Experimental Investigations of the Removal of Methylene Blue from Waste Water using Agricultural Adsorbant

Manoj B. Mandake[1], Santosh Walke[2,*], Makarand Naniwadikar[3], Ganesh Patil[2] and Sandhya D. Jadhav[1]

[1]*Bharati Vidyapeeth College of Engineering (affiliated to University of Mumbai), Navi Mumbai, India*

[2]*Department of Mechanical and Industrial Engineering, College of Engineering, National University of Science and Technology, Oman*

[3]*AISSMS COE PUNE, Savitribai Phule Pune University, India*

Abstract: The colored organic or inorganic chemical compounds which can impart colour to other substance are the Dyes which did significant applications in the most industrial sectors like the textile industry, leather industry, paper industry, plastic, foodstuff industry etc, to impart color to their products. Due to the large volume of dye use in these businesses, a significant quantity of wastewater containing colored organics is generated. Because of insufficient dye-fiber fixation, during the dyeing process, half of the dye is lost in the wastewater. Peanut and rice husk are used to absorb MB from water. Initial Methylene Blue concentration, Peanut and Rice Husk dose, and pH were monitored and compared to current adsorbents to identify the optimal removal conditions. The equilibrium amount of MB adsorbed at time t (min) for rice husk and peanut hull are obtained as 5.1 and 5.19 mg/g respectively. As part of the research, an intra-particle diffusion model was implemented to regulate the mass transfer model's rate-controlling step mechanism.

Keywords: Waste Water, Methylene Blue, Peanut Hull, Rice Husk, Adsorption.

1. INTRODUCTION

Dye in water, even in trace amounts, may be hazardous and very noticeable, making the elimination of color from waste effluents crucial for environmental reasons. Government regulations necessitating the treatment of textile wastewater highlight the ongoing need for an efficient procedure to remove these colors from wastewater, which is an environmental problem in and of itself [1-3]. In the past, dyes were decolored in several ways. The adsorption method is best for removing dyes. Adsorption is a physical process that's cheap and fast [4].

Chemical, physical, and biological methods have all been considered in relation to the elimination of dyes from industrial effluents [5]. Adsorption is becoming more used as a technology for treating aqueous wastewater. Advantages of the adsorption process include its ability to renew cheaply, the use of common process equipment, the lack of sludge during operation, and the recovery of the sorbate [6]. Reducing waste in agriculture via recycling is crucial. Several types of agricultural byproducts are being investigated for their potential to filter out certain colours from water solutions under varying circumstances of use [7, 8]. For the purification process various techniques, likes flocculation-coagulation, precipitation, photocatalytic degradation, biological oxidation, ion exchange, adsorption and membrane filtration, have been investigated [9]. According to their physicochemical properties and cheap cost, agricultural solid wastes may be suitable prospective adsorbents. Agricultural waste has little commercial value and is difficult to dispose of. Membrane filtration blocks passage of contaminants through physical obstruction, chemical adsorption, or a combination of both processes and can remove far more contaminants than any other purification method. Adsorption takes an important role in membrane filtration process [9]. Agricultural waste utilization is important. Several agricultural waste products are being explored for removing dyes from aqueous solutions. Industrial sources pollute water reservoirs with dyes. Textiles, paper, cosmetics, food, and polymers are sources. Adsorption using a membrane gets better adsorption capacity and a relatively faster time than granular form [10]. The most common adsorption materials are activated carbon, membrane, nanomaterial and carbon based materials and the aforementioned adsorbents, membrane has been found to be an excellent adsorbent due to its easy preparation, high porosity and interconnected pore structures [11]. The membranes were reused for more than three-four cycles across a wide pH range, demonstrating their viability as a dye removal substitute. The method is less costly than the commonly used membrane options [12]. Dye pollution in aquatic environments harms human health and the environment [13]. Most dyes are toxic, mutagenic, and

*Address correspondence to this author at the Department of Mechanical and Industrial Engineering, College of Engineering, National University of Science and Technology, Oman; Tel: +968-95965023;
E-mail: santoshwalke@nu.edu.om

