Full Length Research Paper

Removal of Fe(II), Cu(II), Zn(II), and Pb(II) ions from aqueous solutions by duckweed

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Accepted 20 December, 2010

Duckweed was used to study the adsorption of Fe(II), Cu(II), Zn(II), and Pb(II) ions from aqueous solutions. The experimental conditions which includes; pH, contact time, initial concentration, and loading weight on the removal process were investigated. Each adsorption was studied at 30°C. The efficiency of adsorption depends on pH value, it increases with the increase of pH value from (2-8 ) in range time between 60 to 90 min. The most percentage of removal in the main way of loading weighed was 1.5 gm and 50 ml mixed metal ions solution at 50 ppm concentration of each metal ion. The study of isothermal showed that data was confirmed with temkin isotherm model. The removal order was found to be Pb^{2+} < Zn^{2+} < Cu^{2+} < Fe^{2+}. The potential of application for the treatment of solutions containing these heavy metals in multimetal solutions is indicated. The characterization (the infrared) for the surface of duckweed showed the presence of many function groups which can be binding with metal cations.

Key words: Duckweed, heavy metals, adsorption, removal of metals, adsorption isotherm, adsorption from aqueous solution.

INTRODUCTION

The awareness of increasing water pollution implying studies concerning water treatment and the use of removal of heavy metals from industrial wastewater is of primary importance. The use of natural materials for heavy metal removal has become a concern in all countries. Natural materials that are available in large quantities or certain waste from agricultural processes may have potential to use low cost adsorbents, as they represent unused resources, widely available and are environmentally friendly (Afkhami et al., 2008).

To see the decrease of polluted water most researches were concentrated with treatment of heavy metals from industrial wastewater. It uses normal material to removal metals from different sides because it is valid largely in agriculture processes in addition to their low price as adsorbent materials (Deans and Dixon, 1992).

The materials which were used naturally and of low cost include carbonaceous materials, agricultural production, activated carbon and waste by-products which are achieved by previous studies (Kamel et al., 2004; lihan and Fuat, 2000; Yesim and Izzet, 2005; Singh et al., 2005; Amer et al., 2010; Chi et al., 2009; Choi et al., 2009; Noman and Palanisumy, 2005) and were made as substantive material for some expensive methods. This is so because of the technicalities and price involved in the process of precipitation, ion exchange, solvent extraction, liquid membrane and others to remove heavy metals from industrial water (Garadea et al., 2000; Arpa et al., 2000; Mofa, 1995; Gardea et al., 1996; Abia et al., 2002). So materials of biology origin were used to remove these metals (Sag et al., 2001). All these sources were limited to removing one or two materials. Duckweed - an aquatic plant which grows on water surface, lives in shallow water and is valid in south and the central Iraq.

It is one of the most widely distributed plants in most aquatic areas. This kind of plant exists in almost every sides of rivers in South and the Central Iraq.

Accordingly, this study aimed to investigate the adsorption potential of duckweed for the removal of Fe, Cu, Zn^{2+} and Pb^{2+} ions from wastewater within various...
experimental conditions. At the same time, this can be considered a way of recycling such environmentally trouble maker materials.

MATERIALS AND METHODS

Duckweed

Duckweed was collected from different clean area far from those which may be industrially polluted. Duckweed was washed by tap water then cut by a small clean cutter, it was then dried at 80°C at about 36 h. Finally, the dried plants were grinded by clean electric mixer then stored in clean plastic page.

Characterization of duckweed

Duckweed was taken by FT.IR spectrophotometer type shimadzu 8400S which work in approximately (4000-400) cm⁻¹, then the sample introduced as KBr (pellet ).

Preparation of synthetic wastewater

The mixed metal ions solution from cations (Fe²⁺, Cu²⁺, Zn²⁺ and Pb²+) was prepared of Merck – analytical grade stock standard of concentration 1000 ppm. The solution of wastewater was introduced for each metal according to the method of continuous dilution from the sample solution above. The pH of wastewater was adjusted by using 0.1 M HCl and/or NaOH. The final concentration of metal ions in wastewater was analyzed by atomic absorption spectrophotometer type Phoenix – 986.

Bach sorption experiment

Capped tubs containing 50.0 ml of solution test of metal ions with known ion concentration, which was mixed with a known amount of dried untreated plant and the capped tubs were thoroughly mixed, allowing sufficient time for adsorption equilibrium. The mixtures were filtered through filter paper Whatman No. 42 and the metal ions were determined in the filtrate solution by atomic absorption spectrophotometer type Phoenix – 986. Each experiment was carried out at temperature room and was repeated two times, and the results are given as averages.

Calculate of removal percentage of metal ions by duckweed

Amount of removal material by duckweed through series batch investigations were appointed by the following equation:

Removal % = ((C₀ - Cᵢ)/ C₀) × 100

Removal % = \( \frac{C_o - C_i}{C_o} \times 100 \)

Where: \( C_o \) and \( C_i \) are the initial and equilibrium concentration (ppm) of metal ions in solution respectively.

