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SHORT COMMUNICATION

COMPARATIVE ADSORPTION STUDY OF MANGO (*MANGIFERA INDICA*) LEAVES AND NEEM (*AZADIRACHTA INDICA*) LEAVES, AS AN ADSORBENT FOR DYE REMOVAL

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ABSTRACT

The study attempted to evaluate and compare the adsorption capacity (Methylene Blue removal) of non-conventional adsorbents prepared from Neem (Azadirachta indica) leaf and Mango (Mangifera Indica) leaf and Langmuir model or Freundlich model were analyzed. The leaves from Neem and Mango were collected, cleaned, dried (115°C) and powdered. The physiochemical properties were studied. Methylene blue dye was used as the pollutant since it is a frequently used dye for adsorption studies. A series of batch experiments were carried to evaluate the adsorption capacity of Neem leaf adsorbent and mango leaf adsorbent with different dosages and different initial adsorbate concentrations (100, 150, 200 and 250 mg/L). Neem leaf showed the highest adsorption capacity of 83%. The adsorption capacity of the Mango leaves was around 79%. Adsorbent dose and adsorption rate have a positive relation. Adsorption rate increases with adsorbent dose and decreases with increases of adsorbate initial concentration. Langmuir isotherm showed a high coefficient of determination. Both Langmuir separation factor (R_L) and Freundlich constant (n_F) suggest the favorable adsorption of the dye onto the adsorbents. The results indicated that both neem and mango leaves have an attractive property to remove dye from water. Therefore, both can be used as alternative green adsorbents for pollutant removal.

Keywords: *Adsorption, Adsorbents, Langmuir isotherm, Freundlich isotherm, Pollutant Removal*

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1. INTRODUCTION

Wastewater is a serious environmental threat that encourages environmental degradation. Organic, inorganic and biological pollutants are present in a different kind of wastewater. There are plenty of methods available to remove such pollutants. Among those techniques, Coagulation, flocculation, biodegradation, adsorption, membrane separation, ion exchange and oxidation are the most frequently used techniques [1]. However, those methods could be included under Biological, chemi-

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cal and physical treatment. Adsorption is an efficient physiochemical phenomenon of attracting and retaining the molecules of a substance on the surface of a liquid or a solid resulting in a higher concentration of the molecules on the surface [2]. Adsorbate and adsorbent are the two main terms used in adsorption studies. Adsorbate is a substance which is accumulated by adsorbent. The solid surface which the adsorption takes place is defined as adsorbent. According to the attraction between adsorbent and adsorbate, adsorption process is grouped as two: physical adsorption and chemical adsorption. Since activated carbon is a frequent used adsorbent [3], researchers pay attention to the green, non-conventional, low cost adsorbents as an alternative to activated carbon, such as: avocado kernel, banana peel, orange peel wastes of maize, peanut hulls and sugar cane bagasse [4]. Neem (*Azadirachta indica*) leaves [5] and Mango (*Mangifera Indica*) leaves can also be used as alternative adsorbents. Both have a good potential to eliminate the dye [6]. Few studies have been conducted on pollutant removal using neem adsorbent [7].

Neem (*Azadirachta indica*) is in the Mahogany family Meliaceae. It is native to some south Asian countries such as India, Bangladesh, Nepal, Pakistan and Sri Lanka [7]. It suits mostly tropical or semi tropical regions. It contains azadirachtin which is the reason for its unique properties including: antibacterial, antifungal, antimalarial, antiviral, anti-allergic, anti-dermatic, anti-inflammatory, insecticidal and nematocidal properties. Mango (*Mangifera Indica*) tree belongs to the family anacardiaceae. It originated from Myanmar, Bangladesh and India. However, it is extensively cultivated in India. Both neem and mango are easily available in Sri Lanka and powdered leaves have high surface area. A high surface area is the primary requirement of a good adsorbent [8]. Therefore, this study focuses on *Azadirachta indica* and *Mangifera Indica*. In this present study, the adsorption potential of both adsorbents was examined. In addition, adsorption potential was compared and an isothermal study was conducted to identify the adsorption process. Methylene blue (MB) dye was used for this adsorption study, since it has been frequently used in the literature as a model dye. Hetero polyaromatic structure of MB has a strong inhibitive function and hard to be degraded by using general practices [9].

