara, GIDC, Surat, Gujarat, India. Samples were collected in sampling bottles and placed in ice box to preserve the characteristics of wastewater and were analyzed as per standard method[12]. The wastewater was treated with various absorbent dosages (10.0-50.0 g/L) at 300 K, 4 h and agitator speed of 400 rpm to investigated effect of adsorbent dosage. The effect of temperature was studied by treating the wastewater with 50 g/L of natural materials at temperatures of 280, 290, 300, 310, 320 and 330 K at 4 h and agitator speed of 400 rpm. To determine the effect of contact duration, the wastewater was treated with 50 g/L of natural materials for constant contact durations of 60-210 min at constant temperature of 300 K and agitator speed of 400 rpm. The effect of agitation speed was investigated by treated wastewater with 50 g/L of natural materials at 300 K, contact duration of 4 h and agitator speed of 100-600 rpm.

The equilibrium of sorption is one of important physico-chemical aspects for the evaluation of the sorption process as a unit operation. The dye solution is an important factor to establish the sorption capacity of natural materials. Sorption isotherm has the relationship between the sorbate in the liquid phase and the sorbate sorbed on the surface of the sorbent at equilibrium at constant temperature. The distribution of dye molecules between the liquid phase and the sorbent is a measure of the position of equilibrium in the sorption process and can be generally expressed by the two well known models *viz*., Freundlich and Langmuir isotherm. The Freundlich isotherm can be efficient on multilayer and also, heterogeneous surface and is expressed by the following equation.

$$q_e = K_F C_e^{1/n} \text{ or } \log q_e = \log K_F + 1/n \log C_e$$

where, q_e and C_e are the amount of adsorbed adsorbate per unit weight of adsorbent and unadsorbed adsorbate concentration in solution at equilibrium, respectively and K_F and n are Freundlich constant characteristics of the system, which are determined from the log q_e *vs*. log C_e.

Also, Langmuir adsorption is very useful for predicting adsorption capacities and also interpreting into mass transfer relationship. The isotherm can be written as follows:

$$1/q_e = (1/Q_o)\ K_L\ (1/\ C_{eq}) + 1/Q_o$$

where, Q_o and K_L are the Langmuir constants, which measures of monolayer (maximum) adsorption capacity (in mg/g) and energy of adsorption (in g/L), respectively. The Langmuir parameters were obtained[13] from the linear correlations between the values of $1/q_e$ and $1/C_e$.

RESULTS AND DISCUSSION

Table-1 depicted the effect of different doses of various natural materials *viz.* bentonite, zeolite and fuller's earth onto colour removal keeping all other experimental conditions constant. It can be seen that there is a large and continuous reduction in the values of adsorption capacity (q_{eq}), from 21.96-10.52 Hazen L/g at a dosage of 5-30 g/L of bentonite, respectively, from 51.95-28.16 Hazen L/g at a dosage of 5-30 g/L of zeolite, respectively and from 35.95-19.48 Hazen L/gat a dosage of 5-30 g/L of fuller's earth, respectively. The initial value of colour was 2000.0 Hazen. The adsorption capacity of zeolite was higher then other adsorbents. The results show that, as the adsorbent concentration increases, the amount adsorbed per unit mass (adsorption capacity-q_{eq}) of the adsorbent decreases considerably. The decrease in unit adsorption with increase in the dose of adsorbent is basically due to adsorption sites remaining unsaturated during the adsorption reaction[14].

TABLE-1
EFFECT OF ADSORBENT DOSE ONTO COLOUR REMOVAL BY NATURAL MATERIALS

Adsorbent dose (g/L)	Bentonite		Zeolite		Fuller's earth	
	C_{eq} (Hazen)	q_{eq} (Hazen L/g)	C_{eq} (Hazen)	q_{eq} (Hazen L/g)	C_{eq} (Hazen)	q_{eq} (Hazen L/g)
5	1890.20	21.96	1720.25	55.95	1820.25	35.95
10	1800.24	19.98	1545.21	45.48	1690.46	30.95
15	1720.36	18.64	1410.12	39.33	1588.23	27.45
20	1655.24	17.24	1315.21	34.24	1491.25	25.44
25	1590.25	16.39	1225.45	30.98	1415.45	23.38
30	1530.00	15.67	1155.24	28.16	1350.54	21.65

The graph of Freundlich and Langmuir isotherm models were depicted in Figs. 1 and 2, respectively. The linear graphs represented that the data were fitted to both isotherm. Table-2 shows the Freundlich and Langmuir parameters, in which coefficient correlation values (r^2) of Langmuir isotherm were more nearer to 1 than of Freundlich isotherm. So, the Langmuir isotherm was more followed than Freundlich isotherm. The reference literature available that the Freundlich isotherm was best fitted[15,16]. It can be suggested that adsorption capacity of zeolite is higher than other natural materials.

