Science World Journal Vol. 19(No 3) 2024
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University
https://dx.doi.org/10.4314/swj.v19i3.9

Full Length Research Article

DETERMINATION OF ADSORPTION OF BLUE DYE USING SUGARCANE BAGASSE IN AN AQEOUS SOLUTION

*Manasseh Tachia Bwankwot, Nafisa Lawal, Emmanuel Kambai Duniya

Department of Pure and Applied Chemistry, Kaduna State University, P.M.B 2339 Kaduna, Kaduna State, Nigeria

*Corresponding Author Email Address: manasseh.bwankwot@kasu.edu.ng

ABSTRACT
This research provides valuable insights into using raw sugarcane bagasse (SB) as an adsorbent for dye removal from wastewater. Various activation and modification methods for SB were explored, including physical, chemical, and biological treatments, as well as composite formation and grafting. The study examined the effects of different optimization conditions on the adsorption process, such as adsorbent dosage, initial dye concentration, pH, and contact time. Key findings include an equilibrium contact time of 30 minutes for methylene blue dye, resulting in an 86% removal rate. The optimal pH for dye removal was identified as pH 6, achieving an 84% removal rate. The study also found that the optimum dye concentration for removal was 10 ppm, with a 70% removal rate, and the optimal adsorbent dosage was 0.4g, resulting in an 81% removal rate. These results demonstrate the effectiveness of raw sugarcane bagasse in adsorbing methylene blue dye under specific conditions, highlighting its potential as a low-cost and efficient adsorbent for wastewater treatment.

Keywords: Sugarcane bagasse (SB), Adsorbent, Dye removal, Grafting, Adsorbent dosage, Methylene blue dye (MB), Aqueous Solution.

INTRODUCTION
All over the world, production of sugarcane in 2018 was 1.91 billion tonnes, with Brazil producing 39% of the world total, India with 20%, and China and Thailand producing about 6% each (UN FAOSTAT 2019). Each ton of sugarcane delivered to the processing plant yields 260 kg of moist bagasse (130 kg of dry bagasse). After manufacturing sugar and ethanol from sugarcane, a huge amount of waste bagasse is produced. The major part of this waste generated is used to produce energy by burning which results in emission of greenhouse gases into the atmosphere (Yaseen and Scholz, 2019).
Therefore, it is of utmost importance to adopt cleaner alternatives to reuse such waste without harming the environment. One of the alternatives is to reuse waste sugarcane bagasse as adsorbent for wastewater treatment by removal of contaminants like dyes. The direct discharge of dyes from various sources has led to serious threat to global water security (Tkaczyk *et al*., 2020).
Globally, up to 10,000 dyes are present and their annual production is above 7×10^5 tons, which are being used in various industries like textile, paper, food, and pharmaceutical industries to colour their products (Ismail *et al*., 2019). Out of the total annual dye consumption in textile industry about 10–15% of them are being discharged as waste into the environment. Textile industries have been consuming more than 100L of water for processing of 1 kg textiles and as a result, they discharge considerable amount of coloured wastewater which is responsible for pollution of surface and ground water resources in many regions of the country (Leal *et al*., 2018).
Dyes can be classified into different categories including acidic, basic, reactive, disperse, direct, vat and azo dyes which have been studied by researchers for wastewater treatment (Razi *et al*., 2017). It has been reported that 70–80% of all illnesses in developing countries are related to water contamination, particularly affecting women and children (WHO and UNICEF, 2000). Most of dyes cause toxicity thereby affecting living organisms and our ecosystem (El Harfi and El Harfi, 2017).
There are numerous techniques to treat effluents containing dyes hence a wide variety of physical, chemical, and biological techniques have been developed and tested in the treatment of these effluents loaded with dyes. Therefore, adsorption using sugarcane bagasse remains one of the easy-to-implement technologies, as it is widely used for water treatment (Fayoud, 2015). Adsorption has been recognized as an efficient and effective method for sequestration of dye pollutants from wastewater due to its low cost, operational simplicity, easy regeneration, sludge-free operation, and does not involve any toxic intermediate (Rezaei *et al*., 2017). However, development of an ideal adsorbent using sugarcane bagasse is a major challenge for researchers working in this field.
Sugarcane bagasse is the solid residue that remains after extraction of juice from sugarcane. Rocha et al. have reported average composition of 60 samples of SB which includes 42.19% cellulose, 27.6% hemicelluloses, 21.56% lignin, 5.63% of extractives and 2.84% of ashes (Rezaei *et al*., 2017).
The large amount of dyes discharged into natural water bodies by industries causes serious environmental issues as a result of impedes lightweight penetration, therefore displeasing biological processes among a stream. additionally, several dyes are harmful to specific creatures inflicting through demolition of aquatic groups.
Industrial waste is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, mills, and mining operations. Types of industrial waste include dirt and gravel, masonry and concrete, scrap metal, oil, solvents, chemicals, scrap lumber, even vegetable matter from restaurants. Industrial waste may be solid, semi-solid or liquid in form. It may be hazardous waste (some types of which are toxic) or non-hazardous waste. Industrial waste may pollute the nearby soil or adjacent water bodies, and can contaminate groundwater, lakes, streams, rivers or coastal waters (Maczulak, 2010). Industrial waste is often mixed into municipal waste, making accurate assessments difficult.
Hazardous waste, chemical waste, industrial solid waste and municipal solid waste are classifications of wastes used by governments in different countries. Sewage treatment plants can treat some industrial wastes, i.e. those consisting of conventional pollutants such as biochemical oxygen demand (BOD). Industrial wastes containing toxic pollutants or high concentrations of other

