HYDROGEN
JURNAL KEPENDIDIKAN KIMIA
https://e-journal.undikma.ac.id/index.php/hydrogen/index

October 2023. 11(5)
e-ISSN: 2656-3061
p-ISSN: 2338-6487
pp. 803-809

Mercury Metal Absorption Using Ethylene Diamine Tetraacetic Acid Intercalated Carbon

Dahlia Rosma Indah, Husnul Hatimah*
Chemistry Education Study Program, Faculty of Science, Engineering and Applied, Mandalika University of Education
**Corresponding author*: husnulhatimah@undikma.ac.id

Article History
Received: 04-09-2023
Revised: 18-08-2023
Published: 30-10-2023

Keywords:
metal absorption, mercury, silver craft waste, EDTA intercalated carbon

Silver craft waste contains hazardous metals, one of which is mercury metal. If high concentrations of mercury waste are disposed of without treatment, this waste seeps into the soil and pollutes residential water sources because mercury metal is difficult to decompose. Mercury poisoning can cause nerve reactions such as difficulty speaking, blurred vision, muscle weakness, paralysis, impaired sense of taste, and shortness of breath. This research was conducted as an effort to reduce mercury metal levels in silver craft waste in Central Lombok Regency. The method of waste treatment is by adsorption method utilizing carbon bagasse modified with EDTA. The first step is to first determine the level of mercury metal in silver craft wastewater in Central Lombok. Furthermore, wastewater is contacted with EDTA-intercalated bagasse carbon. Making intercalated carbon bagasse consists of 3 stages, namely first dehydration by burning bagasse until it turns into carbon, second carbonation is heating temperature 500ºC, carbon results are sifted 100-200 mesh and third, intercalation is by soaking 100 grams of carbon in 250 mL EDTA solution 10% stirred for 6 hours. After that the carbon is dried at a temperature of 50ºC. A total of 2 grams of intercalated bagasse carbon that has been made is put into 25 mL of wastewater samples. The sample was stirred at contact time variations of 30, 60, 90, 120 and 150 minutes using a stirer. The optimum time obtained is used to calculate the efficiency of reducing mercury metal levels, namely calculating the difference in mercury metal levels before adsorption and after adsorption using EDTA intercalated carbon baggase. Mercury metal levels were analyzed using an Atomic Absorption Spectrophotometer (SSA). From the study, it was found that the mercury metal content in the sample was 50.6398 ppb. The optimum contact time in mercury metal adsorption is at a contact time of 120 minutes which results in an optimum adsorption efficiency in mercury metal of 70.55%.

How to Cite: Indah, D., & Hatimah, H. (2023). Mercury Metal Absorption using Ethylene Diamine Tetraacetic Acid Intercalated Carbon. Hydrogen: Jurnal Kependidikan Kimia, 11(5), 803-809. doi:https://doi.org/10.33394/hjkk.v11i5.10097

https://doi.org/10.33394/hjkk.v11i5.10097

INTRODUCTION

Lombok Island is famous for its tourist beauty. Tourists come for vacation and buy souvenirs typical of Lombok, one of which is silver handicraft souvenirs. The silver handicraft industry is one of the largest Local Original Income (PAD) industries in Central Lombok. Until now there are around 200 silversmiths in Ungga, Central Lombok (Kompas, 2018). One of the hazardous wastes in the silver craft industry process is mercury metal. The function of mercury in this process is as the cathode of the electrolysis cell. Mercury in the form of a moving film forms an amalgam with sodium released from the salt solution at the cathode during electrolysis (Bernhoft, 2012).

Mercury poisoning can cause nerve reactions such as difficulty speaking, blurred vision, muscle weakness, paralysis, impaired sense of taste, and shortness of breath (Palar, 2012). The Food and Drug Administration (FDA) sets the maximum mercury content limit at 0.0005 ppm for water and 0.5 ppm for food. If high concentrations of mercury waste are disposed of untreated, it seeps into the soil and contaminates residential water sources because mercury metal is difficult to decompose (Farina; Aschner; and Rocha, 2011).

