

# Optimization of Phenol Absorption Using Banana Peel (*Musa balbisiana* Colla) as Biosorbent

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## ABSTRACT

Pollution of phenol compounds is a serious problem for the environment. Phenols are toxic and hazardous materials because they have high toxicity in water causing disturbance to aquatic ecosystems and human health. Biosorption is a simple and efficient method to solve the problems caused by phenol compounds. Biosorption is a process of absorbing solids derived from natural materials that can bind to compounds in a solution. The biosorption method used is batch using banana peels (*Musa balbisiana* Colla) as biomass. Optimization of parameter for the absorption of phenol compounds studied are pH and concentration. The results show that optimum conditions at pH 4 obtained with the absorbed concentration of 1.82 ppm and the optimum concentration of 50 ppm. The analysis of phenol compounds absorption is measured by using a spectrophotometer UV-Vis at a maximum wavelength of 265 nm and for the characterization of biosorbents is determined by using FTIR.

**Keywords:** Biosorption, Phenol, Banana peel, Spectrophotometer UV-Vis, FTIR, Batch

## 1. INTRODUCTION

The development of the industry that is expected to meet our current needs has a serious impact on the environment. The pollution is caused by waste that is not handled properly. In general, the industry discharges waste into water without prior processing. It can cause damage to aquatic ecosystems and human health problems (Zultinar, 2011).

The development of industrial environmental problems include the increase in hazardous waste generated. Some industries that have the potential in environmental pollution are the refining industry of petroleum, gas, pharmacy, and home industries that produce phenol liquid waste (Juwita et al, 2011) Phenols are organic compounds (C<sub>6</sub>H<sub>5</sub>OH) by characteristic the scent, toxic and corrosive to the skin causing irritation. Phenol is an organic compound classified as a toxic and dangerous material because it has high toxicity in water, which can cause disturbance to aquatic ecosystems and human health (Juwita et al. 2011).

Phenol induce human impacts because inhalation of phenols in the air can cause short-term effects including irritation of breathing, headaches, and burning eyes, while the harmful effects of exposure to high levels of phenol can cause weakness, muscle pain, anorexia, loss of weight,

and fatigue even cancer and heart disease and impact death (Aufa, 2017).

Some technologies can remove phenols from industrial wastewater classified as conventional and modern methods. The conventional methods that have been applied are steam distillation (Skavos et al, 2015), liquid-liquid extraction (Abbasi et al, 2014), adsorption (Mukherjee et al, 2014), wet air oxidation (Epinosa de los menteros et al, 2015), and biodegradation (Rafiei et al, 2014). The modern technologies for removing phenols include electrochemical oxidation (Tasic et al. 2014), ozonization (Felis and Miksch, 2015), UVH<sub>2</sub>O<sub>2</sub> (Karci et al, 2013), Fenton reaction (Amor et al, 2015), membrane processes (Loh et al, 2016) and treatment enzymatic. However, this method requires expensive cost and a lot of chemicals (Aufa, 2017).

Considering the dangers posed by phenols and the concentration limit allowed, we need a method that can overcome the problem of phenol pollution, i.e. biosorption. This method offers the simple process, able to do in low concentration, and low cost (Ningsih, 2007).

This method uses a biomass that functions as a biosorbent that can absorb a biosorbate. The use of biomass as an alternative and low-cost biosorbent has been widely used and developed because of its abundant presence in nature. Some low-cost biosorbents such as coconut shell charcoal (Gilar, 2013), oil palm empty fruit bunches (Fadli et al,

2002), zeolites (Juwita, 2011, Slamet, 2008), chitin (Zultiniar. 2011), shell of kluwak (Arif, 2015).

These materials can be used to remove phenol compounds because they contain lignocellulosic components, activated carbon, nitrogen, phosphor, potassium, calcium, magnesium, calcium carbonate protein. Recently, it has been investigated that banana peels can be utilized to absorb phenol with an absorption capacity of 0.275 g / L (Achak et al, 2009).

