



Adsorptive Removal of Copper (Cu) in Sasirangan Liquid Waste by Utilization of Rice Husk as Activated Carbon

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Abstract - The business of sasirangan - the conventional texture of Banjar Tribe - has been one of the superb items of South Kalimantan. Sasirangan creation in the shading system utilizes many synthetic components containing weighty metals, which is and its waste possibly dirties the climate. One weighty metal squanders copper (Cu), poisonous to sea-going living beings and people. The treatment for Sasirangan modern wastewater should be possible by an adsorption cycle that utilizations enacted carbon as an adsorbent. This study intends to decide the capacity of enacted carbon produced using rice husk to adsorb Cu from sasirangan fluid burn by dissecting the impact of contact time and adsorbent dose on the adsorption interaction. The bunch framework led the activity with substance and actual actuation. Synthetic initiation was finished by dousing the enacted carbon of rice husk with HCl answer for 24 hours. Simultaneously, actual enactment was done by consuming a heater at 500°C for 2 hours. The adsorption treatment was given on sasirangan burn through examples with varieties in contact time (30, 60, and 120 minutes) and the adsorbent portion (2, 4, and 6 grams). The highest productivity of contained Cu decrease is 72.34% utilizing carbon with initiation. The ideal contact time expected in the adsorption cycle of weighty metal Cu in Sasirangan liquid waste is 120 minutes, with the ideal portion of 4 grams of actuated rice husk carbon adsorbent

Keywords: sasirangan; liquid waste; Cu; adsorption; activated carbon; rice husk

Introduction

Sasirangan is a conventional texture of the Banjar clan in South Kalimantan. Starting around 2007, the Sasirangan business has been assigned as one of ten premium products in South Kalimantan (Putra, 2011). The shading system utilistillc ontainsning weighty metals that the waste material likewise still contains those components. If the waste material is not overseen accurately, the waste material can dirty the climate. The genuine risks that emerge, paying little heed to stylish contemplations, are exacerbated when hued specialists occupy light transmission through water, dial back photosynthetic action in marine life, repress biota development, and hinder the nature of the getting stream, in this manner upsetting organic cycles in the stream, which thus brings about a natural awkwardness (Foo, *et al.*, 2010).

One of the weighty metals in the waste is copper (Cu), which is poisonous to amphibian life forms and people at specific fixation limits. In light of the quality norm of material industry fluid waste, Indonesian Minister of Environment Regulation No. 5/2014, the real happiness of Cu is two mg/L. The toxin boundaries in Sasirangan liquid waste surpass current fluid waste quality guidelines (Rossi, 2014). A successful and effective fluid waste treatment innovation is expected to expect and limit the potential natural effects created. The different examination has been created with broad revelations about fluid waste treatment innovations: precipitation, coagulation - uniting, sedimentation, documentation, filtration, film processes, electrochemical designing, natural cycles, substance responses, adsorption, and particle trade (Li, *et al.*, 2013). Of critical interest is the adsorption cycle by enacted carbon. An adsorbent with a sizeable permeable surface, controllable pore

construction, and warm dependability is perceived as the most proficient and guarantees a critical methodology in fluid waste treatment (Foo, *et al.*, 2012). This adsorption cycle is supposed to have the option to adsorb heavy metal particles in fluid waste. This strategy is more favorable than different techniques due to its minimal expense and the shortfall of poisonous secondary effects (Babaso and Sharanagouda, 2017). Adsorption utilizing enacted carbon is an effective technique that has been growing lately. Initiated carbon can be made by actuating carbon-containing materials under specific circumstances. An enactment interaction is completed to increment actuated carbon's adsorption execution.

