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# The Effectiveness of Activated Charcoal from Coconut Shell as The Adsorbent of Water Purification in The Laboratory Process of Chemical Engineering Universitas Ahmad Dahlan Yogyakarta

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## ABSTRAK

Penelitian ini bertujuan untuk menguji efektivitas arang aktif dari tempurung kelapa untuk pemurnian air di Laboratorium Proses Teknik Kimia, Universitas Ahmad Dahlan, Yogyakarta. Penelitian terdiri dari tiga tahapan: Tahapan pertama, menganalisis kandungan air Laboratorium Teknik Kimia UAD, Tahapan kedua, pengujian efektivitas arang aktif untuk penjernihan air dengan dua (2) cara: (1) filter kolom arang aktif dan (2) pencampuran arang aktif dan air sampel, kemudian dilakukan pengadukan. Tahapan ketiga, menganalisa hasil pemurnian air seperti analisis pH, kadar logam, kesadahan (*hardness*), kadar sulfat (SO<sub>4</sub>), kadar fluoride, dan mineral. Parameter pemurnian air merujuk pada *Clean Water Quality Standards* Kementerian Kesehatan. Hasil penelitian yang diperoleh menunjukkan bahwa pemurnian air menggunakan metode kolom filter dapat mengurangi kesadahan kalsium karbonat (CaCO<sub>3</sub>) hingga 15,33%, kadar asam sulfat (SO<sub>4</sub>) hingga 98,21%, kadar Flourida (F) hingga 93,35% pada ketebalan kolom arang aktif 15 cm. Sedangkan pemurnian air dengan pencampuran arang aktif dan pengadukan selama 30 menit dengan kecepatan 1000 rpm dapat mengurangi tingkat kekesadahan CaCO<sub>3</sub> hingga 26,81%, kadar asam sulfat (SO<sub>4</sub>) hingga 98,23%, dan fluoride (F) hingga 93,35%. Pemurnian air melalui pencampuran arang aktif dan air dengan pengadukan lebih baik daripada penggunaan kolom arang aktif, karena klorida, bahan organik, nitrit, nitrat, Fe, Mn, CN<sup>-</sup> tidak ditemukan dalam air setelah pemurnian.

**Kata kunci:** Arang aktif, kesadahan, kolom filter

## ABSTRACT

This study aims to examine the effectiveness of activated charcoal from coconut shells for water purification at the Chemical Engineering Process Laboratory, Ahmad Dahlan University, Yogyakarta. The first stage, analyzing the water content of the UAD Chemical Engineering Laboratory, Second, testing the effectiveness of activated charcoal for water purification in two (2) ways: (1) activated charcoal column filter and (2) mixing the activated charcoal and water samples, then stirring. The third, analyzing the results of water purification such as analysis of pH, metal content, hardness (*hardness*), sulfate levels (SO<sub>4</sub>), fluoride levels, and minerals. Water purification parameters refer to the Ministry of Health's Clean Water Quality Standards. The results optimum obtained using the column filter in thickness activated charcoal column 15 cm could reduce hardness (CaCO<sub>3</sub>) by 15.33%, sulfuric acid (SO<sub>4</sub>) levels up to 98.21%, Fluoride (F) levels up to 93.35%. While by mixing activated charcoal (15 gram) and water (500 ml) with stirring for 30 minutes at a speed of 1000 rpm could reduce hardness levels by 26.81%, sulfuric acid (SO<sub>4</sub>) levels up to 98.23%, and fluoride (F) up to 93.35%. Purification of water through the mixing of activated charcoal and water with stirring is better than using an activated charcoal column because it is better than the chloride, organic matter, nitrite, nitrate, Fe, Mn, CN<sup>-</sup> are not found in the water after purification.

**Keywords:** Activated charcoal, column filter, hardness

## 1. INTRODUCTION

Water becomes a primary requirement in life. The kinds of water consist of groundwater,

river water, and rainwater. Application water in society has to qualify, for instance, chemical character, physical character, and

bacterial nature, which is not dangerous for the environment and health [1].

Water quality control was required carefully and effectively to avoid environmental problems caused by household wastewater, industrial wastewater, and laboratory wastewater [2]. The water purification was conducted with filter technology through activated charcoal to catch chemical compound.

