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PURIFICATION OF DUG WELL WATER USING ACTIVATED CARBON MADE FROM SAGO FIBER WASTE

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ABSTRACT

The sago fiber waste is promising as an active carbon material which has a high adsorption in purifying water process. The objective of this research was to make activated carbon from sago fiber waste to be applied for water purification and iron (Fe) adsorption with various of contact time. The carbon activation process uses Phosphoric Acid (H_3PO_4) and calcined at 800 °C for 2 hours. After drying, then analyzed the water content and ash content. Furthermore, surface morphology testing was carried out using SEM. The application of activated carbon was carried out in dig well water purification and filtering iron (Fe) based on variations in contact time of 10 minutes, 20 minutes, 30 minutes and 40 minutes. Analysis of water content of activated carbon was carried out 3 times with an average value of 3.9662%. Ash content analysis aims to determine the metal oxide content in activated carbon. Analysis of the ash content of activated carbon was carried out 3 times with an average value of 5.3239%. The average value of ash content meets the quality standards of activated carbon SNI 06-3730-1995 where the standard value of ash content for powdered activated carbon is a maximum of 10%. SEM test results show that the surface of the activated carbon is porous but the size is not uniform. The level of Ferrium (Fe) in water that has gone through the purification process using activated carbon. The most effective contact time was obtained, namely 20 minutes and had met the threshold requirements for water turbidity levels according to Minister of Indonesia health. This means that activated carbon from sago fiber is able to adsorb the material contained in water and also very capable in picking up some bad contents of cloudy and polluted water.

1. Introduction

Sago is a native plant in Indonesia country. It is widespread throughout to the some region of Indonesian area. Sago includes to monocotil plants namely Palmae family, indentity of clan *Metroxylon* and *Sfadiciflorae* order. Nowaday, most utilization of sago plant focuses for starch contained only and one of the staple foods for several regions in Indonesia. Especially in Luwu and North Luwu Regencies, there were several reasons why community used sago as traditional foods such as kapurung, dange, bagea, sinole and cendol. Futhermore, the analyses results found that consumers decide to consume sago was influenced by ethnicity, education, type of processed food and rice price (Hayanti et al., 2014) . One of the parts of sago that has not been used is sago fiber. Sago fibers consist of pith fibers obtained from the grated or squeezed sago stalks. Crude fiber is part of carbohydrates, mostly derived from plant cell walls and contains cellulose, hemicellulose and lignin(Gopal Krishna; S K Ranjhan, 1980). According to (Lim Jew Kiat, 2006), sago fiber contains residual lignin by 21%, while the cellulose content is 20% and the rest is an extractive substance and ash so that it can be used as activated carbon. In addition, sago fiber also has compressive strength which is very supportive in the application of making composite boards (Supu & Jaya, 2018).

Sago fiber can be used as activated carbon and it can be used as adsorptive removal of Mercury (II) from aqueous solution (Kadirvelu et al., 2004), adsorbent for the removal of Rhodamine-B from aqueous solution (Kadirvelu et al., 2005), used to eliminate heavy metals and dyes from aqueous solution (Kadirvelu et al., 2003), as an adsorbent for methylene blue (Dahlan et al., 2017). Activated carbon is a material which contains amorphous carbon and has an internal surface so that it has high adsorption capacity and also can work as an absorbent. Activation can be done in two ways, namely physical and chemical methods. The activators most often used are KOH, $ZnCl_2$, H_3PO_4. Phosphoric Acid (H_3PO_4) is commonly used to produce activated carbon which has a large surface area and large pores. According to (Riyanti, 2006), activated carbon made by H_3PO_4 activator. It will produce activated carbon which have low polarity, so that its adsorption of iodine will take place better than methylene blue.

Activated carbon works by adsorption system. It means when there is a material such as water through the activated carbon, then the material which was contained will be adsorbed. So it's no wonder that activated carbon is able to take some of the bad content from cloudy and polluted water. It can even purify cloudy water and remove odors from the water. Granular Activated Carbon (GAC) is applied for the water purification process.

