ISSN : 2987-5064

UTILIZATION OF DURIAN PEEL WASTE AS BIOSORBENT FOR LEAD (PB) REMOVAL IN INDUSTRIAL WASTE

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Abstract.
Lead (Pb) is one of the toxic and dangerous metals if it accumulates in the body. It comes from industrial waste. The adsorption is one of the efficient methods for handling the impact of water pollution caused by lead waste. This research utilizes durian peel as a raw material for making biosorbent for the removal of Pb in liquid waste. From its characteristics, durian peel can be used as a potential raw material in the manufacture of biosorbent due to the rich in cellulose content of 43.72% which can be utilized as raw material of activated carbon (AC) for eliminating industrial wastewater containing Pb metal. The durian peel waste was converted to AC by chemical activation. The adsorption process was carried out using variations in biosorbent concentration (1; 1.5; 2; 2.5 and 3 grams in 50 ml sample) and contact time with Pb concentration was measured every 15 min for 75 min using Atomic Absorption Spectrophotometry (AAS) equipment. Based on the Langmuir equation, the adsorption capacity and Langmuir coefficient were 43.860 mg/g and 0.318, respectively. The results of the Pb concentration analysis showed that the maximum elimination in Pb levels in industrial wastewater was obtained at the adsorbent amount of 3 grams with contact time for 60 minutes and resulting the adsorption efficiency of 99.48%.

Keywords: Durian Peel Waste, Activated Carbon, Biosorbent, Pb

Introduction

Pollution that generally destroys the environment usually comes from very dangerous wastes that have high toxicity. Highly toxic wastes are generally chemical wastes, either in the form of compounds, elements or ions. Usually chemical compounds that are very toxic to living organisms and humans are chemical compounds that have active ingredients from heavy metals. This toxic power will work as a barrier to the work of enzymes in the physiological process of a body's metabolism and if it accumulates in the body will cause chronic poisoning problems [1]. Some elements of heavy metals are dangerous metals such as Lead (Pb), Cadmium (Cd), Chrome (Cr), Cuprum (Cu), Iron (Fe) and Mercury (Hg), most of these metals have very high affinity for sulfur. These metals attack the sulfur bonds in the enzymes so that the enzymes don't work. Protein, carboxylic acid and amino groups are also attacked by heavy metals. For example, Cd, Cu, and Hg (II) ions are bound to the cell membranes causing inhibition of transport processes through the cell wall [1].

The industries that have the potential to produce waste containing lead (Pb) are related to machining work, metallurgy, metal plating, paint, leather, and mining industry. This heavy metal is toxic to animals, humans, plants and shows persistence. It is nondegradable in aquatic media [2]. Several methods that can be used to reduce the concentration of heavy metal ions especially Pb in wastewater include Photocatalysis [2], precipitation [3], ion exchange using resins [4], and adsorption [5] of pollutants by adsorbents in the form of synthetic resins and activated carbon [6-9].

So far, from the several existing methods, researchers are still trying to choose the most optimal method by studying various variations of the influential process in order to fulfill the quality standards for the disposal of wastewater. The method that is often used for the process of removing heavy metals from polluted environments is using the adsorption method. This method is effective and simple to remove heavy metals. The adsorbent can use durian or banana peel as a biosorbent for the Pb removal in liquid wastewater [6-9].

Durian is one of the most famous fruit crop commodities in Indonesia with a production of 1.350.000 tons in 2021 [10]. In general, Indonesian people only consume durian meat and some also process durian seeds into certain foods. As a result, it produces waste in the form of durian peel which will cause an unpleasant odor and if burned will cause air pollution. The durian peel contains about 47.2% of cellulose, 9.63% of hemicellulose, 9.89% of lignin and 4.2% of ash [11]. It has been extensively studied as a adsorbent of pollutants (heavy metals) and a fuel. The reduction of heavy metals can be done by forming cellulose complex bonds with heavy metals.

