Indonesian Journal of Chemical Research

http://ojs3.unpatti.ac.id/index.php/ijcr Indo. J. Chem. Res., 10(2), 93-96, 2022

The Ecofriendly Biosorbent of Methylene Blue Using Banana Peels Waste

Indri Susanti[1*], Rendy Muhamad Iqbal[2], Novia Amalia Sholeha[3], Khusnul Fatimah Putri[4]

[1]Department of Science Education, Faculty of Teacher Training and Education, Lamongan Islamic University, Jl. Veteran No. 53A Lamongan, Indonesia

[2]Department of Chemistry, Faculty of Mathematic and Natural Sciences, Universitas Palangka Raya, Kampus UPR Tunjung Nyaho, Palangka Raya 73111, Indonesia

[3]College of Vocational Studies, Bogor Agricultural University (IPB University), Jl. Kumbang No. 14, Bogor, Indonesia

[4]Department of Science Education, Faculty of Teacher Training and Education, Lamongan Islamic University, Jl. Veteran No. 53A Lamongan, Indonesia

[*]*Corresponding Author: indri_susanti@unisla.ac.id*

Received: August 2022
Received in revised: August 2022
Accepted: August 2022
Available online: September 2022

Abstract

This research aimed to synthesize and characterize the properties of green banana peel waste to be used as adsorbent material. The green banana peel waste was prepared by sieved to be banana powder and then characterized by XRD, FTIR, XRF, and TGA. The adsorption capacity of methylene blue was tested using a simple method, the "batch method", with further analysis by spectrophotometry UV-Vis. The XRF results of green banana peel showed that most of the composition is potassium and phosphorus. The methylene blue adsorption capacity of banana peel material is up to 75.10% with 0.5 grams of adsorbent, which is more significant than in the banana peel, which is 68.04% with 0.2 grams.

Keywords: Green banana peels, adsorption, methylene blue, UV-Vis, adsorbent.

INTRODUCTION

Methylene blue (MB) is one of the thiazine/cationic dyes most commonly used for colouring among all other dyes of its category. It is selected to represent a group of dyes commonly large in molecular size and complicated to be degraded in the natural environment. It is generally used for dyeing cotton, wool, silk, textiles and leather, printing calico and biological staining (Jawad et al., 2018). The disposal of MB dyes into rivers, groundwater systems, and other water sources represents a severe pollution problem.

Several technologies have been developed for dye removal, including coagulation (Hashem & Amin, 2016), adsorption (Çatlıoğlu et al., 2021), photocatalytic degradation (Iqbal et al., 2021). Among these methods, adsorption has shown to be the simplest to apply, efficient and cost-effective to MB removal using adsorbent material. Using natural waste as adsorbent is an effort to make adsorbents cheaper. Biosorbent does not require expensive cost, and is also easy to treat and can be obtained from agricultural or plantation waste. Biomass from agricultural waste has been studied as a renewable energy source and new product. Several studies have carried out the adsorption of methylene blue with natural ingredients such as papaya seeds (Rafatullah et al., 2010), rice husk (Costa & Paranhos, 2019), bagasse (Mpatani et al., 2020), hazelnut shell (Latupeirissa et al., 2018), sugarcane bagasse (Priyanto et al., 2021), orange peels (Kamsonlian et al., 2011), banana peels (Kamsonlian et al., 2011), corn cobs (Alfiany & Bahri, 2013), bark skin (Turmuzi & Syaputra, 2015), and slacca peel (Klemantan, Kristianto, and Arie 2020). Banana is a widely grown tropical fruit cultivated in over 130 countries. The average weight of a fruit is 125 g (fruit content: approximately 75% water and 25% dry matter) (Pathak & Mandavgane, 2015). Furthermore, banana peels contain galacturonic acid, which acts as a compound that can adsorb dyes (Susanti & Santoso, 2020). Therefore, this research was conducted adsorption of methylene blue using the banana peel as an adsorbent.

