International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 08 | Aug 2019 www.irjet.net p-ISSN: 2395-0072

Treatment of Textile Dye Methylene Blue using Coconut Adsorbent

Ankita Tagade[1], S R Geed[2], K B Samal[3]

[1,2,3]*Department of Chemical Engineering, MITS Gwalior- 474005 M.P. India*

***

Abstract - *Colored wastewaters are hazardous to aquatic biota and human beings. Consequently, presence of dye effluents in water reservoirs is a significant concern to researchers and civilians. A sustainable and effective treatment method of dye effluents should be developed to avoid the consequences. Dye wastewater must be treated before their discharge to reduce its adverse effects on environment and human beings. However, one single technique is inefficient in treating dye effluents. The present research focused on the development of adsorbent for to remove dye from coconut shell. The absorbent were prepared by pyrolysis of coconut shell. The pyrolysis products are adsorbent and bio-oil was obtained. The experiments were conducted to optimized adsorbent dosage (0.1-04 g/l) and pH ranges (5-10). The adsorption experiments were performed to study the adsorption of dye using coconut biochar. Initial COD was 1025 mg/L and reduced to 397 mg/L for the dye removal. Te maximum removal efficiency of 68 % was achieved.*

Key Words: Adsorption, Methylene blue, Coconut shell, Wastewater

1. INTRODUCTION

Since years, water quality is highly deteriorating due to contamination [1]. Various industries utilize dye to colour their raw and finished material, thereby releasing huge quantity of wastewater containing dye into the watercourses [2]. The dismissal of dye effluents results in eutrophication and create disturbance in the aquatic environment [3]. Dyes are highly soluble in water and are enormously used in textile industries [4]. Textile industries tend to generate large amount of wastewaters that contained dyes [5].

Methylene blue (MB) is utmost dye used for dyeing cotton and silk. Since MB is highly soluble it is considered as a toxic colorant. MB is highly visible even in low concentration [3]. Thus release of MB effluents in water bodies leads to aesthetic issues. Water bodies containing MB effluents hinder light transmission thus affecting chemical processes of aquatic plants [6, 7]. It also affects the oxygen transfer mechanism of water body [8]. Exposure to MB can cause harmful effects to human beings and environment. In coming contact with human beings, MB causes toxic effects like skin allergies, tissue necrosis, gastrointestinal irritation, mental shocks and diarrhoea [9, 10]. Decolourization of MB is major environmental challenge [11]. It is an urgent requirement of an effective procedure which could decolourize dye economically.

Various physiochemical and biological treatments are available for removing dyes from wastewater. The treatments include membrane separation [12], fenton reagent [13], ozonation [14], oxidation, biodegradation [15], photocatalysis [16] and coagulation flocculation [17]. Nevertheless, the limitation of these techniques includes high equipment costs, production of toxic sludge and complicate procedure [18]. Moreover, in developing countries like India, these techniques are not sufficient to treat dyes contained in wastewater. In contrast, adsorption is a well-established and extensively used technique [19]. Adsorption is highly capable of eliminating the dye effluents. Adsorption by the suitable adsorbent results in high performance, simple design and convenient operation [20]. Moreover, adsorption is a cost effective technique and it does not result in generation of toxic by product [21].

Recently researchers have focused on the development of absorbents from agricultural waste. Agricultural wastes are inexpensive, easy to regenerate and contain high capacity for adsorption. A large number of adsorbents have been developed and successfully utilized as effective adsorbent such as rice husk [22], vegetable peels [23], coffee waste [24], banana peels [25], pomegranate peels [26], custard apple shell [27].

In the current work, coconut shell is utilized as an inexpensive, agricultural waste for the removal of MB. Large numbers of waste shells are produced yearly and their disposal creates environmental nuisance[28]. By utilizing coconut shells as a vital adsorbent it would reduce the expenditure of shell disposal. Moreover, coconut shells would be economic alternatives to existing expensive adsorbents.

2. Materials and methods:

2.1 Adsorbate

Methylene blue (MB) procured from Sigma Aldrich was used as an adsorbate. The molecular weight and molecular formula of MB resembled as 319.86 g/mol and $C_{16}H_{18}ClN_3S.xH_2O$, respectively. De-ionized water was utilized in experiments.