The manufacture of biosorbent from durian peel can be done by chemical activation method. Previous researcher has studied the use of durian peel as adsorbent with different conditions namely particle size, contact time and different application [8,9]. To the best of our knowledge, the application of sodium hydroxide (NaOH) and nitric acid (HNO_3) as chemical activating agents to convert durian peel into AC that will be used as an adsorbent in Pb

removal with variation of adsorbent mass and contact time is still rarely studied. In this study, we conducted adsorption process for Pb removal from wa ste water with adsorbent mass of 1; 1.5; 2; 2.5 and 3 grams in 50 ml sample and contact time for 15 to 75 minutes.

Methods

The stages of the process of making a biosorbent from durian peel for the absorption of Pb from the liquid waste of the industry include size reduction, drying, refining, chemical activation of biosorbent, sample testing and evaluation. The durian peel that has been prepared was cleaned, cut into small pieces so that the size became ± 1 cm. Then the durian peel was dried in the sun and used an oven to reduce the moisture content to close to 0%. Furthermore, the durian peel was mashed and sieved with a 60 mesh sieve, soaked in a 40% NaOH solution for 4 hours at a temperature of 60ºC. The biosorbent is then filtered and washed. After being activated using an alkaline activator, the biosorbent was immersed in a 20% HNO_3 solution for 4 hours at a temperature of 80ºC at a pH value of 2. The biosorbent which had been activated by an acid activator was then filtered (60 mesh) and washed again, and dried using an oven at 50ºC. The next process was measuring the cellulose content using reflux method and surface area using Surface Area Analyzer (Nova Touch IF, 17017122201/1.04 type) of adsorbent.

Adsorption process was carried out by mixing 50 ml of liquid waste with a biosorben with a mass variation of 1; 1.5; 2; 2.5 and 3 grams and stirred using a shaker for a variation of time 15; 30; 45; 60 and 75 minutes. The results of stirring are then filtered and the filtrate is taken. After that, the concentration of Pb metal was tested using AAS (Shimadzu, AA-6300 type) so that the results of the absorption efficiency of the adsorbent on Pb metal and the Langmuir isotherm adsorption equation were obtained. The adsorption efficiency was calculated by the subtraction of initial concentration before process by final concentration after process divided by initial concentration multiplied by 100%. In this study, the initial concentration of Pb in the wastewater was 5.58 ppm.

Results and Discussion

The result analysis of the cellulose content of durian peel was 43.7%, with a surface area of 1.06 m^2/gram. Table 1, Figure 1 and Figure 2 show the % reduction in Pb concentration (adsorption efficiency, %) at various adsorbent mass, namely 1.0; 1.5; 2.0; 2.5; and 3 grams in 50 ml of wastewater with contact times of 15; 30; 45; 60; and 75 minutes. The larger the adsorbent mass and the longer the contact time up to 75 minutes, the greater the decrease in Pb concentration.

Table 1. *Effect of contact time and mass of durian peel adsorbent on the adsorption efficiency with an initial concentration of Pb 5.58 ppm*

Contact time (minutes)	Adsorbent mass (mg) in 50 ml sample	Concentration of Pb (ppm)			Adsorption efficiency of Pb (%)
		I	II	Average	
15	1	3.549	3.540	3.545	36.47
30		3.179	3.176	3.178	43.06
45		2.736	2.732	2.734	51.00
60		2.591	2.591	2.591	53.57
75		2.635	2.635	2.635	52.78
15	1,5	2.893	2.897	2.895	48.12
30		2.489	2.488	2.489	55.40
45		1.992	1.993	1.993	64.29
60		1.697	1.693	1.695	69.62
75		1.784	1.784	1.784	68.03
15	2	1.889	1.887	1,888	66.16
30		1.491	1.491	1,491	73,28
45		1.272	1.278	1,275	77.15
60		1.083	1.083	1,083	80.59

ISSN : 2987-5064

75		1.095	1.097	1,096	80.36
15	2,5	1.143	1.149	1.146	79.46
30		0.855	0.851	0.860	84.59
45		0.693	0.693	0.693	87.58
60		0.389	0.390	0.390	93.02
75		0.374	0.374	0.374	93.30
15	3	0.299	0.298	0.299	94.65
30		0.097	0.097	0.097	98.26
45		0.043	0.045	0.044	99.21
60		0.029	0.029	0.029	99.48
75		0.031	0.034	0.033	99.42

