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Utilization of pineapple (*ananas comosus l*) leaves plant waste as a natural biosorbent

To cite this article: H. Herlinawati *et al* 2022 *J. Phys.: Conf. Ser.* **2193** 012078

Utilization of pineapple (*ananas comosus l*) leaves plant waste as a natural biosorbent

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Abstract. The adsorption process is more suitable because the costs required are not too expensive and will not cause new contaminants. Currently, research is being promoted on the use of alternative adsorbents derived from nature. Natural adsorbents in addition to having good adsorption ability, are also more economical. Natural biosorbent from pineapple leaves (Ananas comosus L) which had previously been carried out with carbonation, biosorbent activation, and biosorbent characterization using XRD and BET instruments, respectively. The results of the XRD analysis characterization obtained the diffraction pattern of pineapple leaves carbon, there are several sharp peaks, which are very clear at a diffraction angle of 2θ between 25 to 65 degrees, with a crystallinity degree of 32% and pineapple leaves activated carbon, increased the number of degrees of crystallinity at a diffraction angle of 2θ between 20 to 65 degrees, with a degree of crystallinity of 42.26%.The results of the XRD analysis characterization showed that pineapple leaves biosorbent and pineapple leaves activated carbon had amorphous material structure. This material is composed of atoms that are arranged irregularly and randomly scattered. The results of the BET analysis characterization obtained that each graph meets the classification of type I, type II, and type V adsorption isotherms, it means that these carbons have the same type, namely micropores (< 2nm). The surface area according to BET data on pineapple leaves carbon was 70,418 m^2/g and carbon activated had an outer surface area of 39,394 m^2/g. Likewise with the results of BJH data, where the surface area of pineapple leaves carbon is 44,775 m^2/g higher than carbon activated is 25,685 m^2/g.

1. Introduction

Pineapple (Ananas comosus) is a plant with a short trunk. Pineapple plants are monocotyledonous plants and are clumps (sprouts). The leaves are very long, at the edges grow thorns facing upwards (towards the tip of the leaf) and the leaves appear and collect at the base of the stem. The leaves have long fibers (Sunarjono, 2008). Pineapple leaves fiber contains cellulose, lignin, pectin, fat and wax, ash and other substances (protein and other organic acids). According to Hidayat (2008), in pineapple leaves fiber there is a cellulose content of around 69.5-71.5%. So far, pineapple leaves have not been widely used. The part that is usually used is only the fruit. At harvest time, this plant must be replaced with a new pineapple plant while the leaves are only disposed of as waste from pineapple farmers. Pineapple plants will be dismantled after two or three harvests to be replaced by new plants, which results in pineapple leaves waste continuing to grow. Apart from this, the presence of carbon compounds such as cellulose and lignin contained in pineapple leaves, so that it has the potential to be used as an adsorbent base material that can be used to absorb metals in polluted water. Handling and reducing heavy metals in waste needs to be done so that industrial waste does not pollute the environment too much when it is discharged into water bodies. So that it can reduce the danger of contamination from industrial waste containing heavy metals. One way that can be done is an adsorption process, because the costs required are not too expensive and will not cause new pollutants. Currently, research is being promoted on the use of alternative adsorbents derived from nature. Natural adsorbents in addition to having good adsorption ability, are also more economical.

2. Method

2.1. Biosorbent Preparation and Carbonization
In this study, pineapple leaves waste were each cleaned by washing until clean and then each waste was dried in the open air (sunlight) for 7-8 days. Then cut into small pieces. Then each waste is ground using a blender. Biosorbents of pineapple leaves were heated at a temperature of 300 ^{0}C for ± 1 hour, after which they were placed in a closed container. The carbonization results are then ground and sieved using a 70 mesh sieve.

2.2. Biosorbent Activation Process of Pineapple Leaves
Charcoal activation was carried out using an acid solution in the form of H2SO4 referring to the research of Irmanto and Suyata (2010) and Alfiany, et al., (2013). The biosorbent charcoal was weighed as much as 60 grams, soaked while stirring with a magnetic stirrer for 30 minutes in 250 mL H_2SO_4 solution with a concentration of 1 M as much as 250 mL for 24 hours, then filtered. The solids were washed using distilled water and dried in an oven with time and temperature in stages at an initial temperature of 50 ^{0}C for 30 minutes followed by a temperature of 80 ^{0}C for 45 minutes then ground first and then at a temperature of 110 ^{0}C for 45 minutes, then put in a desiccator.

2.3. Water content and Biosorbent Characterization
Empty petri dishes were dried for one hour at a temperature of 105 ^{o}C in an oven, then weighed carefully (W1), after being cooled in a desiccator. A total of 1 g of the test sample was carefully weighed (W2) in a petri dish, then dried again at a temperature of 105 ^{o}C. After reaching constant weight (W3), the water content is calculated. Biosorbents of pineapple leaves were carried out using XRD to determine the structure of biosorbents of pineapple leaves and BET for surface area determination.

3. Result and Discussion

3.1. Biosorbent Preparation
In this study, pineapple leaf waste was cleaned by washing it thoroughly to remove impurities that were still in the pineapple leaves. The washed pineapple leaves are then dried in the open air (sunlight) for 7-8 days to reduce the moisture content and to prevent the emergence of microorganisms on the pineapple leaves. Then the pineapple leaves are cut into small pieces and mashed using a blender. Furthermore, dried pineapple leaves are heated in a furnace at a temperature of 300 ^{o}C for ± 1 hour to reduce the water content. After that it is placed in a closed container. The carbonization results are then ground and sieved using a 70 mesh sieve. The goal is to increase the surface area of the biosorbent so that the adsorption ability is higher. Pineapple leaf samples used as natural adsorbents. In the preparation process, washing is carried out to remove the remaining impurities that are still present in the pineapple leaves. The washed pineapple leaves were then chopped and washed again with running water to obtain cleaner pineapple leaves. Pineapple leaves that have been washed and chopped and then dried in the sun for 7-8 days to dry to reduce water content and extend the shelf life of pineapple leaves to prevent the emergence of microorganisms on pineapple leaves.