pollutants (such as ammonia) require specialized treatment systems. (See Industrial wastewater treatment) (EPA, 2011).
Industrial wastes can be classified on the basis of their characteristics:
i. Waste in solid form, but some pollutants within are in liquid or fluid form, e.g. crockery industry or washing of minerals or coal
ii. Waste in dissolved and the pollutant is in liquid form, e.g. the dairy industry.
Tannery wastewater is one of the most pollution sources. It can cause environmental problems related to its high organic matter, suspended solids and chromium. Chromium (III) salts are the most widely used chemicals for tanning processes, causing the tannery wastewater to be highly pollutant with chromium. Wastes generated from tanneries are the primary pollutant to the environment and has potential to pollute both soil and water because of its properties, such as discoloration, toxic chemical constituents, and high oxygen demand (Song *et al.* 2000).
The leather industry uses large amounts of water because most of the related processes are carried out in the aqueous medium (Gutterres *et al*., 2008). The effluents from the tanneries are treated in treatment plants that typically comprise pretreatment, mechanical and physico-chemical treatment, biological treatment, and treatment of the generated sludge. The dyeing step in leather processing requires large amounts of water. This step is very important because features of leather products, such as color and uniformity of surface appearance, are the first to be visually assessed by the consumer. Currently, most of the dyes used in this step have its color due to the azo chromophore. About 70% of leather and textile dyes reported in the literature are azo dyes. In the industry more than 90% of the hides are dyed by azo dyes (Page, 2001). The effluents generated at this stage are difficult to treat by conventional methods because of the presence of dyes.
Dyes are an important class of industrial pollutants in fields involving paper, leather tanning, food processing, plastics, cosmetics, rubber, printing, dye manufacturing, and textiles. They are organic compounds that have a complex aromatic molecular structure that connect themselves to surfaces to impart color. These structures are present in stable dyes, are very difficult to treat, and have low biodegradability (Yagub *et al*., 2014).
The removal of dyes from wastewater has severe constraints such as high costs, hazardous product formation, and intensive energy requirements. Therefore, the development of efficient, cost-effective, and environmentally friendly technologies is required to reduce dye content in wastewater (Tahir *et al*., 2016). Thus, the search for new solutions, and the development of technologies that can cause less environmental damage are necessary. However, removing color from wastewaters through cheaper and environmentally friendly technologies is a major challenge (Srinivasan *et al*., 2010).
Sugarcane bagasse (SCB) is the major by-product of the sugar cane industry; it is one of the largest agriculture residues in the world. It is a fibrous residue of sugarcane stalks left over after crushing and extracting sugarcane juice (Fomina *et al*., 2014). About 54 million tons of dry SCB are produced annually worldwide and huge amounts of SCB are burned in the fields, resulting in a serious pollution problem. Furthermore, SCB is an abundant, inexpensive, and promising type of industrial waste with a lignin cellulose and polymeric structure (50% cellulose, 25% hemicellulose, and 25% lignin) (Soliman., 2011). Thus, utilization of this agricultural waste as low-cost adsorbent could provide a two-fold advantage with respect to environmental pollution. Firstly, the volume of by-products could be partly reduced, and secondly the low-cost adsorbent could reduce the pollution of wastewaters at reasonable cost (De Gisi *et al*., 2016).
Most current techniques used for the removal of dyes falls under three main classes (Robinson *et al*., 2001).
1. Physical methods (includes process of adsorption involving natural adsorbents, agricultural and industrial adsorbents, surfactants.)
2. Chemical methods (includes advanced oxidation method using Fenton's reagent, hydrogen peroxide, ozonization, solvent-extraction method and electrocoagulation etc.)
3. Biological methods (includes use of algae, bacteria and fungi species.
The aim of the study is to assess the determination of absorption of blue dye using sugarcane bagasse in tannery affluent. The objectives of the study include determining the appropriate absorption approach for the adsorption of blue, identify physiochemical properties of the sugarcane bagasse and lastly to determine the importance of absorbing blue dye using sugarcane bagasse in tannery affluent.

