Effect of pH and Concentration on Biosorption Malachite Green and Rhodamine B Dyes using Banana Peel (Musa balbisiana Colla) as Biosorbent

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Abstract. All Biosorption of Malachite green and Rhodamine B dyes using banana peel (Musa balbisiana Colla) as a biosorbent has been carried out. The purpose of this study was to determine the effect of pH and concentration for biosorption of Malachite green and Rhodamine B by banana peel biosorbent (Musa balbisiana Colla). The method used is the batch method. The maximum wavelength of Malachite green is 618 nm and Rhodamine B 555 nm measured by the UV-Vis Spectrophotometer. The results showed that the optimum conditions for Malachite green adsorption occurred at pH 3, a concentration of 100 ppm 8.0662 mg/g. The optimum conditions for Rhodamine B adsorption occurred at pH 3, a concentration of 120 ppm 16.6614 mg/g. The adsorption isotherm of Malachite green with banana peel (Musa balbisiana Colla) biosorbent tends to follow the Freundlich isotherm with a determinant coefficient (R²) of 0.9996 and Rhodamine B 0.9884.

1. Introduction
Environmental pollution is a quite complicated problem faced by the community and government that has not been resolved properly. One of the problems that occur is due to solid waste or liquid waste. Pollution of the aquatic environment is caused by several factors, including the growing population of people, rapid urban progress, as well as the growing number of industries. This waste is generally disposed of into water areas which cause damage to the ecosystem in the waters and damage the aesthetic value in the environment [1].

Waste can come from textiles, plastics, medicine, cosmetics [2], paper, printing and food industries [3]. Dyes are used in large quantities to color products and are a major source of dye waste. The dyestuff waste that is commonly found is Malachite green and Rhodamine B. Malachite green is one of the basic dyestuffs, the basic ingredient is salt from the organic base color containing the amino [4]. Malachite green is classified as a triphenylmethane dye which is widely used in the textile industry because of its brilliant color, attractive effects, low price and easy to find. But it is carcinogenic. Rhodamine B is a cationic dye from the xanthene class which is widely used in optical science, biology, and analytic. Rhodamine B dye is widely used in the textile industry, namely in the batik coloring process.
Dyestuff waste is an organic compound that is difficult to overcome with conventional methods due to several things such as its complex chemical structure, in terms of color, particle size and difficulty in biodegradation by certain living things. The result is water pollution, so that the availability of water in the community is disturbed and causes various kinds of diseases such as carcinogenic, teratogenic, mutagenic and other diseases that cause disturbance and damage to human organs due to these harmful dyes [5].

Various methods have been carried out to deal with dyes, namely through degradation [6], oxidation, coagulation-flocculation, photocatalytic degradation. The biosorption method appears to be an attraction to overcome this problem which is expected to be able to overcome as a whole. Biosorption is considered effective and environmentally friendly because of its high efficiency, easy operation, and relatively low cost [7].

The biosorption method uses biomass called a biosorbent which is rich in functional groups. This functional group will play a role in binding the biosorbate. Many sources of biosorbents that have been used include banana peels [8], corn [7], applewood[2], cocoa peels [4].

Banana peel is a polysaccharide that is efficiently used as a biosorbent to absorb metals, organic compounds, and dyes. In previous research banana peels have been used to absorb harmful metals such as Mn[9], and Sr[10], phenol [11] and several dyes, namely methylene blue [12]. Banana peels have several chemical components such as pectin, lignin, cellulose, hemicellulose [13]. Various functional groups that play an active role on the surface of banana peels, namely carboxyl (COO), hydroxyl (OH) and amines (NH\textsubscript{2}), have been widely shown to play an important role in the biosorption process [14].

Based on the description above, this study will examine the absorption of Malachite green and Rhodamine B dyes in water using banana peels (Musa balbisiana Colla) as a biosorbent by batch method.

2. Research methods

2.1. Preparing the biosorbents
Banana peel (Musa balbisiana Colla) is cleaned, cut and washed with distilled water then dried. Then mashed and sieved with particle size 150 μm. Biosorbent was activated with 0.1 M HNO\textsubscript{3} for 2 hours, washed with distilled water until neutral. Characterization using Fourier Transform Infrared Spectroscopy (FTIR).

2.2. Treatment by batch method
2.2.1. Effect of pH. 25 mL of Malachite green and Rhodamine B solutions with a pH of 2, 3, 4, 5, 6 and 7. Each was contacted with a banana peel mass of 0.2 gram with a particle size of 150 μm using the batch method. The solution is then shaken at 200 rpm. Then the solution was filtered, the absorbance of the filtrate was measured with a wavelength of Malachite green 618 nm, Rhodamine B 555 nm using a UV-Vis spectrophotometer until the optimum pH was obtained.

2.2.2. Effect of solution concentration. A 25 mL Malachite green solution with a concentration of 120, 100, 80, 60 and 40 ppm was prepared at optimum pH conditions, then the solution was contacted with 0.2 gram of biosorbent with a particle size of 150 μm by batch method. The solution is then shaken at 200 rpm. Then filtered, the absorbance of the filtrate was measured with a wavelength of Malachite green 618 nm Rhodamine B 555 nm using a UV-Vis spectrophotometer to obtain the optimum concentration.

