Adsorption Study of Cadmium (II) and Lead (II) On Rice Husk

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ABSTRACT
Rice husk was used as an adsorbent for the removal of Cd (II) and Pb (II) from aqueous solution. The effects of contact time, pH, concentration, agitation speed, and dose on the removal of Cd (II) and Pb (II) have been evaluated. Our result shows that rice husk powder has high reduction efficiency for both metals. Results showed that low-cost adsorbents can be fruitfully used for the removal of heavy metals with a concentration range of 30–40 g/l. The percentage removal of heavy metals was dependent on the dose and concentration of Rice husk. The contact time necessary for maximum adsorption was found to be 35-40 min. The optimum pH range for heavy metal adsorption was 4–8.

INTRODUCTION

Egyptian cotton leafworm, *Spodoptera littoralis* (Lepidoptera: Noctuidae) is one of the uses of low-cost adsorbents has been examined as a spare for expensive present procedures. Natural Materials or unwanted products from certain productions with a great volume for heavy metals can be obtained, and disposed of with little cost. Heavy metals are often discharged by a number of industries, for example, metal coating services, mining processes, and tanneries, this can lead into the contamination of freshwater and marine environment (Low and Lee, 2000) and (Bailey *et al.,* 1999). Heavy metals are not decomposable and can lead to piling up in organisms, producing several illnesses and troubles (Bailey *et al.,* 1999). It is well recognized that specific metals are dangerous to life and environment, like antimony, chromium, copper, lead, manganese, mercury, cadmium, etc., they are significantly toxic to human beings and ecological environments (Dorris *et al.,* 2000). Rice husk is an unwanted material produced in the country that cultivates rice, mainly in Egypt. The yearly world rice making is about 500 million metric tons, of which 10–20% is rice husk. Dry rice husk contains 70–85% of organic material (lignin, cellulose, sugars, etc.), and the residue contains silica, which is present in the cellular membrane (Hegazi 2013). Researches on the treating of liquid waste bearing heavy metals have detected adsorption to be an extremely active procedure for the elimination of heavy metals from waste stream and activated carbon has been broadly used as an adsorbent (Chand *et al.,* 1994). In recent years, the need for safe and economical methods for the elimination of heavy metals from contaminated waters has

necessitated research Low cost agricultural waste by-products such as Rice husk (Srinivasan *et al.,* 1998) and (Ajmal *et al.,* 2003). The rice husk ash was used as adsorbent to remove some contaminants from water economically better than adsorption with oxidation by TiO_2 as a catalyst (Prakash Chinnaiyan *et al.,* 2018). The rice husk by using sol-gel method converted to silica adsorbent and then used silica to remove some ions such as Cu (II), Zn (II), Mn (II) and Pb (II) from aqueous solution, there was a significant increase in remove metal ions by silica adsorbent (Kukwa *et al.,* 2020). Treating the rice husk chemically and thermally to use it as an adsorbent to remove Cd (II) from aqueous media, the maximum amount of Cd (II) adsorption was 28.27 mg/g at pH 6 (Hoyos-Sanchez *et al.,* 2017). The rice husk as adsorbent has a great benefit to remove phenol from wastewater, the percentage of remove phenol reached up to 95% at optimum conditions such as pH= 7, contact period = 240 min, adsorbent dosage = 6 g/l and temperature =35 ºC (Mandal *et al.,* 2019).

This study objects to use low-priced and unwanted materials like rice husk to eliminate the heavy metal ions and impacts of contact time, pH, concentration, agitation speed and dose on the elimination of Cd (II) and Pb (II)

MATERIALS AND METHODS

Adsorbent Material:
The adsorbent material rice husk was collected from some Egyptian fields. The samples were collected from each location and stored in polyethylene bags and then transported to the laboratory in an icebox within a limited time. The rice husk was collected from its place in a clean plastic bag and was cut, washed with tap water followed by deionized water, dried at 105ºC overnight and ground by a mortar. The rice husk particles were sieved to 60 mesh (ASTM) was collected and stored in a plastic bag.

