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STUDY ON REMOVAL OF LEAD FROM AQUEOUS SOLUTION USING EICHHORNIA CRASSIPES

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ABSTRACT

In this study, Eichhornia crassipes (EC) was used as an adsorbent for the removal of Lead (Pb) from aqueous solution and the adsorption studies were performed in the laboratory by conducting batch experiments. The concentration of the solutions prepared was in the range of 20–100 mg/L, which are diluted as required for batch experiments. The effect of contact time, pH and adsorbent dosage on the removal of lead by adsorption was investigated and studied. It is observed that the maximum percentage of removal of lead was measured as 88.55% by increasing dosage of adsorbent concentration with increasing contact time of neutral pH.

KEYWORDS: Heavy Metals, Eichhornia Crassipes, Bio-Sorption, Adsorbent and Aqueous Solution

INTRODUCTION

The awareness of increasing water pollution implies studies concerning water treatment. Removal of heavy metals from industrial wastewater is of primary importance. The use of natural materials for heavy metals removal is becoming a concern in all countries. Natural materials that are available in large quantities or certain waste from agricultural operations may have potential to be used as low-cost adsorbents, as they represent unused resources, widely available and are environmentally friendly [1].

Heavy metals are considered as the most toxic environmental pollutants. Its contamination of water bodies presents a severe hazard to public health and environment owing to their accumulation in the food chain as non-biodegradable pollutants and persistence in nature. The treatment and removal of these heavy metals from water or wastewater are really challengeable [2]. Various methods (e.g. ion exchange, chemical precipitation, membrane technologies, electrochemical treatment, and evaporation) have been developed for removing heavy metals from contaminated water. However, most of these methods suffer from some drawbacks, such as energy consumption, high reagent or the disposal of the residual floc residues that cause secondary pollution, and especially are not suitable for low concentrations of dissolved metal(s) ranging between 1 and 50 mg/l [3].

Constant efforts are being made to develop improved and innovative methods of wastewater treatment. While developing new methods, economic feasibility and user-friendly concepts are given much importance. Various processes for the removal of metals are available but the most commonly used process is precipitation. By the addition of suitable reagent of the required quantity, under proper reaction condition makes the metal precipitated. But the sludge that is formed contains more amounts of heavy metals and the disposal of such sludge creates another problem. So other treatment processes like ion exchange, reverse osmosis or adsorption processes are required subsequently after the precipitation process and before discharging into water bodies. So the removal of metal requires two processes when the contents are very high. Because in the first process it removes the high metal concentration and in the second process it removes the residual low metal concentration. So the cost of this two-stage treatment is high which sometimes is not suitable for most of the industries. Keeping this in view, considerable attention has been given to developing low-cost adsorbents for the removal of the different heavy metals when the concentration is not very high [4]

In recent decades, a number of research studies demonstrated that biosorption can be used to remove metals from aqueous solutions. Biosorption is an emerging technology that uses biological materials, such as biosorbents, for metal removal from water. In addition, biosorption is a cost-effective and eco-friendly alternative for metal adsorption [7]. Biosorption capacity is highly influenced by some operational conditions, for instance, temperature, pH solution, metal and biomass concentration, stirring speed, and particle size, among others. In addition, the physical-chemical properties of biosorbents and pollutants play a major role in biosorption processes. But several researchers have reported the effects of those operational conditions individually [5]. Lead is used as an industrial raw material for electric battery manufacturing, plating, mining, and tanneries. Due to its acute and chronic toxic effects in animal and human health, Environmental Protection Agency (EPA) standard for lead in drinking water and wastewater is 0.05 and 0.5 mg L−1, respectively [6].

Most of the metal biosorption studies have been conducted taking very high concentration (1000 ppm) of heavy metals and sorbents, which seldom exist. Therefore, it is appropriate to carry out metal sorption studies at low and/or natural concentration of the metals in the industrial effluent as well [6]. Most leaf powder can serve as potent metal sequestering biosorbent. Because of this economical and efficient techniques, based on leaf powder, can be developed for adsorption of heavy metals [9].

The present investigation examines the feasibility of using Eichhornia Crassipes (EC) leafs as a sorbent, it is a floating aquatic macrophytic plant abundantly floated in meso and eutrophic water bodies such as ponds, lakes, rivers and reservoirs etc,. The objectives of the study which reveals the adsorbent capacity of lead (Pb), analyzing the effect of pH of the aqueous solution in the removal of Pb, effect of different doses of biomass in absorption, and contact time.