The purpose of this research is to make activated carbon from sago fiber waste to be applied for water purification and adsorption of ferrous metal *Ferrium* (Fe) with variations in contact time

2. Method

Research design

The experimental design used in this study was a 1-factor completely randomized design without replication. The treatment used in this study was a 50 ml well water with addition 2 grams of activated charcoal, stirred with 500 rpm in stirring

time variation (contact time) as follows: P0: Without treatment (adsorption), P1: Stirring 10 minutes, P2: Stirring 20 minutes,P3: Stirring 30 minutes, P4: Stirring 40 minutes

Table 1. Plot of experiment design

Pra-test	Variabel	Post-test
T1	P0	T2
T1	P1	T2
T1	P2	T2
T1	P3	T2
T1	P4	T2

Information: (T1): before treatment; P1 – P4: with treatment; P0: without treatment; (T2): after treatment

Research Procedural

Sample preparation

Sago fiber waste which has been cleaned of its cork tissue by washing it and then drying under the sunshine.

Carbonization

Sago fibers that have been separated from the cork tissue and dried. The basic material is then carbonized in a furnace for 2 hours (vacuum). Then the sample is cooled, then the sample is ground until it is smooth using a mortar and then sieved using a sieve80 mesh size.

Activation Process

The carbon produced by carbonization process then activated by chemical method with adding a 2.5% concentration of Phosphoric Acid (H_3PO_4) (Fisika & Universitas, 2015). This solution is stirred mixture with carbon then heated at 50 °C while stirring for 3 hours and also allowed to be quiet for 24 hours. The resulting activated carbon in the form of a precipitate is then washed with aquabides to a pH of 7. The resulting precipitate is then calcined at 800 °C for 2 hours to remove water and other organic substances (Susana & Astuti, 2016).

The activated carbon that has been dry is then analyzed for water content formulation. Water was eliminated by drying sample the porcelain plate in a furnace at 110 °C for 30 minutes. Furthermore, the plates were cooled in a desiccator for 30 minutes and the empty weight was weighed. Then, 1 gram of sample is inserted into the empty cup. The sample was flattened and put in an oven which had been set at 105 °C for 3 hours. The cup was removed from the oven and cooled in a desiccator and then weighed. Determination of water content was carried out three times (*Badan Standar Nasional Indonesia. Arang Aktif Teknis (SNI 06-370-1995)*, 1995). Then ash content was determined by drying the porcelain plate in a furnace at 110 °C for 30 minutes. Furthermore, the plates were cooled in a desiccator for 30 minutes. Then, 1 gram of sample is inserted into the empty cup.

The plate that has contained the sample is then put in the furnace at a temperature of 850 °C for 4 hours until the sample becomes ash. Then the cup is removed from the furnace and cooled in a desiccator, then weighed. Determination of ash content was carried out three times (*Badan Standar Nasional Indonesia Arang Aktif Teknis (SNI 06-370-1995)*, 1995).

Sample Characterization

SEM testing

The testing stage is carried out, after the sample is in powder form then then it uses scanning electron microscopy (SEM), which functions to determine the surface morphology of activated carbon.

Water Purification

The treatment was given by varying the contact time between 2 grams of sago fiber carbon and 50 ml of well water. Well water without the addition of activated carbon (P0) as a control and a contact time range of 10 minutes (P1), 20 minutes (P2), 30 minutes (P3), 40 minutes (P4) while the weight of sago fiber carbon (which functions as an adsorbent) is made constant. The stirring was performed at a speed of 500 rpm. Then filtered using filter paper and then tested the level of water clarity using a turbidity meter (Anjani & Koestiari, 2014).

Acidity Degree (pH)

The testing stage was carried out by measuring the degree of acidity of the sample water before treatment (P0) and samples that had gone through the purification process with variations in contact time of 10 minutes (P1), 20 minutes (P2), 30 minutes (P3) and 40 minutes (P4) with using a pH meter.

Determination of Ferrium (Fe) Content

The testing stage is carried out by measuring the iron (Fe) content in the sample water before treatment (P0 and samples that have gone through the purification process with variations in contact time of 10 minutes (P1), 20 minutes (P2), 30 minutes (P3) and 40 minutes (P4) using the *Lovibond Komprotor* tool.