Bananas are the most widely planted and cultivated fruit in more than 130 countries which are tropical fruit. In the banana skin there are many lignin, pectin, cellulose and hemicellulose (Vilardi, 2017). According to Castro et al (2011), in the banana peels, there are also functional groups such as carboxylic groups (-COOH), hydroxyl (-OH), and amine groups (-NH). In this study, banana peels are used as biosorbents to removal phenolic compounds. Banana skin contains several chemical components such as cellulose, hemicellulose, pectin and amino active groups, hydroxyl groups, carboxyl groups that can bind and attract compound or ion in biomass (Kuniasari & Riwayati, 2012)

Based on the description above, this study examines the optimization of phenol absorption using the peel of banana (*Musa balbisiana* Colla) by using the batch method.

## **2. METHODS**

### **2.1 Preparing the Adsorbent**

Samples of banana peel were washed with aquades, air dried, mashed and sieved with a particle size sieve. Then the adsorbent was immersed with HNO<sub>3</sub> 0.1 M for 2 hours, washed until neutral. Methods

### **2.2 Optimization of phenol absorption treatment using banana peel as biosorbent**

#### **2.2.1 Effect of pH**

Prepared 25 ml phenol solution concentration is 50 ppm with variations in pH 2, 4, 6, 8, and 10 then each solution is contacted with 0.2 grams of banana peel using a batch system, the solution is then shaker at a speed of 200 rpm for 60 minutes, then the solution filtered and accommodated the filtrate. The filtrate was measured to phenol concentration by spectrophotometer UV-Vis and the optimum pH of phenol is obtained.

#### **2.2.2 Effect of Solution Concentration**

Prepared 25 ml of phenol solution concentrations are 10, 20, 50, 75, 100, and 125 ppm with optimum pH, then each solution is contacted with 0.2 gram banana peel using a batch system. The solution is then shaker at a speed of 200 rpm for 60 minutes. Then the solution is filtered and the filtrate is collected. The filtrate is measured by using a spectrophotometer UV-Vis. The optimum phenol concentration is obtained.

#### **2.2.3 Effect of Particle Size**

Prepared 25 ml of phenol solution concentration is 50 ppm with optimum pH, then solution contacted of particle size 150, 180, 250, and 355  $\mu$ m with 0.2 gram banana peel using a batch system. The solution is then shaker at a speed of 200 rpm for 60 minutes. Then the solution is filtered and the filtrate is collected. The filtrate is measured by using a spectrophotometer UV-Vis. The particle size optimum is obtained.

#### **2.2.4 Effect of Contact Time**

Prepared 25 ml of phenol solution concentration is 50 ppm with optimum pH, then solution contacted of particle size optimum with 0.2 gram banana peel using a batch system. The solution is then shaker at a speed of 200 rpm for 45, 60, 75, 105, 125, and 150 minutes. Then the solution is filtered and the filtrate is collected. The filtrate is measured using a spectrophotometer UV-Vis. The contact time optimum is obtained.

#### **2.2.5 Effect of Stirring Speed**

Prepared 25 ml of phenol solution concentration is 50 ppm with optimum pH, then solution contacted of particle size optimum with 0.2 gram banana peel using a batch system. The solution is then shaker at a speed of 50, 100, 150, 200, and 250 rpm for contact time optimum. Then the solution is filtered and the filtrate is collected. The filtrate is measured using a spectrophotometer UV-Vis. The stirring speed optimum is obtained.

## **3. RESULT AND DISCUSSION**

### **3.1 pH**

In biosorption process, the pH has an important role because it can determine surface changes at the biosorbent active site (Kurniawati, 2015). Optimization of pH of

phenol solution is studied to find out the adsorption process of pH. Mass of solution from biosorbent banana peels used is 0.2 g with a size of 180  $\mu\text{m}$  and the concentration of the phenol solution of 50 ppm with pH variation used are 2, 4, 6, 8, and 10.