E-ISSN: 2410-1869/23

carcinogenic [14]. MB is an aromatic synthetic cationic dye used in the commercial dyeing of silk, wool, and cotton. MB is also carcinogenic. MB is not considered poisonous, however intake causes burning [15]. Before dumping industrial waste water into the environment, it must be treated. Solvent extraction and membrane [16]. The research gap identified in the previous research work is limited study of effect of operating parameters on equilibrium concentration, in the present work the wide range is selected and its effect on the MB removal is studied. The two agricultural based adsorbents are used for this study such as rice husk and peanut hull, and adsorption Isotherms studies shows that for first order and second order ratio of time and q are directly proportional to time.

The esterification method was used by the authors to study the reactive distillation of ethyl acetate. The decanter is used to separate the product's wastewater from that of the product, and there are various methods for treating that wastewater [17-19]. The methods for producing biogas from palm waste were investigated by the authors in Oman, and the biogas energy can be used for wastewater treatment [20]. Our research team used polyethersulfone and copper oxide-graphene oxide (Cu2O-GO) to create a noble fouling-resistant membrane. The prepared mixed matrix membranes' performance in terms of wastewater treatment and fouling resistance was also investigated [21, 22]. Using two renewable technologies, Saravanan *et al*. conducted an experimental study to purify underground water in remote areas of Oman, generating enough electricity to operate the reverse water purification system and water purification system at the lowest possible cost [23]. Cellulose nanofibers obtained from agricultural waste have gained popularity as an alternative to traditional wastewater treatment materials. Shabib *et al*. studied their isolation and characterization [24]. According to Saravanan *et al*., one of the main sources of wastewater treatment is bloom energy [25].

2. MATERIALS AND METHODS

2.1. Methylene Blue

Methylene Blue was selected because of its high solid adsorption.

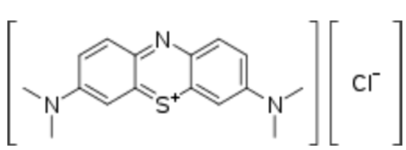

Figure 2.1: Methylene blue structures.

Although the cationic dye methylene blue isn't considered to be immediately dangerous, it does cause a number of problems for humans and animals [26]. Short bursts of fast or difficult breathing may result from inhalation, whereas issues with nausea, vomiting, and gastritis may result from oral consumption [27, 28].

2.2. Materials

Peanut and rice husk are obtained from local farmers. The gathered material is washed with distilled water to eliminate dirt. Continue washing until water is clear. After being properly cleaned, the materials were dried in an 8-hour hot air oven cycle at 85°C [29,30]. The powdered combination of the dry ingredients was made in a kitchen blender and then sieved through a 100 Mesh screen. Later, this combination was preserved in a glass container [31].

2.2.1. Equilibrium Studies

Adsorption at equilibrium can be calculated using Equation (1).

$$q_e = \frac{(C_0 - C_e)V}{W} \quad (1)$$

C_0 and C_e are the initial and final dye concentrations in the liquid phase, measured in milligrams per liter, respectively [11].

Equation for estimating dye removal is given as

$$Adsorption\ Percent\ (\%) = \frac{C_0 - C}{C_0} \times 100 \quad (2)$$

Here C (mg/L) is the concentration in the liquid phase at time t.

2.2.2. Effect of PH

Various pH levels were tested for their influence on color removal (*i.e*. 4, 7 and 10). Both 1 N NaOH and 1 N HCl solutions were used to achieve the desired pH level. Agitation for 4 hours is adequate to attain equilibrium at a steady pace [32]. After centrifuge the samples are tested for COD.

