Biosorption of Lead (II) Ions from Aqueous Solution by Treated Corn (Z. Mays) Leaves Biomass

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***Abstract*-Biosorption of Lead (II) ions from aqueous solution by treated corn (Z. Mays) leaves biomass was studied. The biosorption percent of Lead (II) ions onto treated Z. Maysleaves biomass was evaluated as a function of pH, amount of dose and contact time. The treatment of biosorbent using alkali resulted in an increase in the biosorption. The maximum percentage uptakes values were found as 97.6% at pH 3, 94.1% with the amount of 3.0 g of biosorbent and 93.3% at 180 minutes of contact time with initial Lead (II) concentration of 10 mgL^{-1}. Metal uptake of Lead (II) ions was 0.4833 mg/g at pH 3, 1.74 mg/g with 3.0 g amount of biosorbent and 0.31 mg/g at 180 minutes contact time. The treated Z. Mays biomass was found to be suitable and potential for removal of Lead from aqueous solution.**

Keywords- Z. Mays; Biosorption; Biosorbent; Lead; Biomass

I. INTRODUCTION

Pollution of the environment by toxic heavy metals arises as a result of many activities, which are largely industrial; however, sources such as agriculture and sewage disposal also contribute to the pollution. Heavy metals such as Cadmium, Zinc, Copper, Nickel, Lead, and Mercury are often detected in industrial wastewaters which originate from industries such as metal plating, mining activities, smelting, battery manufacturing, tanneries, petroleum refining, paint manufacturing, pesticides, pigment manufacturing, printing and photographic industries [16, 9, 3]. Due to their toxicity even at low concentrations, they are vital because they may play a toxic role, depending on their concentrations and the nature of the considered organisms. With further rapid economic growth and clustering expected, the environmental pollution by toxic heavy metals can only worsen unless countermeasures are adopted in time [5]. Some commonly used procedures or conventional methods for removing metals ions from dilute aqueous streams are chemical precipitation, chemical oxidation and reduction, ion exchange, filtration, electrochemical treatment, reverse osmosis, evaporative recovery and solvent extraction. However, these methods are generally expensive and have the potential of generating hazardous by-products [19, 7, 13]. With the increase in environmental awareness and governmental policies, there has been a push towards development of new environmentally friendly ways to clean contamination by using low cost methods and materials.

Biosorption is an emerging technology that uses biological materials to remove metals from solution through adsorption. Biosorption is the removal of metal ions from solution by biological materials. Biosorbent from biological materials contains various types of functional sites such as amino, hydroxyl and carboxyl where it can react to form passive uptake of metals from wastewater [6, 16, 17]. Biosorption is a promising technology as it offers lower operating costs, reduced amount of disposal of chemical sludge, and efficiency in decontinuating effluents with dilute metal ion content [10].

This study focused on the metals ions in industrial wastewater. The objective of this study is to determine the optimum biosorption conditions as a function of pH, amount of biosorbent dose and contact time in the biosorption of Lead by treated Z. Mays leaves biomass. For each parameter, it is defined by calculating the percentage uptake and metal uptake in biosorption of Lead (II) ions from aqueous solution.

II. MATERIALS AND METHODS

A. *Materials*

1) *Treated Z. Mays Biosorbent Preparation:*

Z. Mays leaves were used as a biosorbent. The biosorbent preparation began with the collection of Z. Mays leaves. Then, it was washed using deionized water and air-dried. The washed biomass was then alkali treated by boiling it for 15 min in 0.5 M NaOH. After that, it was placed in the oven for 24 hours at 80°C for further drying. The dried Z. Mays leaves were then grinded. The 0.075 mm size was obtained by using sieve. Finally, the ground dried Z. Mays leaves biomass was stored in a plastic bag for the biosorption study.

2) Lead (II) Ions Aqueous Solution Preparation:

Lead (II) ions standard solution was prepared by diluting 1000 mgL^{-1}Lead (II) standard solution into series of concentration of Lead (II) ions aqueous solution to make 10 mgL^{-1}Lead (II) aqueous solutions. The reagents used were of analytical grade.

B. Method

1) Biosorption Parameter of Treated Z. Mays Biomass:

Three parameters were evaluated in this study in order to determine the percentage uptake and metal uptake by treated Z. Mays leaves biomass in biosorption of Lead in aqueous solution. Three samples were prepared by shaking 100 ml Lead(II) ions aqueous solution containing the appropriate amount of treated Z. Mays leaves biomass at 150 rpm at room temperature.

