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Experimental Investigation on Removal of Methylene Blue Dye using Sugarcane Bagasse

K.Samruda¹, S. Raajamurugan²

PG Student, Department of Environmental Engineering, Gnanamani College of Technology, Pachal, Namakkal,
Tamil Nadu, India¹

Assistant Professor, Department of Environmental Engineering, Gnanamani College of Technology, Pachal, Namakkal,
Tamil Nadu, India²

ABSTRACT: Methylene Blue (MB) has been found to be one of the most common dyes used in the textile industries. Adsorption process using Activated Carbon (AC) has been proven to be able to remove MB effectively but the treatment cost using the adsorbent is considered expensive due to its high energy cost. Sugarcane Bagasse (SGB) is an agricultural by-product and abundantly available material in many developing countries. FTIR and XRD were used to confirm the existence of ligno-cellulose content of SGB after experiencing various chemical treatments. SGB had 5 - 40 folds higher MB removal capability than commercial activated carbon, depending on the pH of water medium and the type of SGB. SGB showed a much better performance in adsorbing MB in alkaline environment than in acidic environment. The removal capacity of non-chemical treated SGB (NSGB) and CaCl₂ treated SGB (CSGB) at 84.7458 mg/g and 35.2113 mg/g respectively and NaOH treated SGB (BSGB) with low lignin residue content was the most favourable adsorbent for MB adsorption. An extremely higher MB removal capacity was found for BSGB due to the complexity of the surface site after chemical treatment. The results of this study showed that bagasse pulp is an effective adsorbent material for methylene blue removal with a maximum adsorption efficiency of 95%.

KEY WORDS: Adsorbent, Methylene Blue, Ligno-Cellulose, Sugarcane Bagasse.

I. INTRODUCTION

A large amount of industrial waste is released into aqua systems without treatment, creating pollution issues that seriously threaten both the environment and human health. The waste includes aromatic compounds, heavy metals, dyes, and toxic pollutants waste that are not efficiently removed by traditional wastewater treatment techniques.

Dye is a natural or synthetic material that adds a specific colour to the material it is being applied to. Dye has an ionising and aromatic organic compound that forms an affinity to substrates and binds to them. Synthetic dyes are used in a wide range of industries from commodity manufacturing such as textile making, paper production and food technology, to energy generation such as light-harvesting arrays and photoelectrochemical cells. While synthetic dyes are increasingly used over natural dyes due to their lower costs and cheaper production, synthetic dyes have their own negative impacts. With their visible colour, synthetic dyes reduce the light penetration into the wastewater and adversely affect aquatic growth and photosynthesis. They can also bring severe and/or long-term health effects to organisms. A commonly used synthetic dye of Methylene Blue (MB), which has an empirical formula of C₁₆H₁₈ClN₃S. Due to their complex chemical structure, synthetic dyes are harder to biodegrade and thus more resistant to conventional biological treatment. The traditional physical and chemical processes are also expensive and ineffective in the treatment of various dyes in wastewater. Adsorption is increasingly being used for its high removal rate of dye from wastewater and its low operation cost. Adsorption is a process where a substance adheres to the surface of the adsorbent as compared to absorption where the entire volume of the substance dissolves into the adsorbent. While the absorption substance can only be liquid, adsorption substance can be a gas, liquid or dissolved solid.

Sugarcane bagasse pulp is a product of sugar extraction from sugarcane bagasse. This material is commonly used in the paper industry, and since the paper industry is declining due to e-books and online learning, this waste is abundant in massive amounts. To benefit from its cellulosic structure, availability, and low cost, the adsorption efficiency of the citrate-modified sugarcane bagasse pulp on MB removal at 3 different conditions and their study gave maximum removal efficiency equal to 93%. Activated carbon prepared from the bagasse pulp also shows high removal efficiency

of MB . These results indicate the possibility of the use of sugarcane bagasse pulp and its derivatives in MB removal as an adsorbent. Its mechanical properties are superior to the raw sugarcane bagasse. Therefore, it can be used as raw material for membrane fabrication with different methods such as electrospinning, phase inversion, and dip coating.

