Adsorption of copper metal waste in prototypes on a laboratory scale

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Abstract— **Waste treatment has been carried out to reduce the presence of contaminants such as the content of copper (Cu) which is very dangerous for health. One of the efforts made is by adsorption using activated carbon. The purpose of this study was to determine the efficiency of activated carbon adsorption on Cu in wastewater by using laboratory scale prototypes. Determination of Cu concentration using AAS while the morphology was determined using SEM. The results showed that activated carbon was able to reduce the concentration of Cu in the waste up to 98% with a mass of carbon 125 grams and an interaction time of 5 hours.**

Keywords— *adsorption, activated carbon, Cu metal, waste*

I. Introduction

The general waste is a residual of chemicals that has been used, expired raw materials, or process products in the laboratory such as the remaining specimens. Organic or inorganic waste with a certain concentration and quality can have a negative impact on the environment, especially for human health, so it is necessary to handle waste. As it is known that metals such as chromium, copper, lead, manganese, mercury, cadmium are very dangerous for human health and also the environment because of their toxic nature [1,2].

Heavy metal waste is classified as Hazardous and Toxic (B3) waste, so special handling is needed before disposal to the environment. Lim-containing heavy metal (heavy metal) has high toxicity, so it can kill organisms. But in a low level, heavy metals can be accumulated biologically in the body of the organism (bioaccumulative), so that the bio-magnification process can occur. Biomagnification is the process of multiplying the heavy metal content in living organisms tissues as a result of heavy metals being bound and biologically accumulated. Heavy metals are easily bonded to sulphur elements from several types of amino acids (proteins), so they can form covalent bonds and cannot be excreted from the body again, and will continue to be accumulated slowly until causing the negative damage to body health. Copper (Cu) is toxic to living things. Heavy metals can disrupt the life of biota in the environment and ultimately affect human health [3].

Cu metal can enter into all strata of the environment, whether in the strata of water, soil or air (atmospheric layer). Copper that enters the environment can come from a variety of sources. But sources of Cu metal input into the general and most commonly assumed environmental strata are from industrial activities, household activities and from combustion and mobility of fuels [4]. Adsorption is an effective method to overcome the problem of environmental pollution. The adsorption method depends on the ability of the surface of the adsorbent to attract gas, vapor or liquid molecules. For this reason, over the past ten years extensive research has been directed at the finding types of adsorbents that are cheaper and easier relatively to obtain [5]. Various types of adsorbents have been widely used, one of which is the activated carbon which has been developed and proven successfully to adsorb heavy metal ions

II. Methods

A. Sample collection in the laboratory

Samples from the disposal of laboratory practice activities in each laboratory were accommodated in a container for one activity. Samples were added with concentrated nitric acid and filtered using filter paper, the obtained filtrate was ready to be analyzed

B. Metal adsorption

The adsorbent preparation is done by soaking the adsorbent in aquademin with a volume ratio of 1: 50 and stirring for 2 hours using a magnetic stirer at a speed of 100 rpm. The mixture was precipitated and left for 2 days then filtered and the residue dried in an oven at 105ºC for 24 hours. The adsorbent is mashed with a size of 100 mesh.

For the adsorption process a prototype was prepared and an adsorbent was added with a mass of 25, 50, 75, 100 and 125 grams alternately and 4 liters of laboratory waste was added. The mixture is stirred using a shaker for 1, 3, 5, 7 and 9 hours. The prototype was driven with a motor at a constant speed. The mixture was filtered using a filter paper to separate the filtrate from the adsorbent. The filtrate was added with a few drops of HNO3 and analyzed the Cu ion content using AAS (Perkin Elmer AAnalyst 700).

C. Adsorbent morphology

Morphological determination of adsorbents was carried out using a scanning electron microscop (EVO MA 10)

III. Result and discussion

Cu waste from the laboratory activities was adsorbed using activated carbon. This treatment was carried out at the laboratory scale and showed a significant reduction in waste of almost 99%. Based on these data, Cu adsorption is carried

out using a prototype with a greater amount of waste and adsorbent as in Fig 1.

