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ADSORPTION STUDY OF CADMIUM (II) AND LEAD (II) ON RADISH PEELS

Jamil Anwar, Umer Shafique, Muhammad Salman
Waheed-uz-Zaman and Mehwish Memoona
Institute of Chemistry, University of the Punjab, Lahore-54590, Pakistan

Abstract: The removal efficiency of heavy metals like Cd(II) and Pb(II) from aqueous solutions by adsorption on *Raphanus sativus* (Radish peels) has been studied. The effects of time, pH, concentration of adsorbent and agitation speed on adsorption have been evaluated. It is found that radish peels powder has high removal efficiency for both the metals. Batch adsorption study has shown that Cd(II) and Pb(II) has been removed up to 88% and 86% respectively. Adsorption equilibriums for both metals have been described by the Langmuir isotherm. The maximum amount of heavy metals (Q_{max}) adsorbed at equilibrium were 7.5 and 1.23 mg/g for Cd(II) and Pb(II) respectively as evaluated by Langmuir isotherm. It is concluded that waste materials like radish peels can be used for removal of heavy metals from aqueous streams.

Introduction

Water is a universal solvent and is known as "tonic of life". It is not only essential for all sorts of life on earth but also has an extensive utilization in industries. The enormous use of water in industries has created a large problem of water pollution.[1]

Toxic metals are natural components of the earth's crust which cannot be degraded and destroyed.[2] In traces, some toxic metals are essential to maintain the metabolism of the human body. However, at higher concentrations they are poisonous. The toxic heavy metals including cadmium, lead, copper, selenium and chromium are however also important from industrial point of view.

Cadmium is found in many domestic products like tobacco products, phosphate fertilizers, polyvinyl chloride (PVC) products[3], photocells, petrol, oils etc. Acute exposure to cadmium fumes may cause flue like symptoms including chills, fever, and muscle ache sometimes referred to as "the cadmium blues."[4] Cadmium also is believed to cause pulmonary emphysema and bone disease (Osteomalcia and Osteoporosis).[5]

Lead can be found in candy wrappers, pottery containers and in certain ethnic foods, such as chapulines.[6] Lead can cause lesions in the central nervous system and apparently can damage the cells making up the blood-brain barrier that protects the brain.[7]

The commonly used procedures for removing metal ions from aqueous streams include chemical precipitation, lime coagulation, ion exchange, reverse osmosis and solvent extraction. But another successful, economical and easy technique to remove heavy metals is adsorption. Basha[8] *et al.* studied the adsorption isotherms of Cd(II) and Pb(II) from aqueous solution, onto both raw and treated biomass of brown seaweed (Lobophora variegate). Adesola[9] *et al.* studied the removal of Cd(II) from dilute solutions using maize (Zea mays) leaf. Nadeem[10] *et al.* used an indigenously prepared, steam activated and chemically modified carbon from the husk and pods of Moringa oleifera, an

1-For Proof and Correspondence: **Umer Shafique**

agriculture waste for the removal of lead from aqueous solutions.

Radish is primarily used for edible purposes but in the last decade a new use of radish peels has been developed, which is the removal of heavy metals from aqueous streams. The advantages of using radish peels for adsorption include cheap, quick and easy separation.

Experimental Work

Preparation of Adsorbent

The radish peels were dried in an oven at 105°C overnight. Peels were ground and sieved to 60 mesh (ASTM) and stored in plastic containers.

Standard Solutions

Cadmium chloride ($CdCl_2.2H_2O$), 2.54g and lead nitrate ($Pb(NO_3)_2$), 2.48g were taken in 1000mL measuring flasks separately and dissolved in double distilled water, making volume up to the mark. These were 1000ppm stock solutions of cadmium and lead, respectively. Standard solutions of cadmium and lead (5 50ppm) were prepared by successive dilution of their respective stock solutions.

Instrumentation

pH meter (HANNA-8417) was used for the adjustment of pH with HCl (0.1M) to decrease the pH and NaOH (0.1M) to increase. Absorbance of the standards and samples of cadmium and lead were recorded on atomic absorption spectrophotometer (AAnalyst100) at 228.8nm and 283.3nm, respectively.

Effect of Adsorbent Dose

Sample solution of Cd(50mL of 50ppm) was added in nine separate measuring flasks. Powder of radish peels was added to each flask in different amounts ranging from 0.5 to 4.5g with difference of 0.5g each time. Flasks were agitated on orbital shaker (top loaded) at 150 rpm for 30 minutes. The solutions were filtered to remove the radish peels and the filtrates were subjected to atomic absorption. The same procedure is repeated for lead. From respective graphs, the corresponding concentrations were measured for both cadmium and lead.