2) The pH Dependence Batch Experiment:

The pH of metal solutions has been identified as the most important variable governing metal sorption because it influences not only the specification of metal ions but also the charges on the sorption site of the biomass type [14, 11, 12]. This is partly because hydrogen ions themselves are competing with biosorbates [1]. Since biosorbent from biological materials contains various functional groups, at lower pH, cell walls ligands are protonated and compete significantly with metal binding. With increasing pH, more ligands such as amino and carboxyl groups would be exposed which leads to attraction between these negative charges and the metals and hence increasing the biosorption on the cell surface [4, 18]. The effect of pH on biosorption was evaluated. Experiment was carried out at different initial pH values. The pH ranges chosen were 1.0 to 8.0 for Lead (II) ions solution. 2.0 g of treated Z. Mays leaves biomass and 10mgL^{-1} of Lead (II) ions solution was used. Throughout this step, the mixtures were shaken at 150 rpm for one hour, then were filtered and analyzed using ICP-OES for Lead (II) ions.

3) The Biosorbent Dose Dependence Batch Experiment:

The influence of biosorbent concentrations on Lead biosorption by treated Z. Mays leaves biomass was evaluated at pH 3. Biosorbent doses were varied from 0.5 g to 3.0 g (0.5 g, 1.0 g, 1.5 g, 2.0 g, 2.5 g, and 3.0 g).

4) The Time Dependence Batch Experiment:

The time dependence batch experiments were performed at the pH 3 and optimum amount of biosorbent dose, 3.0 g by shaking the 10 mgL^{-1}Lead (II) ions solution containing treated Z. Mays leaves biomass at varied time using a shaker at 150 rpm. The contact time chosen for the time dependence studies were 1, 2, 3, 4, 5, 6, and 7 hours.

C. Biosorption Analysis

The following equations were used to compute the percentage uptake and metal uptake of Lead (II) ions by the treated Z. Mays leaves biomass;

$$\%metal\ uptake = \frac{C_o - C_f}{C_o} \times 100$$

(Eq.1)

Where:

C_o=initial concentrations of Lead (mgL^{-1})

C_f =final concentrations of Lead (mgL^{-1})

$$q = (C_o - C_f) \times \frac{V}{M}$$

(Eq.2)

Where,

q = metal uptake (mg/g)

C_o=initial metal concentrations in the solution (mgL^{-1})

C_f =final metal concentrations in the solution (mgL^{-1})

V = solution volume (L)

M= the mass of biosorbent (g)

The biosorption process for Z. Mays leaves biomass is summarized in the following flow diagram:

