Activated carbon from cashew nut waste and its application as a heavy metal absorbent

Hunaidah¹, M A A Undu¹*, S Fayanto², Sulwan¹ and K Y Setiawan¹

¹Physics Education, Universitas Halu Oleo, Kendari, Indonesia
²Physics Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia

*Corresponding author: muhammadabdullahazamundu@gmail.com

Abstract. This research aims to determine the influence from particle size and pH variation on lead (Pb) and zinc (Zn) adsorption by using activated carbon from cashew nut waste. Waste samples obtain at Kendari Bay of Southeast Sulawesi. The sample of cashew nut shell dried in the sun for 24 hours, then carbonated sample with temperature 250-500°C for 8 hours using pyrolysis reactor. After that the sample was smoothed with mortar and sieved using particle size variations 60,100 and 200 mesh. The sample was activated using a blast furnace for 20 minutes. Cashew nut shells and massive metal waste are tired using a shaker for 30 minutes. Samples activated with activation temperature 700°C with grain size variations and pH using Atomic Absorption Spectroscopy (AAS). The results of the analysis explained that grain size and pH variations affect the adsorption ability. The results obtained at pH six maximum particle size of 200 mesh on the metal Zn and Pb. The Consequences adsorbed metal of 0.6913 mg/L for Zn metal and 0.7966 mg/L for Pb with the absorption efficiency of 99% for Zn and 95% for Pb. Getting more approaching acidic pH, the better the adsorption ability and the smaller the grain size, the higher the adsorption capacity.

1. Introduction

The appearance of heavy metals in the environment comes from two sources. First of natural processes such as weathering chemical and geochemical activities as well as from decaying plants and animals. Both of the result of human activity, especially industrial waste results in the form of Pb and Zn metal. Heavy metals contained in Kendari Bay waters can come from domestic sewage, industrial fisheries, agriculture, and marine transport activities and come from other urban activities are increasing in the waters around [1]. Revealed that the metals Pb and Zn in the water at each location in Kendari Bay waters have exceeded water quality standards at the highest levels of each 0,018 mg/L and 0.793 mg/L [2].

Several methods have been used today to reduce the solubility of heavy metals such as lead and zinc by using adsorption methods [3]. One method is a simple, cheap and effective way to reduce heavy metal pollution by processing lead is physically (adsorption) using carbon adsorbent [4]. One type of active charcoal suitable for use as an absorbent is activated carbon from waste cashew nutshell [5]. Explained that cashew seed skin current carbon content of 91.51% and cellulose content of 34.36% with the pore structure at the mesoporous level [6]. Meanwhile, activated carbon is biodegradable, so it is environmentally friendly.

Cashew seed skin is a waste of cashew nut processing which is around 67% of unused cashew nuts. Given the effects that may result from heavy metals such as metallic lead (Pb) and zinc (Zn),
especially for the health of living beings, then we need to anticipate it by way of the metal adsorption using activated charcoal.

2. Methods
2.1 Raw material
The Materials used as activated carbon is the cashew nutshell, distilled water, mineral water, metal lead (Pb) and zinc (Zn), an acid solution, an alkaline solution, glassware, oven, heater, magnetic stirrer, shaker, sieve (60 mesh, 100 mesh, 200 mesh), carbonation tube, infrared thermometer, electric furnace, mortar and Atomic Absorption Spectrophotometry (AAS).

2.2 Preparation of active charcoal production of cashew nut waste
The Waste cashew nut shell first washed clean and then washed again using distilled water and then dried in the sun for 24 hours. After drying, the cashew seed waste is carbonate at a temperature of 250 °C -500 °C. After that, the carbonated seed shell waste is pureed using mortar. After pulverized using a mortar and then sieved using a sieve. After crushed using a filter 60 mesh, 100 mesh, and 200 mesh, then the sample is activated on using a furnace with an activation temperature of 700 °C so that it produces biomass of cashew nutshell waste and then in variation pH of 6, 7 and 8.

2.3 Preparation of making control solution and pH solution
The Made control solution is a solution of metallic lead (Pb), and zinc (Zn) is then taken as many as 25 ml were review using atomic absorption spectrophotometry (AAS). This control solution creates with the aim to see how the metal content of lead (Pb), and zinc metal (Zn). The solution used as a comparison control metal content of lead (Pb) and zinc (Zn) to be absorbed with the biomass waste cashew nutshell. Then, 5 grams of biomass samples with particle sizes of 60, 100, and 200 mesh and activation temperature 700 °C included in Erlenmeyer 50 ml. A total of 25 ml of lead (Pb), included in Erlenmeyer containing biomass is then shaken using a shaker for 60 minutes at a speed of 150 rpm at a temperature of 27 °C and then filtered using filter paper, each of grain sizes in varying measure pH (5, 7 and 8) , which in turn lead concentrations the rest is determined using AAS. The treatment repeated with the same procedure for zinc metal (Zn).

