Nigerian Research Journal of Chemical Sciences **(ISSN: 2682-6054)**
Vol. 7, 2019

Adsorption of Heavy Metal (Lead) from Aqueous Solution using *Senna occidentalis*

*Omogbehin, S. A., Umar, S.I. and Yekeen, M.O.
Department of Science Laboratory Technology,
Federal Polytechnic, Ile-Oluji, Ondo State, Nigeria
*Corresponding author: adehugasamsom@gmail.com

ABSTRACT

Toxic metals are often discharged by a number of industrial processes and this has been a challenge for a long time. A number of methods have been developed for the removal of heavy metals from liquid waste using physical and chemical treatments. However, some of these methods have high reagent requirements and generate toxic sludge. In this study the adsorption of heavy metal [Pb(II)] ion using untreated *Senna occidentalis* from aqueous solutions was investigated under batch mode. The effect of solution pH, adsorbent dosage, contact time and initial metal ion concentration of aqueous solution were investigated. Maximum removal of metal ion took place at pH 3-4, the adsorption of heavy [Pb(II)] ion increased with increase in the biomass dosage and reduced with increase in initial metal ion concentration. It was concluded that *S. occidentalis* is a good adsorbing media for Pb(II) ion in aqueous solution.

Keywords: Adsorption, biosorbents, equilibrium, dosage, heavy metals.

INTRODUCTION

Water pollution due to development in technology, continues to be of great concern. With increasing generation of heavy metals from technological activities, many aquatic environments face metal concentrations that exceed water quality criteria designed to protect the environment, animals and humans [1].

Heavy metals are chemical elements with a specific gravity that is at least 5 times the specific gravity of water and is toxic or poisonous even at low concentrations. Some well-known toxic metallic elements are arsenic, (sp.gravity 5,7); iron(sp.gravity 7,9); chromium (sp.gravity 7,19); cadmium (sp.gravity 8.65); lead (sp.gravity 11,34); and mercury (sp.gravity 13,54) [2].

Heavy metals are highly dispersed in a wide variety of economically important minerals. They are released to the environment during mineral extraction process. Therefore, mining are considered as the primary anthropogenic source of heavy metals [3] Heavy metals ions are discharged into water system from various industrial activities such as electroplating industries, electronic equipment manufacturing and chemical process plants. Due to rapid development of industrial activities, the levels of heavy metals in water systems have substantially increased [4]. Heavy metals can easily enter the food chain because of their high solubility in water [1] . Cadmium, copper, chromium, lead and zinc are extremely toxic heavy metals of widespread use in many industries. The heavy metals pollution represents an important problem, with human health concerns and serious ecological consequences. It is therefore essential to remove heavy metal from industrial waste water and drinking water [5].

Plant materials are mainly comprised of cellulose materials that can absorb heavy metal cations in aqueous solution. Numerous waste biomass sources are available in nature in which adsorption properties have been reported e.g. rice husk, saw dust, tea and coffee waste, orange peel peanut shells, activated carbon, dry tree leaves and barks [1, 6] Adsorption of heavy metal ions occurs as a result of physicochemical interaction, mainly ion exchange or complex formation between metal ions and the functional groups present on the cell surface [2].

Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver and other vital organs. Long-term exposure may result in slowly progressing physical, muscular and neurological degenerative processes that mimic alzheimer’s disease, parkinson’s disease, muscular dystrophy, and multiple sclerosis. Allergies are not uncommon, and repeated long-term contact with some metal (or their compounds) may cause cancer. For some heavy metals, toxic level can be just above the background concentrations naturally found in nature. Therefore, it is important to learn about heavy metals and take protective measure against excessive exposure [7].

MATERIALS AND METHOD

Sample Collection and Preparation

The *S. occidentalis* leaf used for this research work was collected from College of Science and Technology at Waziri Umaru Federal Polytechnic, Birnin Kebbi, Kebbi State, Nigeria.

The *S. occidentalis* leaf used was washed in clean container distilled water, air dried under room temperature. They were then ground into fine powder using mortar and pestle and sieved using 200 mesh sieves. It was then stored until time of use.

Preparation of Stock Solution

Lead acetate $(CH_3COO)_2Pb$ salts is used in the preparation of the salt stock solutions. Stock Pb(II) solutions (1,000mg/l) was prepared by dissolving accurately weighed amounts of Lead acetate in 1000 ml distilled water. Working solutions of different concentration were prepared from the stock solution by serial dilution with distilled water [8].

