Low concentration lead ion adsorption determination performance using activated carbon from bambu betung (*Dendrocalamus asper*)

A Zakaria1*, N Yuliani2, A Oktaviani3 and Fachrurrazie2

1) Industrial Waste Treatment Departement, 2) Analytical Chemistry, Politeknik AKA Bogor, Jl. Pangeran Sogiri No.283, Bogor, 16154, Indonesia

3) Department of Biology, 4) Department of Chemistry, Faculty of Mathematics and Natural Science Universitas Nusa Bangsa, Gg. Walet Kukupu No.02/06, Bogor, 16166, Indonesia

Email: ahmad-zakaria@kemenperin.go.id

Abstract. Adsorption is one alternative that is used to reduce lead (Pb) at low concentrations. Activated charcoal from *Dendrocalamus asper* (Schult) known as local name “Bambu Betung” has better performance in low concentration Pb adsorption at the liquid waste. The activation by added Na2CO3 was carried out for 24 hours and followed by neutralization of the filtrate until it reaches pH 7. Determination of optimum adsorption using adsorbent weight, adsorbate pH and contact time was treated concurrently including the design of surface method response statistics central composite design (RSM CCD). An optimal condition conducted to obtain these adsorption Langmuir and Freundlich isothermal mechanism. CCD processing was managed to obtained optimum conditions of pH, weight, and time. The results of the isothermal equation were in accordance with the Langmuir model because the absorption model has given an r value of 0.998 through the Langmuir equation \( y = 0.047x + 0.009 \). Overall, the optimum adsorption capacity of activated charcoal from *D. asper* (Schult) was performed at 21.28 mg per gram adsorbent. Based on the characteristics of betung bamboo activated charcoal test using SEM-EDX it was shown that there was no contamination of lead ion, this is the same as activated charcoal in general.

1. Introduction

The industry has one of the adversarial consequences as the primary contributor to pollution through water and atmosphere. Industrial wastewater frequently carries toxic heavy metal particles such as Hg, Cd, Pb, Cu, Zn, and Ni [1]. Heavy metals that penetrate currents will pollute the waterbody. During expanding over contaminating streams, heavy metals will further sink to deposits that have a dwelling time of up to thousands of years and heavy metals will also accumulate in living bodies through several ways, specifically throughout the respiratory tract, food channels, and through the skin [2].

Lead (Pb) is one of the heavy metals generally enclosed in industrial waste which is usually originating from batteries, ceramics, and paint discharged into the waterbody. Several methods to reduce or even eliminate heavy metals have been carried out with physical, chemical processes, which include precipitation, coagulation, and ion exchange. Although the method mentioned earlier is still relatively expensive.

An adsorption process is an effective purification and separation technique used in the industry because it is considered more economical in water and waste treatment [3]. Adsorption is a technique...
often used to reduce heavy metal ions in wastewater [4]. One of the adsorbents that commonly used is activated charcoal. Activated charcoal is a material consisting of high absorptive porous carbon that has experienced a reaction with chemicals after carbonization to improve its absorption [5]. The main requirement in making activated charcoal is to contain carbon elements [6]. The activated charcoal could also produce from biomass such as bamboo betung (*Dendrocalamus asper*) [5].

2. Materials and methods

2.1 Materials and equipment
The materials used in this study included betung bamboo charcoal; 1.5% Na$_2$CO$_3$; manufactured Pb waste solution; Pb(NO$_3$)$_2$ 1000 ppm from Merck; Pb (II) 200 ppm; NaOH 0.1 N; HCl 0.1 N; and distilled water.

The instruments and tools used in this study were: Shimadzu AA-4000 atomic absorption spectrophotometer, Agilent pH meter, mortar, sieve, analytical balance, shaker, 100 mL Erlenmeyer flask, Whatman 42 filter paper, 50 mL volumetric pipette, measuring flask, a 500 ml glass cup, bulb and, stirring rod.

2.2 Methods
The study consisted of four stages, namely testing the characteristics of activated charcoal, sample preparation, preliminary research, isothermal adsorption. In the initial process, the activated charcoal was crushed using a sifted mortar to obtain relatively uniform and fine particles. After that, preliminary research was carried out to determine the ideal range for adsorption optimization testing. The determination of isothermal adsorption used the Langmuir and Freundlich equations to get the optimum adsorption capacity [7].

