ADSORPTION OF LEAD (II) IONS IN AQUEOUS SOLUTION USING SELECTED AGRO-WASTE

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ABSTRACT

Contamination of water by toxic metal is a worldwide problem. Discharging of heavy metal including lead to the water stream without treating it can cause a significant health threat to all organisms. Lead poisoning in human cause's severe damage to the kidney, liver, nervous and reproductive systems. It also can cause to nephrotoxic effects of high exposure level and bone damage for long term exposure. Adsorption is one of the methods to remove lead. This study was conducted to determine whether local agro-waste which are tea waste and peanut shell are capable to remove lead (Pb) (II) ion from aqueous solution using batch method. Then, the effect of adsorbent dose and contact time in removing Pb (II) ion were also carried out. The prepared bioadsorbents were characterized using Fourier transform infrared (FTIR) spectroscopy. The percentage removal of Pb (II) ion was analyzed using atomic absorption spectroscopy (AAS). The result of FTIR spectroscopy revealed that both tea waste and peanut shell have functional group that capable to bind appreciable amounts of Pb (II) from aqueous solutions. FTIR spectra peaks representing phenols, carboxyl and carbonyl were observed in 3330 cm^{-1}, 1640 - 1604 cm^{-1} and 1027 cm^{-1}, respectively. The percentage removals of Pb (II) at 0.5 g, 1.0 g, 1.5 g were 87.89%, 88.33% and 89.6%, respectively for tea waste as bioadsorbent. Meanwhile, the percentage removals of Pb (II) for peanut shells as bioadsorbent were 74.36%, 74.57% and 74.05% for 0.5 g, 1.0 g, 1.5 g, respectively. Both bioadsorbents showed the percentage removal of Pb (II) increase with the increasing of contact time. All the results reported that local tea waste and peanut shell has the potential and economic to be used as bioadsorbent for removal of Pb (II) ions from contaminated waters

Keywords: bioadsorbent, tea waste, peanut shell, removal, wastewater treatment.

INTRODUCTION

Heavy metal pollution is one of the major worldwide concern. Industrial effluent can cause pollution due to continuously releasing waste and wastewater to the ecosystem. Moreover, it is eventually toxicity to be living being (Hossain *et al*., 2012). The most toxic metals found in industrial wastewater are Cd, Pb, Ni, Cr, As, Cu, Fe. The presence of these heavy metals producing a significant toxic influence on aquatic system. Therefore, cause harmful to a variety of living species (Boudrahem *et al*. 2011).

One of the heavy metals that can cause many problems toward a human being and surrounding is Pb (II). The use of Pb in service pipes can cause the problem of Pb (II) pollution. The battery industry, auto exhaust, paints, ammunition and the ceramic glass industries are other sources of Pb (II) pollution (Qaiser *et al*. 2007). The permissible level of lead (II) in drinking water and wastewater is 0.05 mg/L-^{1}as given by the Environmental Protection Agency (EPA). Meanwhile, the level of lead (II) permitted by bureau of Indian Standards (BIS) is 0.1 mg/L-^{1} (Nwabanne and Ighokwe, 2012).

According to Tao and Xiaoqin (2008), lead poisoning in human causes severe damage not only to the kidney and liver, but also nervous and reproductive systems. It also can cause to nephrotoxic effects at high exposure level and it also can cause bone damage for long term exposure. Many researchers have been established several methods to remove heavy metals including Pb (II) from wastewater such as coagulation-sedimentation, reverse osmosis and ion exchange (Nordiana and Siti, 2013). One of the methods commonly used to remove heavy metal ions from various aqueous solutions is adsorption.

Adsorption has been shown as excellent way to treat industrial waste effluents. This method also offered significant advantages such as availability, cost-effectiveness, ease of operation and efficiency (Demirbas, 2008).

