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Decolourisation of Methylene Blue Dye from its Aqueous Solution Using Powdered Banana Pith as Adsorbent

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Abstract: This study is based on the assessment of decolourisation of methylene blue dye from its aqueous solution using powdered banana pith as adsorbent. The materials used were obtained and treated for the removal of colour at different doses. These materials also evaluated for the removal of colour at different pH and time. The materials were capable of removing colour from wastewater, the colour removal capacity for banana pith was found to be 74%. Banana pith used in the present study was able to remove methylene blue dye effectively. Batch experimental processes as well as conditions that might influence the sorption of the metals were also investigated. These conditions include; effect of pH, contact time, adsorbent dose and particle size. The removal efficiency of banana pith was found to be affected by pH of methylene blue dye solution, contact time, concentration of the dye and amount of adsorbent. pH 2 was found to be the most effective in removing methylene blue dye from aqueous phase, and increased pH results in decreased removal efficiency. The adsorption is very quick; the equilibrium adsorption occurred within 40 min. the experimental adsorption data fitted with the Beer-Lambert law in the used range of concentrations. The banana pith can be used as a sustainable adsorbent to remove methylene blue dye from various effluents efficiently.

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1. Introduction

The present day society has been blessed with glamorous, bright and colorful materials for daily and occasional household needs through modern science and innovative technologies. As the world population is increasing, demands for these materials are rapidly skyrocketing. Dye-utilizing industries like; printing, textile, paper, leather, plastics, rubber, cosmetics, carpets and rug are ever expanding and flourishing. As a result of this, the use of dyes has increased dramatically. Recently, textile dyes production has reached approximately 7.10 x 10^5 metric tons annually [1]. It has therefore been estimated that 10 – 25 % of textile dyes are lost during dyeing process, and 2 – 20 % of such dyes are directly released as aqueous effluents in various environmental constituents [2]. The estimated amounts of textile dyes discharged globally every year is 280,000 metric tons leading to significant water pollution [3]. In many developing countries of the world the dye-laden textile wastewaters are dumped, without being treated, into various water-bodies, this ultimately contribute to environmental degradation, hampering and terminating aquatic lives, and harming human health [4]. In recent years, the uses of natural adsorbents have gained a remarkable importance due to their low cost, environmental friendliness, local availability, and sustainability [5]. Different adsorbents and commercial activated carbons are preferred sorbents for color removal; however, they are not widely used because of high cost. Alternatively, it is evident from the literatures that low cost adsorbents, from agricultural produce or wastes, have demonstrated outstanding dye removal. Many agricultural wastes and natural adsorbents have been tested for the purpose of eliminating many dyestuffs from textile effluents. In the removal of basic and reactive dyes using sugar bagasse [6]; the removal of Basic blue 3 (BB3) and Reactive Orange 16 (RO16) were studied in single and binary systems [7]. The effect of pH was determined in the range of 6 – 8. The removal of basic and reactive dyes using ethylenediamine modified rice hull involves use of various parameters such as pH, initial dye concentration, sorption isotherm, agitation rate, particle size and sorbent dosage through batch

adsorption studies [8,9,10]. Since adsorption process is one of the effective methods of dye removal from textile waste, this pilot study seeks to remove methylene blue (MB) from its aqueous solution and study its effectiveness by considering the calibration curve, effect of amount of adsorbent, effect of pH and effect of contact time.

2. Materials and Methods

The banana fibre was collected from a farm around Sanyo area in Ibadan, the methylene blue dye was obtained from a popular market called Bode in Ibadan and was used without further purification. Sodium hydroxide and Nitrate filter paper were gotten from Lead City, Ibadan chemical Science laboratory. Sieves of 212 µ-pore size and five buckets of 10 L each were also purchased from Oja Oba, Ibadan. The Banana pith was prepared from white central portion (banana pith) of banana stems collected from a farm and cleaned with distilled water. Then it was chopped into pieces of about 2 cm x 2 cm which were boiled in distilled water for 2 hours. The boiled sample (100 g) was washed three times with distilled and deionized water and then the sample was dried at 100 ^{o}C in an oven for 44 ½ hours after drying, the sample was ground with a blender (marlex excella eletroline). Finally, the ground sample was strained with a sieve shaker using a sieve of 212 µ-pore size.