The Langmuir and Freundlich equation is presented as equations 1 and 2.

The Langmuir equation:

$$\frac{C_e}{Q_e} = \frac{1}{a} + \frac{1}{b}C_e$$

Freundlich equation:

$$\log Q_e = \log K + \frac{1}{n} \log C_e$$

Where $C_e$ is concentration of adsorbate in solution (mg / L), $Q_e$ is concentration of adsorbate absorbed per gram of adsorbent (mg / g), $a$ is optimum adsorption capacity (mg / g) in the Langmuir equation, $b$ is empirical constant in press. Langmuir, $K$ is optimum adsorption capacity (mg / g) in the Freundlich equation, and $n$ is empirical constant in the Freundlich equation.

2.2.1. Sample preparation. The sieve method was used to equalize the particle size, activated charcoal a then rocked at the mesh number 80. The study consisted of four stages, namely testing the characteristics of activated charcoal, sample preparation, preliminary research, isothermal adsorption.

2.2.2. Pb ion measurement. Pb Ion Measurement with Atomic Absorption Spectrophotometer. Atomic Absorption Spectrophotometer was under the following conditions:

- **Cathode Lamp:** Pb Wavelength : 283.3 nm
- ** Burning Height**: 7.0 mm
- **Gas**: Acetylene-Air
- **Acetylene Flow Rate**: 2.0 L / min
- **Airflow Rate**: 15.0 L / min
The measurement started by reading the low concentration standard series to high concentration reading for the sample solution. The measurement of the standard series, it obtained a linear equation between the adsorption of cathode lamp rays to the concentration of the analyte.

2.2.3. Characterization betung bamboo active charcoal. The characterization of betung bamboo active charcoal was by Scanning Electron Microscopes-Energy Dispersive X-ray Spectroscopy (SEM-EDX). The adsorbent tip of the spatula was applied to the specimen cylinder holder and then inserted into the chamber on the SEM-EDX device. The Sample chamber was condition into a vacuum state. Electron fired onto the surface of the sample. The beam firing process could observe on a computer screen, where the outside of the sample shot by the beam scanned over the entire area of the observation area.

3. Results and discussion
The method regarding obtaining betung bamboo activated charcoal consisted of individual processes, specifically dehydration, carbonation, also chemical activation methods. Through the dehydration, the method intended to reduce the water content carried in raw forms. Linked to the carbonation process, this goal of carbonation proceeded to separate oxygen and hydrogen.

The introduction to the carbonation process occurred through the enlargement of carbon pores, directly through the time of carbonation. The absorption persisted negative impact because the pores of the were blocked over by tar. Therefore, this continued underpinned with the activation process. Activation hold a treatment of charcoal that endeavored to increase the pore by improving hydrocarbon bonds or oxidizing surface molecules. The charcoal turned both physical and chemical properties and the comprising area spread and influenced the adsorption power.

The activation method was carried out for 24 hours, then the neutralization process was carried out until the filtrate had a pH of 7. Penetration aimed to remove Na2O which turned into NaOH when reacted with water molecules. Na2O must be extracted in this process because the pressure did not cover the pores of activated charcoal so that the adsorption process was not optimal. The optimum value based on the analysis of Pb metal ion adsorption in previous studies was pH 7, with a bio-adsorbent weight of 50 mg, and a contact time of 127.10 minutes.

Table 1. Isotherm adsorption determination of bamboo betong activated carbon.

| C   | Ce  | Qe  | Langmuir | Freundlich |
|-----|-----|-----|-----------|------------|
|     |     |     | cc / cc  | cc / cc  |
|     |     |     | ce / ce  | ce / ce  |
|     |     |     | log ce   | log ce   |
| 0   | 0   | 0   | 0        | 0         |
| 10  | 0.82857 | 9.17 | 0.8286 | 0.0903 | -0.0817 | 0.96844 |
| 20  | 2,8571 | 17.14 | 2,8571 | 0.1667 | 0.45593 | 1.23408 |
| 30  | 6,3857 | 23.61 | 6,3857 | 0.2704 | 0.80521 | 1.37317 |
| 50  | 28,4714 | 21.53 | 28,4714 | 1.3225 | 1.45441 | 1.33302 |
| 60  | 39,5857 | 20.41 | 39,5857 | 1.9391 | 1.59754 | 1.30993 |

