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BIOSORPTION OF WELL WATER USING BIOSORBENT DERIVED FROM ARECA FIBER WASTE

Devie Novallyan[*], Wiji Utami[**]

[*]*Biology Education, Faculty of Tarbiyah and Teacher Training, UIN Sulthan Thaha Saifuddin Jambi, Jambi, Indonesia*, devienovallyan@uinjambi.ac.id

[**]*Chemistry Department, Faculty of Science and Technology, UIN Sulthan Thaha Saifuddin Jambi, Jambi, Indonesia*, wijiutami@uinjambi.ac.id

Email Correspondence : wijiutami@uinjambi.ac.id

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Abstract: The biosorption of well water using biosorbent from areca fiber waste of Jambi province has been performed to elevate well water quality. In environmental preservation, this research aimed to reduce a solid waste of areca fiber waste, which has only been burned so far. This activity would increase carbon emissions in the atmosphere. The researchers obtained this material through carbonizations (300 and 400 $^{\circ}$C) and without carbonization. The proper material is used as a biosorbent was 400 C sized 200 mesh. The material showed several functional groups on the biosorbent surface, such as hydroxyl, amide, amine, and carbonyl. This material increased the quality of well water using 1.25 grams of biosorbent, 50 $^{\circ}$C, 150 rpm, and 30 minutes. The adsorption results were compared with the value from the standard of Permenkes No.146/Menkes/Per/IX/1990. Based on the explanation, it is resumed that biosorbent derived from areca fiber waste is effective, inexpensive, and easy to operate for increasing well water quality.

Keywords: areca fiber waste, biosorbent, well water

Abstrak: Adsorpsi air sumur menggunakan biosorbent dari limbah sabut pinang Provinsi Jambi telah dilakukan untuk meningkatkan kualitas air sumur. Pada pelestarian lingkungan, penelitian ini bertujuan untuk mengurangi limbah padat sabut pinang, yang selama ini hanya dibakar. Kegiatan ini akan meningkatkan emisi karbo ke atmosfir. Para peneliti memperoleh material ini melalu karbonisasi (300 dan 400 $^{\circ}$C) dan tanpa karbonisasi. Material yang tepat digunakan sebagai biosorben adalah 400 $^{\circ}$C berukuran 200 mesh. Material ini memperlihatkan beberapa gugus fungsi pada permukaan biosorben,seperti hidroksil, amida, amina, dan karbonil. Material ini meningkatkan kualitas air sumur pada 1.25 gram biosorben, 50 C, 150 rpm, dan selama 30 menit. Hasil adsorpsi dibandingkan dengan nilai standar Permenkes No.146/Menkes/Per/IX/1996. Berdasarkan penjelasan, hal ini disimpulkan bahwa biosorben dari limbah sabut pinang efektif, tidak mahal, dan mudah untuk menggunakan untuk meningkatkan kualitas air sumur.

Kata kunci: air sumur, biosorben, limbah sabut pinang

Introduction

Water pollutant is becoming a harmful problem because it reduces water quality for living things (Singh et al., 2018). They could not use the water to support their life, so we have to improve our environmental quality for our legacy, especially water quality. Based on data and statistics, the world's requisite of clean water for the next 40 years will be increasing by 19%, including for irrigation and agriculture (Wong et al., 2018). Currently, contaminated water is a critical matter on earth; as many as 2.2 billion people have difficulty accessing clean water (UN Water, 2021). Many researchers and governments are trying to find an advanced technique (Wong et al., 2018). There are methods for purifying contaminated aqueous such as filtration, precipitation, electrochemical, membrane, solvent extraction, ion exchange, microbes, and adsorption. The previous study recommended adsorption using biomass to reduce water pollutants because it has some advantages such as inexpensive, available, environmentally friendly, and efficient (Wong et al., 2018).

One of the potential biomass is areca fiber waste, a by-product from areca seed treatment. A previous study explained that activated charcoal derived from the heartwood of areca could absorb heavy metals of lead(II). In that study, the functional groups were leading for binding heavy metals such as hydroxyl, carbonyl, amide, and amine (Chakravarty et al., 2010b). Furthermore, areca waste also absorbs cadmium and copper at a pH of 5.6 (Zheng et al., 2008). Cu(II), Pb(II) (Chakravarty et al., 2010a; Tiwari et al., 2015). The performance of this biosorbent was tested on adsorption of Brilliant Dye (BG), a dye for industrial purposes, namely paper, wool, cotton, leather, etc. The adsorption of BG occurred on maximum pH of 7 (Sukla Baidya & Kumar, 2021).