3. Results and discussion

3.1. Analysis Fourier Transform Infrared Spectroscopy (FTIR)
FTIR characterization was carried out to analyze the functional groups present in the skin of banana peels (Musa balbisiana Colla). In this study, the wavenumber 4000 - 600 cm\textsuperscript{-1} was used.
In Figure 1, it can be seen that the inactivated banana peel shows that the peak stretch of Hydroxyl (−OH) appears at the wave number 3330 cm$^{-1}$ with a transmittance value of 13.42% T which is the stretching vibration of O-H. A wavenumber 2926 cm$^{-1}$ shows a stretching vibration where there is a stretch of the functional group -CH with a transmittance value of 7.35% T, and at wavenumber 1605 cm$^{-1}$ indicates a stretching of the functional group C = O (carbonyl) with a transmittance value of 13.49% T [14].

In the activated banana peel biosorbent, the stretching of the hydroxyl peaks - (OH) showed a stretch vibration so that it appeared at the wave number 3333 cm$^{-1}$ with a transmittance value of 13.23% T. The transmittance value obtained is 9.32% T. Furthermore, the stretching of the functional group -C = O occurs with a change in the absorption band with a shift appearing at the wavenumber 1622 cm$^{-1}$ with the transmittance value obtained of 2.21% T. Changes that occur in functional groups involved so that the change in wave number occurs. At the time of activation, it allows some compounds to be broken down causing a change in wave number. Then it is also caused by the vibration which causes the bond changes.

3.2. Effect of pH

The effect of pH on the adsorption capacity of Malachite green and Rhodamine B by banana peel (*Musa balbisiana* Colla) can be seen in Figure 2.
Figure 2. Effect of pH of the solution on the adsorption of Malachite green and Rhodamine B using banana peel (Musa balbisiana Colla) as a biosorbent

Figure 2 shows that the biosorption of Malachite green with the biosorbent of banana peel (Musa balbisiana Colla) is optimum at pH 3 with an adsorption capacity of 6.1810 mg / g. In this study, the optimum pH was found at pH 3 with an adsorption capacity of 5.1620 mg/g. At low pH, the influence of H⁺ ions from HCl in the solution is more so that the interaction between the active site of the biosorbent and the biosorbate is less. Then at pH 4 to 7 the adsorption capacity decreases. The OH⁻ group from NaOH added provides an opportunity to interact with one of the functional groups found in the biosorbent of the banana peel (Musa balbisiana Colla)[11].

3.3. Effect of solution concentration

The initial solution concentration of Malachite green and Rhodamine B dyes solution is an important parameter to determine the biosorbent capacity of banana peel (Musa balbisiana Colla) in adsorbing In the biosorption process, the biosorbent was contacted with a solution of Malachite green and Rhodamine B dyes with a concentration variation of 40 - 120 ppm with optimization conditions of pH 3. The effect of the solution concentration can be seen in Figure 3.

Figure 3. Effect of solution concentration of Malachite green and Rhodamine B on adsorption of banana peel (Musa balbisiana Colla)
Figure 3 shows that the biosorption capacity of dyes has increased according to the increase in the concentration of Malachite green and Rhodamine B used. When the initial concentration of Malachite green was increased from 40 ppm to 120 ppm, the biosorption capacity also increased. Optimization occurred at a concentration of 100 ppm with a biosorption capacity of 8.0662 mg/g. Increased biosorption capacity because the Malachite green ion which was bound to the active side of banana peel biosorbent increased. This is because the number of ions adsorbed is proportional to the number of active sites available in the biosorbent [15]. When the active site of the biosorbent is saturated, it appears that at a concentration of 120 ppm, the biosorption capacity will decrease.

The optimum condition Rhodamine B at a concentration of 120 ppm with an adsorption capacity of 16.8814 mg/g. During the Rhodamine B adsorption process, the biosorbent has the maximum ability to take up Rhodamine B continuously before reaching the equilibrium time. So that the density of the biosorbent exchange is occupied with Rhodamine B. The efficiency of increasing the adsorption of Rhodamine B by the Biosoben of banana peels starts from a low concentration of Rhodamine B to a high concentration of Rhodamine B until it reaches equilibrium.

The equilibrium of the adsorption isotherm is obtained from the straight line equilibrium curve relationship. The equilibrium model is determined from the price of the determinant coefficient (R²) which is the highest. The purpose of determining the adsorption isotherm is to show the relationship between adsorption capacity. The adsorption isotherm curve based on Langmuir isotherm and Freundlich isotherm can be seen in Figure 4.

![Figure 4](image-url)
Figure 4 shows that the adsorption of Malachite green and Rhodamine B by banana peel biosorbent (Musa balbisiana Colla) tends to follow Freundlich’s isotherm. The value of the determinant coefficient (R^2) of Freundlich isotherm higher was 0.996 for Malachite green (b) and 0.9884 Rhodamine B (d). This indicates that Malachite green and Rhodamine B which is adsorbed to form a multilayer layer with the active side surface of banana peel (Musa balbisiana Colla) is heterogeneous. The adsorbed molecules are easily released because they do not bind strongly [16].

4. Conclusion

The optimum condition for Malachite green biosorption using banana peel (Musa balbisiana Colla) biosorbent is at a pH of 3 and a concentration of 100 ppm with an optimum adsorption capacity of Malachite green 8.0662 mg/g (Figure 3). The optimum conditions for Rhodamin B biosorption were at pH 3 and a concentration of 120 ppm with an optimum adsorption capacity of Malachite green 16.8814 mg/g (Figure 3). The adsorption isotherm equilibrium tends to follow the Freundlich isotherm model with R^2 = 0.9996 for Malachite green (Figure 4 (b)) and 0.9884 for Rhodamine B (Figure 4 (d)).

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