

REMOVAL OF MERCURY (Hg) FROM CONTAMINATED WATER

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Abstract

There are many traditional gold mining and processing in Murung Raya Regency, Central Kalimantan. The processing of gold mostly uses mercury (Hg) and produces a lot of waste water. It just throws to the river without any treatment. Therefore the concentration of mercury (Hg) in the river water is over than the standard of drinking water and reach up to 0.346 mg dm^{-3} . This situation is very dangerous because almost of the people in the downstream area depend on the river water for their daily purposes. To solve this problem, tuff from local material was used to remove mercury using batch experiment. The result showed that tuff has capability to remove mercury in the significant amount. The main mechanism of mercury removal by tuff is cation exchange processes due to high surface area of tuff. The result of this study can be used as an alternative for waste water treatment in mining area.

Keywords: *Traditional mining, mercury removal, tuff*

1 Introduction

Illegal mining activities by the community generally lead to the environmental degradation in the mine deposit and its surroundings area. There are many illegal mining of gold in the Murung Raya Regency, Central Kalimantan. The gold separation processing is conducted by traditional method using mercury. Because of knowledge and capital limitation of illegal min-

ers, they are generally never carried out the treatment of waste before discharge to the environment. The location of gold processing activities of illegal miners is always close to the river. Therefore the waste from gold processing both liquid and sediment usually is just thrown away to the river. Waste water and tailing can cause contamination of sediments and river water, especially by mercury. According to Resili (2010) the concentration of mercury in the river water reaches up to 0.346 mg dm^{-3} that mostly comes from the gold processing. In other side, the river water is the main source to support daily purpose of people in the downstream area such as for drinking, bathing, washing and agriculture. Therefore, it is urgently required to stop the discharge of waste water and tailing without any treatment to river and to treat contaminated water. There are many technologies to treat mercury from water such as precipitation, absorption, ion exchange and other processes (EPA, 1997). In order to alleviate the prevailing difficulties of water treatment, approaches should focus on sustainable water treatments systems that are low cost, robust and require minimal maintenance and operator skills. Locally available materials can be used towards achieving sustainable safe portable water supply.

2 Experimental

2.1 Material

The reactive material is a tuff from Piyungan, Gunungkidul, Yogyakarta Special Province. The tuff was grinded to become sand size.

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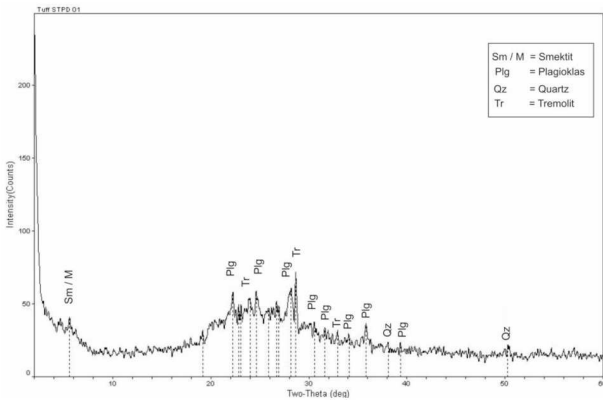


Figure 1: X-ray diffraction analysis of tuff showing the presence of smectite and tremolite

Analysis of surface area of tuff using Brunauer Emmet Teller (BET) method is 24.95 m²g⁻¹ with total volume of void 25.95 e-03 cc/g. Based on the X-rd analysis (Figure 1) of tuff consists Plagioclase (NaAlSi₃O₈-CaAl₂Si₂O₈), Smectite (Na_{0.3}Zn₃(Si,Al)₄O₁₀(OH)₂·4H₂O), Tremolite (Ca₂Mg₅SiO₂₂(OH)₂ and Quartz (SiO₂). Bulk-geochemistry of Piyungan tuff are characterized by major oxides SiO₂ (63.78 wt.%), Al₂O₃ (11.89 wt.%), Fe₂O₃ (5.36 wt.%), CaO (2.99 wt.%), MgO (0.95 wt.%), Na₂O (1.54 wt.%), K₂O (1.8 wt.%) and H₂O (10.68 wt.%).

2.2 Batch experiments

Several batch tests were performed to determine the capability of tuff to remove Hg in water. Five gram of tuff was used to find the sorption isotherm of Hg onto tuff using 0.3 dm⁻³ solutions containing different concentrations of Hg with initial pH 5. The Hg solution was prepared using HgSO₄. All solutions were shaken at 100 rpm and 25°C until sorption equilibrium was attained. Mercury concentration was determined by Atomic Fluorescence Spectroscopy.