Data analysis technique

Analysis of Activated Carbon Water Content

According to SNI (1995) the calculation of water content uses the equation:

$$water\ content\ (\%) = \frac{a-b}{Sample\ Weight} \times 100\% \qquad (1)$$

According to (*Badan Standar Nasional Indonesia. Arang Aktif Teknis (SNI 06-370-1995)*, 1995), the maximum limit for water content of activated carbon in powder form is 15%.

a = empty cup weight + sample weight (carbon) before heating (grams)

b = empty cup weight + sample weight (carbon) after heating (grams)

Analysis of Activated Carbon Ash Content

According to (*Badan Standar Nasional Indonesia. Arang Aktif Teknis (SNI 06-370-1995)*, 1995), the calculation of the ash content uses the equation:

$$Ash\ Content\ (\%) = \frac{a}{b} \times 100\% \qquad (2)$$

a = Ash Weight (grams)

b = Sample Weight (grams)

According to standards that apply nationally in Indonesia (SNI) (*Badan Standar Nasional Indonesia. Arang Aktif Teknis (SNI 06-370-1995)*, 1995) the maximum threshold for ash content of activated carbon in powder form is 10%.

3. Result and Discussion

Phosphoric acid (H_3PO_4) is commonly used to produce activated carbon which has a large absorbent surface and large pores. According to (Riyanti, 2006), activated carbon made with H_3PO_4 activator will produce activated carbon with low polarity and be able to adsorb iodine will take place better than methylene blue so that H_3PO_4 is very effectively used to activate activated carbon.

Calcination temperature affects the quality of activated carbon formed. From the test of activated carbon quality, the best quality of activated carbon was obtained at a temperature of 800 °C with a water content of 1.3%, an ash content of 0.60% that meets the SII 0258-79 standard and has an adsorption capacity for iodine content of 580.0 mg/g which meets SNI 06-3730 standards. Purification of household wastewater, colored water using activated carbon from an activation temperature of 800 ^oC produces water that is clear, odorless and meets the standard pH of water, namely 7.0-7.5 (Jamilatun & Setyawan, 2014).

a. **Water content of sago fiber activated carbon**

Water content analysis aims to determine the hygroscopic properties of activated carbon. Analysis of activated carbon water content was carried out 3 times with an average value of 3.9662% (presented in table 3) and has accordance to quality standards of activated carbon Indonesia National Standard (SNI) 06-3730-1995 (Table 2) where the standard value of water content for carbon active form of powder a maximum of 15%. The following table 3 of the water content value of sago fiber activated carbon that has been carried out

Table 2. Quality standards for activated carbon

Description	Quality Requirements	
	Granules	**Powders**
Flying substance content(%)	Maks 15	Maks 25
Water Content (%)	Maks 4,5	Maks 15
Ash Content (%)	Maks 2,5	Maks 10
The part does not become charcoal	0	0
Iodine (I_2) Adsorption to (mg/g)	Min 750	Min 750
Pure Activated Carbon (%)	Min 80	Min 65
Benzene Adsorption (%)	Min 25	-
Methylene blue Adsorption (mg/g)	Min 60	Min 120
Bulk Density (g/ml)	0,45-0,55	0,3 – 0,35
Escaped Mesh (%)	-	Min 90
Mesh Size (%)	90	-
Hardness (%)	80	-

Tabel Source: (*Badan Standar Nasional Indonesia. Arang Aktif Teknis (SNI 06-370-1995)*, 1995)

The water content of sago fiber activated carbon has met the quality standard according to SNI 06-3730-1995, which is a maximum of 15%, where the average value (Xr) of the sago fiber activated carbon water content is 3.9662% which we can see in the graph in Figure 1. The value of water content has met the standard due to heating treatment at a temperature of 800 °C of activated carbon while water evapo

Table 3. The value of water content of activated carbon from sago fiber

Mass	1st Replication	2nd Replication	3rd Replication
M (gram)	1,0008	1,0009	1,0012
A (gram)	34,2914	34,6079	36,8202
B (gram)	34,2418	34,5754	36,7832
%M (%)	4,9560	3,2471	3,6956
Xr (%)		3,9662	

Information : M: Mass / weight of sample (gram); A: Mass of cup + sample before heating (grams); B: Mass of cup + sample after heating (grams); % M: Percent moisture content (%); Xr: Average value (%)

rates at a temperature of 100 °C.The water content contained in activated carbon is influenced by the amount of water vapor in the air, the way activated carbon is stored after calcination will greatly affect the moisture content of the carbon, therefore carbon storage should preferably be in an airtight container such as a desiccator. High water content will reduce the quality of activated carbon because water adsorbed on the pores of activated carbon will reduce the capacity and adsorption power of liquids and gases. Activated carbon is hygroscopic so it easily absorbs water vapor from the air. This is because the structure consists of 6 Carbons (C) atoms which form a hexagonal lattice that allows water vapor to be trapped and cannot free under oven drying conditions.

b. Ash content of sago fiber activated carbon

Ash content analysis aims to determine the metal oxide content in activated carbon. Ash content analysis of activated carbon was carried out 3 times with an average value of 5.3239% (presented in Table 4). The average value of ash content meets the quality standards of activated carbon SNI 06-3730-1995 where the standard value of ash content for powdered activated carbon is a maximum of 10%.