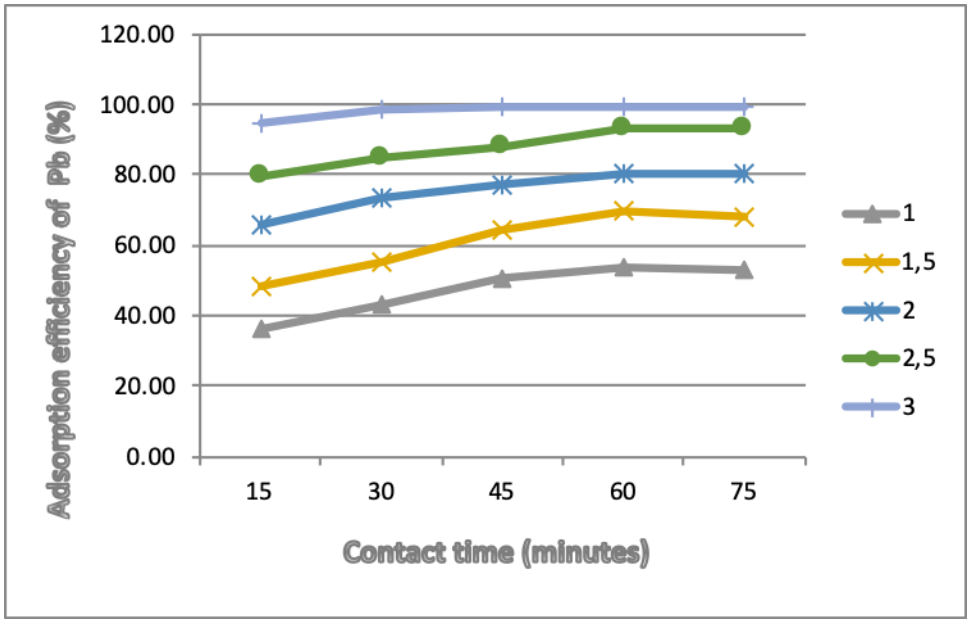

Figure 1. The effect of contact time vs % adsorption efficiency in variations adsorbent mass

ISSN : 2987-5064

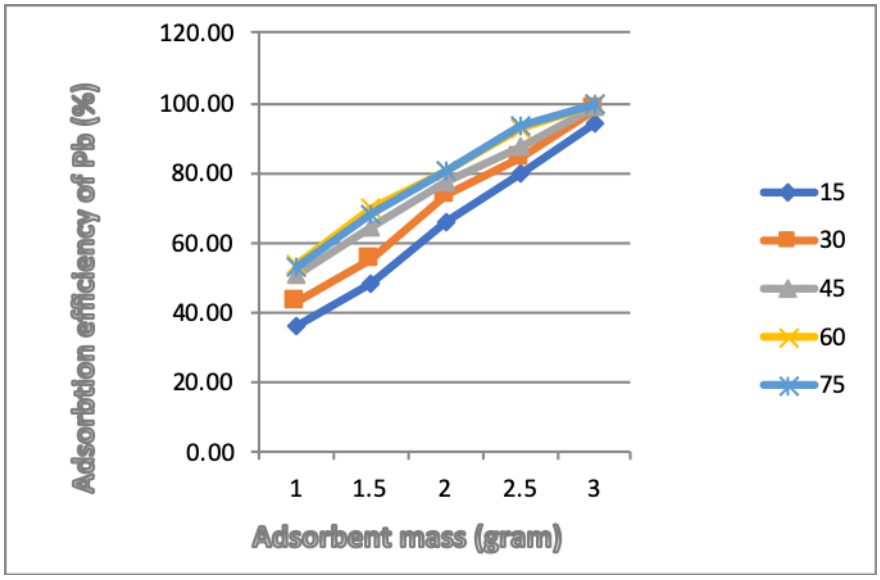

Figure 2. The effect of absorbent mass vs % efficiency in variation of contact time

Based on Table 1, Figure 1 and Figure 2, it can be seen that the best efficiency for the absorption of Pb metal was obtained at 3 grams of adsorbent with a contact time of 60 minutes with an adsorption efficiency of 99.48%. The adsorption capacity has increased because the longer the contact time, the more opportunities for adsorbent particles to contact with Pb metal bound in the pores of the adsorbent. Furthermore, the greater the adsorbent mass, the higher the % adsorption efficiency (the Pb concentration decreases). The same result was also conveyed by previous researchers which the longer the contact time, the greater the adsorption efficiency [12].

