Adsorbent Size's Impact on Removing Heavy Metals

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Abstract: *Numerous variables affect how well adsorption works. The material's surface area is a crucial factor in adsorption. The speed of adsorption by powder material is greater than by granular material. It is related to its surface area. The study aimed to compare the changes of dissolved heavy metals and water pH after adsorption using 60 and 100-mesh adsorbent. A hot plate stirrer was used to carry out adsorption for 5, 10, and 15 minutes. The result showed that the pH of the water changed to neutral after adsorption using 100 mesh adsorbent. Water pH did not meet quality standards after adsorption with 60 mesh adsorbent. The heavy metal Fe in water decreased with an effectiveness rate of 99.5% within 5 minutes of contact time. The concentration of Fe met the quality standards, both in adsorption using 60 and 100 mesh adsorbents. The concentration of Mn did not meet the quality standards. The effectiveness rate of reducing Mn was only 48.6% within 15 minutes of contact time.*

1. Introduction

An adsorbent is a material that can absorb specific elements from liquid phases (Rahmayani & Siswarni, 2013). The presence of many pores is one of the prerequisites for a material to be utilized as an adsorbent. It is related to the surface area. A high surface area is frequently regarded as an important quality to boost the adsorption capacity (Kumar et al., 2019). The more pores of an adsorbent, the greater its surface area (Syauqiah et al., 2011). The powder-shaped adsorbent adsorbs more quickly than the granular adsorbent (Diharyo et al., 2020). Active clay, activated zeolite, and charcoal made from coconut shells were the adsorbents used in this research. Because of its porous nature, activated charcoal can be utilized as an absorbent for heavy metals (Pambayun et al., 2013). Heavy metals can be absorbed by clay quite effectively (Musso et al., 2014). Zeolite can be used as an adsorbent due to the abundance of space in its frame structure (Catri, 2016). To neutralize water's pH, the study combined these three components in a ratio of 25% activated clay, 25% activated zeolite, and 50% activated charcoal (Paradise et al., 2022). The study used adsorbents with variations size of 60 and 100 mesh to examine the efficacy of raising pH and lowering Fe and Mn after adsorption.

2. Method

The study used an experimental methodology. Beaker glass, hot plate stirrer, spatula, 100 mesh and 60 mesh sieves, analytical balance, acid mine water samples, coconut shell charcoal, clay, zeolite, NaOH, and HCl were the materials and tools used in the study. The three components, clay, zeolite, and carbon, were combined in a ratio of 25% clay, 25% zeolite, and 50% charcoal to form the adsorbent. It is necessary to activate the material to openup its pores and remove impurities. Clay activation using 3M NaOH solution. 3M HCl solution, and 4M HCl for zeolite and charcoal activation. The chemical solution's activator and adsorbent have a mass ratio of 1:2. The three components were combined to perform adsorbent (Fong, 2018). Adsorbent A has a material size of 60 mesh, while Adsorbent B has a material size of 100 mesh. At a temperature of 25° C, a volume of 250 ml water (acid mine drainage), a mass of 2.5 grams of adsorbent, and times of 5, 10, and 15 minutes, adsorption was conducted. There are 60 and 100 mesh adsorbents utilized

3. Result and Discussion

Quality standards for coal mining wastewater are regulated in (Keputusan Menteri Lingkungan Hidup Nomor 113 Tahun 2003 Tentang Baku Mutu Air Limbah Bagi Usaha Dan Atau Kegiatan Pertambangan Batubara, 2003) concerning Quality Standards for Wastewater for Coal Mining Businesses and Activities, which specifies quality standards for pH, namely 6-9, Fe 7 ppm, and Mn 4 ppm (Liu, 2019). Acid mine drainage (AMD) from the sump pit of a coal mine had an initial pH value of 2.6, Fe concentration of 13.006 ppm, and Mn concentration of 30.59 ppm. It didn't meet the quality standards set by KEPMEN LH No. 113 of 2003.

a. pH of acid mine drainage (AMD)

The treatment used in the study was adsorption. Adsorption was used to raise the pH of acid mine water for 5, 10, and 15 minutes using 60 and 100 mesh adsorbents (Table 1).