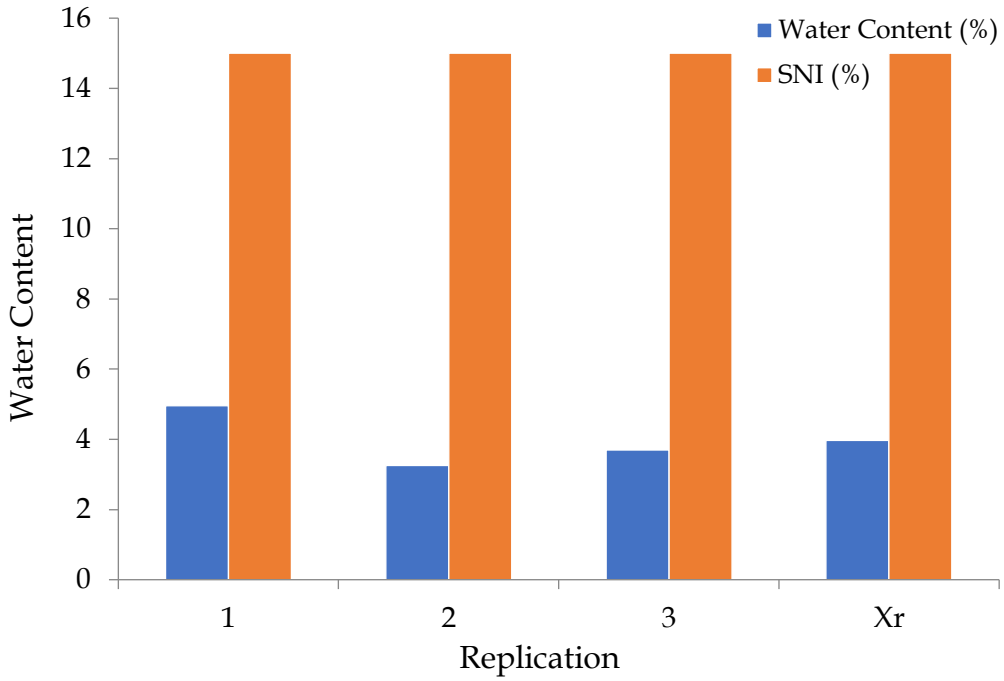

Figure 1. Graph of comparison of water content of sago fiber activated carbon and SNI

Table 4. Value of activated charcoal ash content from sago fiber

Mass	1st Replication	2nd Replication	3rd Replication
B (gram)	1,0011	1,0003	1,0002
M1 (gram)	37,9016	44,3432	36,6307
M2 (gram)	37,9537	44,3951	36,6865
%A (%)	5,2043	5,1884	5,5789
Xr (%)		5,3239	

Information: B: Mass / weight of sample (grams); M1: Mass of empty cup (gram); M3: Mass of empty cup + sample after heating (grams); % A: Percent ash content (%); Xr: Average value (%)

The Figure 2 shows the average value (Xr) of the ash content of activated carbon of sago fiber obtained in accordance with the quality standards of activated carbon according to SNI 06-3730-1995, the standard of ash content according to SNI is a maximum of 10% while the ash content value of activated carbon fiber sago obtained by 5.3239%.

In this study, the carbonization process was carried out in a traditional way, namely inserting sago fiber into a can and then burning it for 2 hours. The ash content contained in the activated carbon is influenced by the method of charring being used and the ash content can also occur because air is introduced during thecoking process due to the cans being used not tightly closed. The ash content in activated carbon can also occur due to the entry of air during the coking process, as a result of the cans being used not tightly closed. High ash content will reduce the adsorption power of activated carbon against liquids or gases because the oxides of metal minerals contained in activated carbon such as Na, K, Mg, and Ca will cover the pores of the carbon.