Activated carbon from the organic waste of rice husks is the prospective adsorbent. This is due to the nature of rice husks which have low nutritional value, are resistant to weathering, have a high ash content, are abrasive, contain wood, and have a high enough carbon content. In addition, it is also related to the availability of rice husk waste which is quite a lot in many places and periods, while the utilization of this waste is still limited (Babaso and Sharanagouda, 2017). According to data from the Central Bureau of Statistics, Indonesia produces waste of rice husks as much as 8.2 to 10.9 tons (Danarto and Samun, 2008). The milling process of rice production produces rice husks of 20% (Lopez, *et al.*, 2014). This enormous waste potential has not been optimally utilized. Rice husks are generally used as conventional fuel, an alternative fuel for brick kiln systems, or burned as rubbing ash. At the same time, rice husk is very potential biomass to be used as a biosorbent (Folletto, *et al.*, 2006). Studies have shown that rice husk contains about 32.12% cellulose, 22.48% hemicellulose, 22.34% lignin, 13.87% mineral ash, 7.86% water, and 2.33% other materials (Sofyan, 2011).

Biomass from plants contains much cellulose, including rice husks which contain 32.12% cellulose. Materials containing cellulose can adsorb metal cations from the arrangement medium. This cellulose content makes it potential to be utilized as a biosorbent for weighty metals from water (Sofyan, 2011). For this situation, it is fundamental for the lead trial to concentrate on the viability of actuated carbon from rice husks in the adsorption of weighty metal cation from the fluid misuse of the Sasirangan business. This examination plans to decide the capacity of actuated carbon produced using rice husk to adsorb Cu from sasirangan fluid burn through by breaking down the impact of contact time and adsorbent dose on the adsorption interaction.

Materials and Methods

Materials

The materials expected in this exploration were sasirangan liquid waste acquired from sasirangan home businesses in Banjarmasin, chloric acid (HCl), nitric acid (HNO₃), and purified water.

Methods

This study was planned to decide the presentation of actuated carbon from rice husks in diminishing Cu content in Sasirangan liquid waste by adsorption process with physical and synthetic enactment. The exploration was directed in a few phases: testing and saving sasirangan liquid waste, the readiness of enacted carbon from rice husk, planning of mother alcohol, and adsorption cycle of weighty metals Cu from the sasirangan fluid waste examples utilizing actuated carbon.

Sampling and Preserving of Sasirangan Liquid Waste (S.N.I. 6989.59:2008) (Simandjuntak, 2015)

The initial step was to take a sample of sasirangan liquid waste, then put it in a closed container and store it in a cool box. If the sample was not used immediately, the sample was preserved by adding HNO₃.

Preparation of Activated Carbon from Rice Husk

The readiness of enacted carbon from rice husks was completed by drying the rice husks dry; then, the pyrolysis interaction utilized a little drum to frame carbon. At the hour of consuming, just a tiny opening was given as a way for the smoke to get away. Then it was squashed and sifted with a size of 50 cross-sections. Rice husk carbon from carbonization was artificially enacted by drenching in 0.1 M HCl answer for 24 hours. Actual enactment was done by consuming charcoal from substance actuation in a heater at a temperature of 500°C.

Preparation of Primary Solution (Dilution of Liquid Waste Sample)

Dilution was conducted by picking up 5 mL of sasirangan liquid waste sample, put in a 50 mL volumetric flask, and diluted with distilled water until the limit mark.

Adsorption by Activated Carbon

The activated carbon was treated with a variation of contact time (30, 60, and 120 minutes) and dose (2, 4, and 6 grams) to obtain optimal results in the adsorption of Cu metal. Then the test and analysis were carried out on the data obtained to provide an overview of the effect of the contact time of activated charcoal adsorbent from rice husks on the adsorption of Cu metal from sasirangan liquid waste.

The consequences of the information examination will be introduced in tables and diagrams, then broken down illustratively to outline the impact of contact time and adsorbent portion on the adsorption of Cu from sasiran liquid waste. The decrease of Cu not entirely settled by the accompanying recipe (Simandjuntak, 2015):

$$E = \frac{C_0 - C_e}{C_0} \times 100\% \quad (1)$$

where :

E = percentage of Cu reduction (%)

C₀ = initial Cu concentration (mg/L)

C_e = final Cu concentration (mg/L)

Results

Rice Husk Carbon Adsorbent with Activation

In this research, activated rice husk carbon with a predetermined variation of contact time was contacted with sasirangan liquid waste, then filtered to separate the adsorbent and filtrate. The filtrate is a sample then tested for its heavy metal concentration. The following are the results of the Cu heavy metal testing in the sample, as can be found in Table 1.