There are many methods in wastewater treatment, one of which is adsorption. Adsorption is an effective purification and separation technique used in industry because it is considered more economical. Adsorbents that are often used for liquid waste treatment include zeolite, alumina, activated carbon, and silica gel. Activated carbon is easiest to find and has the largest surface area, so the ability to absorb is also the greatest (Wahjuni; Danny; and Desty, 2015). Among the three activated carbons made from natural materials, namely coconut shells, palm tree trunks, and bagasse (bagasse), the results showed that the activated carbon that has the best characteristics and absorption is activated carbon from bagasse (Jaguaribe et al, 2015).

Bagasse is a waste product from the sugar industry or the manufacture of sugarcane juice drinks that have not been utilized optimally so that it becomes a problem in the environment. Judging from its constituent components, namely cellulose groups , bagasse can absorb metal ions because it has large fibers and pores in accommodating sugar previously contained in bagasse (Apriliani, 2010). However, carbon bagasse itself has a less than optimal ability to adsorb metals so there needs to be modifications, namely intercalation with the EDTA anion. EDTA is a complexing ligand that acts as a chelating agent because of its ability to bind metals so that it is expected that carbon baggase intercalated with EDTA will be able to adsorp more metal ions (Roto; Beautiful; and Kuncaka, 2015).

The urgency of this research is that the use of bagasse into mercury metal adsorbents has good prospects and is economical to be developed, besides that it is expected to be an added value and increase its carrying capacity to the environment. This research can be used as a contribution to science in waste management efforts so as to reduce environmental pollution caused by hazardous metals.

The problems to be examined in the study are :(1) What are the mercury levels in silver craft industry waste? (2) What is the optimum contact time in the mercury adsorption process? (3) What is the efficiency and sequestration capacity of EDTA-intercalated carbon bagasse as a mercury metal adsorbent?

The specific objectives of the study are to analyze mercury levels in the silver craft industry, test the ability of EDTA-intercalated baggase to absorb mercury metal and utilize bagasse as a result of sugarcane juice beverage merchant waste to be converted into carbon form so as not to pollute the environment.

METHOD

Tools and Materials

The tools used in this study were Atomic Absorption Spectrophotometer, magnetic stirrer, tumblercup, erlenmeyer, measuring flask, measuring pipette, volume pipette, glass funnel, incubator, sieve, analytical balance, pH meter, furnace, and blender. The materials used were bagasse waste (taken from sugarcane juice beverage sellers), silver handicraft wastewater (taken from the silver industry in Ungga, Central Lombok), Nitric Acid 0.1 M; aquades, Whatman 42 filter paper, and EDTA.

Research Procedures

This research will be carried out in four stages. First, the analysis of mercury metal levels in silver craft industry waste. Second, the manufacture of EDTA-intercalated carbon bagasse adsorbents. Third, determination of the optimum contact time and waste concentration on mercury metal absorption. Fourth, after the optimum conditions are known, EDTA-intercalated carbon bagasse is applied to the wastewater of the silver craft industry.

Analysis of Mercury Metal Levels in Silver Craft Industry Waste.

A total of 500 mL of silver handicraft industry waste samples in Ungga were taken from 3 different sources. The sample is put into a bottle and labeled. The initial levels of mercury metal in the sample were analyzed using an Atomic Absorption Spectrophotometer (SSA).

EDTA-Integrated Carbon Bagasse Creation.

Bagasse that has been dried in the sun to dry is burned over low heat and in a closed space until all bagasse turns into carbon, then heated in a furnace at a temperature of about 200 ºC until smoke does not form. The carbon that has been formed is sifted at 100-200 mesh and as much as 50 grams of carbon is immersed in 500 mL of 15% NaOH for 12 hours, then filtered and the residue washed with aquades until the filtrate is neutral washed. After that the carbon is dried at a temperature of 110 ºC and finally heated in a furnace at a temperature of 500 ºC for 1 hour. Intercalation is carried out by soaking 100 grams of carbon in 250 mL of 10% EDTA solution steered for 6 hours.

Determination of the optimum conditions of adsorption.

EDTA-intercalated bagasse carbons weighed 2 grams each, fed into the erlenmeyer. Then put 25 mL of silver craft industry waste samples into the erlenmeyer. Erlenmeyer was placed on a magnetic stirrer during adsorption contact time variations of 30, 60, 90, 120 and 150 minutes. After that the mixture is separated by filtering, the filtered filtrate is taken 10 mL and added 1 drop of nitric acid as a preservative so that there are no changes in the composition of the solution and finally the concentration of mercury metal is measured with AAS.

