INTEK Jurnal Penelitian
Vol. 10, No. 1, pp. 73-77, April 2023

Utilization of Green Betel Leaf as Adsorbent of Lead and Copper Metals in Artificial Wastewater

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Abstract - Green betel leaf contains phenolic compounds that can bind metal ions. The purpose of this study was to determine the effect of variations in the mass of green betel leaf and stirring time based on the efficiency and adsorption capacity of lead and copper metals in artificial wastewater. Adsorption process using the stirring with a magnetic stirrer. The variation used is the stirring time of 30 and 60 minutes and the mass of the adsorbent is 25,30,35, 40 grams. Artificial wastewater is made from 1 gram of each $Pb(NO_3)_2$ and $CuCl_2.2H_20$ in 500 ml of aquadest. Analysis of the metal using the AAS (Atomic Absorption Spectrophotometry). The results of the analysis showed that the optimum adsorption of lead metal was at a mass of 30 grams of betel leaf and a stirring time of 1 hour, where green betel leaves were able to adsorb 99.96% of lead metal, from a Pb level of 6435 ppm to 2.48 ppm. While the optimum results for adsorption of copper metal were 35 grams of betel leaf mass and 30 minutes of stirring time, where green betel leaves were able to adsorb 49.83% copper metal, from 158 ppm Cu level to 79.27 ppm.

Keywords: AAS, Adsorption, Green betel leaf.

I. Introduction

Indonesia is a country that has long been known as a center for biodiversity and the use of herbal plants. Indonesian people use about 31 types of plants to be used as traditional medicine. However, due to the lack of documentation regarding herbal plants, there is a lack of knowledge of the community, especially those living in urban areas, to process these plants, one of which is the betel plant (Firdaus, 2021). The betel plant is a green vine with heart-shaped leaves. This plant from the Piperaceae family originates from South Asia (India, Nepal, Bangladesh, Sri Lanka) and grows widely in Malaysia, Thailand, Taiwan and Indonesia. Sirih (Indonesia) is known in various places under different names, namely betel (English), paan (India), and phlu (Thailand). This plant has the potential to be cultivated because it can be used as an antiseptic and wound medicine (Pratiwi and Muderawan, 2016).

In the journal (Syahrir *et al.*, 2021) explains the characterization of betel leaves using the GC-MS tool. It was explained that the most abundant compound in betel leaf was chromanol with an area of 26.93% with a retention time of 12.309, then eugenol 22.59% with a retention time of 10.833 and phenol 19.49% with a retention time of 9.135. Chromanol and phenol compounds are the chemical structure of vitamin E which consists of nuclear side groups 6-chromanol methylation, then three isoprenoid units and a free ester or hydroxyl bond at C-6 of the chromanol nucleos.

The antioxidant activity of vitamin E possessed by green betel leaves is related to its total phenolic and flavonoid content. Many studies report that phenolic compounds have antioxidant activity because phenolic compounds are able to reduce free radical compounds (Syahrir *et al.*, 2021). Phenolic compounds have the ability to donate hydrogen atoms or electrons to free radicals to form stable intermediates. These compounds bind to free radicals, decompose oxidation products and bind metal ions (Diniyah & Lee, 2020). This is the reason why green betel leaves can act as an adsorbent in the adsorption process.

Adsorption is a separation process based on differences in the affinity or diffusivity of a compound to a solid, which is generally a porous solid. Inside the interior of the solid, the attractive forces between the atoms making up the lattice are balanced, but on the surface of the solid they are unbalanced. As a result, if

DOI : http://dx.doi.org/10.31963/intek.v10i1.4348

there are particles that approach the surface of the solid, they will be attracted to compensate for the imbalance of forces on the solid surface. This phenomenon is called adsorption process. Factors that influence the adsorption process include stirring time, adsorbent mass, stirring speed, adsorbate concentration, adsorbent particle size/adsorbent surface area (Astuti, 2018).