Table 1. The Test Results of Cu Content with Variations in Contact Time of Activated Rice Husk Carbon to Sasirangan Liquid Waste

Contact Time (min)	Adsorbent Dose (g)	Cu Concentration (mg/L)	The efficiency of Cu Reduction (%)
0	2	0.047	0.00
	4	0.047	0.00
	6	0.047	0.00
30	2	0.028	40.42
	4	0.019	59.57
	6	0.021	55.31
60	2	0.029	38.29
	4	0.018	61.70
	6	0.022	53.19
120	2	0.027	42.55
	4	0.013	72.34
	6	0.017	63.82

Rice husk-activated carbon in this study reduced Cu concentration in Sasirangan liquid waste. It is proven by the correlation between the decrease of adsorbate (Cu content) and the variation in contact time with adsorbent. The analysis results of the decrease of Cu concentration in Sasirangan liquid waste by the effect of adsorption contact time with activated carbon are shown in Figure 1.

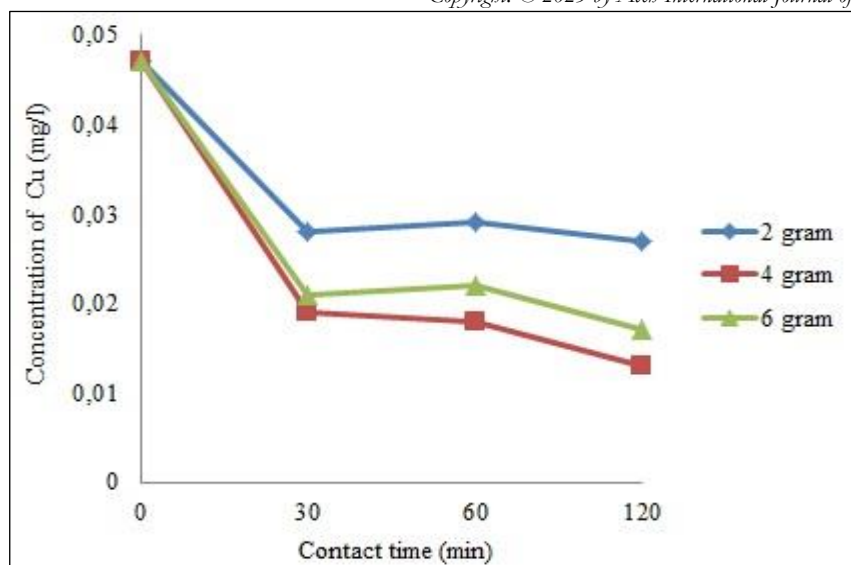


Figure 1. The concentration of Cu in Sasirangan Liquid Waste with Variations of Adsorption Contact Time by Activated Rice Husk Carbon

Based on Figure 1, it can be seen that there was an increase and decrease in Cu concentration in each treatment, varying the dose and contact time of the adsorbent. Before treatment, the concentration of heavy metals in the sasirangan liquid waste sample was 0.047 mg/L. In the variation of contact time of 30 minutes, the highest decrease in concentration was at a dose of 4 grams was 0.019 mg/L, while in contact time of 60 minutes, the highest decrease was also at a dose of 4 grams was 0.018 mg/L. Then at a contact time of 120 minutes, the highest decrease also occurred at a dose of 4 grams, namely 0.013 mg/L.

Considering the data analysis obtained, it can be concluded that the optimum adsorption for heavy metal Cu in this study was shown in the adsorbent dose of 4 grams with a contact time of 120 minutes, namely 0.013 ppm. Then the adsorption efficiency analysis was carried out to determine how much the percentage reduction in Cu concentration in sasirangan liquid waste after contacting it with rice husk activated carbon. The reduction efficiency of Cu concentration at the contact time of 30 minutes was 59.57% at a dose of 4 grams. While at the contact time of 60 minutes, the reduction efficiency of Cu was 61.70% at a dose of 4 grams. The highest reduction efficiency of heavy metal Cu concentration occurred at the contact time of 120 minutes and 4 grams of adsorbent, 72.34%.

