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A Novel Bioadsorbent for the Removal of Methyl Red from Aqueous Solutions

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Abstract: *Low cost pomelo peels were prepared as adsorbents for the adsorption of methyl red from aqueous solution. In the present study, experiments were carried out for the removal of methyl red dye and performed in the laboratory scale using pomelo peels. Factors like adsorbent contact time, pH, and amount of adsorbents were studied for the removal of dyes from aqueous solution. For pomelo peel, maximum removal (93.5%-94.8%) was obtained at adsorbent mass of 1g/100 ml at pH 6.5 and contact time of 80 minutes. The equilibrium adsorption behavior was examined by applying Langmuir adsorption isotherm model. The adsorption capacity of pomelo peel is comparable to other cellulose-based adsorbents. The pomelo peel was found to be very effective adsorbent for methyl red adsorption.*

Keywords: *Adsorption, Adsorption isotherm, Batch Study, Methyl Red, Pomelo peel.*

I. Introduction

Textiles plays an extremely important role of Bangladesh's economy. Currently, the textile industry accounts for about half of all industrial employment in the country and contributes significantly in total national income. Effluent from the textile industry is a major source of environmental pollution especially water pollution. Among the various stages of textile industry, dyeing plant is the most pollutant producing stage. The textile dyeing waste water contains unused or partially used organic compounds, strong color and high Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS). The color removal from textile wastewater has been extensively studied using different Physio-chemical methods [1-4]. Activated carbon is the most widely used adsorbent for this purpose, because of its high capacity for adsorption of organic matter. But its use is limited because of its high cost[5-10]. Chitosan has been used for the removal of reactive dyes [11]. However, chitosan have several other important applications. Various researchers used bio-adsorbents for the removal of Cr (vi) and phenol from industrial wastewater [12,13].The amount of dyes from wastewater using adsorption process by agricultural waste provides an alternative treatment[14,15]. The purpose of this work was to test the possibility of using cellulose-based waste, namely pomelo peel. Pomelo peel (locally called Jambura) is largely composed of cellulose, pectin, hemicellulose, lignin and other low molecule weight organic compounds. It can be used as an efficient and cost-effective bio-adsorbent for removing methyl red from aqueous solution.

II. Materials And Methods

2.1 Preparation of Adsorbents:

The collected pomelo peels (citrus maxima) were washed with distilled water for several times to remove all the dirt particles. The washed materials were cut into small pieces and dried in oven at 80°C for 24 hours. The dried peels were grounded to a fine powder by using mortar and sieved through 600 micron sieves.100 grams of sieved particles were repeatedly washed with hot distilled water until the filtrate water was very clear. Therefore, the adsorbent particles were dried at 80°C for 24 hours in an oven and then stored in plastic bottles for further use.

2.2 Preparation of adsorbate standard solution:

Methyl Red (azo dye) supplied by Merck (Germany) was used for the study. A 1000 ppm stock solution was prepared by dissolving 1000 mg of it in 1000 ml of distilled water and the required standard solutions were prepared by dilution method ($V_1M_1 = V_2M_2$). Prepared standard solution was used for bio-adsorption and for the study of adsorption isotherm. Calibration curve was obtained using 2.5, 5, 10, 15 and 20 ppm standard solutions.

2.3 Adsorption experiments:

Adsorption experiments were performed by the batch technique. The adsorption of a methyl red on pomelo peels were obtained after stirring the beakers containing 30 ml of sample with different amount of adsorbents, different values of pH and different contact time at room temperature. The stirring proceeded for different periods of time after which the mixture was left to settle and filtered. The absorbance of the filtrate was determined by using UV-Vis spectrophotometer at adjustedλ_{max} (410nm).

