CERTIFICATE OF APPRECIATION

No: 561/UN21.11/PG/2020

THIS IS TO CERTIFY THAT

RAINIYATI

PRESENTER

The 3rd Green Development International Conference 2020
Held at Swiss Belhotel, Jambi - Indonesia
October 2, 3 2020

THEME
"Accelerating Advancement in Green Environmental Sustainability: Best Practice for New Normal Era"

Chairman of The Institute For Research and Community Services Universitas Jambi

Dr. Ade Octavia, SE., MM.
NIP. 19741023199903 2 004

Jambi, October 3 , 2020
Chairman of The 3rd Green Development International Conference 2020

Urip Sulistiyo, S.Pd., M.Ed., PhD
NIP. 197603042003121001

Supported by :

CERTIFICATE OF APPRECIATION

No: 762/UN21.11/PG/2020

THIS IS TO CERTIFY THAT

AHMAD RIDUAN

PRESENTER

The 3rd Green Development International Conference 2020
Held at Swiss Belhotel, Jambi - Indonesia
October 2, 3 2020

THEME
"Accelerating Advancement in Green Environmental Sustainability: Best Practice for New Normal Era"

Chairman of The Institute For Research and Community Services Universitas Jambi

Dr. Ade Octavia, SE., MM.
NIP. 19741023199903 2 004

Jambi, October 3 , 2020
Chairman of The 3rd Green Development International Conference 2020

Urip Sulistiyo, S.Pd., M.Ed., PhD
NIP. 197603042003121001

Supported by :

Palm Oil Fuel Ash (POFA) As An Innovative Material For Arsenic Removal From Mining Effluent

Rainiyati[1,*] Ahmad Riduan[1] Sarah Fiebrina Heraningsih[2]

[1] *Fakultas Pertanian, Universitas Jambi*
[2] *Fakultas Teknik, Universitas Jambi*
[*] *Corresponding author. Email: rainiyati@unja.ac.id*

ABSTRACT
Arsenic is toxic element, accumulate in the environment as main contaminant in aqueous waste stream. This study aimed to analyze the capability of raw palm oil fuel ash (pofa) as a potential adsorbent to remove arsenic contamination in the wastewater of mining effluent. Technology applied in this study was adsorption followed by precipitation. The maximum arsenic removal percentage of 100 % and a maximum adsorption capacity up to 0.224 mg/g was discovered. The results indicate that the method for arsenic removal from wastewater using raw pofa was effective, simple and low-cost to apply.

Keywords: *adsorption, agricultural waste, mercury removal, palm oil fuel ash (pofa).*

1. INTRODUCTION

Water pollution has become an important environmental problem nowadays mainly due to the release of several pollutants from the industrial sector as well as from geogenic factors that conduce to changes in water quality [1]. Arsenic is a water pollutant which is relevant due to its dangerous effects on the human body because this metalloid can cause acute and chronic damage depending on the factors associated with the route of exposure (eg, concentration in water, time of exposure) [2]. Arsenic toxicity depends on the oxidation state and health problems caused by living organisms vulnerable to these metalloids including melanosis, cancer, keratosis, brain damage and cardiac disorders [3], [4].

Some anthropogenic activities; such as fossil fuel combustion, mining, smelting, semiconductors processing, fertilizer production, chemotherapeutic drug; produce effluent with toxic metals or oxygen anions, including arsenic, selenium, mercury, molybdenum, barium, lead, cadmium, and chromium [5], [6]. Arsenic is also generated in huge quantities as a result of mining activities, such as ore transportation, mineral extraction, refining, smelting and disposal of waste and wastewater effluent around the mine, both during active operation and long after mine shutdown [5] .

In recent years, various methods to remove Arsenic out of wastewater have been studied, such as coagulation-precipitation, physical separation, filtration, reverse osmosis , adsorption, ion exchange, and other techniques [7]. Surface adsorption and anion exchange predominate as effective physicochemical processes for harmful oxyanions removal, such as Arsenic, from wastewater even low concentrations [8], [9].