Rice Husk Carbon Adsorbent without Activation

The adsorption by rice husk carbon without activation was conducted, and a comparison. The adsorbent without activation resulted from the carbonization process of rice husk and its sieving, which passed 50 mesh. In this research, activated carbon from rice husks with a predetermined variation of contact time was contacted with sasirangan liquid waste, then filtered for separation between adsorbent and filtrate. The filtrate as the sample was then tested for its Cu concentration, and the test results are shown in Table 2 following.

Table 2. The Test Results of Cu Content with Variations in Contact Time of Rice Husk Carbon without Activation to Sasirangan Liquid Waste

Contact Time (min)	Adsorbent Dose (g)	Cu Concentration (mg/L)	The efficiency of Cu Reduction (%)
0	2	0.047	0.00
	4	0.047	0.00
	6	0.047	0.00
30	2	0.042	10.63
	4	0.027	42.55

	6	0.031	34.04
60	2	0.041	12.76
	4	0.025	46.80
	6	0.029	38.29
120	2	0.047	0.00
	4	0.022	53.19
	6	0.029	38.29

The impact of contact time and a portion of carbon adsorbent without actuation on the lessening of Cu focus in sasirangan liquid waste is displayed in Figure 2.

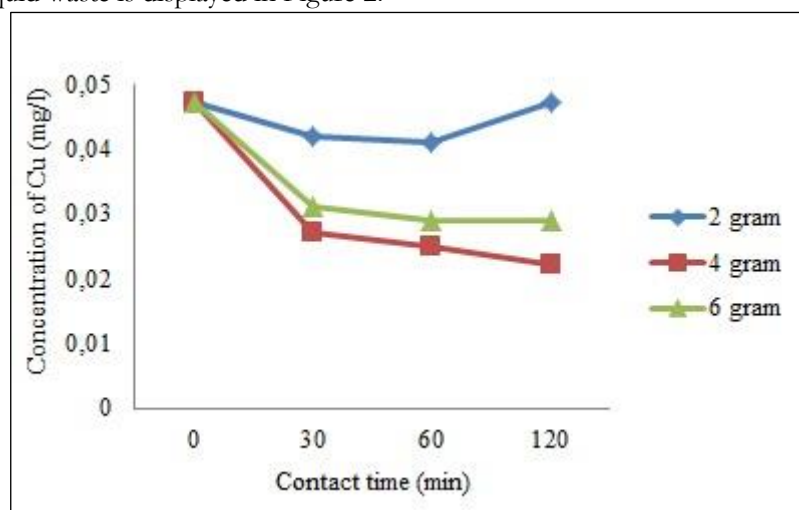


Figure 2. The concentration of Cu in Sasirangan Liquid Waste with Variations of Adsorption Contact Time by Rice Husk Carbon without Activation

Figure 2 shows an increase and decrease of Cu concentration in each treatment, varying dose, and contact time of the adsorbent. Before treatment, the heavy metals concentration in the sasirangan liquid waste sample was 0.047 mg/L. At 30 minutes of contact time, the highest decrease in concentration was at a dose of 4 grams, namely 0.027 mg/L, while at a contact time of 60 minutes, the highest decrease was also at a dose of 4 grams of 0.025 mg/L. At the contact time of 120 minutes, the highest decrease also occurred at a dose of 4 grams, namely 0.022 mg/L. The optimum conditions for adsorption by carbon of rice husk without activation were shown at the adsorbent dose of 4 grams with a contact time of 120 minutes. The concentration of Cu heavy metal decreased to 0.022 ppm. The results of the adsorption efficiency analysis showed that the efficiency of reducing the concentration of Cu heavy metal at the contact time of 60 minutes with a dose of 2 grams was 12.76%. The contact time of 120 minutes and the dose of 4 grams showed the highest reduction efficiency of Cu heavy metal, which was 53.19%. Moreover, at the contact time of 60 minutes with a dose of 6 grams, the efficiency of reducing Cu heavy metal was 38.29%.