Application of EDTA Integrated Bagasse Carbon Use in Silver Craft Waste Samples.

Using the optimum conditions obtained, EDTA-intercalated carbon bagasse was fed into the erlenmeyer, adding 25 mL of silverware wastewater sample at optimum concentration. The Erlenmeyer is placed on a magnetic stirrer during the optimum contact time. The mixture is separated by filtering, the filtered filtrate is taken 10 mL, plus 1 drop of nitric acid as a preservative so that there are no changes in the composition of the solution and finally the concentration of mercury metal is measured by AAS.

Data analysis

The levels of all mercury metals were analyzed using an Atomic Absorption Spectrophotometer (AAS). Determination of efficiency is obtained from the calculation results with the following formula.

$$\text{Mercury metal adsorption efficiency} = (a-b)/a \times 100\%$$

while, a = the rate of mercury metal before being confixed with EDTA-intercalculated bagasse carbon, b = mercury metal content after contact with EDTA-intercalated bagasse carbon.

RESULTS AND DISCUSSION

Mercury Metal Levels in Silver Craft Waste

From the results of testing silver craft wastewater samples in Ungga Village, Central Lombok using Atomic Absorption Spectrophotometry (AAS), the concentration of mercury metal was 50.6398 ppb. These results are obtained from calculations on the standard curve of Hg solution which has the equation Y = 0.025870X + 0.00075238 with a regression coefficient r2 = 0.9969. The copper concentration in the wastewater is then used as the initial concentration of Hg before treatment.

EDTA Integrated Baggase Carbon Manufacturing

Bagasse that has been dried in the sun and dried is burned over low heat and in a closed space until all bagasse turns into carbon, then heated in a furnace at 500 ºC until smoke does not form. The carbon that has been formed is sifted in a sieve of 100-200 mesh and as much as 50 grams of carbon is immersed in 500 mL of 15% NaOH for 12 hours, then filtered and the residue washed with aquades until the washed filtrate is neutral. After that the carbon is dried at a temperature of 110 ºC and finally heated in a furnace at a temperature of 500 ºC for 1 hour. Intercalation is carried out by soaking 100 grams of carbon in 250 mL of 10% EDTA solution steered for 6 hours. The carbon baggase that has been ready for use is then weighed 2 grams each to be contacted with silver craft waste.

Effect of Adsorption Contact Time

A total of 100 mL of wastewater samples were then contacted with 2 grams of activated carbon baggase at a variation of contact time of 30, 60, 90, 120 and 150 minutes. Activated carbon baggase countermeasures to silverware wastewater samples containing mercury were carried out with a batch system that mixed adsorbents in a fixed amount of solution and observed changes in quality at certain intervals. This study was conducted on samples with a mercury concentration of 14.5710 ppm. Test results on contact time variations are presented in Table 1.

Table 1. Variation of contact time to adsorption of mercury metal

Contact Time (minutes)	Initial concentration of mercury (ppb)	Mercury concentration after treatment (ppb)	Adsorption efficiency (%)
30	50,6398	36,9425	27,05
60	50,6398	35,0318	30,82
90	50,6398	34,8678	31,14
120	50,6398	14,9137	70,55
150	50,6398	14,8413	70,69

From Table 1 it can be seen that there is a decrease in mercury concentration after contact with activated carbon baggase. The decrease in mercury concentration in the waste samples ranged from 27.05% to 70.69%. According to Manocha (2013), adsorption is a Initial concentration of mercury

phenomenon that is closely related to the surface where interactions between liquid or gas molecules are involved with solid molecules. This interaction occurs due to the attraction of atoms or molecules that cover the surface. The adsorption capacity of bagasse charcoal depends on the pore type and the number of possible surfaces that can be used for adsorption.

Sulistyawati (2008) states that the adsorption capacity is directly proportional to the time to a certain point, then decreases after passing that point. The concentration of iron on the variation in contact time is shown in Figure 1.