MATERIALS AND METHODS

Materials

The following materials were used in this study; 1000ml volumetric flask for making the stock solution, weighing balance for weighing the sample, 250ml Conical flask, 100ml Beaker, Measuring cylinder, Filter paper, Separating Funnel, Stirrer for stirring in the magnetic stirrer, Magnetic stirrer Pipette, AAS and UV-VIS for analysis.

Reagents

The following analytical grade chemicals were used: 0.5M HCl, 0.5M NaOH, 1g of Methylene blue dye, 5g of Sugarcane bagasse and Sample Distilled water.

Method

Sample Collection

Sugarcane bagasse was collected from unguwan rimi market, it was cut into small segments and dried in sunlight until almost all the moisture evaporated. Then it was grounded to a fine powder of a 35 mesh size and kept it in a bottle awaiting subsequent experiment.

Preparation of stock solution

Methylene blue dye stock solution (1000ppm) was made by dissolving 1g of methylene blue dye to a 1000ml Volumetric flask and made up with distilled water to the top. 0.5M of HCl and 0.5M of NaOH was used for pH adjustment.

Effect of pH

The pH was varied by 0.5M NaOH or 0.5M HCl to adjust the metal solutions at 2.00, 4.00, 6.00 and 8.00 pH values. Their effect on adsorption was investigated using 10ppm of the dye solution, 0.2g of sugarcane bagasse adsorbent and Stirring speed of 30 minutes. The solution was then filtered and the filtrates were subjected to UV-VIS analysis.

Effect of Contact time

A 0.2g of raw sugarcane bagasse Adsorbent was separately added to a 10ppm of the dye solution. The solution adjustment was made to optimal pH, varied time intervals of 10, 20, 30, 40, 50 and 60 minutes on a stirring speed, filtered and analyzed by UV-VIS.

Effect of Concentration

A varied concentration of 5ppm, 10ppm, 15ppm, 20ppm and 25ppm blue dye solution at optimal pH, sorbent dose was stirred at optimal speeds for 30 minutes. The solutions were removed, filtered and their metal ion concentration in the filtrate were determined by UV-VIS.

