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DEVELOPMENT OF BIO-ADSORBENT BASED ON TOFU WASTE TO ADSORB IRON (Fe) AND LEAD (Pb) IN WATER

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ABSTRACT

The purpose of this study is to determine the ability of tofu waste to absorb iron (Fe) ions and Lead (Pb) ions in water which can potentially cause several problems. The adsorbent prepared from tofu waste and the solution made from synthetic solution. Some parameters such as mass of the adsorbent, pH of solution, shaking time, and concentration of solution were examined to get optimum condition. In order to know the characteristic of adsorbent, SEM and FTIR spectra instruments were utilized. This study investigated in batch adsorption method to determine effective the mass of adsorbent and contact time in removing Fe and Pb ions. The result showed that the effective mass adsorbent was 50 mg, Fe concentration was 10 mg/L and the removal up to 98% and Pb concentration was 25 mg/L and the removal up to 98%. The adsorption capacity for Pb is 55 mg/g. It was clear from this study that tofu waste could be potentially used as adsorbent to reduce heavy metals in wastewater.

Keywords: Adsorption; Batch method; Iron; Lead; Tofu waste.

1. INTRODUCTION

In many countres, the environmental pollution with heavy metals such as cadmium (Cd) and lead (Pb) have been considered as one of the serious environmental problems and attracted public concern because of the potential damage to human health and ecosystem. Even the low concentration of cadmium and lead in water is still potential for kidney and bone damage, cancer, disturbing the respiratory and reproduction system due to the accumulation. The concentration of Pb and Cu in the sediment taken from Jakarta bay is up to 6.9 and 4.1 mg/L, respectively (Takahiro H, et al., 2011). It is known that heavy metals such as Cd and Pb are accumulated in the human body and their influences might be found out after several years. The sources of copper and other

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metals in some water areas in Yogyakarta, Indonesia are mostly caused by some handy craft industries.

Many methods have been developed to remove heavy metal ions in water, i.e. membrane technology, ion exchange, phytoremediation, adsorption, etc. (Namasivayam and Ranganathan, 1995). Adsorption is one of the most common technic that have been developed and widely applied for water and wastewater treatment including in Indonesia. The high cost of activated carbon, common adsorbent material, has inspired many researchers into the development of other low-cost adsorbent materials.

In the present study, we develop an alternative bio adsorbent based on tofu waste to remove lead and Fe ions in water. The purpose of this study was to know the ability of tofu waste as bio adsorbent with and without activation by using hydrochloric acid (HCl 10%) for removal of lead and iron ions in water.

2. MATERIALS AND METHODS

2.1 Preparation of adsorbent material

The bio adsorbent used in this study was developed by using solid waste of tofu industry from Sleman, Yogyakarta, Indonesia which usually disposed as solid waste to landfil. The tofu waste was washed with distilled water and dried at 80℃ for 24 hours. After cooling it at room temperature, the tofu waste was crushed into powder form and then sifted with a 50 mesh sieve. The powdery tofu waste was used as bio adsorbent to adsorb Fe and lead ions from water. In order to increase the adsorption capacity of the adsorbent, the powdery tofu waste was put in the solution of HCl (10%) for 24 hours, was with distilled water several times until the pH of solution becomes around neutral. The tofu waste then dried in oven at 80℃ for 24 hours, crushed into powder form using a 50 mesh sieve (product of bio adsorbent).

Some instruments such as Scanning Electron Microscope (SEM) and Fourier Transform Infra Red (FTIR) machines were employed in order to know the surface morphology and active functional groups of the adsorbent.

2.2 Process of adsorption

The process of adsorption in the perent study was conducted by the batch system using 100 ml of erlenmeyer glassware. We investigated some parameters such as dose of adsorbent, pH of the solution, stirring time and the concentration of cadmium ion in the solution in order to know the ability and the optimum condition for adsorption by using the adsorbent based on tofu waste. In order to estimate the effect of mass of the adsorbent, 50, 100, 200, 300, 400 and 500 mg of bio-adsorbent was added into 50 ml of lead and iron solution and agitated at 150 rpm for 2 hours using a magnetic stirrer (Thermo Scientific). The influence of pH on the adsorption of copper ion was

