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Optimisation of pH and Dosage of Banana Peel Activated Carbon in Removing Colour From Textile Wastewater

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Abstract: Textile wastewater is one of contributors to water pollution. Many stages have been involved in the processing of textiles, and most of the process generated wastewater. The wastewater contains chemical substances and colouring agents that may affect to water pollution. However, problem-related to textile wastewater is the high concentration of colour from dyes stuff, i.e., harmful to surrounding, especially human and environment. Improper treatment of the textile wastewater happened when the wastewater discharges to the receiving environment. This study was conducted to optimise pH and dosage in removing colour from the textile wastewater. Adsorption method was applied to reduce the concentration of colour in effluents. Activated carbon from banana peel was used to get the optimum value of pH and dosage by using batch study experiment. Batch study experiment was conducted with different pH and dosage from the range of pH 5 to 10 and amount of activated carbon 2g to 6g. The result of removal colour by using DR6000 Spectrophotometer was used to analysis colour obtained. From the experiment, the optimum value of pH and dosage for removal of colour from the textile sample are found to be at pH 8, and the amount of dosage is 4g. It shows that by using banana peel activated carbon it can improve the textile wastewater treatment for colour removal.

Keywords: Activated Carbon, Adsorption, Banana Peel, Colour

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1. Introduction

Nowadays, the demands of apparel have become higher due to the sense of style in fashion. Many textile factories were set up to meet growing demands. In the normal practice textile wastewater from the types of non-basic colours, the process needs a mix of colour with various chemicals or heavy metals, e.g., ferum and lead [1]. Several stages were involved in textile production and wastewater was generated in most of the process [2]. The wastewater effluent includes mainly organic solvents, along with oils and agents used for colouring. Wastewater from printing and colouring plants is also rich in colour. It includes contaminants of reactive colours and chemicals, e.g., complex parts, other aerosols, significant quantities of chemical oxygen demand and biological oxygen demand concentration as well as products that are much more difficult to remove [3].

The textile industry is considered one of the contributors to water pollution. The pollution of textile wastewater comes from dyeing and finishing processes [4].The colour is applied to the fibres at this phase, which different chemicals may be utilised to enhance the adsorption process between fibres and colour [1]. The dyeing process involves large quantities of wastewater. As the pollutants released from this process, it were very dangerous to the environment as well as to the human being. For the application of dyes and various finishing chemicals, water is used as the primary tool. Due to not all of the process contains for the final product, some of them became waste and caused disposal problems. It is important to remove these pollutants from the wastewater before their final disposal [5]. Figure 1 illustrates the causes of pollutants in textile wastewater. Many methods were explored by textile industriesto solve this issue, e.g., oxidation/reduction, electrochemical treatment, filtration, or precipitation, but it may be ineffective and cost-expensive [6]. Adsorption is one of the good solutions as it functions to remove dyes for the treatment of textile wastewater at a lower cost.