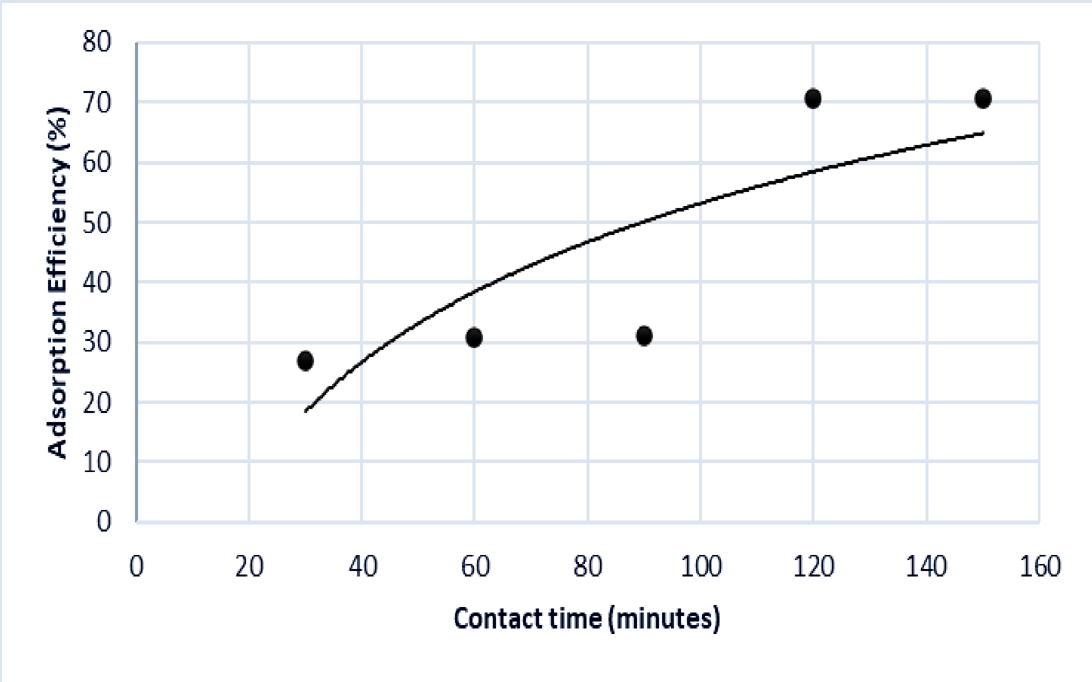

Figure 1. The effect of contact time on mercury adsorption efficiency

From Figure 1 it can be seen that the best mercury adsorption efficiency in silver craft waste samples was at a contact time of 120 minutes which is 70.55%. Sufficient contact time is required for activated carbon baggase to optimally adsorb mercury. The longer the contact time, the more chances the charcoal particles have to come into contact with the mercury metal bound in the charcoal pores. But at a certain contact time, the adsorption efficiency decreases.

Decreased or fixed adsorption efficiency is possible due to the desorption process or re-release of adsorbate during stirring. Desorption occurs due to the saturated adsorbent surface. In the saturated state, the adsorption rate is reduced so that the contact time no longer has an effect. Metal adsorption increases at long reaction times because the number of active sites available on the surface is unsaturated (Roto; Dahlia; and Agus; 2015). In adsorption of mercury metal on activated baggase carbon, after 120 minutes the amount of absorbed mercury metal did not undergo significant changes.

CONCLUSION

Based on the results of research conducted on samples of silver craft waste in Ungga village, Central Lombok using Atomic Absorption Spectrophotometry (AAS) it can be concludedthat the mercury metal content in the sample was 50.6398 ppb. The optimum contact time in mercury metal adsorption is at a contact time of 120 minutes. The optimum adsorption efficiency of mercury metal is 70.55%.

RECOMMENDATIONS

Further research can be done for adsorption of other metals using activated baggase carbon adsorbents that have been modified with chelating materials so that they are more effective in adsorbing.

ACKNOWLEDGEMENTS

Thank you to LPPM Undikma for funding research through internal research grants, laboratories at the Undikma Chemistry Laboratory and all parties who help researchers so that research can be completed properly and on time.

BIBLIOGRAPHY

Apriliani. 2010. Pemanfaatan Arang dari Ampas Tebu Sebagai Adsorben Ion Logam Cd, Cr, Cu, dan Pb dalam Air Limbah. *Skripsi*. Jakarta : Universitas Islam Negeri Syarif Hidayatullah.