Chemicals:
All chemicals used were high-grade chemicals from (Merck, BDH, and Fisher Companies).
1- Buffer solutions of pH equal to 4.01, 6.86, and 9.18 for calibration of the pH meter.
2- Concentrated nitric acid 63%.
3- Individual standard solution for Cd^{2+} ion.
4- Individual standard solution for Pb^{2+} ion.
5- Sodium hydroxide pellets.
Chemical Analysis:
Determination of Heavy Metals:
Instrumentation:
Thermo Elemental model: Solar M Atomic Absorption Spectrophotometer was used for all the measurements. The current, wavelength, and slit bandwidths of each element were adjusted automatically by the instrument software. Table 1 showed the regression data for the calibration plot.
Quality Assurance Procedure:
All the glassware used were washed clean with distilled water after soaking for 24 h in 1% HNO3, and analytical grade reagents purchased from Aldrich Chemical Company Limited, England were used. Reagent blank determinations were used to correct errors.
The recovery and reproducibility of the method were tested continuously by fortified clean samples with each of the metals at concentration levels ranged between 0.03 and 0.05 mg/ kg and processed as previously described. The performance of the

AAS was frequently tested by measuring the characteristic mass. The average recoveries ranged between 88% and 95%. Blank Samples were analyzed with every set of samples and the detection limits (i.e., the concentration produces an absorbance signal three times the magnitude of the baseline noise (Beaty and Kerber, 1993). were estimated for each measured metal. For the analyzed metals, the detection limits ranged 0.002–0.04 mg/ L. Analytical precision and quality assurance

Samples were cautiously collected to avoid contamination and multiplicity of samples (n = 21) for each determination ensured reproducibility of data.

Table 1. Regression data for the calibration plot

Metal Ion	Regression equation	Coefficient of determination (R^2)
Pb	Y=0.0129X+0.0004	0.9995
Cd	Y=0.0799X+0.0003	0.9990

Effect of Adsorbent Dose:

Sample solutions of Cd and Pb (50ml of 50 ppm) were added in ten separate measuring flasks for each element. Powder of rice husk was added to each flask in different amounts ranging from 10-100 g/L with different of 10 g each time. Flasks were agitated on an orbital shaker at 150 rpm for 30 minutes. The solutions were filtered to remove the rice husk and filtrates were subjected to determination.

Effect of pH:

Sample solutions of Cd (50ml of 50 ppm) were added in ten separate measuring flasks. Powder of rice husk was added to each flask in different amounts ranging from 4 g was added to each. pH of each sample solution was adjusted from 1-10. Flasks were agitated on an orbital shaker at 150 rpm for 30 minutes. The solutions were filtered to remove the rice husk and filtrates were subjected to atomic adsorption. The same procedure was repeated for the lead with the adsorbent dose of 2.5g.

Effect of Contact Time:

Sample solutions of Cd (50ml of 50 ppm) were taken in ten separate measuring flasks then add 4 g rice husk powder to every flask. Adjust the pH of each sample solution at 8. Flasks were agitated on an orbital shaker at 150 rpm for the time ranging from 5 to 50 minutes with a difference of 5 minutes. The solutions were filtered to eliminate the rice husk and filtrates were exposed to atomic absorption, also the same steps were repeated for the lead with the adsorbent dose of 2.5g, and pH was adjusted to 4.

Effect of Agitation Speed:

4 g rice husk powder was added to five flasks containing Cd (50ml of 50 ppm) were taken in five separate measuring flasks. The pH of each sample solution was adjusted to 8. Flasks were agitated on an orbital shaker at different speeds ranging from 50 -250 rpm for 40 minutes. The solutions were filtered to remove the rice husk and filtrates were subjected to atomic adsorption. The same procedure was repeated for the lead with the adsorbent dose of 2.5g and pH was adjusted to 4.time of contact lead was 20 minutes.
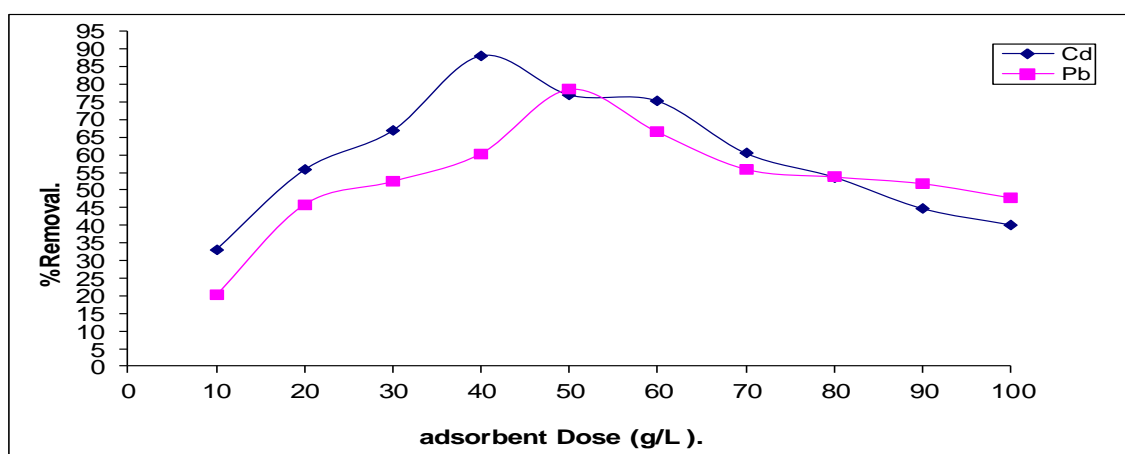
RESULTS AND DISCUSSION

Effect of Adsorbent Dose:

The effect of adsorbent dosage on adsorption of cadmium and lead was studied different dosage in the range 10-100 g/L (Table 1 and Fig. 1). Results showed that adsorption efficiency is highly dependent on the quantity of adsorbent added. Maximum removal was 88.11% and 78.55% for doses of 40 g/L and 50 g/L for cadmium and lead, respectively. This was predictable as with increasing concentration of adsorbent, extra surfaces or in other words, more active sites turn out obtainable for metal adsorption. The decrease in efficiency at higher adsorbent concentration could be explained as a consequence of a partial aggregation of adsorbent, which results in a decrease in effective surface area for metal uptake for metal adsorption (Karthikeyan *et al.,* 2007) and (Anwar *et al.,* 2010). Our finding results are in agreement with (Mandal *et al.,* 2019) and (Kukwa *et al.,* 2020).

Table 2: Effect of adsorbent dose (g/L) on the removal of Cd and Pb (metal concentration 50 µg / ml, contact time,30 min, agitation speed,150 rmp, temperature 25º C.

Adsorbent dose (g/L)	%Removal of Cd	%Removal of Pb
10	33.12	20.23
20	55.78	45.9
30	66.9	52.45
40	88.11	60.35
50	77	78.55
60	75.26	66.45
70	60.45	55.9
80	53.67	53.7
90	44.76	51.8
100	40.12	47.8

Fig.1. Effect of adsorbent dose (g/L) on removal of Cd and Pb (metal concentration 50 µg / ml, contact time,30 min ,agitation speed,150 rmp, temperature 25º C.
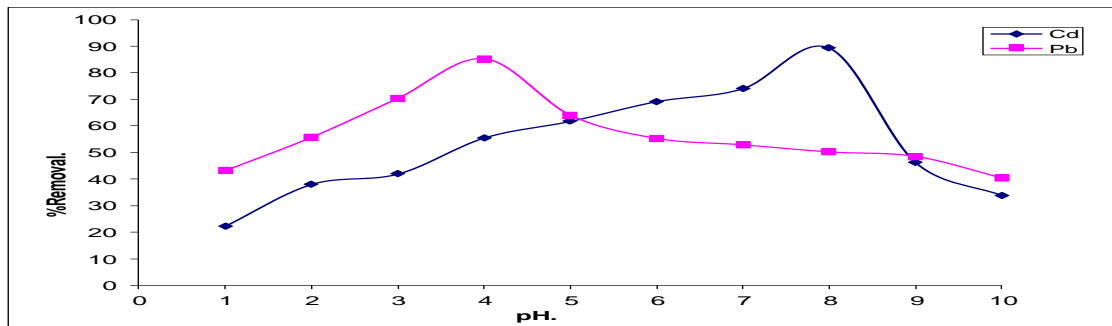
Effect of pH:

From (Table 3 and Fig. 2), it is observed that pH is one of the important factors affecting the adsorption of metal ions. The effect of pH was studied in the range 1–10 that the best results were obtained at pH 8 for Cd and pH 4 for Pb which is 89.34% for Cd and 85.22 % for Pb. Acidic stipulations are necessary for Lead metal where it rises similarity of rice husk to metal ions. Beyond ideal pH, adsorption falls. At smaller pH, H^+ vies with metal cations for the obtainable adsorption position where at greater pH, adsorption a site

does not work. pH influence has been investigated up to 9, then metal cations interact with hydroxide ions and precipitate as metal hydroxide (Anwar *et al.,* 2010) and (Anwar *et al.,* 2009), also the obtained results are compatible with (Kukwa *et al.,* 2020).