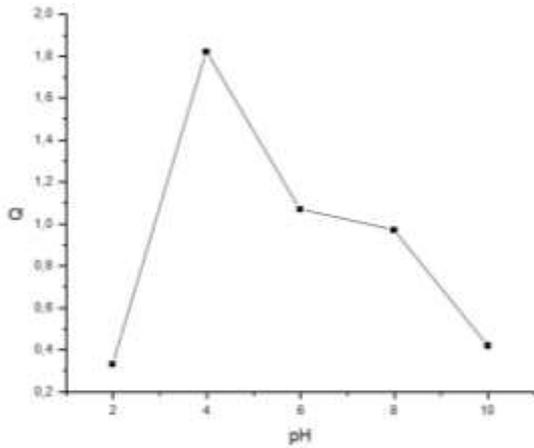


Fig. 1. Absorption of phenol variation in pH (25 ml phenol solution with a concentration of 50 ppm).

From the data obtained, it can be seen that the absorption of phenol solution by banana peel is influenced by pH. At pH of 2, the amount of the concentration of the phenol solution absorbed is low, i.e. 0.4998 mg/L, because an acidic pH will cause the low absorption efficiency in biosorbents. The optimum conditions obtained are at pH 4 with an absorbed concentration value of 1.82 mg/L. This is due to the influence of OH<sup>-</sup> groups from NaOH and H<sup>+</sup> ions from HNO<sub>3</sub> which can provide a gap and interact with one of the functional groups of biosorbent banana peel which can form a hydrogen bond with a hydroxyl group on phenol.

### 3.2 Variation Concentration

Concentration of phenol solution can affect the absorption ability of a biosorbent. The higher the phenol solution, the greater the efficiency of absorption, this is due to the higher concentration, in which the collisions between molecules will increase the molecules to enter the biosorbent pores (Ahmad Fadli et al, 2002). The variation of the concentrations used is 10, 20, 50, 75, 100, and 125 ppm.

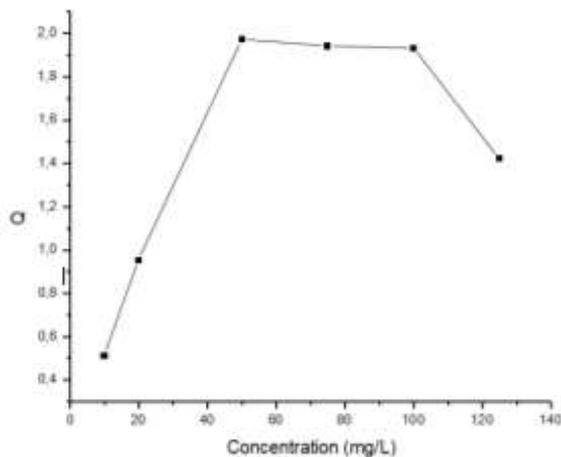


Fig. 2. Absorption of phenol concentration variation (25 ml solution with optimum pH)

From the graph it can be seen that, with increasing concentration of the solution causes the amount of absorbed phenol solution to increase and reach optimum at a concentration of 50 ppm with an absorption capacity of 2.97 mg/L. At the concentration of the phenol is low, the amount of phenol ions contained in the solution is also low, so the interaction between phenol ions and the active side of the biosorbent of banana peels will reduce and the molecule entering the pores will also reduce.

### 3.3 Particle Size Optimization

From the graph it can be seen that, with increasing concentration of the solution causes the amount of absorbed phenol solution to increase and reach optimum at a concentration of 50 ppm with an absorption capacity of 2.97 mg/L. At the concentration of the phenol is low, the amount of phenol ions contained in the solution is also low, so the interaction between phenol ions and the active side of the biosorbent of banana peels will reduce and the molecule entering the pores will also reduce.

