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Research Paper

Effect of Some Factors on Biosorption of Lead by Dried Leaves of Water Hyacinth (*Eichhornia Crassipes*)

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Abstract: *Biosorption and removing some heavy metals such as Cd, Pb, Zn and Cr from the aqueous solutions by dried leaves of water hyacinth was investigated, and effect of pH, contact time and adsorpent dose on biosorption also studied. The results revealed the ability of water hyacinth to remove heavy metals from the aqueous solutions but there was a distinctive variations in biosorpency. Lead was the most adsorbed among other metals, where 58% of Pb were removed. The results showed in the pH of 5,120 min of contact time and 3 gram of adsorbent dose, the maximum removing of Pb was 91%. Biosorption by the dried leaves of water hyacinth is technique can be used for removal metal pollutants from water.*

Keywords: *Eichhornia crassipes*, Biosorption, Lead.

Introduction

Heavy metals introduce aquatic environments through municipal waste, representing a major health issues due to their direct toxic impacts on living organisms in these environments especially at high doses or as indirect health hazards at lower concentrations when accumulate within bodies of fish, crustaceans and others sea foods. These low levels of metals magnified in human bodies whose keep eating such sea foods. Increased concern by environmentalists and governments on the effects of heavy metals and an attempt to protect public health has resulted in increased research in the development of advance technologies to remove heavy metals from waters and wastewaters (Shetty and Rajkumar, 2009; Resmi *et al.*, 2010). Such treatment efforts involved application of unit operations or unit processes such as chemical precipitation, coagulation, adsorption, ion exchange and membrane filtration (Georg Steinhauser, 2008). Furthermore, among aforementioned treatment technologies, adsorption had been reported as an efficient and economic option (Malakootian *et al.*, 2009). The promising solution for such riddle is the biosorption by using algae, bacteria, fungi and plants. Water hyacinth *Eichhornia crassipes* is a promising biosorbent, this vascular fast growing floating plant commonly found in tropical and subtropical regions of the world with a well developed fibrous root system and large biomass. It can adapt easily to various aquatic conditions and play an important role in extracting and accumulating metals from water (Weiliao and chang, 2004). This capability is useful in removing toxic heavy metals and trace elements from contaminated soils and water in a process referred to as phytoremediation by using plants to extract sequester and/ or detoxify (Meagher, 2000). This study aims to investigate the ability of water hyacinth (*E. crassipes*) for biosorption and removing some heavy metals such as Cd, Pb, Zn and Cr from the aqueous solutions and study the influence of some factors on the removing of these metals such as adsorbent dose, contact time and pH.

Materials and Methods

Sample Preparation

Water hyacinth (*Eichhornia crassipes*) plants were collected from Dijla River in Baghdad. The plants were thoroughly washed with deionised water before being left to air dry. The dried leaves were subsequently pulverized in a laboratory blender to obtain a fine powder. (Al Rmalli *et al.*, 2005)

Metal Salts Used and Preparation of Stock Solution of Metal Ions

The following metal salts were used to prepare the stock solution of metal ions in aqueous form: Potassium dichromate (K2Cr2O7), Lead nitrate (Pb (NO3)2 and Cadmium nitrate Cd (NO3)2 and Zinc nitrate Zn (NO3)2 For each of the metal ions, a stock solution was prepared separately by dissolving 1gm of the metal salts in 1000 ml of distilled water. The solutions were prepared using a standard flask. The range of concentrations used was prepared by serial dilution of the stock solution with deionized water (Ideriah *et al*., 2012).

Batch Sorption Experiment

The sorption studies were carried out at room temperature using a conical flask, containing 50.0 ml of the test solution, with 1000 ppm of metal ion concentration.

Before mixing with adsorbent, the pH of the solution was adjusted to 7.0 with 1M HC1 and or NaOH. A known amount of dried water hyacinth leaves powder (1 g) referred as biomass was added into the conical flask containing metal ion solution and tightly covered with cellophane and shaken thoroughly, allowing sufficient time for adsorption. The content of the flasks was filtered on Whatman filter paper of 0.42 μm porosity and centrifuged at 2800 rpm for 5 min and the supernatants were analyzed by Flame Atomic Absorption Spectrophotometer version 2.02 (Padmapriya and Marugesan, 2012).