Table 3: Effect of pH on the removal of Cd and Pb (metal concentration 50 µg / ml, contact time,30 min, agitation speed,150 rmp, temperature 25º C.

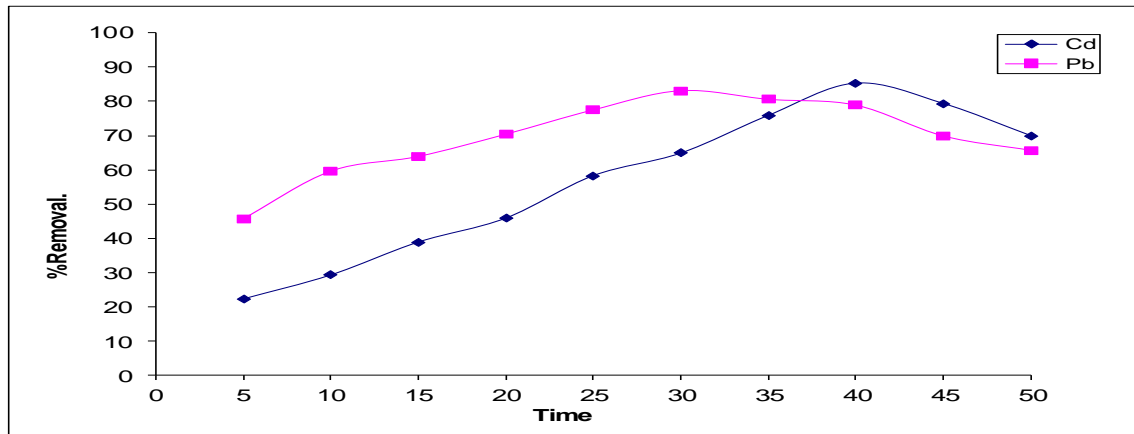| pH	%Removal of Cd	%Removal of Pb
1	22.4	43.24
2	38.1	55.76
3	42	70.4
4	55.56	85.22
5	61.8	63.98
6	69.24	55.3
7	74.13	52.9
8	89.34	50.23
9	46.26	48.56
10	33.9	40.46

Fig.2. Effect of pH on the removal of Cd and Pb (metal concentration 50 µg / ml ,contact time,30 min ,agitation speed,150 rmp, temperature 25o C.

Effect of Contact Time:

       The effect of time on the removal of cadmium and lead was investigated and the results are shown in (Table 4 and Fig. 3). Increase in the removal efficiency with increase in time of contact can be attributed to the fact that more time becomes available for metals ions to make attraction complex with rice husk. The most adsorption of cadmium has happened at 40 min while for lead, at 35 min. (Anwar *et al.,* 2009), also our findings results are compatible with many investigators (Mandal *et al.,* 2019), (Kukwa *et al.,* 2020) and (Lawagon and Amon, 2020).

Table 4: Effect of time on the removal of Cd (pH8)and Pb (pH4)(metal concentration 50 µg / ml ,contact time,30 min ,agitation speed,150 rmp, temperature 25º C.