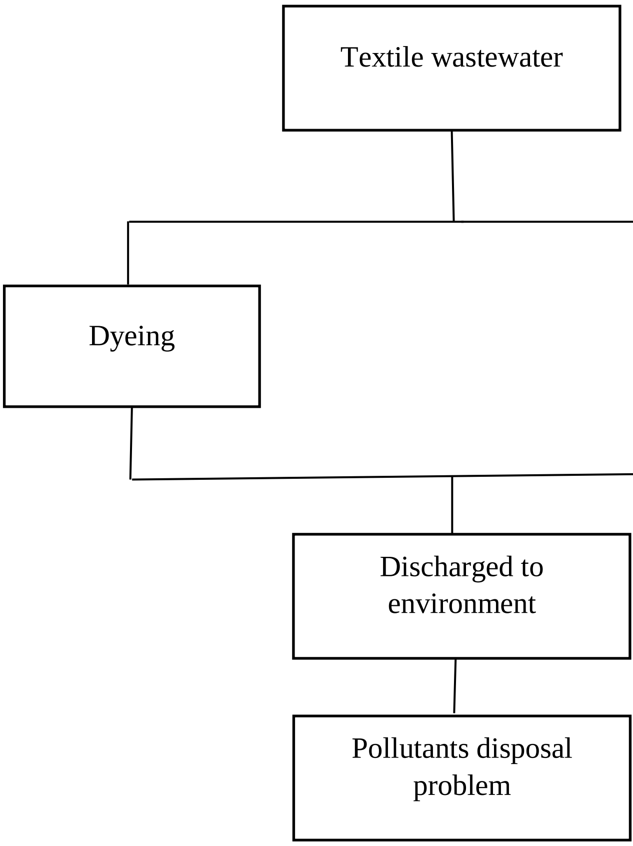

Figure 1: The causes of pollutants in textile wastewater

In this study, adsorption was run by using banana peel activated carbon (BPAC). Activated carbons are known as highly effective adsorbents due to their highly developed porosity, variable surface chemistry characteristics and high surface reactivity [6]. According to Khusaibi *et al.* banana peel are strong antioxidant and colour absorber [7]. Thus, the objective of this study is to optimize the pH and dosage for removing colour from textile wastewater.

2. Materials and Methods

2.1 Textile wastewater sampling

The sample of textile wastewater was collected from the textile factory in area Sri Sulong, Batu Pahat, Johor. The sample was directly collect from the secondary clarifier treatment in the wastewater treatment plant of the fabric manufacturing during peak flow which in optimum process. In this study, three high density polyethylene (HDPE) bottles were used to collect the sample.

2.2 Preparation of activated carbon

Banana peel used in this study was collected from the Small Medium Industry (SMI) in Senggarang, Batu Pahat. The banana peels were washed immediately to maintain the condition and moisture content. The collected material then was washed for three times with tap water and then once with distilled water to remove dirt and contaminants present [8]. The banana peels were sun-dried for ±7 days and moved to oven-dry at 60 ^oC for ±5 hours until reaching a constant weight. Then, the banana peels were impregnated with 25% phosphoric acid (H_3PO_4) for 6 hours and oven-dry at 110 ^oC for 24 hours. Next, impregnated-banana peel was carbonised at 470 ^oC. After that, banana peel activated carbon was washed again with distilled water at a temperature of 90 ^oC until reached neutral pH. It used to remove stains and suspended impurities. After washed, the activated carbon was dried in an oven for 2 hours at 110 ^oC, and the sample was weighted before ground into powder through 425-micron sizes for testing [9].

2.3 Batch study experiments

The experiments of batch adsorption were conducted to study the optimum removal of colour from textile wastewater [10]. The investigation was done to study two parameters in the sequence of pH and dosage in colour removal at each different batch experiment. Each experiment was conducted for three times with blank samples to get an approximate value and to reduce error. So, accurate results can be obtained. The blank sample was used for each series of experiments as controls. In this experiment, different pH value was conducted. The pH value was between 5 to 10 (5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5, and 10) [11]. The pH adjustment of solutions was made using 0.01M NaOH and 0.01M HCl solution. The volume of sample for each experiment was constant, which was 100 mL and placed in 250 mL conical flask. Batch adsorption experiment was performed with a constant amount of activated carbon, i.e., 4g for whole experiments. Then, the sample was agitated at 125 rpm at 90 minutes under room temperature as in Figure 2. After that, the sample was filtered using Whatman filter paper [10]. From that, the observed changes in the sample can be seen. The entire experiment was repeated by varying the dosage of banana peels activated carbon, which was range 2.0g to 6.0g with constant pH.

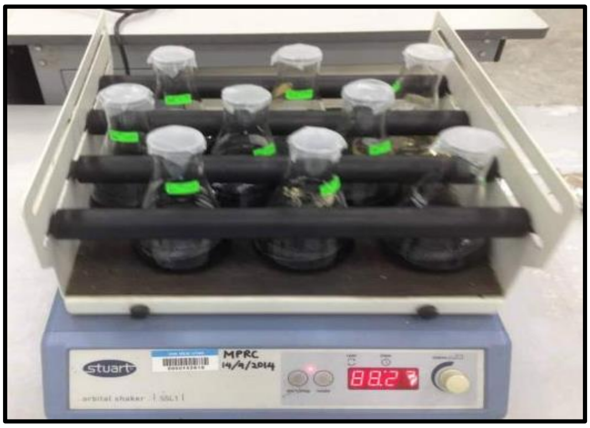

Figure 2: Shaking of a mechanical shaker with sample and activated carbon

2.3 Spectrophotometer Method

DR6000 Spectrophotometer HACH as in Figure 3 was used to analyse the concentration of colour from the textile wastewater sample. It has a high-speed wavelength of 190 to 1100 nm. By using this DR6000 Spectrophotometer, the maximum optimum value of pH and dosage to remove colour can be obtained.