Bernhoft RA. 2012. Mercury Toxicity and Treatment : A Review of The Literature. *Journal of Environmental and Public Health*. 56 (1) : 46-56.

Farina M, Aschner M, Rocha JBT. 2011. Oxidative Stress in MeHg-induced Neurotoxicity.
Toxicology and Applied Pharmacology. 256(1) : 405-417.

Furieri L.B., Fioresi M, and Junior R.F.R. 2011. Exposure to Low Mercury Concentration in vivo Impairs Myocardial Contractile Function. *Toxicology and Applied Pharmacology*.255(2) : 193-199.

Handoko, C.T., Yanti, T.B., Syadiyah, H., dan Marwati, S. 2013. Penggunaan Metode Presipitasi Untuk Menurunkan Kadar Cu dalam Limbah Cair Industri Perak di Kotagede. *Jurnal Penelitian Saintek*. 18 (2) : 51-58.

https://travel.kompas.com/read/2017/05/24/15510540/Desa.Ungga.Sohor.karena.Kerajinan.Perak. Retrieved July 10, 2018.

Imelda,H., Silalahi, Zahara, T.A., dan Tampubolon, H.M. 2012. Kapasitas Adsorpsi
Merkuri Menggunakan Adsorben Sargassum Crassifolium Teraktivasi. *Biopropal Industri*.(1) : 28-38.

Indah, D.R. dan Hendrawani. 2017. Upaya Menurunkan Kadar Ion Logam Besi pada Air
Sumur Dengan Memanfaatkan Arang Ampas Tebu. *Jurnal Ilmiah Pendidikan Hydrogen*.5(2) : 68-74.

Jaguaribe, E.F., Medeiros, L.L., Barreto, M.C.S.,and Araujo,L.P. 2015. *The Performance of Activated Carbons from Sugarcane Bagasse, Babassu, and Coconut Shells in*

Kargi, F. and Cikla, S. 2016. Biosorption of Zinc (II) Ions Onto Powdered Waste Sludge
(PWS) : Kinetics and Isotherms. *Enzyme and Micobial Technology*. 38(5) : 705-710.

Kaur S., Walia T.P.S.,and Mahajan R.K. 2008. Comparative Studies of Zink, Cadmium, Lead, and Copper on Economically Viable Adsorbents. *Journal Environ. Eng. Sci.* 7 :1-8.

Manocha, S. M. 2013. Porous Carbons. *Jurnal Sadhana*. Vol. 28, part 1 dan 2.

Palar, H. 2012. *Pencemaran dan Toksikologi Logam Berat*. Jakarta : Rineka Cipta.

Roto, R., Indah, D.R., dan Kuncaka, A. 2015. Hydrotalsit Zn-Al-EDTA Sebagai Adsorben Untuk Polutan Ion Pb (II) di Lingkungan. *Jurnal Manusia dan Lingkungan*. 22 (2) : 226-232.

Selvi, K., Pattabhi S and Kardivelu K. 2011. Removal of Cr(VI) from Aqueous Solution by Adsorption Onto Activated Carbon. *Bioresour Technol*. Vol 80 : 87-89.

Shofa. 2012. Pembuatan Karbon Aktif Berbahan Baku Ampas Tebu dengan Aktivasi Kalium Hidroksida. *Skripsi*. Jakarta : Fakultas Teknik Kimia Universitas Indonesia.

Sulistyawati, S. 2008. Modifikasi Tongkol Jagung Sebagai Adsorben Logam Berat Pb (II). *Skripsi*. Bogor : FMIPA IPB.

Tandy, E., Fahmi, I., and Hamidah. 2012. Kemampuan Adsorben Limbah Lateks Karet Alam Terhadap Minyak Pelumas dalam Air. *Jurnal Teknik Kimia*. 1 (2) : 70-75.

Wahjuni, N.S., Danny, A., dan Desty, R. 2015. Perbandingan Tingkat Adsorpsi Chitin dan Karbon Aktif dalam Menjerap Logam Chromium dalam Tangki Berpengaduk. *Seminar Teknik Kimia Fakultas Teknik UNS, Surakarta*. Hal. 71-76.