II. MATERIAL AND METHODS

An estimated 5 kg of sugarcane bagasse was collected from one of the local drink stall using a plastic bag. MB with an empirical formula of $C_{16}H_{18}ClN_3S \cdot 3H_2O$, a molecular mass of 373.8 g mol^{-1} , and a pure grade of 98.5% is used in the adsorption process. NaOH (98%) and HCl (37%) are used in adjusting the pH of the solution. All required chemicals are purchased. A 500 mg/L stock solution of MB is prepared by dissolving 0.5 g of MB in 1000 ml distilled water in a volumetric flask. MB solutions of different concentrations of 25,50,100 and 200 mg/L are prepared by serial dilution from a stock solution according to the following equation.

$$C_o \times V_o = C_d \times V_d$$

Where, C_o -stock solution's concentration, V_o - volume of stock solution being diluted, C_d -Dilute solution's concentration, and V_d - volume of the dilute solution. After each experiment, the dye solution is filtered by using Whatman (number 541) filter paper and the filtrate is then analysed to get the MB concentration after adsorption. The concentration of MB in the filtrate is determined by using a dual-beam UV-Visible spectrophotometer.

$$\text{Removal efficiency(\%)} = (2) (C_o - C_e) / C_o \times 100$$

Where, C_o -The initial concentration(mg/L) and C_e -The residual concentration (mg/L) of the MB being studied. An estimated 5 kg of SGB was collected from one of the local drink stall in hawker centre using a plastic bag. The soft, pale fibres were collected from the inner side of SGB by using hands to tear it off. Bagasse is another by-product of the sugar production process. It is a dry and pulpy residue left behind when sugarcane stalks are crushed. There is a similar material called 'agave bagasse' made from the agave plant. Bagasse is principally used in the manufacturing process of paper, pulp and building materials as well as a biofuel for the production of energy, heat and electricity.

Adsorption process using Activated Carbon (AC) has been proven to be able to remove MB effectively but the treatment cost using the adsorbent is considered expensive due to its high energy cost. Sugarcane Bagasse (SGB) is an agricultural by-product and abundantly available material in many developing countries.



Fig 1 Sugarcane bagasse

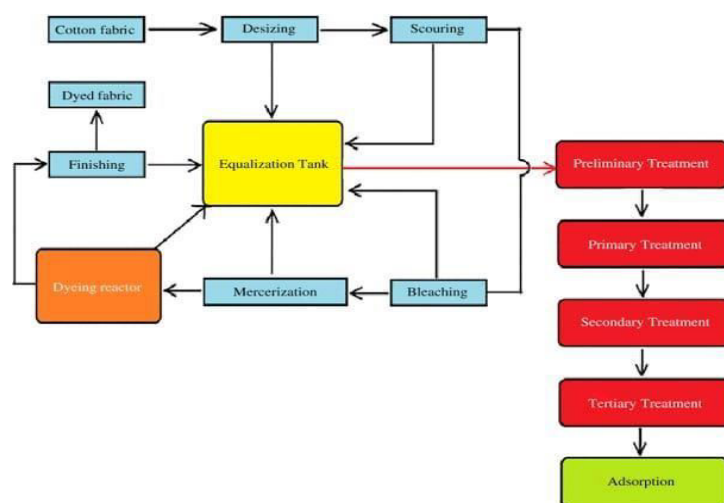


Fig 2. Process used in textile industry flow chart

III. PREPARATION OF NSGB,CSGB,BSGB

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The soft, pale fibres were collected from the inner side of SGB by using hands to tear it off. Approximately 30 g of SGB were weighed using a three-decimal place mass balance before being rinsed with 800 mL of tap water. Further tap water rinsing was conducted to ensure SGB free from any attached dust or fine particles. After that, 800 mL of deionized water were used to sanitise the SGB. The SGB were placed on an aluminium tray and dried in an oven at 103°C overnight to fully remove water moisture. The SGB was collected on the next day and it was cut into smaller pieces using scissors. The smaller pieces of SGB were blended using Electric Blender until becoming fine particles. The blended SGB were then sieved by passing through a 2.0 mm sieve and collected in a 850 µm sieve. The NSGB were then stored as NSGB in a labelled container. The CSGB was prepared by adding 10 g of NSGB in 500 mL of 0.0248 mol/L calcium chloride (CaCl₂) solution to mineralise SGB and remove lignin content, similar to Rowell when trying to remove lignin from woods but using sodium chloride. The mixture was manually shaken for a couple of minutes before being left overnight. SGB was filtered and dried in the oven overnight before being stored as CSGB. Bio adsorption are the recent materials employed in various sectors to remove dyes and other pollutants. Charcoal, peat, chitin, microbial biomass (fungi, bacteria, yeast, etc.), wood bark, and other agricultural and industrial wastes are frequently used bio-adsorbent. The CSGB were then stored as CSGB in a labelled container. The BSGB was prepared by mixing 2 g of NSGB with concentrated 1 M of NaOH in 500 mL beaker glass to delignify SGB. The mixture was left overnight and the SGB was filtered and dried in the oven the next day for approximately 4 hours. The SGB was then stored as BSGB in a labelled container. The same pre-treatment procedure of SGB was repeated after the existing supply was used up. Pale yellow NSGB samples will turn darker yellow after calcium chloride and alkaline treatment. BSGB also showed the darkest yellow among three samples and fragile and amorphous. The BSGB were then stored as BSGB in a labelled container.