2.2.3. Isotherm

The Langmuir model is often expressed in the well-known form of

$$q_e = \frac{q_{max}\, K\, C_e}{1 + K\, C_e} \quad (3)$$

Where, q_e is the amount of MB adsorbed at equilibrium (e), Ce is the equilibrium solution concentration, and qmax is the maximum adsorption capacity.

$$\frac{Ce}{qe} = \frac{1}{k\ qmax} + \frac{Ce}{qmax} \tag{4}$$

Freundlich equation is given in the following form:

$$Q_e = K_F C^{1/n} \tag{5}$$

Adsorption capacity is represented by K_F, while n is a measure of adsorption strength.

$$ln(q_e) = ln(K_F) + \frac{1}{n}\ ln\, C_{eq} \tag{6}$$

The values for adsorption capacity and 1/n are calculated from the scatter plot of ln (qeq) vs ln (Ceq).

2.2.4. Adsorption Kinetics

In order to ascertain the mechanism, kinetic models have been presented. Lagergren has presented first and second order kinetic models which are pseudo in nature, for dissecting the process of MB onto DPH [33, 34].

$$ln\ (q_e - q) = ln\ (q_e) - k_1 t \tag{7}$$

Here we have the rate equation for first order adsorption: where q is the equilibrium adsorption capacity, qe is the adsorption capacity at time t (min), and k_1 is the rate constant [35].

2.2.5. Model: Pseudo-Second Order

The rate of adsorption may be thought of as a pseudo-second order process. Eq (8) demonstrates the linear integration version of this model, and (9)

$$\frac{t}{q} = \frac{1}{k_2\ q_e^2} + \frac{t}{q_e} \tag{8}$$

$$q = f\left(\frac{Dt}{rp}\right)^{1/2} = k_i t^{1/2} \tag{9}$$

Here Ki is the intra-particle diffusion rate.

3. RESULTS

3.1. Initiation of Fluctuation in Dye Concentration

Figure **3.1** presents the COD reduction % vs contact time.

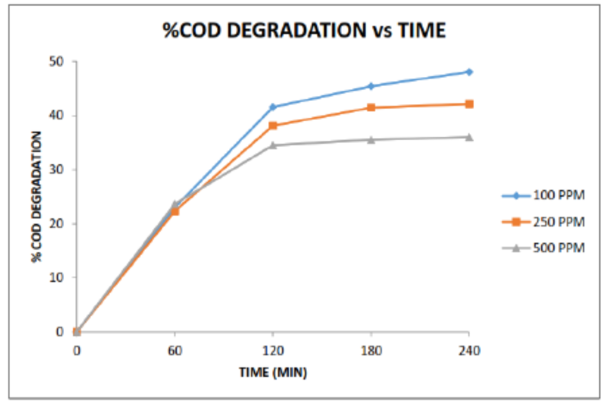

Figure 3.1: Removal of MB by Rice Husk: Influence of Initiating Concentration (W=1 gm/100 mL at 25 degrees Celsius).

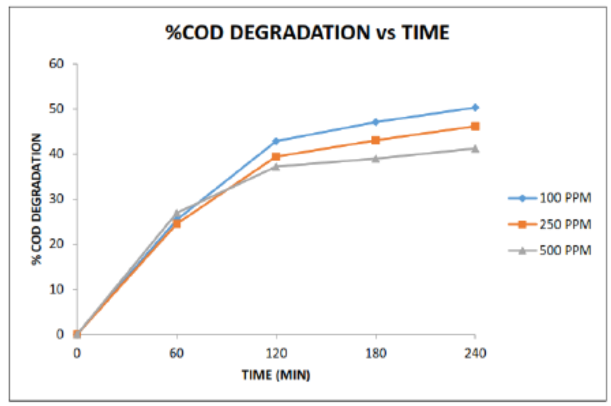

Figure 3.2: Removal of MB by Peanut Hull: Influence of Initiating Concentration (W=1 gm/100 mL at 25 degrees Celsius).