According to Irmanto and Suyato [3], activated charcoal was able to reduce Biochemical Oxygen Demand (BOD) level up to 33.51%, Chemical Oxygen Demand (COD) level up to 78.92%, and Total Suspended Solids (TSS) level up to 61.05% on the liquid waste of industry. Activated charcoal applications can use to filter the magnesium oxide (MgO) [4]. Riyani [5] reported that the use of activated charcoal could reduce the photodegradation of textile dyes on the liquid waste of textiles. The capability of activated charcoal can reduce 64.69% of ammonia content, 52.35% of nitrite and 86.40% of nitrate has researched by I. Suyata [6]. Other benefits of activated charcoal are improving bio-oil and liquid smoke quality as alternative fuels [7] and food preservatives [8,9].

Based on Franco Cataldo [10] was explained that the benefit of activated charcoal with a pore area of 120 m<sup>2</sup>/g could reduce Iron (Fe) level to near 0 mg/L from 12.60 mg/L, Nitrate (NO<sub>3</sub>) level from 23.90 mg/L to 0 mg/L, metals and other compounds such as manganese (Mn), ammonium (NH<sub>4</sub>), nitrogen dioxide (NO<sub>2</sub>), sulfate (SO<sub>4</sub>), and chloride (Cl).

The activation process is a process to remove hydrocarbons that line the surface of charcoal to increase carbon porosity [11,12]. The activation of charcoal conducted in two ways: (i) the physical activation process and (ii) the chemical activation process. The material activation is the distribution of water vapor or carbon dioxide (CO<sub>2</sub>) gas to the charcoal. While the chemical activation is the immersion of charcoal in a chemical compound before it is heated, it expected that

the activating agent enters between the hexagonal layers of activated charcoal and then opens a closed surface [13-15].

Absorption of activated charcoal is enormous, which is 25%-100% of the weight of activated charcoal. Activated charcoal is divided into activated charcoal as the pale and activated charcoal as the absorbent of steam. Activated charcoal usually in the form of a fine powder, pore diameter reaches 1000Å<sup>o</sup> and use in the liquid phase. The benefit serves to remove the irritating substances that cause unexpected colors and odors, freeing solvents from the disruptive materials and other uses, namely on the chemical industry and new industries [14-16] Activated charcoal production can conduct through the process of pyrolysis of biomass as the raw materials. According to Jamilatun et al. [17] have done that activated charcoal from coconut shells. Besides, the experiment from Jamilatun, et al. [17,18] performed that the increased yield of activated charcoal by activating with sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) with a variation on temperatures and times.

Based on previous research, the use of activated charcoal as the adsorbent has been carried out by [19], reporting that the effectiveness of activated charcoal by the thermal method and in-situ regulation. According to [20] has researched activated charcoal from the banana peel as a methyl blue absorbent. Another benefit of activated charcoal was the increase in liquid smoke [21,22].

Furthermore, in this study, we conducted the application of activated charcoal to water purification in the laboratory process of Chemical Engineering, Universitas Ahmad Dahlan. Analyzing water in the Laboratory of Chemical Engineering Process, Universitas Ahmad Dahlan, Yogyakarta (UAD) found the level of metal, mineral, pH, and bacteria so that it was determined how to improve its quality. One way to enhance water quality is to use absorbent in the form of activated charcoal.

## 2. METHODS

### 2.1 Materials

The primary raw material in this study included: activated charcoal from coconut shell, water, Iodine (I<sub>2</sub>), and potassium permanganate (KMnO<sub>4</sub>). The activated charcoal used has a size of 80 mesh with an Iod number of 580 mg I<sub>2</sub>/gram of charcoal. Water samples obtained from the laboratory process of Universitas Ahmad Dahlan with flow velocity is 33.33 ml/hour.

### 2.2. Water test equipment

The tools used to test water include the Atomic Absorption Spectrophotometer (AAS) 700 Perkin Elmer Analyst, UV-Vis Winlab Perkin Elmer Spectrophotometer, Turbidimeter, Salinometer, and water quality checker.

