Adsorption Of Pb(II) From Synthetic Solution By Pomelo Peel

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Abstract
Agricultural biomass waste can be used for producing adsorbents, because it is as low cost material and friendly for environment. This research aimed to study adsorbent preparation from pomelo peel by chemical activation with 0.1 M HNO_3 for investigating the removal efficiency and adsorption isotherm for adsorption of Pb(II) in synthetic solution. The batch experiment was carried out at various initial concentrations (10, 20, 40, 60, 80, 100, 120, 140 mg/L) by using adsorbent dose of 0.3 g and contact time of 30 min. The experimental conditions were implemented at solution pH 5-6, rotary-shaker speed of 120 rpm, particle size of activated pomelo peel at less than 0.2 mm and at room temperature.
The results show that the maximum removal efficiency of Pb(II) was 96.12 % at initial concentration of 10 mg/L. Experimental equilibrium data for Pb(II) adsorption were analyzed by the Langmuir and Freundlich isotherm models. The best fit was achieved with the Langmuir isotherm equation with maximum adsorptioncapacity of 909.09 mg/g. The study results can be a guideline for removal of Pb(II) in industrial wastewater.

Keywords: Pomelo Peel, Adsorption, Pb(II), Adsorption Isotherm

1. Introduction

Wastewater containing heavy metals originates from many industries, such as metal finishing, electroplating, plastics, pigments and mining industries [1]. The specific gravity of heavy metals is generally 5 times more than that of water. So, heavy metals can be accumulated in the environment as sediment form. The living organisms in the water will receive the metals from water, sediment and aquatic plants from up taking through food chain. Thus metal accumulation in animal tissue and plant tissue are increased from accumulated pollution and following consumption. Lead is an important heavy metal in contaminated wastewater that discharged from industries. Many industries usually relate to lead substance, such as battery, tanneries, stabilizers, metal plating, textile production, smelting and others [2].

Lead produces negative human health effects because it can be absorbed into human bodies by three routes such as inhalation, ingestion and dermal contact. Lead toxicity includes irreversible brain disorders, effect on hemoglobin, renal breakdown, weakness and finally dead. The target organ of lead is bone and lead can be transmitted through mother's placenta and can be toxic to the nervous system of baby [3]. Therefore, it is urgent to remove the toxic heavy metal from wastewater.

Many methods have been used to remove heavy metals from wastewater or aqueous solutions, such as chemical precipitation, oxidation-reduction, electro-chemical treatment, evaporative recovery, filtration, ion exchange and membrane technologies. But, some of them may be less effective especially at low metal concentrations and require high cost in treating the metals. So the agricultural or biomass waste has been interested and considered for using as low-cost adsorbent material land it is also friendly for environment. Lead removal in many experiments was studied by adsorption technique with waste biosorbents which showed potential removal of heavy metals from aqueous solutions [4], such as using crab shell [5], wheat straw [6], rice straw [7], grape bagasse [8], mango peel[9], citrus peel and coffee husks [10]orange peels [11],and others.

The pomelo fruit is a famous Thai fruit, which a major producer of the fruit is in Nakhornpathom province of Thailand. The fruit is consumed within the country and also exported to neighboring countries. Generally, a pomelo fruit with weight of 940-1,060 g. has 320-400 g. of its peel [12]. So, it happened a lot of peel as utilizable waste. The aim of this research is to study the adsorbent prepared from pomelo peel. The pomelo peel adsorbent was prepared by chemically modified with nitric acid for investigating the adsorption of lead [Pb(II)] from synthetic solution. The parameters on initial concentration of the metal ion, adsorbent dose, contact time, solution pH, shaker speed, temperature, and particle size of pomelo peel were taken into account for studying the removal efficiency and adsorption isotherm of adsorbing Pb(II) in synthetic solution. The research results can be an application guideline for removal of lead in industrial wastewater.

2. Materials and methods

2.1 Preparation of adsorbents

Pomelo peel was dried for 24 hrs. in a convection oven at a temperature of 105 C^{o}. The dry product was crushed and screened to the particle size of lower than 0.2 mm. The sorbent material was activated with 0.1 M HNO_3 10g of peel/L by soaking for 6 hrs. After activation, washed the pomelo peel with distilled water until the solution reached neutral pH value, and dried in oven at 105 C° for 24 hrs.