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investigated by using the solution of pH 3, 5 and 7. Acetic acid, HNO_3 and NaOH were employed to adjust the desired pHs of solution. Various stirring time from 15 to 120 minutes was used to know the influence of stirring time on the adsorption of lead and iron ions. After equilibrium, the solution was filtered and then the concentration of lead and iron ions in supernatant solution were determined by using Atomic Absorption Spectrophotometer instrument (Avanta, GBC). The efficiency of adsorption is calculated by using the following equation:

$$E = \frac{C_0 - C_1}{C_0} x100\%$$

……..(1)

Where:

E = the efficiency of removal (%)

C_0 = the initial concentration of Pb and Fe (mg/l)

C_1 = the concentration of Pb and Fe after stirring time (mg/l)

3. RESULTS AND DISCUSSION

3.1 Characteristic of adsorbent

Figure 3.1 show the photograph of scanning electron microscopy (SEM) of raw and activated adsorbent with HCl reveals the surface texture and porosity of these adsorbent. The surface structure of activated adsorbent was similar to raw adsorbent indicated that activation by using HCl did not give significant influence on the structure of the adsorbent. Therefore, it is very difficult to identify the effect of activation of the adsorbent by using SEM instrument. The availability of the pores and internal surface is requisite for an effective adsorbent to remove heavy metal ions in water (Rao et al., 2006).

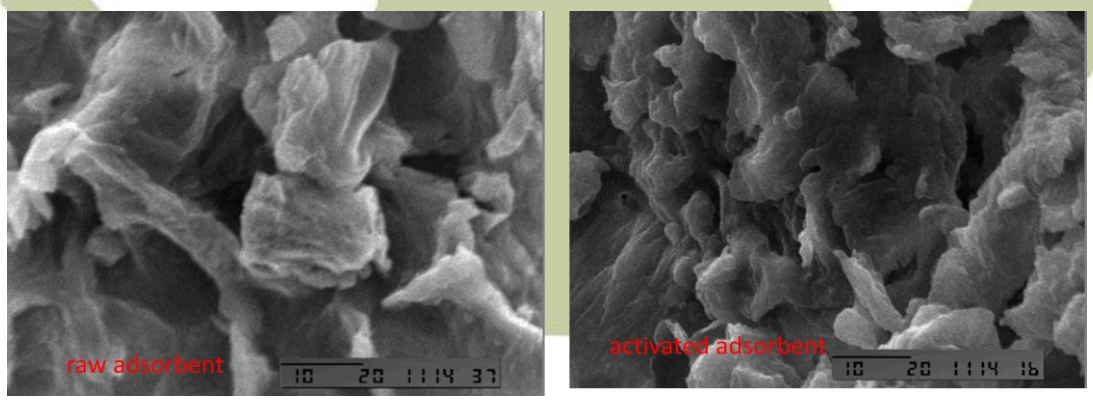

Figure 3.1 Figure of SEM a. Without activation and b. Activated with citric acid

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Fig. 3.2 shows FT-IR spectra of the adsorbents (raw adsorbent and activated adsorbent with HCl) based on the tofu waste. The FT-IR spectrum showed some absorption peaks, indicating the complex nature of the adsorbent material.

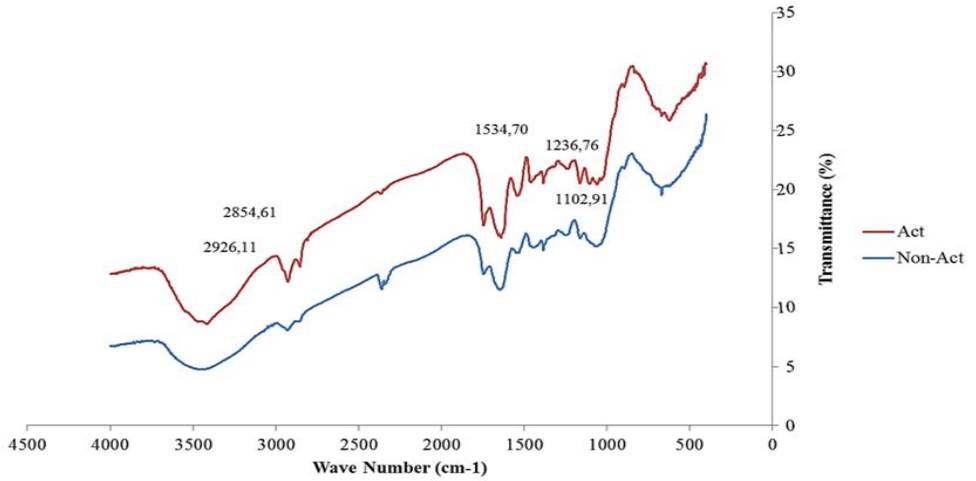

Figure 3.2 Figure of FTIR spectra of activated adsorbent and inactivated adsorbent