METHODOLOGY

Materials

The materials used in this research were green banana peels waste collected from Kembangbahu Lamongan, methylene blue (0.3% p.a, Merck), and aquadest (UD Sumber Ilmiah Persada, Surabaya, Indonesia). While the tools used in this research were analytical balance, the batch method set (beaker glass, stirrer, separating funnel, and filter paper),

diffractometer type XPert MDP, XRF diffractometer, and FTIR spectrophotometer.

Methods

Banana peel waste as a raw material in this research was cut and sieved to become banana peel powder. Banana peel powder was washed with distilled water, dried under the sun for seven days then denoted as BP. The BP was characterized by XRD (X-Ray Diffraction) to analyze the composition phase and the crystallite materials. The sample was oven dried at 100°C. The XRD characterization was done using diffractometer type XPert MDP with Cu-Kα radiation, operating voltage of 40kV, 30mA current, and recorded on 2θ of 5-100°. The FTIR (Fourier Transform InfraRed) was studied to analyze the functional groups in BP materials. The BP material was crushed and prepared with KBr forming pellets. Using an FTIR spectrophotometer, the spectra were recorded in the frequency range of 400-4000 cm^{-1}. Furthermore, the BP material was also synthesized by XRF (X-Ray Fluorescence) to analyze the compounds of BP material. The measurement was done with an operating voltage of 30kV and time analysis for 60 seconds.

Methylene Blue Adsorption Test

The BP materials are prepared to be an adsorbent in methylene blue adsorption. The methylene blue adsorption test was tested by batch methods and performed at various times and masses of adsorbent. The concentration of methylene blue was measured using a spectrophotometer UV-Vis corresponds with previous research (Ngapa and Ika, 2020).

RESULTS AND DISCUSSION

Characterization of BP

BP material was prepared in this research characterized by XRD (X-Ray Diffraction) to analyze the phase composition and the crystallite materials, FTIR (Fourier Transform InfraRed) to analyze the functional groups, and XRF (X-Ray Fluorescence) to analyze the compounds of BP material. The XRD characterization of BP material is presented in Figure 1. Based on the XRD patterns of BP, BP showed a hump which indicated an amorphous material due to the composition of BP, such as lignin, pectin and hemicelluloses, with previous literature (Xue et al., 2019). The FTIR characterization of BP material is shown in Figure 2 and aims to elucidate the material's molecular structure.

