Production of Activated Charcoal from Natural Material Extraction Laboratory Waste Residue as an Effort for Laboratory Waste Utilization and Reduction, and Heavy Metal Absorption Activities

Rachmawati Rachmawati[1*] Idah Dianah Wati[2] Ani Sa'adah[3]

[1, 2, 3] State University of Surabaya, Surabaya, Indonesia
Jl. Lidah Wetan, Lidah Wetan, Lakarsantri, Surabaya, Jawa Timur 60213
rachmawatirachmawati@unesa.ac.id

Abstract. Organic waste is a waste with a high carbon content. This waste has a negative impact on the environment, so it can be utilized, one of which is to make activated charcoal as an absorbent agent for heavy metal waste (Pb, Cu, and Fe). This study aims to make activated charcoal from maceration residue waste as an absorbent to reduce the levels of heavy metal waste (Pb, Cu, and Fe). The stages begin by disposing of the remaining extraction waste in a furnace at a temperature of 550 °C; then the activation process is carried out, including soaking with NaOH and HCl. Various active materials obtained were tested for their metal removal ability on Pb, Cu, and Fe metals. The test showed that a gram of the active compound left on the surface for 30 minutes could remove 4.06 ppm of Pb (14.96% of the original amount), 2.40 ppm of Cu (8.80% of the original amount), and 2.48 ppm of Fe (9.08%). Meanwhile, at a contact time of 60 minutes, the removal ability for Pb metal was 4.66 ppm (% Removal = 17.15%); Cu was 6.70 ppm (% Removal = 24.58%); and Fe was 6.05 ppm (% Removal = 22.13%). Further research can be conducted to optimize the effect of pH and temperature on the active environment's absorption ability. Applied research can be conducted to design a tool with one of the activated charcoal components as a waste processing tool with activated charcoal material from waste.

Keywords: Active carbon, charcoal, heavy metal.

1 Introduction

The laboratory is a place that provides both practical and research services. These services are carried out to give the best efforts in developing research for both students and researchers [1]. The research then conducted by researchers in the laboratory is gestural materials such as organic materials. This is done to analyze the potential of natural materials as an alternative to something. However, this research provides the potential for large organic waste. This is because the use of natural materials as raw materials requires large amounts to produce large yields [2]. The potential for waste

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becomes large and has an impact on the management of B3 waste [2]. So efforts are needed to overcome the disposal of organic waste in the form of residues from natural material extracts.

Natural materials are organic materials, the main components of which are carbon atoms (C), hydrogen (H), and oxygen (O) [3]. Natural materials are often extracted to remove the matrix's active materials (active compounds). So when the compounds in the matrix have been extracted, natural materials only leave waste that mainly contains carbon atoms. This can be used as a material for making activated charcoal, where there are many published reports on the use of waste materials from plants that are used as natural biosorbents [4–6]. However, research on the use of waste residues from natural material extracts to manufacture natural adsorbents has never been done. This provides the potential for the manufacture of activated charcoal to be used in many ways, especially in reducing the levels of other waste such as metal, color, COD, and BOD. So, this study provides the potential for utilizing waste to minimize the potential for other waste.

Laboratory waste must be treated before being disposed of into the environment to reduce the risk of adverse environmental impacts. Heavy metal waste is one of the hazardous wastes and has a significant effect on the environment [7]. This waste profoundly impacts organisms if consumed; the most severe is death. Heavy metal waste often used includes Cu, Pb, and Fe metals, which are often used in laboratories as reagents or pure metals. The potential for pollution caused by heavy metals is severe, so efforts are needed to overcome this problem. Some alternatives that can be used are reducing the levels before being disposed of, which can be done by using adsorbents, one of which is a natural adsorbent in the form of active substances. Reports show that the active range of sugarcane bagasse provides good ionization percentage results for heavy metals Cd, Cu, and Cr, where the absorption capacity of each metal is Cd 0.19 mg/g, Cu 0.19 mg/g, and Cr 0.19 mg/g [8]. The optimum absorption of Cd, Cu, and Cr metals with an adsorbent mass of 1 g is to adsorb Cd 0.7981 mg/g, Cr 0.7995 mg/g while for Cu metal 0.755 mg/g [8]. Further research with modifications to the manufacture of silica/activated carbon composites (2:3) showed the effectiveness of absorption on nickel [9].