Effect of adsorbent dosage

An optimal concentration of the dye solutions at optimal pH was added to raw sugarcane bagasse adsorbent separately with varying masses of 0.2g, 0.4g, 0.6g and 0.8g and optimal time with stirring speed, the mixture was filtered and analysed by UV-VIS.

RESULTS

Effect of pH

Table 1; Effect of pH table of pH value and percentage removal

pH	% removal
2	**43%**
4	**73%**
6	**84%**
8	**78%**

A GRAPH OF % REMOVAL (%) AGAINST pH

Figure 1; Effect of Dosage on amount of methylene blue adsorbed by Sugarcane bagasse

The effect of pH on the adsorption of methylene blue dye from aqueous solution was analyzed, using 0.2g of sugarcane bagasse as the adsorbent, as shown in Table 1 and Figure 1. An increase in the quantity of dye absorbed was observed as the pH increased. Specifically, the percentage removal of methylene blue increased rapidly from pH 2 to 6, reaching an optimum at pH 6, followed by a less rapid decrease at pH 8. The adsorption behavior can be attributed to the chemistry of the solute and the active sites of the adsorbent. At lower pH values, the adsorbent surface is surrounded by hydrogen ions, which compete with methylene blue ions for binding sites. At higher pH levels, the surface of the biomass particles becomes negatively charged due to the ionization of the OH groups on the cellulose-based biomass surface, enhancing the adsorption of the positively charged dye cations through electrostatic attraction.

Sharma and Kaur (2011) highlighted that the pH value of the solution is a crucial factor in adsorption studies. They adjusted the pH between 1 and 9, using a digital pH meter (Model LT-10) for measurements. They found that adsorption increases with pH, likely because the adsorbent surface becomes negatively charged at higher pH values, which promotes the adsorption of positively charged methylene blue cations via electrostatic attraction. Although Evans Blue (EB), an anionic dye, still shows maximum adsorption at high pH (7-9), indicating minimal effect of hydroxide ions at these values. Zhang *et al*. (2011) observed that at neutral pH, EB achieves maximum adsorption, revealing that the amount of dye adsorbed at pH 7 and 9 is nearly the same.

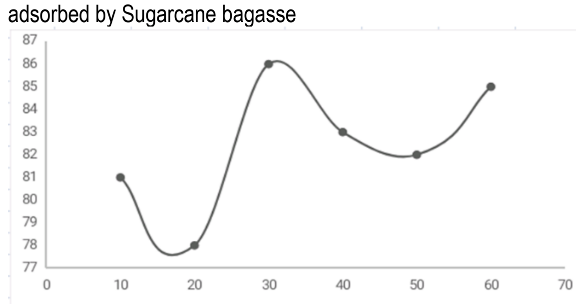
Effect of Contact time

Table 2; Effects of Contact time table of time and percentage removal

Time (mints)	% Removal
10	**81%**
20	**78%**
30	**86%**
40	**83%**
50	**81%**
60	**85%**

A GRAPH OF % REMOVAL (%) AGAINST TIME (mints)

Figure 2; Effect of Contact time on amount of methylene blue adsorbed by Sugarcane bagasse



The impact of contact time on the adsorption of methylene blue dye from aqueous solutions using sugarcane bagasse is detailed in Table 2 and Figure 2 above. The results indicate that at 30 minutes, optimal adsorption of methylene blue dye was achieved using sugarcane bagasse at a concentration of 10 ppm, 0.2g of adsorbent, and a pH value of 6. Beyond this equilibrium point, further increases in contact time resulted in minimal changes in the percentage of dye removal. This initial rapid phase is attributed to the abundance of vacant adsorption sites at the beginning, which creates a high concentration gradient between the dye in solution and the dye adsorbed on the surface.