Fig 3 NSGB



Fig 4 CSGB



Fig 5 BSGB

IV. CHARACTERIZATION OF WASTEWATER

Colour-In the present investigation, the colour of the untreated effluent was dark yellow. Colour is a qualitative characteristic that can be used to assess the general condition of wastewater. Wastewater that is light brown in colour is less than 6 hold, while a light-to-medium grey colour is characteristic of wastewaters that have undergone some degree of decomposition or that have been in the collection system for some time.

Odour-From the available data, it was observed that untreated SIWW have fishery odour. Unpleasant odours in food industry wastewater are usually caused by gases produced by anaerobic decomposition of organic matter. The most common odour causing compound is hydrogen sulphide whose characteristic odour is that of rotten eggs.

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Temperature- Temperature is basically important for its effect on certain chemical and biological radiations taking place in water for organism and inhabiting aquatic media. It was observed that temperature of the untreated effluent was recorded as 40 °C.

pH- pH is the value expressed as the negative logarithm of the hydrogen ion concentration. Its range was give between 0 to 14, if the value is 7 means neutral less than 7 being acidic and above 7 being basic or alkaline. The wide narration in the pH value of effluent can affect the rate of biological reaction and survival of various microorganisms. The presence or absence of various ionic species can have direct relation with pH of the effluent. Subsequently, such effluent can influence the quality of soil. In the present investigation, the pH value of the untreated effluents was 5.5.

V. CHARACTERIZATION OF SGB

Textural Characterization- The measurement of the specific surface of pore diameters and pore volume of SCB was obtained by using the nitrogen adsorption-desorption isotherm curve (Micromeritics ASAP 2010) using the Brunauer–Emmett–Teller (BET) method. Morphological analysis was made by scanning electron microscopy (SEM) type (VEGA3 TESCAN) coupled with EDX and quantitative analysis of the elemental composition of SCB was employed using X-ray energy dispersion spectroscopy (EDX).

Chemical Characterization- The chemical functions of the molecules present in the SCB were analyzed by Fourier Transform Infrared Spectroscopy (FTIR) type (Shimadzu, JASCO 4100). IR spectra were recorded over a wavelength range of 400 and 4000 cm^{-1} . The zero point charge was determined to clarify the net charge was carried by the surface of the SCB.

Adsorption Procedure- The adsorption tests were conducted in the batch reactor, at ambient temperature; the colored synthetic solution of MB in the presence of the adsorbent SCB is stirred for an hour; and homogenization of the mixtures was carried out by a Shaker type incubator agitator with a stirring speed equal to 127 rpm. The adsorbate-adsorbent separation was performed using a 0.45 μm diameter Wothman-type filtration system, and the supernatant absorbance was measured by a UV-Visible type spectrophotometer at a wavelength corresponding to the maximum absorbance of MB ($\lambda_{\text{max}} = 665$).

VI. COLLECTION OF WASTEWATER FROM TEXTILE INDUSTRY

The study area selected was Tirupur and it is a textile city in the South Indian state of Tamil Nadu, India. Tirupur is the knitwear industry hub of India and the city is now known as the “Dollar City”. This knitwear capital of India has 5 lakhs workers from various parts of India, Sri Lanka and Nepal. In the year 2012 – 2013 the export of knitwear fabric from Tirupur worth Rs.70312 crores. Tirupur, in India, (located 55 km to the east of Coimbatore City, Tamil Nadu) accounts for 90% of India’s cotton knitwear export. There are more than 2500 apparel manufacturing units and 750 dyeing units in Tirupur. Methylene blue (MB) is a model cationic dye employed by industries such textile industry for a variety of purposes such as in coloring paper, dyeing cotton, wools, silk, leather, and coating for paper stock.