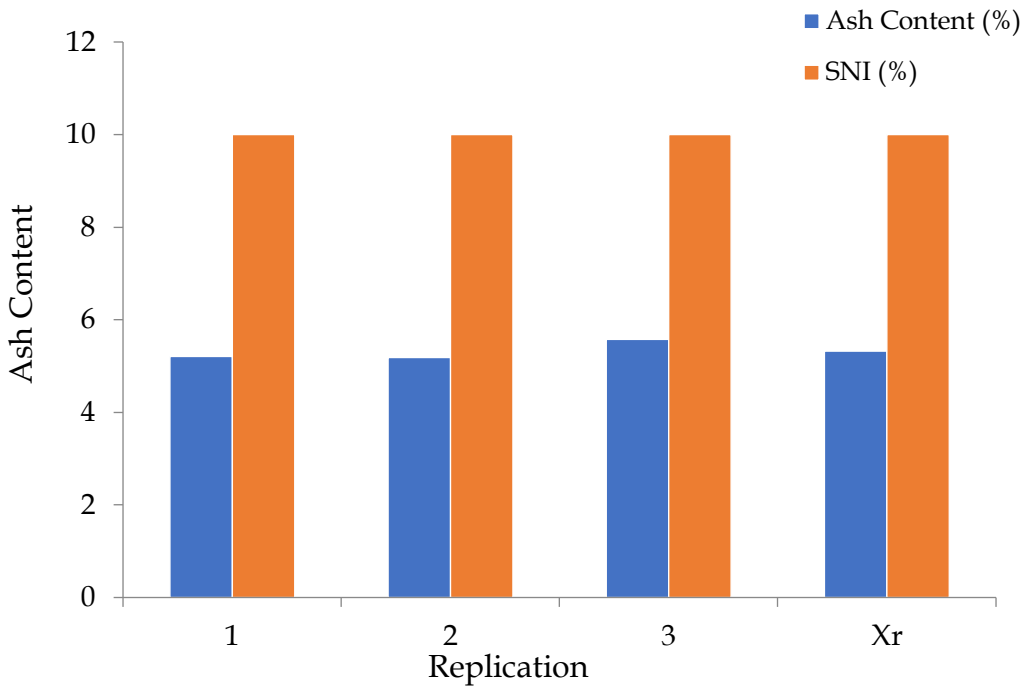

Figure 2. Graph of comparison of water content of sago fiber activated carbon and SNI

The compounds in sago fibers contain groups such as –NH2, -OH which can bind with metal ions to form complex compounds. This statement shows that the sago fiber is very easy to bind to metals which affects the quality of the ash content of the activated carbon obtained and this is most likely the case during the traditional charcoal process using cans.

c. SEM (Scanning Electron Microscopy)

The following is a surface morphology of activated carbon made from sago fiber which has been tested by *Scanning Electro Microscopy* (SEM). The SEM characterization (Figure 3.) was carried out to determine the surface morphology of activated carbon made from sago fiber which was activated using a 2.5% concentration of H3PO4 solution and calcined at a temperature of 800 °C with a magnification of 10,000x. It was seen that the surface of the activated carbon was porous but the size was not uniform.

Based on the Figure 3. activated carbon made from active sago fiber has a porous surface. The activation process that has been carried out using a 2.5% H_3PO_4 solution and calcined at 800 °C causes many pores to open on the surface. This is because the H_3PO_4 activating solution can reduce the hydrocarbons that coat the surface of the activated carbon. In addition, the calcination process with a temperature of 800 °C has an increase in temperature of activated carbon which causes impurities such as organic materials, namely carbon monoxide, H_2, methane and those that still cover the pore surface during the carbonization process leaving the activated carbon surface to form new pores (Bahtiar et al., 2015).

d. Water purification

This research was conducted to determine the optimum stirring time (contact time) between activated carbon and well water. The adsorption process was carried out by varying the stirring time (contact time), with a variation of 10 minutes as P1, 20 minutes as P2, 30 minutes as P3, 40 minutes as P4 and well water without adsorption namely P0 (without treatment) as a control. The well water sample used is dig well water that is used by the community daily as a source of drinking water.