In a similar study, Sharma and Kaur (2011) conducted batch adsorption experiments with varying contact times (10, 30, 60, 90, 120, 150, and 180 minutes) using an initial dye concentration of 100 mg/L and a 200 mg adsorbent dose of sugarcane bagasse in a 25 mL dye solution at neutral pH and a temperature of 308 K. Their findings also revealed that the initial rapid phase of adsorption is due to the high availability of vacant sites, which gradually becomes saturated over time. The aggregation of dye molecules with increased contact time hampers deeper diffusion into the adsorbent structure, especially at higher energy sites, thus diminishing the influence of prolonged contact time (Mall *et al*., 2005).

Mall *et al*. (2005) further explained that as the adsorption sites

Science World Journal Vol. 19(No 3) 2024
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University
https://dx.doi.org/10.4314/swj.v19i3.9

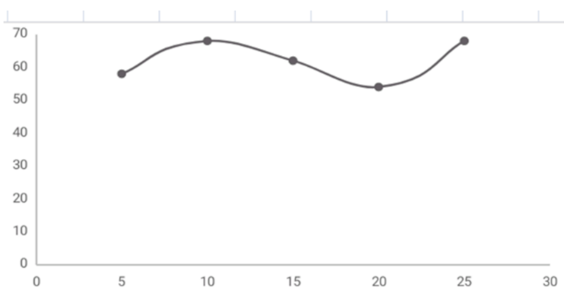
become saturated, the pores fill up and start resisting the diffusion of additional dye molecules, leading to an equilibrium state. Their study found that an equilibrium time of 1 hour is generally sufficient for maximum adsorption, aligning with the observations in this research where equilibrium was achieved around 30 minutes, after which the percentage removal plateaued.

Effects of Concentration

Table 3; Effects of Concentration for concentration and percentage removal

Concentration (ppm)	% Removal
5	58%
10	70%
15	62%
20	53%
25	68%

A GRAPH OF % REMOVAL (%) AGAINST CONCENTRATION (PPM)
Figure 3; Effect of concentration on amount of methylene blue adsorbed by Sugarcane bagasse



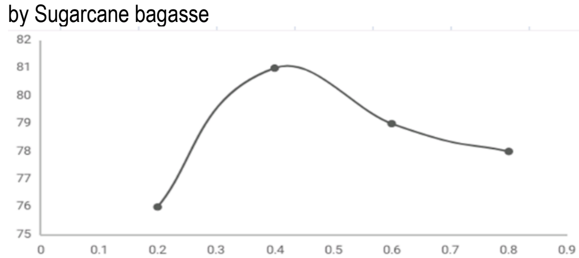
he effects of methylene blue dye concentration on adsorption using sugarcane bagasse, as shown in Table 3 and Figure 3, indicate that increasing the initial dye concentration from 5 ppm to 10 ppm results in an increased quantity of dye absorbed. This phenomenon can be explained by the enhanced driving force created by a higher concentration gradient, which improves the adsorption efficiency.
In comparison, Sharma and Kaur (2011) investigated the adsorption of Erythrosin Blue (EB) and methylene blue (MB) dyes at neutral pH with an equilibration time of 1 hour. Their study varied the initial dye concentrations for EB (10, 100, 200, 400, and 600 mg/L) and MB (100, 500, and 1000 mg/L), using sugarcane bagasse doses of 50, 200, and 400 mg. They observed that while the adsorption percentage decreased with increasing dye concentration, the absolute amount of dye removed at equilibrium increased. This trend is attributed to the initial dye concentration providing the necessary driving force to overcome mass transfer resistance between the aqueous and solid phases (Azhar *et al*., 2005).
This comparative analysis reinforces the understanding that higher initial dye concentrations enhance the driving force for adsorption, thereby increasing the total amount of dye removed, despite a reduction in the adsorption percentage.

