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BIOSORPTION OF LEAD (II) ION FROM AQUEOUS SOLUTION USING DUM PALM KERNEL

Babagana Gutti, Habu Mohammed Iyodo* and Umar Abdullahi Isah
Department of Chemical Engineering, University of Maiduguri, Nigeria
*Corresponding author: mohammedhabu@unimaid.edu.ng

Abstract

Biosorption of the lead ions from aqueous solutions using dum palm kernel was studied, the lead ion removal depends on the contact time, pH and adsorbent dosage. The optimum contact time, pH and adsorbent mass with in the experimental limit of this work were 100 minutes, 6-7, and 2.5g/L respectively. The maximum percentage of lead ions removed was 87%. The data fitted well with Temkin and Langmuir models, the regression correlation were obtained to be 0.9660 and 0.8667, respectively. The biosorbent may be economical if developed further for industrial wastewater and natural contaminated water treatment.

Key words: biosorption, lead (II) ion, dum palm kernel, Temkin model, Langmuir model

Introduction

The detrimental effect of heavy metals generated by industrial activities and those occur naturally in our ground water cannot be over emphasized. In 2011, it had been reported on NTA that many children have died of lead poisoning and some adults were left with acute kidney problems in Zamfara State, as a result of mining activities taking place in their vicinity.

It has been reported that highest percentage of kidney patient at University of Maiduguri Teaching Hospital, (UMTH) are from Gashua, (UMTH, 2010) this has been traced to lead ions presence in their underground water. Many works have been done on removal of lead ions in aqueous solution by adsorption using activated carbon prepared from different sources and biomass (biosorption). Biomass has been proved to have higher uptake compare to activated carbon (Azouaou *et al* 2013). Biosorption of lead (II) and chromium (VI) ions on groundnut hull has been studied (Qaiser & Saleemi, 2009). Biosorption of aqueous solutions of lead on xylopia aethiopica (Ethiopian pepper) has been investigated (Ajaelu *et al*, 2011). Biosorption of lead (ii) from aqueous solutions by pleurotus as a toxicity biosorbent has been investigated (Chia-Chay *et al.*, 2009). Biosorption of lead (II) and zinc (II) from aqueous solutions by nordmann fir (abies nordmanniana (stev.) spachsub sp. nordmanniana) cones has been investigated (Kaya & Handan, 2009). Biosorption of lead (ii) ions from aqueous solution by treated corn (z. mays) leaves biomass has been investigated (Suhaimi *et al.*, 2013). Adsorption of lead from aqueous solution onto untreated orange barks has been studied (Azouaou *et al.*, 2013). Biosorption of Lead by Bacillus cereus Isolated from Industrial Effluents has been investigated (Murthy *et al.*, 2012). Lead (ii) removal from aqueous solutions by adsorption onto chitosan has been studied (Asandei *et al.*, 2009). Biosorption of Lead (II) ions from aqueous solution using Moringa oleifera pods has been studied. It was found to be poor adsorbent for removal of lead ion in aqueous solution, (Adelaja *et al.*, 2011). It is therefore imperative to think of more low cost means of removing this deadly contaminant from our environment.

However, no previous studies have been reported on the application of dum palm kernel for removal of lead ion in waste water or water treatment. It is well known that extracted dum palm fruit comprises solid waste, in the places, these plants are found, like far part of Northern and Eastern Nigeria. Therefore its use for lead ion removal from waste water may be frugal.

The objective of these studies is to investigate the adsorption capacity and of dum palm kernel for removal of lead ion in aqueous solution by considering the effect of contact time, biomass load, and pH of the solution.

Materials and Methods

Preparation of the Biosorbent

The extracted dum palm fruit was collected and the shell was cracked to obtain the kernel. The kernel was collected and crushed in to granules using mortar. The granules obtained were washed with deionized water and dried in a laboratory oven at 70^0c until there was no more weight loss.

Preparation of Lead Contaminated Water

Contaminated water was prepared by dissolving 1.6g of lead II Nitrate salt (analytical grade) in distilled water forming solution of 1000 mgL^{-1} Lead (II) ion. The pH of the solution was determined. Other concentrations were prepared from this solution by serial dilution.

