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REMOVAL OF LEAD (II) IONS FROM SYNTHETIC WASTEWATER USING *ACALYPHA INDICA* LEAVES BIOCARBON - A NOVEL APPROACH.

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ABSTRACT

Lead is a very toxic element known to cause detrimental effects to human health even at very low concentrations. Biosorption is a versatile method for the removal of heavy metals from industrial wastewater. In this study, a novel biocarbon is produced from leaves of the medicinal plant called *Acalypha indica* by the sulphuric acid activation process. The biosorption capacity of the biocarbon was evaluated by considering the effect of various parameters such as pH of the solution, biocarbon dose, contact time, and initial metal ions concentration and to optimize the conditions for maximum adsorption. Batch adsorption kinetic experiments revealed that the adsorption of Pb (II) onto *Acalypha indica* leaves biocarbon (AIBC) involved a fast process. The adsorption process was found to be highly pH dependent, which made the biocarbon particles selectively adsorb this metal from synthetic wastewater. The biosorption results reveal that 94.8% of Pb (II) was removed from the synthetic wastewater. The optimum pH required for maximum adsorption of lead was found to be 6.0. The maximum contact time for the equilibrium condition is 150 min and the optimum biocarbon dose was 2.5g/100mL. The experimental data clearly demonstrated that AIBC can be used as a suitable adsorbent for Pb (II) ion removal from any industrial wastewater.

Keywords: *Acalypha indica*, Biosorption, Biocarbon, Lead, Industrial wastewater.

INTRODUCTION

The life forms on earth and the environment faces a very serious threat from the heavy metal pollution has been one of the important environmental problems due to their toxicity, persistence and bioaccumulation affinities. Metals and their compounds are essential to the industrial, agricultural, and technological development of any country. The various applications of metals for commercial uses continue to grow with the developments in modern science and technology [1, 2].

Many of the industries consume a large volume of fresh water for their industrial operations including production, cooling and cleaning purposes. Equally, it releases plenty of wastewater which contains appreciable amounts of various pollutants including toxic heavy metals. Heavy metal pollution is not a recent problem, but its management and prevention are still of global concern [3].

Particularly, heavy metal pollutants are predictable contaminants that are not easily biodegradable chemically or biologically. When these metals are present in significant quantities in the environment, they constitute a source of pollution and a great threat to the environment, human, animal and aquatic organisms. Removal of trace amounts of heavy metal ions from wastewater and drinking water is of extraordinary significance due to their high toxicity [4, 5].

Lead is one of the most toxic elements found in nature. Its pollution in the environment is primarily due to anthropogenic activities, making it the most ubiquitous toxic metal in the environment [6]. It affects the central nervous system, kidney, liver, and gastrointestinal system, and it may cause many diseases such as anemia, encephalopathy, hepatitis, and the nephritic syndrome directly or indirectly [7, 8]. It enters into natural waters from various industrial activities such as metal plating, oil refining, and manufacturing of storage batteries, printing, paints, pigments, photographic materials, gasoline additives, matches and explosives [9, 10].

Removal of toxic metals from industrial wastewater is primarily achieved by the application of several processes such as adsorption, precipitation, electroplating, chemical coagulation, ion-exchange, reverse osmosis, membrane separation and electrokinetics. Each method has been found to be limited to cost, complexity, and efficiency, as well as secondary waste disposal problems [11 – 15].

In recent years, development of different types of low-cost adsorbents from agricultural wastes and surface modified activated carbon has gained importance in wastewater treatments. Adsorption and biosorption is a versatile and simple method for the removal of different pollutants from industrial wastewater [16]. Recently, a variety of cheap materials has been examined as adsorbents for the removal of heavy metals from aqueous solution with the aim of finding cheaper alternatives for conventional sorbent materials such as commercial activated carbon. Some of the low-cost adsorbents include snail shell waste, bamboo waste, tea waste and other industry waste materials which have been used for the purpose [17 – 20].

In the current research studies, a novel biocarbon is produced from a medicinal plant called *Acalypha indica*. The use of leaves biocarbon and its metal removal performance would add to its economic value, help reduce the cost of waste disposal, and most importantly, provides a potentially inexpensive alternative to existing commercial activated carbon.

MATERIALS AND METHODS

Preparation of Metal Solution

The concentration of 1000 mg/L of Pb (II) ions was prepared by dissolving 1.615g of pure analytical grade $Pb(NO_3)_2$ substances in 1L of deionized water. Further, working solutions were prepared by dilution with deionized water to obtain the concentration of 25 – 100 mg/L.

Preparation of Biocarbon

Acalypha indica is an important medicinal plant widely dispersed in agricultural fields. The plant leaves were collected and air dried for 48 h. The dried leaves were pulverized in ball mills and screened homogeneous powder was used for the preparation of biocarbon. It is prepared by treating the leaves powder with the concentrated sulphuric acid (Sp. gr.1.84) in a weight ratio of 1:1.8 (biomaterial: acid). The resulting black product is kept in an air-free oven, maintained at 160 ± 5 °C for 6 h followed by washing with double distilled water until free of excess acid, then dried at 105 ± 5 °C. The particle size of biocarbon screened between 100 and 120 µm was used. This material is used as an adsorbent in the treatment of industrial wastewater [21].