3.2. Variable Adsorbent Dose

The methylene blue adsorption results are shown in Figure **3.3**

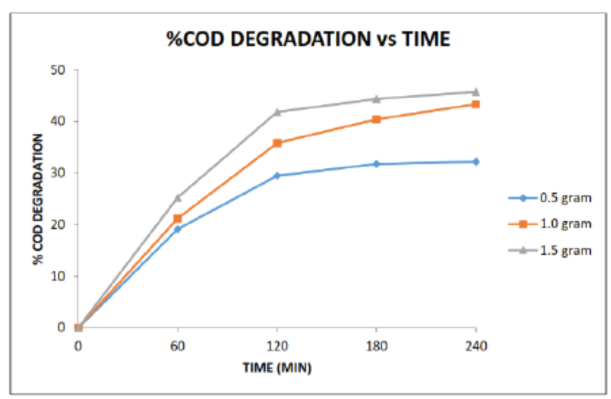

Figure 3.3: Adsorbent Mass and MB Adsorption on Rice Husk (100 mg/L, 100 mL at 25 degrees Celsius).

The dyes uptake reduces with increasing adsorbent dose in peanut husk is illustrated in Figure **3.4**.

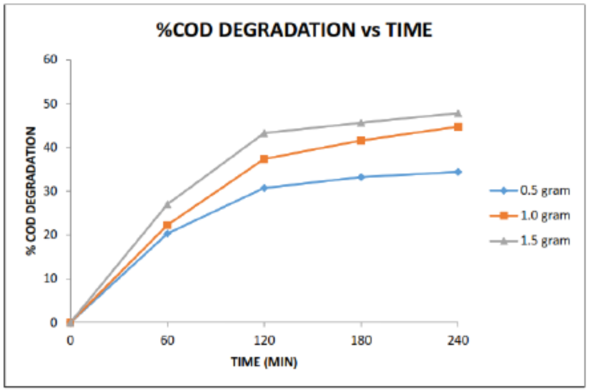

Figure 3.4: Adsorbent Mass and MB Adsorption on Peanut Hull (100 mg/L, 100 mL at 25 degrees Celsius).

3.3. Adsorption Isotherms Studies

The Langmuir or Freundlich adsorption isotherm at constant temperature is presented below.

$$q_e = \frac{\text{qmax K Ce}}{1 + \text{K Ce}} \quad (10)$$

$$\frac{Ce}{qe} = \frac{1}{k\,qmax} + \frac{Ce}{qmax} \quad (11)$$

Langmuir isotherms are described by the dimensionless constant separation factor R_L using Eq. (12),

$$R_L = \frac{1}{1 + bC_0} \quad (12)$$

The initial adsorbent concentration Co (mg/L), RL denotes the isotherm's shape.

The MB adsorption and constants and correlations are presented for Rice husk and Peanut hull in Table **3.1**.

Table 3.1: MB Adsorption and Adsorbent Constants and Correlations

Adsorbent	Rice Husk	Peanut Hull
qmax (mg/g)	36.1	55.2
b(l/mg)	0.0025	0.0018
R_2	0.98	0.99
RL	0.78	0.82

$$q_e = K_F C^{1/n} \quad (13)$$

Where KF indicates adsorption capacity and n intensity. This equation's logarithm is:

$$ln(q_e) = ln\,k_F + \frac{1}{n} ln\,Ce \quad (14)$$

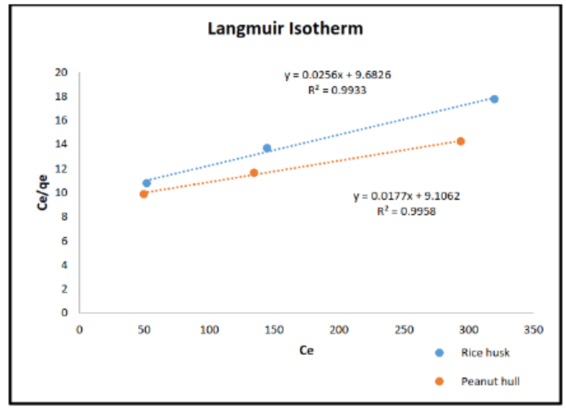

Figure 3.5: Analysis of MB adsorption onto rice husk and peanut hull using Langmuir isotherms.