Batch Sorption Experiment

Definite amount 0.2 of *Senna occidentalis* leaf was added to the metal ion solution (200 ml) in a 250 ml stopper conical flask and agitated for the desired contact time using orbital shaker at 200 rpm. The contents of the lead(II) ion in the test flask were separated from bio-sorbent by filtration through a filter paper and was analyzed using Atomic absorption spectrophotometer (AAS) (Buck Scientific, Model 205). The sorption capacity of metals was investigated under different condition and calculated using

$$Q_e = \frac{(C_o - C_e) \times V}{m}$$

Where Qe = adsorption capacity at equilibrium, V = volume of adsorbate solution (ml), m = mass of *Senna occidentalis* leaf (g), Co = initial concentration in mg/L, Ce = concentration at equilibrium (mg/L) [9].

The removal percentage (R %) is defined as the ratio of difference in metal concentration before and after adsorption (Co – Ce) to the initial concentration before and after adsorption (Co – Ce) to the initial concentration of the adsorbate in aqueous solution (Co) shown below:

$$\%R = \frac{(Co - C_e) \times 100}{C_o}$$

Where Co initial concentration in mg/L, Ce = concentration at equilibrium (mg/L) [9].

Effect of pH

The optimum pH for adsorption for adsorption of (Pb) by the biosorbents was determined experimentally using the method of Barakat [10]. Metal solutions with the concentration of 100mg/L were prepared in distilled water from the stock solutions. Samples of 100bml from these solutions were poured into 8 Erlenmeyer flasks. The initial pH of the samples was adjusted to various values in the range of 2 to 6 and each sample was adjusted using either 0.1 M H_2SO_4 or NaOH solution. Subsequently, 0.5g of biosorbents was added to each flask. Equilibrium condition for heavy metal adsorption was obtained after 2 hours of agitation at room temperature and 120 rpm. Samples were taken after filtering the samples by Whatman filter paper, after equilibrium was achieved and heavy metal concentration were analyzed by using atomic absorption spectrometer [10].

Effects of Biosorbents Doses

To investigate the effects of biosorbent doses, 100 ml of water samples at pH 4 with 100 mg/l of initial metals [Pb (II)] concentration were stirred in a 250 ml Erlenmeyer flask. Doses of specified biosorbent (between 0.2-1.2 g per 100ml water) were added to each Erlenmeyer flask and shaken at 120 rpm for 2-8 hours. At the end of the shaking period, the Erlenmeyer flask was removed from the shaker and the contents allowed to settle for 5 minutes and then filtered through Whatman filter paper. The filtrates were then separately analyzed [10].

Effects of Contact Time

The effects of contact time (5-30 minutes) on adsorption of metals (Pb) onto biosorbents were studied at the optimum stirring rate, initial metal concentration (100mg/l) and adsorbent dose. The experimental procedure was the same as in the effect of adsorbent dose except that the beakers were removed from the batch apparatus in the course of the experiment at specified intervals (between 5-30 minutes) and analyzed for residual concentrations of metals [10].

Effects Initial Metal Concentrations

The effects of initial metal concentration [Pb(II)] ion on adsorption onto biosorbents were examined with optimum pH, doses and contact time for 100-300 mg/l metals concentration in 100 ml water. After filtering the water samples were analyzed for residual concentrations of metals. The optimum concentrations of metals were taken on in this study during other experiments [10].

RESULTS AND DISCUSSION

Effects of pH on Adsorbate Solution

pH is one of the most important environmental factor forbiosorption of heavy metal ions. pH values influence the site dissociation of a biomass as well as the solution chemistry of heavy metal [11].

The effect of pH on adsorption of Pb(II) ion was investigated using 100mg/l *Senna occidentalis* and the result shown in figure 1.

Fig.1 shows that a rapid increase from 55.00% removal to 95.00%when the pH value changes from 2.0 to 5.0. The pH plays an important role in the adsorbtion process by affecting the surface charge to adsorbent, degree of ionization and speciation of the adsorbate [12].