Discussion

Rice Husk Activated Carbon as Adsorbent

Rice husk was handled into two unique adsorbents in powder-sized 50 cross-sections: rice husks were handled with the enactment stage and without activation. Rice husks can be utilized as biosorbents for ecological treatment of water sources polluted by big metal waste. Rice husk biomass contains a ton of cellulose, particularly 32.12% cellulose, 22.48% hemicellulose, and 22.32% lignin (Frita and Susanto, 2011). Materials containing cellulose can adsorb metal cations from the arrangement medium. The underlying treatment of rice husks was carbonization, where at this stage, pyrolysis ignition was completed to become enacted carbon. The purpose of carbonization was to remove oxygen and hydrogen elements to produce carbon with its structure. Carbonization

occurs in several stages, including removing water components or dehydration, changing organic matter into carbon elements, and tar decomposition to increase the carbon pores. There was a physical transformation in the rice husk during the carbonization process, changing its color to black.

Activation of the adsorbent is carried out by chemical activation using hydrochloric acid (HCl) and physical activation. According to Sofyan (2011), the activation of the adsorbent with hydrochloric acid (HCl) causes the surface to occur due to the presence of protons that can dissociate or release H^+ ions from the carboxylate group (-COOH) and hydroxyl group (-OH) contained in the adsorbent. The hydroxyl group (O.H. group) interacts with the adsorbate component. Physical activation is carried out by flowing steam or air at high temperatures using a furnace to expand the carbon pores so that the absorption capacity becomes large. In this study, the absorption of heavy metal Cu, which experienced the most significant decrease, was by using activated carbon with an efficiency reduction of 72.34%. In contrast, activated carbon from rice husks without activation reduced efficiency by 53.19%.

Effect of Contact Time and Activation Process of Adsorbent on Efficiency of Cu Removal in Sasirangan Liquid Waste

Adsorption is a process of a substance (molecule or ion) attached to the adsorbent surface. The adsorption mechanism is described as a process by which molecules initially present in the solution physically attach to the surface of the adsorbent. A molecule can be adsorbed if the adhesion force between the adsorbate molecule and the adsorbent molecule is greater than the cohesion force on each molecule (Basset, 1994). The length of contact time in the adsorption process affects the efficiency and capacity of adsorption. In this study, the Cu concentration in the sasirangan liquid waste decreased slowly. The longer the contact time, the more significant the decrease in Cu concentration (Eckenfelder, 2000). This is due to more chance for rice husks activated carbon to absorb Cu^{2+} ions with the longer contact time. Based on the statistical analysis performed by Pratisto (2005) using SPSS 12.0, it appears that contact time and the final concentration of Cu were closely related and have a negative pattern. This means that the longer the contact time between the waste and activated carbon, the less the final concentration of Cu will be. The optimum adsorption for heavy metal Cu from the variation of contact time with rice husk activated carbon and activation in this study was shown at the adsorbent dose of 4 grams with a contact time of 120 minutes, namely 0.013 ppm. Meanwhile, the optimum conditions for adsorption of rice husk-activated carbon without activation were shown at the adsorbent dose of 4 grams with a contact time of 120 minutes. The concentration of Cu heavy metal decreased to 0.022 ppm.

In this research, the adsorption performance to heavy metal Cu resulted in the most significant reduction of its concentration by applying rice husk carbon with activation. The reduction efficiency was 72.34%. Whereas for rice husk carbon without activation, the reduction efficiency value was 53.19%. Activation of adsorbent with hydrochloric acid (HCl) caused surface acidity due to the presence of protons that can dissociate or release H^+ ions from the carboxylic group (-COOH) and hydroxyl group (-OH) presented in the adsorbent. The connected hydroxyl group (-OH group) will be reliable with the adsorbate component. Physical activation was conducted by channeling steam or air at high temperatures using a furnace to expand activated carbon pores so that its adsorption performance improved. Based on the results of the adsorption process, it can be said that activated carbon has a higher adsorption performance than carbon without activation. According to Widayanti *et al.* (2012), activated carbon has a high adsorption performance because pores covered by other organic compounds have been opened due to the activation process. This activation process will cause the impurities that clog the pores to disappear so that the activated carbon pores become bigger and improve their adsorption performance to liquids.