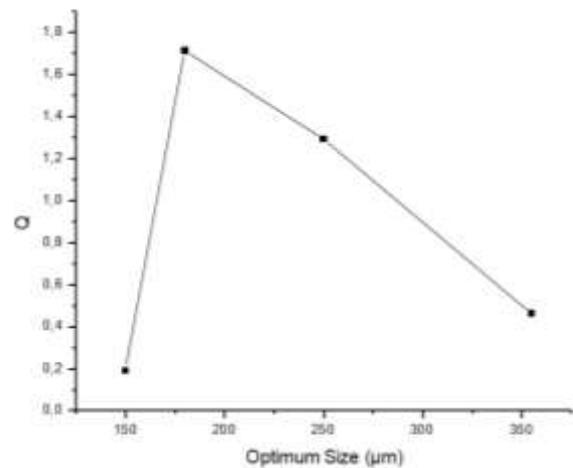


Fig. 3. Effect of particle size on phenol absorption by using banana peels (*Musa balbisiana* Colla) as biosorbent for (0.2 grams of biomass, 25 mL optimum concentration solution, optimum pH).

From the data above shows that the optimum absorption capacity of phenol at 180  $\mu\text{m}$  biomass size with an absorbed concentration of 1.7 mg/L. The smaller the size of the biosorbent used, the better the absorption capacity. Because the smaller the diameter of the biosorbent means the contact of surface area between the biosorbent and phenol is getting bigger. In addition, the surface area is also directly proportional to the many pores that belong to the union of biosorbent particles (Aji, 2012). However, if the particle size is too small, about 150  $\mu\text{m}$ , the absorption is not optimal, because the size of the 150  $\mu\text{m}$  biosorbent clumps when it is inserted into the phenol solution.

### 3.4 Effect of Contact Time on Phenol Absorption

Contact time optimization is used to show the adsorption process over time. In addition to knowing the duration of contact time in providing a gap to the adsorbent to bind to

the adsorbate. The mass of the banana peel biosorbent used was 0.2 g contacted with 50 ppm phenol solution with contact time variations of 45, 60, 75, 105, 125, and 150 minutes.

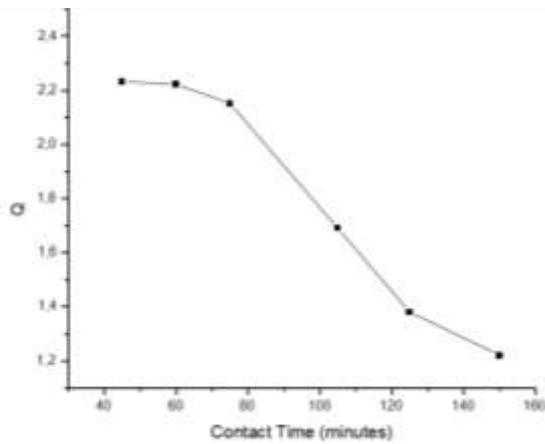


Fig. 4. Effect of contact time on phenol absorption by using banana peels (*Musa balbisiana* Colla) as biosorbent for (0.2 grams of biomass, 25 mL optimum concentration solution, optimum biomass size, optimum pH)

Based on the graph above, it shows that the concentration of the phenol solution at 45 minutes was the most absorbed, but at 60, 75, 105, 125 and 150 minutes, the concentration of the absorbed phenol solution showed a decrease. This is caused by the active side of the banana peel covalently bonding with the phenol solution reaching the saturation point where the active side of the banana peel cannot absorb the phenol solution anymore (Juwita, et al. 2011).

### 3.5 Effect of Stirring Speed on Phenol Absorption

Speed is one of the important parameters when the phenol ions bind with biomass. The stirring speed is used to determine the stirring speed at which the phenol ions can be absorbed optimally. According to the theory, the faster the stirring speed is used, the higher an ion will be absorbed so that if it has reached the equilibrium point, the absorption will undergo a constant state (Lestari, et al., 2015). Stirring speed variations are carried out starting from 50, 100, 150, 200 and 250 rpm.

