Natural Batch Adsorption Operation to Remove Dissolved Copper (II) by Carbon Charcoal Rambutan

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Abstract. Carbon charcoal was made from rambutan rods and used as an adsorbent. A gram 70/100 mesh size of adsorbent was then used to adsorb 100 ml of copper ion solution with a 70 ppm concentration. In this investigation, the batch procedure was used without shaking (naturally). The charcoal carbon rambutan ability to remove the copper ion was measured by AAS. The percentage result was 48.135% or about 33,694 ppm. SEM and EDX instrument analysis have applied to confirm the presence of copper ions on the adsorbent surface. The copper ion was found at a concentration of 0.09 percent of the total weight. The carbon charcoal adsorbent in rambutan rods has the ability to purify the water contaminated by metal ions.

1. Introduction

The ability of some solids to adsorb particular compounds from a solution and deposit them on a solid surface is referred to as liquid-solid adsorption. This liquid-solid interaction can be used to remove pollutants such as metal ions and organic compounds from wastewater [1]. Adsorption is a cost-effective way of eliminating metals from water. This method is employed in the purification of water all over the world. Heavy metals such as cadmium, chromium, copper, lead, nickel, and zinc have been demonstrated to be effective and cost-effectively removed from water via adsorption [2].

In many nations, the rise of the chemical industry sector has resulted in increased heavy metal contamination. Heavy metals dissolved in water at high concentrations have an environmental impact, can be poisonous, and do not decompose [3]. These heavy metals make water quality decrease and damage the ecosystem.

Copper has long been known and used by humans. It was one of the first metals to be mined and used, and it has made a significant contribution to civilization. Apart from the benefits and wide range of applications of copper, it is unavoidable that copper wastes are a major source of heavy metals. The maximum amount of waste copper that can be found in water is 1.0 mg/L. Because the copper waste output from the source should not exceed 0.1 mg/L. Copper is required in aquatic habitats, however, the concentration must not exceed 0.01 mg/L. If the copper concentration in the water is too high, the fish will perish. Copper is an essential metal in the human body, along with iron and zinc. Copper is essential for the production of red blood cells, and the World Health Organization recommends that persons consume no more than 1-3 mg of copper each day [4]. On the other hand, high quantities can affect the kidneys and liver, as well as produce tissue edema, depression, and necrosis. Controlling the number of heavy metals in water is essential to avoid the harmful repercussions that can result [5].
The purpose of this research was to confirm the ability and adsorption interaction of rambutan rod carbon charcoal to dissolve copper ion in solution in a batch operation without shaking. The goal of this research is to learn more about the potential of rambutan rods charcoal as an adsorbent in purifying water contaminated with metal ions.

2. Methods
Charcoal rambutan rods from the Charcoal Factory Jl. Mulio Sejati, Tuntung Village, Deli Serdang Regency were used as adsorbent resources in this research. Copper (Cu$^{2+}$) was obtained from CuSO$_4$$\cdot$5H$_2$O. CV. Rudang Jaya provided hydrochloric acid (HCl), sodium hydroxide (NaOH) as a pH regulator, and water (H$_2$O) as a solvent. Atomic Absorption Spectroscopy (AAS) (iCE 3300, Thermo Scientific, USA), Scanning Electron Microscope (SEM), and Energy Dispersive X-ray Spectroscopy (EDX) (Phenom ProXDesktop SEM, Thermo Scientific, USA) were the principal analysis tools employed in this investigation.

The rambutan rods were cleaned with aqua to remove debris from the surface. The rambutan rods came from the plant at Tuntungan region. A furnace was used in the carbonation process to produce charcoal rambutan rods. To reduce the size of carbon rambutan, it was ground for 2 hours in a ball mill and then sieved to a 70/100 mesh size. To lower the water content, the drying stage was performed in the oven for 2 hours at 100°C [6]. Cu$^{2+}$ 70 ppm was dissolved in a 2.5 L solution at pH 4.5 [7]. For the adsorption experiment, 100 mL [8] of Cu$^{2+}$ 70 ppm solution was used, followed by 1 gram of charcoal rambutan rods 70/100 mesh in a 500 mL Erlenmeyer. The batch adsorption operation was naturally without shaking [9]. The sample was collected after 120 minutes to analyze the copper concentration in solution by using AAS instrument. The following equation can be used to calculate the copper removal percentage [5]:

\[ R\% = \frac{(C_o - C_f) \times 100\%}{C_o} \]  

By comparing the charcoal before and after usage as an adsorbent, SEM and EDX were used to examine the surface properties of the adsorbent as well as the presence of chemical compounds. All of the steps in this investigation are depicted in Figure 1.

This study took place at the Chemical Engineering Operations Laboratory and the Surfactant and Application Laboratory of the Chemical Engineering Department of the Faculty of Engineering at the Universitas Sumatera Utara in Medan.