Utilization of natural biosorbents and activated carbon in reducing the potential of environmental pollutant waste, especially heavy metals that are often used, the utilization of activated carbon from African oil palm fruit gives good results where activated carbon shows significant ability in removing heavy metals; Cadmium, Copper, Nickel, and Lead from wastewater. Higher removal percentages were observed at 80 °C (93.23 ± 0.035, 96.71 ± 0.097, 92.01 ± 0.018, and 95.42 ± 0.067% for Cadmium, Copper, Nickel, and Lead, respectively) and at optimum contact time of 60 min (99.235 ± 0.148, 96.711 ± 0.083, 95.34 ± 0.015, and 97.750 ± 0.166% for Cadmium, Copper, Nickel, and Lead, respectively) [10]. The use to remove color (methylene blue) showed promising results, where activated charcoal from lontar shells had the best absorption capacity for methylene, which was 27.84 mg/g [11]. This provides the potential for using active ingredients as natural absorbents to reduce waste so that waste does not pose a greater risk if disposed of in landfills. However, there has been no published report on the manufacture of activated charcoal as a solution to reduce laboratory waste, providing the potential to conduct this research.

2 Materials and Method

2.1 Preparation and Manufacture of Activated Charcoal from Waste Extract

The study began by taking samples of the extract residue waste in a laboratory using natural materials. After obtaining the extract residue waste, it was cleaned and drained using a furnace at 550 °C for 7 hours, then cooled and stored in a desiccator.

2.2 Delignification with NaOH 2M

The fine charcoal sample was then activated by adding NaOH at a concentration of 2 M and soaked for 2 hours. It was then rinsed with distilled water until the pH was neutral. The sample was oven-dried at 200 °C for 1 hour and cooled in a desiccator.

2.3 Activation with HCl 2M

The obtained sample was then soaked in HCl at a concentration of 2 M for 2 hours. Furthermore, the sample was rinsed with distilled water until the pH was neutral, opened at 200 °C for 1 hour, and cooled in a desiccator.

2.4 Water Content Testing

Water content testing uses a moisture balance tool by heating at a temperature of 110°C until the mass obtained is constant.

2.5 Testing the Absorption Capacity of Pb, Cu, and Fe Metals

The percent removal of heavy metals was tested using an atomic absorption spectrophotometer (AAS) instrument. The liquid waste samples were identified for their Cu, Pb, and Fe metal content, which were then treated with activated charcoal to determine the percent removal of activated charcoal.

3 Result and Discussion

The making of activated charcoal is done in a step-by-step process; in the first stage of maceration, waste is dried in sunlight to remove the organic solvents that have been used; after drying, the waste is assembled using a furnace at a temperature of 550 °C for 7 hours to oxidize organic compounds into carbon and then stored in a desiccator to keep the carbon from absorbing air. After the charcoal process, the delignification process is carried out by adding 2M NaOH for 2 hours. This is processing a strong base where the lignin will dissolve in a strong base until the color turns brown [12].

Fig. 1. Activated Charcoal Activation Results

The OH- ions from NaOH will break the bonds of the basic structure of lignin so that lignin is easily dissolved. Dissolved lignin is marked by a black color in the solution [4]. The delignification process is carried out to break the remaining lignin bonds in the matrix that have not been oxidized into carbon; the breaking process includes the reactions presented in Figure 2:

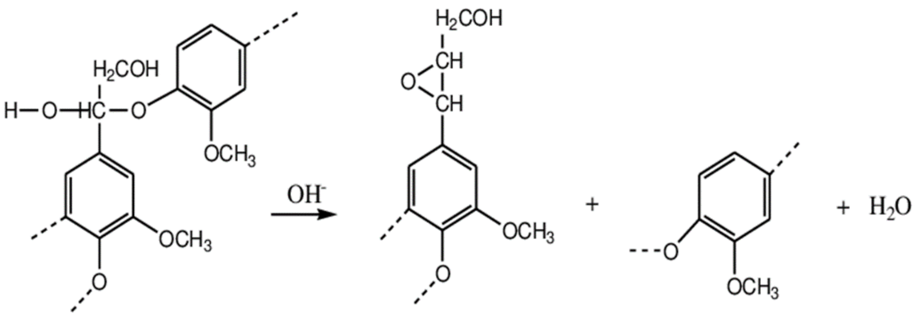

Fig. 2. Delignification Reaction with Base Addition

After that, rinse with distilled water until the pH is neutral and continue heating at a temperature of 200 °C, which aims to evaporate the existing water. Furthermore, after delignification, an activation process is carried out by adding a strong acid to clean the carbon pores formed from impurities. Soaking with HCl is to exchange cations in the biosorbent with H^+ cations from the acid and as a solvent for dirt contained in the biosorbent so that the biosorption capacity also increases. When the activator is removed with strong acid, its absorption capacity decreases [13]. The stirrer is expected to dissolve with strong acid, especially metal stirrers that dissolve with HCl 2 M strong acid for 2 hours, followed by a rinsing process with distilled water until the pH is neutral, then re-ovented at a temperature of 200 °C after which it is stored in a desiccator.

Water content testing is carried out using a moisture balance tool with the principle of heating at a temperature of ±110 °C until the sample temperature is constant, where the temperature is the temperature of water that can evaporate. When water evaporates, the mass decreases, and when all the water evaporates, the mass remains constant. Water content testing on various activation results obtained a water content of 8.9%.

The results of the absorption test of metals are presented in Table 1; it was obtained that with a mass of 1 gram with a contact time of 30 and 60 minutes, Pb, Cu, and Fe metals were absorbed well. The results showed that the longer the absorption time, the higher the percentage of removal of heavy metals. The absorption result diagram of the three metals is presented in Figure 3. Carbon-based adsorbents refer to porous carbon materials with highly specific surfaces made from coal or organic materials [13]. Activated carbon is one of the most widely used carbon materials [14]. A new type of activated carbon has been prepared; it uses straw as a precursor because the carbon content in straw is around 40%. The efficiency of heavy metal removal is not less than 90% [15,16]. And the adsorption-desorption experiment showed that the adsorbent is entirely reusable.

Table 1. Absorption Results for Each Metal

Metal	**Time (min.)**	**Intial Concentration (ppm)**	**Final Concentration (ppm)**	**Absorbed Concentration (ppm)**	**Removal (%)**
Pb	30	27.1880	23.1214	4.0666	14.96
	60		22.5264	4.6616	17.15
Cu	30	27.2788	24.8784	2.4004	8.80
	60		20.5742	6.7046	24.58
Fe	30	27.36275	24.8784	2.4844	9.08
	60		21.3074	6.0554	22.13