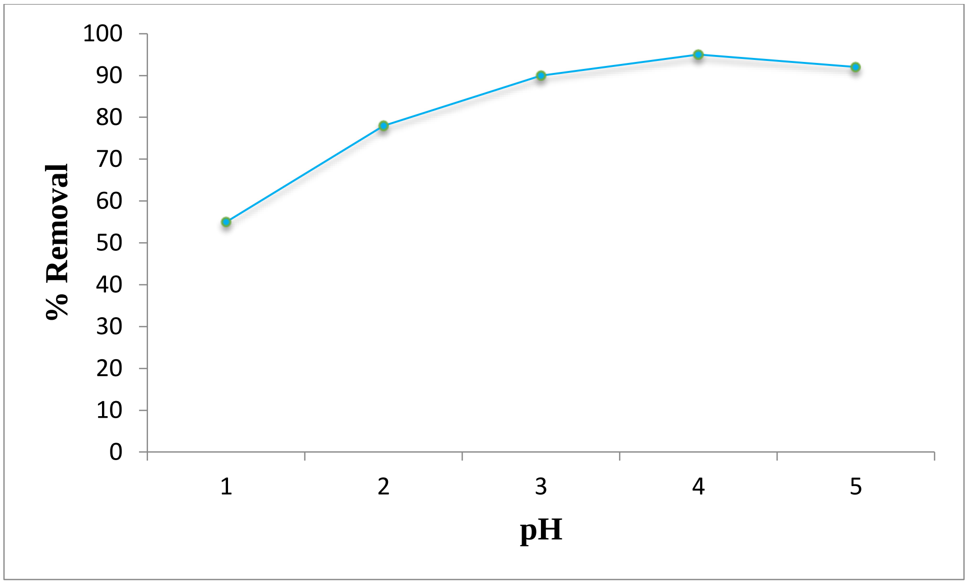

Figure 1: Effect of pH on % Pb (ii) Removal

Effect of Adsorbent Dosage

This is an important parameter in an adsorbtion system as it indicates the number of binding sites available for adsorbtion of metal cations. A good adsorbent is one which has many binding sites such that, a small mass adsorbent can adsorb a big quantity of pollutant [13]. The biosorptive efficiency for Pb(II) ion as a function of biomass dosage was investigated with adsorbent dosage ranging from 0.2 to 1.2g when the concentration was kept constant of 100mg/L and the result displayed in fig. 2. From the result it can be seen that the percentage of metal ion adsorped on *S. occidentalis* increased with increase in the adsorbent dosage and maximum % removal was

98.52% at a dosage of 0.6g at which point the effectiveness of the removal begins to drop. The result clearly indicates that an increase in the mass of biosorbent increases the mass of biosorbent, this lead to increase the number of available adsorption binding sites hence an increase in the percentage adsorption [11].

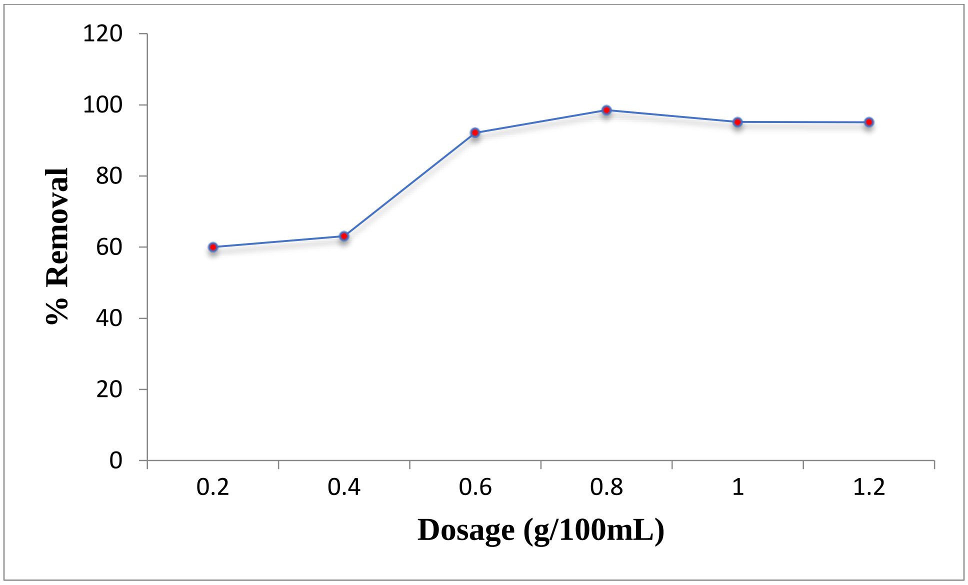

Figure 2: Effects of *S.occidentalis* dosage on %Pb (ii) Removal

Effect of Contact Time

Contact time plays a key role in the adsorption process and it often determines the amount of metal ions adsorbed on an adsorbent. It is an important parameter for successful use of the adsorbent for practical applications. The effect of contact time on adsorbtion on Pb(II) ion was investigated and the result displayed in figure 3. The percentage of lead adsorbed was found to increase with contact time for the first 10 minutes and began to drop gradually until it becomes constant after 25 minutes. This is because at low metal ion concentration the adsorption sites seemed to have taken up the available Pb ions more quickly due to less competition among the Pb ions for available binding sites. As time progresses there could be some repulsion between the cation. In the solution and the cation already adsorbed. However, once the binding sites have been occupied to saturation no more of the ions get adsorbed [14].