Other analytical tools are Erlenmeyer, pH meter, burette, measuring flask, goblet, thermometer, goiter pipette, analytical balance, hot plate, spray flask, dropper, and magnetic stirrer.

### 2.3. Water purification methods

Figure 1 shows the water purification phases of the laboratory of UAD by using activated charcoal from coconut shells by three steps.

1) The first step is to analyze the Chemical Engineering laboratory's water content based on Clean Water Quality Standards. Furthermore, preparing the coconut shell activated charcoal and conduct laboratory-scale.

2) The second stage, there are two ways the purification water as follows:

a) Water purification through activated charcoal filter column uses bottled drinking water with a diameter of 6 cm, a height of 20 cm. Height of activated charcoal pile with variations of 5, 10, and 15 cm.

b) Water purification by stirring activated charcoal together with water waste. The use of 15 grams of activated charcoal to purify 500 ml of water, with a stirring speed of 500 rpm with time varied 5, 10, 15, and 30 minutes.

3) The third stage is the analysis of water purification results such as pH, metal content, hardness, sulfate content, fluoride content, and minerals.

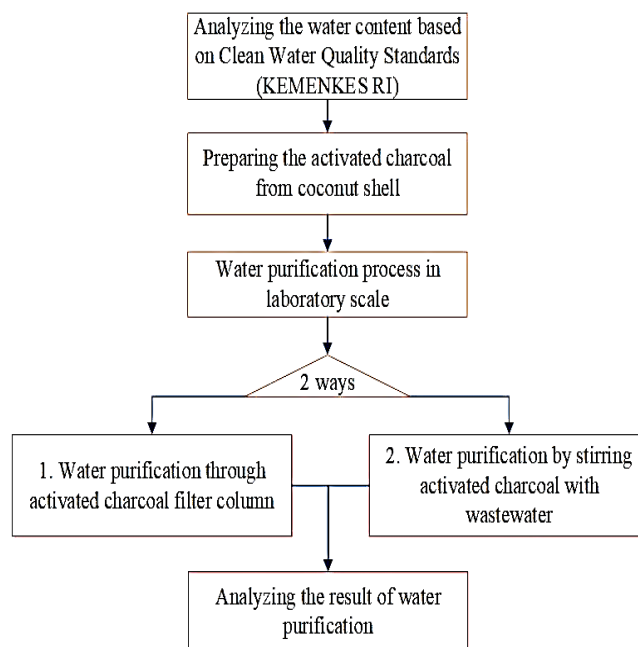


Fig. 1. The stages of water purification

Figure 2 shows the purification water by activated charcoal in the laboratory process of Ahmad Dahlan University.

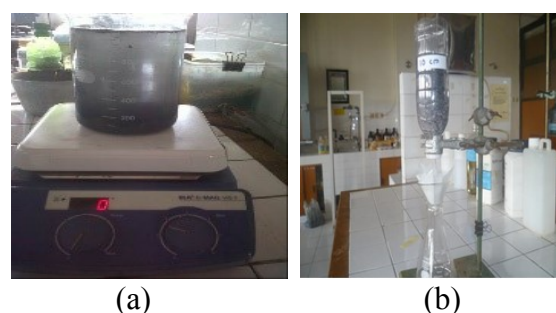


Fig. 2. The purification water by activated charcoal in the laboratory process of UAD: (a) filter column and (b) mixing and stirring

## 3. RESULTS AND DISCUSSION

### 3.1. Characteristics of activated charcoal

Activated charcoal has a water content of 1.3%, the ash content of 0.60% meets the SNI (Standard Nasional Indonesia) 0258-79 standard. It has an absorbency of the iodine

content of 580.0 mg/g that meets the SNI 06-3730 standard and granular size of 80 mesh.

### 3.2. Analysis of water content based on Clean Water Quality Standards

This analysis as the baseline to compare the water content in the laboratory of UAD before going to the experiment by using activated charcoal. The Clean Water Quality

Standards have followed as the baseline in this parameter. Table 1 shows the test results of water content in the laboratory of UAD. It uses a set of the Clean Water Quality Standards allowed with Regulation of the Minister of Health of the Republic of Indonesia No. 416/MENKES/PER/IX/1990 [23].