2. MATERIAL AND METHODS

Basically, two different adsorbents were obtained from neem (*Azadirachta indica*) leaf and Mango leaf by following the same procedure. Fresh Raw materials were collected and washed to remove the impurities and dust particles. They were kept in the oven drying at a temperature of 115℃ overnight. Dried particles were powdered eventually and sieved. Different concentration of adsorbents (1 g, 1.5 g, and 2 g) was used.

Methylene blue (MB) dye was used as an adsorbate. The stock solution was prepared by dissolving 1 g of MB into 1000 ml distilled water. Four level of working concentrations (100 mg/L, 150 mg/L, 200 mg/L, 250 mg/L) were prepared from the stock solution. Thereafter, a basic characterization study was conducted to find moisture content, organic matter content, ash content, pH, electrical conductivity and bulk density. A series of Batch experiments were conducted to determine the removal of methylene blue dye by adsorption using two types of adsorbents at three different dosage levels. Three replicates were used for each experiment. One hundred milliliters of adsorbate were

taken into a 250 ml beaker and a predetermined amount of adsorbent (1 g, 1.5 g, and 2 g) was added. Then the mixture was shaken in a mechanical shaker (250 rpm) for about 60 minutes and allow for settling. Whatman filter paper was used to filter the solution and the dye concentration in the solution was determined by measuring the absorption at 660 nm. The absorption was taken using a UV visible spectrophotometer (UV-1240, Japan). The amount of adsorbed dye (mg/g) and adsorption percentage was calculated. Continuously, the effect of different adsorbents on adsorption, and the effect of adsorbent dosage on adsorption efficiency were studied. Thereafter, the adsorption method was analyzed by an isothermal study. Freundlich and Langmuir isotherms were tested to determine the adsorption process. For Langmuir isotherm following linearized equation was used [10].

$$\frac{C_e}{Q_e} = \frac{1}{Q_{max} k_L} + \frac{c_e}{Q_{max}}$$

where

Q_e - Amount of methylene blue adsorbed per unit weight of adsorbent (mg/g);
Q_m - Maximum amount of methylene blue adsorbed per unit weight of adsorbent (mg/g);
K- Adsorption equilibrium constant (L/mg);
C_e – Equilibrium concentration of methylene blue (mg/L).

The following equation was used to determine the adsorption process by Freundlich isotherm [10].

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

where

q_e- Amount adsorbed at equilibrium (mg/g);
K_f - Freundlich constant;
1/n - Heterogeneity factor, related to the capacity and intensity of the adsorption;
Ce - Equilibrium concentration (mg/L).

3 RESULTS AND DISCUSSION

The adsorption process depends on the physiochemical properties of adsorbents. The high fixed carbon level (>68%), low ash content level (<15%) and high bulk density are the main properties that can be used to identify a good adsorbent [11]. Both adsorbents have shown optimum level of MC%, ash % and OM%. The values are given in table 1.

Table 1: Properties of adsorbents

Adsorbents	**Physiochemical property**			
	Moisture Content %	**Organic Matter %**	**Ash**	**pH**
Neem Leaves	1.4(±0.07)	91.25(±0.73)	8.75(±0.05)	5.66(±0.04)
Mango Leaves	2.3(±0.03)	96.36(±0.05)	3.64(±0.05)	6.02(±0.08)

3.1 Color removal of different adsorbents

The Figure 1 shows the calibration curve of Methylene blue dye which was obtained at 660 nm wavelength and the coefficient of determination (R^2) value shows the goodness of fit. Application of adsorbents was encouraged to reduce the MB dye concentration along with the time. Five milliliters of adsorbate were taken to determine the dye removal during the following time intervals: 12hours, 24 hours, 48 hours 72 hours and 96 hours. The dye removal rate was very high during 12 hours for both adsorbents. Thereafter, removing rate is decreasing with time (Figure 2).