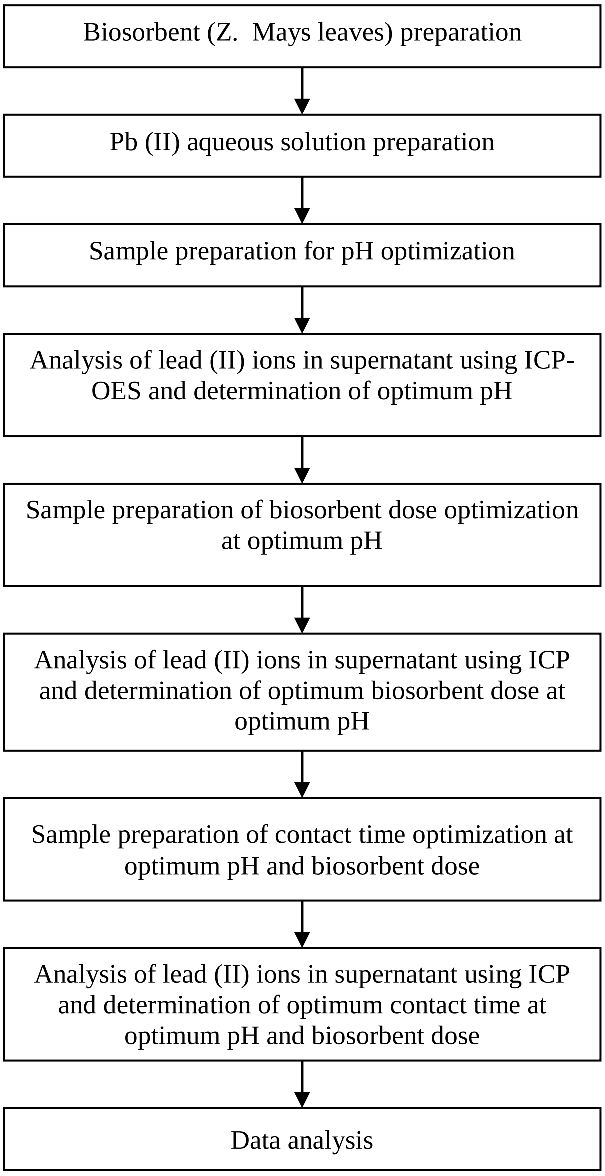

Fig. 1 Flow diagram for the biosorption of lead (II) ions from aqueous solution by using treated Z.Mays leaves biomass

III. RESULTS AND DISCUSSION

A. The pH Dependence Batch Experiment

The influence of pH of the metal ion solution on the sorption of Lead (II) ions by treated Z. Mays leaves biomass has been studied. The pH of solution was found to significantly influence the biosorption. According to previous study [19], the maximum absorption and uptake capacity of Lead by pretreated orange peel was observed at pH 4.5-6.0. In this study, the initial Lead solution was fixed at 10 mgL^{-1} and solution pH was varied from pH 1 until pH 8. Fig. 2 shows the percentage uptake of Lead (II) ions from aqueous solution by treated Z. Mays leaves biomass at different pH. Only 71.4% of biosorption occurred at pH 1, increases at pH 2 and maximum biosorption occurred with 97.6% at pH 3. The biosorption remains relatively constant at pH 4 and pH 5 and above pH 5 it began to decrease. Meanwhile, the metal uptake by treated Z. Mays leaves biomass was studied by batch experiment technique. The constant V/m was used in calculating the metal uptake as shown in Eq. 2. As shown in Fig. 3, the metal uptake by this biomass showed a similar trend with the percentage uptake. It was found that the optimum metal uptake was 0.48 mg/g at pH 3. It remained relatively constant at pH 4 and pH 5 and above pH 5 it began to decrease. At low pH, biosorption of Lead (II) ions was minimum due to the presence of hydrogen ions, which prevents the Lead (II) ions from binding to the binding sites on the biosorbent and resulting in the repulsive force. At highly acidic pH ($pH < 2.0$), the overall surface charge on the active sites became positive and metal cations and protons compete for binding sites on cell wall, which results in lower uptake of metal [2, 8]. Biosorption decreases above pH 6 which may be attributed to the presence of hydroxide ions in the solution. The hydroxide ions caused the hydrolysis of Lead (II) ions and formed precipitates of Lead (II) ions that decrease the efficiency of metal uptake of treated Z. Mays leaves biomass [1].

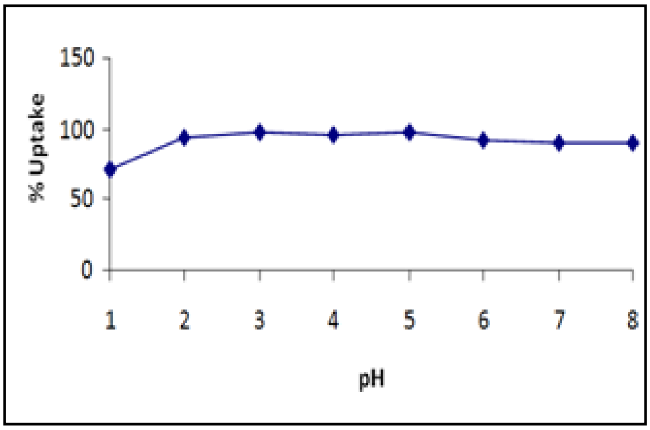

Fig. 2 The Percentage Uptake of Lead (II) Ions from Aqueous Solution by Treated *Z. Mays* LeavesBiomass at Different pH

