ADSORPTION OF HEAVY METALS (LEAD Pb II) FROM AQUEOUS SOLUTION USING *Sida Cordifolia* BIOMASS

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Abstract

The use of Sida cordifolia as low-cost adsorbents was investigated for the replacement for currently costly methods for the adsorption of Pb (II) ions from aqueous solutions. Batch adsorption studies showed that Sida cordifolia was able to adsorb Pb (II) ions from aqueous solution. The effect of contact time, effect of initial concentration, effect of adsorbent dose and effect of pH. have been reported. The result obtained indicate that the adsorption of Pb (II) on Sida cordifolia is better at lower metal ion concentration and higher adsorbent dose. The maximum adsorption capacity was found to be 94.28% which was obtained at 100mg/L. Pb (II) ion concentration 96.10 % at 1.0 mg/l adsorbent dose. pH 4 was chosen as the optimum pH. The results demonstrated that Sida cordifolia have potential to be employed as the adsorbent for the adsorption of Pb (II) metal ions from aqueous solution.

Keywords*:* Adsorption. Biosorption, Heavy Metal, pollutant, Toxicology.

Introduction

The current pattern of industrial activity alters the natural flow of materials and introduces novel chemicals into the environment (Faisal and Hasnain, 2004). The rate at which effluents are discharged into the environment especially water bodies have been on the increase as a result of urbanization. Most of these effluents contain toxic substances especially heavy metals. The presence of heavy metals in the environmental is of major concern because of their toxicity, bio-accumulating tendency, threat to human life and the environment (Horsfall and Spiff, 2005; Igwe and Abia, 2003). Lead, cadmium and mercury are examples of heavy metals that have been classified as priority pollutants by the U.S. Environmental protection Agency (U.S.EPA) (Keith *et al*., 1979).

Heavy metals are among the conservative pollutants that are not subject to bacterial attack or other break down or degradation process and are permanent additions to the marine environment (El-Nady and Atta, 1996). As a result of this, their concentrations often exceed the permissible levels normally found in soil, water ways and sediments. Hence, they find their way up the food pyramid. When they accumulate in the environment and in food chains, they can profoundly disrupt biological processes. The primary sources of heavy metals pollution in coastal lagoons are input from rivers, sediments and atmosphere, which can affect aquaculture profitability in certain areas (Krishnani *et al.*, 2004). The anthropogenic sources of heavy metals include wastes from the electroplating and metal finishing industries, metallurgical industries, tannery operations, chemical manufacturing, mine drainage, battery manufacturing, leather tanning industries, fertilizer industries, pigment manufacturing industries, leachates from landfills and contaminated ground water from hazardous waste sites (Read *et al*., 1994; Jackson and Alloway, 1991; Faisal and Hasnain, 2004). Heavy metals are also emitted from resources recovery plants in relatively high levels on fly ash particles (Neal *et al*., 1990). Rapid urbanization and industrialization generates enormous volumes of partially treated and untreated wastewater which consists of heavy metals. These heavy metals have potential health risks associated with metal uptake via food chain, dermal adsorption or inhaling. High levels of exposure to heavy metals have been known to cause cancer, organ damage, joint diseases, and in extreme cases, death (Holan and Volesky, 1995).
To alleviate the problem of health risk of wastewater associated with contaminated heavy metals, different treatment options such as chemical precipitation, chemical redox reactions, electrochemical treatment, membrane processes and ion exchange have been employed. But those technologies are extremely expensive, inefficient to very low concentrations, further toxic wastes, and creating yet another disposal problem. On the other hand, biosorption, the passive uptake of pollutants such as heavy metals by biological materials, can be both highly efficient and cost effective.

MATERIALS AND METHOD

COLLECTION OF SAMPLE

The *Sida cordifolia* used for this research was collected from the surrounding of Waziri Umaru Federal Polytechnic Birnin Kebbi, in Kebbi State.

Sample Preparation

The samples were washed to remove soluble impurities and were oven dried, the dried samples were crushed and finally ground sheaved with a mesh of 250.