3 Results and discussion

The raw data for sorption isotherm of Hg onto tuff at 25°C was presented in Figure 2. The equilibrium pH of the solutions from tuff is around 3 and all of them are lower than the initial pH. It shows that the sorption equilibrium was achieved after 24 hour.

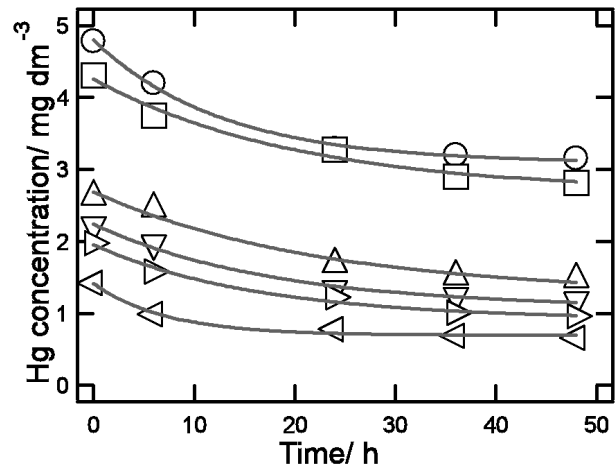


Figure 2: Sorption of Hg onto tuff at initial pH 5 and 25°C

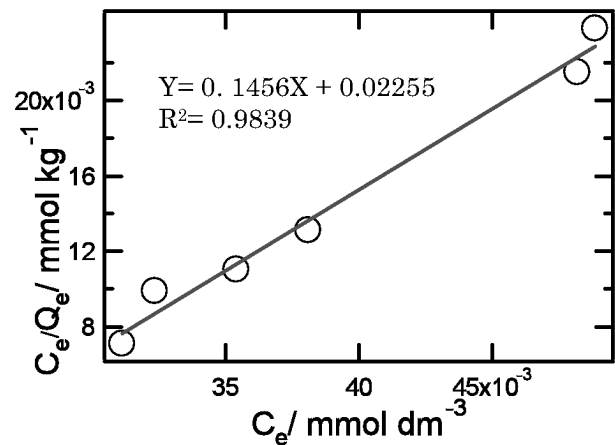


Figure 3: Plots for sorption of Hg onto tuff showing linearized Freundlich isotherm fits to the data

Freundlich isotherm model is fit to the equilibrium data of sorption isotherm of Hg onto tuff following the equation:

$$\log Q = \log K_f + n \log C_e \quad (1)$$

Where Q is the sorbed Hg per unit amount of sorbents (mmol kg⁻¹) at the equilibrium, C_e is equilibrium concentration of mercury (mmol dm⁻³), and K_f and n are constants representing the adsorption capacity and adsorption intensity of the adsorbent, respectively (Wilopo, *et al.*, 2008). The data plotted according to the Freundlich model (Figure 3) showed good correlation coefficients (Table 1).

In addition, Langmuir isotherm model also

Table 1: Summary of Freundlich constants in sorption isotherm of Hg onto tuff

Sorbent	K_f	n	R^2
Tuff	4.37	1.69	0.98

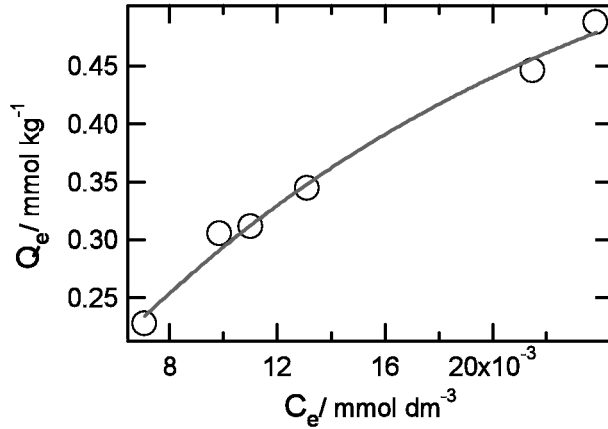


Figure 4: Plots for sorption of Hg onto tuff showing Langmuir isotherm fits to the data

fit to the sorption isotherm data of Hg onto tuff following this equation:

$$Q = \frac{q_{max} C_e}{(C_e + K_d)} \quad (2)$$

Where Q_{max} is the maximum of sorbed Hg per unit amount of sorbents (mmol kg^{-1}), K_d is the dissociation coefficient of the solute-adsorbent complex which represents the affinity between the solute and the adsorbent. The Langmuir model was fit to the equilibrium data of Hg sorption onto Tuff with R^2 of 0.98 as shown in Figures 4 and 5 following the Equation 3. The maximum capacity of tuff to remove Hg is $44.44 \text{ mmol kg}^{-1}$ as shown in Table 2.