2.1 The Calibration Curve

A stock solution of Methylene Blue dye was prepared by dissolving 0.01 g of dye in a 10 ml of distilled water in a 1 litre volumetric flask. The stock solution was then diluted by adding distilled water to make standard solutions of different concentrations. The standard solutions were scanned by a UV-Visible spectrophotometer to find out the λmax of the dye. A calibration curve was drawn by measuring the absorbance of the prepared standard solution at the obtained λmax.

2.2 Interaction of the Adsorbent and Dye Solution

A particular amount of the banana pith adsorbent was taken in a small beaker and Methylene Blue dye solution was added to the beaker. A magnet was inserted in the beaker which was then placed in a magnetic stirrer for 10 – 60 mins. The adsorbent was separated from the aqueous phase by filtration with the help of cellulose nitrate filter [11]. Finally, the dye concentration in the filtrate was measured by the UV-Visible spectrophotometer at the obtained λmax.

2.3 Effect of Amount of Adsorbent

The effect of amount of adsorbent was studied in the range of 0.005 – 0.2 g of adsorbent when 30 ml of dye solutions of constant concentration (10 ppm) were used for 20 mins.

2.4 Effect of pH

0.1g of the adsorbent was interacted with 30 ml of dye solution of 10 ppm concentration. The dye concentration in the filtrate was observed using the pH meter in the pH range 2 – 12. It exhibited lower removal efficiency at higher pH values. As the pH values decreases, the removal efficiency increased.

2.5 Effect of Contact Time

Adsorption was carried out in different contact time while all other parameters were kept constant i.e. contact time, pH, amount of adsorbent and amount of dye solution.

3. Results:

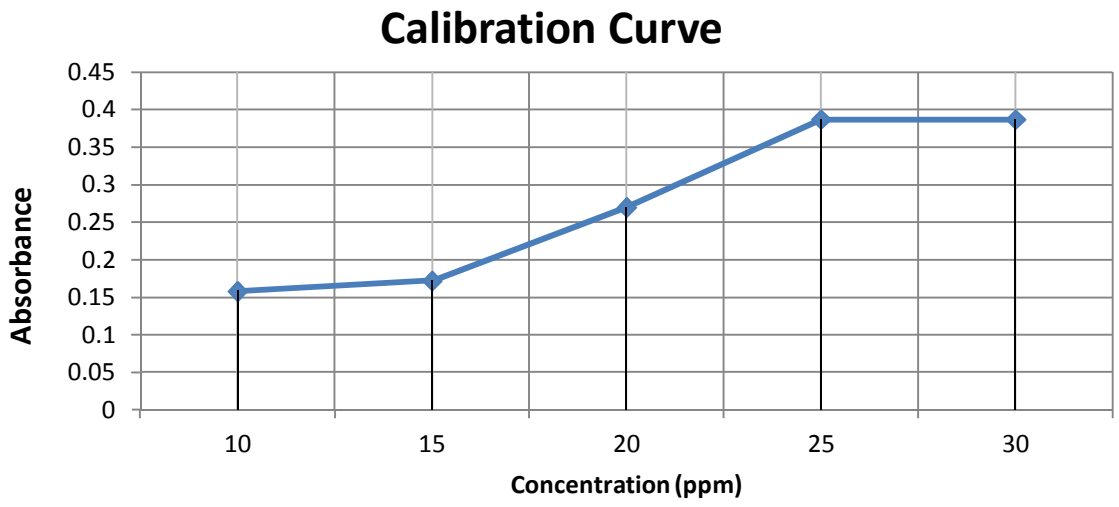


Fig. 1: Calibration Curve

Standard dye solutions of 10, 15, 20, 25 and 30 ppm concentrations were prepared for developing the calibration curve for Methylene Blue dye. The λ_{max} of the methylene blue dye was determined by subjecting all the dye solution concentrations to scanning in the range 0f 100 – 1000 nm with the help of the UV-Visible spectrophotometer. The obtained λ_{max} of the methylene blue dye was 614 nm. Absorbance of all the standard solutions was measured at 213 nm and the calibration curve was drawn. The absorbance of the solvent (i.e. distilled and deionized water) used in these experiments was also measured and it was found that the absorbance at 614 nm was 0.158. From the curve, it is in accordance with the Beer=Lambert in the used range of concentrations.