Table 1. pH of AMD after treatment

Adsorbent	5 minutes	10 minutes	15 minutes
100 mesh	6.3	6.5	6.8
60 mesh	4.4	4.6	4.7

According to Table 1, adsorption was successful in raising AMD's pH. After treatment with 100 mesh adsorbent, AMD's pH increased more than it did with 60 mesh adsorbent. The pH of AMD rose and met quality standards after adsorption using a 100-mesh adsorbent (Gonzalez, 2022). After adsorption, the pH of AMD changed to 6.3 after 5 minutes, 6.5 after 10 minutes, and 6.8 after 15 minutes of contact . Acid mine drainage's pH has been successfully changed by adsorption from acidic to neutral in about five minutes.

The pH changes generated by 60 mesh adsorbent were not as effective as those caused by 100 mesh adsorbent. The pH rose but remained acidic when adsorption was conducted with 60 mesh adsorbent (Petrovic, 2022). The pH of AMD changed following adsorption, going from 4.4 after 5 minutes to 4.6 after 10 minutes to 4.7 after 15 minutes.

b. Fe Concentration

Table 2 shows that the concentration of Fe in AMD decreased following adsorption.

Table 2. Fe Concentration after treatment

Adsorbent	5 minutes	10 minutes	15 minutes
100 mesh	0.060	0.047	0.021
60 mesh	0.16	0.15	0.13

Adsorption successfully absorbed Fe to meet the required quality standards, as shown in Table 2. Both at 60 mesh and 100 mesh adsorbents, the reduction in Fe concentration was highly significant. The concentration of Fe was reduced to 0.060 ppm for the 100 mesh adsorbent and 0.16 ppm for the 60 mesh adsorbent after just 5 minutes of contact time (Lv, 2018). It demonstrated the adsorbent's suitability for absorbing Fe in AMD (Franchina, 2021). Until the concentration met the required quality standards, the activation process successfully absorbed Fe.

c. The Concentration of Mn in AMD

According to Table 3, the concentration of Mn changed after adsorption.

Table 3. Mn Concentration after treatment

Adsorbent	5 minutes	10 minutes	15 minutes
100 mesh	16.48	15.77	15.72
60 mesh	17.89	17.72	17.022

The adsorbent could not reduce the Mn concentration to the required level. After being adsorbed on 60 and 100 mesh adsorbents for 5, 10, and 15 minutes, the Mn concentration was still above the quality requirement. It didn't meet the quality standard.

d. Effectiveness of Ph increases

Based on Figure 1, using 100 mesh adsorbent to increase pH after treatment is more successful than using 60 mesh adsorbent. The efficiency of pH increasing for 5 minutes, 10 minutes, and 15 minutes in the adsorption utilizing 100 mesh adsorbent achieved 58.73%, 60%, and 61.76%, respectively (Khalil, 2020). While the efficiency of pH rising after 5 minutes of contact with 60 mesh adsorbent was only 40.91%, 43.48% during 10 minutes of contact, and 44.68% during 15 minutes of contact
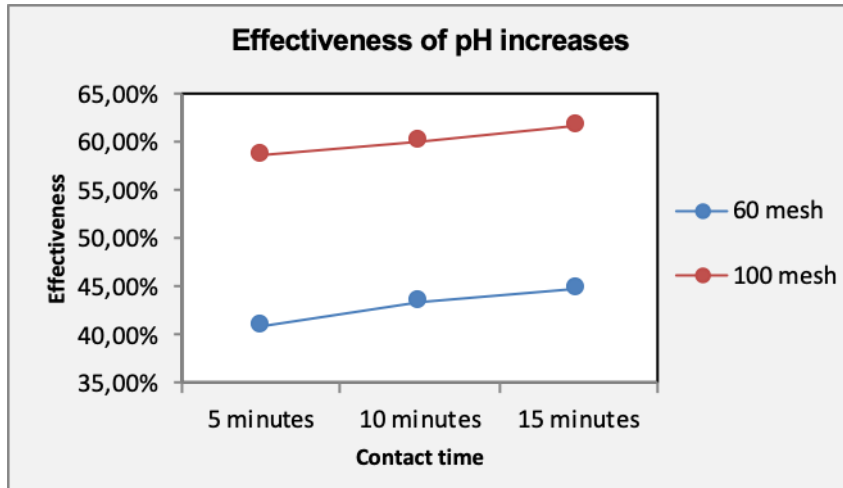