Effect of pH

Nine measuring flasks were taken and sample solution of cadmium (50mL of 50ppm) were added to each. Peels powder (4g) was added to each flask. pH of each sample solution was adjusted from 1 to 9. Flasks were agitated on orbital shaker (top loaded) at 150 rpm for 30 minutes. The solutions were filtered and filtrates were subjected to atomic absorption. The same procedure was repeated for lead with adsorbent dose of 2g. From graphs, the corresponding concentrations was measured.

Effect of Contact Time

Sample solutions of cadmium (50mL of 50ppm) was taken in nine measuring flasks. 4g radish peels powder was added to each flask. pH of each sample solutions were adjusted to 8. Flasks were agitated on orbital shaker (top loaded) at 150 rpm for the time ranging from 5minutes to 45 minutes with the difference of 5 minutes. The solutions were filtered and the filtrates were subjected to atomic absorption to record the absorbance of cadmium. The same procedure was repeated for lead with 2g adsorbent dose and pH was adjusted to 4. The corresponding concentrations for both metals were measured from their respective graphs.

Effect of Agitation Speed

Radish peels powder (4g) was added to nine flasks containing cadmium (50mL of 50ppm). The pH of each sample solution was adjusted to 8. Flasks were agitated on orbital shaker at different speeds ranging from 50 rpm to 250 rpm for 40 mins. The solutions were filtered and the filtrates were subjected to atomic absorption to record absorbance of cadmium. The same procedure is repeated for lead but 2g adsorbent was used and pH was adjusted to 4. Time of contact for lead was 20 mins. Absorbance of filtrates were taken. From relevant graphs, the corresponding concentrations were measured for both metals.

Study of Adsorption Equilibriums

In six measuring flasks, sample solutions (50mL) of Cd (30ppm-80ppm) were added. The optimum conditions for adsorption of cadmium (obtained from above experiments) were maintained. The solutions were filtered to remove the peels and absorbances of filtrates were taken on atomic absorption spectrophotometer. The same procedure was repeated for lead on its optimum conditions. From graphs, the related concentrations were measured for both metals. Langmuir isotherm was plotted and the respective parameters were measured.

Results and Discussion

Water pollution is the main cause of many diseases in Pakistan. Since the country is not rich therefore, waste materials like peels of radish are good choice to remove heavy metals from waste waters. The plant of Radish has a fastgrowing tendency with high biomass and it has high potential to adsorb metals, therefore, a study has been carried out to find the optimum conditions required to adsorb metal on peels of radish.

The study of effect of adsorbent dose on metal adsorption has shown that adsorption has increased for both metals with increase in amount of radish peels. For cadmium(50ppm, 50mL), minimum percentage removal was 59.30% for the dose of 10g/L to maximum value 88.80% for dose of 80g/L, whereas, for lead(50ppm, 50mL), minimum value was 73.89% for the dose of 10g/L to maximum value of 84.44% for dose of 40g/L as shown in Fig-1. The increase in adsorption with the increase in amount of radish peel dose may be attributed to the fact that more surface area is available for adsorption to occur. The number of available adsorption sites increases by increasing the sorbent and this results an increase in removal efficiency. It can be concluded that by increasing the adsorbent dose, the removal efficiency increases.

From Fig-2, it is observed that pH significantly affects the adsorption process of both metals. The best results were obtained at pH-8 for cadmium and pH-4 for lead which is 88.23% for Cd and 85.58% for Pb. At very low pH, functional oxidized groups (carboxylic, phenolic on which adsorption takes place) of the radish peels are protonated and thus active sites of radish peels for binding of metal ion become less available thus removal efficiency decreases. At higher pH, insoluble cadmium hydroxide & lead hydroxide starts precipitating from the solution, making actual sorption studies impossible. So, it is concluded that pH of the solution should be 4 for lead and 8 for cadmium.

Effect of contact time on adsorption was studied and the results are shown in Fig-3. Increase in removal efficiency with increase in time of contact can be attributed to the fact that more time becomes available for metals ions to make an attraction complex with radish peels. Initial removal occurs immediately as soon as the metal and peels came into contact. But after that when some of the easily available active sites engaged, metal needs time to find out more active sites for binding. So it is concluded that metal and radish peels should be in contact for 40 minutes for cadmium and 20 minutes for lead, respectively in order to get good results.

