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Economic Impacts on the Use of Zeolite, Claystone, and Active Charcoal in Reducing Levels of Mercury (Hg) in Waste from Unlicensed Gold Mining Activities (PETI) in Kapuas Sub Watershed, Ulak Jaya Sintang Village

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Abstract

Research on the use of zeolite/clay/ activated charcoal composites as Hg heavy metal adsorbents has been carried out. Zeolites and clays were previously activated using NaOH, while activated charcoal was activated using HCl. The adsorbent characterization was carried out by Fourier Transform Infrared Analyzer (FTIR), X-Ray Diffraction (XRD), and mercury levels using Atomic Absorption Spectroscopy (AAS).Hg metal adsorption experiments were carried out by varying the composition of zeolite/claystone/ activated charcoal. The location of the study was Unlicensed Gold Mining (PETI) in the Kapuas watershed, Ulak Jaya Village, Sintang. The results showed that zeolite/claystone/ activated charcoal succeeded in reducing mercury levels in wastewater. The purpose of this study was to prove that the wastewater from gold mining could be reused to meet the needs of the community and improve environmental sustainability.

Keywords: Economy; Zeolite; Claystone; Activated Charcoal; Economy; Environmental Sustainability

Introduction

In economic activities, the production and consumption of goods can cause benefits or produce products of value to the owner or others. Conversely, economic activities can also produce adverse effects or reduce the effectiveness of others. The state of a process can cause benefits or losses to others called externalities (Grafton et al., 2004).

The economic concept of environmental pollution caused by the exploitation of natural resources is an externality that occurs if one or more individuals experience or suffer losses in the form of loss of their welfare (Monke & Pearson, 1989). Pollution is the most complicated and dangerous problem. Pollution can not only result in death but also damage the preservation of the environment, which can inherit inheritance to posterity (Haryati, 2013).

In the gold mining industry carried out by gold miners who do not have qualifications in the mining sector often produce waste that is damaging to the environment. In most areas in West Kalimantan, there is high gold content. The gold contained in the land attracts the interest of small scale miners / traditional miners. According to Hidayah (2016), the gold mining industry is one of the industries that the Indonesian government relies on to bring in foreign exchange.

In addition to bringing in foreign exchange, the mining industry also opens up employment opportunities, and for districts and cities is a source of local own-source revenue (PAD). One of the locations of illegal gold mining (PETI) is in the Village of Ulak Jaya Sintang, Sintang District, Sintang District, West Kalimantan. This gold mining is done traditionally, where the processing process does not use high technology and only uses elementary equipment.

Economically gold mining generates enough or even more wages to meet daily needs; this is what underlies the local community to switch professions from farmers to gold miners. On the other hand, the socio-cultural location of a gold mine close to a settlement allows residents to exploit it (Habibi, 2018). Unlicensed Gold Mining (PETI) in Ulak Jaya Sintang Village, Sintang District, Sintang Regency, West Kalimantan, which discharges waste directly into the Kapuas River Basin (DAS) becomes blackened and smelly.

This condition is certainly detrimental to the surrounding community who, in the end, can not use river water to meet their daily needs due to polluted gold mining wastewater. Although there are other alternatives, such as using groundwater taken from wells, it costs much more. The cost of drilling wells costs between 4 million and 10 million with a depth of 40-50 meters in order to get clean water. As for the installation of PDAMs, it costs between Rp. 627,500 to Rp. 55,528,500 depending on field conditions (Pamjaya.co.id).

Seeing how this pollution will be hazardous if left unchecked, it is necessary to anticipate steps by utilizing zeolite, claystone, and activated charcoal to reduce mercury content in gold mining wastewater. This step is considered valid also can reduce costs in practice prevention. In principle, the process is the absorption or adsorption of natural zeolite and metal ions in the gold mining wastewater. On the other hand,economically making tools with zeolite, claystone,and activated charcoal specifications is cheaper and has a good impact on environmental sustainability.

Result and Discussion

1. Zeolite Ability in Absorbing Mercury in Wastewater

According to Sutopo (1991) it is known that zeolites can reduce iron (Fe) levels from 1.466 mg / L to 0.120 mg / L, manganese (Mn) from 2.220 mg / L to 0.060 mg / L, copper (Cu) from 0.430 mg / L to 0.030 mg / L, and zinc (Zn) from 0.180 mg / L to 0.110 mg / L. Experiments using zeolites as absorbent (absorbent) of mercury (Hg) contained in water this is possible, because zeolite has the nature of an absorber and has a hollow structure. According to Government Regulation No. 82 of 2001 glasses of water containing mercury as raw material for drinking water (class I), a maximum of 0.0010 mg / l, if the number exceeds this number, will interfere with the health of its consumption.