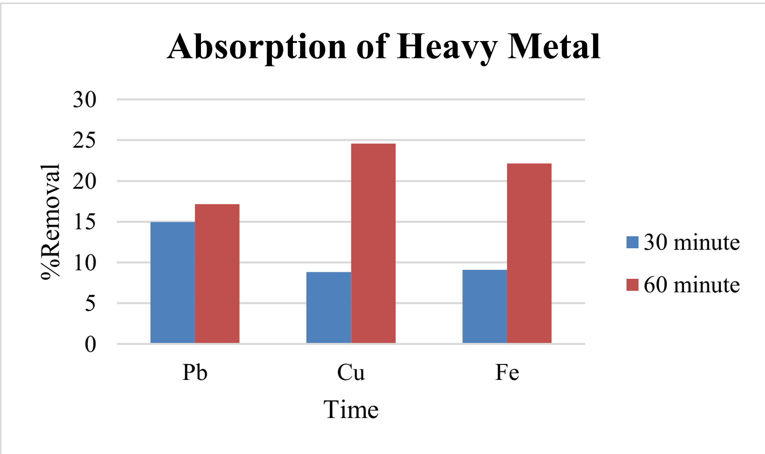

Fig. 3. Absorption Diagram of Each Metal with its Contact Time

4 Conclusion

The manufacture of activated carbon from laboratory extraction waste with the NaOH delignification process and HCl activation has absorption activity on heavy metals Pb, Cu, and Fe. The best % removal is in the absorption of Cu, Fe, then Cu. Further research can be done to determine the effect of pH, temperature, and type of activator to produce activated carbon that has better absorption activity. Applied research can be done by applying activated carbon from waste to waste processing equipment.

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References

[1] Ramadhani SP (2020) Pengelolaan Laboratorium. Depok Yiesa Rich Found.

[2] Gonzales AL, Bronce RA (2019) Chemistry Laboratory Waste Management Practices of Selected Universities and Colleges in Batangas City, Philippines. Asia Pacific J. Educ. Arts Sci.

[3] Marzuki I (2021) Pengantar Kimia Organik Fisis.

[4] Audina M (2017) PENGOLAHAN LIMBAH CAIR LABORATORIUM TEKNIK LINGKUNGAN DENGAN KOAGULASI DAN ADSORPSI UNTUK MENURUNKAN COD, Fe, DAN Pb. J Teknol Lingkung Lahan Basah 5:1–10

[5] Utomo S (2014) Pengaruh waktu aktivasi dan ukuran partikel terhadap daya serap karbon aktif dari kulit singkong dengan aktivator NaOH. Pros. Semnastek 1:

[6] Zulkania A, Hanum GF, Sri Rezki A (2018) The potential of activated carbon derived from bio-char waste of bio-oil pyrolysis as adsorbent. MATEC Web Conf. https://doi.org/10.1051/matecconf/201815401029

[7] Sarkar B (2002) Heavy metals in the environment. CRC press

[8] Tasanif R, Isa I, Rewini Kunusa W (2020) Potensi Ampas Tebu Sebagai Adsorben Logam Berat Cd, Cu dan Cr. Jambura J Chem 2:35–45

[9] Karnib M, Kabbani A, Holail H, Olama Z (2014) Heavy Metals Removal Using Activated Carbon, Silica and Silica Activated Carbon Composite. Energy Procedia 50:113–120

[10] Abdulrazak S, Hussaini K, Sani H (2016) Evaluation of removal efficiency of heavy metals by low-cost activated carbon prepared from African palm fruit. Appl Water Sci. https://doi.org/10.1007/s13201-016-0460-x

[11] Nitsae M, Solle HRL, Martinus SM, Emola IJ (2021) Studi adsorpsi metilen biru menggunakan arang aktif tempurung lontar (Borassus flabellifer L.) asal Nusa Tenggara Timur. J Kim Ris 6:46–57

[12] Sudiarta IW, Sahara E (2011) Biosorpsi Cr (III) Pada Biosorben Serat Sabut Kelapa Teraktivasi Sodium Hidroksida (NaOH). J. Kim. (Journal Chem.

[13] Shahrivar J, Gharabaghi M (2020) Separation of AuCN2- by activated carbon and functionalized graphene/activated carbon composite. Adv Powder Technol 31:4648–4656

[14] Wang R, Deng L, Fan X, Li K, Lu H, Li W (2021) Removal of heavy metal ion cobalt (II) from wastewater via adsorption method using microcrystalline cellulose-magnesium hydroxide. Int J Biol Macromol 189:607–617
[15] Wang H, Xu J, Liu X, Sheng L (2021) Preparation of straw activated carbon and its application in wastewater treatment: A review. J Clean Prod 283:124671
[16] Jiang D, Yang Y, Huang C, Huang M, Chen J, Rao T, Ran X (2019) Removal of the heavy metal ion nickel (II) via an adsorption method using flower globular magnesium hydroxide. J Hazard Mater 373:131–140