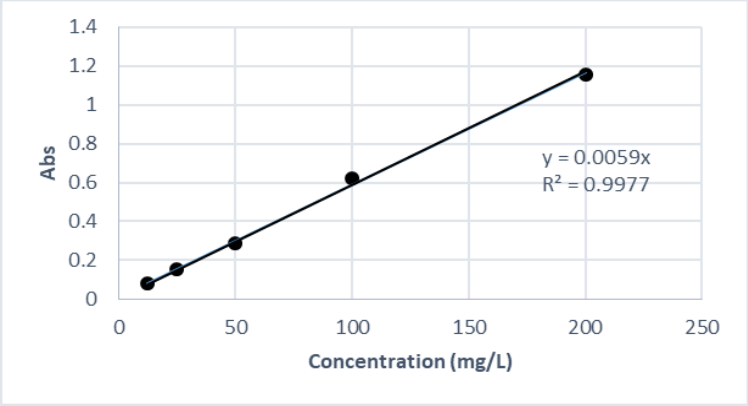

Figure 1: Calibration curve of Methylene Blue at 660nm wavelength

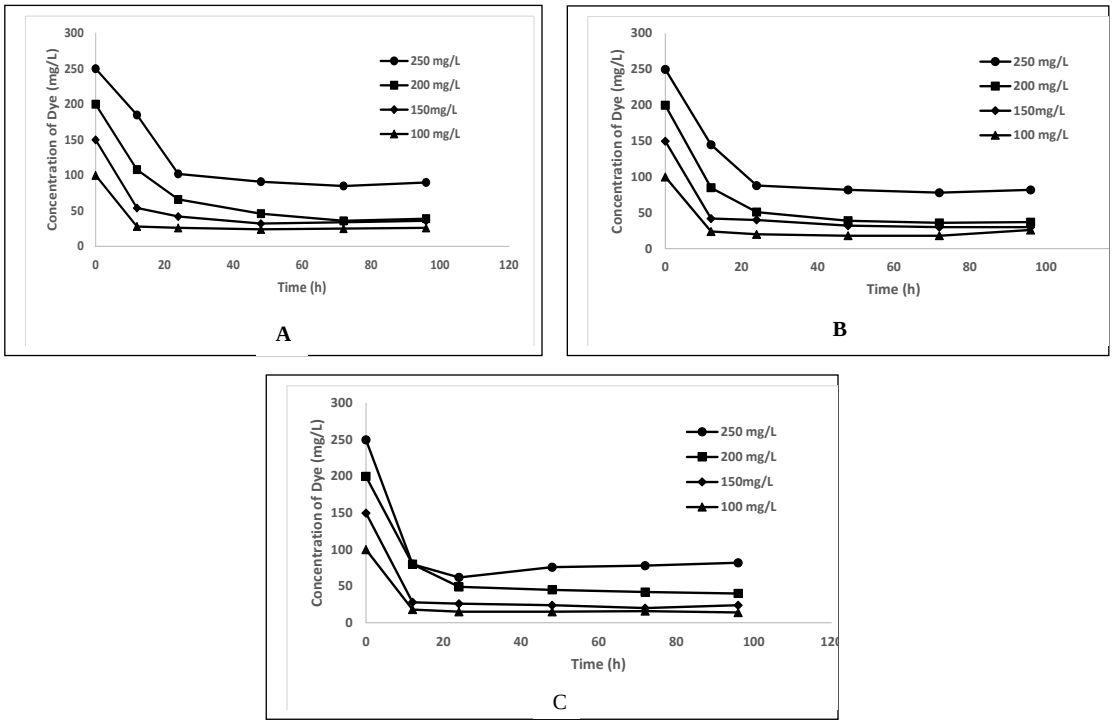

Figure 2: Reduction of dye by adsorbent obtained from neem leaves along with time at different doses of 1g(A), 1.5g(B) and 2g(C).

Both adsorbents showed satisfactory pollutant removal efficiency. Neem leaf (*Azadirachta Indica*) and Mango *(Mangifera Indica)* leaf removed dye 83.5% and 79 % respectively. General Linear model ANOVA was used to determine the adsorption efficiency of both adsorbents with the various adsorbent doses and various initial adsorbate concentrations. The average adsorption capacity of mango and neem adsorbents is shown in Figure 4.