FTIR analysis was carried out to determine zeolite functional groups, and the effect of the zeolite activation process was carried out with 1M HCl. The use of this concentration is by the results reported by (Sastiono, 1993),which carried out zeolite activation of mordenite and clinoptilolite types and obtained CEC results from the zeolites increased. However, the use of HCl of more than 1 N has decreased the CEC value. According to (Lestaria, 2010) zeolites will experience dealumination that will continue to occur if the more significant the concentration of acid used.

The results of IR zeolite spectra, before and after activation, are shown in Figure 1.

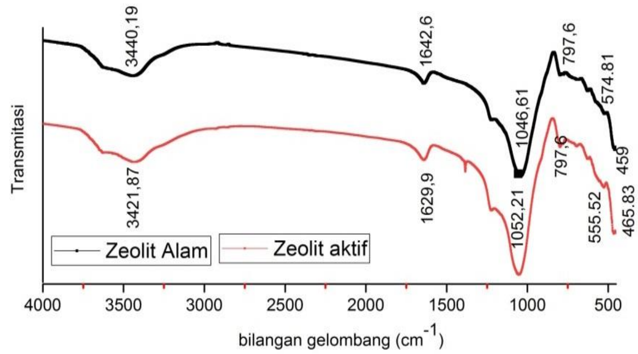

Figure 1. FTIR Spectra of Natural and Activated Zeolite Samples

From image number 1 the absorption of natural zeolite FTIR identified at wave number 3440.19 cm-1 is the peak of the hydrated -OH group, this FTIR spectrum is in accordance with research (Heraldy, 2003; Tony Suroto, 2004) also shows that OH uptake occurs at numbers successive waves 3442.7; 3435.0 and 3424 cm-1. The vibration of buckling OH from H2O adsorbed, according to Suroto, (2004) occurred at wave number 1637.5 also occurred in natural zeolites at wave number 1642.6 cm-1. In the study of Heraldy, (2003) Al-O or Si-O stretching vibrations appeared at wavenumbers 1052.3 and 1043.3 cm-1 while in a study from Suroto, (2004) Al-O or Si-O stretching vibrations occurred at wave number 1055.0 cm-1.

In this study, Al-O or Si-O stretching vibrations from natural zeolites appeared at wave number 1046.61 cm-1. The vibration of Si-O natural zeolite buckling, according to research by Heraldy (2003), appeared at wave number 794.6 cm-1, while research from Suroto (2004) vibration buckling Si-O appeared at wavenumbers 777.4 and 796.5. In this research, natural zeolite has the vibration of Si-O at wave number 797.6, and it is not much different compared to the reference. Figure 1 shows that active zeolite spectra are almost the same as natural zeolite spectra; this shows that the role of activation does not change the structure of natural zeolites.

Functional groups	Wave Number (cm-1)		
	References	Natural Zeolites	ActiveZe olites
- OH Hydrated	3442,7[1] 3435[3] 3442,7[2] 3424[4]	3440,19	3421,87
Vibrating buckling OH from H2O adsorbed	1637,5[2]	1642,46	1629,92
Al-O or Si-O stretching vibrations	1055,0[2] 1043,3[1] 1052,3[1]	1046,61	1052,21
Si-O Bend Vibration	796,5[2] 777,36[2] 794,6[1]	797,6	797,6
T-O Bend Vibration	471,6[1] 445,5[2]	441 459	465,83
Al-OH absorption is bending	690-705[5]	695,37	695,37
Vibration buckling Si-O or Al-O	579 485[6]	574,81	-

Info: [1]Heraldy(2003), [2]Tony Suroto(2004),[3] (2005)

2. Claystone analysis to reduce levels of mercury in mining wastewater

Clay or claystone is a pozzolanic material by-products from the rest of the coal. Claystone is formed due to the presence of non-combustible minerals contained in coal, such as Silica (Si), Alumina (Al), and Iron (Fe). The mineral content in claystone varies depending on the type of coal used. Because of the high content of silica and alumina in it, claystone can be used as a source of silica and alumina in the synthesis of zeolite material. Clay minerals or claystone can be used as a catalyst, adsorbent, and as a resin for ion exchange, to exchange ions, clay must first be activated in order to increase the absorption of clay (Catherina, 2014). Claystone or claystone has great potential as an adsorbent because of its abundant, large surface area with active groups such as silanol and aluminol in its skeletal structure and easily dispersed in water (Pranoto, et al., 2018).

Activation of claystone is made from clay samples washed with distilled water several times and filtered until the clay is completely clean from impurities, then dried in an oven at 120oC for 2 hours, after which it is crushed and sieved with 80 mesh size. Clay samples that have been prepared are then taken ± 100 grams and immersed in an Erlenmeyer containing NaOH solution with a concentration variation of 1.5 M, then heated for 8 hours. After it was washed two times with distilled water, one time with composite methanol and distilled water (1: 1) and two times with methanol, then dried at room temperature (Catherina, 2014).