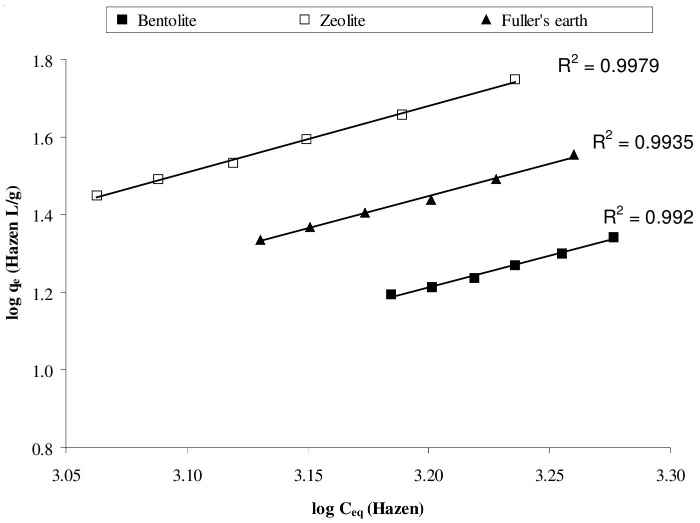

Fig. 1. Freundlich plots for colour removal by different natural materials

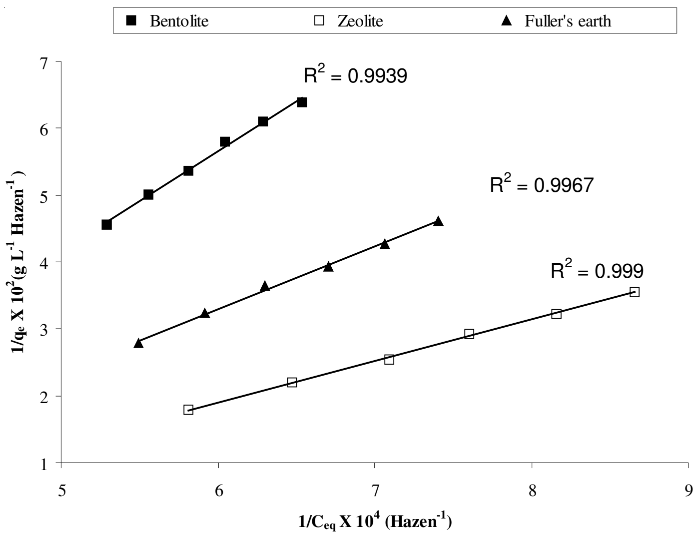

Fig. 2. Langmuir plots for colour removal by different natural materials

TABLE-2
FREUNDLICH AND LANGMUIR PARAMETERS FOR COLOUR REMOVAL BY NATURAL MATERIALS

Natural materials	Freundlich parameters			Langmuir parameters		
	K_F (L/g)	n	r^2	K_L (L/g)	Q_o (L/g)	r^2
Bentonite	1.123×10^{-4}	0.620	0.9920	3407.00	54.945	0.9939
Zeolite	1.507×10^{-4}	0.852	0.9979	4003.61	62.553	0.9990
Fuller's earth	1.361×10^{-4}	0.602	0.9935	4547.09	30.581	0.9967

The effect of temperature on the colour removal was investigated at 280, 290, 300, 310, 320 and 330 K (Fig. 3). It was evident that best removal was found at 320 K and then after equilibrium was attained. Increasing the temperature is known to increase the rate of diffusion of the adsorbate molecules across the external boundary layer and in the internal pores of the adsorbent particle, owing to the decrease in the viscosity of the solution. Thus, a change in temperature change the equilibrium capacity of the adsorbent for a particular adsorbate[17].

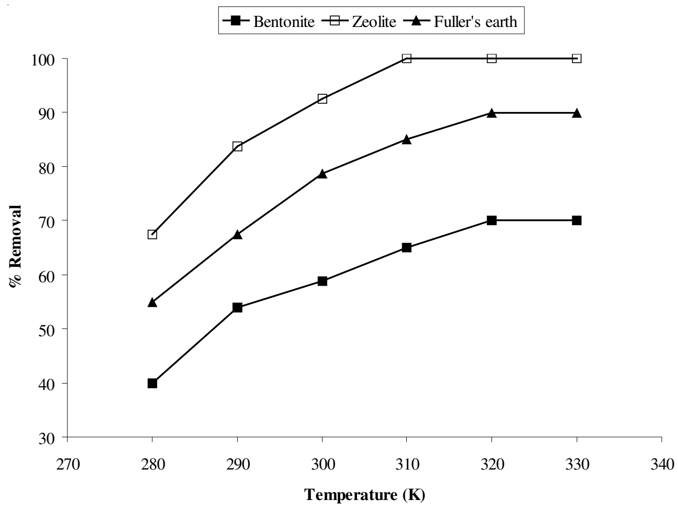

Fig. 3. Influent of temperature for colour removal by different natural materials