2.2. Preparation of adsorbent

The coconut shell (CS) was obtained from local temple in Gwalior, Madhya Pradesh. CS was firstly washed water in order to eliminate impurities. CS was further kept for 8-10 hours sun dry for removal of moisture content. The CS was hand crushed, then was send to ball mill for further grinding. Further, the pieces were sieved using sieving machine BS5000. The sieved pieces of <1 mm were utilized for preparing coconut shell biochar.

2.3 Preparation of biochar

Biochar is a solid carbon enriched product produced through burning organic biomass under limited or without oxygen. Because of the large microscopic surface area and charged surface, biochar is a vial potential for adsorbing contaminates like dye. The final particle size of ground CS sieved was less than 1 mm .The dried sample was finally converted into biochar through pyrolysis at 450oC for 2-3 h pyrolyser are as shown in figure 1.

Figure 1. Pyrolysis coconut shell

The resulting biochar was crushed and sieved into less than 2.0 mm size. Then the sieved biochar of coconut shell was kept in an oven at temperature 60 o C for time 48 h for reduction of the moisture content. After air dried coconut shell biochar was stored in an air tight container for additional analysis.

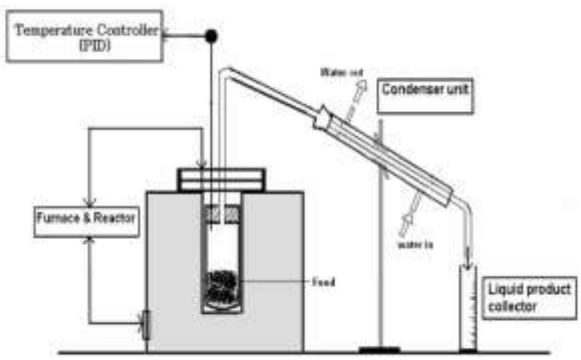

Figure 2. Experimental setup for pyrolyser

Figure 2 depicts a systematic diagram for experimental setup of the pyrolyser. Pyrolyser consisted of semi batch made reactor constructed of stainless steel. The reactor from one end was sealed and at another end it had an outlet end. Electric furnace heated the reactor externally. The temperature was estimated using thermocouple of type Cr-Al: K. The thermocouple was held inside the reactor and PID controller managed the temperature. Fixed amount of coconut shell was loaded into the pyrolyser. The liquid product formed was collected via condenser. Solid residue formed was collected and weighed.

2.4 Adsorption experiments:

The MB adsorption on CSB were performed batch mode. Adsorption experiment were performed in 250 ml Erlenmeyer flasks. A 100 ml of MB solution was taken and adsorbent was added in the flasks. The flasks opening were covered and placed on a mechanical shaker. Adsorption parameters were studied such as pH(5-10) and adsorbent dosage (0.1-04 g/l). The best adsorption uptaking conditions were determined. The acidic pH of MB solution was regulated by addition of HCl while the basic pH was regulated by addition of NaOH. The % RE was estimated using the following equation

$$\% RE = (C0 - Ce)/ C0 \times 100$$

Where C0 is the initial concentration of MB, Ce is the equilibrium of MB

3. RESULTS

3.1 Effect of solution pH on adsorption

The pH is one of the most influencing parameter of adsorption process [29]. Figure 3 presents the influence of pH on the adsorption. The consequence of the pH on the adsorption of MB onto CSB was examined at variable pH 5.5-9. When the pH was acidic, the surface of CSB was charged positively thereby, resulting in the effective competence of H+ ions with the cations present in MB. Hence, rate of adsorption was found to be decreased at an acidic pH. In contrast, at pH 7, MB uptake on CSB was found to be highest resembling dye removal efficiency with 60%. Further when the pH was kept basic the adsorption rate was found to decrease. In the present work, pH 7 was fixed for further experiments.