Effect of agitation speed on adsorption of Cd and Pb was studied. From the Fig-4, it can be observed that shaking speed significantly affects the adsorption of Cd, however, adsorption of lead is not disturbed much. With increase in shaking speed, adsorption increases. If shaking speed is slow, radish peels instead of spreading in the sample, accumulates and various active sites are buried under the above layers. So, removal occurs only by the above layers and the under burried layers do not take part in the process as they have no contact with metal. This indicates that shaking rate should be sufficient to assure that all the surface binding sites are readily available for metal uptake. Agitation speed of 100 rpm and 250 rpm were selected as the optimum speeds for Cd and Pb respectively.

Langmuir isotherms are shown in Fig-5 and -6, for cadmium and lead respectively and the parameters are given in Table-1. Linear Langmuir plot indicates the formation of monolayer coverage of adsorbate on the surface of absorbent. Qmax value for Cd is high as compared to that of Pb. The values are 7.54mg of Cd(II) per gram of radish peels and 1.23mg of Pb(II) per gram of radish peels. Value of R^2 shows correlation or linear relationship. The relationship becomes more linear with the value closest to 1.

Conclusion

The present study was aimed to evaluate the adsorption efficiency of radish peels for Cd(II) and Pb(II). The study exposed that radish peels adsorption efficiency towards Pb(II) is low than Cd(II). The adsorption of Cd(II) and Pb(II) ions are dependent on the initial concentrations of metal ions, sorbent amount, pH, time of contact and agitation speed. pH of 8 was found to be optimum for maximum Cd(II) uptake and 4 for Pb(II) by radish peels. The suitable time of contact is approximately 40 and 20 minutes for Cd(II) and Pb(II) respectively. The Cd(II) and Pb(II) adsorption on radish peels was described by the Langmuir isotherm. The maximum Cd(II) and Pb(II) removal was 7.54mg of Cd(II) per gram of radish peels and 1.23mg of Pb(II) per gram of radish peels as evaluated from Langmuir isotherm. From the present study, it is concluded that indigenous and cheap materials like radish can be used to overcome water pollution. Since the peels are of no use, so the waste peels can be used for the removal of Cd(II) and Pb(II) from effluents of paints, fertilizers and textiles.