Adsorption experiment

The reagent used in this study is of analytical grade. Stock solution of lead was prepared using lead Acetate in the double distilled water and the required concentration was obtained by diluting the stock solution. Adsorption experiments were carried out by adding 0.2g dried adsorbent per 100ml metal solutions stock and shaken using the shaker at 30^0c, after 2 hours the samples were taken and filtered and analyzed using atomic adsorption spectrophotometer.

Preparation of stock solution

Lead Acetate $(CH_3COO)_2$ Pb salt was used in the preparation of the salt stock solutions. Stock Pb (II) solution (1,000 mg/l) was prepared by dissolving accurately weighed amounts of Lead acetate in 1000ml distilled water. Working solution of different concentration was prepared from the stock solution by serial dilution with distilled water (Reed *et al.*, 1994).

3.2.5 Batch Sorption Experiment

Definite amount 0.2g of *Sida cordifolia leaf* was added to the metal ion solution (200ml) in a 250ml 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 by atomic adsorption spectrophotometer (AAS). 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 *Sida cordifolia leaf* in (g), Co = initial concentration in mg/L, Ce = concentration at equilibrium (mg/L). (*Ashraf et al., 2011*):

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) (Ashraf *et al.,* 2011).

Effect of biosorbents doses

To investigate the effect of biosorbent doses, 100ml of water samples at pH 4 with 100 mg/L of initial metals (Pb (II)) concentration was stirred in a 250 ml Erlenmeyer. Doses of specified biosorbent (between 0.2 to 1.2g per 100ml water) were added to each Erlenmeyer and shaken at 120 rpm for 2hours. At the end of the shaking period, the Erlenmeyers were removed from the shaker and the contents allowed to settle for 5 minutes and then filtered through whatman^{TM} filter paper. The filtrates were then separately analyzed for residual concentrations of specific metal.

Effect of pH

The optimum pH for adsorption Pb (II) by the biosorbents were determined experimentally. Metals solutions with the concentration of 100 mg/L were prepared in distilled water from the stock solutions. Samples of 100ml from this solution were poured into Erlenmeyer flasks.

Effect of contact time

The effect of contact time (5 to 30 minutes) on adsorption of metal Pb onto biosorbent was studied at the optimum stirring rate, initial metals 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 to 30 minutes) and analyzed for residual concentrations of metals.

Effect of initial metal concentrations

The effects of initial metal concentration Pb (II) on adsorption onto biosorbents *Sida cordi*folia were examined with optimum pH, doses and contact time for 100 to 300 mg/L metals concentrations in 100ml 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 (Reed *et al*., 1994).

RESULTS AND DISCUSSION

EFFECT OF pH ON ADSORBATE SOLUTION.

The effect of pH on adsorption of lead was done between the solutions pH of 2 to 6. An increase of pH beyond 6 will lead to the reaction of the metals and the metal ion causing the precipitation of OH which makes biosorption process impossible (Chimie, 2014). Lowering the pH below 2 leads to competition between proton and metal ions for the binding of the adsorbent site which results in decreasing of biosorption level.

The effect of pH on sorption of Pb(II) ion on *Sida cordifolia* is shown in fig 1. From the plot it was observed that the maximum amount of lead was adsorbed at pH of 4 with a maximum percentage removal of 97.20% where the sorption begins to reduce as the pH increased from 4 to 6. This may be due to the fact that at pH above it, the amount of OH^- ion increases causing a decrease in adsorption or metal ions (Thakur and Pamar, 2013)

