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Adsorptive removal of Methylene blue using *Azadirachta Indica* (Neem) Leaf

Shubhra Bhattacharjee
Auditor – Social Compliance, TGT Asia Sourcing, BANGLADESH
djzsb@yahoo.com

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Abstract

The use of eco friendly and low cost adsorbents were studied as an alternative substitution of activated carbon for removal of dyes from wastewater. Laboratory investigation was done to identify the effectiveness of Azadirecta indica leaves (Neem) to remove methylene blue from aqueous solution. Neem leaves were dried in a thermostatic oven at 105°C for 24 hours. These leaves ground into fine powder with 10-15um mesh size. 1 gm/ 10 lt, 2 gm/ 10 lt, 3 gm/ 10 lt, 4 gm/ 10 lt and 5 gm/ 10 lt working solution were prepared by serial dilution of stock solution. It was noted that percentage of adsorption increased from 43.2% to 80.1% with increased amount of adsorbent. Langmuir adsorption isotherm was applied and R^2 value was calculated which shows, Langmuir adsorption is a good fit for the experimental data. The result shows that the 80.1 % colour removal efficiency was achieved at the dose of 5 gm/10lt.

Keywords: Adsorption, Neem leaves, Methylene blue.

Introduction

The release of large quantities of textile dyes poses serious environmental impact. Untreated or partially treated dyes contribute to pollution load. Low concentration of dyes can affect aquatic life and food chain as some of the synthetic dyes has mutagenic and carcinogenic characteristics[1]. The anaerobic breakdown of dyes in the sediment or incomplete bacterial degradation often produces toxic amines which able to cause serious environmental pollution[2].

The removal of textile dyes from colored effluent is one of the major concerns[3]. A number of techniques have been introduced to treat the textile wastewater. The conventional methods are most of the case expensive[4]. A number of adsorption studies were carried by various researchers as adsorption is quite popular for its simplicity and efficiency[5]. Activated carbon is commonly used in adsorption method. However, raw material of this technique is relatively expensive[6]. As a result, implementation of activated carbon in large effluent treatment is rare[5].

A wide range of bio-absorbent are used to treat large quantity of textile effluent as a cost effective technique. It has potential advantages over the conventional methods as adsorption technique is low cost, high efficiency on heavy metal removal and discoloration, less use of chemicals, regeneration characteristics and minimum waste[7]. The present study is an attempt to identify the adsorption and removal of dyes from aqueous solution characteristics of Neem leaves (*Azadirecta indica*).

Materials and Methods

The present study was carried out in the month of March 2015 at environmental laboratory of Jahangirnagar University, Bangladesh. For experiment, Neem leaves were collected from the Rajendrapur Army housing area, Gazipur. Initially, leaves were repeatedly washed by using distilled water to remove moisture and soluble impurities and then dried in a thermostatic oven at 105°C for 24 hours till leaves turn pale yellow. Then Neem leaves were ground to fine powder and screen by 10-15um mesh size. Prepared leaves were kept in a refrigerator at a temperature of 278 K to avoid decomposition.

Methylene blue was collected from a composite dyeing factory of Gazipur, Bangladesh. The stock solution was prepared through dissolving 1 g of methylene blue in 1000 ml of distilled water. The Neem samples were taken and put in dryer for about 30 minutes. After the sample dried, the sample was weighed as 1 gm, 2 gm, 3 gm, 4 gm and 5 gm.10 mg/lt working solution was prepared by serial dilution of stock solution. These samples were put in the conical flask of 250 ml of the dye solution. Then the flask was shaken for 10 minutes through rotary shaking machine at 150 rpm and allowed to stand still for 48 hours. 48 hours later, the sample was shaken and filtered. The filtered sample was collected in small plastic bottles. The colorimetric reading was taken of all filtered solution.

The removal efficiency was calculated by using following formula[8];

$$\text{Absorption (\%)} \quad \frac{C_i - C_f}{C_i} \times 100$$

Where: C_i = Initial Concentration (mg/lt) and C_f = Final Concentration.

For modelling adsorption, the Langmuir adsorption isotherm was used. The equation is as follows;

$$q_e \quad \frac{q_m K C_e}{1 + K C_e}$$

The above formula is linearized to,
Ce / qe= 1/qm K + Ce/ qm
Where q_e is the amount of methylene blue adsorbed per unit weight of adsorbent, q_m is the maximum amount of methylene blue adsorbed per unit weight of adsorbent, K is the adsorption equilibrium constant and C_e is the concentration of methyleneblue in liquid phase at adsorption equilibrium. Evaluation of the coefficients q_m and K can be obtained using linearized form of above equation[9]. In the case of Langmuir adsorption isotherm, graphs of $1/q_e$ v/s $1/C_e$ were plotted.