In this study, adsorption process was used to remove Pb (II) from aqueous solution using two types of agro-waste. Both natural adsorbents which are peanut shells and tea waste abandoned, low cost, cheap, readily available and environmentally friendly bio-material. In Malaysia, production quantity of industry containing peanut is 637 tonnes per year, meanwhile 17 464 tonnes is the production quantity of tea industry (www.factfish.com). Tea is traditional drinks where after brewing the tea, the waste was disposed and constitutes part of the household waste (Tan, 1985). Meanwhile, peanut shell is an agro- waste that discarded all over the world as useless material.

The objective of this study is to investigate the probability of Pb (II) ion removal from aqueous solution using tea waste and peanut shells. Effects of adsorbent dose and contact time of the removal also were carried out.

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MATERIALS AND METHODS

Adsorbents

The tea wastes used in the present study are collected from local restaurant of Malaysia product tea (BOH plantation). Peanut shells were obtained from local small peanut industry in Terengganu, Malaysia. The tea waste and peanut shells washed with boiling water to remove any soluble and colored components. Both materials were then washed with distilled water and were dried in oven for 12 hours at 100 ^{0}C. The dried tea waste was sieved to obtain 600 µm particle sizes. Meanwhile, peanut shells were crushed and sieved to get 600 µm particle sizes too. Both types of adsorbents kept in sealed container prior to use. Infrared spectra were recorded using Bruker, Fourier Transform Infrared (FTIR) model Tensor 27 with OPUS 6.0 software. Samples were tested using Attenuated Total Reflectance (ATR) in powder form. The scans were carried out from 400 to 4000 cm^{-1}. FTIR spectra can showed appropriate transmittance of functional group.

Adsorbate

A stock solution of Pb (II) (1000 ppm) was prepared by dissolving $Pb(NO_3)_2$ in deionized water. Before mixing with the adsorbent material, the pH of each solution was adjusted to 6.0 for the adsorption of Pb (II) ions, by adding 0.1M NaOH or 0.1M HNO3. The desired Pb (II) ion concentration was prepared from the stock solution by making fresh for the adsorption experiments.

Batch Adsorption Procedure

Effect on adsorbent dose

0.5 g of adsorbent is weighed and was added to the Pb (II) solution in a 100 ml Erlenmeyer flask. The mixture was stirred at 160 rpm for 60 minutes. After 60 minutes, the solution is filtered with filter paper. The amount of Pb(II) ions in the solution was estimated by atomic absorption spectrophotometry (AAS) at a 283.3 nm wavelength. The experiment is then repeated with 1.0 g and 1.5 g adsorbent.

Effect on contact time

The Pb (II) solution was put into a 100 ml Erlenmeyer. Then, 1.0 g of adsorbent was added into the solution. The mixture was stirred at 110 rpm at different duration which is 30, 60, 90 minutes. Then, the solution was analysed by using AAS to measure the adsorption of Pb (II).

The adsorption percentage (removal (%)) of Pb (II) ions from aqueous solution is computed as follows:

Percentage of removal (%) = $\left(\frac{C_0-C_n}{C_0}\right)x100$ %

where C_0 is initial concentration of Pb (II) ans C_n is the final concentration of Pb (II)

RESULTS AND DISCUSSIONS

Characterization of adsorbents

Fourier Transform Infrared Spectroscopy (FTIR) analysis was carried out in order to identify the functional groups present in tea waste. Functional groups of adsorbents not only affect the adsorption behavior, but also dominate the adsorption mechanism (Wan *et al*., 2014). The peaks appearing in the FTIR spectrum were assigned to various functional groups according to their respective wavenumbers.

Figure-1 a) shows the FTIR spectrum of tea waste, meanwhile Figure-1b) shows the FTIR spectrum for peanut shell. Table-1 summarized the observed peaks and its descriptions. Among the functional groups, amine, carboxylic acid and hydroxyl have been proposed to be responsible for the adsorption heavy metal ions on the cell surfaces of adsorbent. While, amine group have been found to be the most effective groups to remove pollutant from aqueous solutions (Li *et al*., 2010). Adsorption can also happen as plant materials was mainly contained cellulose materials that can adsorb heavy metal cations in aqueous medium (Amarasinghe and Williams, 2007). Their importance for metal uptake depends on factors such as the quantity of sites, its accessibility and chemical state, or affinity between site and metal. Based on FTIR spectra results, tea waste and peanut shells have the characteristics to be used as potential bioadsorbent.