A. Effect of mass of adsorbent on the efficiency of Cu adsorption

The mass of adsorbent used is varied based on laboratory scale processing. Mass variations used are: 25, 50, 75, 100 and 125 grams in 4 liters of waste containing Cu. The results obtained are shown in Table 1 and Fig 2.
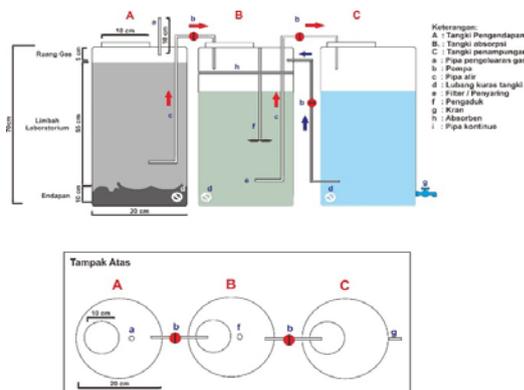

Fig. 1.   Prototype of waste treatment

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TABLE I.   EFFECT OF ADSORBEN MASS ON ADSORPTION OF CU

Amount of adsorbent (grams)	Initial amount (ppm)	Amount of Cu adsorbed (ppm)	Remaining Cu (ppm)
125	221.275	217.257	4.0178
100	221.275	216.491	4.784
75	221.275	215.76	5.515
50	221.275	214.835	6.44
25	221.275	214.76	6.515

Based on the results obtained in Table 1, it shows that the greater the amount of adsorbent added, the increase of the amount of adsorbed Cu in the waste. Based on these data, the adsorption efficiency reach of 97-98% (Fig.2). This shows that activated carbon can reduce the amount of Cu in the waste up to 98% with 125 grams of carbon. The more carbon added, the more likely the carbon will interact with the metal to be adsorbed. In its structure activated carbon has imperfect twisted tissue, and forms cross bonds from the aliphatic group. Activated carbon can cause the interaction of free radicals on the surface of carbon with atoms such as oxygen and nitrogen, which originate from processing or the atmosphere, causing the carbon surface to become chemically reactive and affect its adsorption properties. The

waste containing Pb was reduced by 83% by using activated carbon by 20 mg in 20 ml of metal-containing waste [6]. Another study mentioned that activated carbon was successfully used to remove Fe (III) and Mn (II) ions from the El-General drainage water of the coast of Alexandria, Egypt [7].

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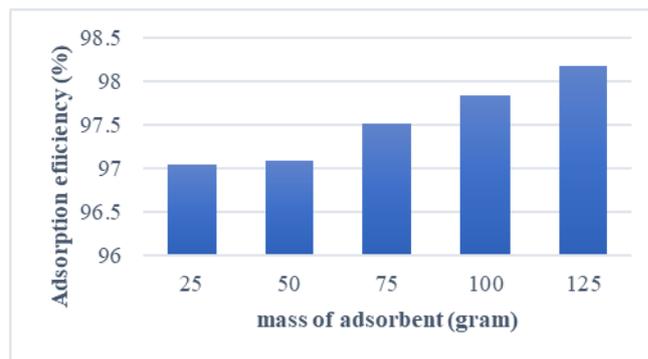

Fig. 2.   Efficiency Of Waste Reduction With Variations In The Mass Of Adsorbent

B. Effect of interaction time of activated carbon and Cu metal on the efficiency of Cu adsorption

One of the factors that determines the amount of metal that can be adsorbed by adsorbents is the time of interaction between the adsorbents and the metals. The interaction time of carbon with Cu metal used was 1, 3, 5, 7 and 9 hours. The results obtained are shown in Table 2 and Fig 3.
Based on the data that has been obtained shows that there is a reduction in the concentration of Cu metal in the waste in the presence of activated carbon adsorbents. The interaction time of 5 hours of adsorbent with metal shows the highest efficiency because it can reduce the concentration of waste up to 99.8% (Fig 3). This means that the wastewater is safe from Cu