2.4 Equilibrium Studies:

A fixed amount of adsorbent (1.0 g) was added into a set of each 100 ml beakers containing 50 ml of different concentrations of methyl red solution with adjusted pH of 6.5. The beakers were stirred on a magnetic stirrer for 2 hours until the equilibrium was reduced. At time t=0 and equilibrium, the absorbance were measured by a double beam UV-Vis spectrophotometer (Model DR 4000 U, HACH,USA).

Each experiment was duplicated under identical conditions. The amount ofadsorption at equilibrium, qe (mg/g), was calculated by:

qe= $(C_o - C_e)$ V / W, where, C_o and C_e (mg/L) are the liquid-phase concentrations of dye at initial and equilibrium time, t, respectively, V is the volume of the solution L, and W(g) is the mass of adsorbent used. The percentage of dye-removal can be calculated as follows:

Removal percentage = $C_o - C_t / C_o \times 100$,Where, C_t(mg/L) is the liquid-phase concentrations of dye at time, t.

2.5 Effect of contact time:

The contact time ranged from 20-120 minutes, pH of the aqueous dye solution was adjusted to pH 6.5. The amount of adsorbent was 1g/150ml. the dye concentration was 100 ppm.

2.6 Effect of pH:

The pH ranges from 3.0 to 9.0; the amount of adsorbent was 1g/50ml, where the contact time was 80 minutes. The pH was adjusted by adding a few drops of 0.1 M NaOH or 0.1 M HCl.

2.7 Effect of amount of adsorbent:

The range of amount of adsorbent was 0.5 to 2 g for 50 mL solution. The pH was fixed at 6.5 and the contact time for the experiment was 80 minutes.

III. Results And Discussion

3.1 Effect of contact time :

The time dependent behavior of dye adsorption between adsorbate and adsorbent was measured using conditions that were previously described. The results were shown in figure1.For pomelo adsorbent, adsorption of methyl red reaches a removalefficiency of about 95% after 80 minutes.After 80 minutesthe removal efficiency was found to decrease because of desorption.

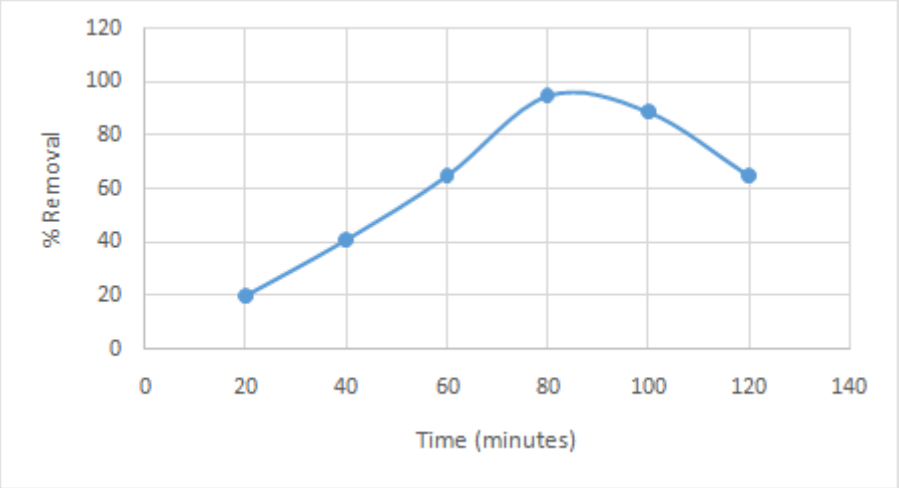

Figure 1: Effect of contact time for adsorption of methyl red on pomelo peel. $C_o$was 100 ppm at pH = 6.5; temperature = 25°C)

3.2 Effects of amount of adsorbent:

The effects of pomelo peel dose on the removal of dyes are shown in figure 2. The percentage of dyes adsorbed increased as the adsorbent dose was increased over the range 0.5 g - 2.0 g/50mL. The optimum contact time between adsorbate and adsorbent was 80 minutes. The results explained that the waste removal percentage was very low at the beginning and then increased with increasing dosage. This is due to the presence of higher active site of adsorbent with increasing adsorbent dose. The figure 2 shows that the optimum amount of dose of adsorbent is 1 gram for 50 mL of dye solution of 100 ppm concentration.The maximum removal of dye correspond to 90-95%.

