Removal of Erichrome Black T (EBT) From Aqueous Solutions by Organic Adsorbent Using Bagasse Adsorptive Method

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ABSTRACT

Tans and Textile waste comprises large volume of poisonous substances that requires substantial quantity of oxygen and are often deposited into natural water bodies, there by polluting important water sources. These wastes need to be pretreated before transferred to any water ecosystems. This current work is aimed to provide a cheap and sustainable natural (Biogasse) for effective commercial elimination of EBT from water sources. The Parameters that affect adsorption mechanism of dye include but not limited to period of contamination, quantity of EBT present, the amount of adsorbent, temperature, pH, and adsorption period were considered in the analysis. Results analysed with adsorption isotherm models. Kineticology was undertaken to differentiate between first order model and second order model so as to ascertain the most appropriate to use. at the end of further thermodynamic studies, the results concludes that sugar cane bagasse is a better adsorbent for the removal of dye such as Erichrome Black T dye in industrial waste water.

Key Words: Dye, Adsorbent, Bagasse, Kinetics, Erichrome Black T

INTRODUCTION

Dyes were known to be artificial aromatic water-soluble carbon-based materials with multifaceted molecular structure and used widely for pigmentation in diverse industries. The majority of colouring materials are known to be Most of the dyes are poisonous and even oncogenic (Aksu, 2005). The removal these materials from seepage and waste is necessary to our surroundings. Handling of colorant wastes is problematic for the reason that it has an artificial source and comprise multiple aromatic molecular structure that are unchanging and not easily degradable (Abdel-Ghani, *et al.,* 2007).

Recently, numerous adsorbents are made from agricultural products and waste materials like sugarcane bagasse (Zhang *et al.,* 2011), are used in elimination of ionic and nonionic dye molecules from water. The application of agricultural derivatives as bioadsorbents was extensively debated, revealing that the solution pH and type of colorant, coupled with and the chemical composition of adsorbents significantly distress the adsorption processes of the substances (Mo'denes *et al.,* 2015).

In sourcing for cheap and environmentally friendly bio adsorbents and agricultural waste materials, cane sugar could be regarded as a potential low cost biosorbent even for commercial utilization (Maaloul *et al.,* 2017).

Erichrome Black T (EBT) is preferred as prototypical colorant due to its harmful, cancer causing and poisonous nature. The chemical composition of Erichrome Black T (sodium1-[1-hydroxynaphthylazo]-6-nitro-2-naphthol-4-sulfonate) shows that it is a distinctive mono-azo dye. The dye is commonly utilized in industries, investigations and research laboratories (Gautam *et al.,* 2015)

Aim

The purpose of this research is to determine the consequence of time, pH and preliminary concentration of dye on the deletion of Eriochrome black T in aqueous solution.

Objectives

a. To understand the adsorbtion and desorp tion characteristics of cane sugar bagass e as recyclable surface-assimilatives.
b. To know the adsorption competence of dynamic cane sugar bagasse for removal of Eriochrome black T colorant from aqueous solution.

LITERATURE REVIEW

Studies by Khalid *et al.,* (2014) on the decontamination of aqueous solution by alizarin red dye using activated charcoal was carried out successfully. It was concluded from thy study that the quantity of dye (such as EBT) per unit mass increases with increase in concentration. The mechanism of adsorption of dye was also determined a pseudo-first order and pseudo-second order kinetic model was studied and was found that adsorption kinetics is best described by pseudo-second order equation.

According to Rim *et al.,* (2017), utilization of Almond shell as bioadsorbent for the cleansing of Eriochrome Black T (EBT) dyes from aqueous substances is very effective. Specific Surface Area was used to categorized the natural materials found. other possible techniques that can be used includes Scanning Electron Microscopy (SEM), Fourier Transform
Infrared Spectroscopy (FTIR), Thermogravimetr ic Analysis, And X-Ray Diffraction.