It was clear that the adsorbents have strong bands at 3800-3575 cm^{-1} indicating –OH in the carboxyl group (Choi and Yun, 2006), the bands appearing at 1102-1534 cm^{-1} indicated the formation of oxygen functional groups like a highly conjugated C=O stretching in carboxylic groups (Rao et al., 2006). The band at around 1534 cm^{-1} indicating N-H in the amine group and some absorption bands at around 1100 cm^{-1} can be considered the presence of phosphonate group (Choi and Yun, 2006; Won et al., 2006, Siswoyo et al., 2014).

3.2 Effect of adsorbent mass

In the present study, the effect of adsorbent mass was investigated and the result is shown in the Figure 3.3. For 10 mg/L of initial lead concentration, the adsorption capacity of activated adsorbent for all mass is almost constant, however, the adsorption capacity for raw adsorbent increased by increasing mass of the adsorbent. This result proved that the adsorption of lead ion in the water was absolutely due to the presence of the adsorbent (Siswoyo et al., 2014).

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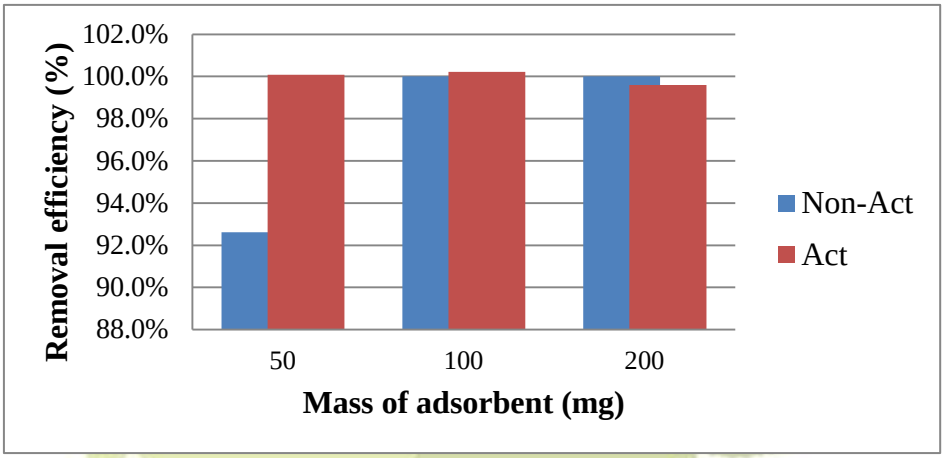

Figure 3.3 Effect of adsorbent mass on adsorption of Pb

3.3 Effect of shaking time

The effect of shaking time on the adsorption of lead ion is shown in the Fig. 3.4. The equilibrium adsorption for raw and activated adsorbents for 10 mg/l of lead was achieved after around 120 minutes. In the process of adsorption, the quick equilibrium time is due to the particle size (Messaouda *et al*., 2012). This result is important because the equilibrium time is one of the considerations for the application of economical wastewater treatment plant (Kadirvelu and Namasivayam, 2003; Rao *et al*., 2006).