**Table 1.** Water analysis results in the laboratory process of UAD before treatment using activated charcoal

No	Parameters	Units	Results	Maximum Allowable Level
1.	Color	TCU Scale	10	15
2.	Turbidity	NTU Scale	0.45	5
3.	Dissolved Solids (TDS)	mg/L	948	500
4.	pH	-	6.87	6.5-8.5
5.	Chloride	mg/L	33.98	250
6.	Hardness (CaCO <sub>3</sub> )	mg/L	183.08	500
7.	Organic Substances(KMnO <sub>4</sub> )	mg/L	3.16	10
8.	Sulfate (SO <sub>4</sub> <sup>2-</sup> )	mg/L	67.69	250
9.	Florida (F <sup>-</sup> )	mg/L	0.40	1.50
10.	Nitrite (NO <sub>2</sub> <sup>-</sup> -N)	mg/L	0.002	300
11.	Nitrate (NO <sub>3</sub> <sup>-</sup> -N)	mg/L	7.31	50
12.	Iron (Fe)	mg/L	<0.003	0.30
13.	Mangan (Mn)	mg/L	<0.002	0.40
14.	Cyanide (CN <sup>-</sup> )	mg/L	<0.006	0.07

\*Yogyakarta Health Laboratory Testing Laboratory: Maximum allowable level according to Clean Water Quality Standards No: 416/MENKES/PER/IX/1990 (Request Parameters) [23]

### 3.3. Water purification through an activated charcoal filter column

Table 2 shows the effect of the activated charcoal column (5, 10, and 15 cm) on the characteristics of the purified water. From this table, it can seem that the most optimal clarification results obtained at a column thickness of 15 cm, there are three parameters decreased, namely hardness (from 183.03 to 155 mg/L), sulfate levels (from 67.69 to 1.21 mg/L) and fluoride (from 0.4 to 0.002 mg/L). This reduction factor influenced by the thickness of the activated charcoal layer in the column. Whereas organic matter, nitrite, nitrate, and CN<sup>-</sup> were not found in the product water. As for other parameters such as color,

turbidity, dissolved solids, chloride, iron, and manganese, have increased significantly. Activated charcoal impurities cause increased turbidity and suspended solids-the increase in Fe, chloride, and Manganese content generated by the metal in the activated charcoal. The metal dissolves when the water sample flows into the column. It caused by the washing of activated charcoal, which is less than the maximum, so it pollutes the water.

Industrial water treatment for removal of metals and other contents passed through sand filters and activated charcoal piles so that the hardness and metal content become zero flowed in the ion exchanger. So, for the

use of activated charcoal, it is not suitable for water purification that has appropriate characteristics based on Clean Water Quality Standards. Activated charcoal is beneficial in cleaning colored wastes (solutions) and reducing odors. The result is very significant in processing batik waste [5,24].

Purifying water with an active column still leaves a large number of impurities in the

product water. This phenomenon is due to less optimal absorption of metals and contaminants; the sample water only flows on the surface of activated charcoal, unable to reach the inside of the pores. The results will be more effective if mixed water samples and activated charcoal are accompanied by stirring [5,24].

**Table 2.** Test data with active carbon filter column with a thickness of 5, 10 and 15 cm

No	Parameters	Units	Early	5 cm	10 cm	15 cm
1.	Color	mg/L	10	500	600	2,000
2.	Turbidity	mg/L	0.450	133	227	135
3.	Dissolved Solids (TDS)	mg/L	948	1,218	1,304	1,604
4.	pH	mg/L	6.87	6.50	6.50	6.50
5.	Chloride	mg/L	33.98	58.34	63.88	77.10
6.	Hardness (CaCO <sub>3</sub> )	mg/L	183.08	168	165	155
7.	Organic Substances (KMnO <sub>4</sub> )	mg/L	3.16	-	-	-
8.	Sulfate (SO <sub>4</sub> <sup>2-</sup> )	mg/L	67.69	16.87	2.81	1.21
9.	Flourida (F <sup>-</sup> )	mg/L	0.40	0.06	0.03	<0.02
10.	Nitrite (NO <sub>2</sub> <sup>-</sup> -N)	mg/L	0.002		-	-
11.	Nitrate (NO <sub>3</sub> <sup>-</sup> -N)	mg/L	7.31		-	-
12.	Iron (Fe)	mg/L	<0.003	1.22	0.96	0.49
13.	Mangan (Mn)	mg/L	<0.002	0.02	0.13	0.29
14.	Cyanide (CN <sup>-</sup> )	mg/L	<0.006	-	-	-