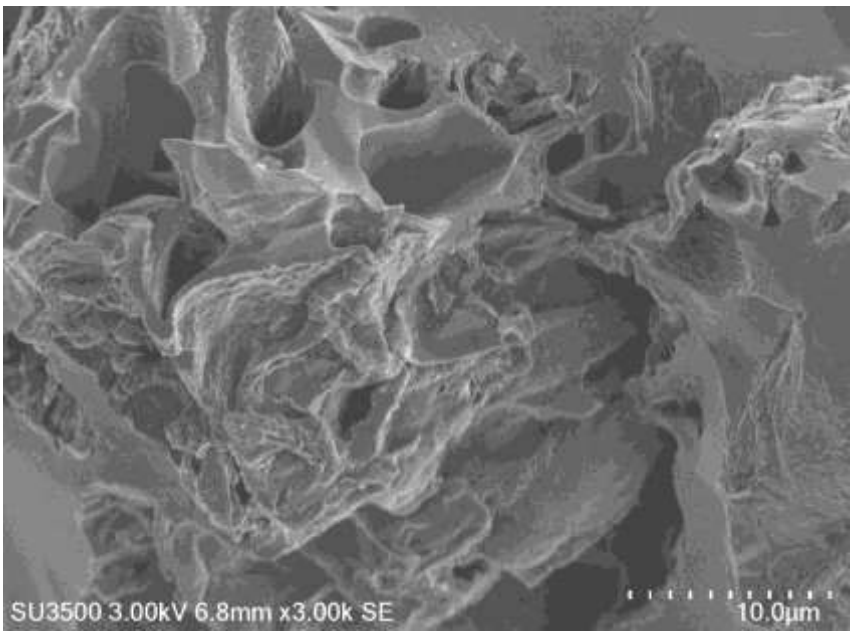

Figure 3. SEM test results for sago fiber activated carbon

The clarity test for each treatment experienced a change after the stirring process with activated carbon was carried out. The test results can be seen in the following table 5.

Table 5. The results of the well water clarity test before and after treatment

Treatment	Water Purity Level (Nephelometric Turbidy Unit /NTU)	
	Before Treatment was Given	**After Treatment was Given**
P0	89,3	89,3
P1	89,3	4,80
P2	89,3	4,78
P3	89,3	6,28
P4	89,3	6,54

In this study, the water purification test was carried out by examining the effect of stirring time of activated carbon with activated carbon (P1-P4) and P0 as a control without the addition of activated carbon. Based on the results of research that has been done. In table 6, it can be seen that the turbidity level P0 as a control without the addition of activated carbon is 89.3 NTU, P1 is 4.80, namely NTU, P2 is 4.78 NTU, P3 is 6.28 NTU and P4 is 6.54 NTU. These results indicate that P4 has the highest turbidity level, namely 6.54 NTU and P2 has the lowest turbidity level, namely 4.78 NTU. This indicates that the optimum contact time in this study is 20 minutes (P2). Sago fiber activated carbon as an adsorbent has a saturation point, which is when activated carbon can no longer absorb dissolved material in water (Talunoe et al., 2015), this can be seen in graph 9 at 20 minutes (P2) the turbidity value is the lowest. However, the results of the application of contact time have not been effective in this study because the distance of the variation in contact time is too far.

The results of this study also show that activated carbon is very effective in reducing the turbidity level of well water where the results show that P1 and P2 have met the maximum turbidity standard of Minister of health regulations No: 907/SK/VII/ 2002, namely: 5 NTU (*Nephelometric Turbidy Unit)*(Suhartana, 2007). The P2 sample has the best turbidity value because the P2 sample with 20 minutes of stirring is the most effective contact time in the process of absorbing activated carbon to the well water purification process.

The adsorption process on activated carbon occurs in three basic stages, namely the substance is absorbed on the outer carbon, then goes to the carbon pores, and is absorbed on the inner wall of the carbon, so that the organic particles in the water can be absorbed. With the stirring process, the particles contained in the water will often make contact or collide with activated carbon. If it continues to experience collisions, the particles will approach the activated carbon and eventually the elements move from the water to the activated carbon, then these particles will spread out and fill or stick to the pore walls or the surface of activated carbon.