Results and Discussion

Table-1 illustrates the behaviour of adsorbent and concentration of solution. It was noted that the concentration of solution decreased with increased amount of adsorbent.

The Figure-1 shows the efficiency of adsorbent to remove dyes from the solution. It can be summarized that the amount of adsorbent increases the concentration of solution decreases as the surface of adsorption increases.

The Figure-2 shows the percentage of adsorption for different amount of adsorbent. The quantity of adsorbent increases with the adsorption percentage increases as surface of adsorption increases.

Langmuir adsorption isotherm graph is plotted with $1/q_e$ v/s $1/C_e$ (Figure-3). The straight lines for the adsorption data of methylene blue using different adsorbents were plotted. The linear regression was conducted and it was found that R^2 values are closer to 1, indicating that the Langmuir adsorption isotherm is a good fit for all the adsorption data.

Discussion: Dyes are one of the main components of textile waste water. Biological treatment plant takes long time to decolouring the textile waste water. Therefore, physico-chemical treatment, coagulation, photo-oxidation and adsorption techniques are studied to decolouring the textile waste water within short time[10]. Among them adsorption technique is widely used for this purpose[11]. To identify the effectiveness of the adsorbent and dosages, Langmuir adsorption isotherm plays an important role. In this regard, R2 value close to 1 indicates that the all adsorption data feet for experiment[5].

There were different adsorbent dosages experimented to address the adsorption capacity. It was noted that the adsorption percentage increased with the adsorption dosages. The absorbent amount increased 1 gm/10 ml to 5 gm/10 ml and noted 43.2% to 80.1% adsorption. Similar result was noted at different experiments which were carried out by various researchers[5,6,12-14].

Table-1
Effect of adsorbent dosage to removing methyleneblue solution

Weight of adsorbent/volume of solution	Reading of Colorimetric	Adsorption (%)
1 gm/ 10 ml	0.22	43.2
2 gm/ 10 ml	0.18	55.1
3 gm/ 10 ml	0.15	67.9
4 gm/ 10 ml	0.12	72.3
5 gm/ 10 ml	0.07	80.1