One of the uses of the adsorption process is to control environmental pollution caused by heavy metals. Heavy metals have properties toxicity that can threaten living things. Lead and copper are one of these heavy metals which have a very dangerous toxicity to living things. This research begins with the preparation process of betel leaf as an adsorbent that will bind lead and copper metals and to produce artificial wastewater containing lead and copper. Furthermore, variations in the mass of green betel leaves and stirring time were carried out to determine the level of efficiency and adsorption capacity of the betel leaf adsorbent.

II. Research Methodology

A. Betel Leaf Sample Preparation

Green betel samples are dried in direct sunlight. The dried samples were crushed into powder/powder form, so that the samples were ready to be used as research materials. After that, sieving is carried out so that the particle size of the betel leaf powder is uniform. In this study, the particle size used was 16 mesh or 1.18 mm.

B. Preparation of Artificial Wastewater

Solids are weighed $Pb(NO_3)_2$ and $CuCl_2.2H_20$ 1 gram each. The two solids were then dissolved in 500 ml of distilled water. Once dissolved, the solution is ready to be used in the adsorption process as artificial wastewater.

C. Adsorption Process

The adsorption process was carried out by interacting with artificial wastewater with betel leaf powder with a mass variation of 25,30,35,40 grams using a magnetic stirrer and the interaction time was 30 and 60 minutes with a stirring speed of 1100 rpm (constant). After the adsorption process is complete, a filtering process is carried out to separate the betel leaf adsorbent from the solution. The adsorption solution was then put into a 500 ml sample bottle.

D. Characterization of Heavy Metal Content of Samples

Samples of artificial wastewater were analyzed using an atomic absorption spectrophotometer (AAS) before and after the adsorption process to determine the effect of adding green betel leaf powder on levels of Pb and Cu metals.

The sample is inserted into the Teflon beaker evenly for a perfect drying process in the oven at a temperature of 105 °C for 4 hours. The sediment sample that has been dried is crushed until smooth and grated with a thickness of 150 μm, then the sample weighs with an analytical weight of 0.4 grams and then inserts in the vesser in the addition of HNO_3 9 ml and HF 3 ml is heated in a simple microwave at 180 °C at a pressure of 30 bar for 25 minutes until all sediments are dissolved (Warni, D et al, 2017).

Heavy metal analysis is carried out using atomic absorption spectrophotometry (AAS) based on the Lambert-Beer law, which is the number of rays absorbed in relation to the level of matter. Since the absorber of light is an atom, the ion or heavy metal compound must be converted into an atomic form. The standard solution of the sample is inserted into the reaction tube available on the AAS device, adjustments are made on the computer of the user's AAS tool, lights and AAS cathode lights are turned on, the position of the lamp is also adjusted to obtain maximum absorption. Then the standard solution is inhaled into the acetylene air flame, indicating the measurement readings should be zero. In sequence the raw solution is analyzed using AAS, the atomic absorption measurement results are recorded and then calculated to obtain the metal concentration on the sample solution.

The concentration of heavy metals will be calculated based on the regression concentration value shown on the AAS. The regression is obtained on the basis of the calibration curve regression value.

E. Data Analysis

Data analysis used in this research is descriptive. The measurement results obtained were analyzed by presenting them in tabular and graphical form using Excel for the benefits of adding betel leaf ethanol extract

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in absorbing heavy metals in artificial wastewater samples.

To get the adsorption percentage of Lead (Pb) and Copper (Cu) metals in seawater, it can be calculated using the formula:

Percentage of Reduction (%):

$$\frac{\text{Initial Concentration} - \text{Final Concentration}}{\text{Initial Concentration}} \times 100\% \quad (1)$$

The number of metal ions adsorbed milligrams per gram (mg/g) adsorbent is determined using the equation:

$$q_c = \frac{(Co-Ce)V}{W} \quad (2)$$

Where:

q_c : amount of adsorbed metal ion (mg/g)
Co : metal ion concentration before adsorption (mg/l)
Ce : Concentration of metal ions after adsorption (mg/l)
V : Volume of metal ion solution (L)
W : Mass of adsorbent (gr).