![Figure 1. The Investigation's Steps.](image)
3. Results And Discussion

3.1 Results

The physical shape of rambutan charcoal utilized as an adsorbent is shown in Figure 2. The surface structure of the physical form of rambutan charcoal before utilized to adsorb is shown in Figure 2A. The charcoal is solid black in color and has a uniform particle size. Figure 2B is carbon rambutan after used as natural adsorbent. The charcoal particles become rougher on the surface due to the interaction of copper ions on the surface. From the figure, it shows that the rambutan charcoal particles change physically and in color before and after adsorption, although not significant. Further studies can be carried out on the interaction model that occurs between the metal and the adsorbent surface as has been done to the natural adsorbent sand [10] and corn stalks [11].

![Figure 2. (a) Charcoal before Adsorbing and (b) Charcoal After Adsorbing with Natural Operation.](image)

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![Figure 3. SEM EDX of Charcoal Natural before Adsorbing (a) SEM and (b) EDX.](image)

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SEM EDX was used to examine the surface characteristics and chemical components of adsorbent charcoal rod rambutan. At a magnification of 5000x. Figure 3A depicts the natural adsorbent surface before being used in an adsorption process. Figure 3A depicts the physicochemical characteristics of carbon rambutan. Pore slits can be seen on the rambutan shaft's surface. The porous surface will increase
the surface area, which is the amount of space available for the metal element to absorb [12]. Figure 3B shows a chemical compound analysis on the surface of a carbon rambutan. It demonstrates that rambutan stem charcoal includes carbon (C) and oxygen (O) according to EDX results. Copper initial concentration (Co) is 70 ppm according to the AAS analysis. The charcoal rod rambutan absorbed around %R 48.1351 or about 33.694 ppm in a natural adsorption operation without speed treatment with a contact time of 120 minutes. The study on adsorption batch operation with shaker speed effect was reported with the adsorption ability of carbon rambutan charcoal 62.1% [13]. As shown in Figure 4A, a SEM examination was performed to illustrate the surface characteristics of carbon after it was applied as an adsorbent. As shown in Figure 4B, the EDX analysis was used to validate the existence of the copper ion on charcoal carbon surfaces. Table 1 reveals that after adsorption, the charcoal rod rambutan has a copper weight concentration 0.09%.

![Figure 4. SEM EDX of Charcoal After Adsorbing Operation Natural (a) SEM and (b) EDX.](image)

**Table 1.** The presence of copper ions on the surface of charcoal.

| Element Number | Element Symbol | Element Name | Atomic Conc. | Weight Conc. |
|----------------|----------------|--------------|---------------|--------------|
| 6              | C              | Carbon       | 78.81         | 73.58        |
| 8              | O              | Oxygen       | 21.18         | 26.34        |
| 29             | Cu             | Copper       | 0.02          | 0.09         |

4. Conclusion

The copper ions dissolving in the solution might interact with the charcoal rambutan rod. The copper ion was absorbable (%R) 48,135 or 33,694 ppm in a batch adsorption process without shaking. Copper ions were found on the charcoal surface during a SEM EDX test. The copper ions content on the charcoal surface was found to be 0.09% of the total weight. The charcoal rambutan has the potential to be used as an adsorbent to remove metal ions from water, according to this preliminary investigation.

References

[1] Juan Carlos M, Gómez R and Giraldo L 2010 *Mater.* 3 pp 452-66
[2] Kabbanib K M, Holaila A and Olamaa Z 2014 *Energy Procedia* 50 pp 113–20
[3] Murat T, İmamoğlu M, Saltabaş O and Turk T 1999 *J Chem. Vol.* 23 pp 185-91
[4] World Health Organization 2004 *WHO/SDE/WSH/03.04.88.* pp 11-18
[5] Qing D, Longjun X and Caixi C 2018 *IOP Conf. Ser. Earth Environ. Sci.* 108 p 042039
[6] Hsu S T, Chen L C, Lee C C, Pan T C, You B X and Yan Q F 2009 *J. Hazard. Mater.* 171 pp
References

[7] Haryanto B, Tambun R, Haloho H, Panjaitan F and Sitorus S. 2017 J. Eng. Appl. Sci. 12 pp 5263-70
[8] Haryanto B, Singh W B, Barus E S, Ridho A and Rawa M R 2017 J. Phys. Conf. Ser. 801 p 012098
[9] Ellerby A D, Hernandez R, Wu A, Amarasiriwardena D 2017 Microchem. 135 pp 129–39
[10] Haryanto B, Saragih F T, Sinaga W K, Turmuzi M and Misran E 2020 IOP Conf. Ser. Mater. Sci. Eng. 801 p 012070
[11] Haryanto B, Siswarni M Z, Chang C H, Kuo A T, Singh W B 2018 IOP Conf. Ser. Mater. Sci. Eng. 308 p 012020
[12] Maria A and Masduqi A 2019 Ecol. Eng. 20 pp 94-103
[13] Tarigan K S, Haryanto B, Tambun R, Manik K and Lumbangaol A K 2020 J. Phys. Conf. Ser. 1542 p 012047