Determination of the Effect of pH

A 50.0 ml of the standard Pb^{+2} solution was poured into each of six conical flasks and the pH condition varied from 2 to 9 as 2, 3, 4, 5, 6, 7, 8, and 9 respectively by the addition of either dilute HC1 or NaOH using a pH meter. Then 2 g of the pretreated biomass was added to the standard metal ion solutions of Pb^{+2} and the flasks tightly covered with cellophane and shaken vigorously for 2. The suspensions were filtered and analyzed (Salfabas *et al*., 2012).

Determination of the Effect of Contact Time

A 50.0 ml solution of the standard Pb2+ solution was poured into each of six conical flasks and the contact time varied from 30 to 180 min as 30, 60, 90, 120, 150, and 180 min respectively and maintaining the pH condition at 5.0 (Salfabas *et al*., 2012).

Determination of the Effect of Adsorbent Dose

A 50.0 ml solution of the standard Pb^{+2} solution was poured into each of six conical flasks and the contact adsorbent dose from 1 to 5 gm as 1, 2, 3, 3, 4, and 5 min respectively and maintaining the pH condition at 5.0 and contact time 120 min. (Salfabas *et al*., 2012).

Calculation of Metal Ions uptake by Biomass

The metal uptake was calculated by simple concentration difference method, while the adsorption capacity that is; amount of metal ions (mg/g) adsorbed per g (dry mass) of biomass was calculated using the equation below: (Ideriah *et al*., 2012).

$$q_t = (C_i - C_e)\frac{V}{W}$$

Where, Ci and Ce the initial arsenic concentrations (mg/l) and at equilibrium, respectively, V the volume of the arsenic solutions (ml), and W the weight of biosorbent (mg).
The percentage removal was calculated as follows

$$\text{Removal }(\%) = \frac{(C_i - C_f)}{C_i} \times 100$$

Where Ci and Cf are the initial and final concentrations respectively.

Results and Discussion

Distinctive variations in biosorpency of water hyacinth (biosorbent) on Cd, Cr, Pb and Zn were recorded with establish the experimental factors and parameters (1gm dose of the biosorbent, pH 7 and one hour was the conducted time of the experiment). 58%, 46%, 30% and 26% of Pb, Cr, Cd and Zn respectively were removed by the biosorbent as shown in (figure. 1)

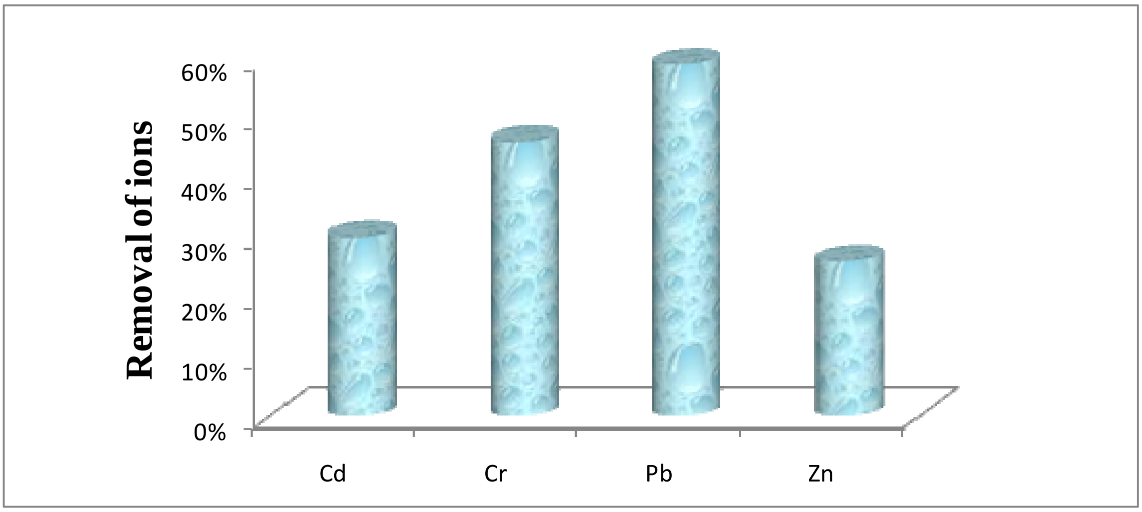

Figure 1: Biosorption (removal %) of metal ions (Cd, Cr, Pb and Zn) by dried water hyacinth leaves (1 gm) at pH 7 and contact time 1 hr.