2.2 Adsorbate solution

Stock solution of Pb(II) were prepared 1000 mg/L by dissolving lead nitrate AR grade in distilled water, and adjusted pH in the range between 5 - 6 with 1M NaOH and 1M HCl.

2.3 Batch adsorption experiment

Adsorption studies were carried out by batch process for investigating the removal efficiency and adsorption isotherm for adsorption of Pb(II) in synthetic solution. The experiment was conducted by using 0.3 g sample of adsorbent which was placed in a Erlenmeyer flask contained with 100 mL solution of Pb(II)at various initial concentrations (10, 20, 40, 60, 80, 100, 120 and 140 mg/L) and contact time of 30 min for mixingon a rotary shaker with speed of 120 rpm at room temperature.The mixture was then filtered by filter paper (Whatman No.42)and the sample after digestion was analyzed by Flame Atomic Absorption Spectrometer (FAAS), Thermo scientific Solar, ICE 3000 series, United States.

3. Results and discussion

3.1 Removal efficiency

The results of percent removal efficiency of Pb(II) in synthetic solution on pomelo peel are shown in Fig.1.

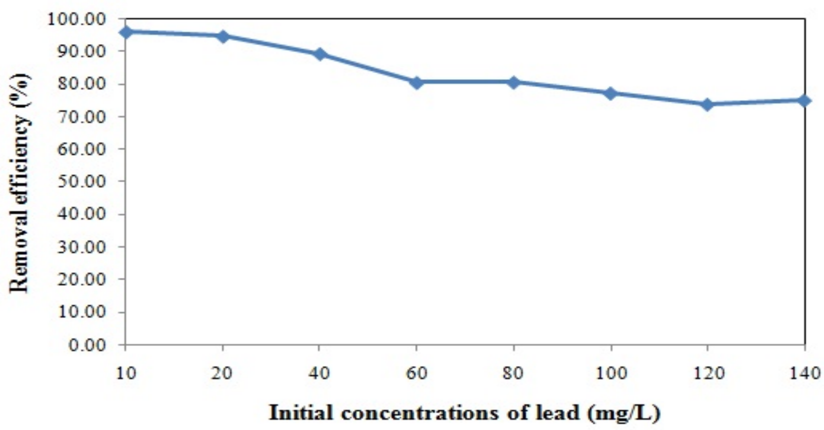

Fig 1: Removal efficiency (%) of Pb(II) in synthetic solution

From Fig 1, the adsorption of Pb(II) was maximum efficiency of 96.12 % at initial concentration of 10 mg/L and minimum efficiency was 73.75 % at initial concentration of 120 mg/L under the same experimental conditions were adsorbent dose of 0.3 g, contact time of 30 min and solution pH 5-6. At the fitted experimental conditions it were equilibrium for adsorption Pb(II) by pomelo peel because at pH lower than 2 it given low adsorption efficiency. Because the surface charge of the biomass is positive, which is not favorable to cations biosorption. Meanwhile, hydrogen ions compete strongly with metal ions at the active sites, resulting in less biosorption. Therefore, with increasing pH, electrostatic repulsions between cations and surface sites and the competing effect of hydrogen ions decrease. Consequently, the metal biosorption increases[16] and from study of Lasheen M.R et al [17], had been done to show the equilibrium time for sorption of Pb(II) ions onto the modified orange peel was reached within 30 min and at equilibrium adsorbent dosage 0.3 g.

It can be concluded from this figure that adsorption efficiency was affected by initial concentration. At higher initial concentration, the removal efficiency of Pb(II) was around 73-80 %. While with the lower initial concentration the removal efficiency of Pb(II) was around 89-96 %. Because in the adsorption process at higher initial concentrations result in lower heavy metals adsorption due to at lower initial concentrations cation in the adsorbate was low. So when used adsorbent it can uptake well in adsorption. While at higher initial concentrations it has many cation so it made cation uptake are not. Another study of Lasheen M.R et al [17] It was found that the removal efficiency 99.5 % at low initial concentrations 20 mg/L . So, it might can explained that at higher initial concentrations result in low removal efficiency adsorption.