Contact time is the time required for carbon powder to adsorb optimally. The longer the contact time, the more particles that are adsorbed because the more opportunities the activated carbon particles come in contact with the metal, this causes more particles to be bound in the pores of the activated carbon. It is known that the

length of contact time or adsorption time between adsorbate and adsorbent greatly affects the adsorption process itself (Talunoe et al., 2015).

e. Degree of Acidity (pH)

The degree test aims to determine the intensity of the acidic or alkaline state of the well water samples before and after the purification process by measuring the degree of acidity of the sample water before treatment and samples that have gone through the purification process with variations in contact time of 10 minutes, 20 minutes, 30 minutes and 40 minutes with using a pH meter.

Table 6. Test results of the acidity of well water before and after treatment

Treatment	Acidic Degree (pH)	
	Before treatment was given	**After Treatment was given**
P0	7,5	7,5
P1	7,5	7,6
P2	7,5	7,7
P3	7,5	7,6
P4	7,5	7,6

The degree test aims to determine the intensity of the acidic or alkaline state of the well water sample before and after the purification process by measuring the degree of acidity of the water sample P0. P1, P2, P3 and P4 using a pH meter obtained the results of the acidity degree of the sample P0 as a control, namely 7.5, P1 namely 7.6, P2, namely 7.7, P3 namely 7.6 and P4. namely 7.6. The results of this study indicate that the pH of the water from P0-P4 all meet the standard requirements for the water pH threshold according to Minister of health regulations No: 907/SK/VII/2002, namely pH 6.5-8.5. (Suhartana, 2007). The cause of changing water pH is due to the presence of cations in activated carbon dissolved in the water during the stirring process in the water purification stage by stirring which causes contact between the carbon and water.

Figure 4 shows the value of the acidity (pH) test results of well water before and after treatment. According to (Jamilatun & Setyawan, 2014) pH is a factor that must be considered considering that the degree of acidity in water will greatly affect the processing activities that will be carried out, especially processing for drinking water. There is a relationship that an increase in the pH value of water can be caused by the presence of cations in activated carbon dissolved in water when there is contact between carbon and water.

f. Ferrium (Fe) Content

The degree test aims to determine the iron content of well water samples by measuring the iron content of water samples before treatment and samples that have gone through the purification process with variations in contact time of 10 minutes, 20 minutes, 30 minutes and 40 minutes using the Lovibond Komprotor tool. The results of the iron content test are presented in table 7.

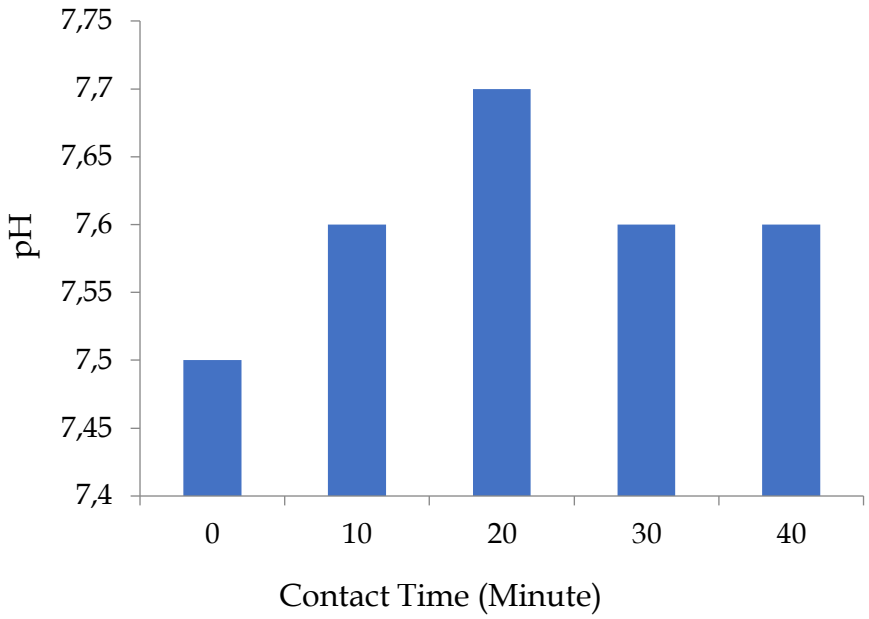

Figure 4. Graph of the degree of acidity of well water (pH)

Table 7. Results of Ferrium (Fe) test in dig well water before and after treatment

Treatment	Ferrium Conten (mg/L)	
	Before Treatmen was Given	**After Treatment was Given**
P0	0,2	0,2
P1	0,2	0,1
P2	0,2	0,1
P3	0,2	0,1
P4	0,2	0,1