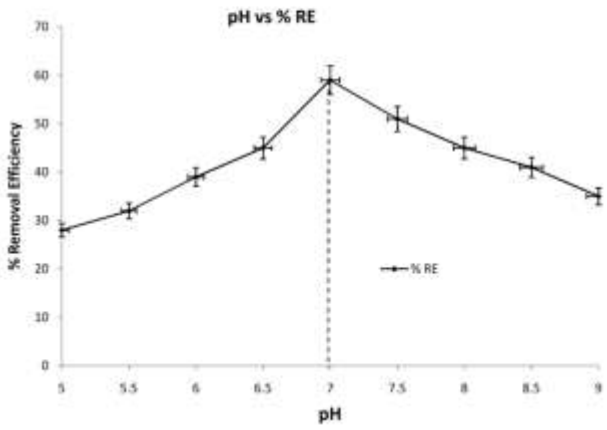

Figure 3. Effect of pH on the adsorption capacity of MB by

CSB at [MB]o = 100 mg/L, agitation rate = 150 rpm, temperature = 30°C, contact time = 60 min

3.2 Effect of the coconut shell biochar dosage

The effect of CSB dose on the adsorption of MB was examined at CSB dose range of 0.25-2 g/l. The figure 4 results that a CSB dose of 1 g/l gave the maximum MB percentage removal efficiency (60%). The maximum MB removal by higher concentration of CSB corresponds with the greater availability of specific surface and binding sites of the adsorbent. However, beyond 1 g/l of adsorbent dose, no consequential changes was observed in MB removal. This is attributed to the adsorbent's conglomeration, there by resulting in the decreased surface area for the adsorption.

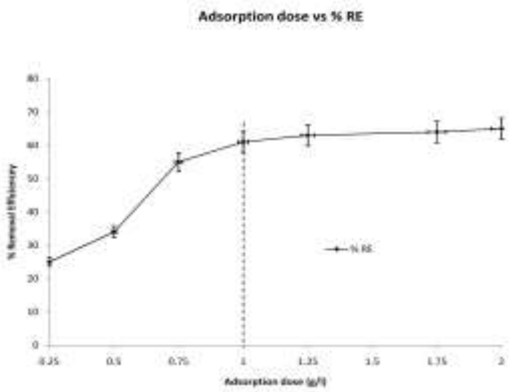

Figure 4. Effect of CSB dosage on %RE of MB.

3.3 Effects of contact time on adsorption

MB adsorption onto CSB was examined by varying contact time (60-240 min). Figure 5 resembles influence of contact time on MB adsorption onto CSB adsorbent. Initially, MB adsorbed onto the CSB increased rapidly. And after 180 min of contact time the adsorption process slowed down progressively. Hence, the equilibrium was reached by 180 min. At the preliminary stages, large vacant sites for adsorption was available and after an interval of time the available vacant sites were occupied by dye molecules thereby creating repulsive force between CSB on the MB surface and in bulk phase. The maximum MB removal was 69% for the contact time of 180 min.

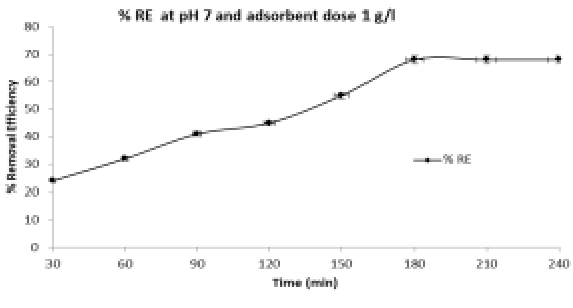

Figure.5 Effects of contact time on MB adsorption

3. CONCLUSION

The research work demonstrated the potential use of low cost and agricultural waste coconut shell for the MB removal from aqueous solution. Various adsorption parameters were studied and it was estimated that adsorption was greatly influenced by pH, adsorbent dosage and contact time. It is concluded that the coconut shell was proved to be promising for MB removal from wastewater. In addition, coconut shell is cheap and abundantly available. Coconut shell being a waste can resolve its disposal issue by utilizing as a efficient adsorbent.

REFERENCES

[1] L. Borah, M. Goswami, P. Phukan, Adsorption of methylene blue and eosin yellow using porous carbon prepared from tea waste: Adsorption equilibrium, kinetics and thermodynamics study, J. Environ. Chem. Eng. 3 (2015) 1018–1028. doi:10.1016/j.jece.2015.02.013.

[2] P.S. Kumar, A. Saravanan, 11 - Sustainable wastewater treatments in textile sector, Elsevier Ltd, 2017. doi:10.1016/B978-0-08-102041-8.00011-1.