MATERIALS AND METHODS

Preparation of Biomass

After collecting a required quantity of EC leaves in a jute bag, it was dried in sunlight for three days. The leaves were washed first with tap water, de-ionized water and oven-dried at 80 °C for 24 h, grounding in a ball mill and sieved to particle size range of 200 to 300 μm for use. The powder is washed twice with distilled water to remove unwanted materials, followed by washing with 0.1 HCl solutions, which is diluted with distilled water and heated it for 10 minutes. Finally, the biomass is washed with distilled water until all the color of the biomass is removed.

Preparation of Stock Solution and Biosorption Studies

The solution of lead is prepared by dissolving lead metal in concentrated HCl. The concentration of the prepared solution is 1000 ppm. The solution of lead was prepared by diluting to 1000ml by dissolving 1.598g of $Pb(NO_3)_2$ in a minimum amount of 1+1 HNO_3 and add 10ml of concentrated HNO_3. From the stock solution, 6 ml of solution is taken and added with 994 ml of distilled water the 6ppm of the lead solution is used for experimental pourpes1g of biomass powder was contacted with 100ml metal ion solution in a conical flask by placing it in a mechanical shaker. Sample was taken out at the specific duration of time and centrifuged at 1000rpm for 15min. The supernatant liquid was separated for low residual Pb ions and analyzed by AASP. The Atomic Absorption spectrophotometer 210 CHEMTO (AASP) is a spectroanalytical procedure for the quantity determination of chemical elements using the absorption of optical radiation (light) by free atoms in the gaseous state.

RESULTS AND DISCUSSIONS

Effect of Contact Time on Removal of Lead from EC

Figure 1 indicates the uptake of metal ions vs. contact time at pH 6.35 and the initial dosage of biomass as 1 g. The removal Pb ranges between 76.87% and 85.75% at 60-300 min at the concentration of 100 ppm. The rate of Pb binding with EC leaf powder is more at initial stages and further gradually increases and remains constant during the period. Equilibrium contact time was found to be 120 min. These results are important, as equilibrium time is one of the important parameters for selecting a wastewater treatment system. Where the time consumed for wastewater disposal should be considered.

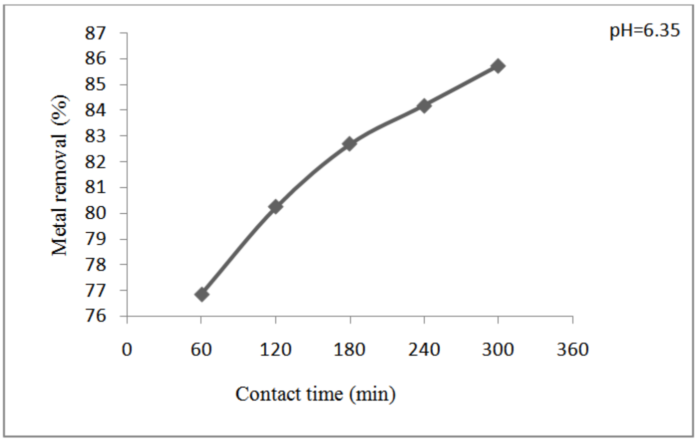

Figure 1: Effect of Contact Time on Percentage of Removal of Pb by Eichhornia Crassipes

Effect of pH on Adsorption

The effect solution of pH on the Pb removal was studied by varying the initial pH and keeping the other process parameter as constant. The experiments were carried out at 1.0 g/100 mL EC leaves powder mass at room temperature at different initial pH of the aqueous solution (pH 2.0 ~ pH 11.0). The effect of solution pH on the uptake of Pb is presented in figure 2. The figure also shows that Pb removal increased drastically in pH from 6 to 11. The maximum sorption capacity of 90.85%.was attained at pH 7. At low pH, low metal adsorption has been caused by the competition of metal ions with hydrogen ions for the available adsorption sites as well as the positive charge density on the metal binding sites where the high concentration of protons in solution inhibiting metal removal. In contrast, the negative charge density on the adsorbent surface increases as pH increases due to deprotonation of metal binding sites and thus enhance the adsorption efficiency. Experiments were carried out at pH 6.35 due to Pb obtained the best removal at this pH value in the acidic range plus metal precipitation occurred at higher pH values. The result suggests that the absorption is mainly due to the ionic attraction between biomass and metal ions.