Effects of Dosage
Table 4; Effect of Dosage table for percentage removal and Dose value

Dosage(g)	% Removal
0.2	76%
0.4	81%
0.6	79%
0.8	78%

A GRAPH OF % REMOVAL (%) AGAINST DOSAGE (g)

Figure 4; Effect of Dosage on amount of methylene blue adsorbed by Sugarcane bagasse



The effects of dosage on the adsorption of methylene blue dye using sugarcane bagasse are depicted in Table 4 and Figure 4. The results demonstrate a relative decrease in the amount of dye adsorbed as the sugarcane bagasse adsorbent weight increases. The optimal adsorption dosage was found to be 0.4g. This trend can be explained by the fact that adsorption sites remain unsaturated during the adsorption process, while the number of available adsorption sites increases with a higher adsorbent dose. Sharma and Kaur (2011) have shown that optimizing the adsorbent dose is crucial in an adsorption system. Their study investigated the effect of varying doses of sugarcane bagasse, from 50 to 1,500 mg, on the adsorption of dyes. These experiments were conducted at neutral pH, 308 K, with an equilibration time of 1 hour, and at different dye concentrations. They found that an increase in adsorbent dosage led to greater adsorption due to the larger surface area and more available adsorption sites (Sharma *et al*., 2010; Gupta *et al*., 2004). For instance, a 50 mg dose of sugarcane bagasse was sufficient for 100% adsorption of a 10 mg/L dye solution, though higher dye concentrations required larger doses.

Conclusion
The research concluded that sugarcane bagasse is highly effective as an adsorbent for methylene blue dye. Various parameters, including pH, contact time, concentration, and dosage, were found to significantly influence the dye's uptake. The equilibrium contact time for methylene blue dye was determined to be 30 minutes, resulting in an 86% removal rate. The optimal pH for dye removal was found to be pH 6, with an 84% removal rate achieved at this pH. Similarly, the optimum concentration for dye removal was 10 ppm, with a 70% removal rate. As for the adsorbent dosage, the optimum amount was 0.4g, resulting in an 81% removal rate.

Availability of data
Data availability is not applicable.

Funding
This research work is self-funded.

Conflicts of interest
No conflict of interest was associated with this work.

https://dx.doi.org/10.4314/swj.v19i3.9

REFERENCES

Azhar SS, Liew AG, Suhardy D, Hafiz KF, Hatim MD. (2005). Dye removal from aqueous solution by using adsorption on treated sugarcane bagasse. Am J App Sci 2:1499–1503.

De Gisi, S., Lofrano, G., Grassi, M., & Notarnicola, M. (2016). Characteristics and adsorption capacities of low-cost sorbents for wastewater treatment: A review. Sustainable Materials and Technologies, 9, 10-40.

El Harfi, S., & El Harfi, A. (2017). Classifications, properties, and applications of textile dyes: A review. Applied Journal of Environmental Engineering Science, 3(3), 311-320.

EPA. (2011). Industrial wastewater treatment. Environmental Protection Agency. Retrieved from [URL not provided].

Fayoud, N., Younssi, S. A., Tahiri, S., & Albizane, A. (2015). Kinetic and thermodynamic study of the adsorption of methylene blue on wood ashes. Journal of Materials and Environmental Science, 11, 3295–3306.

Fomina, M., Kholodov, V., & Gadd, G.M. (2014). Biosorption: Current perspectives on concept, definition, and application. Bioresource Technology, 160, 3-14.

Gupta VK, Suhas AliI, Saini VK. (2004b). Removal of rhodamine B, fast green, and methylene blue from wastewater using red mud, an aluminum industry waste. Ind Eng Chem Res 43:1740–1747.

Gutterres, M., Zampieri, F., & Mocellin, A. (2008). The Leather Industry: Water Usage and Wastewater Treatment. Journal of Environmental Management, 88(3), 1269-1278.