Biosorption Experiment

Determination of Optimum Sorption Time

The adsorption experiment was conducted at 32^0c. The sample solution was divided in to three, and was adjusted to PH of 6.2, 7.1, and 8.2 of the biosorbent was added to the 100ml each of the samples and stirred at 80rpm for 20, 40, 60, 80, 100 and 120minutes, respectively. The treated solution was filtered by a filter paper. The lead ions concentration in the filtrate was determined by atomic adsorption spectrometer, (AAS). The metal concentrations adsorbed on the biosorbent were calculated from the difference between lead ions content in the liquid solution before and after sorption. The optimum sorption time was determined.

Determination of Optimum Biosorbent Load

The procedure in section 2.3.1 was repeated with adsorbent mass of 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0g for each of the sample at the pre-determined time.

Data Analysis

The mass balance equations below were used to calculate the adsorption capacity and sorption percentage (%Sorption) by the biosorbent, respectively.

$$q = \frac{(Ci - Ce)V}{1000w} \qquad (1)$$

$$\%\text{Sorption} = \frac{(Ci - Ce)}{Ci} x100\% \qquad (2)$$

Where q is metal ion uptake in mg/g
Ci initial concentration mg/L
Ce concentration at any time t in mg/L
V volume in mL
W mass of adsorbent in g

The resulted data were analyzed using Langmuir, and Temkin models.
The two models are presented in linearized form respectively:

$$\frac{c}{q} = \frac{1}{bQ} + \frac{c}{Q} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where q is the biosorbent uptake, C is concentration at time t, K is Langmuir constant, Q is the saturation capacity,

$$q = BlnA + BlnC \dots\dots\dots\dots\dots\dots\dots.\dots (2)$$

$B=RT/b_T$

Where q is the biosorbent uptake, C is concentration at time t, B is related to the heat of adsorption, and A is the maximum binding energy of the adsorbate to the biosorbent, b_T is Temkin constant.