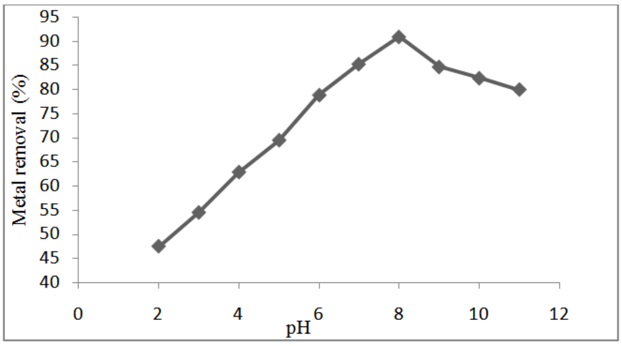

Figure 2: Effect of pH on Percent Removal of Pb by Eichhornia Crassipes

Effect of Biomass Dose on Adsorption

The figure 3 illustrated the relationship between percentage removal and dose variation ranges from 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0g at pH 6.35 for contact time of two hours. It reveals the removal of Pb range between 70.5% to 88.55% percent at 120 minutes for the concentration of 100ppm. The rate of Pb ion concentration binding with EC leaf powder is increases gradually and varies in minimum percentage when the dosage of biomass increases with concentration and pH remains constant at 120 minutes. Further to, figure.4 illustrated the effect of initial to increasing concentration of lead and the increasing concentration of biomass dosage on percent removal of Pb. This reveals that the higher concentration of biomass (2.5g) reducing the maximum removal of 87.75% for a lesser concentration of 2 ppm of aqueous lead solution.

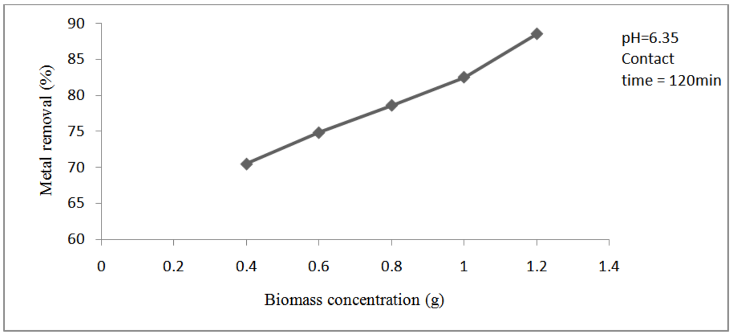

Figure 3: Effect of Biomass Dosage on Percent Removal of Pb by Eichhornia Crassipes

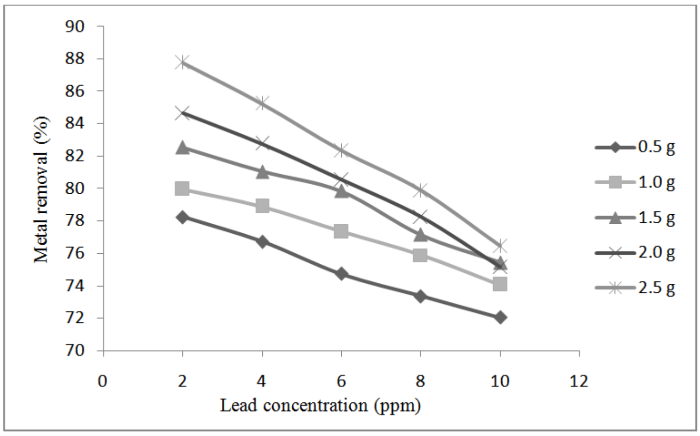

Figure 4: Effect of Initial Concentration and Biomass Dosage on Percent Removal of Pb by Eichhornia Crassipes

CONCLUSIONS

Eichhornia crassipes (EC) leaves powder has been studied as an adsorbent of Pb removal under various parameters. If the contact time between the solution containing the heavy metal and the biomass is more, then the efficiency of removal of heavy metals could also be high. This depends on the amount of biomass added to the solution and pH of the solution maintained during the experiment. This study revealed that the adsorption capacity of Pb was 88.55% by using Eichhornia Crassipes (EC) as an absorbent. Eichhornia Crassipes is found to be a good adsorbent for the removal of metal cations from mixed metal ions solution, representing an effective and environmentally clean utilization of waste matter.

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