Investigation of the adsorption rate of Alizarin Red S from aqueous solution by base triggered Typa grass (*T. latifolia*) with batch system in a regulated environment was undertaken by Musa and Abdullahi, (2022) in a recent study. The adsorbent surface was determined by Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) techniques and the point of zero charge (PZC). The kinematics were designated by pseudo-second order reproductions. The use of other materials like the by-products of ryegrass straw (*Lolium multiflorum* Lam.), dried straw, and the biochar obtained from the grass applied as adsorbent materials was carried out by Da silva *et al.*, (2020). The results showed that, the adsorption was viable and natural. It was then concluded that, the base triggered Typha grass is a probable adsorbent for the elimination of toxic materials in effluent.

Material and Methods

Materials

Commercially obtained analytical grades solvents were used for the purpose of this study. The Erichrome Black T (EBT) dye was obtained commercially and directly used lacking further decontamination. The EBT stock solutions for the adsorption study were set using suitable measures of EBT in 1L of deionized water. Adjustment was made to the pH of solutions through addition 0.1 m HCL/NAOH.

Experiment

The concentration of EBT was analysed by Ultra Violet spectrophotometer, furthermore, Infra-Red absorption bands were obtained using the Fourier transformed Infra-Red spectrometer in the wave range of 400-4000 cm^{-1}. The Scanning Electron Microscopy technique was used to study the external structural assembly of the dye. Digital pH meter was used to measure the pH of the colorant in the Laboratory.

Preparation of Bagasse

The bagasse (cane sugar) was gotten from the sugar industry then cleanse by washing it using deionized water, dried and grided to powder, then sieved and further dried at 110^{o}C for 6 hours followed by preservation in a laboratory using a desiccator.

Kinetics and Thermodynamics

The volume of substances (EBT) adsorp by Activated Cane Sugar Bagasse (ACSB) was determined using kinetic study. This was done by utilizing 100 ml of EBT dye (8.5 mg/L) solution with 0.25g of ACSB at 34^{o}C. this is stirred at 250rpm in an orbit shaker and the concentration is obtained varied time intervals of10-100min. Varied temperatures of 30 – 40^{o}C were used to determine the thermodynamic variables in the study.

Adsorption studies

The standard methods used by Ahmed and Dhedan, (2012) was adopted in this study. Adsorption of the EBT dye concentration was obtained by means of UV spectrometer at wave length of 529nm.

RESULTS AND DISCUSSION

The spectrum for the active cane sugar bagasse using FT-IR is presented in Fig 1 below. the presence of N-H stretching, C-H stretching and C=C aromatic was observed at peaks 3401.03cm^{-1}, 2981.66$cm^{-1}$and 1568.16 cm^{-1}. Similar observation was made by El Hendawy, (2006), and that peaks that were observed in cane sugar bagasse are typically attributed to the presence of C-OH stretching.