Fig. 4 represented the effect of contact duration for colour removal using natural materials maintaining other parameters. The results reveal that the rates of per

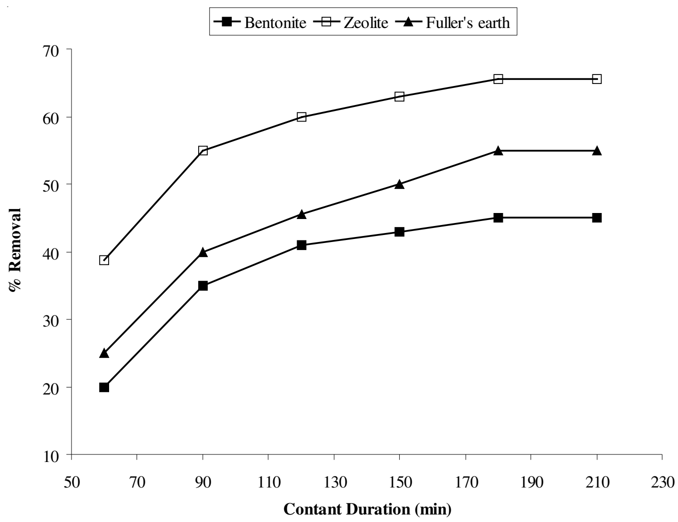

Fig. 4. Influent of contact duration for colour removal by different natural materials

cent colour removal are higher at the beginning (60-150 min). That is probably due to the larger surface area of natural materials at the beginning for the adsorption of colour. As the surface adsorption sites become exhausted, the uptake rate is controlled by the rate at which the adsorbate is transported from the exterior to the interior sites of the adsorbent particles[18]. Also, straight line after contact duration of 180 min suggested that equilibrium attained at 180 min.

The influence of agitator speed onto colour removal by different natural materials is represented in Fig. 5, in which graph of percentage removal *vs.* agitator speed was drawn. It can be seen that continuous increment in percentage removal with increasing agitator speed upto 500 rpm and equilibrium attained at 500 rpm, as these was straight line after 500 rpm. An enhanced sorption rate at higher shaking speeds is probably due to an increase in the mobility of sorbing species[19].

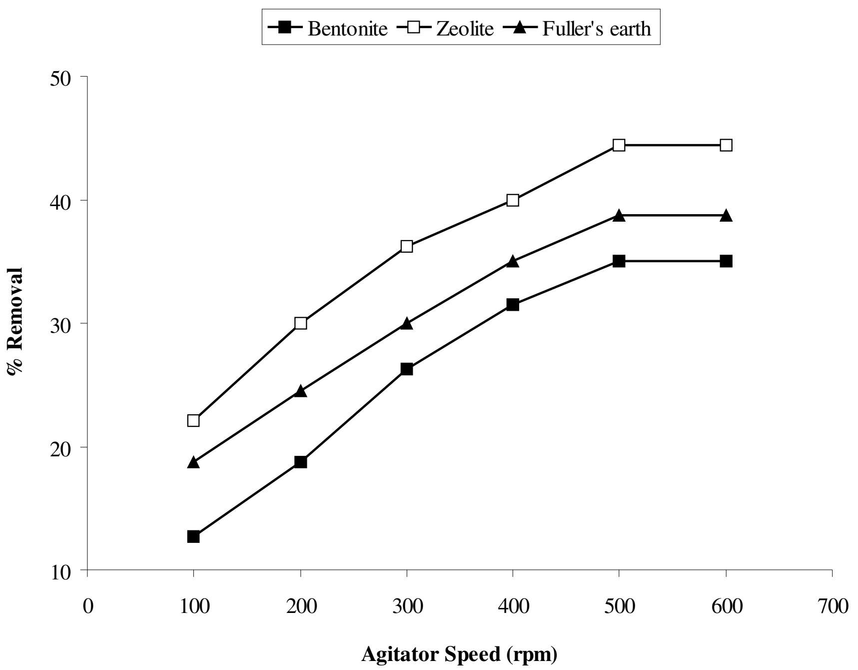

Fig. 5. Influent of agitator speed for colour removal by different natural materials

Conclusion

From above discussion, it is clear that zeolite is found to be most effective for removing colour from textile wastewater among used natural materials *i.e.* bentolite, fuller's earth. The process parameters like adsorbent dosage, temperature, contact duration, agitator speed are used for colour removal, in which total colour removal was attained using parameter of temperature. The equilibrium data have been analyzed using Langmuir and Freundlich isotherms, in which Langmuir isotherm is more fitted than Freundlich isotherm, derived from correlation coefficients.

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