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PERFORMANCE OF LOW COST ADSORBENTS FOR THE REMOVAL OF METHEYLENE BLUE FROM AQUEOUS SOLUTIONS BY ADSORPTION

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Abstract: Dyes removal from wastewater has been a matter of concern, both in the aesthetic sense and health point of view. Dyes removal from textile effluents on a continuous industrial scale has been given much attention in the last few years, not only because of its potential toxicity, but also mainly due to its visibility problem. There have been various promising techniques for the removal of dyes from wastewater. Economically feasible adsorbents of bio-origin with more adsorptive capacity are in demand for the removal of textile dyes from waste water. As the textile dyes are perilous to the environment, they should be removed from the industrial effluents before their disposal. Methylene blue dye is one of the most widely used in textile industries. Therefore we propose low cost adsorbents for the removal of Methylene blue dye. Present research mainly focuses on the removal of Methylene blue dye from aqueous solutions. A series of experiments were conducted in batch wise to estimate the effect of system variables on the amount of percentage removal of Methylene blue dye from the aqueous solution. The effects of variables such as contact time, initial concentration of Methylene blue dye in solution, amount of adsorbent dosage and temperature of the solution on the adsorption were studied. The adsorption data were well fitted by Freundlich isotherm model for neem leave and Langmuir isotherm model for Jatropha. Neem and Jatropha leave powder showed 89% and 98% removal of Methylene blue dye at the optimum operating conditions.

Keywords: Adsorption, Methylene blue dye, low-cost adsorbents, Wastewater treatment.

I. INTRODUCTION

Pollution of water due to dye is the major cause of concern for chemical and environmental engineers, due to release of pollutants into the environment. Industrialization and urbanization create a major problem to the environment. So the removal of dyes from waste water by low cost adsorbent is essential. Increase in the industries leads to increase in the usage of various different synthetic chemical dyes mainly in textile industry, paper and pulp, dyeing, leather treatment, printing etc .The discharge of coloured wastes into streams not only effects the environment and ecosystem, but also interferes with the transmission of sunlight into streams and therefore reduces photosynthetic activity, so removal of dyes using physically or chemically activated adsorbent by adsorption principle is essential. Need to maintain cleaner environment for survival of all living creatures including human beings, this subject made more concern to the environmentalist.Dyes are the group of complex organic materials which enter the environment due to various processes by industrial activities, the waste water need to be treated effectively as per standard guidelines. Discharge of waste water without proper treatment from textile industries in to water bodies has been reported to impair the normal function of aquatic life. Several methods have been developed for the removal of dye from waste water. These include physiochemical, chemical and biological methods such as coagulation and flocculation, ozonation, electro chemical methods, fungal decolonization and adsorption. Among the techniques mentioned, adsorption is the method of choice because of its ease of operation and design. Adsorption employ adsorbent- a substance which attaches the substrate or solvent molecule to its surface and several materials have been applied as adsorbent for the treatment of waste water. Agricultural waste and its activated carbon have proven very efficient as adsorbent for many compounds including various classes of dyes.

II. MATERIALS AND METHODS:

All the chemicals used in this study were of analytical grade and they were from SD Fine Chemicals Limited (Chennai, Tamilnadu, India). Concentrations of Methylene blue dye were measured by Colorimeter (CL 157), pH measurements were made with pH meter (ELICO, LI613).

2.1 Preparation of Dye samples:

The textile dye used for the experiment was Methylene blue. This dye is acid type dye. To one gram of the dye a few drops of soap solution is added in a beaker and diluted using hot water that it is at a temperature of 600^0C.The dye is stirred well to form a homogenous solution and is made to a solution of 100 ml .The mixture is poured into a 100 ml standard flask and shaken well to form a homogeneous solution. This solution is diluted the required concentration and experiments are conducted. The dye solution is prepared in small quantities when ever required because the solution if stored for long time will get hydrolyzed.

2.2 Batch Adsorption Studies:

The batch experiments are carried out in 250 mL borosil conical flasks by stirring a pre-weighed amount of the adsorbent with 100 mL of the aqueous solutions of known concentration and pH. The dye solutions were agitated in a rotary shaker at 120 rpm for a desired time interval. The samples were withdrawn from the shaker at the regular time intervals and adsorbent was separated by filtration using filter paper. The experiments were carried out by varying the dye concentration in the solution (10-75 mg/L), adsorbent dosage (1.0-2.5 g/L) and temperature (30-50 ºC) for 3 h contact time.