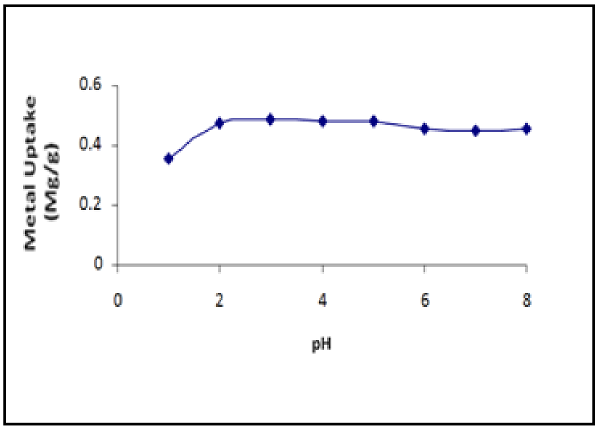

Fig. 3 Metal Uptake of Lead (II) Ions from Aqueous Solution by Treated *Z. Mays* Leaves Biomass at Different pH

B. The Biosorbent Dose Dependence Batch Experiment

The effect of biosorbent dose to the biosorption of Lead (II) ions from aqueous solution was studied. The concentration of Lead (II) solution was fixed at 10 mgL^{-1} and the shaking time was 1 hour, while the amount of biosorbent were varied from 0.5 g to 3.0 g, the amount of Lead adsorbed increases with the increase in S. CuminiL. dosage [8]. The percentage of Lead removal increases from 87.1 to 98 % for an increase in biomass dosage from 0.1 to 0.5 g at an initial concentration of 20 mgL^{-1}. Fig. 4 shows the percentage uptake of Lead (II) ions from aqueous solution by treated Z. Mays leaves biomass at different amount of biosorbent. It was observed that the amount of Lead (II) ions adsorbed varied with varying adsorbent dosage. The biosorption increases with increase in biosorbent dosage. Similar trend was also observed for Lead removal using S. CuminiL. as biosorbent. The maximum amount of dosage within range of dosage studies was 3.0 g with the percentage uptake was 94.9%. The increase of percentage uptake was due to increasing biomass surface area. The metal uptake by treated Z. Mays leaves biomass also was studied for this parameter. Fig. 5 shows the metal uptake of Lead (II) ions from aqueous by treated Z. Mays leaves biomass at different amount of dose. It was observed that the metal uptake decreases with the increase of the amount of dose. The highest metal uptake value for this study was 1.74 mg/g at 0.5 g and the lowest metal uptake was 0.31 mg/g at 3.0 g of the biosorbent.

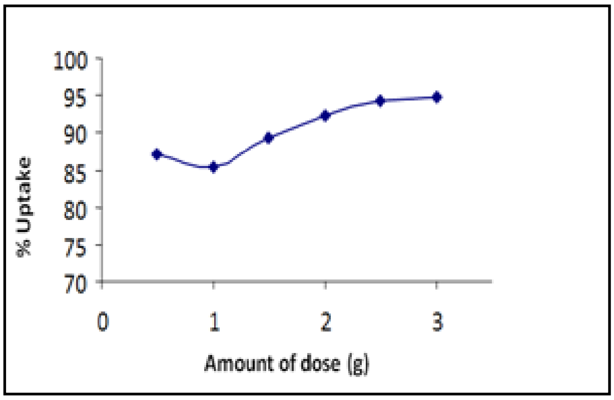

Fig. 4 The Percentage Uptake of Lead (II) Ions from Aqueous Solution by Treated *Z. Mays* Leaves Biomass at different amount of dose

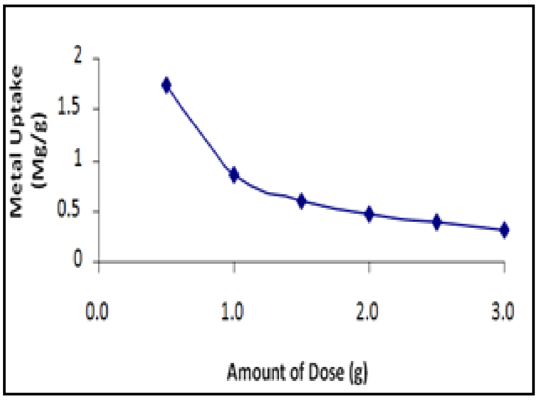

Fig. 5 Metal Uptake of Lead (II) Ions from Aqueous Solution by Treated *Z. Mays* Leaves Biomass at Different Amount of Dose