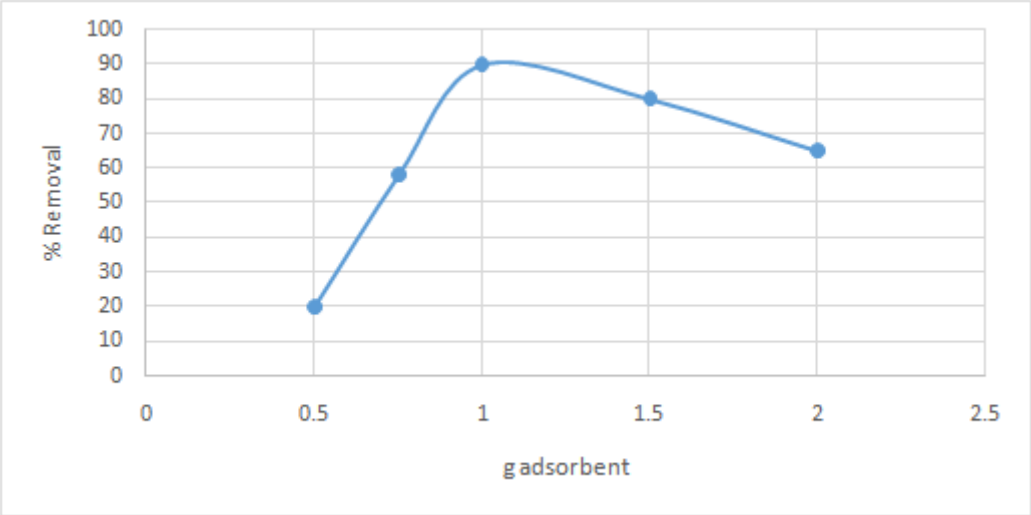

Figure 2: Effect of pomelo peel dose on the removal of methyl red. (C_oWas 100 ppm at pH = 6.5; temperature 25°C).

3.3 Effect of pH on removal efficiency:

The dye adsorption was found to be pH dependent. The effect of solution pH on the equilibrium uptake capacity of the pomelo adsorbent was studied at 100mg/L initial dye concentration and temperature at 30°C between pH 4.0 to 9.0 as shown in figure 3. The highest removal efficiency was found to be at pH 6.5. An increase of adsorption efficiency was observed between 4.0 to 6.5 but further increase in pH 6.5 to 8.0 did not affect any adsorption processes. At pH 6.5, the maximum removal efficiency was found to be 93.5-94.8%.

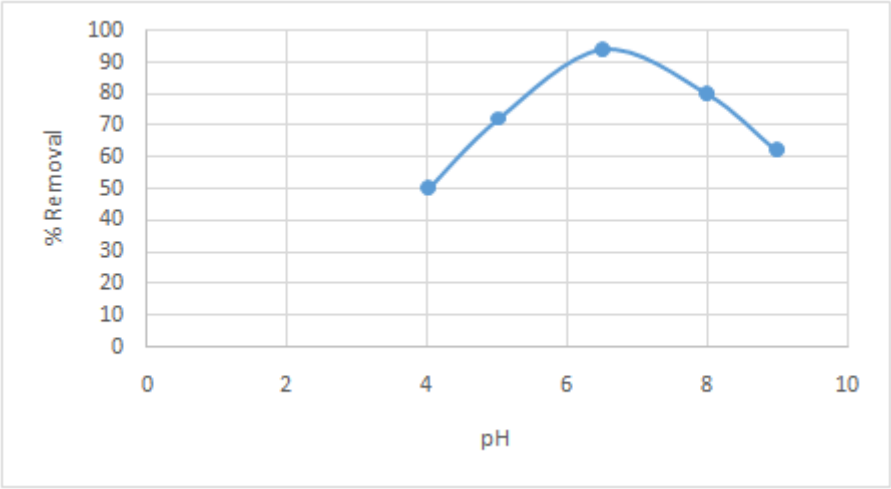

Figure 3: Effect of pH on the removal of methyl red by pomelo peel.