3.2 Adsorption isotherm

The equilibrium adsorption data has been analyzed by the Langmuir and Freundlich isotherm models. The Langmuir isotherm can be expressed in equation (1).

$$Q_e = \frac{Q_{max} b C_e}{1 + bC_e} \quad (1)$$

Where Q_e is the amount of solute adsorbed per unit weight of adsorbent at equilibrium (mg/g), Q_{max} is maximum adsorption capacity (mg/g), b is Langmuir's constant and C_e is the equilibrium concentration of the solute in the bulk solution (mg/l). [13]

Moreover, the Langmuir equation can be rearranged in linear form as shown by :

$$\frac{1}{Qe} = \frac{1}{Qmax} + \left(\frac{1}{bQmax}\right)\left(\frac{1}{Ce}\right) \quad (2)$$

However, the adsorption isotherm could be described by the Freundlich adsorption equation. The Freundlich isotherm can be expressed by equation (3).

$$Q_e = KC_e^{1/n} \tag{3}$$

Where Q_e is the amount of solute adsorbed per unit weight of adsorbent at equilibrium (mg/g), C_e is the equilibrium concentration of the solute in the bulk solution(mg/l), K is Freundlich constant and 1/n is Freundlich slope.[14]

The Freundlich equation can be rearranged in linear form as shown by equation (4).

$$\text{Log } Q_e = \log K + (1/n) \log C_e \tag{4}$$

Moreover, summary of isotherm models it was observed from Table 1

Table 1
Isotherm models and their linear forms [15]

Isotherm model	Isotherm Equation	Linear form	Plot
Freundlich	$Q_e = KC_e^{1/n}$	$\text{Log } Q_e = \log k + (1/n) \log C_e$	$\text{Log } Q_e$ vs $\text{Log } C_e$
Langmuir	$Q_e = \frac{Q_{max} b C_e}{1 + bC_e}$	$\frac{1}{Qe} = \frac{1}{Qmax} + (\frac{1}{bQmax})(\frac{1}{Ce})$	$\frac{1}{Qe}$ vs $\frac{1}{Ce}$
		$\frac{Ce}{Qe} = \frac{1(Ce)}{Qmax} + (\frac{1}{bQmax})$	$\frac{Ce}{Qe}$ vs C_e