Lead was the most adsorbed among other metals. This trend could be explained based on the modes of adsorption on cellulosic materials. The adsorption of metal ions on cellulosic materials can be attributed to two main terms; intrinsic adsorption and coulombic interaction (Gang and Weixing, 1998). The coulombic term results from the electrostatic energy of interactions between the adsorbents and adsorbate. The charges on substrates as well as softness or hardness of charge on both sides are mostly responsible for the intensity of the interaction. Coulombic interaction can be observed from adsorption of cationic species versus anionic species on adsorbents (Gang and Weixing, 1998). The intrinsic adsorption of the materials is determined by their surface areas which can be observed by the effect of different sizes of adsorbents on adsorption capacity (Igwe and Abia, 2003).This optimistic result could become a solution for the grown threat of this widespread of this metal in the Tigris and Euphrates rivers in Iraq, especially after the catastrophic accident represent by leak of approximately 1300 tons of tetraethyl lead from midland fuel refineries company near Abu Ghraib in Baghdad followed by severe symptoms appeared on the locals. This result could be improved after further pretreatments and cell walls modulations of the biosorbent or more optimizations of the parameters.

The results showed maximum adsorption in the pH of 5 and 6, 70% and 63% respectively removal of Pb, as shown in figure (2)

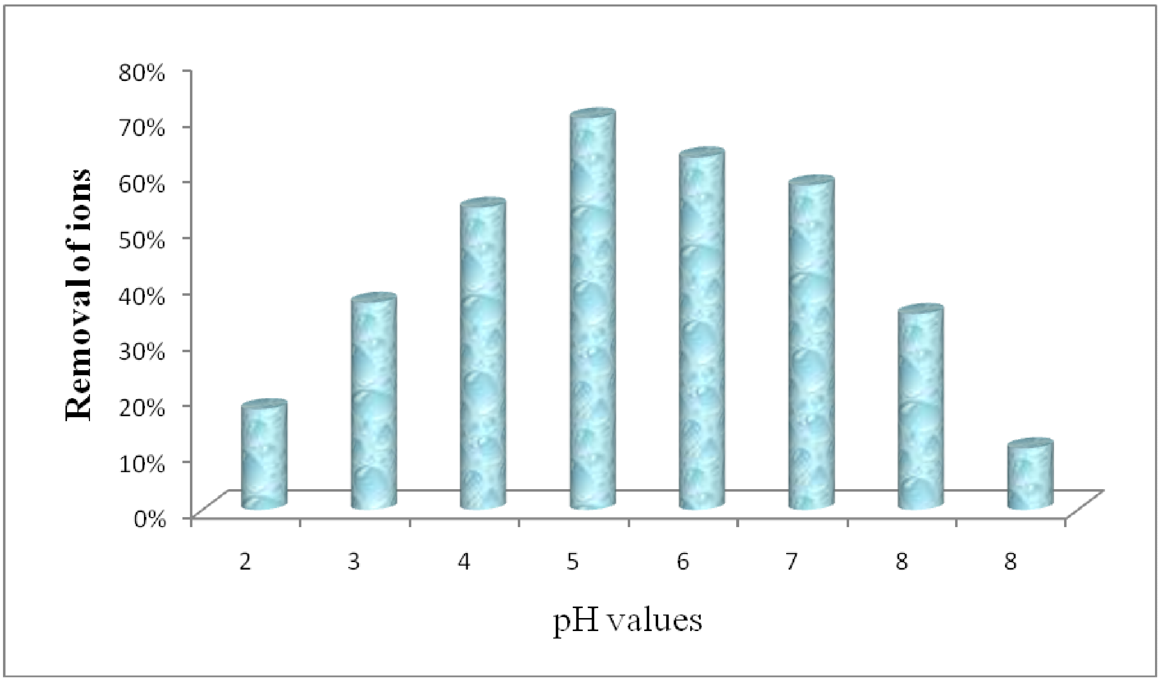

Figure 2: Effect of pH on removal of Pb by 1 gm of dried water hyacinth leaves at contact time 1 hr.