Journal of Physics: Conference Series **2193** (2022) 012078 doi:10.1088/1742-6596/2193/1/012078

3.2. Carbonization and Carbon Activation

At the carbonization stage, the volatile components contained in the biosorbent samples of pineapple leaves were evaporated. Each biosorbent was carbonized at 500ºC for 2 minutes to remove volatile components in order to obtain pineapple leaf carbon. In the carbonization process, the volatile organic content is indicated by the amount of smoke produced. The carbonization process is complete, it is indicated by the sample has changed evenly to black color and has less smoke. The decomposition of organic matter in the pineapple leaves will evaporate the volatile components and will create a pore structure. High temperatures can speed up the reaction but if it is too high, such as above 1000°C, it can cause a lot of ash to close the pores. The activation process of activated carbon was carried out by soaking each of the carbon of pineapple leaves and cocoa peel in H_2SO_4 for 24 hours. The activation process aims to activate the carbonized carbon, remove impurity components such as water and volatile components that cover the carbon surface pores, and form new surface pores that will expand the activated carbon surface. This study uses acid activation with H_2SO_4 because H_2SO_4 is widely used as an activator in the manufacture of activated carbon.

3.3. XRD characterization for biosorbents and activated charcoal

XRD characterization was carried out to determine the crystallinity of the layer formed on the biosorbent and activated carbon of pineapple leaves. The results can be seen in Figure 1.

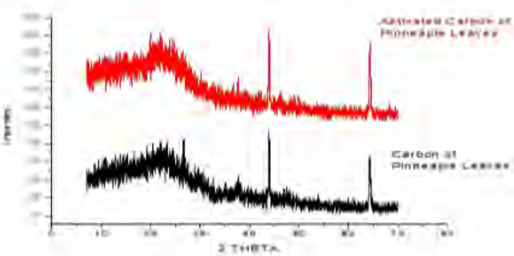

Figure 1. XRD pattern diffractogram of pineapple leaves biosorbent and activated carbon of pineapple leaves

Based on the Figure 1, it can be seen that the resulting graphic form is different from pineapple leaf biosorbent and pineapple leaf activated carbon, this is influenced by the degree of crystallinity formed. It can be seen on the Table 1.

Table 1. Degree of crystallinity carbon of pineapple leaves and activated carbon of pineapple leaves

Sample	Degree of Crystallinity
Carbon of pineapple leaves	32%
Activated carbon of pineapple leaves	42.26%

3.4. BET characterization for biosorbents and activated charcoal

After the analysis, the data obtained in the form of average pore size, specific surface area and pore volume of each carbon. To determine the pore volume, the BET method can be used, while to determine the average pore, the BJH method can be used. It can be seen on the Table 2. Based on the Table 2, it can be seen that the surface area of each carbon has a wide range of differences. The surface area according to BET data on pineapple leaf carbon was 70,418 m2/g and carbon that had been activated with H_2SO_4 had an outer surface area of 39,394 m2/g. Likewise with the results of BJH data, where the surface area of pineapple leaf carbon is 44,775 m2/g higher than carbon that has been activated with H_2SO_4 which is 25,685 m2/g. For brown skin carbon, the surface area according to BET data is 8,290 m2/g, and for brown skin carbon that has been activated with H_2SO_4 it has a lower surface area, which is 1,995 m2/g. The surface area of brown shell carbon and brown shell activated carbon according to BJH data results also have a considerable difference. Where the brown skin carbon, the surface area obtained is 5,322 m2/g, while the brown skin activated carbon is 0.787 m2/g. From these data it can be seen that each unactivated carbon has a higher surface area than the carbon that has been activated with H_2SO_4 acid.

Table 2. Carbon characteristics by BET analysis

No.	**Analysis result**		**Sample**	
			Pineapple leaves carbon	Pineapple leaves activated carbon
1.	Surface area	BET (m^2/g)	70.418	39.394
		BJH (m^2/g)	44.775	25.685
2.	Pore Volume (cm^3/g)		8.183	5.133
3.	Average Pore Size (nm)		15.711	15.599
4.	Pore Type		micropores	micropores

4. Conclusion

The results of the XRD analysis characterization obtained the diffraction pattern of pineapple leaves carbon, there are several sharp peaks, which are very clear at a diffraction angle of 2θ between 25 to 65 degrees, with a crystallinity degree of 32% and pineapple leaves activated carbon, increased the number of degrees of crystallinity at a diffraction angle of 2θ between 20 to 65 degrees, with a degree of crystallinity of 42.26%.The results of the XRD analysis characterization showed that pineapple leaves biosorbent and pineapple leaves activated carbon had amorphous material structure. This material is composed of atoms that are arranged irregularly and randomly scattered. The results of the BET analysis characterization obtained that each graph meets the classification of type I, type II, and type V adsorption isotherms, it means that these carbons have the same type, namely micropores (< 2nm). The surface area according to BET data on pineapple leaves carbon was 70,418 m^2/g and carbon activated had an outer surface area of 39,394 m^2/g. Likewise with the results of BJH data, where the surface area of pineapple leaves carbon is 44,775 m^2/g higher than carbon activated is 25,685 m^2/g.

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