Figure 3: DR 6000 Spectrophotometer HACH

The batch study was analysed to find the optimum condition of the pH and dosage to remove the colour. The removal efficiency of the amount of colour and uptake capacity of adsorption can be calculated by using Eq. (1) and (2):

$$\textit{Removal efficiency (\%)} = [(Co\text{-}Ce) / C0] \times 100 \quad (1)$$

where Co is the initial colour concentration (ADMI)and Ce is the final concentration of colour.

$$q = (Co\text{-}Ce)\,(V / m) \quad (2)$$

where q is the colour uptake (mg/g), Co is the initial concentration of colour, Ce is the final concentration of colour, V is the volume of solution (L), and m is mass of adsorbent (g).

3. Results and Discussions

The adsorption is the process by which the gas molecules, vapour, or liquid spontaneously concrete at the contacting surface without undergoing any reaction. Furthermore, adsorption is the adhesion of a chemical material (adsorbate) onto the solid's surface (adsorbent). In this study, the observation of adsorption capacity of banana peels activated carbon using parameter dosage and pH was applied for removal of textile dyes.

3.1 Effect of pH on colour removal from textile wastewater

The pH range was evaluated at pH in between 5 to 10 study the effect of pH on the colour removal of banana peel activated carbon, as in Table 1. Based on Table 1, it can be observed that the maximum removal of colour from the textile wastewater is at pH 8. The percentage of colour removal was 98.34%.From the previous studies, the removal kindly depends on pH, and it is observed that adsorbent shows the change in adsorption capacity with variation in pH [10]. Besides, the high removal efficiency at higher pH, i.e., at pH 8 is a possibility due to hydrogen bonding or weak force between adsorbent and adsorbate [12].

Table 1: The results of colour concentration of pH

pH	Initial colour concentration (ADMI)	Final colour concentration (ADMI)	Percentage of colour removal (%)	Uptake Capacity (mg/g)
5.0	241	6.7	97.22	5.86
5.5	241	6.0	97.51	5.88
6.0	241	6.0	97.51	5.88
6.5	241	8.3	96.56	5.83
7.0	241	7.0	97.05	5.85
7.5	241	6.3	97.39	5.87
8.0	241	4.0	98.34	5.93
8.5	241	6.7	97.22	5.86
9.0	241	7.3	96.97	5.84
9.5	241	10.0	95.85	5.78
10.0	241	5.7	97.63	5.88

From Figure 4, after it reached the optimum value of pH, the removal decreased with the increase of the pH solution, i.e., pH 8.5, 9 and 9.5. It happened due to the presence of H^+ ion competing with cations in colour leads to lower adsorption at lower pH when reaching the increment in pH [13].