TABLE II. THE EFFECT OF ADSORBENT INTERACTION TIMW ON ADSORPTION OF CU

Interaction time (hours)	Initial amount (ppm)	Amount of Cu adsorbed (ppm)	Remaining Cu (ppm)
1	53.89	1.159	52.729
3	53.89	38.25	915.629
5	53.89	53.829	0.059
7	53.89	51.904	1.984
9	53.89	51.62	2.268

This tendency shows that in the initial adsorption process, there are many active sites available on the surface of the adsorbent so as to facilitate the adsorption process. With increasing time it turns out that the active side of the adsorbent becomes saturated with adsorbate so that the ability to adsorb Cu metal begins to decrease [8]. Absorption of activated charcoal is an accumulation or concentration of components on the surface or interface in two phases. When the two phases interact with each other, a new phase will be formed which is different from each of the previous phases. This is due to the attraction between molecules, ions or atoms in the two phases. Another factor that affects the absorption of activated charcoal, namely the polarity of the surface of activated charcoal. [9]. Several studies related to adsorption include, Cu metal showed that the interaction time was 90 minutes [7]. Another research shows that the best time for activated carbon to adsorb Fe and Mn metals in waste is 100 and 120 minutes respectively [8].
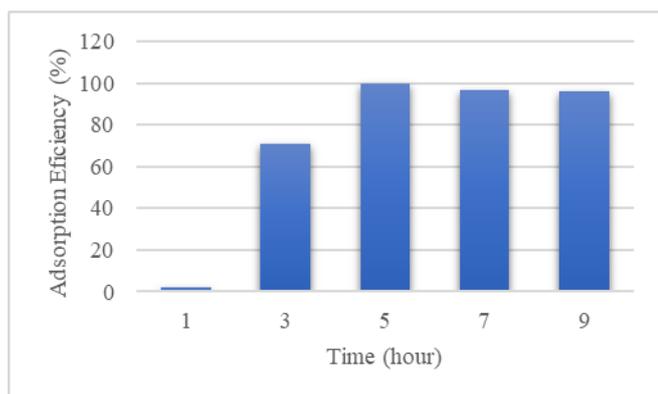

Fig. 3. Efficiency of waste reduction with variations of the adsorb time and the adsorbate interactions

C. Morphology of activated carbon as an adsorbent

Activated carbon has a larger pore, this is because the activation process can break the hydrocarbon bonds or oxidize surface molecules so that the carbon undergoes a change in surface area that increases in size so that it will affect its adsorption power [11]. Morphological determination of activated carbon before treatment showed a change in surface pores as shown in Figure 4. Based on the pore measurement results obtained that carbon has a pore area of 756.54 m2 / g and a pore volume of 263.49 cc / g. After interaction at a certain time, it appears that the pores have been filled with adsorbate. At the time of interaction of 5 to 9 hours showed almost the same amount. This supports the value of efficiency at that time the decrease is not too different.
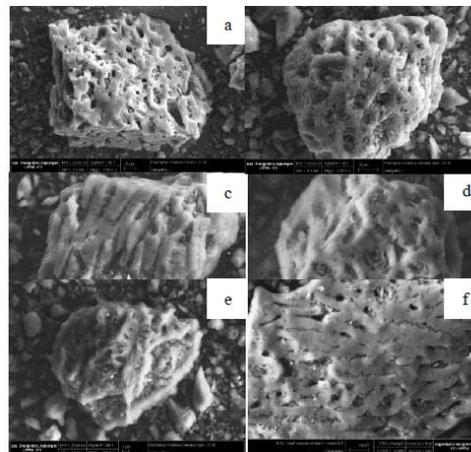

Fig. 4. Fig 4. Carbon morphology using SEM magnification 250x before being interacted (a) after being interactes 1 hour (b), 3 hours (c), 5 hours (d), 7 hours (e) and 9 hours (f)

V. CONCLUSION

The prototype that has been designed can be used for the process of adsorption of metals in waste. Cu metal processing from waste using activated carbon as much as 125 grams in 4 liters of waste with an interaction time of 5 hours can reduce the amount of Cu with an efficiency of 99%.

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