III. RESULTS AND DISCUSSION

3.1. Effect of Contact Time:

Initial concentration 10 mg/l were tested to study the effect of contact time. These studies were carried at different temperatures 30^0C,40^0C and 50^0C to study the effect of temperature simultaneously. The batch samples were drawn at regular intervals and tested to study the adsorption process. The effect of contact time on the adsorbed percentage of color at different temperatures is plotted in the fig 1. It can be observed that the adsorption is very rapid during the initial period of contact later it is slow. This is due to more available free surface area during the initial period of contact. However, equilibrium is attained with in 150 to 180 min. The benefit of the neem leaf powder could be seen clearly. The percentage removal was calculated using the following formula:

$$\textbf{\% Removal of dye} = \left(\frac{C_i - C_t}{C_t}\right) X100$$

Where; C_i the initial concentration of Methylene blue in mg/L and C_t is the concentration of Methylene blue in mg/L at time respectively.

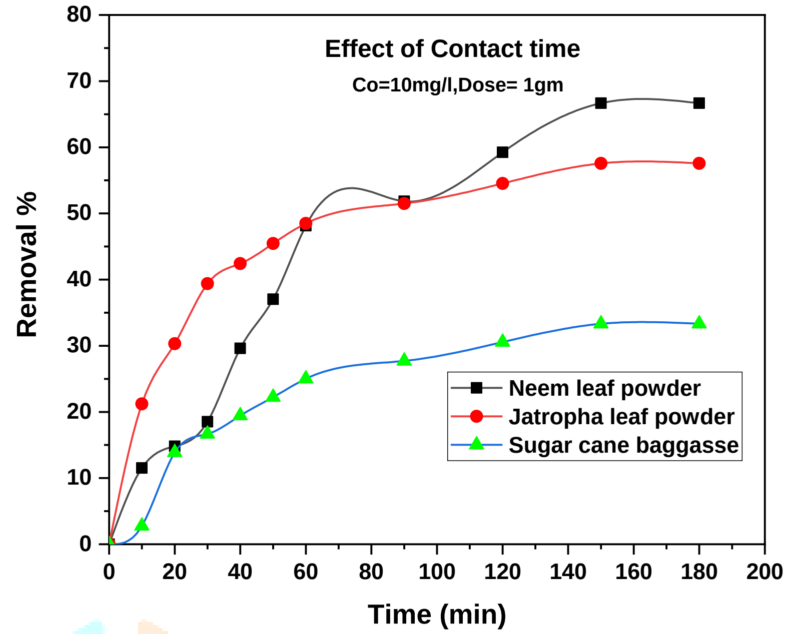

Fig.1 Effect of Contact time on percent of color removal (at temperature 30^0C ,initial concentration 10 mg/l)

3.2 Effect of Initial Concentration:

The methylene Blue liquor solution having initial concentrations of 0.01gm/lt, 0.025gm/lt, 0.05gm/lt, 0.075gm/lt have been tested to observe the effect of initial dye concentration on percentage of color removed. Figure 2 shows that for dilute solution with 0.01gm/lt initial concentration the percentage of color removed is 85.18%for 2.5gm of neem leaf powder as adsorbent and for long contact time. But, in case of concentrated solution used in the experimentation with 0.075gm/lt the percentage of color removed is 47.58%. Similar trend is observed in the case of Jatropha leaf powder and Sugar cane bagasse.The reason for this is the adsorption process is highly dependent on initial concentration of effluent. It is because of that at lower concentration, the ratio of the initial number of dye molecules to the available surface area is low and subsequently the fractional adsorption becomes independent of initial concentration.However at higher concentration the available sites of adsorption becomes fewer and hence the percentage removal of dye is dependent on initial concentration.