Results and Discussion

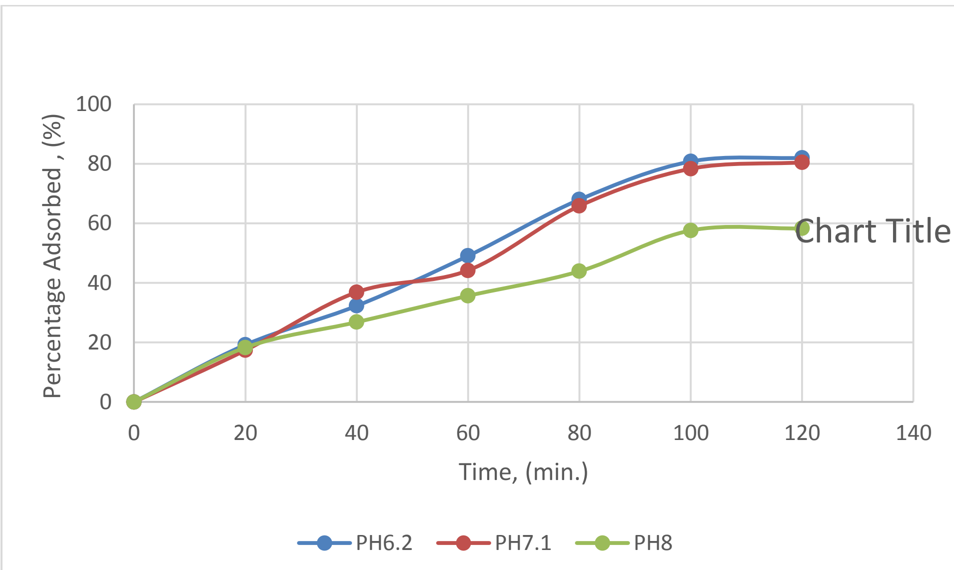

Fig. 1: Effect of Contact Time and pH on Lead Ion Sorption

Fig. 1, shows the effect of contact time on adsorption of lead (II) on dum palm kernel at pH of 6.2, 7.1 and 8. The percentage of the adsorbate uptake for all the pH occurs at same rate for the first period of 20 minutes. The adsorption rate increases steadily for the period of 20 to 100 minutes for pH of 6.2 and 7.1, however percentage adsorbed remained constant from 100 to 120 minutes, this shows there is no significant adsorption with in the last 20minutes. For pH of 8 there was relative decline in percentage of the adsorbate uptake. This trend observed might be due to the fact that the NaOH used in adjusting the pH have occupied the active site of the adsorbent. Equilibrium adsorption was attained with fewer uptakes relative to that of pH of 6.2 and 7.1. The maximum percentage adsorbed was observed at contact time and pH of 100 minutes and 6.2-7.1, respectively. These results agree with was found by Kaya *et al.*, 2008, using nordmann fir biosorbent and Emongor, 2007, using Kale plants as biosorbent.

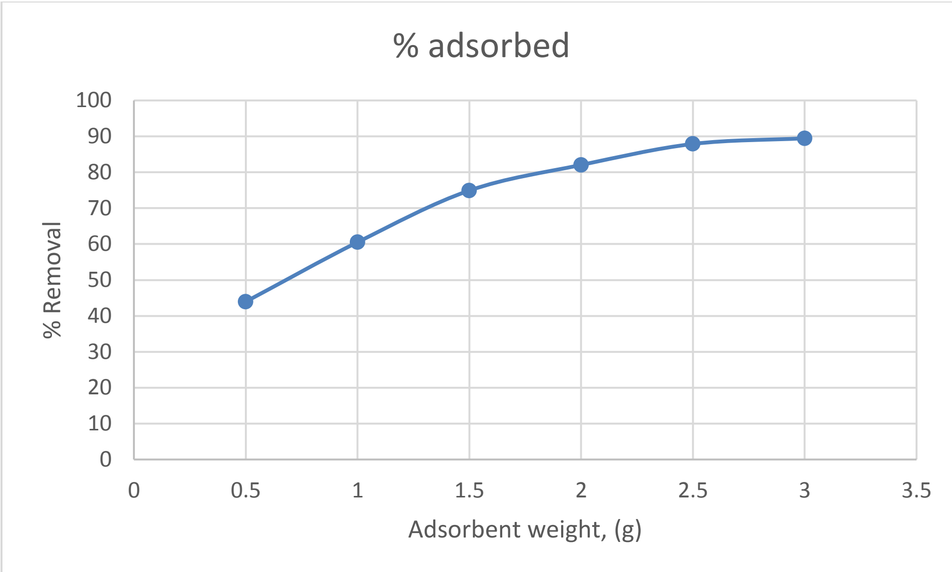

Fig. 2: Effect of Biosorbent weight on Lead Ion Sorption

Fig. 2 shows the effect of biosorbent dosage on adsorption of lead II ions. The adsorption depend on the adsorbent dosage, at a fixed time of 100minutes the percentage adsorbed was 43% for dosage of 0.5 gram. At dosage of 1 gram, the percentage adsorbed increases to 60%. However, at dosage of 2.5 gram the maximum adsorption of 87% was attained in which there is no significant increase in from this point. This shows that the economical adsorbent dosage may be chosen as 2.5g/100ml of the contaminated water. This trend is true, because the more adsorbent introduced, the more active site made available for adsorption but not proportional to the quantity of adsorbent. This trend is in agreement with Karaca *et al.*, using lyophilized aspergillus niveus.