3.1 Interaction of the Adsorbent with the Methylene Blue Dye and Calculation of Removal Efficiency

0.1g of the adsorbent was interacted with 30 ml of Methylene Blue dye solution of specified concentration. The dye concentration in the filtrate was calculated from the calibration curve with the help of the obtained absorbance. The removal efficiency of the adsorbent was calculated by using the formula:

Removal efficiency (%) = $\frac{C_0 - C_1}{C_1} X\ 100$

Where, C_0 = initial concentration of dye solution (ppm)

C_1 = concentration of dye at any time (ppm)

$C_0 = 0.158$

$C_1 = 0.04$ at 20 mins

Removal efficiency = $\frac{0.158 - 0.04}{0.158}$ X 100

= 74 %

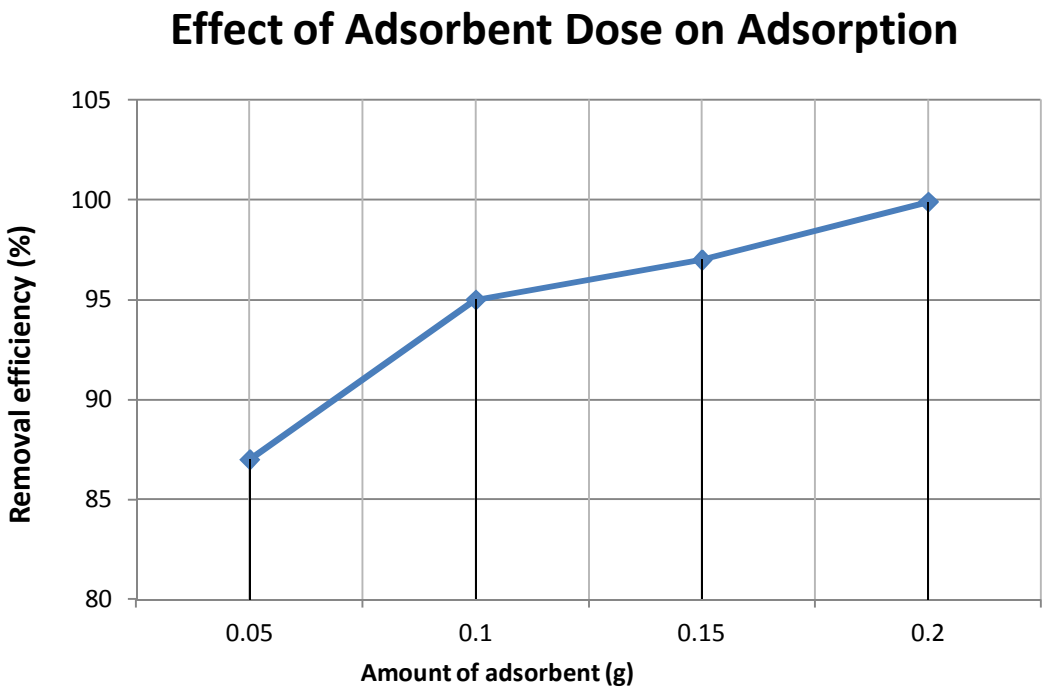