Concerning arsenic removal from water [10] reviewed the low-cost adsorbents for heavy metals removal from wastewater, and simply discussed the adsorption of arsenic in water using coal fly ash as adsorbent. Swami, 2006 [11] has reviewed the removal of contaminants from industrial wastewater through various nonconventional technologies, and adsorption of arsenic from water by coal fly ash was also concisely discussed. Chiban, 2012 [12] reviewed concisely about arsenic chemistry and also the application of low-cost adsorbents for arsenic removal from water. Despite utilization of coal fly ash as adsorbent economically and technically effective, in the other hand using Coal Fly Ash can let go another toxic element to environment [13]. Due to these limitations, some researchers have innovated to find adsorbents to absorb heavy metals without having a negative impact on the environment. One kind of this type of adsorbent was palm oil fuel ash (pofa). Palm Oil Fuel Ash is one kind of agricultural waste, as by-product in palm oil industry. Application Palm Oil Fuel Ash as heavy metal removal propose low

cost technology and also lower accumulation of Palm Oil Fuel Ash in the environment [14].

2. MATERIALS AND METHOD

2.1. Adsorbent Preparation

The main raw material as adsorbent for arsenic removal was palm oil fuel ash as residual combustion from industrial boilers. Palm oil fuel ash obtained then stored in a closed container and maintained at atmospheric temperature before the adsorption process is carried out with a sample of mining effluent.

2.2. Sampling

The effluent examined in this study obtained from gold mining effluent taken from 3 location points in Pangkalan Jambu, Merangin Regency, Indonesia. Gold mining location coordinates was 1o44'04"S 101o34'35E.Samples are stored in a closed container and kept at room temperature. Samples were then coded with A, B, C to distinguish the sampling location and then numbered 1, 2, 3 to distinguish the adsorption time of each sample . Research matrix of arsenic removal on gold mining eflluent using palm oil fuel ash was shown in Table 1 and gold mining location coordinates shown at Figure 1.

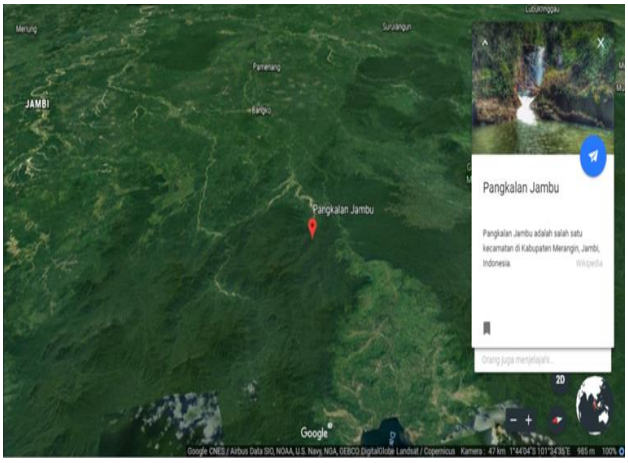

Figure 1 Sampling location coordinates in Merangin Regency, Jambi Province.

2.3. Adsorption Method

The mercury adsorption process is carried out by contacting fly ash with wastewater from gold mining. The temperature used in the stirring process is room temperature at atmosferic condition. The ratio of wastewater to adsorbent was 1: 4. Stirring time varies from 15 minutes, 30 minutes to 45 minutes. Process diagram of mercury adsorption showed in Figure 2.

Table 1. Research Matrix

Sample	Adsorption time (minutes)
A_1	15
A_2	30
A_3	45
B_1	15
B_2	30
B_3	45
C_1	15
C_2	30
C_3	45

Note : A = Sampel from location A; B = Sampel from location B; C = Sampel from location C

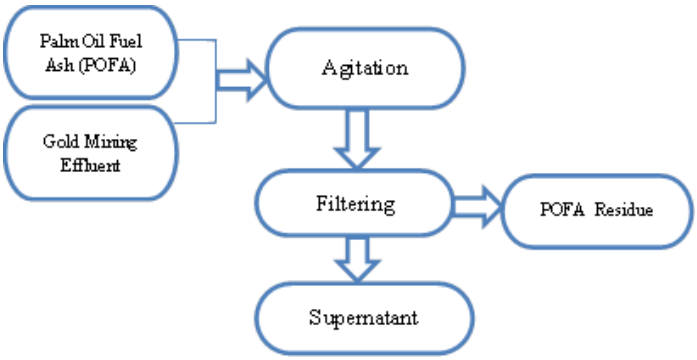

Figure 2 Process Diagram of arsenic removal using palm oil fuel ash.