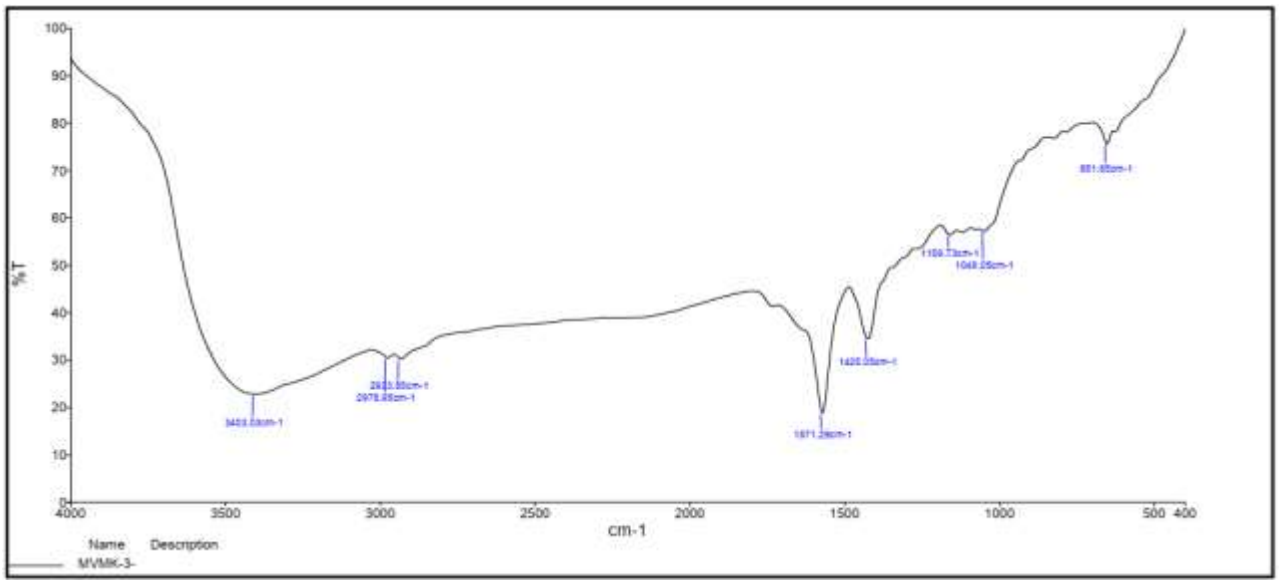

Figure 1 : FT-IR spectrum of cane sugar bagasse before adsorption

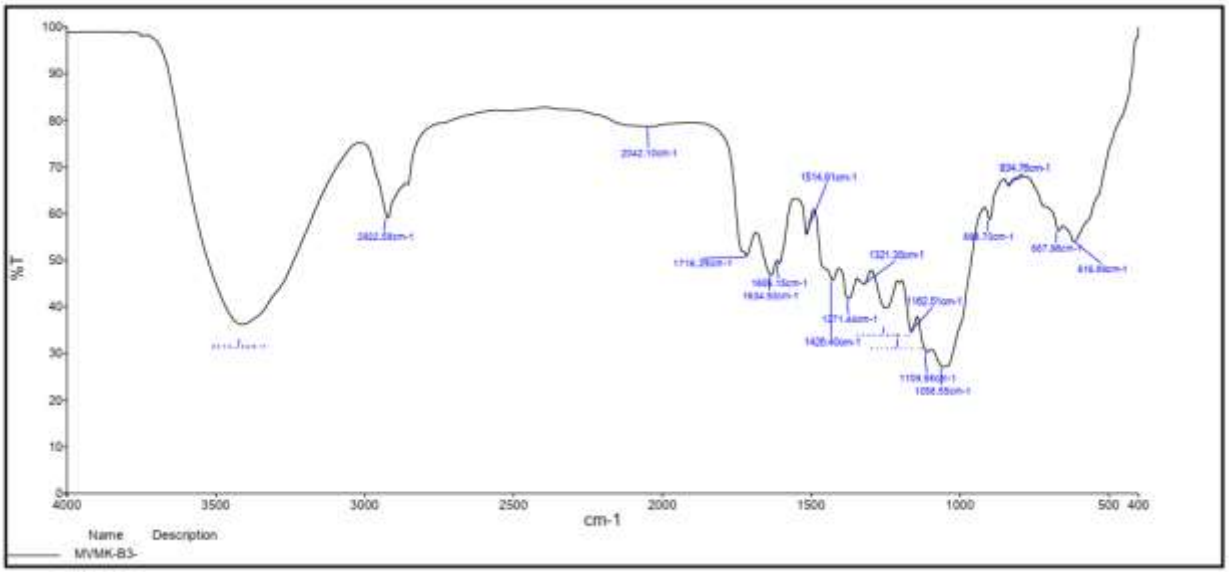

Figure 2: FT-IR spectrum of cane sugar bagasse after adsorption

The appearance of a new peak at 1715.29cm^{-1} indicates the presence of C=O ketone group at the superficial of the bagasse (Cane sugar) as a result of the adsorption of the EBT dye from the aqueous solution (See Figure 2). This characterizes a distinctive FT-IR spectra of dye adsorbed by cane sugar bagasse.

Adsorption Studies

The maximum adsorption time observed from the results was 100 min as shown from the equilibrium studies within a variation of 10 -120 min on EBT dye removal which is regarded as the optimum time.

Variation in concentration Activated Cane Sugar Bagasse (ACSB)

Difference in initial amount of the EBT absorption using 2.5g/l activated bagasse and upholding 7-10mg/L quantity via the interaction time of 100 min at standard revolution per minutes of (250rpm) at standard temperature and pH of 7, indicated that the decolouration is inversely proportional to increase in initial concentration of the dye. This is attributed to the formation of monolayer on the exterior which deters the further layer formation.