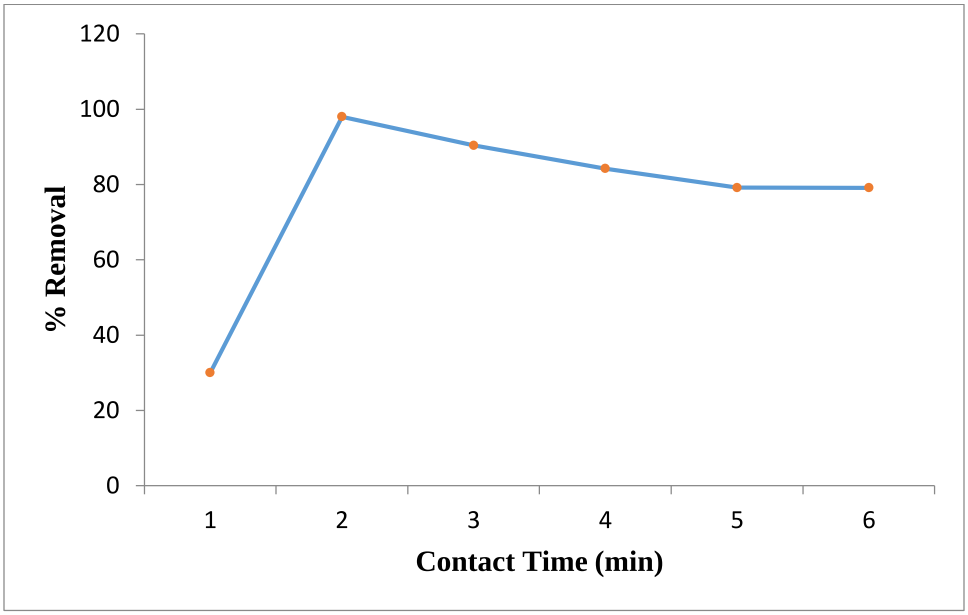

Figure 3: Effects of contact time on % Pb (ii) removal at pH 5.

Effects of Initial Concentration

Initial concentration is one of the key parameters that must be considered in setting of a sorption system. Adsorption experiment in Pb (II) ion with concentration from 100 to 300 mg/l with fixed adsorbates doses of *Senna Occidentals* was investigated. The percentage Pb(II) ion removals ranges from 89.14 to 95.00% for mass of 0.20 g. The result is shown in figure 4. The result shows that the percentage Pb(II) ion adsorbed decreases with increased Pb(II) ion concentration. This can be attributed to the fact that the biosorbent have a limited number of active sites. The initial concentration provides an important driving force to overcome all mass transfer resistance of metal ion between the aqueous and solid phase, hence a higher initial concentration of metal ion may increase the adsorption capacity. However, at lower concentration there is plenty of binding sites available on the biosorbent for the attachment of the metal ions. At higher initial concentration there is competition for the binding sites as reported by Semerjian [15].