Table-1. Summarized of FTIR peaks

Wavenumber (cm^{-1})		Assignment
Tea waste	**Peanut shells**	
1031	1027	C=O stretching
1233	1231	-SO3 stretching
1515	1529	Secondary amine group
1619	1620	C=O stretching
2139	2118	Amine group
2919	2918	Aliphatic C-H group
3306	3330	Bonded -OH group

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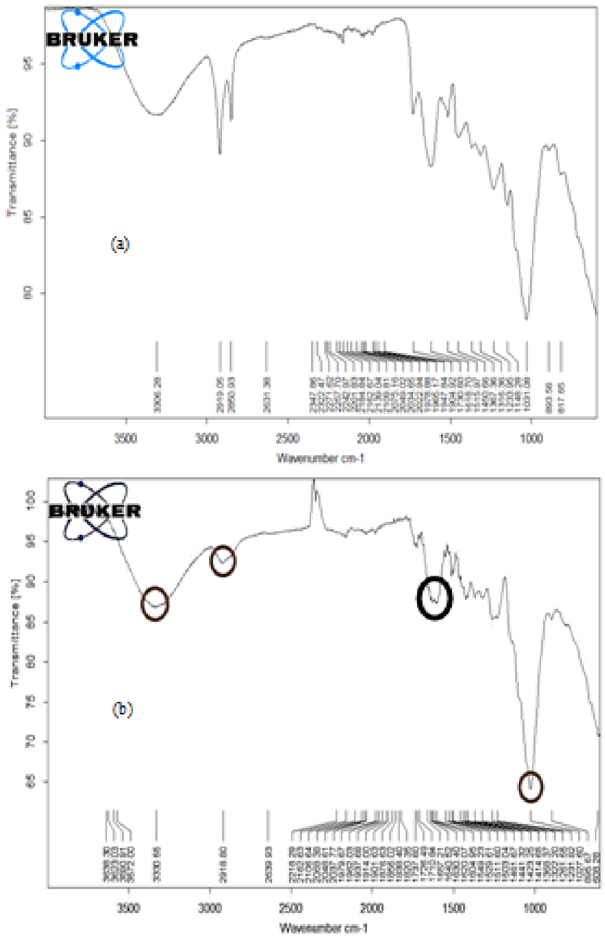

Figure-1. FTIR spectrum of tea waste (a) and peanut shells (b).

Effect on Adsorbent Dose

The dose of adsorbent various from 0.5 to 1.5 g, all other experimental variables are kept constant (pH 6, initial concentration 10 ppm, contact time 60 minutes and agitation speed 160 rpm). Figure-2 presents the adsorbent dose against Pb (II) removal percent using peanut shell and tea waste. As shown in the Figure-2, when adsorbent dose of tea waste increase, percentage of removal will also increase. Percentage of removal of lead increased from 87.89% to 89.60 % when adsorbent dose per 100 ml was increased from 0.5 g to 1.5 g. This is because the number of adsorption sites or surface area increases with the weight of adsorbent and hence results in a higher percent of metal removal at high adsorbent dose (Amarasinghe and Williams, 2007).

It was observed that on increasing the adsorbent dose of peanut shell, the percentage of removal of Pb(II) increases up to a peanut shell dose of 1 g. The maximum adsorption is obtained at the adsorbent dose 1.0 g with 74.57 % removal of Pb (II) ions. This may be attributed to the increasing of sorbent surface area. Availability of more sorption sites also resulting from the increased dose of the sorbent. At an amount of adsorbent higher than 1 g, the incremental Pb (II) removal becomes very low. This probability due to the surface Pb(II) concentration and the solution Pb (II) concentration come to equilibrium with each other (Boudrahem *et al*. 2011).