III. Results and Discussion

A. Results of Lead (Pb) and Ccopper (Cu) Adsorption Tests on Artificial Wastewater

The results of the lead (Pb) and copper (Cu) adsorption test results using green betel leaf adsorbents where the initial concentration of artificial wastewater containing Pb metal was 6435 ppm and 158 ppm Cu. The variations used were the stirring time of 30 minutes and 60 minutes, and the adsorbent masses of 25 grams, 30 grams, 35 grams and 40 grams where the speed time was set constant at 1100 rpm and the surface area of the betel leaf adsorbent was 16 mesh or 1.18 mm, it can be seen in table 1.

Table 1. Lead (Pb) and Copper (Cu) Adsorption Test Results Data Using AAS

Number	Sample Code	Parameter	
		Pb, ppm	Cu, ppm
1	25 grams/30 minutes	15,22	200
2	25 grams/60 minutes	31,74	124
3	30 grams/30 minutes	16,96	117
4	30 grams/60 minutes	2,48	84,55
5	35 grams/30 minutes	26,74	79,27
6	35 grams/60 minutes	36,74	113
7	40 grams/30 minutes	31,96	176
8	40 grams/60 minutes	15,65	198
9	Artificial Wastewater	6435	158

Based on the results of the adsorption test for lead and copper by green betel leaf adsorbents, table 1 shows the results of the removal of the initial concentrations of lead and copper which were quite significant in each treatment variation. This means, betel leaf is able to absorb and bind metal ions. This is in accordance with the journal Diniyah and Lee (2020), the phenolic compounds contained in green betel leaves have the ability to donate hydrogen atoms or electrons to free radicals to form stable intermediates. These compounds scavenge free radicals, decompose oxidation products and bind metal ions.

B. Effect of Adsorbent Mass and Stirring Time on the Absorption Percentage of Lead (Pb) and Copper (Cu) Metals

To determine the effect of adsorbent mass and stirring time on the absorption percentage of lead (Pb) and copper (Cu) metals by betel leaf adsorbents, an analysis of the results of calculating the absorption capacity of lead (Pb) and copper (Cu) metals was carried out which can be seen in table 2 and 3.

Table 2. Effect of adsorbent mass and stirring time on the absorption percentage of lead metal

No	Adsorbent mass/mixing time	Final concentration of lead metal (ppm)	Concentration of adsorbed metal ions	Absorption percentage (%)
1	25 gram/30 menit	15,22	6419,78	99,76
2	25 gram/60 menit	31,74	6403,26	99,51
3	30 gram/30 menit	16,96	6418,04	99,74
4	30 gram/60 menit	2,48	6432,52	99,96
5	35 gram/30 menit	26,74	6408,26	99,58
6	35 gram/60 menit	36,74	6398,26	99,43
7	40 gram/30 menit	31,96	6403,04	99,50
8	40 gram/60 menit	15,65	6419,35	99,76
9	Artificial Wastewater	6435		

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Table 3. Effect of adsorbent mass and stirring time on the absorption percentage of copper metal

Number	Adsorbent mass/mixing time	Final concentration of copper metal (ppm)	Concentration of adsorbed metal ions	Absorption percentage (%)
1	25 gram/30 menit	200	-42	-26,58
2	25 gram/60 menit	124	34	21,52
3	30 gram/30 menit	117	41	25,95
4	30 gram/60 menit	84,55	73,45	46,49
5	35 gram/30 menit	79,27	78,73	49,83
6	35 gram/60 menit	113	45	28,48
7	40 gram/30 menit	176	-18	-11,39
8	40 gram/60 menit	198	-40	-25,32
9	Artificial Wastewater	158		