The application of organic waste as a raw material for biosorbent production is a solution to reduce solid waste. Jambi province is one of the largest exporters of areca in Indonesia, has not yet to carry out post-treatment processing of areca. The primary goal in areca treatment is to obtain the seed to remain areca fiber as solid waste to the environment (Wong et al., 2018). This solid waste is just thrown and burned, which can add carbon emissions to the atmosphere (Gogoi et al., 2017). The cellulose and lignin contents in this waste make this waste appropriate to be used as a biosorbent using the carbonization process. Based on the explanation, this research was conducted to obtain biosorbent from areca fiber waste for purifying well water. Well, water quality before and after adsorption Well water quality before and after adsorption will be observed and characterized comprehensively based on several parameters: odor, colour, temperature, pH, Total Dissolved Solid (TDS), Total Suspended Solid (TSS), and turbidity Fe, Pb, and *E-Coli* bacteria.

Experimental Method

Biosorbent Preparation

Areca fiber waste was obtained from Tanjung Jabung Timur regency, Jambi province. This waste is a residue from the treatment of seed's Areca in that area. We performed a washing of Areca fiber waste using fluent water to eliminate inorganic impurities. This waste was dried under the sun for seven days to evaporate water vapor content. The drying process was continued using the oven at 105°C for 1 hour to omit the remaining water content on the material. The making of biosorbent from areca fiber waste is performed in two ways, such as carbonization and without carbonization. The carbonization processes were conducted at 300 and 400°C for 1 hour, so we produced three biosorbents, such as 400°C (A), 300°C (B), and without carbonization (C). The biosorbents were sifted using a 200 mesh sieve and stored in the desiccator to keep their quality (Utami, 2019).

Biosorbent Characterization

We characterized the powdered biosorbent to explore the performance of the porous material as a biosorbent. This characterization is a critical key in material design for better application. To evaluate biosorbent performance, we conducted an analysis, such as dush and water contents, and functional group using Fourier transform infrared (FTIR) (Tiwari et al., 2015).

Adsorption Batch of Well Water

We selected the proper biosorbent based on preliminary observations from 300°C, 400°C, and without carbonization. 1.25 grams of areca fiber waste was poured into 100 mL well water in a 1000 mL Erlenmeyer flask for 30 minutes. This activity was stirred at 150 rpm at 50 °C (Burakov et al., 2018; Wong et al., 2018).

Characterization of Well Water

The well water has a low quality due to pollutants from human activities in a modern lifestyle. The researcher collected well water near State Islamic University Sulthan Thaha Saifuddin Jambi. The sample area was listed in Figure 1. Based on Fig. 1, we could show that the condition of well water is not feasible to use and consume. Therefore, the researcher decided to treat this water using biosorbent from areca fiber waste. The well water was measured before and after adsorption with several characterizations based on Permenkes No. 146/Menkes/Per/IX/1990, namely odor, colour, temperature, pH, TDS, TSS, Pb, and *E. coli* (Sivakumar et al., 2014).