These results may be due to partial hydrolysis of metal ions, Furthermore, the low solubility of hydrolyzed metal species may be another reason for maximum adsorption in this pH range according to (Onundi *et al*., 2010). The mechanism of metals adsorption by the adsorbent with pH variation could be explained with the same concept as put forward by Corapcioglu and Huang (1987), Bansal and Goyal (2005), Najua *et al*. (2008), The minimum adsorption observed at low pH of 2 could be, on one hand due to the fact that the presence of higher concentration and higher mobility of H^+ ions favoured H^+ adsorption compared to metal ions and on the other hand due to the high solubility and ionization of metals salt in the acidic medium. Another explanation could be suggested, at lower pH value, the surface of the adsorbent is surrounded by hydronium ions (H^+), thereby preventing metals ions from approaching the binding sites of the adsorbents. At higher H^+ concentration, the adsorbents surface becomes more positively charged such that the attraction between adsorbents and metal cations is reduced. In contrast, as the pH increases, more negatively charged surface becomes available thus facilitating greater metals removal. According to Igwe *et al*., 2005, at around neutral pH, the adsorption is minimum and maximum at acidic and alkaline medium. The uptake of metal ions from aqueous solutions by cellulosic materials is usually accompanied by a reduction in the pH (Okieimen *et al.*, 1988). At initial pH 5, adsorption of Pb2+ was practically total (100%) for all concentrations range studied while it decreased to as low as 37 % adsorption at pH 3 (Abdus-Salam. and Adekola, 2005).

Generally, metal ions are more soluble at lower pH values and this enhances their adsorption (Olayinka *et al*. 2009). Oyedeji *et al*., 2010, came up with significant result that 90% of Fe(III) was removed at pH 5; further increase in pH above 5 led to decreased adsorption of Fe(III).

The results revealed a direct proportion between contact time and Pb reduction or its adsorption which approached the maximum at 120 min. with 77% removing of lead ions then biosorption rates reached to a steady state, as observed in figure(3).

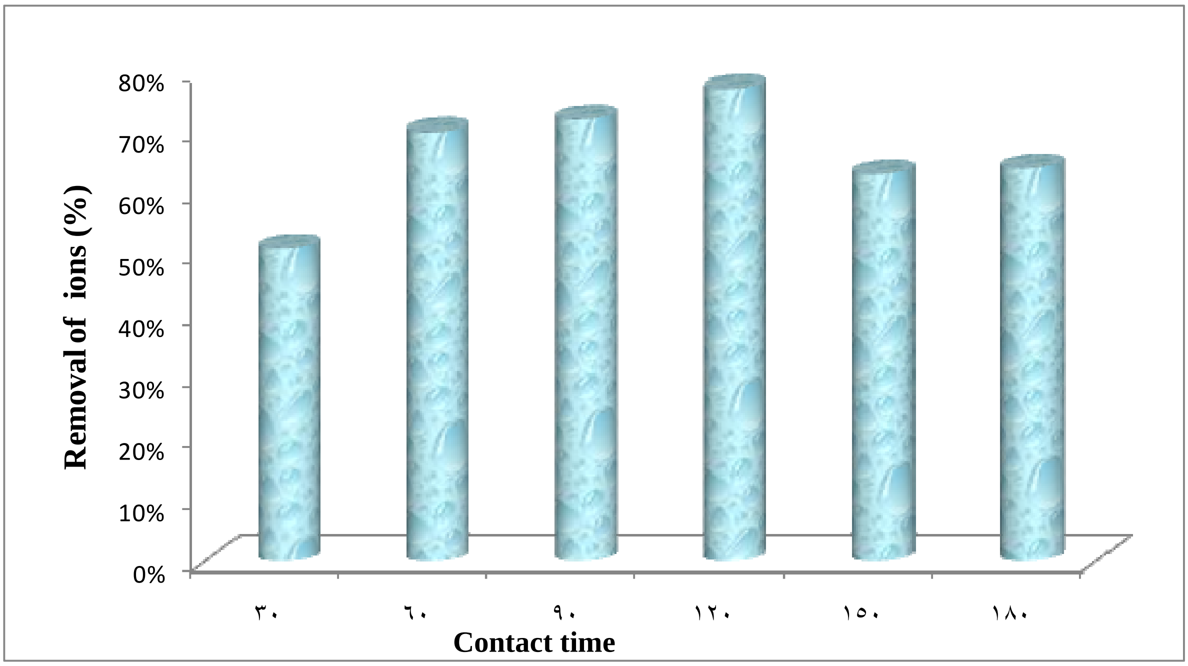

Figure 3: Effect of contact time on removal of Pb by 1 gm. of dried leaves of water hyacinth at pH 5