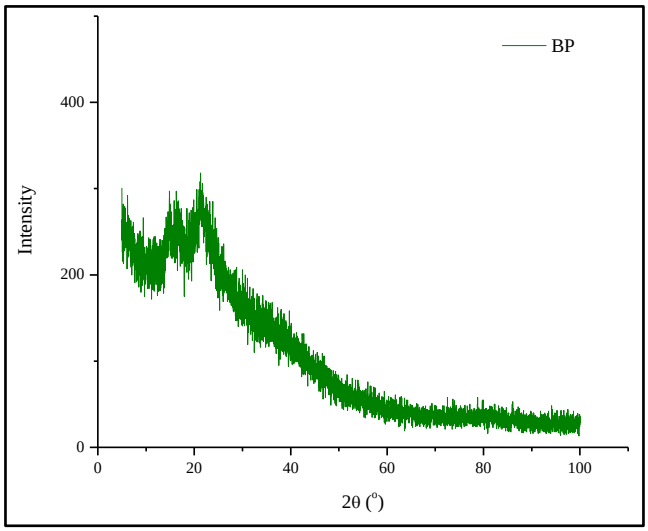

Figure 1. XRD pattern of BP material

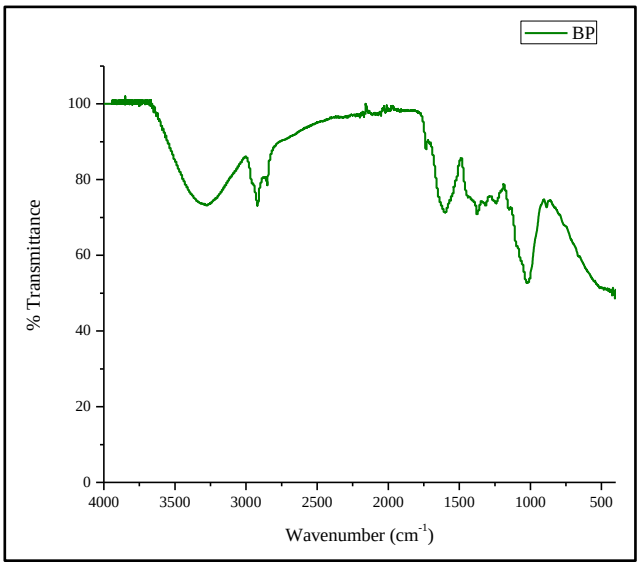

Figure 2. FTIR Spectrum of BP material

Based on the FTIR, the BP material showed a small absorption peak in 920 cm^{-1}, which was attributed to the C-H vibrations of carbohydrates; the band at 1055 cm^{-1} was associated with the C-O-C the band at 1253 cm^{-1} corresponded to the C-O vibrations. The high intensity of the peaks at 1611 cm^{-1} corresponded to carboxylic groups in the ionic form. The peak at 2933 cm^{-1} corresponds with –CH vibrations in aliphatic hydrocarbons, and the peak at 3419 cm^{-1} was associated with –OH from pectin structure or water adsorption O-H groups (Pavia et al., 2000) (Dmochowska et al., 2020).

Table 1.XRF Analysis of Materials

Oxide	Concentration (%)
P_2O_5	2.4
SO_3	0.43
K_2O	96.5
MnO	0.2
Fe_2O_3	0.21
CuO	0.05
Rb_2O	0.004
Re_2O_7	0.2

The XRF of BP composition analysis is shown in Table 1. The BP materials had large quantities of K_2O (96.5%) and P_2O_5 (2.4%). In comparison, the minor compositions of BP were SO_3, MnO, Fe_2O_3, CuO, Rb_2O, and Re_2O_7. It indicated that the main composition of the green banana peel was potassium and phosphorus.

Methylene Adsorption Test on BP Material

The adsorption test of BP material was carried out with a simple "batch method" at various contact times to determine the time equilibrium, as shown in Figure 6 (Moubarak et al., 2014). The trend is increased adsorption capacity with longer contact time and higher adsorbent mass. However, the adsorption process was still not constant at a time of 50 minutes which means the adsorption test can be carried out until the contact time is above 50 minutes.

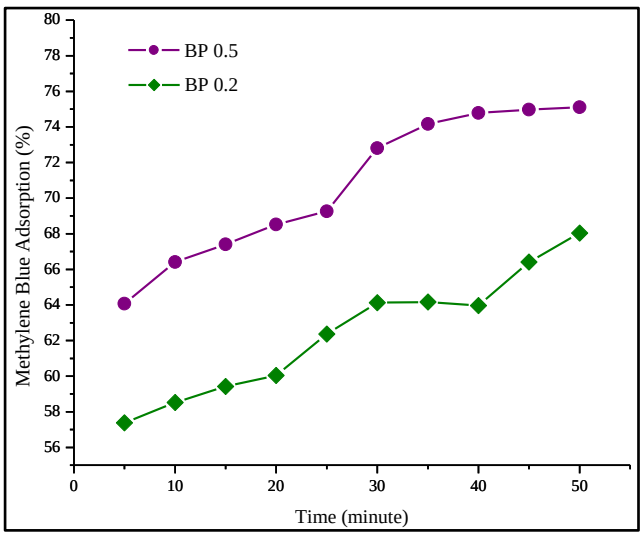

Figure 3. Methylene Blue Adsorption on BP Material

Table 2. Methylene blue adsorption on BP Material

Mass of BP (gram)	MB Adsorption Capacity (%)
0.2	68.04
0.5	75.10

Based on Figure 3 and Table 2, BP has the highest adsorption capacity of methylene blue in the value of 68.04% and 75.10% in 0.2 grams and 0.5 grams adsorbent, respectively. It was implied that using the adsorbent mass of 0.5 grams proved that a more significant amount of methylene blue was adsorbed.