VII. CHARACTERIZATION TECHNIQUES

Fourier transformation infra radiation FTIR- FTIR is carried on the sugarcane bagasse pulp powder to determine the functional groups and chemical bonds present. Attenuated total reflectance (ATR) mid-infrared spectra are acquired using a Tensor 27. The spectrometer is equipped with a deuterated triglycine sulphate (DTGS) detector and a heated single

reflectance diamond ATR accessory (Grase by Specac) with a sealed sapphire anvil. Spectra with 128 scans at 4 cm⁻¹ resolution are selected for both samples at room temperature. The spectra are vector normalized over the entire wavelength range of 400–40 cm⁻¹.

X-ray diffraction XRD-XRD is utilized to determine and analyse the degree of crystallinity and physical properties of bagasse pulp powder. The spectra of the samples are collected using a Siemens D500 X-ray diffractometer using Cu k-alpha X-rays at 4 kV and 25 mA.

SEM (scanning electron microscopy)-SEM is used to study the morphological properties, homogeneity, and voids present in the bagasse powder. The small particles of bagasse pulp are glued into a holder using Tissue Tek O.C.T compound and brought down to solid nitrogen temperature under vacuum, and then, they are fractured by a blade from the side brought up to 90 °C and platinum-coated and then imaged.

Adsorption study-A beaker containing 50 mL of MB solution is used in the experiments. The effect of adsorbent dose, temperature, initial concentration, contact time, shaking speed, pH, and particle size is examined. The experimental procedures start with a temperature equal to 25 °C, at pH equal to 7, adsorbent dose equal to 20 g/L, initial dye concentration equal to 100 mg/L, at a shaking speed of 130 rpm, adsorbent particle size equal to 500 µm and take place as follows.

Examining the effect of pH-The effect of pH is studied by performing the experiments at pH 4, 7, 9, 10, 12 while keeping all the other parameters constant. The pH is adjusted by using an HCl (chloride acid) purity of 37% (0.1 M) and NaOH (sodium hydroxide) purity of 98% (0.1 M).

Examining effect of adsorbent dose-MB solution is divided into 6 beakers. Each beaker contains 50 ml of MB prepared solution. Different doses of sugarcane bagasse pulp adsorbent are added as follows (4, 8, 10, 20, 30, 40) g/L. The optimum adsorbent dose is chosen for continuing the study.

Examining the effect of dye initial concentration-Five different initial concentrations of MB are prepared by dissolving 25, 50, 100, 200, and 300 mg of dye solution in a 1000-mL beaker keeping all the other parameters constant at their initial values, dose, pH, and temperature at their optimum values.

Examining the effect of contact time-The chosen dose of sugarcane bagasse pulp is added to the solution prepared at the optimum initial concentration to experience different contact times (15, 30, 60, 120, and 180) minutes. The experiments are carried out at the chosen dose, temperature, and pH. Particle size = 500 µm and shaking speed equals 130 rpm.

Examining the effect of shaking speed-Different shaking speeds (80, 100, 130, 200, and 300) rpm are examined while keeping all the other parameters constant at their optimum values.

Examining the effect of particle size-Finally, the effect of adsorbent particle size is investigated at (200, 500, and 1000 (µm)), where all the other factors remain constant as shown at their optimum conditions.

VIII. PROCESS

Batch Adsorption Experiment-Various amount of SGB were weighed using a four-decimal-place mass balance and placed into 50 mL test tubes filled with 30 mL of MB wastewater. The MB water in the test tubes were mixed thoroughly using an adjustable rotator at 30 rpm and subsequently centrifuged for 1 minute in a centrifuge machine at 6000 rpm. 10 mL of each sample was withdrawn using a dropper and put into 15 mL test tubes to separate SGB from the mixture. The supernatant liquid was then extracted using a dropper and recorded the absorbance using a UV Spectrophotometer. These procedures were used to determine the optimum adsorption time, effect of pH and effect of SGB concentration on the removal rate of MB.



Fig 6 Rotator



Fig 7 Centrifuge Machine



Fig 8 UV Spectrophotometer

To investigate the effect of pH, some drops of concentrated H₂SO₄ and NaOH were added into MB dye water for a pH alteration. Subsequently, 0.833 g/L of SGB was put into the test tube to obtain various pH. After reaching the equilibrium time, the result was measured using the pH meter. Experimental analysis of sample was setup in duplicates and relative standard deviation (RSD) was calculated for each result.