The graph in Figure 5 shows the value of the acidity (pH) test results of well water before and after treatment. The iron content test aims to determine the iron content of the well water sample by measuring the iron content of the water sample before treatment and samples that have gone through the purification process P0, P1, P2, P3 and P4. The results obtained in this study were iron levels P0 as a control, namely 0.2 mg/L, P1 is 0.1 mg/L, P2 is 0.1 mg/L, P3 is 0.1 mg/L and P4 is 0 , 1 mg/L. The results of this study showed that the iron content of the well water sample without treatment was P0 from 0.2 mg/L to 0.1 mg/L after treatment (P1-P4). Minister of Health Indonesia Republic 492/IV/2010 regarding the maximum threshold for Fe levels in water, namely 0.3 mg/L.

The decrease in Fe in water occurs because during the process of purification of particles, organic substances, iron and metals contained in water will be absorbed into the pores in activated carbon and one of them is Fe which causes iron levels in water to automatically decrease after going through the process. purification using activated carbon. Contact time is required for charcoal powder to adsorb metal optimally. The longer the contact time will cause more metal will be adsorbed because the more opportunities for activated charcoal particles to contact with metals, one them are

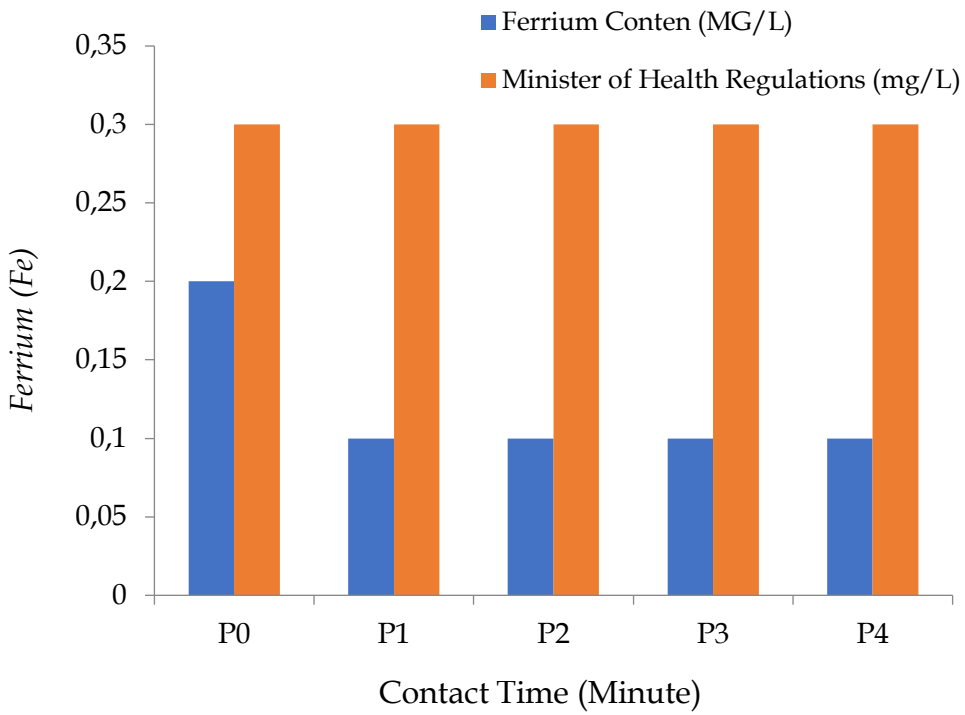

Figure 5. Graph of Fe conten in dig well water before and after treatment

Ferrium (Fe) metals. This causes more metal bounded with pores of activated carbon. It is known that the length of contact time or adsorption time between adsorbate and adsorbent most influenced to the adsorption process (Talunoe et al., 2015).

4. Conclusion

Changes in bandgap energy (Eg) occur due to differences in the duration of laser ablation. The increase in ablation duration also causes a change in the wavelength of the ultraviolet absorption so that the energy gap (Eg) produced is getting smaller. The fluorescence emission and absorption shift to a larger wavelength due to the electronic transition. Changes in ablation time also indicate the value of Eg based on the type of transition, namely direct and indirect transitions. The particle size of CDs was normally distributed in an inhomogeneous form and morphologically in the form of small balls seen in the Transmition Electron Microscope measurements.

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