This shows that adsorption is a phenomenon which is closely related to the surface area where the interaction between liquid or gas molecules and solid molecules is involved. This interaction occurs due to the attraction of atoms or molecules that cover the surface of the adsorbent. However, at the contact time of 75 minutes, the adsorption efficiency did not increase significantly compare to 60 minutes (Figure 2) since the surface area of the adsorbent was saturated with Pb. In the use of 3 grams of adsorbent, the contact time from 15 and 75 minutes has little effect as indicated by the adsorption ability which is relatively slightly changed between 94.65-99.48%. The surface area is influenced by the size of the particles or pores, the shape of the pores, the arrangement of the pores in the particles and the number of adsorbents. The larger the surface area of the adsorbent, the greater the adsorption that occurs because the possibility of substances sticking to the surface of the adsorbent increases. According to the Regulation of the Minister of the Environment of Indonesia Number 5 of 2014 concerning the quality standard of clean water, the maximum Pb content for industry group 1 is 0.1 ppm. This condition was achieved with the use of 3 grams of adsorbent with a contact time of 30 minutes with a final Pb concentration of 0.094 ppm as shown in Table 1.

The adsorption process is influenced by several factors and has a specific adsorption isotherm pattern. The type of adsorbent, the type of substance being absorbed, the surface area of the adsorbent, the concentration of the adsorbed substance, and temperature are several factors that influence the adsorption process. With these factors, every adsorbent that absorbs a substance will have the different adsorption pattern. From the research data, it can be then developed in a calculation and plotting on the graph so that the Langmuir adsorption isotherm equation will be obtained which is used to study the adsorption ability of durian peel biosorbent on Pb metal.

Figure 3 shows the equation of the line in the Langmuir adsorption isotherm with Ce = the concentration of Pb in the solution after adsorption at equilibrium, Xm/m = the amount of adsorbate that is adsorbed into the adsorbent at equilibrium (mg/g).

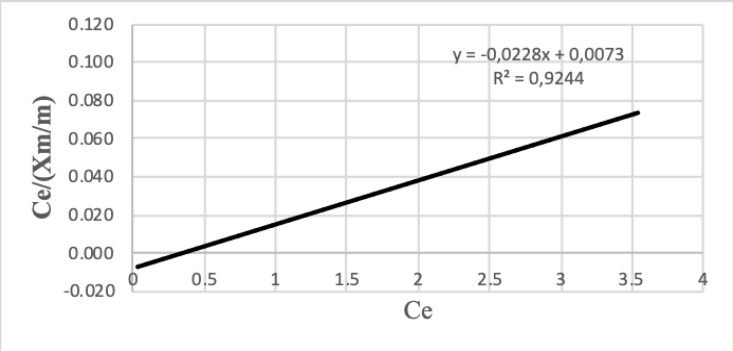

Figure 3. *Langmuir isotherm adsorption equation*

From Figure 3, it can be calculated that the adsorption capacity was 43.860 mg/g and the Langmuir constant of 0.318. The application of the adsorption isotherm model shows a linear relationship between the amount of substance adsorbed per gram of absorbent and the parameters of the Langmuir equation.

Conclusion

Durian peel can be used as a biosorbent so that it can reduce environmental pollution. The highest adsorption efficiency was obtained at the condition of using 3 grams of adsorbent and a contact time of 60 minutes with an efficiency of 99.48%. The adsorption capacity and the Langmuir constant were 43.860 mg Pb/g adsorbent and 0.318 respectively.

Acknowledgment

The authors would like to thank to SMAK Padang for the cooperation in the use of its Laboratory.

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