Determining the Removal Rate of MB-In quantitative analysis, the adsorptive capacity of adsorbents of SGB was analysed as follows. The removal rate of MB was expressed as mg/g and calculated using the following formula:

$$\text{Mole of MB removed (mol)} = [(C_i - C_f) * 10^{-6}] * \frac{\text{Volume of MB used}}{1000}$$

$$\text{Mass of MB removed (mg)} = \text{Mole of MB removed} * 373.90 \text{ g/mol} * 1000$$

$$\text{Removal rate of MB (mg/g)} = \frac{\text{Mass of MB removal (mg)}}{\text{Mass of bagasse (g)}}$$

where, C_i = Initial concentration of MB solution (μmol/L), C_f = Final concentration of MB solution (μmol/L). Molecular Weight of MB = 373.90 g/mol.

Determining the MB Removal Capacity Using Langmuir and Freundlich Models-In quantitative analysis, the adsorption data was analysed by fitting them to Langmuir and Freundlich equations. Each linearized equation is presented below:

Linearized Langmuir Isotherm equation:

$$\frac{1}{x} = \frac{1}{b C_e X_m} + \frac{1}{X_m}$$

where, X = Removal rate of MB (mg/g), X_m = Monolayer capacity of SGB in adsorbing MB (mg/g), C_e = Final concentration of MB solution (mg/L), b = Equilibrium binding constant of the MB adsorption (L/mg).

Linearized Freundlich Isotherm equation:

$$\log X = \log K + \frac{1}{n} \log C_e$$

where, X = Removal rate of MB (mg/g), C_e = Final Concentration of MB Solution (mg/L), K = Equilibrium constant that indicate a measure of multi-layer adsorption capacity (mg/g), 1/n = Equilibrium constant that indicate a measure of intensity of adsorption. The plots of 1/X versus 1/C_e and log X versus log C_e were made to test the data fitness to the Langmuir and Freundlich adsorption models, respectively.

IX. RESULT AND ANALYSIS

Fourier transformation infrared radiation (FTIR)-The FTIR spectra of samples BSGB, CSGB and NSGB. The bands at 3400 cm⁻¹ and 2910 cm⁻¹ are assigned to O-H stretching and C-H stretching and exist in all three samples. NSGB has the highest intensity at band of 3400 cm⁻¹ (O-H stretching) among the samples. Band at 1740 cm⁻¹ represent C=O stretching which is absent in BSGB sample. The band at 1640 cm⁻¹ is assigned to O-H bending of absorbed water.

Moreover, the conjugated C=O stretching lignin also appeared at this wave number. The lignin-associated bands at 1600cm^{-1} and 1510cm^{-1} , which are assigned to aromatic skeletal vibrations, have low intensity (weak signals) in BSGB sample, indicating low residue lignin content.

The band at 1430cm^{-1} is assigned to the CH_2 scissoring motion and it appeared in all samples. Bands at 1380cm^{-1} and 1320cm^{-1} are also assigned to C – H (methyl) group of bonding and they appear in all samples. Band at 1260cm^{-1} is also assigned to C-H (methyl) group of bonding but the intensities of different samples are different, with BSGB having the lowest intensity while NSGB having the highest intensity.

Band at around $1040 - 1060\text{cm}^{-1}$ is assigned to C-O (primary alcohol) which the CSGB is having the lowest intensity at this band. Besides, broad band at $650 - 700\text{cm}^{-1}$ which assigned to C-H (substituted alkene) was found only in CSGB sample. The spectra are vector normalized over the entire wavelength range of $400 - 4000\text{cm}^{-1}$.

X-ray diffraction XRD-The XRD results of the three samples (BSGB, CSGB and NSGB). The diffraction spectrum at 22° and $15^\circ - 18^\circ$ showed the existence of cellulose. BSGB showed the highest intensity at 22° at the intensity of 002 among the samples. However, the crystallinity of cellulose CrI, is 68.4%, 73.4%, 21.4% for BSGB, CSGB and NSGB, respectively.

CSGB, although not having highest intensity at 002 peaks as compared to BSGB, has the highest value of CrI (73.4%) due to the lowest amount of amorphous content in the corresponding solid, relevant to the CSGB and BSGB physical appearance more yellowish in colour and less amorphous. NSGB had the similar intensity of 002 peaks with CSGB, showed the lowest value of CrI (21.4%) among three samples due to its highest amount of amorphous content. In addition, according to the Scherrer's sizes of the crystallite for BSGB, CSGB and NSGB are 3.245, 3.327 and 3.196 nm, respectively with the details of 002 peaks as shown in Table 10.1. Although NSGB have the smallest crystallite size among the samples, all samples have very similar crystallite size. Thus, the effect of NSGB, BSGB and CSGB crystallite size on MB removal rate could be inconclusive.