RESULTS AND DISCUSSION

Duckweed surface characterization

The infrared spectrum was taken for duckweed in (Figure 1) in 3412.01,2926.11 and 2856.67 cm⁻¹ which refers to group (-OH), identical alkyl group(=CH₂) and aldehyde group (-CHO), respectively. Also, the spectrum cleared bands at 1660.77 and 1095.60 cm⁻¹ were to be the presence of (C=C) and (C-O), respectively (Stuart, 1996). The surface IR-characterization of duckweed indicated the presence of many functional groups which were able to bind with the metals cations.

The effect of different operating conditions (contact time, pH, adsorbent loading weight and initial ions concentration) on the removal by adsorption onto duckweed was investigated. The metals removal studies were illustrated graphically in Figures 2, 3, 4 and 5, and showed that their removal was strongly affected by these different operating conditions.

Effect of contact time equilibrium

Figure 2 clarifies the effect of touching time on removal of cation ions (Fe³⁺, Cu²⁺, Zn²⁺ and Pb²⁺). This took 30, 60, 90, 120 and 150 min. It was found that the best time to remove these metal ions was 90 min. The results showed that the removal percentage order at equilibrium was Pb²⁺ (94%) > Zn²⁺ (72%) > Cu²⁺ (65%) > Fe³⁺ (50%). These results are important, as equilibrium time is one of the important parameter for selecting a wastewater treatment system, when the time consumed for wastewater disposal should be considered.

Effect of pH

Effect of pH on process of adsorption movement on duckweed was at a range of (2 - 8) as it is in (Figure 3). It was noticed that the ability of removing iron, copper, zinc and lead ions by adsorbent depends on pH solution and this depends on the ion state and nature of material. In low pH value, binding sites are generally protonated or positively charged (by the hydronium ions). Thus, repulsion occurs between the metal cation and the adsorbent at a higher pH value; binding sites start deprotonating, and makes different functional groups available for metal binding. In general, cation binding increases as pH increases (Forssner and Wittman, 1981; Esposito et al., 2002).

Effect of loading weight of duckweed

It studied the effect of loading weight of duckweed in initial concentration 50 ppm taking the range of the weight (0.5 - 2) gm. It was noticed that the weight of the adsorbent material increase the ability of removal as in Figure 4 which represented the amount of the adsorbent at saturation stage, and also depends on the physical properties of the duckweed (Qadeer and Sohail, 2005).
Also, from Figure 4 it can easily be inferred that the percent removal of metal ions increases with the increasing of weight of duckweed; this is due to the greater availability of the exchangeable sites or surface area at higher dose of the adsorbent. These results are in agreement with previous studies on many other adsorbents (Choi et al., 2009; Asubiojo and Ajelabi, 2009).
Figure 3. Effect of PH on metal ions adsorption in there mixed solution by duckweed.

Figure 4. Effect of loading weight of duckweed on metal ions adsorption in mixed solution.
Effect of initial metal ions concentration

Figure 5 clarifies the effect of initial metal concentration on the ability of adsorption by duckweed. It took many different concentrations at a range of (10 - 50) ppm for the mixture of metal ions. The reduction of removal metal ions on duckweed was found with increase of initial concentration from 10 to 50 ppm. This was due to the increase of metal ions concentration which was completed on the effective site. Also this may be a limited active site for adsorbent material. Therefore, more metal ions were left unabsorbed in solution at higher concentration levels.

Isothermal studies

In the experiment, the information from the removal of metal ions by duckweed was dealt by many adsorption isothermals (langmuir, tekmin and freundlich) which were known. By this information we got, the best isothermal confirmation was tekmin for introducing (chemical adsorption) between the metal ions and duckweed. Tekmin isothermal model was given by the following equation:

\[ x = a + b \ln c \]

where \( c \) = concentration of adsorbate in solution at equilibrium (mg/L), \( x \) = amount of metal adsorbed per unit weight of adsorbent (mg/g), \( a \) and \( b \) are constant related to adsorption capacity and intensity of adsorption.

Figure 6 clarifies drawing of \( x \) against \( \ln c \) for Fe (II) on duckweed as example on tekmin model isotherm. This gave a sign of straight line in fixed slope (b). The amount of (b) 11.56 on to duckweed was found.

Conclusions

The result of batch adsorption clarifies the percentage of removal of metal ions from their wastewater solution. Their amounts were between (50 - 94) ppm with experimental conditions as time contact, pH, initial concentration and the weight of loading material. The batch adsorption result showed that removal percentage was \( \text{Pb}^{2+} \) (94%), \( \text{Zn}^{2+} \) (72%), \( \text{Cu}^{2+} \) (65%) and \( \text{Fe}^{2+} \) (50%). These results are important, as equilibrium time is one of the important parameter for selecting a wastewater treatment system.

It shows that duckweed is active to clean the environment from the wastewater. Also, duckweed is found to be a promising adsorbent for the removal of metal cations from mixed metal ions solution, representing an effective and environmentally clean waste matter.
Figure 6. Plot of (x) against Ln (C) for Fe (II) sorption onto duckweed.

REFERENCES