[3] A.H. Jawad, R.A. Rashid, R.M.A. Mahmuod, M.A.M. Ishak, N.N. Kasim, K. Ismail, Adsorption of methylene blue onto coconut (Cocos nucifera) leaf: optimization, isotherm and kinetic studies, Desalin. Water Treat. 57 (2016) 8839–8853. doi:10.1080/19443994.2015.1026282.

[4] R. Kant, Textile dyeing industry an environmental hazard, Nat. Sci. 04 (2012) 22–26. doi:10.4236/ns.2012.41004.

[5] M.T. Yagub, T.K. Sen, S. Afroze, H.M. Ang, Dye and its removal from aqueous solution by adsorption: A review, Adv. Colloid Interface Sci. 209 (2014) 172–184. doi:10.1016/j.cis.2014.04.002.

[6] B. Merzouk, K. Madani, A. Sekki, Using electrocoagulation-electroflotation technology to treat synthetic solution and textile wastewater, two case studies, Desalination. 250 (2010) 573–577. doi:10.1016/j.desal.2009.09.026.

[7] N. Puvaneswari, J. Muthukrishnan, P. Gunasekaran, Toxicity assessment and microbial degradation of azo dyes, Indian J. Exp. Biol. 44 (2006) 618–626.

[8] M.A. Chia, R.I. Musa, Effect of indigo dye effluent on the growth, biomass production and phenotypic plasticity of Scenedesmus quadricauda (Chlorococcales), An. Acad. Bras. Cienc. 86 (2014) 419–428. doi:10.1590/0001-3765201420130225.

[9] J.H. Huang, C.F. Zhou, G.M. Zeng, X. Li, J. Niu, H.J. Huang, L.J. Shi, S.B. He, Micellar-enhanced ultrafiltration of methylene blue from dye wastewater via a polysulfone hollow fiber membrane, J. Memb. Sci. 365 (2010) 138–144. doi:10.1016/j.memsci.2010.08.052.

[10] M.T. Uddin, M.A. Islam, S. Mahmud, M. Rukanuzzaman, Adsorptive removal of methylene blue by tea waste, J. Hazard. Mater. 164 (2009) 53–60. doi:10.1016/j.jhazmat.2008.07.131.

[11] J. Wang, L. Qin, J. Lin, J. Zhu, Y. Zhang, J. Liu, B. Van der Bruggen, Enzymatic construction of antibacterial ultrathin membranes for dyes removal, Chem. Eng. J. 323 (2017) 56–63. doi:10.1016/j.cej.2017.04.089.

[12] E.M.V. Hoek, V. V. Tarabara, I. Koyuncu, K. Güney, Membrane-Based Treatment of Textile Industry Wastewaters, Encycl. Membr. Sci. Technol. (2013). doi:10.1002/9781118522318.emst127.

[13] Y.S. Woo, M. Rafatullah, A.F.M. Al-Karkhi, T.T. Tow, Removal of terasil red R dye by using fenton oxidation: A statistical analysis, Desalin. Water Treat. 52 (2014) 4583–4591. doi:10.1080/19443994.2013.804454.

[14] S. Miralles-Cuevas, I. Oller, A. Agüera, M. Llorca, J.A. Sánchez Pérez, S. Malato, Combination of nanofiltration and ozonation for the remediation of real municipal wastewater effluents: Acute and chronic toxicity assessment, J. Hazard. Mater. 323 (2017) 442–451. doi:10.1016/j.jhazmat.2016.03.013.

[15] A.R. Khataee, A. Movafeghi, S. Torbati, S.Y. Salehi Lisar, M. Zarei, Phytoremediation potential of duckweed (Lemna minor L.) in degradation of C.I. Acid Blue 92: Artificial neural network modeling, Ecotoxicol. Environ. Saf. 80 (2012) 291–298. doi:10.1016/j.ecoenv.2012.03.021.

[16] A.H. Jawad, M. Azharul Islam, B.H. Hameed, Cross-linked chitosan thin film coated onto glass plate as an effective adsorbent for adsorption of reactive orange 16, Int. J. Biol. Macromol. 95 (2017) 743–749. doi:10.1016/j.ijbiomac.2016.11.087.