3.1. Results of determination of adsorption isotherms
The data experiment Pb ion isothermal adsorption by activated betung bamboo that following 2 equation models, Langmuir and Freundlich equations. The layers that occurred on the surface of the adsorbent against the adsorbate result based on the correlation coefficient and optimum adsorption capacity. The results achieved by the study lead to developing the Langmuir model because this gave an r-value of 0.998 with equation y = 0.047x + 0.009. The Freundlich equation eventually received r of 0.790 with equation y = 0.186x + 1.084. The Langmuir equation would be implemented to the adsorption of Pb²⁺ metal ions by betung bamboo activated charcoal. Based on that we proposed the Pb²⁺ metal ions built a single layer on the surface of betung bamboo activated charcoal. Meanwhile,
from the Langmuir equation, the optimum capacity of activated charcoal was 21.28 mg / g of activated charcoal. Isothermal adsorption curves are presented in table 1.

3.2. Characteristics of bamboo betung active charcoal
Following activating betung bamboo, when measurement characteristics using SEM that supported to recognize the structure and contour of smaller-scale surfaces and EDX that could detect elements in the surface body. The activated charcoal pore hold a diameter between 6.031 µm to 21.44 µm CO₃ and is discussed in the pore charcoal besides comprises impurities. Activated charcoal manages to be clean figure 1b, the diameter of activated charcoal ranges from 1.117 µm to 6.701 µm.

The pore size means thought to affect the adsorption power of charcoal. If the pore size of the adsorbent gets less, the ability of the adsorption increases, assuming that the adsorbed component can enter its porous cavity. The greater amount of adsorbent would provide a greater surface area for the adsorbate to be desorbed. In addition, the more amount of adsorbent would also give a greater chance of contact with adsorbate molecules (Sembodo, 2006). EDX test results showed the highest carbon content is inactivated charcoal is 90.03% compared to activated charcoal which is 78.28%.

This happened because before the charcoal was activated figure 1a. The element carbon in charcoal binds with hydrogen and oxygen, can form hydroxy phenols, carboxylic acids, and others. During the process of activation and further calcification of the elements, hydrogen and oxygen will evaporate so that the carbon content of the activated charcoal increases [5].

![Figure 1. Betong bamboo activated charcoal SEM test results a) untreated, b) treated](image)

**Table 2. EDX betung bamboo test results.**

| Elements | Density Activated Carbon Untreated (%) | Density Activated Carbon Treated (%) |
|----------|----------------------------------|----------------------------------|
| C        | 78,28                            | 90,03                            |
| O        | 10,23                            | 7,01                             |
| Mg       | 0,17                             | 0,32                             |
| Si       | 1,87                             | 0,21                             |
| F        | 0,44                             | 0,23                             |
| Cl       | 0,39                             | 0,36                             |
| K        | 4,14                             | 0,33                             |
| Cu       | 1,06                             | 1,03                             |
| In       | 3,42                             | 0,47                             |
EDX test results for betung bamboo charcoal activated or not activated are presented in Table 2. EDX test results showed the highest carbon content was in activated charcoal. This happened because before the charcoal was activated. The carbon element in charcoal binds with hydrogen and oxygen, can form hydroxy phenols, carboxylic acids, and others. The data also showed there is no contamination of Lead element from activated charcoal in term of making process. During the process of activation and further calcification of the elements, hydrogen and oxygen will evaporate so that the carbon content of the activated charcoal increases [5].

4. Conclusion
Based on the characteristics of betung bamboo activated charcoal test using SEM EDX, method shows that the surface shape of betung bamboo activated charcoal has clean pores in compared to unactivated charcoal, this is the same as activated charcoal in general. Optimum determination of isothermal adsorption of Pb metal ions by the appropriate betung bamboo activated charcoal is the Langmuir equation with a correlation (r) of 0.998 and the optimum capacity of activated bamboo betung charcoal is 21.28 mg/g.

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