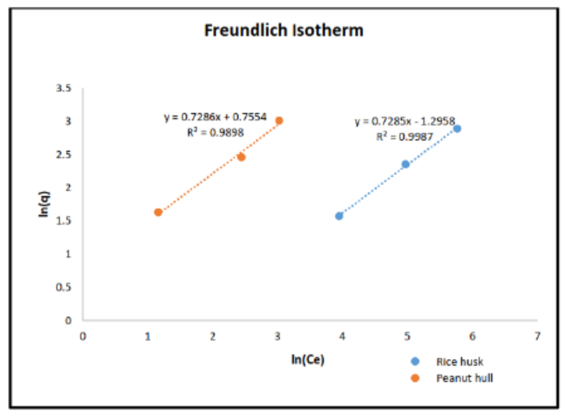

Figure 3.6: Analysis of MB adsorption onto rice husk and peanut hull using Freundlich isotherms.

Model: Pseudo-First Order

$$ln\,(q_e - q) = ln(q_e) - k_1 t \quad (15)$$

The pseudo-first order adsorption rate constant, k_1, is defined as follows: where q is the equilibrium amount of

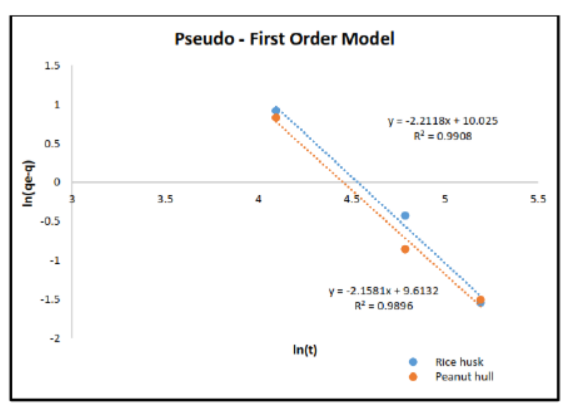

Figure 3.7: Methylene Blue Adsorption Kinetics at Room Temperature (Pseudo-First Order).

MB adsorbed at time t (min), and q and q_e are the time t (min) values.

Model: Pseudo-Second order

This model may be expressed in a linear integrated form, which is

$$\frac{t}{q} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e} \qquad (16)$$

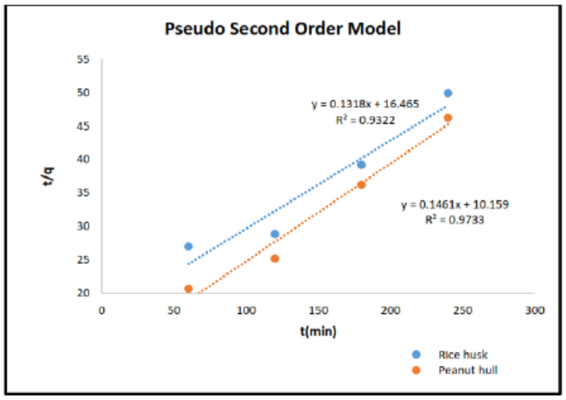

Figure 3.8: Methylene Blue Adsorption Kinetics at Room Temperature (Pseudo-Second Order).

The rate constants in psedo first and second order adsorptions are presented in Table **3.2**.

Table 3.2: Rate Constants for Adsorption in Pseudo-First and Pseudo-Second Orders

Adsorbent	qe, exp (mg/g)	First Order		Second Order	
		K_1 (per min)	Qe (mg/g)	K_2 (per min)	Qe (mg/g)
Rice husk	5.1	3.21	18954	$1.055*10^{-3}$	7.58
Peanut hull	5.19	2.15	14960	$2.101*10^{-3}$	6.84

4. DISCUSSION

The first % COD decrease is very rapid up to 120 minutes for all here PPM variables and similar trend is observed in peanut husk as was hypothecated by Ahmed *et al.* [36]. Adsorption, as determined by dye absorption (mg/g), is positively affected by initial dye concentration.

At first, the solute molecules were quickly adsorbed onto the outside of the adsorbent particles. This adsorption process eventually reached its maximum, meaning the molecules had to diffuse through the pores of the adsorbent in order to continue being adsorbed. This caused the rate of adsorption to decrease [36]. Figure **3.2** below shows the outcomes for using peanut hull as an adsorbent.