CONCLUSION

This research showed that BP material had large quantities of K2O and P2O5, which are 96.5% and 2.4%, respectively. The result was also showed that methylene blue can be absorbed by BP material up to 75.10% with 0.5 gram of adsorbent, which greater than 0.2 gram, which is only 68.04%. Furthermore, the adsorption capacity was increased alongside the contact time.

ACKNOWLEDGMENT

The authors wish to thank the Litbangpemas Universitas Islam Lamongan for the research grant under the PDP scheme and for providing the facilities for this research.

REFERENCES

Alfiany, Herlin, & Syaiful Bahri. (2013).Kajian Penggunaan Arang Aktif Tongkol Jagung Sebagai Adsorben Logam Pb Dengan Beberapa Aktivator Asam." *Jurnal Natural Science 2*(3):75-86.

Çatlıoğlu, Fatmanur, Sema Akay, Ersan Turunç, Belgin Gözmen, Ioannis Anastopoulos, Berkant Kayan, & Dimitrios Kalderis. (2021). Preparation and Application of Fe-Modified Banana Peel in the Adsorption of Methylene Blue: Process Optimization Using Response Surface Methodology." *Environmental Nanotechnology, Monitoring and Management* 16(February). doi: 10.1016/j.enmm.2021.100517.

Costa, José Arnaldo Santana, & Caio Marcio Paranhos (2019). Evaluation of Rice Husk Ash in Adsorption of Remazol Red Dye from Aqueous Media. *SN Applied Sciences 1*(5). doi: 10.1007/s42452-019-0436-1.

Dmochowska, Anna, Joanna Czajkowska, Roman Jędrzejewski, Wojciech Stawiński, Paweł Migdał, & Marta Fiedot-Toboła. (2020). Pectin Based Banana Peel Extract as a Stabilizing Agent in Zinc Oxide Nanoparticles Synthesis. *International Journal of Biological Macromolecules 165*:1581-92. doi: 10.1016/j.ijbiomac.2020.10.042.

Hashem, F. S., & M. S. Amin. (2016). Adsorption of Methylene Blue by Activated Carbon Derived from Various Fruit Peels. *Desalination and Water Treatment 57*(47):22573-84. doi: 10. 1080/19443994.2015.1132476.

Iqbal, Rendy Muhamad, Indri Susanti, Rahadian Abdul Rachman, Tri Agusta Pradana, & Erwin Prasetya Toepak. (2021). Synthesis, Characterization, and Photocatalytic Activity of N-Doped TiO2/Zeolite-NaY for Methylene Blue Removal. *The Journal of Pure and Applied Chemistry Research 10*(2):132-39. doi: 10.21776/ub.jpacr.2021.010.02.572.

Jawad, Ali H., Ramlah Abd Rashid, Mohd Azlan Mohd Ishak, & Khudzir Ismail. (2018). Adsorptive Removal of Methylene Blue by Chemically Treated Cellulosic Waste Banana (Musa Sapientum) Peels. *Journal of Taibah University for Science*. *12*(6):809-19. doi: 10.1080/16583655.2018.1519893.

Kamsonlian, S., S. Suresh, C. B. Majumder, & S. Chand. (2011). Characterization of Banana and Orange Peels : Biosorption Mechanism. *International Journal of Science Technology & Management 2*(4):1-7.

Klemantan, Johan, Hans Kristianto, & Arenst Andreas Arie. (2020). Microwave Assisted KOH Activation of Salacca Peel Dericed Activated Carbons as Adsorbents for Methylene Blue Removal from Aqueous Phase. *IOP Conference Series: Materials Science and Engineering 742*(1). doi: 10.1088/1757-899X/742/1/012046.