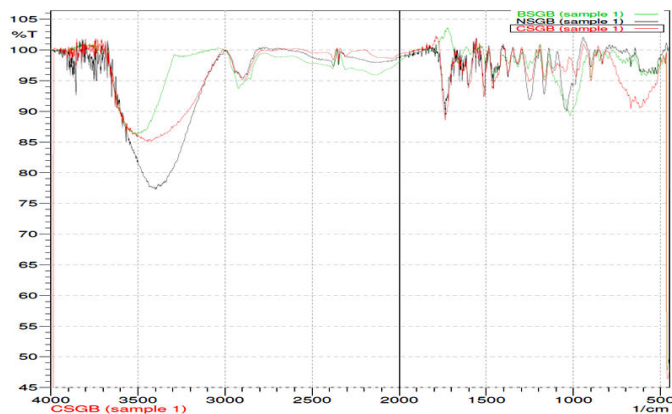


Fig 9 FTIR analysis

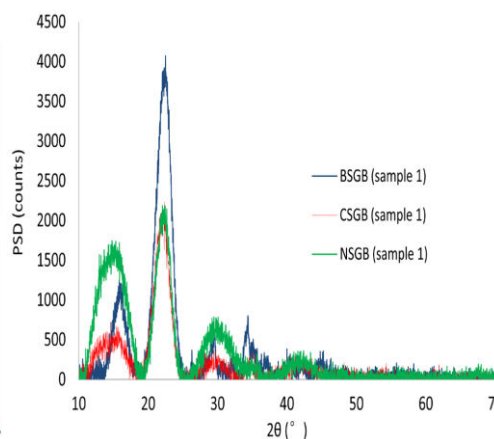


Fig 10 XRD Analysis

Table 1 Crystallite size measurement of samples BSGB, CSGB and NSGB at 002 peaks.

(22.5°) (002)						
Types of sample	2θ	θ	$\cos\theta$	FWHM β (degree)	FWHM β (radian)	Crystallite size D (nm)
BSGB	22.2750	11.1435	0.971150	2.594	0.044529	3.245
CSGB	22.3820	11.1970	0.970969	2.533	0.043464	3.327
NSGB	22.0340	11.0130	0.971587	2.631	0.043174	3.196

Scanning Electron Microscope(SEM)-The sugarcane bagasse pulp SEM image shows no agglomeration of its fibres. This indicates that the functional groups of the sugarcane bagasse pulp will be more subjected to the reaction with the dye. In adsorption experiments, the more the agglomeration decreases, the more the usable surface area, and thus, the more efficient the adsorption.

Effect of Adsorption Time on the Removal Rate of MB-The MB adsorption rate was occurring very fast. Within 15 minutes, the MB could be adsorbed onto NSGB surface. The experiment was repeated three times by increasing the concentration of NSGB from 0.833 g/L to 1.667 g/L, 3.333 g/L and up to 8.333 g/L (10 folds than the earliest NSGB concentration). The higher the NSGB concentration showed the smaller MB removal rate of MB per gram of NSGB. An increasing order of the removal rate of MB from the highest to the lowest SGB concentration i.e. 8.333 g/L, 3.333 g/L, 1.667 g/L and 0.833 g/L of NSGB in every single recorded adsorption time, before reaching plateau. It suggested that MB might be attached onto active SGB surface site for every gram of SGB before reaching equilibrium adsorption time. In addition, although the lowest concentration of NSGB of 0.833 g/L gave the highest MB, the optimum adsorption time to reach its plateau was the latest, approximately twice longer (30 minutes) than the other NSGB concentrations. Thus, it showed that, at a fixed MB concentration of 10 μ M (3.739 mg/L), the lower NSGB concentration, the more time needed for MB to be fully adsorbed onto the active surface sites of the NSGB. In the next batch of experimental studies, a minimum 30 minutes equilibrium time was used.