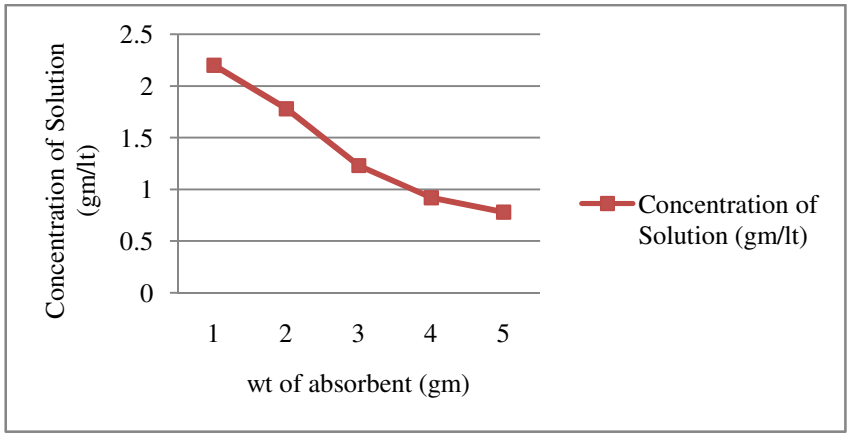

Figure-1
Colorimeter reading for different amount of adsorbent

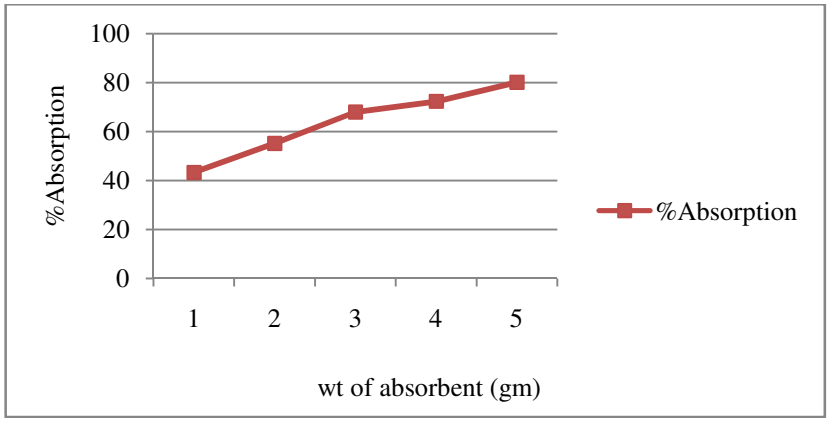

Figure-2
Adsorption percentage for different amount of adsorbent

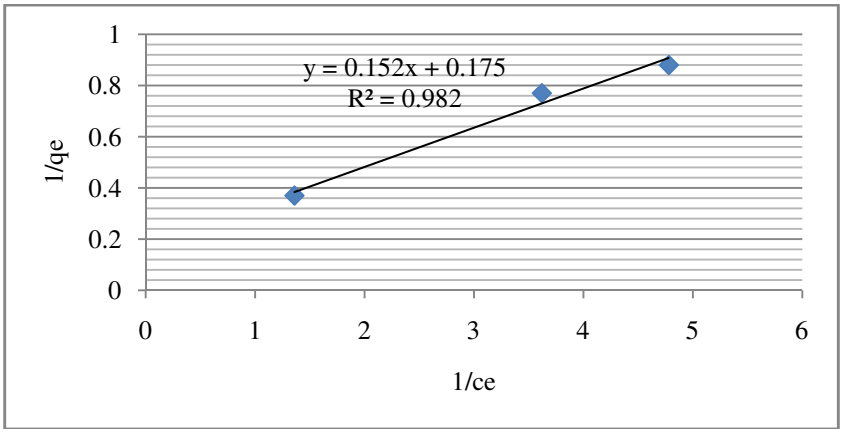

Figure-3
Langmuir adsorption isotherm of adsorbent

During the colorimetric experiment, it was noted that the concentration of solution decreased from 2.2 gm/lt to 0.8 gm/lt with increased adsorbent dosage. This was occurred as the surface of adsorbent dosages increased. Initially the adsorption was low as available surface area of adsorbent was low. Subsequently, the percentage of adsorption increased as area of available sites increased[15,16]. Pandhare et al.[6] noted that the concentration of solution decreased rapidly with the increased of adsorbent dosages. Similarly, Kavitha and Senthamilselvi[17], used bioadsorbent to reduce the concentration of methylene blue and found similar kind of result. Rana and Singh[5] experimented with Neem leaves to address the effectiveness of this adsorbent to reduce the concentration of methylene blue. They noted that concentration of coloring agent decreased significantly with increased amount of adsorbent. The result of present study showed consistent with the previously performed experiments.

In the present study, the percentage of adsorption increased 43.2% to 80.1% for different amount of adsorbents. The percentage of adsorption increased with increased Neem concentration, which was attributed to increase surface area and the availability of more adsorption sites. Similar outcomes noted by different researchers who experimented with Neem leaves to address its adsorbent characteristics. In 2013, Gopalakrishnan et al.[14], found increased removal percentage of textile dyes from 13.7% to 100% as the amount of Neem powder was increased from 0.25 gm to 3 gm. Pandhare et al. observed removal percentage 44% for I gm/50 lt amount of adsorbent which increased into 79% for 5 gm/50 lt amount of Neem powder[6]. In 2012, Durairaj and Durairaj noted 74.2% textile dyes removal percentage for 500 mg/250 ml Neem solution[13].

By plotting 1/qe v/s 1/Ce in Langmuir adsorption isotherm graph, 0.9823 R2 value found which is close to 1. The slope of isotherm satisfied the condition of $0<n<1$ for favorable adsorption. The present result showed consistency with the previously performed experiment. Rana and Singh[5] observed 0.9867 R2 value for isotherm graph.

Conclusion

The present study is an attempt to identify the low cost adsorbent to discoloring the textile wastewater. Neem leaves are found widely in Bangladesh and it can be easily converted to activated carbon by chemical activation. This transformation

enables the adsorbent characteristics of Neem. As a result, Neem was considered as a low cost adsorbent for present study. From the experiment, it was observed that the Neem leaves can be used as an effective adsorbent material for removing methylene blue dye. Various amount of Neem leaves were used to identify the removal efficiency. It was noted that the removal efficiency increased with the increased amount of adsorbent. From the different amount of adsorbent, maximum removal efficiency noted 80.1% for 5 gm/10 lt of Neem solution.

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