

Adsorption of Lead Ions from Aqueous Solution by using Sunflower Husks

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Abstract - The present study investigates the possibility of removing lead ions from aqueous solution in batch process by the adsorption onto low cost biosorbent sunflower husks. The influences of different adsorption parameters such as pH, contact time, adsorbent dosage and metal concentration have been studied. The best removal efficiency (94.5%) achieved when pH 5, 120 min contact time, 1 g/100 ml dosage and 10 mg/l initial metal concentration at room temperature. The equilibrium sorption data was fitted to the Langmuir and Freundlich isotherm models. The Freundlich model represents the equilibrium data better than the Langmuir model. Result showed that the sunflower husk was found to be low-cost adsorbent for the removal of Pb⁺² ions from wastewater.

Keywords: adsorption, lead removal, sunflower husks, biosorption, heavy metals.

I. INTRODUCTION

The increase in industrial technology has led to an increase in pollution on a continuous basis and a great effort has been made to treat this pollution and to keep it away from animals, plants and humans. Heavy metal contamination causes health risks if its concentration exceeds permissible limits. Even when the concentration of these minerals does not exceed the permissible limits, the risk of these pollutants remains large in the long term because they are accumulated within the biotic systems [1-3]. Heavy metals are found in many industrial wastes such as petrochemicals, electricity, oil refineries, paints, tanneries, electronics and mining [4]. The existence of heavy metals in ecosystems is a major concern for their toxic effects on the biological system [5-8]. Heavy metals differ from organic pollutants as they do not degrade over time into non-harmful products of the biological system [9]. The environment is contaminated with lead from various industrial sources such as the manufacture of leaded batteries, metal smelting and treatment, chemical industries, secondary production of metals and lead contaminated waste. The use of lead in gasoline is one of the most common sources of lead contamination in some countries. Lead is usually found in groundwater, surface water and land in the form of elemental lead, lead oxides and lead hydroxides, or it is complex with oxygen and is

commonly most occurs as oxidation state of 0 or ^{+II}[10,11]. The lead is stable and essential in the form of Pb⁺² ion in vegetables grown in areas contaminated with lead and causes a lot of toothpaste and toxic to those who consume these vegetables [12]. One of the most efficient methods used to treat heavy metals from aqueous solutions is the adsorption method [13]. One of the new technologies for remove heavy metal ions from aqueous solutions is Biosorption. Biosorbents Categorized to the following class fungi, agricultural wastes, bacteria, industrial wastes, algae and other polysaccharide materials [14]. Many studies covered the use of agricultural wastes (sunflower husks) directly or convert to activated carbon in the removing of heavy metals from wastewater [14-18].

The objective of the present study is to investigate the adsorption potential of Iraqi sunflower husks directly without any change in the removal of Pb⁺² ions from aqueous solution. The effects of pH, adsorbent amount, contact time and concentration of metal ions in the solution. The Langmuir and Freundlich isotherms models are used to explore the equilibrium statistics.

II. MATERIALS & METHODS

a) Preparation of sorbent

Sunflower was collected from local market and separation the husks from the seeds by hand and washed by distilled water and dried by oven at the temperature of 60°C for 24 hours and uses this husks as biosorbent for removing lead ions from aqueous solution. Fig. 1 show the FTIR test for sunflower husks.

b) Adsorbate solution

Lead was chosen to represent heavy metal pollutants. It used the formula of Pb(NO₃)₂ from AVONCHEM Company (UK). The desired concentration of Pb⁺² was dissolved in distilled water; pH of the synthetic solution was adjusted by adding HNO₃ or NaOH and measured by pH meter.

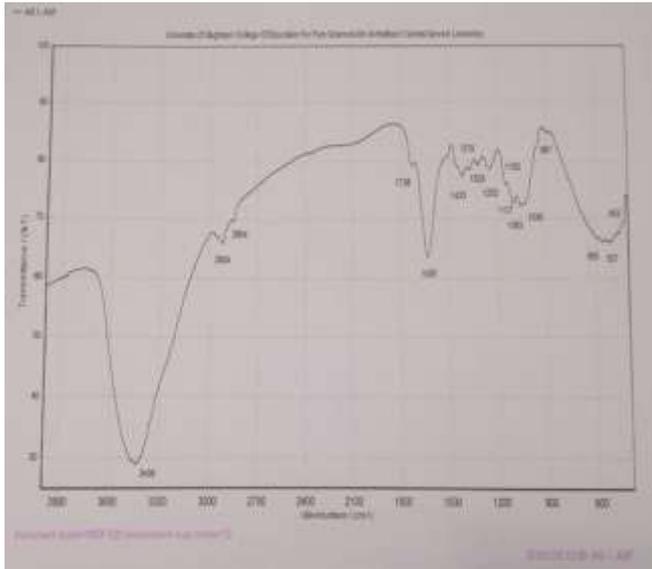


Figure 1: FTIR test for sunflower husk

c) Adsorption Study

Experiment of adsorption was follow up at the concentration of the metal ion solution, pH, contact time and adsorbent dosage level. Sample of 100 ml of Pb⁺² ions known concentration was added to each flask (250 ml) with a required amount of sunflower husks with a speed of 200 rpm in shaker (GEMMY orbit shaker, model VRN-480), at temperature equal to 25°C for a identified period of contact time then solution filtered with filter paper (Whatman No. 40), and analysis the remaining concentration of Pb⁺² ions by atomic absorption spectrophotometer (novAA 300(Germany)). Removal efficiency R% was calculated by the different of the initial and equilibrium concentration of lead ions according to the following Equation:

$$R(\%) = \frac{C_o - C_e}{C_e} \times 100$$

Where:

C_o : Initial concentrations of heavy metal (mg/l)

C_e : Final concentrations of heavy metal (mg/l)

III. RESULTS AND DISCUSSIONS

a) Effect of Ion Concentration

The feasibility and efficiency of a biosorption process depend not only on the properties of the biosorbents, but also on the ion metal concentration in the solution. The effect of initial concentration on the sorption of Pb⁺² ions was carried out with the concentrations of 10, 50, 100 and 200 mg/l as shown in Fig.2, we can clearly see that removal efficiency decreasing with lead concentration increasing because, when

the concentration of metal ions is high, the percentage removal decrease since the available sites for sorption becomes less due to saturation of sorption sites [1]. In this study I chose the high concentration (200 mg/l) and 1gm of sunflower husks as biosorbent to study the visibility of uses sunflower husks as biosorbent at high concentration and study the effect of other parameters at high concentration.

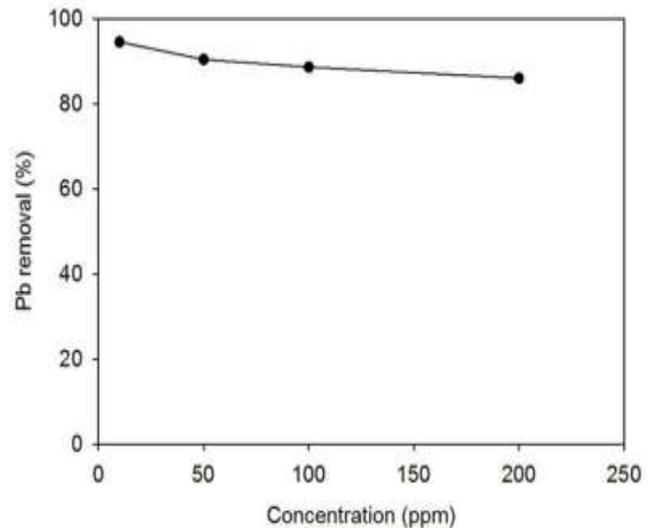


Figure 2: Effect of initial metal ion concentration on the adsorption of lead ions onto Sunflower husks at Temperature= 20°C, pH=5, Mixing speed=200 rpm, Solution volume=100 ml, Adsorbent mass = 1g, Contact time=2h

b) Effect of pH

pH is one of significant parameters that lead to metal ions sorption on different adsorbents is the solutions. That is partly because of the nature of hydrogen ion itself as a strong competing sorbate and partially to the truth that the pH of solution can influence the chemical speciation of metal ions. The pH effects on Pb⁺² ions adsorption onto Sunflower husks is shown in Fig.3. This figure show that at low values of pH, the adsorption efficiency is low; because of increasing in positive charge density(protons) on the clay surface sites, resulting in an electrostatic repulsion among the Pb⁺² ions and edging groups with positive charge (Si-OH⁺²) on the surface [19]. When the pH increases, metal uptake increased with pH from 3 this is due to more ligands with a negative charge being exposed with the subsequent increase in attraction sites to positively charged metal ions. Beyond this point, there is not much further increase in efficiency until pH 6. After pH reach to 6 the efficiency of the increases drastically due to the formation of metal hydroxides with their respective metal concentration of the metal ions. This is mostly due to the metal precipitation as ions hydroxides which depend on the pH and ion concentration but not due to the biosorption [20].

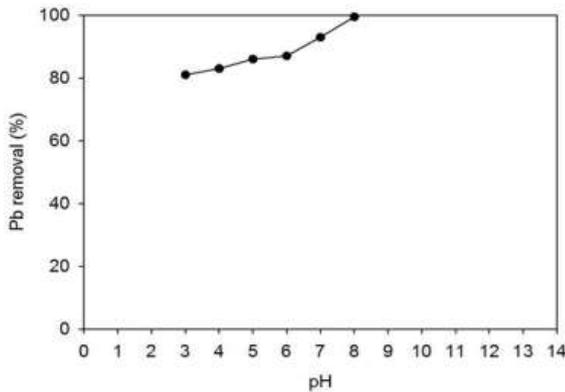


Figure 3: Effect of pH on the adsorption of lead ions onto sunflower husks at Temperature= 20°C, mixing speed=200 rpm, solution volume=100 ml, contact time =2h and adsorbent mass=1g, Pb⁺² concentrations = 200 mg/l