2.3. Sample analysis

The analysis of mercury in sample using Inductively Coupled Plasma (ICP) conducted at Water laboratory of Universitas Andalas, Sumatera Barat, Indonesia.Samples were ruined using concentrated nitric acid (HNO_3) in a beakerglass and heated using hotplate. After the extraction process, the sample was cooled, and then filtered and stored in a clean sample bottle before analysis. Determination of metal elements in solution can be achieved by using spectroscopic inductively coupled plasma (ICP) techniques. This method measures the specific light of the element emitted by the metal in the sample. Arsenic equilibrium adsorption capacity and arsenic removal percentage was calculated using the following equation [15]–[17].

$$q_e = \frac{(c_o - c_e)\,V}{m} \quad (1)$$

$$Removal\ Percentage\ (\%) = \frac{(c_o - c_e)}{c_o}\ x\ 100\ \% \quad (2)$$

where qe (mg/g) was equilibrium adsorption capacity, Co (mg/L) was the initial concentration of Arsenic in solution, Ce (mg/L) was final concentration of Arsenic in solution, V (L) was the volume of effluent and m (g) was the mass of palm oil fuel ash

3. RESULT AND DISCUSSION

3.1. Adsorption capacity and removal percentage

Amount of arsenic concentration before and after adsorption processes have been tabulated. Based on these data, the calculations of the equilibrium adsorption capacities value have been calculated using Equation (1) and the calculations of the arsenic removal percentage have been calculated using Equation (2). The results of this calculation are shown in Table 2.

Table 2. Percentage of Arsenic Adsorption and Adsorption Capacity

Sample Code	As (mg/L)	Adsorption Capacity (mg/g)	Removal Percentage (%)
A1	0.034	0.136	50.00
A2	0.022	0.184	67.65
A3	0.012	0.224	82.35
B1	0.022	0.084	67.65
B2	0.017	0.104	75.00
B3	0.008	0.14	88.24
C1	0.006	0.064	91.18
C2	0	0.088	100.00

Note : A = Sampel from location A; B = Sampel from location B; C = Sampel from location C

Based on Table 2, graphs are arranged to show the relationship between adsorption capacity over time and also the relationship between removal percentage over time. The results of research by [16] about arsenic removal in wastewater using Fe_2O_3 nanocubes-impregnated graphene aerogel stated the longer the contact time, the greater the adsorption capacity and removal percentage achieved. That was in line with the result of this study as described in Figure 3 and Figure 4.

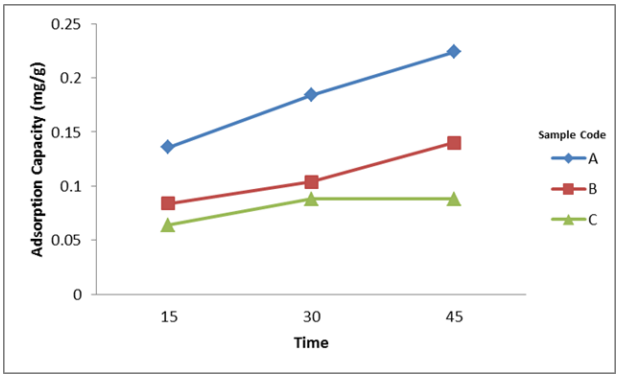

Figure 2 The effect of adsorption capacity (mg/g) over Time.