When the adsorption of the exterior surface reached saturation, the molecules will need to diffuse through the pores of the adsorbent into the interior surface of the particle, a similar observation was previously reported for the treatment of pulp and paper mill wastewaters with poly aluminium chloride and bagasse fly ash The results are in line with the M. Rafatullah [37].

5. CONCLUSIONS

Since government regulations mandate the treatment of textile wastewater and dye removal from wastewater is seen as an environmental concern, there is a continuing demand for an efficient method to remove these colours. In the recent past, a variety of processes were used to decolorize dyes. The most effective method for removing dyes from them all is adsorption. It is generally acknowledged that adsorption is a physical process that costs less money and takes short time. The research indicates that rice husk and peanut hull, an agricultural waste biomaterial, can remove methylene blue from aqueous solutions. Dye absorption (mg/g) increases with solution concentration and pH and decreases with adsorbent dose. In the first stages of dye uptake, intra-particle diffusion is the governing force. Dye absorption (mg/g) increases with solution concentration and pH and decreases with adsorbent dose. Equilibrium observations corresponded well with Langmuir isotherm model with 36.1 mg/g for rice husk and 55.2 mg/g for peanut hull at room temperature. Early dye absorption is governed by external mass transfer and later by intraparticle diffusion. Adsorption Isotherms investigations demonstrate that for First order and second order ratio of time and q is linearly proportional to time, and the two agricultural adsorbents employed in this research are rice husk and peanut hull.

REFERENCES

[1] R. Gong, Removal of cationic dyes from aqueous solution by adsorption on peanut hull. J. Hazard. Mater 2005; 1(3): 247-250. https://doi.org/10.1016/j.jhazmat.2005.01.029

[2] BH. Hameed, DK. Mahmoud, and AL. Ahmad, "Equilibrium modeling and kinetic studies on the adsorption of basic dye by a low-cost adsorbent: coconut (Cocos nucifera) bunch waste," J. Hazard. Mate 2008; 158(1): 65-72. https://doi.org/10.1016/j.jhazmat.2008.01.034

[3] BH. Hameed, RR. Krishni, and SA. Sata, "A novel agricultural waste adsorbent for the removal of cationic dye from aqueous solutions," J. Hazard. Mater., 2009; 162(1): 305-311. https://doi.org/10.1016/j.jhazmat.2008.05.036

[4] SK. Singh, Neetu Sharma, DP. Tiwari, Decolourisation of Synthetic Dyes by Agricultural Waste- A Review. 2012; 3(2): 1-10.

[5] PNT Robinson, G McMullan, R Marchant, Remediation of dyes in textile effluent: a critical review on current treatment technologies with a proposed alternative, Bioresour. Technol. 2001; 77(3): 245-255. https://doi.org/10.1016/S0960-8524(00)00080-8

[6] Amit Bhatnagara Mika Sillanpää, "Utilization of agro-industrial and municipal waste materials as potential adsorbents for water treatment-A review," Chem. Eng. Journal, 2010; 157(2): 277-296. https://doi.org/10.1016/j.cej.2010.01.007

[7] M. Amit Bhatnagar, Minocha, A. K, Sillanpää, "Adsorptive removal of cobalt from aqueous solution by utilizing lemon peel as biosorbent," Biochem. Eng. J., 2010; 48(2): 181-186. https://doi.org/10.1016/j.bej.2009.10.005

[8] M. Al Hinai, A. Al Kalbani, B. Al Rubkhi, U. Al Kalbani, and S. Walke, Protein extraction from spirulina platensis, Int. J. Innov. Technol. Explor. Eng, 2019; 8(12): 1524-1530.