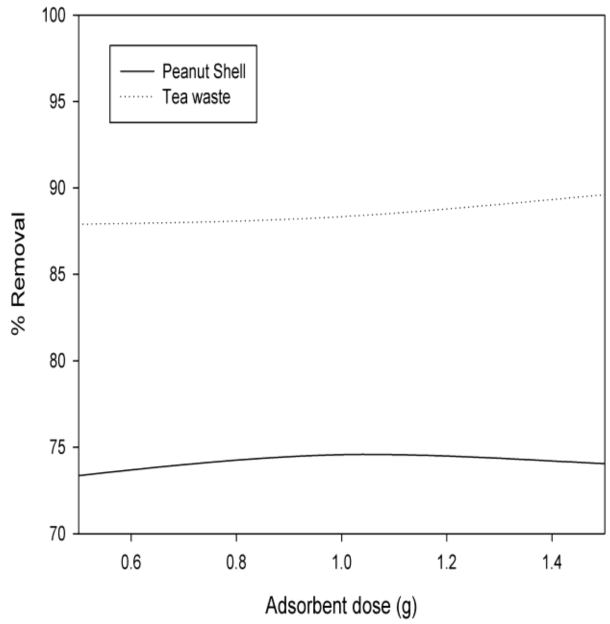

Figure-2. Adsorbent dose against percentage of removal for both tea waste and peanut shells.

Effect on Contact Time

Based on the result in Figure-3, it can be seen that the trend of the percentage removal of lead was increased linearly with time for both type of adsorbent (peanut shell and tea waste). At 30 minutes, the percentage of removal of lead was the minimum one but increase at 60 and 90 minutes.

The fast metal uptake by adsorption at first 90 minutes may be attributed to the abundant availability of active sites on the adsorbent and it is highly porous and mesh structure which provide complete access and large surface for the adsorption of metal on the binding sites. This result is line with the obtained result that reported by Lo *et al*., (2012). The finding by Lo *et al*. (2012) stated that removal efficiency increased with increasing soaking time.

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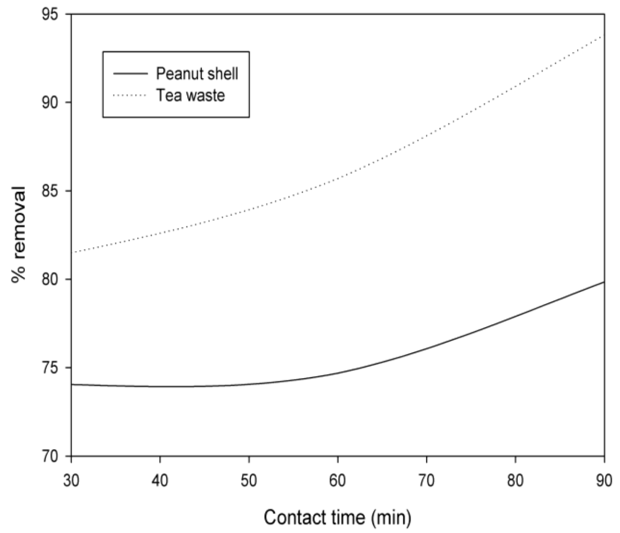

Figure-3. Contact time against percentage of removal for both tea waste and peanut shells.

CONCLUSIONS

The present study shows that peanut shell and tea waste can be used as a biosorbent in removing lead from aqueous solutions. The sorption of lead onto both bioadsorbents depends on, contact time and adsorbent dose. However, it is suggested to study more parameter such as solution pH, initial concentration of Pb (II) and temperature in order to determine optimum condition for both bioadsorbents to remove Pb (II) ions at maximum percentage. Furthermore, modifications of those bioadsorbent need to carry out for enhancing the efficiency of Pb (II) removal.

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