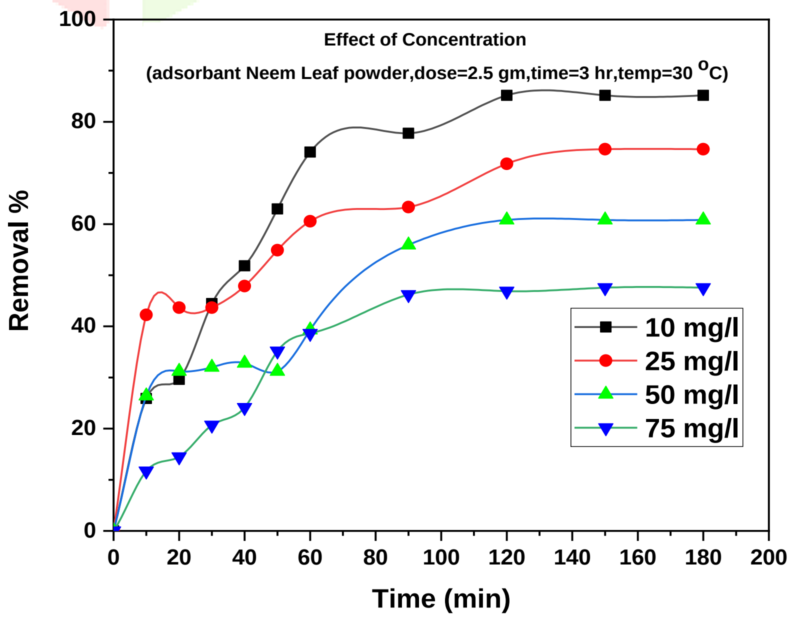

Fig.2 Effect of initial concentration on percentage of color removal using Neem leaf powder as adsorbent (at temperature 30^0C time 3 h and adsorbent dosage 2.5 gm)

3.3 Effect of Adsorbent Dosage:

It can be observed that the amount of adsorbent used effects the percentage of color removal for the neem leaf, jatropha leaf powder and sugar cane bagasse.The color removed is obtained as increasing the quantity of adsorbent used can be observed from figure 3. The maximum percentage of color removed is 80 %with a quantity of 2.5gm and it decreases to 64 % when 1.0gm of adsorbent as neem leaf powder. The similar trend was observed in the case of the jatropha powder and sugar cane bagasse.

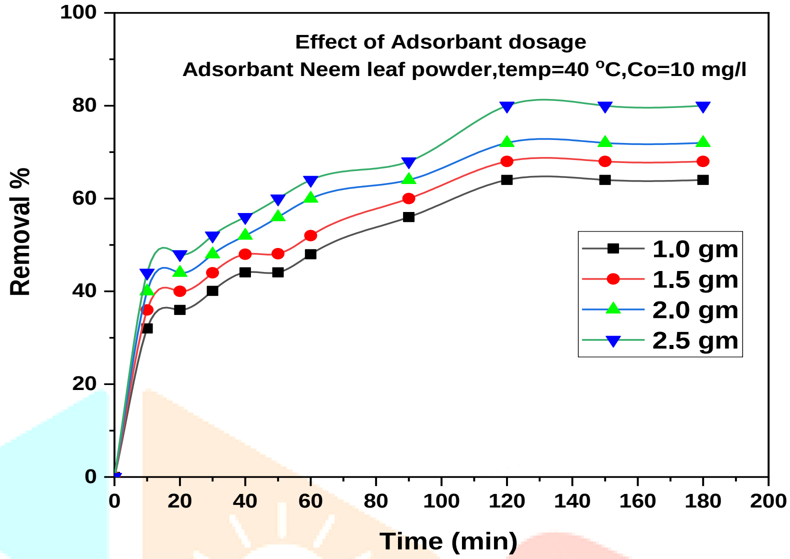

Fig.3 Effect of Adsorbent dosage on percent of color removal using Neem Leaf powder as adsorbent (at temperature 40^0C ,initial concentration 10 mg/l)

3.4 Effect of type of the adsorbent:

The effect of type of adsorbent is shown in figure 4 by plotting for neem,jatropha leaf powder and sugar cane bagasse. In removing the dye methylene Blue. It has been observed that different adsorbents adsorb differently. Adsorption mainly depends on the surface area available for adsorption and the composition of the adsorbent like the amount of alumina present, the amount of unburnt carbon and also silica content. It has been observed that at a temperature of 30^0C, 0.01gm/lt initial concentration and dosage of 2.5gm of neem powder the color removal is 85.18%. For the same condition applied for the jatropha leaf powder and sugar cane bagasse the color removal observed is 72.72%, 41.66% and 72.22% respectively. The percentage of color removal of the used three adsorbents were found to be in the order.