The following graph shows before and after the activation of claystone on gold mining waste.

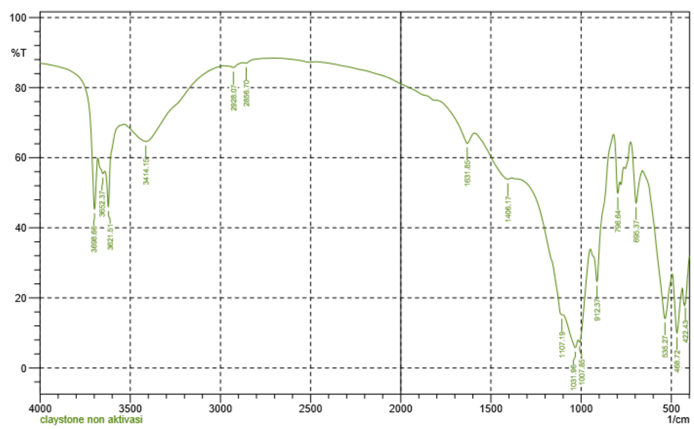

Figure 2. Claystone chart before activation

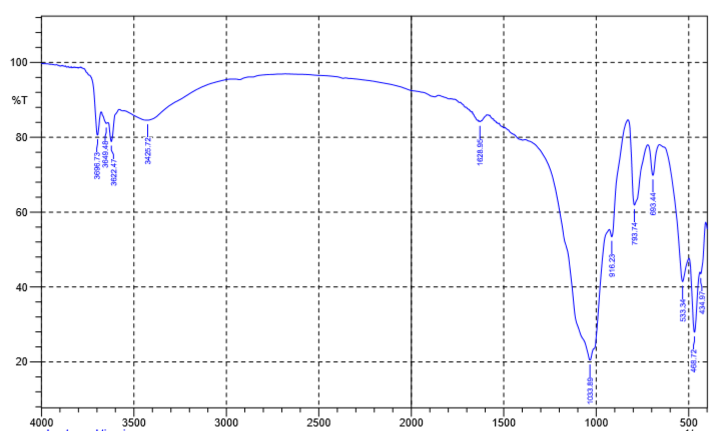

Figure 3. Claystone chart after activation

The two graphs above show a very significant change after gold mining waste is activated by claystone. The concentration of mercury (Hg) drops, which means the levels are reduced, and it shows that claystone is useful for snapping harmful contents in the waste.

3. Benefits of Active Charcoal as Absorbers of Mercury in wastewater

Mercury (Hg) absorbent by using activated charcoal, which is activated by H3PO4, that activated charcoal is excellent in the absorption process. This is proven by the absorption of Ni (II) metal, which is absorbed by 95.08%, while the Pb (II) metal is absorbed by 52.77%. Activated charcoal has a composition composed of elements of carbon, calcium, sulfur, phosphorus, lignite, and cellulose. High carbon and cellulose content (36.00%) and lignite (20.90%) contained active charcoal so that it can be used in the adsorption process. The content contained in rice husk charcoal is not much different from the element content contained in activated carbon. The ability of activated charcoal as an absorbent is not the same from one another, because absorption is not necessarily good for the other absorption process. Differences in pore particle size and activation rates can affect the optimization of the use of activated charcoal (Pari, 2004).

The chemical activation of activated charcoal is carried out by the addition of a 4 M HCl solution, which aims to dissolve impurities on the surface of the charcoal so that the pores of the charcoal will open and its surface area increases. The effect of activation on activated charcoal can be observed in the FTIR spectra shown in Figure 6. The results of the FTIR spectra in Figure 6 show the appearance of new peaks in activated charcoal after activation. A new peak appears at wave number 1037 cm-1, which is the absorption of C-O. The dissolution of impurities causes the emergence of new peaks during the activation process. Based on the data in Table 4 shows there are some differences between activated charcoal before and after activation, such as shifting of wavenumbers from 3427 cm-1 to 3421 cm-1, which shows the absorption of the -OH group experiencing peak widening.

The absorption peaks of C = O, C = C, and C-O after activation look sharper, indicating an increase in absorption intensity. Increased intensity is possible because of impurity on the activated charcoal after it dissolves by the activation.