[17] C.Z. Liang, S.P. Sun, F.Y. Li, Y.K. Ong, T.S. Chung, Treatment of highly concentrated wastewater containing multiple synthetic dyes by a combined process of coagulation/flocculation and nanofiltration, J. Memb. Sci. 469 (2014) 306–315. doi:10.1016/j.memsci.2014.06.057.

[18] V.D. Gosavi, S. Sharma, Journal of Environmental Science , Computer Science and Engineering & Technology A General Review on Various Treatment Methods for Textile Wastewater, 3 (2014) 29–39.

[19] V.K. Gupta, B. Gupta, A. Rastogi, S. Agarwal, A. Nayak, A comparative investigation on adsorption performances of mesoporous activated carbon prepared from waste rubber tire and activated carbon for a hazardous azo dye-Acid Blue 113, J. Hazard. Mater. 186 (2011) 891–901. doi:10.1016/j.jhazmat.2010.11.091.

[20] M. Amran Mohd Salleh, D. khalid Mahmoud, K. Wan azlina wan abdul, I. Azni, Cationic and anionic dye adsorption by agricultural solid wastes : A comprehensive review, Desalination. 280 (2011) 1–13. doi:10.1016/j.desal.2011.07.019.

[21] A.H. Jawad, R.A. Rashid, M. Azlan, M. Ishak, K. Ismail, Adsorptive removal of methylene blue by chemically treated cellulosic waste banana (Musa sapientum) peels banana (Musa sapientum) peels, J. Taibah Univ. Sci. 0 (2018) 1–11. doi:10.1080/16583655.2018.1519893.

[22] A. Malik, A. Khan, M. Humayun, Preparation and chemical modification of rice husk char for the removal of a toxic dye (Orange G) from aqueous medium, Zeitschrift Fur Phys. Chemie. 233 (2019) 375–392. doi:10.1515/zpch-2018-1190.

[23] C. Samet, S. Valiyaveettil, Fruit and Vegetable Peels as Efficient Renewable Adsorbents for Removal of Pollutants from Water: A Research Experience for General Chemistry Students, J. Chem. Educ. 95 (2018) 1354–1358. doi:10.1021/acs.jchemed.8b00240.

[24] G.K. Cheruiyot, W.C. Wanyonyi, J.J. Kiplimo, E.N. Maina, Adsorption of toxic crystal violet dye using coffee husks: Equilibrium, kinetics and thermodynamics study, Sci. African. 5 (2019) e00116. doi:10.1016/j.sciaf.2019.e00116.

[25] F. Temesgen, N. Gabbiye, O. Sahu, Biosorption of reactive red dye (RRD) on activated surface of banana and orange peels: Economical alternative for textile effluent, Surfaces and Interfaces. 12 (2018) 151–159. doi:10.1016/j.surfin.2018.04.007.

[26] M.E.M. Ali, H. Abdelsalam, N.S. Ammar, H.S. Ibrahim, Response surface methodology for optimization of the adsorption capability of ball-milled pomegranate peel for different pollutants, J. Mol. Liq. 250 (2018) 433–445. doi:10.1016/j.molliq.2017.12.025.

[27] E.A. Khan, Shahjahan, T.A. Khan, Adsorption of methyl red on activated carbon derived from custard apple (Annona squamosa) fruit shell: Equilibrium isotherm and kinetic studies, J. Mol. Liq. 249 (2018) 1195–1211. doi:10.1016/j.molliq.2017.11.125.

[28] P. Taylor, O.S. Bello, M.A. Ahmad, O.S. Bello, M.A. Ahmad, Separation Science and Technology Coconut (Cocos nucifera) Shell Based Activated Carbon for the Removal of Malachite Green Dye from Aqueous Solutions Coconut (Cocos nucifera) Shell Based Activated Carbon for the Removal of Malachite Green Dye from Aqu, Sep. Sci. Technol. 47 (2012) 903–912. doi:10.1080/01496395.2011.630335.

[29] Y. Önal, C. Akmil-Başar, D. Eren, Ç. Sarici-Özdemir, T. Depci, Adsorption kinetics of malachite green onto activated carbon prepared from Tunçbilek lignite, J. Hazard. Mater. 128 (2006) 150–157. doi:10.1016/j.jhazmat.2005.07.055.