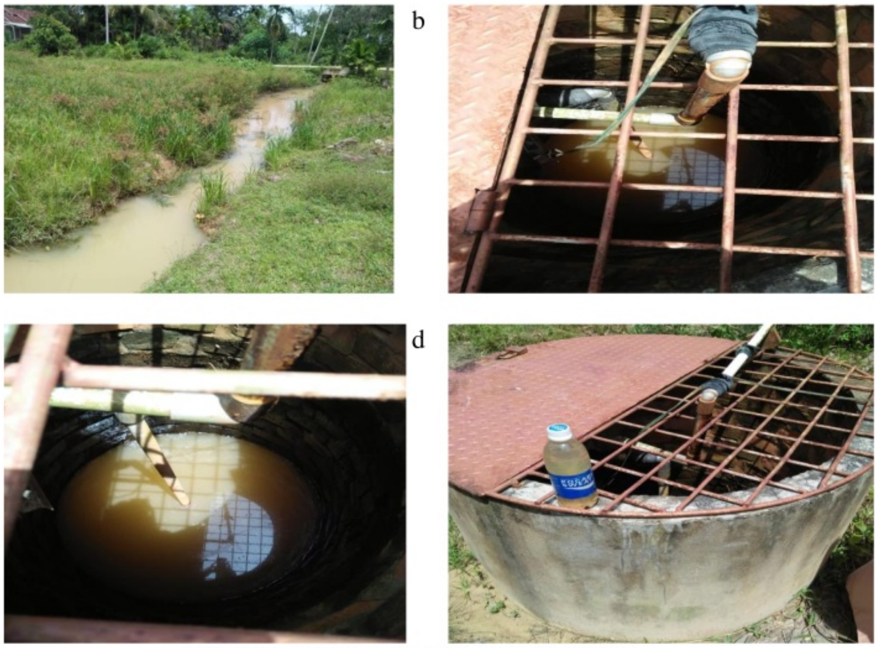

Figure 1. The sample area of this research

Result and Discussions

Biosorbent characterizations

The washing of an areca fiber waste was for eliminating the inorganic impurities, sand, and sludge. The samples were divided into several categories (Table 1). Before the biomass was calcined at a specific temperature, we collected and sun-dried procedure to reduce water content for seven days (Chakravarty et al., 2010a; Gogoi et al., 2017). The result of dush content analysis in Table 1 shows that sample C complies with the standard of SNI No. 06-3730-1995. Based on that standard, the best charcoal has a dush content maximum of 10%. The dush contents in biosorbent cause blocking a sensitive compound, and it increases thermal stabilization. While the A and B samples have a dush content higher than standard. The increasing of the dush content in the material due to oxidation processes in high temperature. Other than that, we performed a water content analysis. We can see in Table 1; sample A has the lowest water content of 23.06%. The maximum water content based on the SNI No. 06-3730-1995 is 15, and all samples do not conform to that standard. It is caused by water contamination during retention. Furthermore, temperature and dampness of storage influence water content increasing in the material. Besides dush and water contents, biosorbent performance is supported by the functional group's presence in the biosorbent surface (Jobby et al., 2018).

Table 1. Characterization of biosorbent from areca fiber waste

Samples (C, hour)	Code	Dust content (%)	Water content (%)
400, 1	A	27.02	23.06
300, 1	B	43.99	24.74
Without carbonization	C	2.45	26.48

The impurities removal from well water using biosorbent is based on the active functional group on that surface material. The functional groups in biosorbent have an affinity for trapping impurities in the active site. These functional groups found in biosorbent are carbonyl, amine, hydroxyl, amide, and metal (Chakravarty et al., 2010b). Moreover, carboxyl, phenol, lactone, and quinone are also established in biosorbent, bound in the edge of graphite-like(Burakov et al., 2018; Deliyanni et al., 2015). The wavenumber and spectra from biosorbent characterization are represented in Table 2 and Figure 2.

Table 2. The functional group of biosorbents from areca fiber waste using FTIR

A (cm^{-1})	B (cm^{-1})	C (cm^{-1})	Description
1500		1599.06	amine
1735			CO (aldehydes)
1850			CO (acylhalides)
	2112,14		CO (ester)
	2664.14		SH (sulfur)
3145.39			NH (amide)
		3173.04	NH (amide)
	3216.44		NH (amide)
3500-3600	3500-3600	3580-3600	OH (hydroxyl)

Based on Table 2, sample A has five peaks that specify a specific functional group. Peaks of 1500, 1735, and 1850 cm^{-1} represent amine and CO (aldehydes and acyl halides), respectively (Sukla Baidya & Kumar, 2021). The study's result is similar to previous research, which states that the area indicated C=O stretching and CO chelate stretching (Chakravarty et al., 2010a). The peak of 3145.39 cm^{-1} illustrates NH (amide). Simultaneously, the peak of 3660-3500 cm^{-1} represents OH (alcohol), and this peak is the sharpest than samples B and C (Chakravarty et al., 2010b).

For sample B, there are several dominant peaks such as 2112.14 cm^{-1} for CO (ester), 2664.14 cm^{-1} for SH (sulfur), and 3216.44 cm^{-1} for NH (amide), respectively. In Fig. 1, sample B shows a stretching vibration from OH (alcohol), but the peak is sloping in the 3600-3500 cm^{-1} area. This study's results are similar to previous studies, which resulted in dropping OH stretching (Bhattacharjee et al., 2020). Next, there are peaks in sample C, namely 1599.06 cm^{-1} for CO and 3173.04 cm^{-1} for NH. This material also shows OH spectrum in 3600-3580 cm^{-1} area. Based on the explanation about dush and water contents and functional groups analysis, the researchers conclude that sample A is the proper material for adsorbing well water to increase the quality.