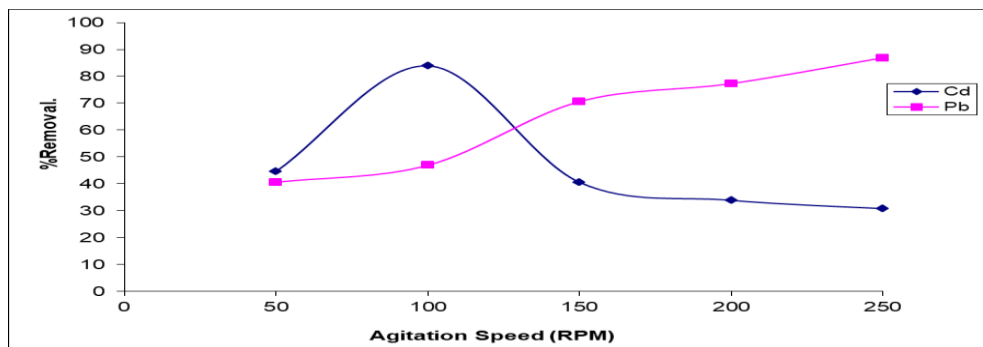| Time(min.)	%Removal of Cd	%Removal of Pb
5	22.3	45.7
10	29.3	59.6
15	38.9	63.9
20	45.9	70.4
25	58.3	77.5
30	64.9	83.12
35	75.9	80.6
40	85.34	78.9
45	79.4	69.9
50	70	65.7

Fig.3. Effect of time on the removal of Cd (pH 8) and Pb (pH 4)(metal concentration 50 µg / ml ,contact time,30 min ,agitation speed,150 rmp, temperature 25° C.

Effect of agitation speed

One of the important factors affecting the adsorption of metal ions is the agitation speed of the solution. The effect of agitation speed was studied at different speeds ranging from 50 -250 rpm for 40 minutes. As shown in (Table 5 and Fig. 4), maximum adsorption of cadmium has taken place at agitation speed 100 rpm whereas for lead, at 250 rpm, it can be observed that shaking speed significantly affects the adsorption of Cd, however, adsorption of lead is disturbed much (Anwar *et al.,* 2009), also our findings results are in harmony with (El–Moselhy *et al.,* 2017) and (Kukwa *et al.,* 2020).

Table 5: Effect of agitation speed on the removal of Cd (pH8) and Pb (pH4) (metal concentration 50 µg / ml, contact time, 30 min, temperature 25° C.

Agitation speed (RPM)	% Removal of Cd	% Removal of Pb
50	44.6	40.6
100	83.9	46.9
150	40.6	70.6
200	33.9	77.3
250	30.8	86.9

Fig.4. Effect of agitation speed on the removal of Cd (pH 8) and Pb (pH 4) (metal concentration 50 µg / ml, contact time, 30 min, temperature 25° C.

Conclusion

1. Results presented that little price adsorbents can be successfully used for the elimination of heavy metals with a concentration range of 30–40 g/l.

2. The percentage elimination of heavy metals was reliant on the dose of little price adsorbent and adsorbent concentration.

3. The contact time necessary for the most adsorption was found to be 35-40 min.

4. The ideal pH range for heavy metal adsorption was 4–8.

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ARABIC SUMMARY

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دراسة امتزاز الكادميوم (II) والرصاص (II) على قش الأرز

طارق عبد العليم عبد الرحمن¹ ـ ايمن سميح عريبى سلومه² ـ اسماعيل ابراهيم اسماعيل²

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٢- قسم بحوث تحليل المبيدات – المعمل المركزى للمبيدات- مركز البحوث الزراعية – الدقى - جيزه – مصر

تم استخدام قش الأرز كمادة ممتزة لإزالة عنصرى الكادميوم والرصاص من المحلول المائي وتم تقييم آثار وقت التعرض، ودرجة الحموضة، والتركيز، وسرعة الحرق والجرعة على إزالة العنصرين محل الدراسة. حيث اظهرت النتائج أن مسحوق قش الأرز لديه كفاءة عالية في خفض التركيز لكل من عنصرى الكادميوم والرصاص . وكذلك اظهرت النتائج أن المواد الممتزة منخفضة التكلفة يمكن استخدامها بشكل مثمر لإزالة المعادن الثقيلة ذات نطاق تركيز يتراوح من ٣٠ إلى ٤٠ جم / لتر وتعتمد النسبة المئوية لإزالة المعادن الثقيلة على جرعة وتركيز قش الارز وجد ايضا ان وقت التعرض اللازم للحد الأقصى من الامتزاز يتراوح ما بين ٣٥-٤٠ دقيقة وكان نطاق درجة الحموضة الأمثل لامتزاز المعادن الثقيلة يتراوح بين ٤-٨.

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