**3.4. Water purification by stirring activated charcoal together with water**

The effect of stirring time (with a rotating speed of 500 rpm) on water purification by mixing activated charcoal (15 grams) and sample water (500 ml) shown in Table 3. From the table it can be seen that the longer the stirring time can reduce the level of hardness (from 183.03 to 134 mg/L), sulfate levels (from 67.69 to 1.2 mg/L), and fluoride levels (from 0.4 to 0.03 mg/L). Whereas chloride, organic matter, nitrite, nitrate, Fe, Mn, CN<sup>-</sup> were not found in the water after purification with 5, 10, 15, and 30 minutes of stirring. The turbid water can be clarified again by sedimentation.

The overall results of the experiment showed that the purification of water

through the mixing of activated charcoal and water with stirring (method 2) was better than flowing water in the column (first method). The first method still found turbidity, TDS, chloride, Fe, Mn, while in the second way chloride, organic matter, nitrite, nitrate, Fe, Mn, CN<sup>-</sup> were not found in the water after purification.

Mixing with stirring gives better results because the contact between the activated charcoal and the water sample to be extracted by the metal or impurity component is more effective. Metal or impurity components are absorbed more in the pores of activated charcoal. Stirring turn makes water to wet all parts from activated charcoal, so metals also contaminants incorporated into pores' holes.

**Table 3** Data of test results via stirring for 5, 10, 20, and 30 minutes

No	Parameters	Units	Early	5	10	15	30
1.	Color	TCU	10	-	-	-	Turbid
2.	Turbidity	NTU	0.45	-	-	-	-
3.	Dissolved Solids (TDS)	mg/L	948	-	-	-	-
4.	pH	mg/L	6.87	6.48	6.48	6.48	6.48
5.	Chloride	mg/L	33.98	-	-	-	-
6.	Hardness (CaCO <sub>3</sub> )	mg/L	183.08	150	145	135	134
7.	Organic Substances (KMnO <sub>4</sub> )	mg/L	3,16	-	-	-	-
8.	Sulfate (SO <sub>4</sub> <sup>2-</sup> )	mg/L	67.69	15.0	1.81	1.25	1.20
9.	Flourida (F-)	mg/L	0.40	0.06	0.04	0.03	0.03
10.	Nitrite(NO <sub>2</sub> <sup>-</sup> -N)	mg/L	0,002	-	-	-	-
11.	Nitrate (NO <sub>3</sub> <sup>-</sup> -N)	mg/L	7.31	-	-	-	-
12.	Iron (Fe)	mg/L	<0.003	-	-	-	-
13.	Mangan (Mn)	mg/L	<0.002	-	-	-	-
14.	Cyanide (CN <sup>-</sup> )	mg/L	<0.006	-	-	-	-

#### 4. CONCLUSION

The water purification through the activated charcoal stirring activated charcoal together with a water sample is better than the filter column. The experiment result shows that activated charcoal filter column can reduce calcium carbonate (CaCO<sub>3</sub>) hardness up to 15.33%, sulfate (SO<sub>4</sub>) levels up to 98.21%, Fluorine (F) content up to 93.35% at 15 cm active filter column thickness. In comparison, the water purification via stirring for 30 minutes on contact between activated charcoal and water can cause a decrease in hardness of 26.81% and a reduction in sulfate (SO<sub>4</sub>) levels of 98.23, and a decrease in Flouride (F) content of 93.35%. The overall results of the experiment showed that the purification of water through the mixing of activated charcoal and water with stirring was better than flowing water in the column. The first method still found turbidity, TDS, chloride, Fe, Mn, while in the second way chloride, organic matter, nitrite, nitrate, Fe, Mn, CN<sup>-</sup> were not found in the water after purification.

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