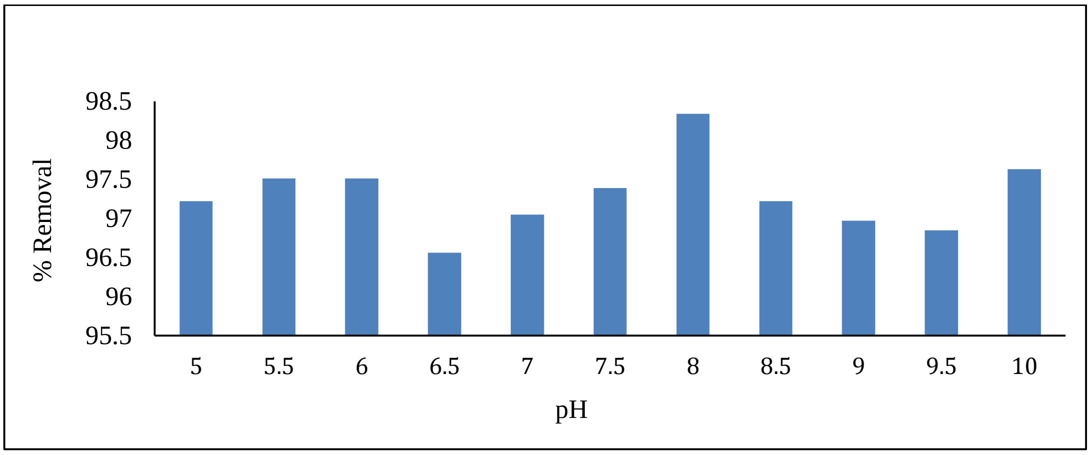

Figure 4: Effect of pH on colour removal of textile wastewater

The uptake capacity was shown in Figure 5. From the figure, the pattern of the graph shows the highest uptake capacity was at pH 8. The highest uptake capacity for the banana peel to remove the colour is 5.93 mg/g with the 98.34% of removal on the pH 8.

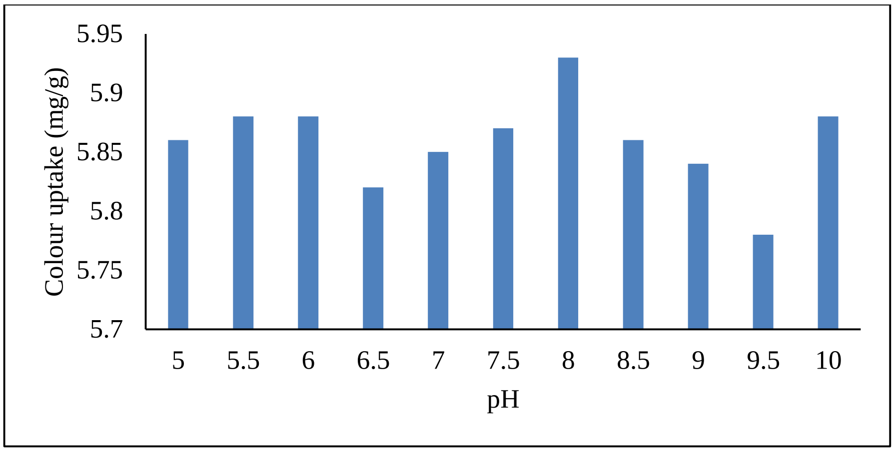

Figure 5: Effect of pH in uptake capacity using banana peel activated carbon

3.2 Effect of dosage on colour removal from textile wastewater

The effect of dosage was investigated on the adsorption of banana peel activated carbon. Different dosage of adsorbent as in Table 2 was taken from 2-6 g with 100 mL textile effluent in a conical flask in a mechanical shaker at 125 rpm with room temperature. Based on the table, the evaluated dosage shows that the maximum colour removal efficiency for banana peel activated carbon is at 4 g, i.e., 92.24% in 100 mL of textile wastewater sample. As can be shown, the amount of colour loss was increased with the increasing of adsorbent. Increase of adsorption happens because of an increase in the surface area of the adsorbent, which effectively increases the amount of binding sites when it remains unsaturated along with the adsorption reaction [14].

Table 2: The results of the colour concentration of dosage

Dosage (g)	Initial colour concentration (ADMI)	Final colour concentration (ADMI)	Percentage of Colour removal (%)	Uptake capacity (mg/g)
2	241	38	83.23	10.15
3	241	40	83.40	6.70
4	241	18.7	92.24	5.56
5	241	19.3	91.99	4.43
6	241	20.7	91.41	3.67

From the graph in Figure 6 shows that the percentage of removal of colour increase from dosage 2 to 4 g, but adsorption does not show additional improvement at dosage 5 and 6 g. It was found decreasing further, and the removal efficiency is insignificant with an increase in dosage when have reached the optimum of dosage. Removal efficiency is insignificant may because of aggregation happen at the active sites of the adsorbents that limited to adsorb high amount of colour [3].