3.4 Adsorption isotherm:

Adsorption isotherm describes the equilibrium of the adsorption of materials at a surface at constant temperature. In order to establish the most appropriate correlations for the equilibria data in the design of adsorption system. Langmuir adsorption assumes that the adsorption takes place as homogenous sites, all sites are equivalent and there are no interactions between adsorbent molecule and adjacent sites. The adsorption data

were analyzed according to the linear form of the Langmuir isotherm equation. The linear form of the Langmuir equation can be written as,

$q_e = q_m K_a C_e / 1 + K_a C_e$

$1/q_e = 1/ K_a q_m C_e + 1/ q_m$

where q_e is the amount of dye is adsorbed per unit weight of adsorbents and C_e is the equilibrium concentration of the adsorbate (mg L^{-1}). Langmuir constants, q_m and K_a are related to maximum adsorption capacity and energy of adsorption through Arrhenious equation, respectively. q_m can also be interpreted as the total number of binding sites that are available for sorption. When $1/q_e$ is plotted against $1/ C_e$, a straight line with slope $1/ q_m K_a$ is obtained and intercept corresponds to $1/ q_m$.The R^2 rules (0.988) suggest that the Langmuir isotherm provides a good fit to the isotherm data.

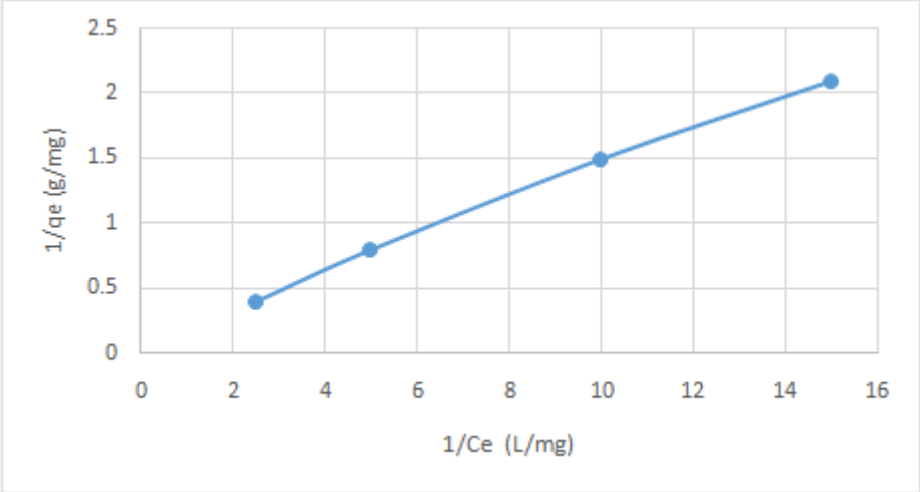

Figure 4: Langmuir plot for the adsorption of methyl red onto pomelo peel at room temperature.

IV. Conclusion

The result revealed tha potential of Pomelo Peel, an agricultural waste material to be an effective bio-adsorbent for removal Methyl Red from aqueous solution. Equilibrium data are in well agreement with Langmuir adsorption isotherm model at 25°C. The adsorption capacity was found to be maximum at pH 6.5 and at adsorbent mass of 1g/100ml dye concentration within 80 minutes of physical adsorption. The major advantage of using bio-adsorbents for removing dues is due to their highly selective nature of adsorption. Preliminary results indicate that Pomelo Peel is a good bio-adsorbent for removing dyes from textile wastewater.

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