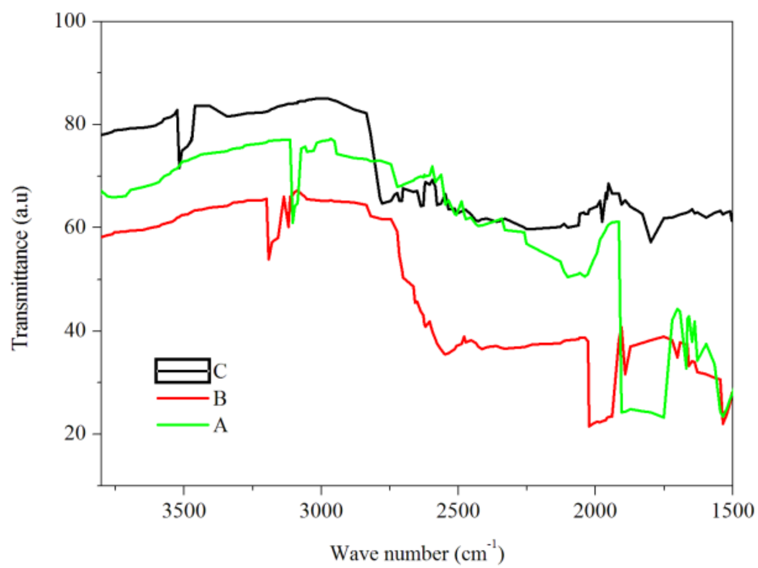

Figure 2. FTIR of biosorbent derived from areca fiber waste

Adsorption of well water using biosorbent from areca fiber waste

Nowadays, water treatment is becoming a concern for scientists because water is a crucial in this life. The adsorption method using biosorbent is promising because it has advantages, such as high specific area, high porous, presence of functional groups, and volume micro (Burakov et al., 2018; Kang et al., 2008). The measurements of well water adsorption using sample A are listed in Table 3. Table 3 shows that there are nine parameters tested before and after adsorption. Colour and odor parameters were conducted using the organoleptic test. Before adsorption, well water looks muddy and nasty smells. These conditions are caused by the presence of solvated organic matter in water. The organic compound is originated from decaying organic matter, a microscopic organism, and other chemical compounds such as H_2S. Moreover, the location of the well is near the swamp, so the water of the swamp sink and contaminate the well water. Previous studies claimed that muddy and smell in water were also caused by leachate from rainwater passing through the garbage pile. This leachate contains various organic materials, even heavy metals (Wong et al., 2018). Fortunately, after adsorption using this biosorbent, the colour of the well water was changed to clearer, and the biosorbent could reduce the nasty smell.

These phenomena are happened due to the trapping of organic compounds in the active site of the biosorbent. The difference between well water before and after treatment could be seen in Figure 3. This research is also supported by a previous study that biosorbent derived from areca fiber waste adsorbed dye compounds. This process occurs due to the mass transfer of substance absorbed in the biosorbent pores (Sukla Baidya & Kumar, 2021).

Table 3. The quality of well water between before and after adsorption using biosorbent derived from areca fiber waste (400 °C)

Parameters	Units	Before	After	Standards*
Odor	-	nasty odor	Little odor	no odor
Colour	-	muddy	clearer	no colour
Temperature	°C	27.4	28.1	±30
pH	-	5.0	7.0	6-9
TDS	mgL^{-1}	73	21.7	1000
TSS	mgL^{-1}	34	5.6	1000
Pb	mgL^{-1}	<0.03	<0.03	0.05
E.coli	JPT/100	32	11	0

*Permenkes No.146/Menkes/Per/IX/1990

Besides, the temperature is also vital for water quality. Based on Table 3, it can be seen that there was an increase in well water temperature from 27.4 to 28.1 °C. Furthermore, the pH of well water needs to be known because this is an important parameter. The acidic and alkaline water can cause damage to organs and daily life supplies. Adsorption using biosorbent changes pH from acidic (5) to neutral (7). This result is according to Permenkes No. 416/Menkes/PER/IX/1990 regarding the requirements for clean water.

Figure 3. The colour of well water before (left) and after (right) adsorption using a biosorbent derived from areca fiber waste

The other physical properties measured are TDS and TSS. These properties are experienced decreasing after adsorption (see Table 3). A previous study described falling these values because there is an active site at the biosorbent surface so that entrapment particles can take properly (Sia et al., 2017). The performance of biosorbent is also tested in the removal of Pb in well water.

The presence of Pb in water can harm humans and animals. Previous research noted that Pb exposure in water is due to the pulp and paper industry, fuel plant, battery, gun, and waste treatment. This heavy metal has not biodegradable properties, so it needs a method to remove it from water (Chakravarty et al., 2010b). The concentration of Pb metal after adsorption did not show any change. This is due to the saturation of the active site of the binding on the biosorbent surface (Chakravarty et al., 2010b).

Next, microbiological properties which measured for identification the quality of well water is *E.coli* content. This contaminant is originated from human and animal feces, which can cause gastrointestinal (Parker et al., 2010). Surprisingly, the content of bacteria in well water is 32 but has decreased by 65.63% after adsorption. The reduction of *E. Coli* in well water is due to pores of different sizes on the biosorbent surface, so this material provides a sufficient active site to absorb bacteria. This process reduces *E.coli* content (Pongener et al., 2017; Rahman et al., 2020). Based on the explanation, biosorbent derived from areca fiber waste can be developed to be biosorbent for absorbing impurities in well water.

Conclusion

Biosorption using biosorbent derived from areca fiber waste is a promising method for removing impurities in well water. This research provides insights into several sectors, such as improving well water quality and reducing areca fiber waste as a by-product. After characterization of the material, the researchers recommend this material is developed with advanced treatment.

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