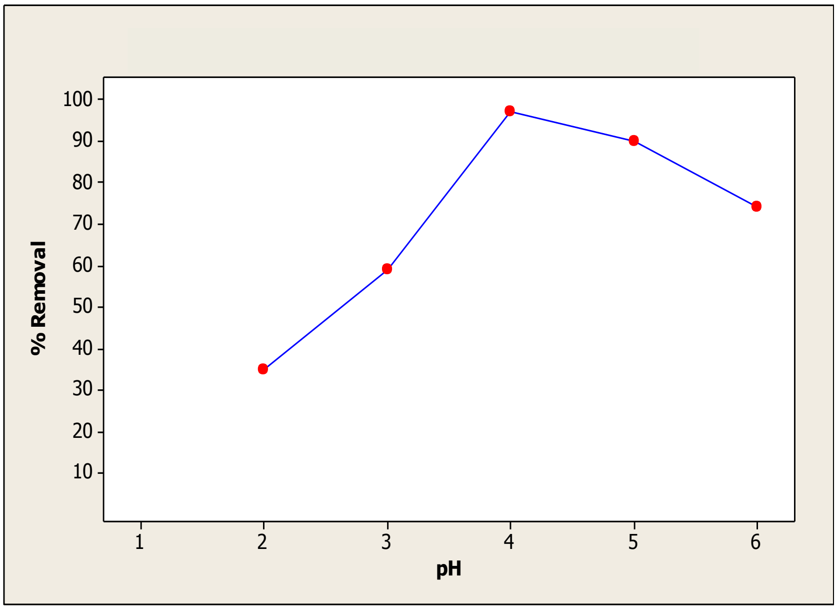

Fig 1: Effect of pH on Pb^{2+} removal

EFFECT OF *Sida cordifolia* DOSAGE ON ADSORPTION REMOVAL OF Pb (II)

A fixed volume of 100ml of metal solution containing 100mg/l of Pb^{2+} ion was used to determine the effect of dose (g) on sorptive removal of Pb^{2+} ion from an aqueous solution. As shown in Fig.2 a range of 0.2 to 1.2g/100ml dosage of *Sida cordifolia* was used for the investigation at a constant pH of 4 and contact time of 2hours (120 minutes). At a dosage of 0.4g the percentage removal was 63% which increased to 96.1% as the dosage increases to 1.0g in 100ml of metal solution. This adsorption increment is due to the fact that the availability of more adsorbate surface site for metal to adsorb will lead to increase in metal ion removal (Agarwal and gupta, 2015), further addition of the *Sida cordifolia* dosage leads to a negligible increment in the percentage removal of the Pb (II) ion.

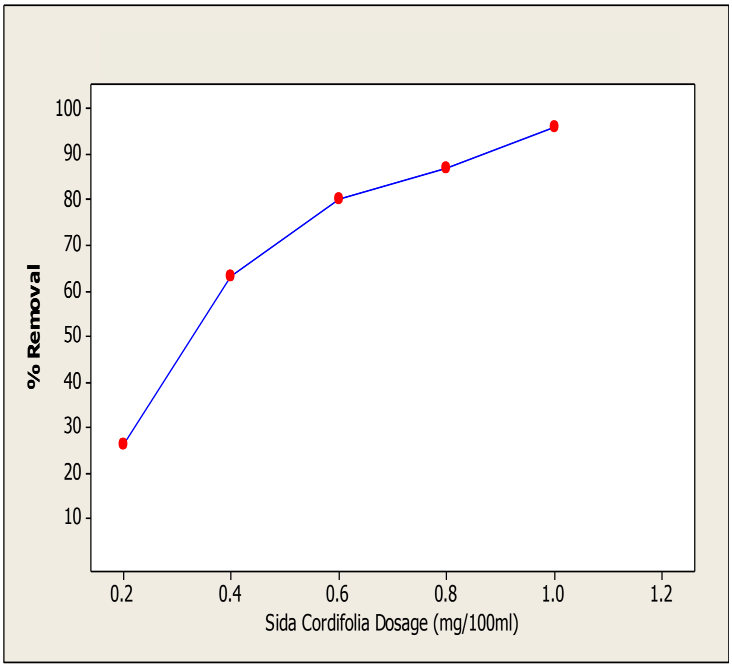

Fig 2: Effect of *sida cordifolia* dosage on Pb (II) % removal

EFFECT OF CONTACT TIME

Fig. 3 shows the effect of contact time on adsorption of Pb (II) from the aqueous solution. Adsorption of Pb (II) increased up to a time of 30 minutes after which the adsorption lead to reach equilibrium and remained constant after 40 minutes at a percentage removal capacity of 78.2% for the same concentration. The percentage removal of heavy metals increased with increase in contact time till equilibrium is attained (Thakur and Parmar, 2013).

The result shows that the optimal contact time of Pb (II) to attain equilibrium with *Sida cordifolia* adsorbed was 40 minutes with removal efficiency of 78.22%.