Conclusion

The present investigation revealed the versatility of activated carbon produced from rice husk in copper (Cu) adsorption from sasirangan liquid waste. The highest Cu reduction efficiency was 72.34% using rice husk carbon adsorbent with activation. The optimum contact time required in the adsorption process was 120 minutes with 4 grams of rice husk carbon. The activation of activated carbon made from the biomass can be developed as an adsorbent for other pollutant metals. Further research is required with various adsorbents to obtain the best results to apply to sasirangan liquid waste. The processes required in synthesis and adsorption are convenient and efficient.

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References

- Babaso, P. N., Sharanagouda, H. 2017. Rice Husk and Its Applications: Review. *International Journal of Current Microbiology and Applied Sciences*, 6(10): 1144-1156.
- Bassett, J. 1994. Buku Ajar Vogel Kimia Analisis Kuantitatif Anorganik. Penerbit buku Kedokteran EGC. Jakarta.
- Danarto, Y.C., Samun, T. 2008. Pengaruh Aktivasi Karbon dari Sekam Padi pada Proses Adsorpsi Logam Cr(VI). *Ekuilibrium*, 7(1): 13-16.
- Eckenfelder. 2000. *Industrial Water Pollution Control*. Mc Graw Hill Book Company. Singapore.
- Folieto, E. L., Ederson, G., Leonardo, H. O. 2006. Conversion of Rice Husk Ash Into Sodium Silicate. *Material Research*, 9(3): 335-338.
- Foo K. Y., Hameed, B. H. 2012. Potential of Activated Carbon Adsorption Processes for The Remediation of Nuclear Effluents: A Recent Literature. *Desalin. Water Treat.* 41: 72-78.
- Foo K. Y., Hameed, B. H. 2010. An Overview of Dye Removal via Activated Carbon Adsorption Process. *Desalin. Water Treat.*, 19: 255-274.
- Frita, Y., Susanto, H. 2011. Kajian Pemanfaatan Arang Sekam Padi Aktif Sebagai Pengolah Air Limbah Gasifikasi. *Jurnal Teknik Kimia Indonesia*, 10: 9-17.
- Li, J.Y.K., Zhao, B. L., Zhang, L. J., Han, R. P. 2013. Biosorption of Copper Ion by Natural and Modified Wheat Straw in Fixed-Bed Column. *Desalin. Water Treat.* DOI: 10.1080/19443994.2012.762945.
- Lopez, F. J., Sugita, S., Tagaya, M., Kobayashi, T. 2014. Geopolymers Using Rice Husk Silica and Metakaolin Derivatives: Preparation and Their Characteristics. *Journal of Materials Science and Chemical Engineering*, 2(1): 35-43.
- Pratisto, A. 2005. Cara Mudah Mengatasi Masalah Statistik dan Rancangan Percobaan dengan SPSS 12. PT. Elex Media Komputindo. Jakarta.
- Putra. M. R. A.. 2011. Analisis Peranan Industri kain Sasirangan Terhadap Perekonomian Kota Banjarmasin dan Strategi Pengembangan. Departemen Ilmu Ekonomi. Institut Pertanian Bogor.
- Rossi, B. S. 2014. Penurunan Konsentrasi Logam Pb dan Cd pada Limbah Cair Industri Sasirangan dengan Metode Fitoremediasi. *Jurnal Teknologi Agro Industri*, 1.
- Simanjuntak, R. A. 2015. Pengurangan Konsentrasi Cd pada Limbah Cair Industri Sasirangan Menggunakan Arang Aktif dari Sekam Padi. Skripsi, Universitas Lambung Mangkurat.
- Sofyan, A. G. 2011. Biosorpsi Logam Berat di Lingkungan Akuatik Menggunakan Limbah Sekam Padi Sebagai Biosorben. Universitas Indonesia. Depok.
- Widayanti, I.I., Aman, L.O. 2012. Studi Daya Aktivasi Arang Sekam Padi pada Proses Adsorpsi Logam Cd. Jurusan Pendidikan Kimia Fakultas MIPA. Universitas Gorontalo.