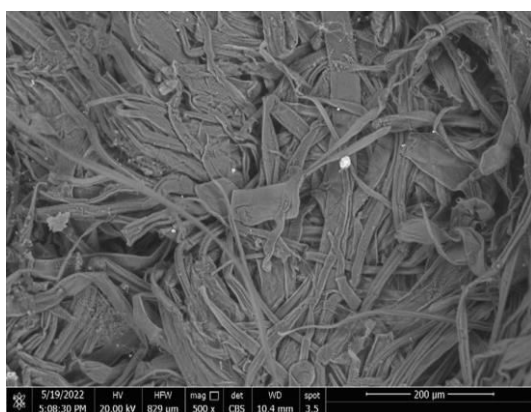


Fig 11 SEM of SGB Pulp

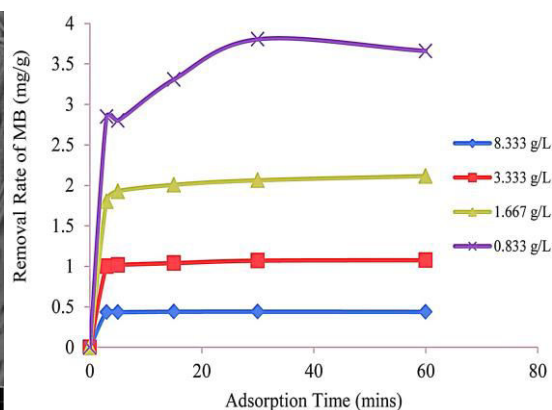


Fig 12 Adsorption Time on the Removal Rate of MB

Effect of pH Value on the Removal Rate of MB and AC-pH is an important parameter in the absorption process, and it affects the adsorption capacity. The degree of its adsorption onto the adsorbent surface is influenced by the surface charge on the adsorbent which in turn is influenced by the solution pH. The lower SGB concentration will result in more MB adsorbed per gram of SGB. Therefore, 0.833 g/L SGB is used to determine the range of pH that the SGB could be used to adsorb MB. The SGB could remove approximately 4 mg/g to 4.5 mg/g of MB at higher pH range, from pH 8 to 12. At the intermediate pH, approximately $4 < \text{pH} < 8$, the BSGB showed the highest among the other types of NSGB and CSGB. The result might reveal that the delignification using concentrated NaOH may increase the MB adsorptive properties of SGB. Minimum lignin residue content was found in BSGB after FTIR scanning. At low pH, the number of negatively charged adsorbent sites decreases, and the positively charged surface sites increase which will not favour the adsorption of cationic dyes due to electrostatic repulsion which will occur between the adsorbent surface and the MB ions. On the other hand, the results show increasing the dye removal efficiency with increasing system pH till it reaches 93.85% .

Effect of Initial MB Concentrations on the Removal Rate of NSGB, CSGB and BSGB-The removal rate of MB at the different initial concentrations of MB for NSGB, CSGB and BSGB. In general, it could be observed that BSGB had a higher MB removal rate than those NSGB and CSGB had, for every initial MB concentration. The higher initial MB concentration used the larger difference of MB removal rate. It also confirmed that BSGB was the most favourable adsorbent for MB adsorption. At the highest initial of MB concentration of 30 μ M (11.217 mg/L), the BSGB, NSGB, CSGB gave the MB removal rate of 13.0034, 11.4292 and 10.9044 mg/g of the adsorbent respectively. This experiment was also to confirm that, due to the nature of BSGB which had a low lignin residual content, the SGB was able to have more adsorptive properties. This finding was in line with the finding from Begum and Mahbub (2013), who were

suggesting that more cellulose content in SGB could effectively adsorb MB.

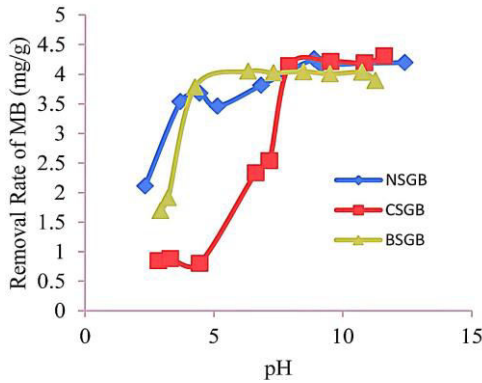


Fig 13 pH Analysis

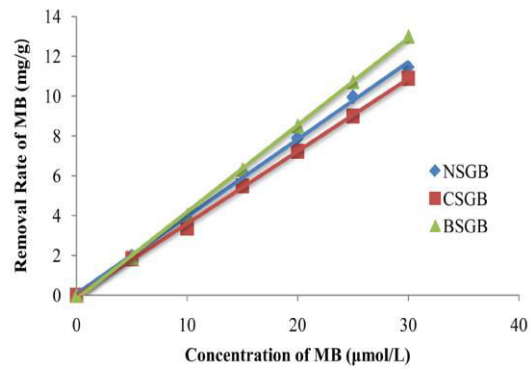


Fig 14 Removal rate of MB at initial MB conc.