Oyedeji *et al*. 2010 found that 70% of Cu (II) was removed after 30 min and further increase in time resulted in the desorption of the metal ion from the adsorbent surface. However, the removal of Pb(II) and Fe(III) increased with and reached a maximumat 45 min. after which further increase in time did not bring about any improvement , but resulted in desorption of the ions from the adsorbent surface. The amount of the adsorbed metal ions increased as the time lapses (Gueu, *et al.,* 2007). The percentage metal removal approached equilibrium within 30 min for Pb and 75 min. for Cu and Ni. That was probably due to the concentration gradient between the adsorbate in solution and the number of vacant sites available on the dried leaves of water hyacinth surface at the beginning. The progressive increase in adsorption and consequently the attainment of equilibrium adsorption may be due to limited mass transfer of the adsorbate molecules from the bulk liquid to the external surface of water hyacinth.

The percentage of lead removal by dried water hyacinth increased as the adsorbent loading increased approached to 91% adsorption of Pb by 3 gm of the adsorbent (figure 4).

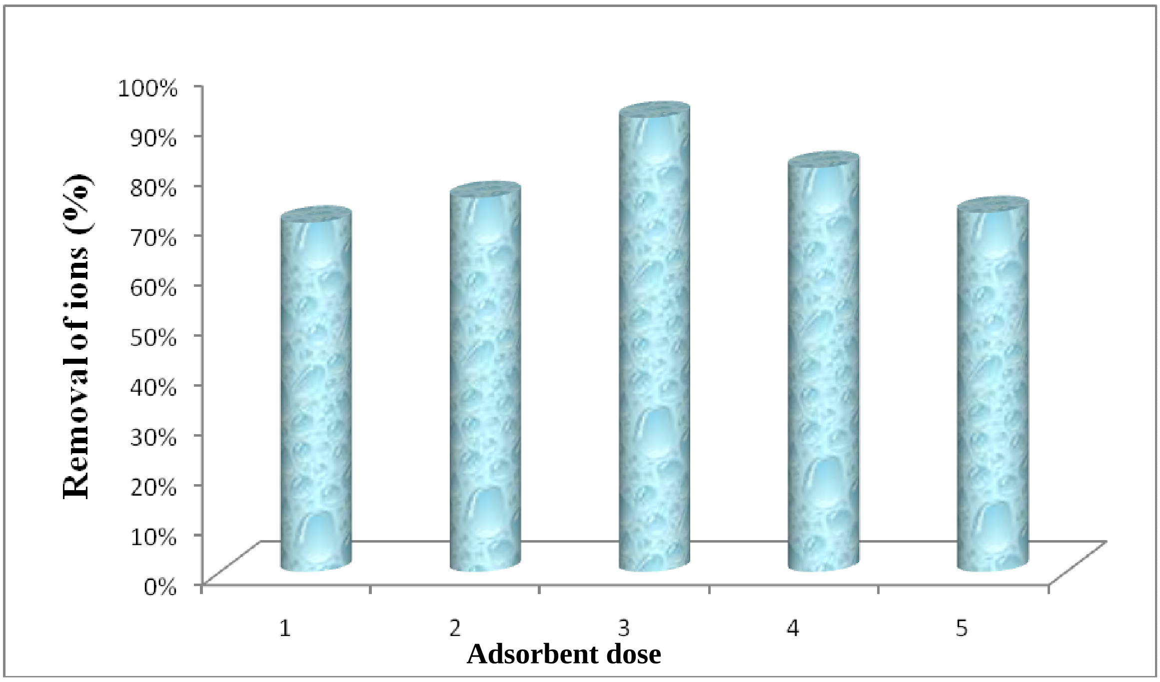

Figure 4: Variations of % removal of Pb by adsorbent dose in 120 min. as contact time and pH 5

The elevating in the adsorption rate followed by increase in adsorbent dosage could be explained since number of adsorbent particles increases and thus more surface areas were available for metals attachment. Onundi *et al*.,2010 found that over 1 gm. of the adsorbent (palm shell) dose showed no change in removing lead, while results of Gyananath and Balhal, 2011 revealed that adsorbent dosage (chitosan beads) above 5 gm. brought no change in removing lead from aqueous solution.

Conclusion

This study showed that water hyacinth offers several advantages including cost effectiveness, high efficiency and minimization of chemical sludge with metal recovery especially lead. Biosorption by the dried leaves of water hyacinth is technique can be used for removal metal pollutants from water.

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