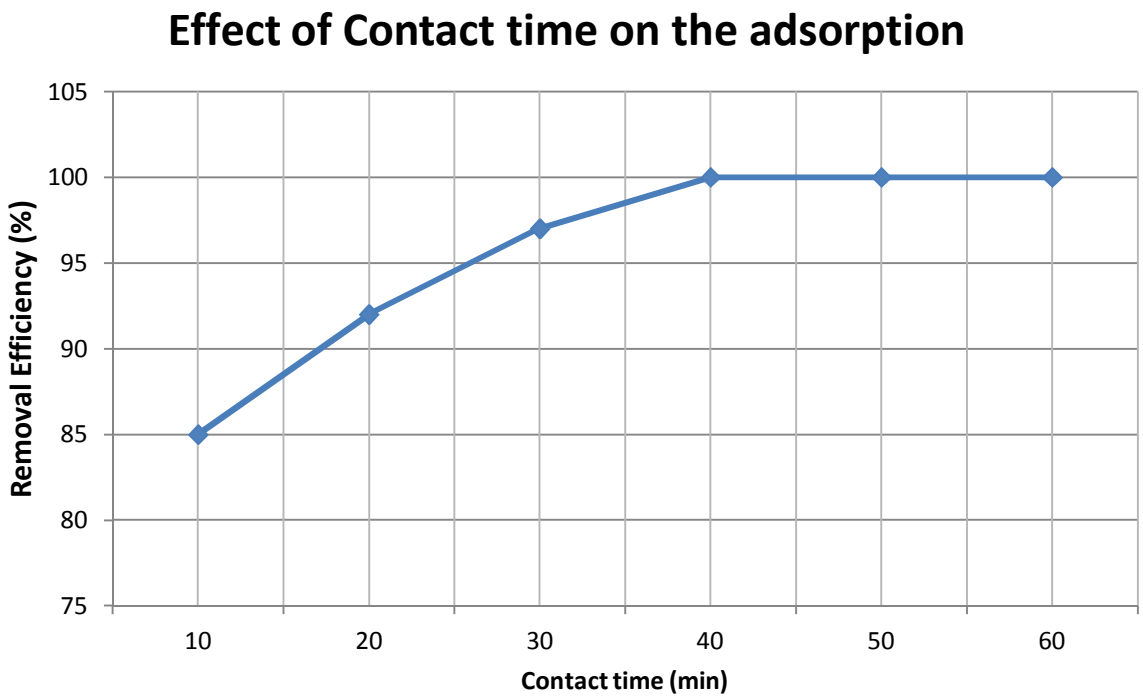
Figure 2: Effect of adsorbent dose on Adsorption

3.3 Effect of Adsorbent Dose on Adsorption

The effect of amount of adsorbent was studied in the range of 0.005 – 0.2g of adsorbent when 30 ml of methylene blue dye solutions of constant concentration (10 ppm) were used for 20 minutes each time. It was observed that as the dosage of adsorbent was increasing, the removal efficiency became higher. Increase in the removal efficiency of Methylene Blue dye with the increased amount of adsorbent dose is due to the increased surface area and the availability of additional adsorption sites. It was found that 0.2g of banana pith resulted in 100% removal of Methylene Blue dye in this particular condition.