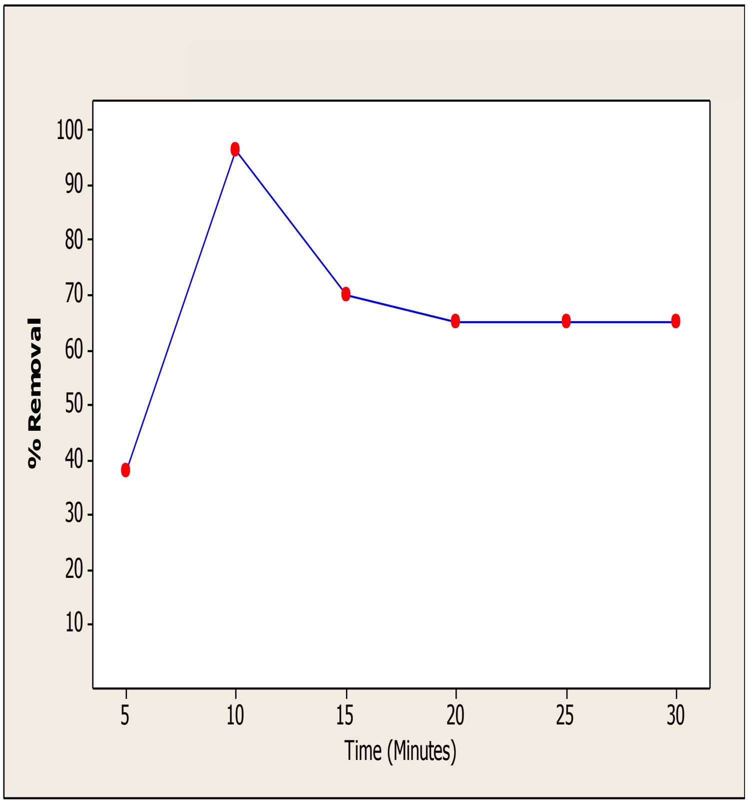

Fig3: Effect of contact time on Pb (II) removal at pH4.

EFFECT OF INITIAL METAL ION CONCENTRATON

The rate of adsorption is a function of initial concentration of metal ion which makes it important factor to be considered for effective biosorption (Itodo *et al*., 2014).

Figure 4 shows that the removal efficiency of the Pb (II) ion by *Sida cordifolia* decreases with increasing the metal ion concentration. This is due to the fact that at low concentration biosorbent site takes up available metal more quickly and when the metal ion concentration is high the metal removal rate decreases due to the saturation of the binding sites (Abdelghani and Elchaghaby, 2014).

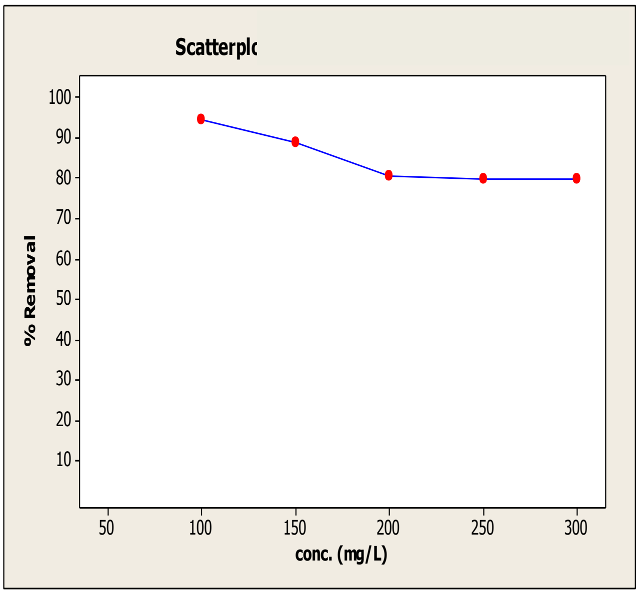

Fig 4: Effect of initial concentration on % Pb (II) removal

CONCLUSION

From the above study, it may be concluded that the leaf of *Sida cordifolia* has a great potential to be used as a low cost effective adsorbent material for the removal of Pb (II) ion from aqueous solution. The sorbent does not require any chemical modification and hence may be considered as an environmental friendly sorbent.

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