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Removal of Lead (Ii) from aqueous solution using composite adsorbent of Cassava Peel Waste/ Mahogany Sawdust/Bentonite

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ABSTRACT

The objective of the research was to evaluate the ability of composite adsorbent of cassava peel waste/ mahogany sawdust/bentonite to remove lead (II) from aqueous solution. The study was performed with dried and powdered composite adsorbent in batch mode. Important parameters of adsorption were evaluated. The experiments were carried out at varied pH (2 to 7), varied lead concentration (5 to 200 mg/ L) and varied contact time (5 to 150 minutes). The characterization of adsorbent was performed using FTIR analysis. The results showed that the highest lead (II) removal was obtained at pH near neutral. Increasing lead concentration resulted in diminution of lead removal while increasing contact time resulted in increase of lead removal. FTIR analysis showed functional groups of cassava peel waste, mahogany sawdust and bentonite interacted with lead. The composite adsorbent prepared has good potential for wastewater containing lead.

Key words: *Adsorption, Lead, Cassava Peel, Mahogany Sawdust, Bentonite*

Introduction

Water pollution caused by wastewater bearing heavy metals is one of the actual problems faced in the modern civilization. The generation of wastewater laden with heavy metals is a consequence as it uses in industrial process. Lead is one of the toxic heavy metals. It can come from textile and paint industry.

Lead causes negative effects to environment and especially to human health. Lead can accumulate to organism issues. The accumulation of lead on fish consumed by people can cause serious health problem. Lead can damage nervous and another organ (Depnath *et al.,* 2019). Lead has negative impact on sleep quality and digestive system (Mohammadyan *et al.,* 2019).

Because of its toxicity, wastewater laden with heavy metals needs treatment before release to environment. There are many methods for heavy metals removal. The methods can be used are chemical precipitation, ion exchange, adsorption, membrane filtration, coagulation-flocculation and flotation (Bolisetty *et al.,* 2019). Among the methods, adsorption has advantages. It is easy to operate, and it does not produce sludge as in the chemical precipitation. It can provide high pollutants removal. However, the need of alternative adsorbent is urgent. The use of commercial adsorbent such as active carbon, poses sometimes financial problem. Many attempts have carried out to use low cost adsorbent materials such as agricultural wastes, soil, and mineral, aquatic and terrestrial biomass, locally available waste materials (Joseph *et al.,* 2019), tofu solid waste (Kuncoro *et al.,* 2019).

Cassava peel waste haspotential to be used as heavy metals adsorbent (Jorgetto *et al.,* 2014). Mahogany sawdust has been tested for its potential to remove metal (Rochmah *et al.,* 2017). Bentonite is known for long time to be used as adsorbent of metals (Akpomie and Dawodu, 2015). The adsorbent studied in this work was adsorbent prepared from the mixture of cassava peel waste, mahogany sawdust, and bentonite.

The objectives of this work were to investigate the ability of adsorbent prepared for lead removal from aqueous solution, to investigateadsorbent characteristics and to investigate the effect of pH, contact time, and initial metal concentration on the adsorption of lead by adsorbent.

Materials and Methods

Adsorbent was prepared from wastes (cassava peel waste and mahogany sawdust) collected from Surabaya, East Java, Indonesia. Wastes were dried under sun light for several days. The wastes then were sieved to get the particle size of 100-200 mesh. The wastes then were mixed with bentonite. The obtained adsorbent then heated in an oven. After cooling from oven, adsorbent was ready to be used as adsorbent. The lead solution was prepared by dissolving $Pb(NO_3)_2$(Merck) into demineralized water to get working concentration.

Instrumentation

The lead concentrations of the samples were determined using atomic absorption spectrophotometer (AAS, Shimadzu). The chemical functional groups were identified using Fourier Transform Infrared (FTIR) spectroscopy (FTIR, Shimadzu).