C. The Time Dependence Batch Experiment

The effect of contact time to the biosorption of Lead (II) ions was studied by using Lead nitrate solution 10 mgL^{-1} at pH 3 and the amount of biosorbent used was 3.0 g. The relation between the contact time and the percent biosorption of Lead (II) ions by treated Z. Mays leaves biomass is shown in Fig. 6. The sorption equilibrium was rapidly established in about one hour [19]. In this study, the Lead biosorption reaches equilibrium state at 180 minutes of contact time. The percent uptake was relatively constant about 93%. When it reaches the equilibrium, the biosorption of Lead (II) ions did not significantly change with time. This was due to the saturation of binding site. While metal uptake of Lead (II) ions from aqueous solution by treated Z. Mays leaves biomass at different contact time is shown as in Fig. 7. It was similar with the result for the percentage uptake. The metal uptake reaches equilibrium state at 180 minutes of contact time with about 0.3 mg/g.

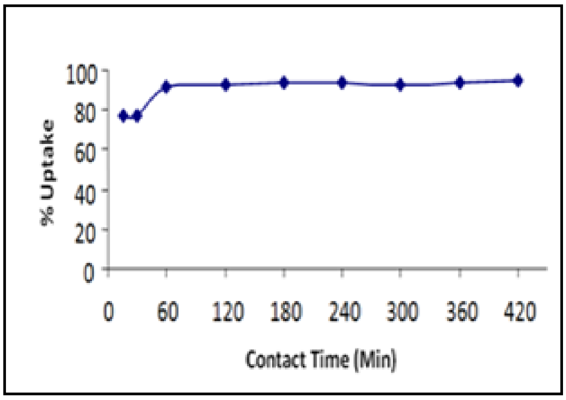

Fig. 6 The Percentage Uptake of Lead (II) Ions from Aqueous Solution by Treated *Z. Mays* Leaves Biomass at different Contact Time

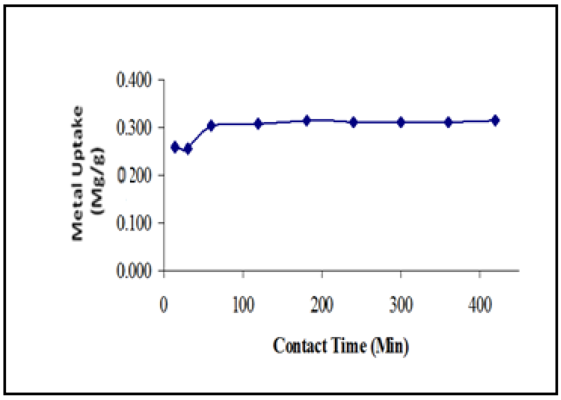

Fig. 7 Metal Uptake of Lead (II) Ions from Aqueous Solution by Treated Z. Mays Leaves Biomass at Different Contact Time

IV. CONCLUSION

In conclusion, the results presented in this work show that Lead (II) ions were potentially removed by treated Z. Mays leaves biomass. The Z. Mays leaves that were treated with 0.5 M NaOH gave high potential in removing heavy metals from aqueous solution. From this study, alkali treated Z. Mays resulted above 90% of Lead (II) ions removal in all three parameters that were investigated which were pH, amount of dose and contact time.

The pH of the aqueous solution strongly affects the percent uptake and the metal uptake. The minimum biosorption occurred at pH 1 with 71.4 %, biosorption increase at pH 2 and optimum biosorption at pH 3 with 97.6 %. The biosorption remains relatively constant at pH 4 and pH 5 and above pH 5 it began to decrease. This result was similar for the metal uptake for this parameter, which is 0.4883 mg/g at pH 3. The amount of Lead (II) ions adsorbed varied with varying biosorbent dosage. The optimum amount of dosage was 3.0 g with the percent uptake was 94.91%. The metal uptake decreases with the increase of the amount of dose. The highest metal uptake value was 1.7439 mg/g at 0.5 g and the lowest metal uptake was 0.3158 mg/g at 3.0 g of the biosorbent. For the contact time parameter, the Lead (II) ions biosorption and metal uptake reaches equilibrium state at 180 minutes of contact time with about 93% and 0.3 mg/g respectively.

These results indicate the possibilities that exist in the cleanup of the environment with the use of agriculture waste. Thus, alkali treated Z. Mays leaves biomass can be used as a biosorbent of Lead (II) removal from aqueous solution and biosorption provides a reusable material and environmentally friendly technology in removing heavy metals.

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