2.4 Data analysis technique
2.4.1 Calculate the adsorbed concentration
\[ L_i = L_{cw} - L_{ak} \]  
where;
\[ L_i \] = the concentration is adsorbed (mg/L)  
\[ L_{cw} \] = initial concentration (mg/L)  
\[ L_{ak} \] = final concentration (mg/L)  

2.4.2 Adsorption capacity
\[ q = \frac{C_i - C_f}{m} \times V \]  
where;
\[ q \] = Adsorption capacity (mg/g)  
\[ C_i \] = initial concentration (mg/L)  
\[ C_f \] = final concentration (mg/L)  
\[ m \] = activated charcoal mass  
\[ V \] = volume of solution (mL)
2.4.3 Calculate adsorption efficiency (%)

\[
\% \text{ [adsorbed]} = \left( \frac{C_o - C_d}{C_o} \right) \times 100\%
\]

where;

- \(C_o\) = initial concentration (mg/L)
- \(C_d\) = final concentration (mg/L)

3. Result and Discussion

The results of analysis using equation (1, 2 and 3) at various pH (6, 7 and 8) and the variation of grain size (60 mesh, 100 mesh, and 200 mesh) for Pb and Zn can be seen in Table 1 and Table 2.

| Grain size variation (mesh) | pH | Initial concentration (mg/L) | Final concentration (mg/L) | The concentration is adsorbed (mg/L) | Adsorption capacity (mg/g) | Absorption efficiency (%) |
|-----------------------------|----|-----------------------------|----------------------------|-------------------------------------|---------------------------|--------------------------|
| 60                          | 6  | 0.0920                      | 0.6043                     | 0.0050                              | 87                        |
| 7                           | 0.1051                      | 0.5911                     | 0.0049                      | 85                        |
| 8                           | 0.1396                      | 0.5567                     | 0.0046                      | 80                        |
| 6                           | 0.0411                      | 0.6552                     | 0.0055                      | 94                        |
| 100                         | 0.6962                      | 0.6453                     | 0.0054                      | 93                        |
| 7                           | 0.0509                      | 0.6404                     | 0.0053                      | 92                        |
| 8                           | 0.0558                      | 0.6913                     | 0.0058                      | 99                        |
| 6                           | 0.0049                      | 0.6371                     | 0.0053                      | 92                        |
| 200                         | 0.0591                      | 0.6092                     | 0.0051                      | 88                        |

Based on Table 1 the initial concentration of Zn solution of 0.6962 mg/L and decreased the frequency of each particle size and pH. It is seen that pH (6, 7 and 8) affects the metal adsorption ability of Zn. The decrease in the concentration of the most significant solution was at pH eight that is 0.1396 mg/L for 60 mesh, 0.0558 mg/L for 100 mesh and 0.0870 mg/L for 200 mesh. While the concentration of adsorbed optimum at pH six size of 200 mesh. Table 1 explains that the particle size does not significantly influence the concentration of the adsorbed solution, it is evident from Table 1, which shows the variation of the intensity of adsorbed, while pH affects the adsorption capacity that is closer to the acidic pH the higher the adsorption capacity [7].

The adsorption capacity of activated charcoal made from cashew nut shells shows a different value (Figure 2) with an absorption efficiency of 99% 200 mesh size pH 6. The mesh size of the activated charcoal of cashew nut shells shows the ability to remove Zn metal, 60-200 adsorbent mesh showed the best results on Zn metal removal (Table 1). The illustrates that activated charcoal from cashew nut shells has a strong affinity for polar compounds with mesopore surface structures that allow it to bind large molecules during adsorption [8].
Table 2. Result of calculation of total concentration and Pb metal adsorption capacity