Procedure

Adsorption experiments were carried out followed the following procedure, 100 mL of lead solution placed in a 150 mL bottle and 1 g of adsorbent was added. The bottle then was placed on a shaker. After being shaken, the solution then filtered and analyzed by atomic absorption spectrophotometer to determine the final metal concentration. To study the effect of pH, the variation of pH used was 2 to 7, lead concentration used was 20 mg/L, and 90 minutes of contact time. To study the effect of contact time, the variation of contact time used was 5 to 150 minutes, pH used was 6, and lead concentration used was 25 mg/L. To study the effect of initial metal concentration, the variation of initial metal concentration was 5 to 200 mg/L, pH used was 6, and 90 minutes of contact time. All experiments were repeated three times. The lead removal was calculated by using the following equation:

$$R = [(Co-Ce)/Co)] \times 100\%$$

where Co and Ce were the initial and final lead concentrations, respectively.

Results and Discussion

FTIR analysis

The FTIR spectra of adsorbent are shown in Figure 1 and 2. Figure 1 shows the FTIR spectra of adsorbent before contact with lead. It was observed a number of peaks indicating the presence of OH (3324.1 cm^{-1}) (De Castro *et al.,* 2018), carboxylic (1720.32 cm^{-1}) (Jorgetto *et al.,* 2014), Si-O (996.84 cm^{-1}) (De Castro *et al.,* 2018) and Al-Si-O (510.23 cm^{-1}) (De Castro *et al.,* 2018). Figure 2 shows the FTIR spectra of adsorbent after contact with lead. It was found that there was shift of group wavelength. This change indicates the participation of functional group in the adsorption of lead.