The consequence of using different amount of ACSB was considered, in which the mass of 1.0 to 4.0 g/L was used in an interaction time of 100 minutes at the same concentration parameters above. It was observed from the results as presented in figure 3., that the rate at which the EBT is removed is increased as the dosage of the ACSB in increase. This is directly related to the improvement in the site of adsorption of the dye.

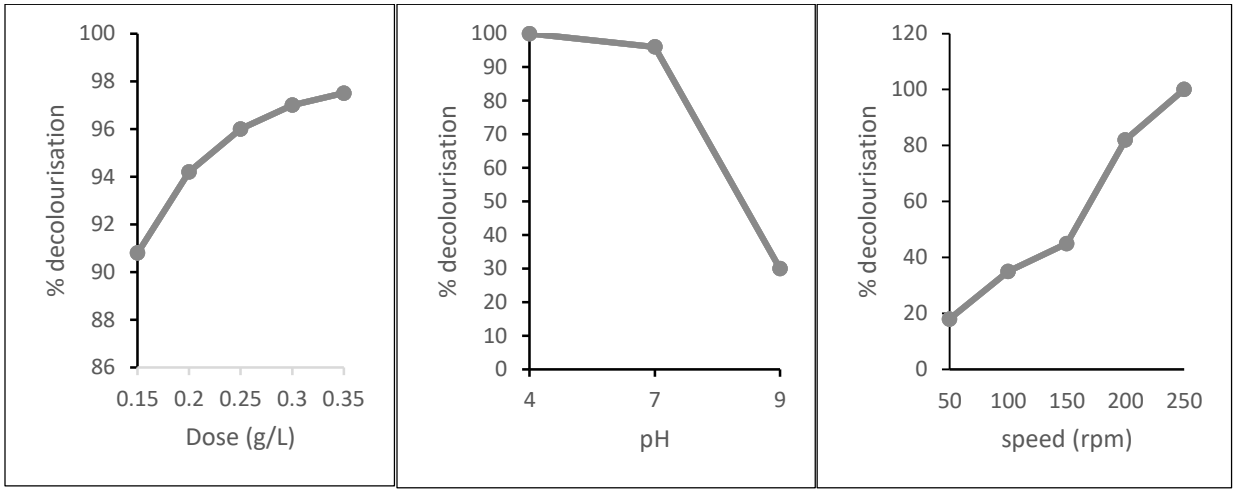

Figure 3: Variation of ACSB dose (a), pH (b) and desorption (c)
Fig 3. The desorption rate increases with increase in concentration

Variation of Physiochemical Parameters

The effect temperature was studied by varying the different temperature (34, 37 and 40^{o}C) maintaining contact time to 100min, dye concentration to 8.5mg/L, ACSB dose 2.5g/L, pH 7 AND agitation speed at 250rpm. The equilibrium data evident that % decolourisation increased with increasing temperature due to the excitation of adsorbent particles.

Change in pH was known to affect the adsorption capacity as a result of changes resulting from charge difference in the adsorption surfaces (Annadurai, *et. al.*, 2002). Similar observation was made (figure 3b) in which the there is an increase in EBT adsorption due to decrease in pH of the dye solution. The rate of agitation of the solution was seen to also affect EBT adsorption in which change in agitation speed from 50 – 250rpm which resulted in increased unrest with decreasing limit layer thickness about the adsorbent particles leads to increase in adsorption.

The rate at which adsorption occurs was also studied over time. The period of activation of Activated Cane Sugar Bagasse with changes in time from 30 – 120 minutes showed that the quantity of EBT absorbed increase as the activation time in increased.

SEM ANALYSIS

The structural morphology of the materials was carried out using Scanning Electron Microscopy (SEM)before and after application of the EBT of the cane sugar.