Ismail, M., Akhtar, K., Khan, M., Kamal, T., Khan, M. A., Asiri, A. M., Seo, J., & Khan, S. B. (2019). Pollution, toxicity and carcinogenicity of organic dyes and their catalytic bio-remediation. Current Pharmaceutical Design, 25, 3645-3663.

Leal, T. W., Lourenço, L. A., Scheibe, A. S., de Souza, S. M. G. U., & de Souza, A. A. U. (2018). Textile wastewater treatment using low-cost adsorbent aiming water reuse in dyeing process. Journal of Environmental Chemical Engineering, 6, 2705-2712.

Maczulak, A. E. (2010). Pollution: Treating Environmental Toxins. New York: Infobase Publishing.

Mall ID, Srivastva VC, Agarwal NK, Mishra IM. (2005). Removal of Congo red from aqueous solution by bagasse fly ash and activated carbon: kinetic study and equilibrium isotherm analyses. Chemosphere 61:492–501.

Page, L. E. (2001). The Role of Azo Dyes in the Leather and Textile Industry. Journal of Industrial Dye Chemistry, 23(4), 345-357.

Rezaei, H., Haghshenasfard, M., & Moheb, A. (2017). Optimization of dye adsorption using Fe3O4 nanoparticles encapsulated with alginate beads by Taguchi method. Adsorption Science & Technology, 35, 55-71.

Robinson, T., McMullan, G., Marchant, R., & Nigam, P. (2001). Remediation of dyes in textile effluent: a critical review on current treatment technologies with a proposed alternative. Bioresource Technology, 77(3), 247–255.

Scholz, M., & Yaseen, D. (2019). Textile dye wastewater characteristics and constituents of synthetic effluents: a critical review. International Journal of Environmental Science and Technology, 16, 1193-1226.

Sharma P, Kaur R, Baskar C, Chung WJ. (2010). Removal of methylene blue from aqueous waste using rice husk and rice husk ash. Desalination 259:249–257

Sharma P and Kaur H. 2011). Sugarcane bagasse for the removal of erythrosin B and methylene blue from aqueous waste. *Appl Water Sci* (2011) 1:135–145. DOI 10.1007/s13201-011-0018-x.

Soliman, A. M. (2011). Utilization of sugarcane bagasse for the removal of heavy metals from wastewater. Environmental Progress and Sustainable Energy, 30(1), 93-102.

Song, Z., Williams, C. J., & Edyvean, R. G. J. (2000). Tannery Wastewater Treatment Using An Upflow Anaerobic Fixed Biofilm Reactor (UAFBR) with and without Pretreatment. Water Research, 34(6), 2173-2180.

Srinivasan, A., & Viraraghavan, T. (2010). Decolorization of dye wastewaters by biosorbents: A review. Journal of Environmental Management, 91, 1915–1929.

Tahir, H., Sultan, M., Akhtar, N., Hameed, U., & Abid, T. (2016). Application of natural and modified sugar cane bagasse for the removal of dye from aqueous solution. Journal of Saudi Chemical Society, 20, S115–S121.

Tkaczyk, A., Mitrowska, K., & Posyniak, A. (2020). Synthetic organic dyes as contaminants of the aquatic environment and their implications for ecosystems: A review. Science of The Total Environment, 717, 137222.

UN FAOSTAT. (2019). Production of sugarcane in 2018. Retrieved from UN FAOSTAT.

World Health Organization (WHO) and United Nations Children's Fund (UNICEF). (2000). Global Water Supply and Sanitation Assessment 2000 Report. WHO and UNICEF.

Yagub, M. T., Sen, T. K., Afroze, S., & Ang, H. M. (2014). Dye and its removal from aqueous solution by adsorption: A review. Advances in Colloid and Interface Science, 209, 172–184.

Zhang G, Li X, Li Y, Wu T, Sun D, Lu F. (2011). Removal of anionic dyes from aqueous solution by leaching solutions of white mud. Desalination 274:255–261.