Adsorption Isotherm

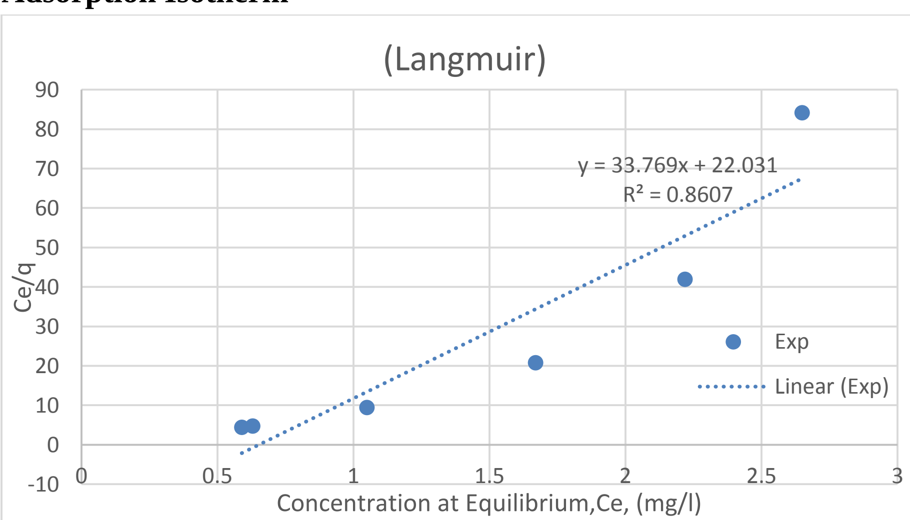

Fig. 3: Langmuir Plot of Experimental Data

Fig. 3 shows the Langmuir plot of the experimental data obtained, the maximum adsorption of lead ion is 33.769 mg/g adsorbent. The regression correlation, R^2 is 0.8607, the data fairly fit to Langmuir isotherm.

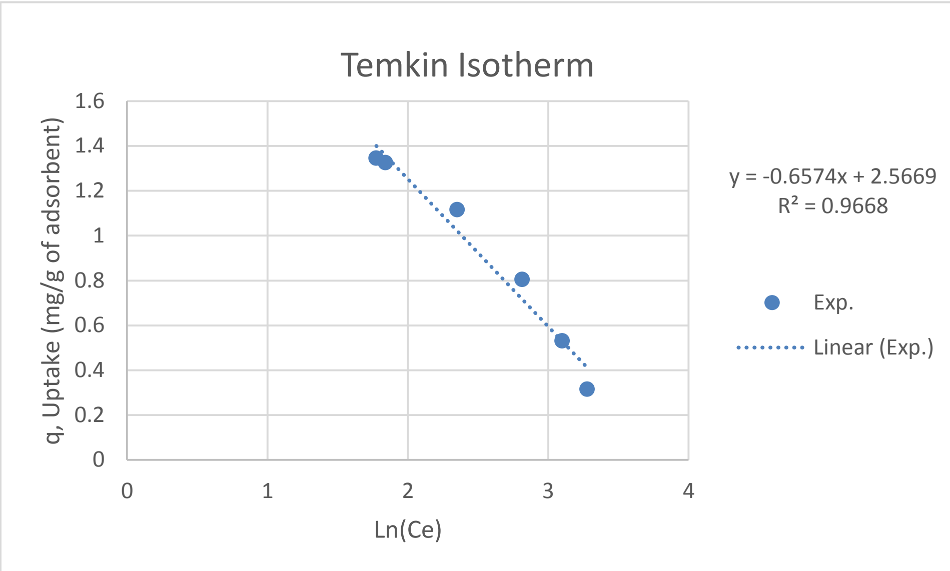

Fig. 4: Temkin Plot of Experimental Data

The binding energy between the adsorbate and the adsorbent is a parameter of interest which indicates how firm the adsorbate is binded to the adsorbent. Temkin isotherm has been explored to reveal these as shown in Fig 4. The maximum binding energy was computed from the regression to be I.0022 J/mol. This value is in the range of physical adsorption as suggested by Temkin's model

Table: Langmuir and Temkin Constants Parameters for Lead II ion adsorption on Dum Palm Kernel

Langmuir			Temkin			
Q_{max}	b	R^2	A	B	b_T	R^2
33.7690	0.6470	0.8607	1.0022	-0.6574	-266	0.9665

Conclusion

Removal of the lead ions from aqueous solutions using dum palm kernel was studied, the lead ion removal depends on the contact time, pH and adsorbent dosage. The percentage of lead ion removed increases with contact time, the equilibrium contact time was attained within 100 minutes. The changes in percentage adsorbed with solution pH do not have definite direction, but adsorption at pH of 6-7 was more favorable. Increase in percentage adsorbed was observed with increase of the adsorbent mass, the optimum dosage was obtained at 2.5g/100 ml. However, the sorption efficiency decreases with adsorbent load from 1.5 g up to the 3.0g of these studies. The Results showed maximum adsorption capacity to be 33.76 mg/g of biosorbent, and binding energy of 1.002J/mol of adsorbate based on the Temkin isotherm.

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