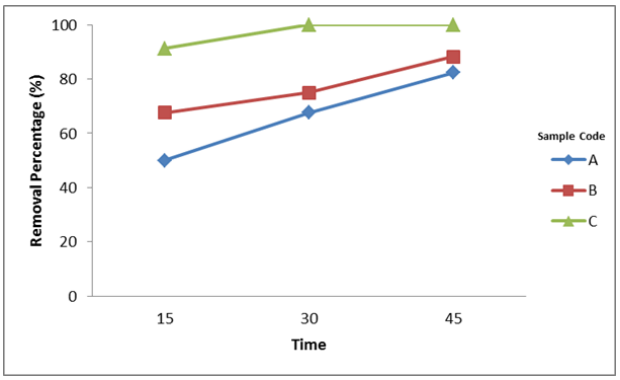

Figure 3 The effect of Time against Removal Percentage (%).

Comparisons have been made between palm oil fuel ash used in this study and the adsorbent used in several previous studies to see the arsenic adsorption value (Table 3). The results of this study indicate that palm oil fuel ash (pofa) has higher adsorption yield compared to some of adsorbents studied from previous studies. An additional advantage of using palm oil fuel ash as an adsorbent is the low cost and available in large

Table 3. Comparison of adsorption yields of various adsorbents for arsenic removal

Adsorbent	C_o (mg/L)	Adsorption Capacity (mg/g)	Removal Percentage (%)	Reference
Raw Coal Fly Ash	1	0.075	38,4	[2]
HCl- Fly Ash	3.5	0.35	-	[18]
Fe-ASOH	1	0.20	99.8	[2]
HIOFAA	50	19.46	99	[19]
W Zeolite	25	-	99	[20]
Palm Oil Fuel Ash (POFA)	0.068	0.224	82.35	This Study

Note : A = Sampel from location A; B = Sampel from location B; C = Sampel from location C

quantities. Because of these properties, palm oil fuel ash has great potential to adsorp arsenic from gold mining effluent.

4. CONCLUSION

The problem that often arises with a gold mining is the emergence of wastewater effluent containing heavy metals. One of the heavy metals contained in mining effluent were arsenic. Arsenic is a dangerous and toxic element to the human body. Therefore it is necessary to remove arsenic from wastewater such as mining effluent. The use of palm oil fuel ash (pofa) to adsorp arsenic from wastewater effluent can reduce the amount of arsenic by 100% with a maximum adsorption capacity up to 0.224 mg/g. From this study it is known that the longer contact time of the palm oil fuel ash with wastewater effluent, the more efficient of the arsenic removal process. Therefore, it can be concluded that the use of palm oil fuel ash (pofa) as an adsorbent is an alternative solution to overcome the problem of heavy metal in mining effluent.

ACKNOWLEDGMENTS

This work was supported by LPPM Universitas Jambi, Indonesia for priority applied research schemes.

REFERENCES

[1] J. A. Rodríguez-Romero *et al.*, "Preparation of a new adsorbent for the removal of arsenic and its simulation with artificial neural network-based adsorption models," *J. Environ. Chem. Eng.*, vol. 8, no. 4, p. 103928, 2020.

[2] K. Zhang and D. Zhang, "Arsenic removal from water using a novel amorphous adsorbent developed from coal fly ash," *Water Sci. Technol.*, vol. 73, no. 8, pp. 1954–1962, 2016.

[3] S. Shankar, U. Shanker, and Shikha, "Arsenic contamination of groundwater: A review of sources, prevalence, health risks, and strategies for mitigation," *Sci. World J.*, vol. 2014, 2014.

[4] WHO, "Arsenic," *World Health Organization*, 2018. [Online]. Available: https://www.who.int/newsroom/%0Afact-sheets/detail/arsenic.

[5] J. E. Langsch, M. Costa, L. Moore, P. Morais, A. Bellezza, and S. Falcão, "New technology for arsenic removal from mining effluents," *J. Mater. Res. Technol.*, vol. 1, no. 3, pp. 178–181, 2012.