The adsorption data were shown by linear transformation as in Fig. 2

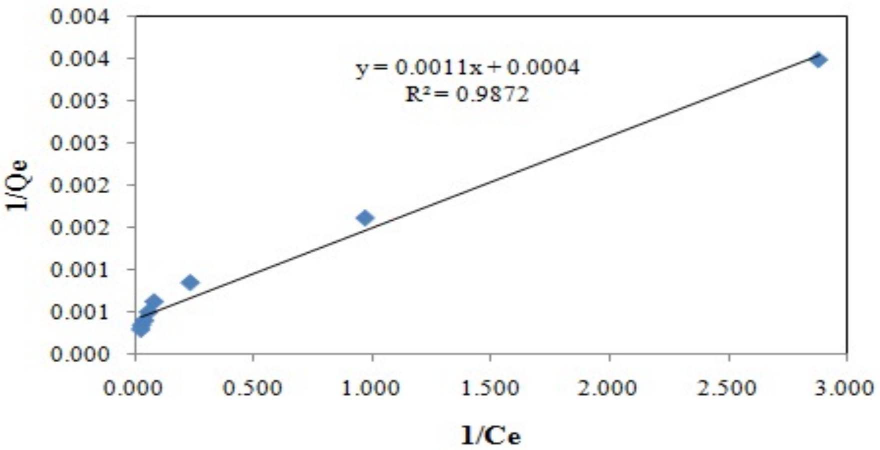

Fig 2: Linear Langmuir adsorption isotherm of Pb(II) on pomelo peel adsorbent

The adsorption data were shown by linear transformation as in Fig. 3

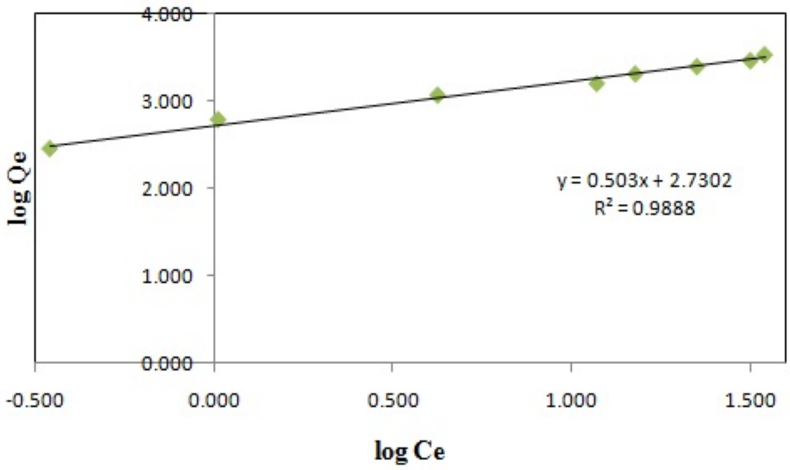

Fig 3: Linear Freundlish adsorption isotherm of Pb(II) on pomelo peel adsorbent

Due to their simplicity, the Langmuir and Freundlich equations are the most widely used models to describe the relationship between equilibrium metal uptake (Q_e) and final concentrations (C_e) at equilibrium. So, summary of isotherm model for adsorption Pb(II) by pomelo peel shown as Table 2

Table 2
Summary of isotherm model parameters adsorption Pb(II) by pomelo peel

Isotherm model	Isotherm parameters	Pb (II)
Langmuir Isotherm	Q_{max} (mg/g)	909.99
	b	2.75
	R^2	0.9872
Freundlich Isotherm	K (mg/g)	537.27
	1/n	0.503
	R^2	0.9888

The correlation coefficients (R^2) of Pb(II) adsorption isotherm by pomelo peel adsorbent in Langmuir's equation and Freundlich's equation were 0.9872 and 0.9888 respectively. The adsorption isotherm data was fitted to both the Freundlich and Langmuir isotherm equations because R^2 values closer 1 (R^2> 0.9).

However, the Langmuir adsorption isotherm model for the adsorption of Pb(II) showed higher adsorption capacity (Q_{max}). The maximum monolayer adsorption capacity obtained from Langmuir isotherm model was 909.09 mg/g for the adsorption of Pb(II) by pomelo peel adsorbent. So, it meaning adsorption of Pb(II) by pomelo

peel adsorbent fitted well with Langmuir isotherm assumes this adsorption was a monolayer adsorption surface without any lateral interaction between adsorbed molecules[18].

While the Freundlich model does not describe the saturation behavior of the sorbents, the Langmuir model can explained about the monolayer saturation at equilibrium or the total capacity of the adsorbent for heavy metals in this adsorption experiments. Similar results were obtained by Lasheen et al. [17], on their studies of adsorption/desorption of Cd(II), Cu(II) and Pb(II) using chemically modified orange peel: equilibrium and kinetic studies and Anirudhan et al. [18], studies of adsorptive removal of heavy metal ions from industrial effluents using activated carbon derived from waste coconut buttons.

4. Conclusions

The present investigation showed that the adsorbent prepared from pomelo peel can be used as a potentially low-cost adsorbent for the removal of Pb(II) in synthetic solution. Batch adsorption test indicated that the extent of Pb(II) adsorption was dependent on initial metal concentrations. The maximum removal of Pb(II) was 96.12 % at the initialmetal concentration of 10 mg/L.

The Langmuir and Freundlich adsorption isotherm models could be used to evaluate the experimental data, but the previous model was better fitted for the adsorption of Pb(II) than the other one. The equilibrium experimental data fitted well with the Langmuir model showed the maximum Pb(II) adsorptioncapacity of 909.09 mg/g for the pomelo peel adsorbent.

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