Biosorption Process

In the biosorption process, rationalization of biocarbon does and respective contact time for attaining proper equilibrium is very much essential. Hence, in the biosorption experiment, the contact time is kept constant at 180 min and pH of the original test solution was 6.0. The impact of biocarbon dose was carried out by varying from 0.5 – 4.0g with the initial concentration of Pb (II) as 100mg/L in eight Erlenmeyer flasks of 250mL capacity. All the experimental flasks were fitted in Remi orbital shaker system and equilibrated at 250 rpm for specified contact time.

Subsequently, by fixing the biocarbon does of 2.5g/100mL the effect of pH was carried out at in the range of 2–8. The pH of the metal solution was adjusted using 0.1M NaOH and 0.1M HCl. The contact time was established by changing the time from 30 to 210 min. The effect of temperature was investigated from 30 to 80 °C using a temperature controlled agitation system.

The influence of initial metal ion concentration on the removal of Pb (II) ions was also done using the concentration from 25 to 75 mg/L at a pH value of 6.0. After the accomplishment of each experiment, the content of the flasks was filtered and Pb (II) ions concentrations in the filtrates were determined using the Perkin Elmer AAS. The amount of metal ions adsorbed in milligram per gram was determined using the mass balance equation:

$$q_e = \left(\frac{C_o - C_e}{w} \right) \times V \qquad (1)$$

Where q_e = amount of metal ions adsorbed (mg/g), V = volume of synthetic wastewater (mL), w = mass of biocarbon (g), C_o = initial metal ions concentration (mg/L) and C_e = concentration of metal ions at equilibrium (mg/L). The percent of metal ions removal was evaluated from the equation:

$$\%\ \text{Removal} = \left(\frac{C_o - C_e}{C_o} \right) \times 100 \qquad (2)$$

The analytical data were analyzed and standard deviations of the statistical tests were carried out using program of analysis of variance (ANOVA) by using SPSS program.

RESULTS AND DISCUSSION

Physicochemical Analysis of Biocarbon

The physicochemical analysis of the biocarbon is very important to ascertain the biosorption capacity of the biocarbon material. Most importantly, the surface area examination of the biocarbon reveals that its surface area is 335 (m^2/g). The bulk density is 0.85 (g/mL) and the methylene blue index is 38.4 (mL/g). The moisture content of the biocarbon is 4.98%. The yield of the biocarbon is 87.5%. The results support that, the biocarbon has excellent potential for biosorption of heavy metals in wastewater.

Effects of Contact Time and Initial Metal Ions Concentrations

The influence of contact time and initial metal ion concentrations on the amount of metal adsorbed on the biocarbon matrix is illustrated in Figure 1. The adsorption processes steadily increase progressively to 150 min and then became slower. The progressive initial sorption process was likely due to extracellular binding and the slower sorption likely resulted from intracellular binding as the biocarbon surfaces were being mostly covered by metal ions. The events of metal ions uptake as a function of time is a continuous process and leading to saturation. This is due to the possibility of monolayer coverage of the metal ions on the surface of the adsorbent [22]. The amount of metal ions adsorbed per unit weight of biocarbon was found to be increased with the increasing initial metal ions concentration. This is due to the enhanced driving force expedited by abundantly available metal ions in solution [23, 24].

Effects of pH and Biocarbon Dose

Influence of pH of the solution is one of the most important analytical factors in adsorption of metal ions in aqueous solution. It has a significant role in solubility of metal ions, surface charge on adsorbent and degree of protonation of binding sites on the biocarbon during the sorption process [25, 26]. There are four probable forms of lead at different pH values exist in solutions are Pb^{2+}, $Pb(OH)^{+}$, $Pb(OH)_2$, and $Pb(OH)^{3-}$. Normally, at pH < 6, the dominant form of the lead is Pb^{2+} while with an increase in pH, other forms are created. It is noticed from the Figure 2 that, the sorption process is initiated from pH 3.0 and below this pH value, there is no adsorption. This trend can be attributed to competition between H^+ and Pb (II) ions for occupying the available active sites [27]. The optimum pH for the removal of Pb (II) ions in this experiment is found to be 6.0.

The effect of the amount of biocarbon on the removal percentage of Pb (II) ions was shown in Figure 3. It is clearly seen that an increase in adsorbent dose is in favor of Pb (II) ions removal. The sorbent dose increases from 0.5 to 4.0g and the percent removal of Pb (II) ions progressively increased. The maximum removal of 94.8% is attained at the optimum biocarbon dose of 2.5g/100mL. Increase in adsorption with adsorbent dosage can be attributed to increased adsorbent surface area and availability of more adsorption sites [28].