[6] Z. Rahman and V. P. Singh, "The relative impact of toxic heavy metals (THMs) (arsenic (As), cadmium (Cd), chromium (Cr)(VI), mercury (Hg), and lead (Pb)) on the total environment: an overview," *Environ. Monit. Assess.*, vol. 191, no. 7, 2019.

[7] A. Basu, D. Saha, R. Saha, T. Ghosh, and B. Saha, "A review on sources, toxicity and remediation technologies for removing arsenic from drinking water," *Res. Chem. Intermed.*, vol. 40, no. 2, pp. 447–485, 2014.

[8] A. C. Dias and M. P. F. Fontes, "Arsenic (V) removal from water using hydrotalcites as adsorbents: A critical review," *Appl. Clay Sci.*, vol. 191, no. January, p. 105615, 2020.

[9] T. V. Toledo, C. R. Bellato, K. D. Pessoa, and M. P. Ferreira, "Remoção De Cromo (Vi) De Soluções Aquosas Utilizando O Compósito Magnético Calcinado Hidrotalcita- Óxido De Ferro: Estudo Cinético E De Equilíbrio Termodinâmico," *Quim. Nova*, vol. 36, no. 3, pp. 419–425, 2013.

[10] S. Babel and T. A. Kurniawan, "Low-cost adsorbents for heavy metals uptake from contaminated water: A review," *J. Hazard. Mater.*, vol. 97, no. 1–3, pp. 219–243, 2003.

[11] D. Swami and D. Buddhi, "Removal of contaminants from industrial wastewater through various non-conventional technologies: A review," *Int. J. Environ. Pollut.*, vol. 27, no. 4, pp. 324–346, 2006.

[12] M. CHIBAN, M. ZERBET, G. CARJA, and F. SINAN, "Application of low-cost adsorbents for arsenic removal: A review," *J. Environ. Chem. Ecotoxicol.*, vol. 4, no. 5, pp. 91–102, 2012.

[13] M. Attari, S. S. Bukhari, H. Kazemian, and S. Rohani, "A low-cost adsorbent from coal fly ash for mercury removal from industrial wastewater," *J. Environ. Chem. Eng.*, vol. 5, no. 1, pp. 391–399, 2017.

[14] N. Zainudin, K. Lee, A. Kamaruddin, S. Bhatia, and A. Mohamed, "Study of adsorbent prepared from oil palm ash (OPA) for flue gas desulfurization.," *Sep. Purif. Technol.*, vol. 45, no. 1, pp. 50–60, 2015.

[15] Z. Liu, W. Yang, W. Xu, and Y. Liu, "Removal of Elemental Mercury by Bio-chars Derived from Seaweed Impregnated with Potassium Iodine," *Chem. Eng. J.*, 2018.

[16] X. Yu *et al.*, "Chemosphere Ultrafast and deep removal of arsenic in high-concentration wastewater : A superior bulk adsorbent of

porous Fe 2 O 3 nanocubes-impregnated graphene aerogel," *Chemosphere*, vol. 222, pp. 258–266, 2019.

[17] T. Aprianti, B. D. Afrah, and T. E. Agustina, "Acid mine drainage treatment using activated carbon ceramic adsorbent in adsorption column," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 7, no. 4, pp. 1241–1247, 2017.

[18] M. Balsamo, F. Di Natale, A. Erto, A. Lancia, F. Montagnaro, and L. Santoro, "Arsenate removal from synthetic wastewater by adsorption onto fly ash," *Desalination*, vol. 263, no. 1–3, pp. 58–63, 2010.

[19] Y. Li, F. S. Zhang, and F. R. Xiu, "Arsenic (V) removal from aqueous system using adsorbent developed from a high iron-containing fly ash," *Sci. Total Environ.*, vol. 407, no. 21, pp. 5780–5786, 2009.

[20] A. Medina *et al.*, "Fly ash from a Mexican mineral coal. II. Source of W zeolite and its effectiveness in arsenic (V) adsorption," *J. Hazard. Mater.*, vol. 181, no. 1–3, pp. 91–104, 2010.