The results of the analysis showed that the optimum adsorption of lead metal was at a mass of 30 grams of betel leaf and a stirring time of 1 hour, where green betel leaves were able to adsorb 99.96% of lead metal, from a Pb level of 6435 ppm to 2.48 ppm. While the optimum results for adsorption of copper metal were 35 grams of betel leaf mass and 30 minutes of stirring time, where green betel leaves were able to absorb 49.83% copper metal, from 158 ppm Cu level to 79.27 ppm. Even though desorption occurs/reaches a saturation point where almost the entire surface of the adsorbent has been covered by the existing adsorbate particles.

Based on the results of the analysis of the adsorption capacity, it was found that the influence of the mass of the adsorbent is a very important part in supporting the adsorption process to run optimally. According to Zuninra (2000) in (Edward et al, 2016), the more adsorbent used the more metal will be absorbed, but the adsorbent has a limit to its ability to absorb and excess adsorbent can also cause saturation. One of the saturation factors is due to the higher adsorbent mass. This can cause interference (disturbance) between the bonding spaces due to adsorbent clumping resulting in the active surface of the adsorbent not being fully exposed to adsorb the metal so that the adsorption process is not effective.

Based on the journal (Syahrir et al, 2021) explaining the characterization of betel leaves using the GC-MS tool. It was explained that the most abundant compound in betel leaf was chromanol with an area of 26.93% with a retention time of 12.309, then eugenol 22.59% with a retention time of 10.833 and phenol 19.49% with a retention time of 9.135.

Phenolic compounds in betel leaves have antioxidant activity because phenolic compounds are able to reduce radical compounds. Phenolic compounds have the ability to donate hydrogen atoms or electrons to free radicals to form stable intermediates. These compounds bind to free radicals, decompose oxidation products and chelate metal ions (Diniyah & Lee, 2020). This is the reason why green betel leaves can be adsorbents. The total phenolic content (when made up in the extract) depends on the polarity of the solvent used in the extraction. The high solubility of phenolic compounds in polar solvents gives a high concentration of extracts obtained using polar solvents during extraction. The higher the phenolic content, the higher the free radical scavenging activity (Indra, Nurmalasari, and Kusmiati, 2019). Free radicals are compounds that are unstable and quickly react with other compounds to form more free radicals in chains. Free radicals are formed from chemical reactions that last very long or from environmental pollution such as nitrogen, dioxide, ozone, heavy metals, and cigarette smoke.

IV. Conclusion

Based on the results obtained, the following conclusions can be drawn:

1. The results of the analysis showed that the optimum adsorption of lead metal was at a mass of 30 grams of betel leaf and a stirring time of 1 hour, where green betel leaves were able to adsorb 99.96% of lead metal, from a Pb level of 6435 ppm to 2.48 ppm.
2. The optimum results for adsorption of copper metal were 35 grams of betel leaf mass and 30 minutes of stirring time, where green betel leaves were able to

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absorb 49.83% copper metal, from 158 ppm Cu level to 79.27 ppm.

3. The presence of heavy metals can become pollutants when their concentration exceeds the specified threshold. Heavy metals enter water bodies and settle on sediments occurs through three stages, namely the presence of rainfall, adsorption and absorption by water organisms. Heavy metal in the water environment is absorbed by the particles and then accumulated in the sediments. Therefore, there is a need for methods to reduce the concentration of heavy metals by using the ingredients that are available in the deep, including green leaves that serve to absorb the heavy metal in the waters.
4. The recommendations for its use are very simple just by planting more green leaves and mixing with the substance you want to reduce the level of heavy metals.

Acknowledgement

The publication of this article could not have been separated from the help and encouragement of various parties, so on this occasion we would like to express our deepest gratitude to the honorable Director of PNUP and Chair of P3M PNUP for facilitating the implementation of this research.

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DOI : http://dx.doi.org/10.31963/intek.v10i1.4348