3.4 Effect of Contact Time

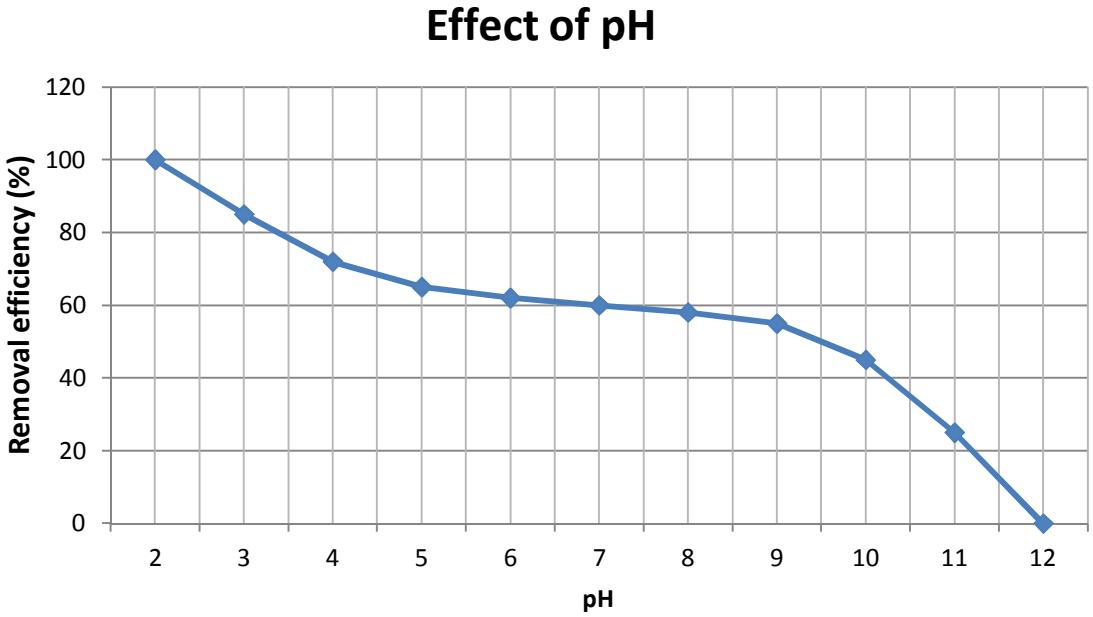
Adsorption was carried out at different contact time (ranging from 10 – 60 minutes) while all other parameters were kept constant. About 85 % of removal occurred in 10 min, and it reached to approximately 92 % in the following 10 min (i.e. at 20 min), and 100 % removal efficiency took place at 40th minute (Fig.4.3). Allowing the adsorption further (i.e. 50 and 60 mins), no change was observed in the absorbance and change in colour (i.e. it became colourless) indicating that adsorption was completed within 40 minutes.as no methylene blue dye molecule was observed in the aqueous phase keeping the dye bearing adsorbent up to 60 mins. It can be assumed that there was no desorption of methylene blue dye molecules at that period. The banana pith adsorbent is found to be more efficient than orange peel [13] and fly ash [14] whereas it is comparable with modified banana trunk fibres [15]. The banana pith adsorbent takes less time compared to other adsorbents in removing methylene blue dye from the bulk aqueous phase.



3.5 Effect of pH

The adsorption of methylene blue dye molecules on the adsorbent was observed in the pH range 2 – 12 (Fig. 4.4). It exhibited low removal efficiency at higher pH values (alkaline states). At pH 12, no significant removal took place and it was only 4 %. As the pH value decreases, the removal efficiency is increased and it becomes 100 % at pH 2. It is due to the fact that as pH of the methylene blue dye solution is decreased, the number of negative charges on the surface sites decreased and the number of positively charged surface sites increased, and this favors

the adsorption of methylene blue dye anions due to electrostatic attraction [16,17,18]. A similar observation was also recorded for the adsorption of Acid Red 183 and Acid Green 25 on the shells of bittim and removal of Acid blue 62 (AB62) on aqueous solution using calculated colemanite ore waste [19].



4.0 Conclusion

Banana pith used in the present work was able to remove methylene blue dye efficiently. The removal efficiency of banana pith was found to be affected by pH of the methylene blue dye aqueous solution, contact time, concentration of methylene blue dye in the solution and the amount of adsorbent used. pH of 2 was found to be the most effective in removing methylene blue dye from its aqueous solution, and increased pH results in decreased removal efficiency. The adsorption was very quick, and the substantial adsorption occurs within 40 min. therefore, it can be concluded that the process is relatively less time consuming. The adsorbent was also found to have removed reactive dye methylene blue dye from raw wastewater efficiently [20,21,22]. The treatment with the present adsorbent leads to a significant decrease in pH which needs to be adjusted with the help of an alkali before discharging treated wastewater into natural surface water systems [23]. The banana pith can be used as a sustainable adsorbent to remove various reactive methylene blue dyes from various effluents, since the adsorbent can be recovered 100 % after use [24].

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