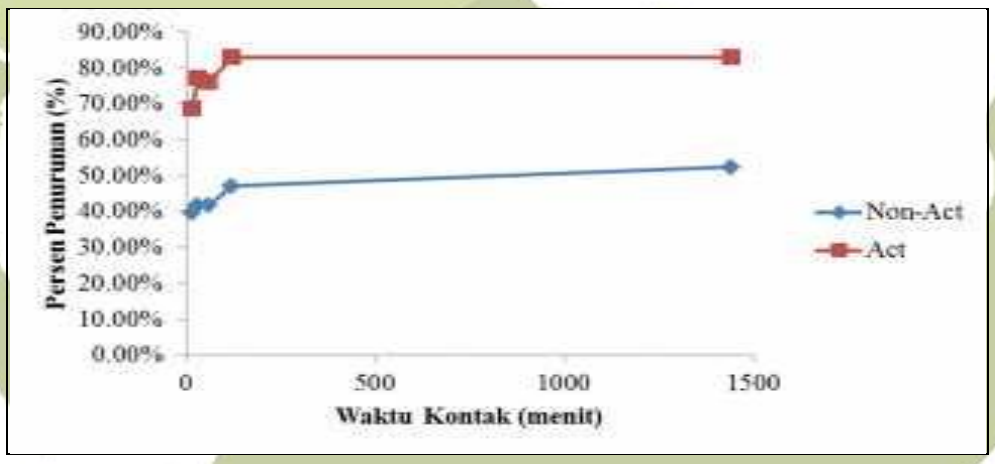

Figure 3.4 Effect of shaking time on adsorption of Pb

3.4 Effect of pH

The removal efficiency of raw and modified adsorbents for lead ion is shown in Figure. 3.5. The binding of Pb with surface functional groups strongly depended on the pH of solution. The removal efficiency of lead ion increased with pH of the solution because lead ion form complex with some functional groups in the adsorbent. The removal of metal cation at any pH was much greater than that by hydroxide

precipitation. Adsorption of metal cation on adsorbent depends upon the nature of adsorbent surface and the distribution of metal species which distribution also depends on the pH of the solution.

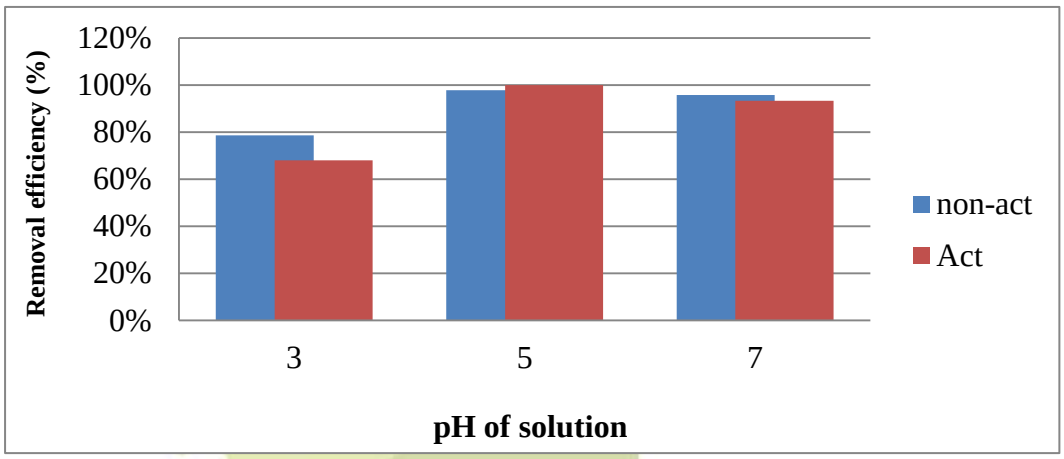

Figure 3.5 Effect of pH on adsortion of Pb

The removal efficiency of lead decreased with the decrease of pH, because protons compete with metal ion for the adsorption sites on the adsorbent surface as well as the ion existing decrease of negative charge by association of the functional group with proton (Siswoyo et al, 2014). The increase in the removal of metal ions as pH increase can be explained on the basis of the decrease in H^+ on the surface, which results in less repulsion with adsorbing metal ions (C. Namasivayam and K. Ranganathan, 1995) and (Souag R., et al., 2011).

4. CONCLUSION

The present study confirmed that a bio adsorbent based on tofu waste modified with hydrochloric acid had high capacity on the adsorption of lead ion in the water. However, the adsorption capacity of the adsorbent for iron in water was not high. The adsorption of lead ion was strongly pH-dependent and pH 5 was favorable for the adsorbent. Therefore, with this high removal efficiency, easiness in preparation and operation, low cost and environmentally friendly for the removal of lead ion in the water, the adsorbent could be considered as one of a promising adsorbent material for water and waste water treatment in the near future.

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