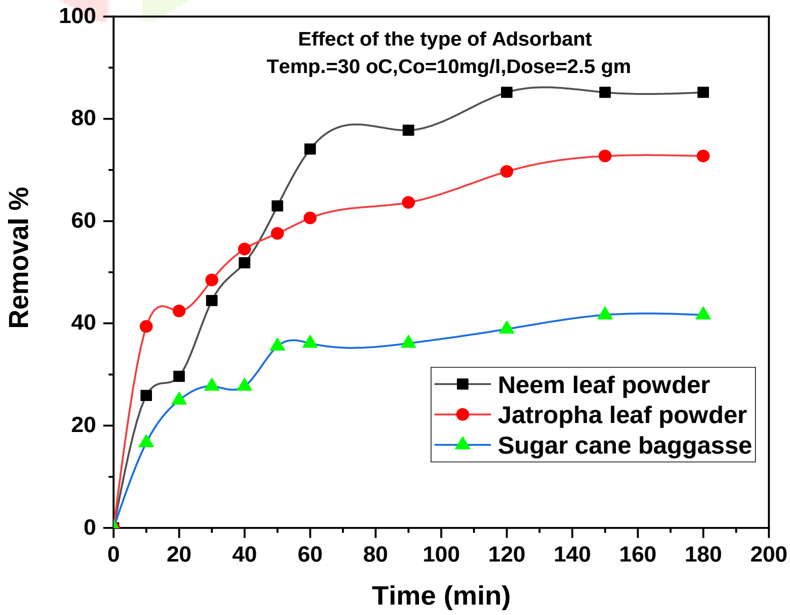

Fig.4 Effect of type of Adsorbent on percent of color removal

3.5 Effect of Temperature:

The effect of the temperature on the removal of color from methylene blue dye using Neem leaf, powder, Jatropha powder and Sugar cane bagasse as adsorbents are presented in the graphs from figure 5 .In the case of the neem leaf powder when 2.5gms was used the percentage of color removal for a 0.01gm/lt dye solution at a temperature of 30^0C is found to be 85.18%. At 40^0C the color removal fell to 80% and at a temperature of 50^0C it further reduced to 72.2%. A similar trend is also observed in the Jatropha leaf powder and Sugar cane bagasse too. The reason for the fall in the percentage of color removal at elevated temperatures may be that at elevated temperatures a part of the dye leaves the solid phase and re enters the liquid phase.

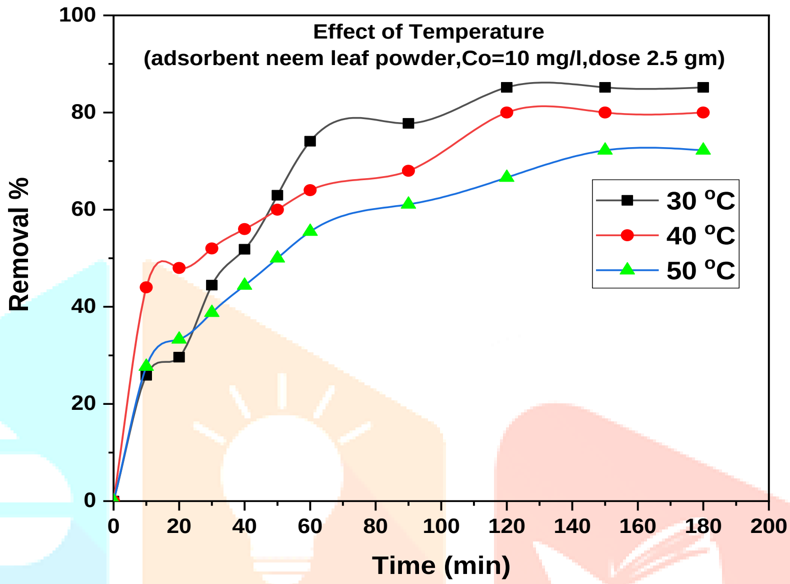

Fig 5. Effect of temperature on percentage of color removal using Neem leaf powder as adsorbent (at initial conc.10 mg/l, contact time 3 h and adsorbent dosage 2.5 gm)