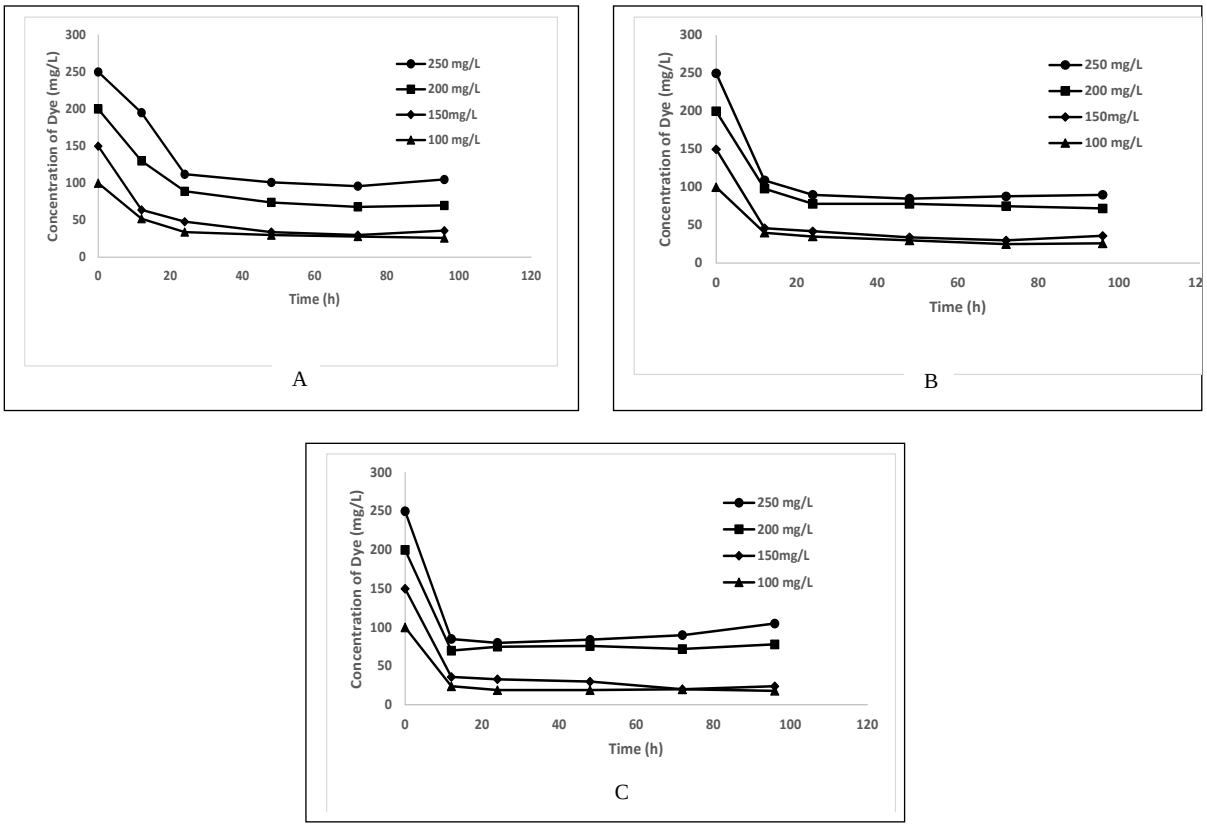

Figure 3: Reduction of dye by adsorbent derived from Mango leaves with time at different doses of 1g(A), 1.5g(B) and 2g(C).

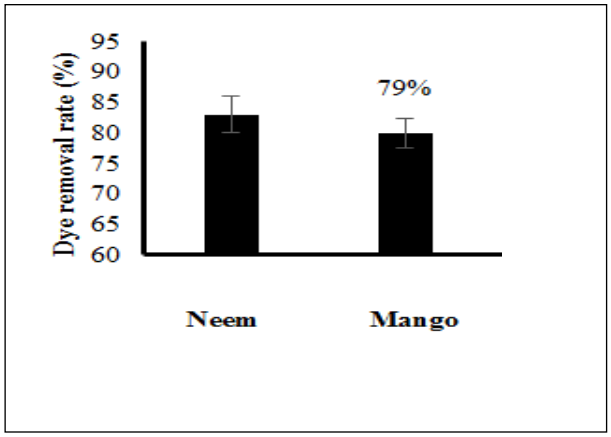

Figure 4: Adsorption rate of synthesized adsorbents

3.2 Isotherm

An Optimum dose of 2g was considered to draw the isotherms or adsorbents. Below model (figure 5) explores the Langmuir constant and maximum amount of adsorbate adsorbed per unit weight of adsorbent. Separation factor R_L was calculated. R_L value of both falls between 0-1. It suggests that the adsorption process of two adsorbents is favorable for adsorption [12]. However, value of coefficient of determination show more fitness in the adsorption study using mango adsorbent than neem adsorbent.