[9] Li. Q, Li. Y, Ma X, Du Q, Sui, K, Wang D, D. ; W. C. ; L. H. ; X. Yan Zhi,. Filtration and adsorption properties of porous calcium alginate membrane for methylene blue removal from water. Chem. Eng. J 2017; 316: 623-660. https://doi.org/10.1016/j.cej.2017.01.098

[10] ES. Budi Hastuti, Siti Nur Afifah, Bakti Mulyani, Adsorption of Methylene Blue Dyes Using Pectin Membrane, in Journal of Physics: Conference Series, 2019; 1503. https://doi.org/10.1088/1742-6596/1503/1/012031

[11] Y. Zhang, JJ. Liu, XL. Du, and W. Shao, Preparation of reusable glass hollow fiber membranes and methylene blue adsorption, J. Eur. Ceram. Soc, 2019; (39): 4891-4900. https://doi.org/10.1016/j.jeurceramsoc.2019.06.038

[12] SS. Vedula and GD. Yadav, "Wastewater treatment containing methylene blue dye as pollutant using adsorption by chitosan lignin membrane: Development of membrane, characterization and kinetics of adsorption," J. Indian Chem. Soc., 2022; 99(1): 100263. https://doi.org/10.1016/j.jics.2021.100263

[13] MB. Mandake, SV. Anekar, and SM. Walke, Kinetic Study of Catalyzed and Uncatalyzed Esterification Reaction of Acetic acid with Methanol, Am. Int. J. Res. Sci. Technol. Eng. Mat., 2013; 3(1): 114-121.

[14] K. Singh and S. Arora, "Removal of synthetic textile dyes from wastewaters: A critical review on present treatment technologies," Crit. Rev. Environ. Sci. Technol., 2011; 41(9): 807-878. https://doi.org/10.1080/10643380903218376

[15] S. W. VJ Hattimattur, VR Sangale, PS Zade, MB Mandake, "Review: epoxidation of vegetable oils," Int. J. Trend Res. Dev, 2018; 5(2): 542-548.

[16] WC. Qian, XP. Luo, X. Wang, M. Guo, and B. Li, "Removal of methylene blue from aqueous solution by modified bamboo hydrochar," Ecotoxicol. Environ. Saf 2018; 157: 300-306. https://doi.org/10.1016/j.ecoenv.2018.03.088

[17] Patil GN, Gnanasundaram N. Energy-saving investigation of vacuum reactive distillation for the production of ethyl acetate. Chemical Product and Process Modeling 2022. https://doi.org/10.1515/cppm-2021-0060

[18] Patil GN, Gnanasundaram N. Energy Saving Investigation of Entrainer Enhanced Vacuum Reactive Distillation for Ethyl Acetate Production, ECS Trans 2022; 107: 9841-9853. https://doi.org/10.1149/10701.9841ecst

[19] Patil GN, Gnanasundaram N. A review on process parameters of various process intensification techniques for ethyl acetate production, Rasayan J. Chem 2020; 13; 920-933. https://doi.org/10.31788/RJC.2020.1325640

[20] Rashdi Shabib, Patil Ganesh, Balushi Noura. Research Journal of Biotechnology 2022; 17(12): 159-164. https://doi.org/10.25303/1712rjbt1590164

[21] Balushi Noura, Rashdi Shabib, Rizwan SM, Patil Ganesh, Saravanan AM. Development of a Noble Fouling-Resistant Membrane for Wastewater Treatment. International Journal of Membrane Science and Technology 2022; 9: 55-60. https://doi.org/10.15379/2410-1869.2022.09.02.04

[22] Saravanan AM, Hosni N, Patil GN, Walke S M, Rashdi S, Balushi N. "Experimental Scrutinization on Treatment of Organic and Inorganic Effluents using Adsorption Process". International Journal of Membrane Science and Technology 2022; 9(2): 48-54. https://doi.org/10.15379/2410-1869.2022.09.02.03

[23] Rashdi S, Ganesh Patil, Balushi N, Saravanan AM. Isolation And Characterization Of Cellulose Nanofiber Obtained From Agriculture Waste. Recent Innovations in Chemical Engineering 2022; 15(3): 189-201. https://doi.org/10.2174/2405520415666220905120334

[24] Balushi F, Saravanan AM, Patil G, Walke S. Studies on Bloom Energy Server. Recent Innovations in Chemical Engineering 2022; 15(3): 214-225 https://doi.org/10.2174/2405520415666220729122436