Figure 1. Effectiveness of pH increases
(Source: Mycelia)

e. Effectiveness of Fe Reduction

According to Figure 2, the effectiveness of Fe reduction exceeded 99.5% in just 5 minutes using 100 mesh adsorbent and 98.77% in 5 minutes using 60 mesh adsorbent. In addition, after 15 minutes of contact with a 100 mesh adsorbent (Köse, 2020), the effectiveness of decreasing Fe exceeded 99.8%. It proved the adsorbent's extremely high effectiveness for adsorbing Fe.
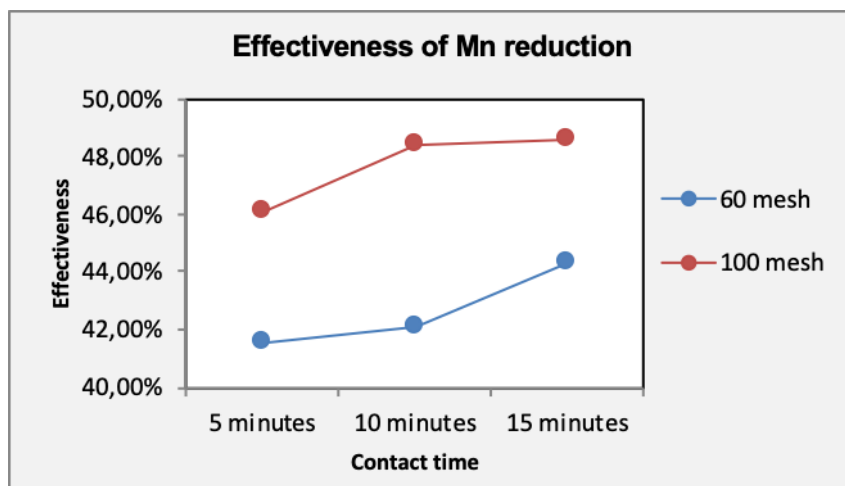

Figure 3. Effectiveness of Mn reduction
(Source: Mycelia)

The results showed that the adsorbent's grain size impacted the adsorption of Fe and Mn. The more heavy metals the adsorbent can absorb, the smaller its grain size must be. It is in line with (Kusumastuti, 2014), which found that choosing an adsorbent with the smallest particle size results in the highest adsorption capacity. According to research in 2018 by (Suliestyah et al.,

2018)the adsorbent's grain size impacts how well heavy metals are absorbed by wastewater. However, in all variants of contact time, Fe still had higher removal efficiency than Mn. It might be because Fe has smaller ionic radii than Mn, which allowed Fe ions to get to the adsorption site first. It is related to the research conducted by (Indah et al., 2016). Another research showed that particle size affects arsenite and arsenate's adsorption (Yean et al., 2005)

4. Conclusion

The following conclusions can be taken from this study: The effectiveness of adsorption is determined by the grain size of the adsorbent, both in decreasing concentrations of Fe and Mn. A 100-mesh adsorbent is more effective than a 60-mesh adsorbent for adsorption. Acid mine drainage's pH is acceptable for 60 and 100 mesh adsorbents. After only 5 minutes of contact, the concentration of Fe in acid mine drainage satisfies the quality criteria (both on 60 and 100 mesh adsorbents). Up to 15 minutes of contact time, the Mn concentration in acid mine drainage did not match the quality standards.

Acknowledgement

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