IV. ADSORPTION ISOTHERMS

Adsorption Equilibria has been studied through Langmuir Isotherms.

$$q_{e}=\frac{abC_e}{1+bC_e}$$

Where q_e is the amount of dye adsorbed at equilibrium (mg/g)
C_e is the equilibrium concentration of dye (mg/l)
a is the Langmuir constant related to adsorption capacity (mg/g)
b is the Langmuir constant related to energy of adsorption(1/mg)

4.1 Langmuir Adsorption Isotherm:

Langmuir equation is given by

$$q_{e}=\frac{abC_e}{1+bC_e}$$

Langmuir equation is linearized to the form

$$(1/q_e) = (1/ab)(1/C_e) + (1/a)$$

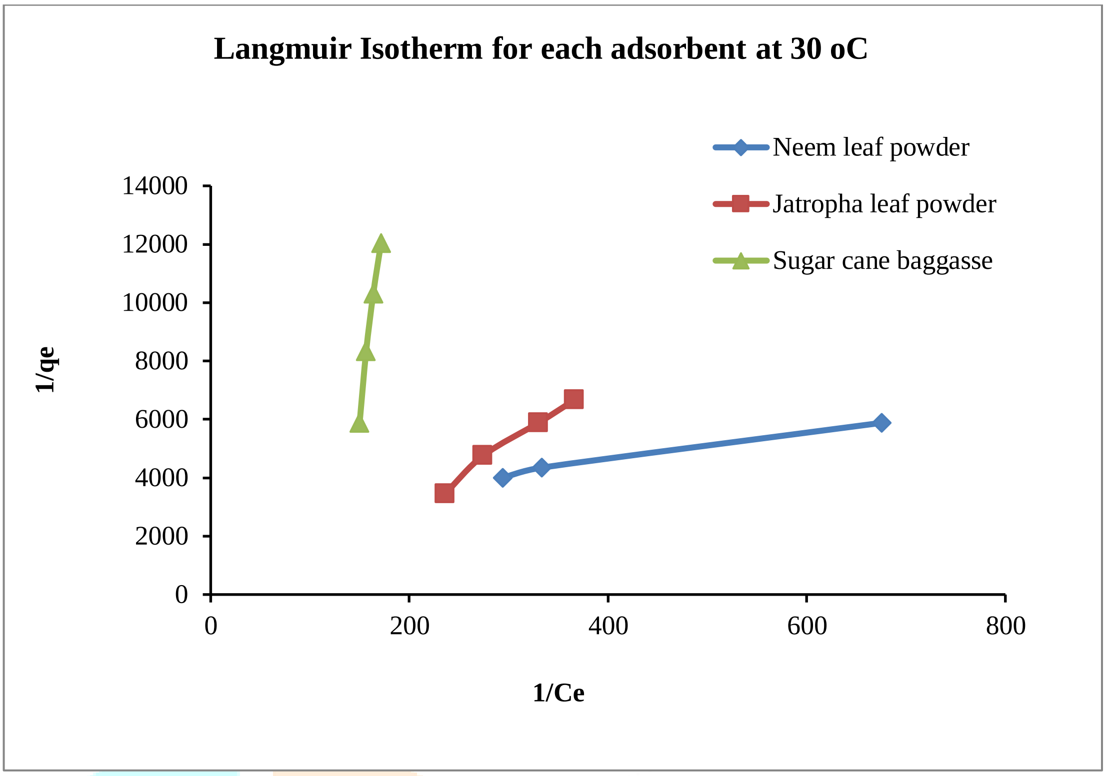

Fig 6. Langmuir Isotherm for different adsorbents at 30^{0}C

4.2 Freundlich Adsorption isotherm: Herbert Max Finley Freundlich, a German physical chemist, presented an empirical adsorption isotherm for non ideal sorption on heterogeneous surfaces as well as multilayer sorption and is expressed by the equation:

$$q_e = KC_e^{1/n}$$

Where q_e is the amount of dye adsorbed at equilibrium (mg/g

C_e is the equilibrium concentration of dye (mg/l)