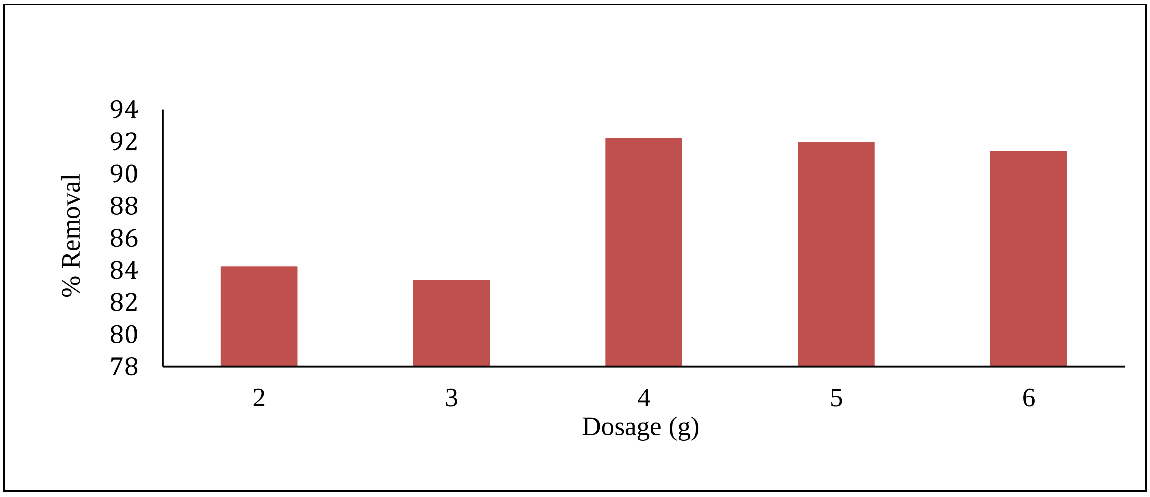

Figure 6: Effect of dosage on colour removal of textile wastewater

The results of the uptake capacity of the dosage were shown in Figure 7. The uptake capacity of dosage was found decreases from 10.15 to 3.67 mg/g. For the dosage amount of 4 g, the uptake capacity found was 5.56 mg/g. It can be concluded that the optimum condition of dosage in the adsorption process by using banana peel activated carbon was 4 g because it has the highest removal of colour.

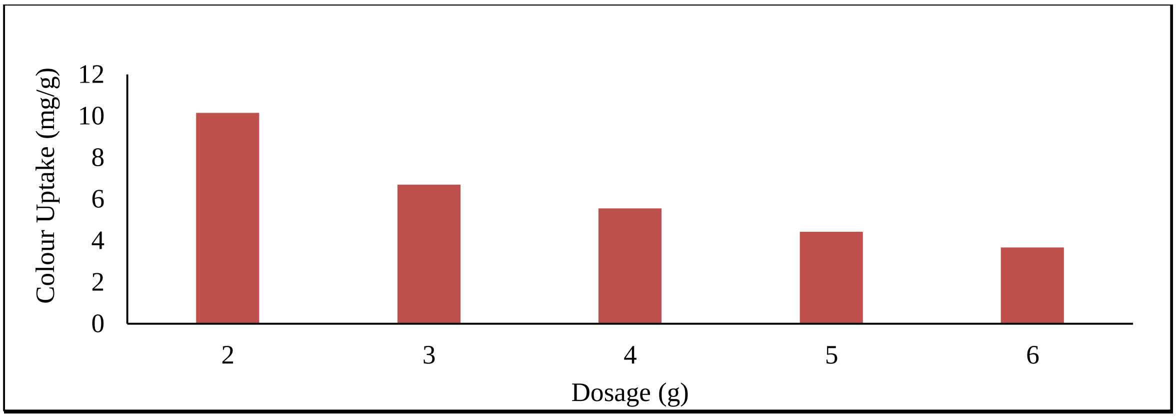

Figure 7: Effect of dosage in uptake capacity using banana peel activated carbon

4. Conclusion

Based on this study, the modification of banana peel with acid treatment has slightly improved the colour adsorption capacity than using the raw banana peel. H_3PO_4 was used to impregnate the banana peel for the activation process. Overall, the objectives of this study can be achieved for the removal of colour using two factors, i.e., pH and dosage. The optimum value of the pH and dosage has been evaluated from the results obtained. From the batch study experiment, the result of the study shows that the adsorbent was effective at pH 8. The removal of the colour concentration is □98%. The optimum dosage achieves from this experiment was 4 g with the removal colour efficiency at □92%. Although the use of dosage quite big, it due to the type of banana and also the process of preparation to produce the adsorbent. Despite that, it can be proved that banana peel activated carbon is one of the alternative adsorbents for the adsorption, which can be used to remove colour for the treatment of textile wastewater. Besides, the usage of banana peel activated carbon from waste materials has great potential as the low-cost adsorbent to increase the performance of textile wastewater treatment. Hence, recycling banana peel waste can help to protect the environment from pollution.