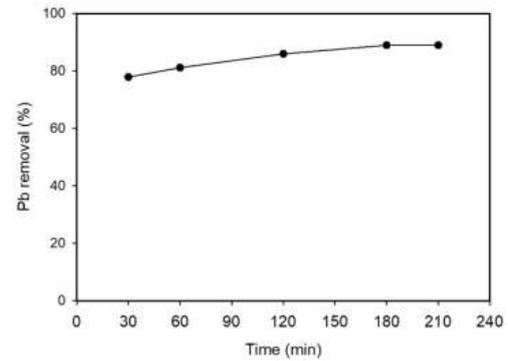


Figure 5: Effect of contact time on the adsorption of lead ion onto sunflower husks at Temperature=20°C, pH=5, Mixing speed=200 rpm, Solution volume=100 ml, Adsorbent mass = 1g, Pb⁺² concentrations = 200 mg/l

c) Effect of Adsorbent Mass

The effect of varying the adsorbent mass of lead ions is shown in Fig.4. It is clearly seen that the removal efficiency increases as the sunflower husks mass increases. As the sunflower husk mass increases, the number of binding sites for the ions also increases.

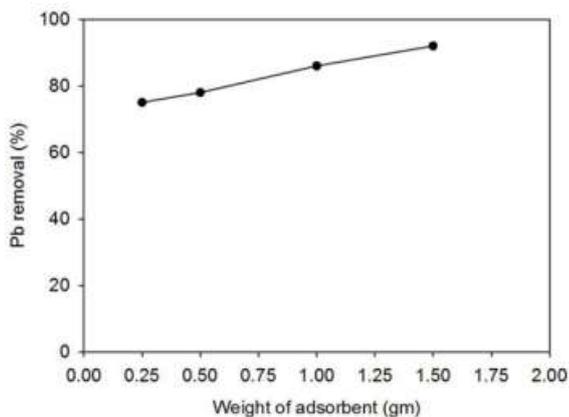


Figure 4: Effect of adsorbent mass on the adsorption of lead ions onto sunflower husks at Temperature=20°C, pH=5, Mixing speed=200 rpm, Solution volume=100 ml, Pb⁺² concentrations = 200 mg/l

d) Effect of Contact Time

Contact time plays a significant part in the efficient removal of heavy metals using sunflower husks. The influence of contact time on the capacity for the metal ion is shown in Fig. 5. We can clearly note that the rate of adsorption is higher at the beginning and this is due to the availability of a large number of active sites on the adsorbent. When the time increases the available site is saturation and efficiency is stable.

e) Adsorption Isotherm

Langmuir and Freundlich models were utilized to study the equilibrium process (Fig. 6 & 7). The Langmuir model studies the homogenous surface adsorption; these models depend on three conditions: adsorption process works on monolayer only, every surface of his ability on the adsorption equality and the ability of active side to adsorb was changed from one to another. The Freundlich isotherm is an experimental relation finding the interplay between adsorbate particles and diverse surfaces.

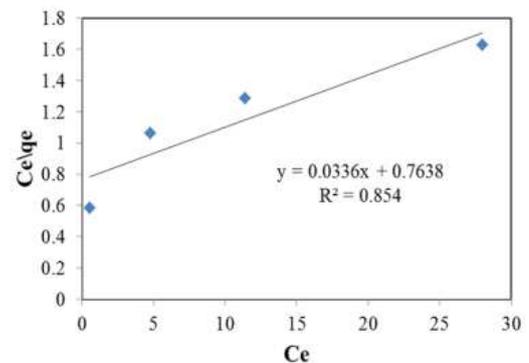


Figure 6: Langmuir plot of lead sorption on sunflower husks

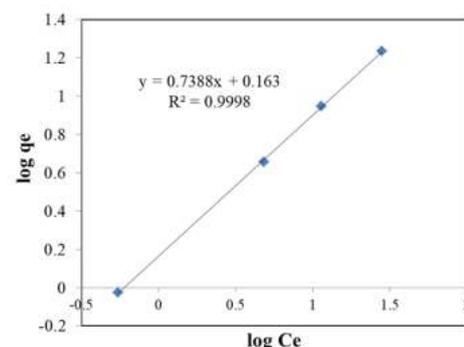


Figure 7: Freundlich plot of lead sorption on sunflower husks

Table 1 shows the Langmuir, Freundlich isotherms parameters. The result indicates that the Freundlich model provides the best fit as judged by its correlation coefficient for the lead sorption. Hence, the metals bind onto the heterogeneous surface of sunflower husks [14].

TABLE I
Langmuir and Freundlich isotherms Parameters for lead sorption on sunflower husks

Langmuir model	lead	Freundlich model	lead
R ²	0.854	R ²	0.9998
q _m	29.76	1/n	0.7388
b	0.0439	K	1.4554

IV. CONCLUSION

Based on the results obtained from the present experimental measurements, from this study, it was found that the sunflower husks are a good biosorbent for lead, from aqueous solution. Freundlich isotherm model provides the best fit for the experimental isotherm data. The maximum adsorption potential of sunflower husk adsorbent for Pb⁺² ions removal was 29.76 mg/g. Good efficiency to remove toxic metal ions was achieved by the usage of this agricultural by product.

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