$$Q = \frac{44.44 C_e}{(C_e + 0.02)} \quad (3)$$

The effect of tuff grain size was also studied using mesh number 36, 60 and 115. It shows that the tuff with fine grain size (mesh 36) is

Table 2: Summary of Langmuir constants in sorption isotherm of Hg onto tuff

Sorbent	$Q_{max} (\text{mmol kg}^{-1})$	K_d	R^2
Tuff	44.44	0.02	0.98

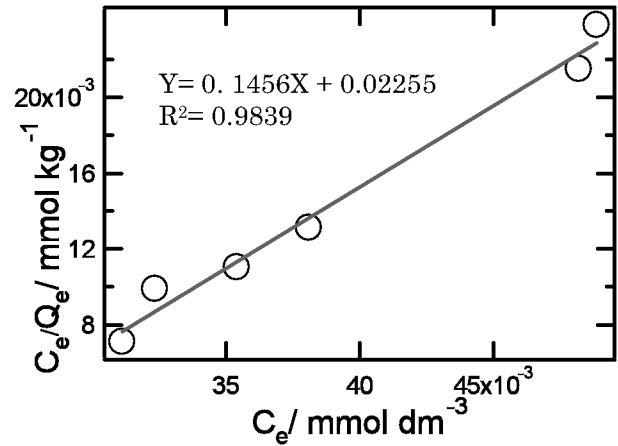


Figure 5: Plots for sorption of Hg onto tuff showing linearized Langmuir isotherm fits to the data

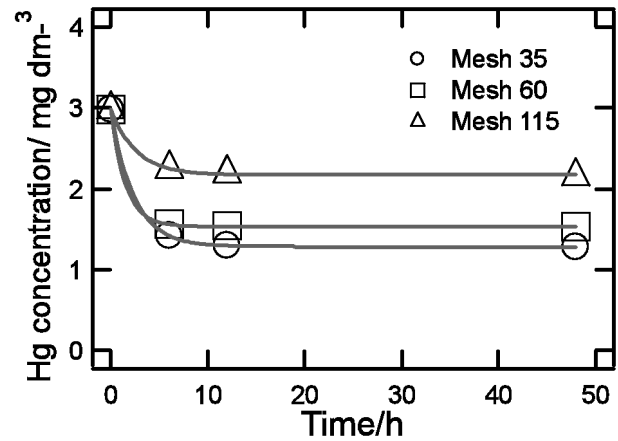


Figure 6: The effect of grain size in the Hg removal by tuff

more effective than others due to increase of surface area of tuff as shown in Figure 6.

Analysis of cations concentration before the experiment and after the reach the equilibrium show that most of cation concentration after reaching the equilibrium are higher than before the experiment, especially for sodium and calcium (Table 3). This data indicates that the mechanism of Hg removal onto tuff is not only by physical sorption due to high surface area but also cations exchange from smectite. Because smectite has a CEC value $90 \text{ meq}/100 \text{ gram}$ and charges range from 0.3 to 0.7 per layer (Velde and Bruswitz, 1986). Smectite also have capability to remove cadmium from aqueous solutions (Bedoui *et al.*, 2008).

Table 3: Cations concentration before and after the experiment

Cation (mg dm ⁻³)	Before reaction (0 hours)			After reach equilibrium (48 hours)		
	Enl. 1	Enl. 3	Enl. 6	Enl. 1	Enl. 3	Enl. 6
Ca ²⁺	0	0	0	11.02	12.90	19.87
Na ²⁺	0	1.39	0.38	25.12	28.18	9.44

4 Conclusions

It can be concluded that tuff is a good sorbent of Hg. The adsorption isotherm analysis by using tuff was found to follow the Langmuir and Freundlich isotherms for single metal system. The maximum Hg removal was estimated 44.44 mmol kg⁻¹ of tuff according to the Langmuir equation. The mechanism of Hg removal onto tuff is not only physical sorption due to high surface area of tuff but also cations exchange.

Acknowledgment

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