Fig-1: Effect of absorbent dose on the adsorption of Cadmium and Lead

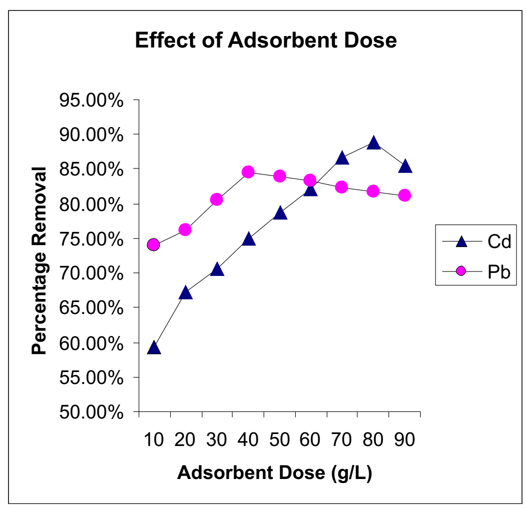

Fig-2: Effect of pH on the adsorption of Cadmium and Lead

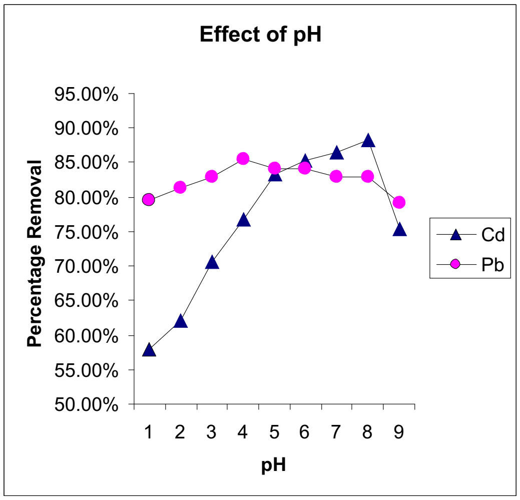

Fig-3: Effect of Contact time on the adsorption of Cadmium and Lead

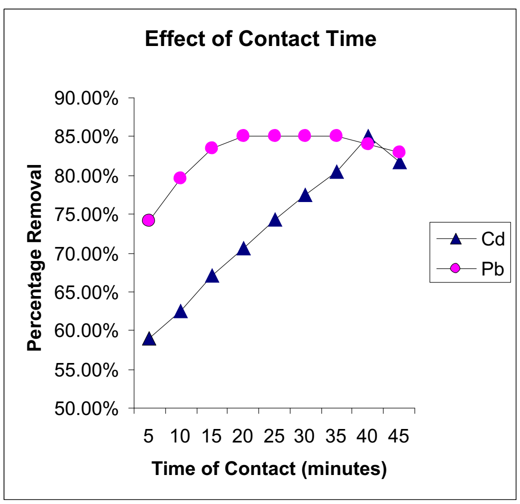

Fig-4: Effect of Agitation speed of Cadmium and Lead

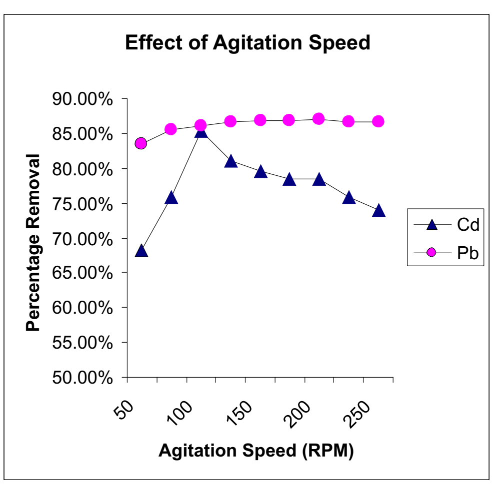

Fig-5: Langmuir Isotherm for Cadmium

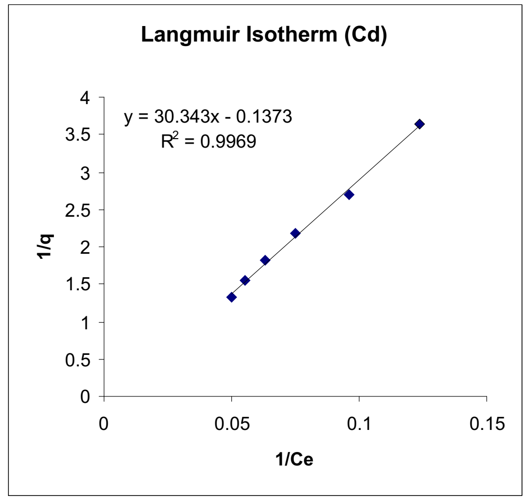

Fig-6: Langmuir Isotherm for Lead

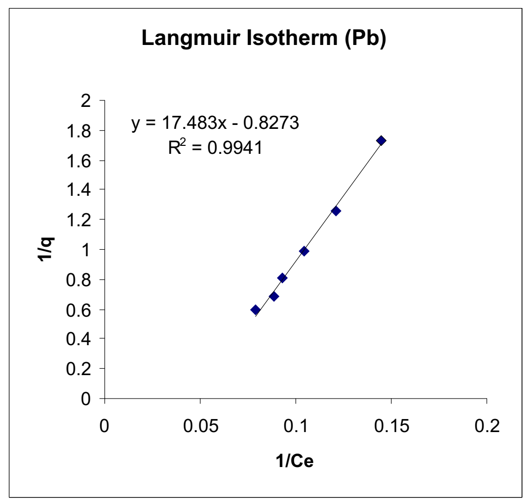

Table-1: Langmuir parameters

Metal	Qmax	b	R^2
Cadmium	7.54	0.004	0.99
Lead	1.23	0.047	0.99

References

1. Trivedi, R. K. *Pollution Management in Industries*, Environmental Publications: Karad, 1N, 1st ed., **1989**, 170.

2. Duffus, J. H. *Heavy Metals*. **2002**, 74(*5*), 793-807.

3. Sitting, M. *Handbook of Toxic & Hazardous Chemicals and Carcinogens*, Noyes Publications: USA, **1991**, 3rd Edition.

4. Wallace, Hayes. *Principles and Methods of Toxicology*. **2001**, *4*.

5. Thun, M. *Journal of the National Cancer Institute*. **1985**, 74*(2*), 325 333.

6. Rooney, Corinne. U.S. Patent 6, 211,126, **2005**.

7. Richards, Wadsworth, *Journal of American Chem. Sec.* **1916**, 38, 221.

8. Shaik, Basha; Bhavanath, Jai. *Discipline of Marine Biotechnology and Ecology*. **2008**, 53(2), 449-455.

9. Adesola, N. A.; Bubarinde, J.; Oyebamiji, Babulola; Olalekan, Sanni. *International Journal of Physical Sciences*. **2007**, 2(*8*), 207-211.

10. Muhammad, Nadeem; Mahmood, A.; Shahid, S. A.; Shah, S. S.; Khalid, A. M.; Macky, J. *Journal of Hazardous Materials*. **2006**, 138(*3*), 604-613.