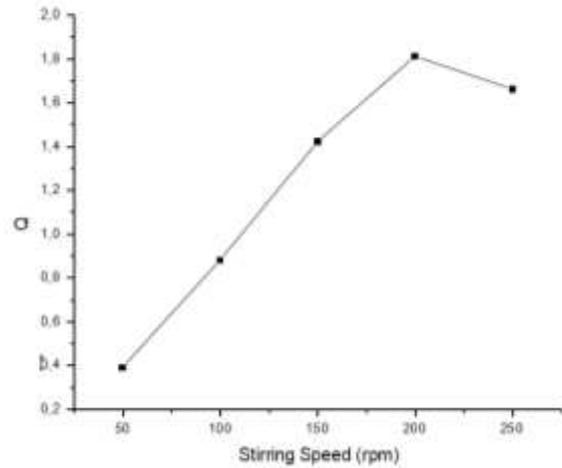


Fig. 5. Effect of stirring speed on phenol absorption using banana peels (*Musa balbisiana* Colla) as biosorbent for (0.2 grams of biomass, 25 mL of optimum solution concentration, optimum size of biomass, optimum pH and optimum time)

The phenol absorption capacity of the biosorbent of banana peels increases with the speed of stirring until equilibrium occurs. The optimum absorption of phenol occurs at a speed of 200 rpm with an absorbed concentration of 1.809 mg/L. At the speed of 250 rpm, absorption begins to decrease because the active groups in the biosorbent undergo saturation and decrease slightly because the rapid stirring will result in phenol compounds bound to biosorbents released from the active side due to very high speeds.

### 3.6 FTIR

Analysis FTIR is a functional group analysis method contained in a sample based on infrared light absorption spectra (Chaber, 2017). Analysis was carried out on banana peels before and after being activated and after being contacted by FTIR spectrum and banana peel before and after being activated with HNO<sub>3</sub> 0.1 M.

Fig. 6. FTIR Spectrum (A) Banana peel biomass before activation (B) Banana peel biomass has been activated with 0.1 M HNO<sub>3</sub> for 2 hours. (C) Banana peel biomass has been contacted with phenol solution.

In the figure, it can be seen that for unactivated banana peels, the hydroxyl peak (-OH) appears at a wavelength of 3304 cm. At this wavelength indicates that the presence of a polymeric life-free hydroxyl group, this corresponds to the frequency range for the hydroxyl group between 3600-2800 cm which indicates the presence of polymeric compounds (Soštarić, 2018). At a wavelength of 2925 cm, there is a -CH functional group with a frequency range of 2800-3000 cm, and at a wavelength of 1606 cm, there is a C-O (carbonyl) functional group with a frequency range of 1640-1820 cm.

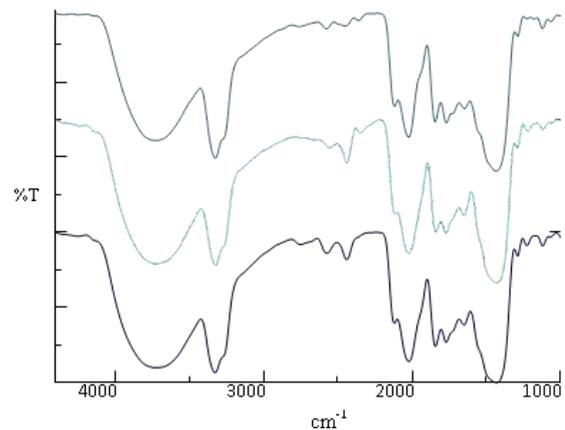
In activated banana peel biomass, the hydroxyl peak (-OH) appears at a wavelength of 3332 cm, and experiences a decrease in transmittance value and changes in absorption band with a shift in wavelength from 2925 cm to 2924 a for the CH- function group and in the functional group -CO changes in absorption band which indicates vibrations and transmittance value decreases. In kapok banana peel biomass contacted with phenol solution, it can be seen the absorption in each functional group in biomass, because it clots with phenol compounds. So it can be indicated that the function groups contained in banana peel biomass have binded with phenol compounds.

#### 4. CONCLUSION

Banana peel (*Mussa balbisiana* Colla) contains carboxyl and carbonyl groups so that biomass can be put into place to absorb phenol compounds at pH 1. The optimum condition obtained is at pH 4 with the absorbed concentrations of 1.82 ppm with 68.71 % absorption and the optimum concentration is 50 ppm with an absorption of 74.25 %. The maximum wavelength of absorption for phenol compounds by spectrophotometry UV-Vis was 265 nm.

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