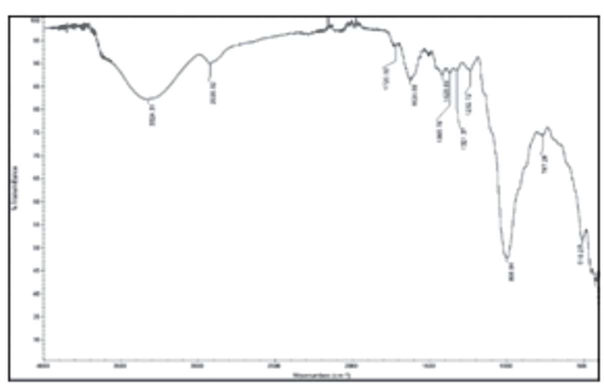

Fig. 1. Adsorbent spectra before adsorption

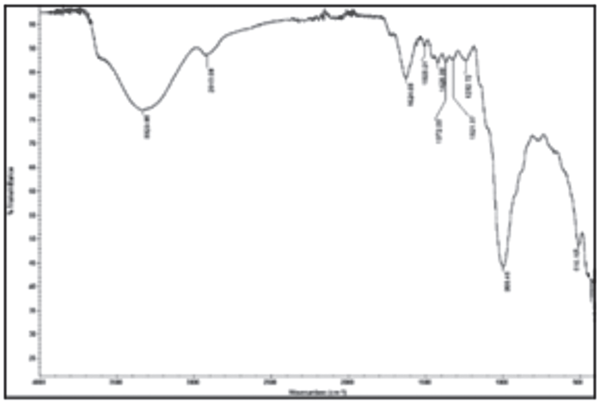

Fig. 2. Adsorbent spectra after adsorption

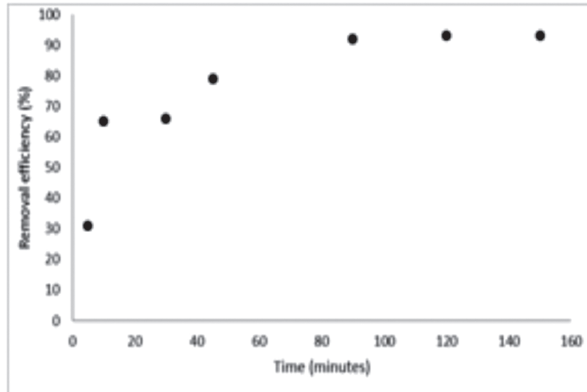

Fig. 4. Effect of contact time on the lead removal

Effect of pH

pH is an important factor affecting metal ion sorption. pH affects metal ion solubility, metal ion speciation and surface charge of the adsorbent. The results obtained are shown in Figure 3. Lead sorption was low in highly acidic medium (pH 2). The low lead sorption can be explained by the fact that in this pH, the high concentration of H^+ competes with lead ion to be adsorbed onto adsorbent, the repulsive force is great, so the lead sorption is low. The optimum pH of leadremoval was 6. The increase of lead removal as function of pH can be explained by deprotonation of the adsorbent functional groups resulting sorption of lead ion. The trend of lead removal in this research is similar with lead adsorption using other adsorbent (Ali *et al.,* 2019; Amro *et al.,* 2019).

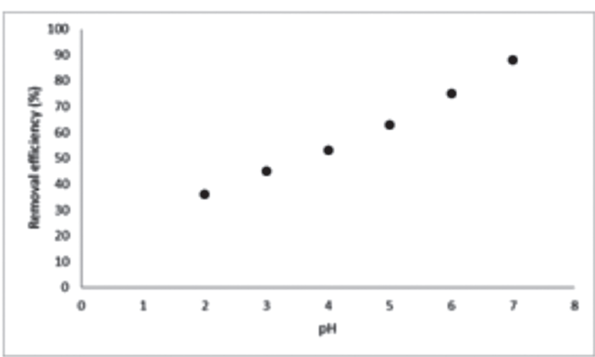

Fig. 3. Effect of pH on the lead removal

Effect of contact time

Figure 4 shows the effect of contact time on the adsorption of lead ion onto adsorbent. The lead removal was rapid during the first 10 minutes of contact time. The rapid lead removal due the abundant free surface sites in the beginning of the process. The optimum contact time was 90 minutes. The increase of lead removal due to the fact that adsorption is an accumulation of adsorbate onto adsorbent surface, the longer contact time increases the possibility of adsorbate sorption. The result obtained in this research has the same trend as in the case of other adsorbent (Ali *et al., 2*019; Amro *et al.,* 2019).

Effect of initial concentration

Figure 5 shows the effect of initial metal concentration on the adsorption. The highest lead removal obtained at the lead initial concentration of 5 mg/L (99% of lead removal). Increasing initial lead concentration resulted in the decrease of lead removal. Using 100 mg/L of lead concentration, lead removal decreased to 30%. Further decrease obtained at the initial lead concentration of 200 mg/L. At the low initial metal concentration, high metal removal obtained because there are many available active sites on adsorbent. Increasing initial metal concentration,

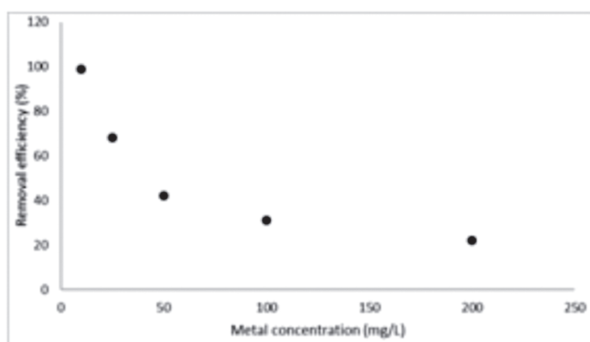

Fig. 5. Effect of initial lead concentration on the lead removal

there are less available active sites on adsorbent that resulted in the decrease on metal removal. The trend of the results in this work is similar to other work (Ali *et al.*, 2019).

Conclusion

Based on the results obtained in this work, adsorbent from mixture of cassava peel waste, mahogany sawdust and bentonite can be used as an alternative adsorbent for lead removal. The optimum pH for lead adsorption was 6, the optimum contact time was 90 minutes, respectively. The highest lead removal obtained at initial lead concentration of 5 mg/L. FTIR analysis revealed the participation of functional groups of the adsorbent for lead removal.

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