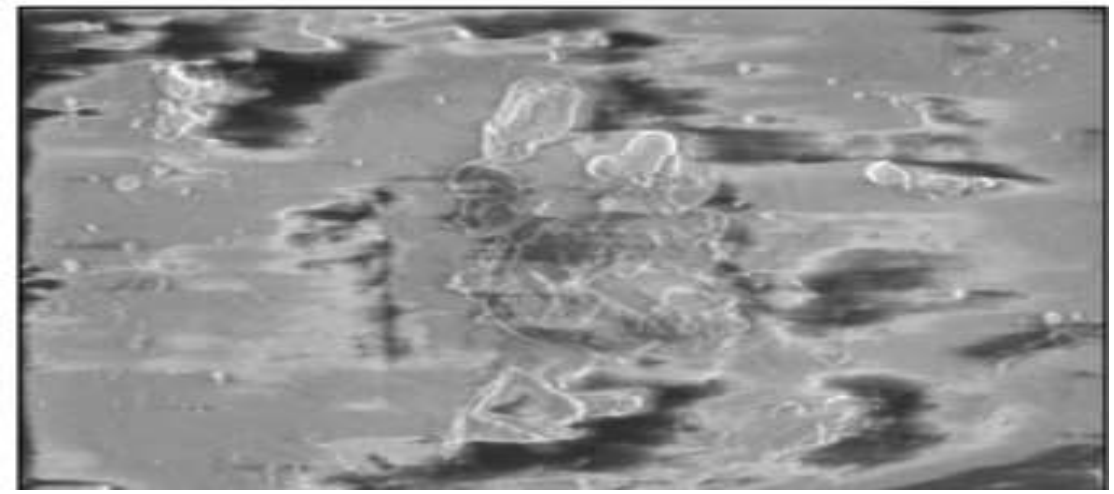

Figure 4. SEM of cane sugar before adsorption

The figure 4 illustrates the external structure and heterogeneity of cane sugar.

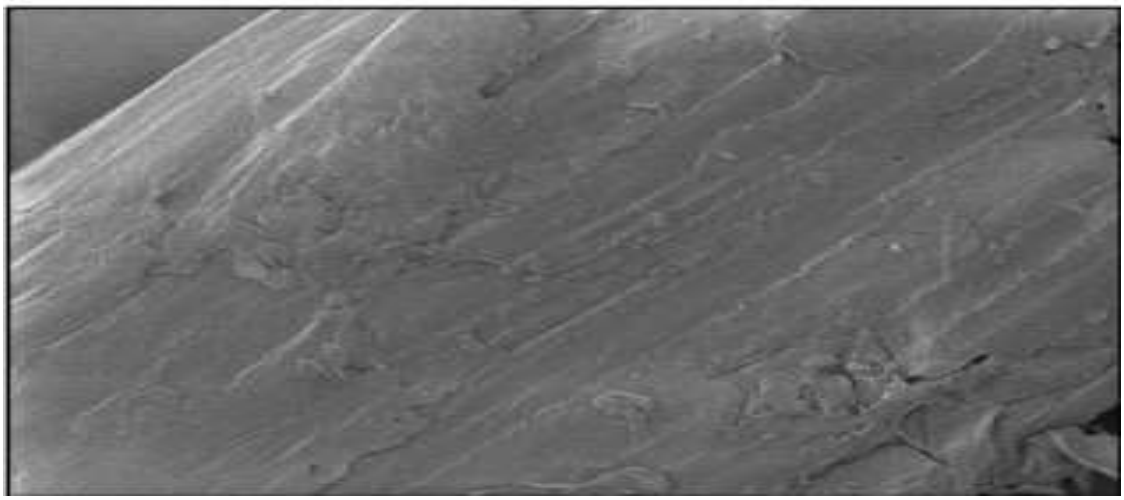

Figure 5. SEM of cane sugar after adsorption

The Figure 5 shows distinctive black dots that indicates presence of EBT on the adsorbent

CONCLUSION

The rate of Adsorption of Activated Cane Sugar Bagasse for Erichrome Black T at a balance time of 100min indicates 96.5% from the findings of the study. Certain factors that affect the level of adsorption of the dye includes but not limited to quantity of dye present, pH, amount of heat in the system and duration. During the experiment, it was observed that the adsorption progression followed pseudo-second order kinetics 9f thermodynamics. Therefore, it was concluded

that Activated Cane Sugar Bagasse can be applied as an adsorbent for the decontamination of Erichrome Black T in aqueous substances. This is an important finding in dealing with environmental pollution and management especially as a cheaper means of sewage management in the industries.

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