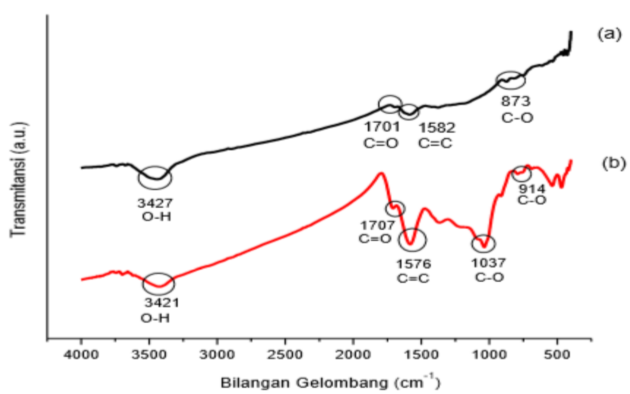

Figure 4. FTIR spectra of activated charcoal before activation (a) and after activation

No	Gugus Fungsi	Bilangan Gelombang (cm^{-1})		
		Pustaka	Sebelum aktivasi	Sesudah aktivasi
1	O-H	3425(1)	3427	3421
2	C=O	1705(1)	1701	1705
3	C=C	1589(1)	1582	1576
4	C-O	1300-800(2)	873	914; 1037

(b) Ket:(1) Kurniati *et al.* (2011), (2) Silverstain *et al.* (2000)

The results of the FTIR analysis showed that there were O-H, C = O, C = C, and C-O uptake in the activated char spectra, which showed the presence of active groups. XRD analyzed the mineral content of activated charcoal.The results of XRD analysis of activated charcoal before and after activation are shown in Figure 7. The activated charcoal diffractogram was identified in the cristobalite, fayalite, and standard manganoan minerals found in ICSD (Inorganic Crystal Structure Database) shown in Appendix 4. Peak diffraction of activated charcoal before activation is shown in 2θ = 24.22º, which is the mineral cristobalite while the peak of diffraction of activated charcoal after activation is shown at 2θ = 21.91º (cristobalite), 26.723 (fayalite), 27.86 (manganoan) and 35.84 (manganoan + fayalite). The diffractogram comparison after activation shows the appearance of a new peak. The appearance of a new peak indicates that the impurity has dissolved due to the activation process. Soluble impurity will open the pores on the surface of activated charcoal and cause an increase in mineral content.

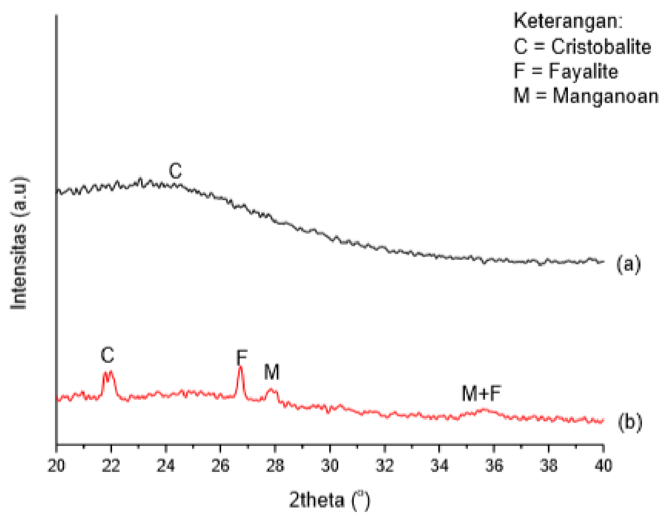

Figure 5. Diffraction of activated charcoal before activation (a) and after activation (b)

4. Costs for Making Mercury Absorbers in Gold Mining Wastewater

Based on the analysis above, where zeolite, claystone, and activated charcoal have succeeded in absorbing and even being able to neutralize water cleanly from mercury pollution, which is very dangerous for the body if the water is consumed. Therefore, it is necessary to make a tool that can be used for that purpose. From the results in the field, making tools with the specifications of zeolite, claystone, and activated charcoal costs Rp. 750,000. With this tool, the surrounding community can re-use water that has been neutralized using zeolite, claystone, and activated charcoal.

Seeing that, the use of zeolite, claystone, and activated charcoal can be a middle ground for people affected by waste, especially waste containing mercury in order to be able to use river water again. Economically, this tool can reduce the cost of tool production and can be an alternative way rather than choosing to use well water or PDAMs that are far more expensive.

Conclusion

Environmental sustainability is something that cannot be negotiated to ensure the economic needs of the present generation without sacrificing the environmental carrying capacity for future generations. Protecting the environment is not only needed to limit pollution but also to ensure eco-efficiency in meeting the needs of the current generation. Environmental pollution caused by gold mining that pollutes water sources is very detrimental to many people.

With tools built from zeolite, claystone, and activated charcoal components, it can reduce the costs incurred by the community in order to enjoy clean water. Zeolite, claystone and activated charcoal have been proven to be able to absorb mercury levels beyond the acceptable threshold so that this tool can economically help Masyarakat affected by wastewater pollution in water sources such as rivers that occur in Kapuas Sub-watershed, Ulak Jaya Sintang Village due to Unauthorized Gold Mining (PETI).

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