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References

[1] D. A. Yaseen and M. Scholz, "Textile dye wastewater characteristics and constituents of synthetic effluents: A critical review," Int. J. Environ. Sci. Technol., pp. 1–34, 2018, doi: org/10.1007/s13762-018-2130-z.

[2] S. Dey and A. Islam, "A review on textile wastewater characterization in Bangladesh," Resour. Environ., vol. 5, no. 1, pp. 15–44, 2015, doi: 10.5923/j.re.20150501.03.

[3] I. W. K. Suryawan, Q. Helmy, and S. Notodarmojo, "Textile wastewater treatment: Colour and COD removal of reactive black-5 by ozonation," IOP Conf. Ser. Earth Environ. Sci., vol. 106, no. 1, pp. 1–6, 2018, doi: 10.1088/1755-1315/106/1/012102.

[4] F. M. D. Chequer, G. A. R. de Oliveira, E. R. A. Ferraz, J. C. Cardoso, M. V. B. Zanoni, and D. P. de Oliveira, "Textile dyes: Dyeing process and environmental impact," in Eco-Friendly Textile Dyeing and Finishing, 2013, pp. 151–176.

[5] R. Kant, "Textile dyeing industry an environmental hazard," *Nat. Sci.*, vol. 4, no. 1, pp. 22–26, 2012, doi: org/10.4236/ns.2012.41004.

[6] S. Mohammad, S. Ahmed, A. Badawi, and D. El-Desouki, "Activated carbon derived from Egyptian banana peels for removal of cadmium from water," J. Appl. Life Sci. Int., vol. 3, no. 2, pp. 77–88, 2015, doi: 10.9734/jalsi/2015/16652.

[7] T. M. Al Khusaibi, J. J. Dumaran, M. G. Devi, L. N. Rao, and S. Feroz, "Treatment of dairy wastewater using orange and banana peels," Treat. Dairy Wastewater using Orange Banan. Peels Thuraiya, vol. 7, no. 4, pp. 1385–1391, 2015.

[8] O. P. Prastuti, E. L. Septiani, Y. Kurniati, Widiyastuti, and H. Setyawan, "Banana peel activated carbon in removal of dyes and metals ion in textile industrial waste," Mater. Sci. Forum, vol. 966, pp. 204–209, 2019, doi: 10.4028/www.scientific.net/MSF.966.204.

[9] S. Gautam and S. H.Khan, "Removal of methylene blue from waste water using banana peel as absorbent," Int. J. Sci. Environ., vol. 5, no. 5, pp. 3230–3236, 2016.

[10] N. Zerin and K. A. Mohiuddin, "Removal of color from textile wastewater by adsorption," in Proceedings of the 3rd International Conference on Civil Engineering for Sustainable Development, 2016, no. February, pp. 313–322.

[11] H. Gupta and R. Kumar, "Removal of PAH anthracene from aqueous media using banana peel activated carbon," Int. J. Sci. Res. Environ. Sci., vol. 4, no. 4, pp. 109–114, 2016, doi: 10.12983/ijsres-2016-p0109-0114.

[12] N. K. Mondal and S. Kar, "Potentiality of banana peel for removal of Congo red dye from aqueous solution : isotherm , kinetics and thermodynamics studies," Appl. Water Sci., vol. 8, no. 157, pp. 1–12, 2018, doi: 10.1007/s13201-018-0811-x.

[13] M. A. M. Razi, M. N. A. M. Hishammudin, and R. Hamdan, "Factor affecting textile dye

removal using adsorbent from activated Carbon: A Review," MATEC Web Conf., vol. 103, pp. 1–17, 2017, doi: 10.1051/matecconf/201710306015.

[14] O. Prachpreecha, K. Pipatpanyanugoon, and P. Sawangwong, "A study of characterizations and efficiency of activated carbon prepared from peel and bunch of banana for methyl orange dye adsorption," IOSR J. Environ. Sci. Ver. II, vol. 10, no. 4, pp. 2319–2399, 2016, doi: 10.9790/2402-1004021726.