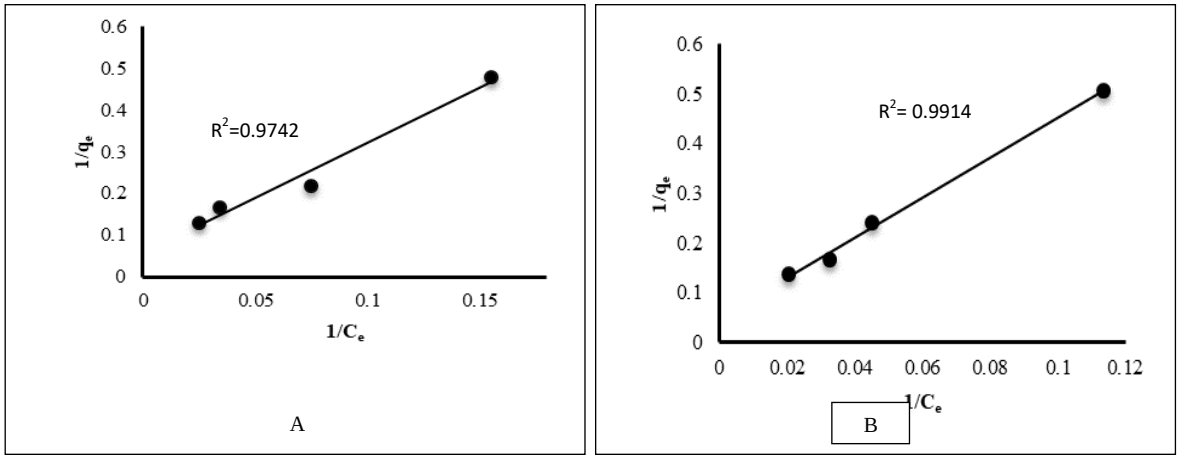

Figure 5: Langmuir isotherm for neem adsorbent (A) and Mango adsorbent (B)

Freundlich isotherm was plot (Figure 6) in between log C_e and log q_e at the optimum dosage 2g.

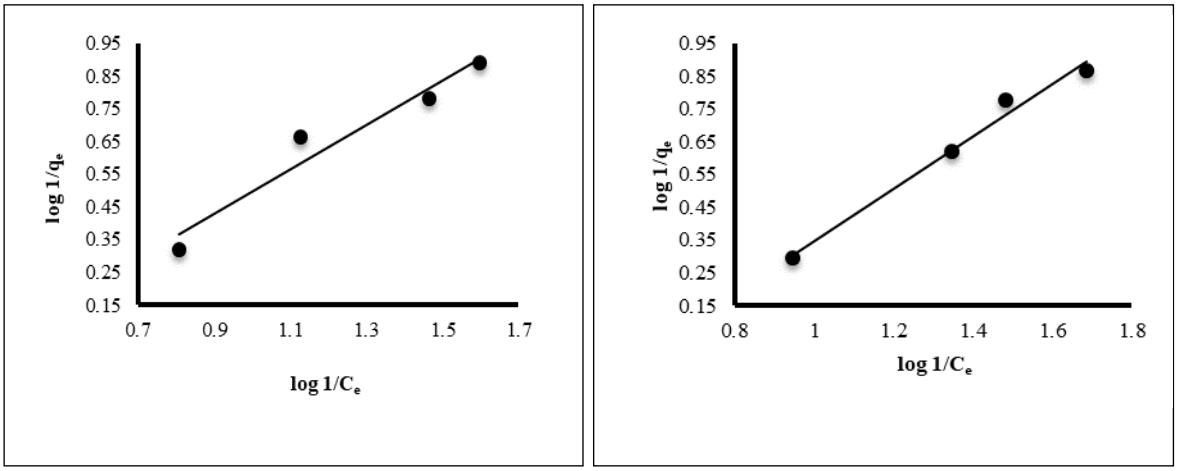

Figure 6: Freundlich isotherm for neem leaves (A) and mango leaves (B)

CONCLUSION

The study explored that Mango leaf powder adsorbent and Neem leaf powder adsorbent have the ability to remove the methylene blue from an aqueous solution. Comparatively neem leaf powder showed high adsorption capacity than mango leaf powder. Dye removal is increased when the adsorbent does is increased.

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