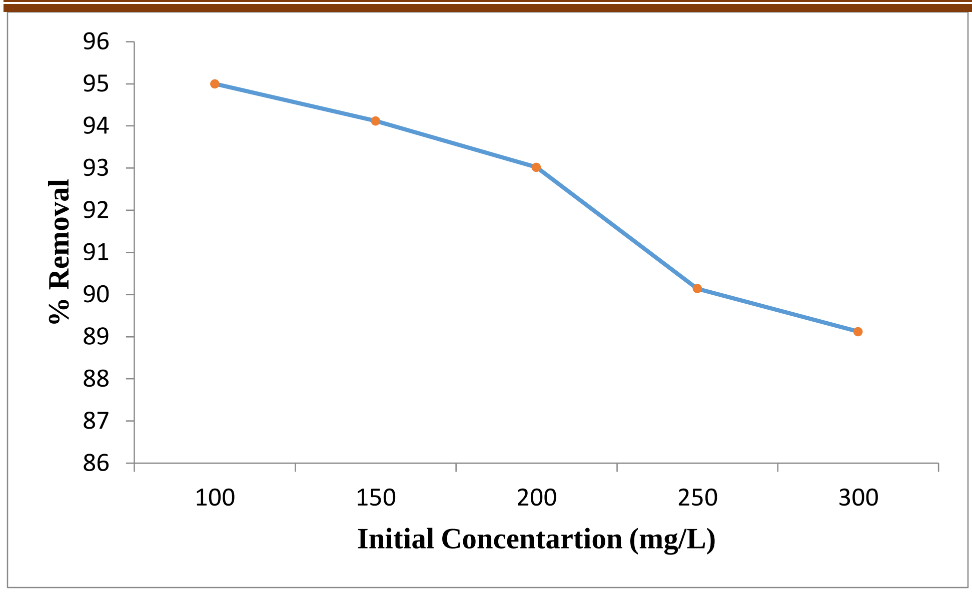

Figure 4: Effect of metal concentration on % Pb (II) Removal.

CONCLUSION

From the study it can be concluded that S. occidentalis can be used as a natural sorbent for the removal of Pb (II) ion from aqueous solution. The removal of the Pb (II) ion is affected by condition such as pH, biomass dosage contact time and initial concentration.

REFERENCES

1 Asma, S, Muhammed, I. & Akhtar, M.W. (2005). 'Removal and recovery of lead(II) from single and multimetal (Cd,Cu,Ni,Zn) solutions by crop milling waste (black gram husk)',. *Journal of Hazardous Materials*, 117, 65-73.

2 Kishore, K.K., Xianguang, M., Christodoulatos, C. & Veera, M.B. (2008). Biosorption mechanism of nine different heavy metal onto biomatrix from rice husk, J*ournals of hazardous materials*, **53.** Pp. 1222-1234.

3 Demirbas, A. (2008). Heavy metal adsorption onto agro-based waste materials: A review' *Journal of Hazardous Materials*, 157, 220-229.

4 Demirbas, A. (2008). Biodiesel a realistic fuel alternative for diesel engines. Springer-Verlag London Limited, London.

5 Ferda, G. & Selen, S.D. (2012). Adsorption study on orange peel: Removal of Ni(II) ions from aqueous solution', *African Journal of Biotechnology*, 11**,** 1250-1258.

6 Nuria, M., Cesar, V., Ignasi, C., Maria, M. & Antonio, F. (2010). Cadmium and lead removal from aqueous solution by grape stalk wastes: Modeling of a Fixed Bed Column, *Journal of Chemical Engineering Data,* 55, 3548-3554.

7 Prakasham, R.S., Merrie, J.S., Saswathi, N, Ramakrishna, S.V. & Sheela, R. (1999) Bbiosorption of Cr(VI) by free and immobilized *Rhizopusarrhizus*, *Environmental Pollution*, 104, 421-442.

8 Ajmal, M., Rao, R.A.K., Ahmad, R. & Ahmad, J. (2000). Adsorption studies on citrus reticulate (fruit peel of orange): removal and recovery of Ni(II) from electro-plating wastewater, *Journal of Hazardous Materials*, 79 (1-2), 117-131.

9 Ashraf, M.A., Wajid, A., Mahmood, K., Jamil, M. M. & Yusuff, I. (2011). Removal of heavy metals from aqueous solution by using mango biomass, *African Journal of Biotechnology,* 10 (11), 2163-2177.

10 Barakat, M.A. (2011). New trends in removing heavy metals from industrial wastewater, *Arabian Journal Chemistry*, 4, 361-377.

11 Wang, X.S, Li Zhong, Z & Tao.S.R (2009), 'Removal of chromium (VI) from aqueous solution using walnut hull, *Journal of Environmental Manag*ement, 90 (2) 721-729.

12 Amir, H., Mahvi, Dariush, N., Forugh, V. & Shahrokh, N. (2005). Teawaste as An Adsorbent for Heavy Metal Removal from Industrial wastewaters, *American Journal of Applied Sciences*, 2**,** 372-375.

13 Aksu, Z. & Gonen, F. (2004). Biosorption of phenol by immobilized activated sludge in Process.*Biochemistry,* 39, (5) 599-613

14 Hanif, M.A., Nadeem, R., Bhatti, H.W., Altonaid, N.R. & Ansari, Tim (2007). Nickel(II) biosorption by cassia fistula (golden shower biomass). *Journal of hazardous materials* ,139, 345-355.

15 Semerjian, L. (2010). Equilibrium and kinetic of cadmium adsorption from aqueous solution using untreated pinushalepensis sawdust, *Journal of hazard materials*, 173, 236-242.