Effect of Temperature on Adsorption

The effect of temperature on Pb (II) ions removal was studied at six different temperatures from 30 to 80 °C. The results are presented in Figure 4, and it is clearly noticeable from the figure that increasing the temperature significantly affected the amount of Pb (II) ions. The improvement in the adsorption on biocarbon matrix might be due to the chemical interaction between metal ions and sorbent sites or the increased rate of intraparticle diffusion of Pb (II) ions into the pores of the biocarbon [29, 30].

Figure 1. Effect of contact time and initial concentrations.

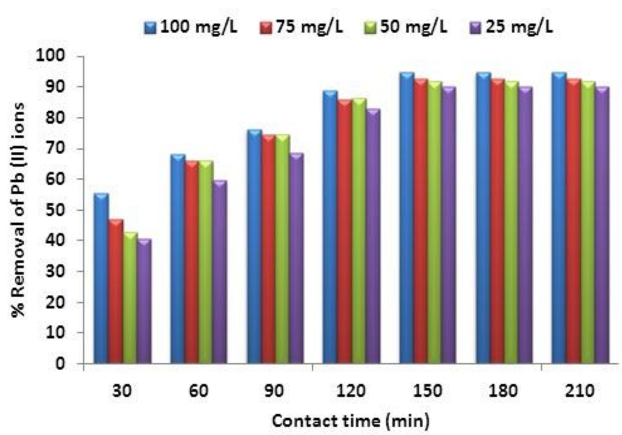


Figure 2. Effect of pH on the removal of Pb (II) ions.

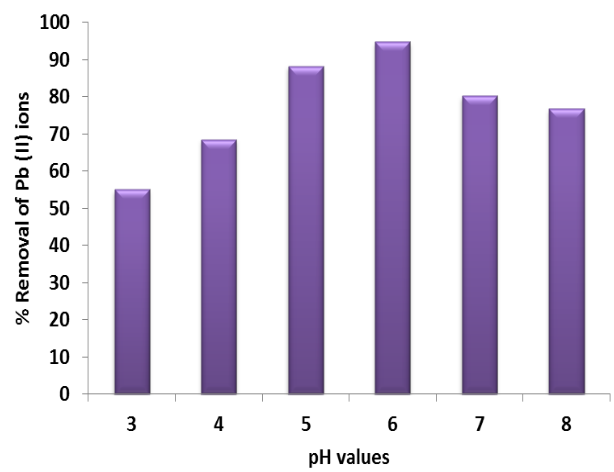


Figure 3. Effect of biocarbon dose on the removal of Pb (II) ions.

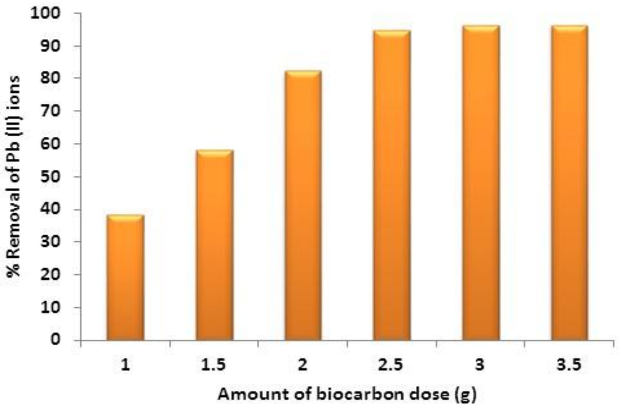
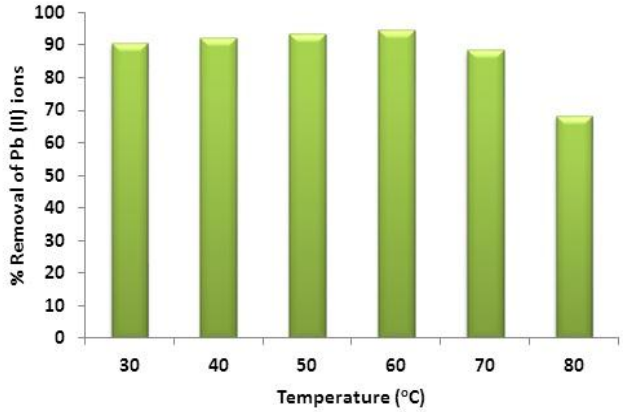


Figure 4. Effect of temperature on the removal of Pb (II) ions.



CONCLUSION

The adsorption capability of *Acalypha indica* leaves biocarbon (AIBC) has been investigated. The analytical results reveal that it has been successfully used to produce high-quality adsorbent because of its inherent high densities and rich carbon content. The main benefits of this removal procedure include simplicity, cost effectiveness, rapidity and a higher removal efficiency of lead ions. The sorption process is pH dependent and the maximum adsorption capacity of Pb (II) is at pH 6.0. It is found that 94.8% of Pb (II) ions removal is achieved in synthetic wastewater with the short time period of 150min. The main adsorption mechanism is probably a chemisorption reaction.

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