K is the quantity of dye adsorbed (mg/g)

I/n is the measure for adsorption intensity (1/mg)

Freundlich isotherm is linearized in the form

$$\text{Log}(q_e) = \log(K) + (1/n)\log(C_e)$$

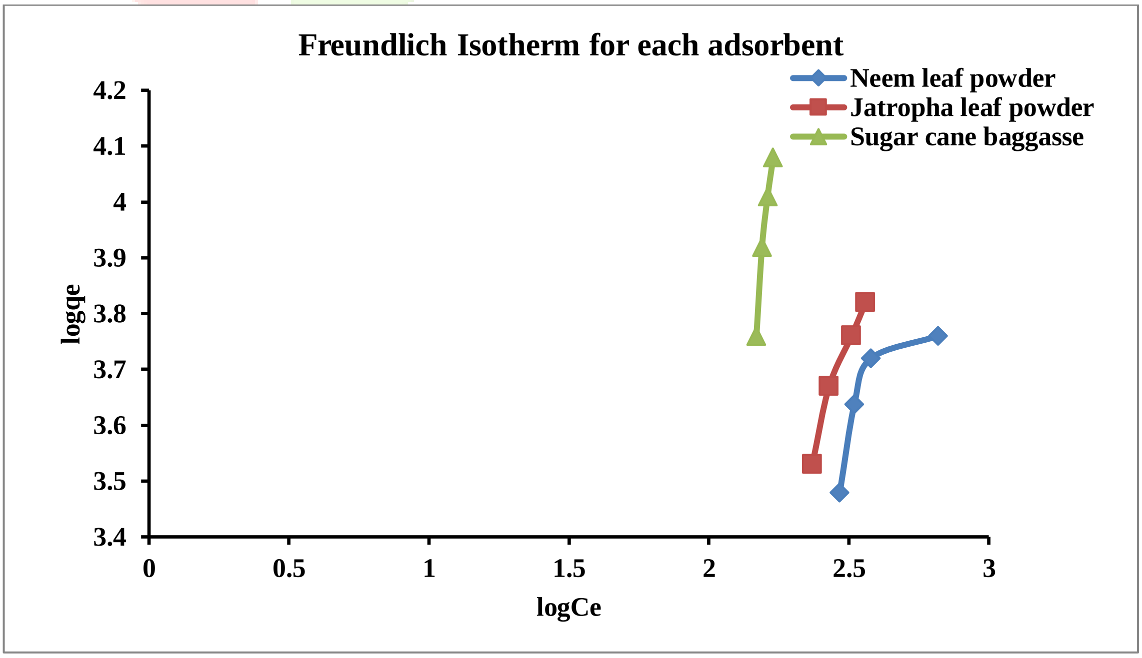

Fig 7. Freundlich isotherm for different adsorbents at 30^{0}c

The suitability of adsorption isotherm can be decided to experimental data through the R^2 factor. The experimental data was plotted $\log q_e$ vs. $\log c_e$ for Freundlich isotherm and $1/c_e$ vs. $1/q_e$ for Langmuir isotherm. The R^2 values computed by linear regression for two types of the isotherms. From figures 6 to 7 indicate that the best fit isotherm is a function of the adsorbate and adsorbent considered each time. For example it can be observed from the table of values that the adsorption of the methylene blue dye by neem leaf powder at 40^0C with 0.01 initial concentrations is most appropriate Freundlich isotherm. Langmuir isotherm is most appropriate for methylene blue dye at 30^0C with 0.025 initial concentrations.

V. CONCLUSIONS:

This study indicates that Neem leave,Jatropha leave powder and Sugar cane bagasse has rapid adsorption rate as well as good adsorption capacity for methylene blue. The methylene blue adsorption was found to be dependent on initial concentration, contact time, adsorbent dose and temperature.The adsorption of methylene blue was found to be fitted the Langmuir isotherm model for neem and Freundlich for jatropha leaves, which suggests monolayer coverage of adsorbent surface.This work showed that neem and jatropha powders could be used as a good adsorbent material for methylene blue removal from dilute aqueous solution. Neem and Jatropha powders are readily obtained, and they were considered as waste products. These materials were cheaper and environmental friendly alternatives. In this way, their use should be seriously considered for this task.

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