Effect contact time on MB adsorption-The contact time effect has been studied by varying the contact time from 15 to 180 min while keeping all the other parameters constant. The dye adsorption is rapid at first with a high dye removal efficiency in the first 15 min reaching 94%. The removal efficiency then begins to decrease at a slow rate as the contact time increases from 15 to 180 min reaching a removal efficiency equal to 88%. This result is obtained because sugarcane bagasse pulp's active sites are accessible for adsorption during the first 15 min, and afterward, the active sites become gradually occupied reducing the amount being adsorbed, since repulsion action takes place between bulk phases and the sugarcane bagasse pulp adsorbed molecules. The optimum contact time for continuing the study is chosen to be 15 min.

Effect of particle size-The effect of particle size is studied by examining 3 different particle sizes 200, 500, and 1000 µm. The results show that the increase in particle size will increase the removal efficiency to a maximum value, and then, the efficiency will be decreased again with further particle size increase. This is explained by the fact that at very small particle sizes the adsorbent particles will be carried on the surface of the solution. Therefore, a large part of the active sites will be missed, while increasing the particle size over a certain value will result in declining the accessibility of the dye to the adsorbent pores. Therefore, the efficiency decreases again. The optimum particle size is then chosen to be 500 µm.

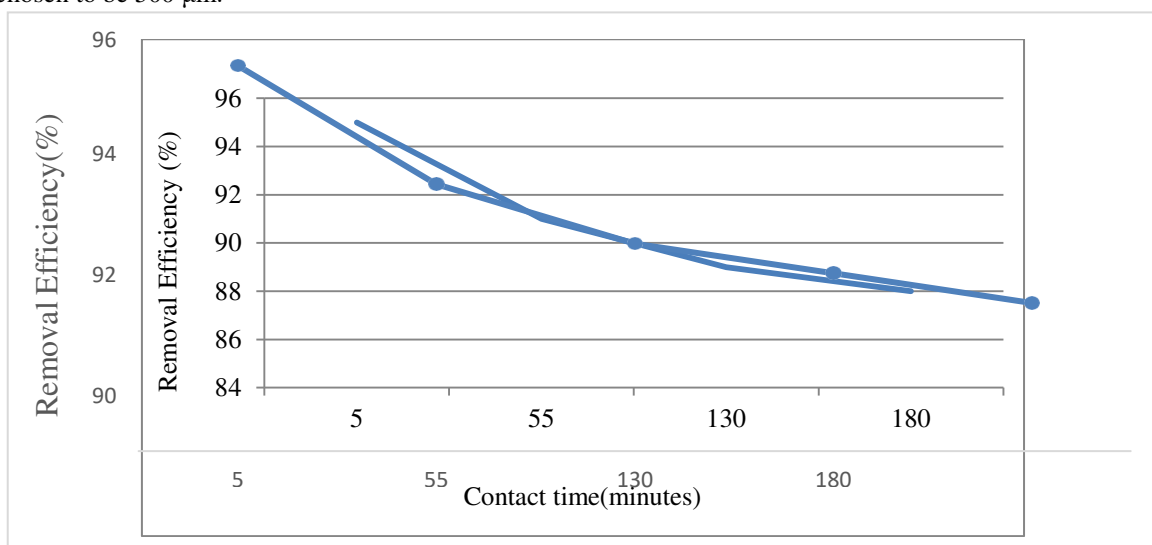


Fig 15 Effect of contact time

X. CONCLUSION

The adsorption process of MB on the SCB was the aim of this study. In this study, sugarcane bagasse pulp is examined as an adsorbent for MB removal, the FTIR analysis of the surface shows the presence of OH, C=O, and CO groups which are responsible for Mb removal, XRD analysis proves its cellulosic structure, while SEM image shows no agglomeration in its fibres. Parameters affecting the adsorption are studied.

In general, SGB was capable in removing MB in water medium whether the SGB contained lignin or mixture lingo-cellulose. SGB had 5 - 40 folds higher MB removal capability than commercial activated carbon, depending on the pH of water medium and the types of SGB. SGB showed a much better performance in adsorbing MB in alkaline environment than in acidic environment.

The removal capacity of NSGB and CSGB at 84.7468 mg/g and 35.2213 mg/g respectively. An extremely higher MB removal capacity was found for BSGB due to the complexity of the surface site after chemical treatment. BSGB with low lignin residue content was the most favourable adsorbent for MB adsorption. In conclusion, the cellulose rich BSGB could better remove organic dyes in neutral alkaline water environment.

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