Latupeirissa, Jola, Matheis F. J. D. P. Tanasale, and Sigit Hardianto Musa. (2018). Kinetika Adsorpsi Zat Warna Metilen Biru Oleh Karbon Aktif Dari Kulit Kemiri (Aleurites Moluccana (L) Willd). *Indo. J. Chem. Res.* 6(1):12-21. doi: 10.30598//ijcr.2018.6-jol.

Moubarak, Faiçal, Rachid Atmani, Ibtissam Maghri, M'hamed Elkouali, Mohammed Talbi, Mona Latifa Bouamrani, Mohammed Salouhi, & Abdelkbir Kenz. (2014). Elimination of Methylene Blue Dye with NaturalAdsorbent Banana Peels Powder. *Global Journal of Science Frontier Research: B Chemistry 14*(1):1-7.

Mpatani, Farid Mzee, Aaron Albert Aryee, Alexander Nti Kani, Kang Wen, Evans Dovi, Lingbo Qu, Zhaohui Li, & Runping Han. (2020). Removal of Methylene Blue from Aqueous Medium by Citrate Modified Bagasse: Kinetic, Equilibrium and Thermodynamic Study. *Bioresource Technology Reports* 11(May):100463. doi: 10.1016/j.biteb.2020.100463.

Ngapa, Yulius Dala, and Yasinta Embu Ika. (2020). Optimasi Adsorpsi Kompetitif Pewarna Biru Metilena Dan Metil Oranye Menggunakan Adsorben Zeolit Alam Ende-Nusa Tenggara Timur (NTT). *Indo. J. Chem. Res.* 8(2):151–59. doi: 10.30598//ijcr.2020.8-ydn.

Pathak, Pranav D., & Sachin A. Mandavgane. (2015). Preparation and Characterization of Raw and Carbon from Banana Peel by Microwave Activation: Application in Citric Acid Adsorption. *Journal of Environmental Chemical Engineering 3*(4):2435–47. doi: 10.1016/j.jece. 2015.08.023.

Pavia, Donald L., Gary M. Lampman, George S. Kriz, & James R. Vyvyan. (2008). *Introduction to Spectroscopy 4th Edition*, Cengage Learning Publisher, USA.

Priyanto, Ade, Malik F, Muhdarina Muhdarina, and Awaluddin A. (2021). Adsorption and Characterization of Activated Sugarcane Bagasse Using Natrium Hydroxide. *Indo. J Chem. Res.* 8(3):202-9. doi: 10.30598 //ijcr.2021.7-ade.

Rafatullah, Mohd, Othman Sulaiman, Rokiah Hashim, & Anees Ahmad. (2010). Adsorption of Methylene Blue on Low-Cost Adsorbents: A Review. *Journal of Hazardous Materials 177*(1-3):70-80. doi: 10.1016/j.jhazmat.2009.12.047.

Susanti, Indri, & Agus Santoso. (2020). Efektivitas Lempung Alam Dan Kulit Pisang Sebagai Bahan Komposit Untuk Adsorpsi Metilen Biru. *Barometer 5*(2):258-60. doi: 10.35261/ barometer.v5i2.3803.

Turmuzi, Muhammad, & Arion Syaputra. (2015). Pengaruh Suhu Dalam Pembuatan Karbon Aktif Dari Kulit Salak (Salacca Edulis) Dengan Impregnasi Asam Fosfat (H_3PO_4). *Jurnal Teknik Kimia USU 4*(1):42-46.

Xue, Mingzhe, Wanzheng Lu, Chen Chen, Yan Tan, Bing Li, & Cunman Zhang. (2019). Optimized Synthesis of Banana Peel Derived Porous Carbon and Its Application in Lithium Sulfur Batteries. *Materials Research Bulletin* 112 (December 2018):269-80. doi: 10.1016/j. materresbull.2018.12.035.