| Grain size (mesh) | pH  | Initial concentration (mg/L) | Final concentration (mg/L) | The concentration is adsorbed (mg/L) | Adsorption capacity (mg/g) | Absorption efficiency (%) |
|-------------------|-----|-----------------------------|----------------------------|--------------------------------------|---------------------------|--------------------------|
| 60                | 6   | 0.8138                      | 0.4079                     | 0.4059                                | 0.0034                    | 50                       |
|                   | 7   | 0.4833                      | 0.3305                     | 0.0028                                | 30                        |                          |
|                   | 8   | 0.5711                      | 0.2427                     | 0.0020                                | 79                        |                          |
|                   | 6   | 0.1715                      | 0.6423                     | 0.0054                                | 79                        |                          |
| 100               | 7   | 0.1946                      | 0.6192                     | 0.0052                                | 76                        |                          |
|                   | 8   | 0.2427                      | 0.5711                     | 0.0048                                | 70                        |                          |
|                   | 6   | 0.0439                      | 0.7699                     | 0.0064                                | 95                        |                          |
|                   | 7   | 0.1464                      | 0.6674                     | 0.0056                                | 82                        |                          |
|                   | 8   | 0.2385                      | 0.5753                     | 0.0048                                | 71                        |                          |

Table 2 shows that the decline in the concentration of the solution using activated charcoal made from cashew nutshell. Initial solution concentration was 0.8138 mg/L with final concentrations varying at each pH (6, 7 and 8) and grain size (60 mesh, 100 mesh, and 200 mesh). The smallest final concentration at pH 6 is 200 mesh size with final concentration 0.0439 mg/L, 0.1715 at pH 7 mesh size 100 and 0.4079 mg/L at pH 6 60 mesh size. While the concentration of the largest concentration is at pH eight results that vary in each grain size. pH 8 mesh size 60 The final concentration is 0.5711 mg/L, 100 mesh size of 0.2385 mg/L and at 200 mesh concentrations obtained at 0.2385 mg/L.

Meanwhile, the highest concentration adsorbed at pH six at 0.7699 mg/L size of 200 mesh and lowest concentrations adsorbent on the grain size of 60 mesh pH of 8 is equal to 0.2427 mg/L. While the value of absorption efficiency of 95% on a size 200 mesh pH 6. The smaller the pore size, the bigger the adsorption capability. Thus, the smaller the particle size interaction between particles the greater the adsorption ability and the greater the bonding force between molecules in solution [9], the following graph of the relationship between variations in pH and grain size on Zn metal adsorption capacity can see on Figure 1.

![Graph of the relationship between variations in pH and grain size on Zn metal adsorption capacity](image)

**Figure 1.** Graph of the relationship between variations in pH and grain size on Zn metal adsorption capacity

Based on Figure 1 explains how the effect of grain size and pH on the ability of activated charcoal adsorption capacity made of cashew seed skin on metal Zn. Figure 1 shows that pH and grain size affect the ability of adsorption. The highest capacity adsorption is at pH 6 to 200 mesh size of 0.0058.
mg/g, and the lowest is at pH 6 to 60 mesh size of 0.0046 mg/g. While for the size of 100 mesh highest adsorption capacity of 0.0054 mg/g at pH 6 and the lowest was 0.0053 mg/g and for the size of 60 mesh highest capacity of 0.0034 mg/g and a low of 0.0020 mg/g. This identifies the closer to the acid of a solution the better the adsorption ability [10], the following Graph of the relationship between variations in pH and grain size on Pb metal adsorption capacity can see on Figure 2

![Graph of the relationship between variations in pH and grain size on Pb metal adsorption capacity](image)

**Figure 2.** Graph of the relationship between variations in pH and grain size on Pb metal adsorption capacity

Figure 2 represents a data that explains that the particle size affects the ability of adsorption capacity made from activated charcoal cashew nut shells on Pb metal — seen from Figure 2 pH and grain size effect on the capacity of the metals Pb adsorption. The highest adsorption capacity is at pH 6 for each particle size of 60 mesh, 100 mesh and 200 mesh (Table 2). Whereas, for the lowest capacity is at 8 for each particle size explains that when a solution approaches acidic pH, the adsorption ability is getting better [11]. Then, the smaller the particles, the greater the capability of the particles to absorb [12]. The concluded that the structure of particle size, pH and temperature is a significant parameter to achieve the best adsorption capacity.

**4. Conclusion**

It has been successful in analyzing the effect of grain size variation and pH on adsorption ability - the results obtained at pH six maximum particle size of 200 mesh on the metal Zn and Pb. Results adsorbed metal of 0.6913 mg/L for Zn metal and 0.7966 mg/L for Pb with the absorption efficiency of 99% for Zn and 95% for Pb. The closer the acid pH is the better the adsorption ability.

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