[25] BH. Hameed and M. I. El-Khaiary, Sorption kinetics and isotherm studies of a cationic dye using agricultural waste: Broad bean peels, J. Hazard. Mater 2008; 154(1-3): 639-648. https://doi.org/10.1016/j.jhazmat.2007.10.081

[26] AO. Dursun Ozer , Gülbeyi Dursun, "Methylene blue adsorption from aqueous solution by dehydrated peanut hull," J. Hazard. Mater 2001; 144(1-2): 171-179. https://doi.org/10.1016/j.jhazmat.2006.09.092

[27] WJ. C. Pankaj Sharma, Ramnit Kaur,Baskar Chinnappan, "Removal of methylene blue from aqueous waste using rice husk and rice husk ash," Desalination 2010; 259(1-3): 249-257. https://doi.org/10.1016/j.desal.2010.03.044

[28] A. Amran Salleh, Dalia Khalid Mahmoud, Wan Azlina Wan Ab Karim Ghani, Cationic and Anionic Dye Adsorption by Agricultural Solid Wastes: A Comprehensive Review, Desalination 2011; 1(3): 1-13. https://doi.org/10.1016/j.desal.2011.07.019

[29] AW. Tan, AL. Ahmad, and BH. Hameed, "Adsorption of basic dye on high-surface-area activated carbon prepared from coconut husk: Equilibrium, kinetic and thermodynamic studies," J. Hazard. Mater 2008; 154(1-3): 337-346. https://doi.org/10.1016/j.jhazmat.2007.10.031

[30] ATMDN. Nasuha, BH. Hameed, "Rejected tea as a potential low-cost adsorbent for the removal of methylene blue," J. Hazard. Mater 2010; 175(1-3): 126-132. https://doi.org/10.1016/j.jhazmat.2009.09.138

[31] SM. Walke and VS. Sathe, "Study on the gas holdup of triangular pitch and square pitch sparger geometry in bubble column," Int. J. Fluid Mech. Res 2012; 39(1). https://doi.org/10.1615/InterJFluidMechRes.v39.i1.60

[32] EA. Sackey, Y. Song, Y. Yu, and H. Zhuang, "Biochars derived from bamboo and rice straw for sorption of basic red dyes," PLoS One, 2021; 16(7). https://doi.org/10.1371/journal.pone.0254637

[33] MS. Mia, P. Yao, X. Zhu, X. Lei, T. Xing, and G. Chen, "Degradation of textile dyes from aqueous solution using tea-

polyphenol/Fe loaded waste silk fabrics as Fenton-like catalysts.," RSC Adv 2021; 11(14): 8290-8305. https://doi.org/10.1039/D0RA10727A

[34] AM. Saravanan, GN. Patil, ZH. Mohammed, SM. Walke, and M. Achuthan, "Experimental studies and analysis on the treatment of groundwater using solar and wind energy," Rasayan J. Chem 2022; 15(3). https://doi.org/10.31788/RJC.2022.1536955

[35] B. H. H. A.A. Ahmad, "Reduction of COD and color of dyeing effluent from a cotton textile mill by adsorption onto bamboo-based activated carbon," J. Hazard. Mater., 2009; 172: 1538-1543. https://doi.org/10.1016/j.jhazmat.2009.08.025

[36] S. Chandrasekhar and P. N. Pramada, "Rice husk ash as an adsorbent for methylene blue-effect of ashing temperature," Adsorption, 2006; 12(1): 27-43. https://doi.org/10.1007/s10450-006-0136-1

[37] M. Rafatullah, O. Sulaiman, R. Hashim, and A. Ahmad, "Adsorption of methylene blue on low-cost adsorbents: A review," J. Hazard. Mater 2010; 177(1-3): 70-80. https://doi.org/10.1016/j.jhazmat.2009.12.047

Received on 11-10-2022 Accepted on 08-01-2023 Published on 19-01-2023

DOI: https://doi.org/10.15379/2410-1869.2023.10.01.01