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Adsorption Studies of Lead on α- Alumina

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Abstract

The presence of toxic metals like lead, mercury, chromium, arsenic, etc. in water is major problem these days. This investigation involves the removal of lead from water by batch adsorption technique using α- alumina ($A1_2O_3$) as adsorbent. Percentage adsorption was determined for alumina-lead solution system as a function of pH, temperature, contact time and adsorbate dose. The known quantities of lead in solutions have been adsorbed on α-alumina and the concentration of lead in the solution after adsorption was determined by atomic absorption spectrophotometer. Maximum adsorption of lead was observed at pH 10, temp.15 ^{O}C, 30 minutes and low adsorbate dose. Adsorption data has been interpreted in terms of Freundlich equation. The results suggest that α-alumina is effective adsorbent for lead removal.

Key words: Toxic metals, Adsorbent, α-Alumina

Introduction

Lead metal has adverse effects on human health if present in significant amount in body. The daily intake of lead contents from all sources i.e. automobile emissions, lead smelter, burning of coal and oil, lead arsenates and pesticides, smoking, mining and plumbing, plastics, paints, house dust and new print, lead batteries, is in the range of 200-300 µg of which 10% is adsorbed in the body (WHO 1972). The special clays were used for heavy metal removal from waste-water (Andrade *et al.* 2005). The heavy metal contents in solution were analyzed before and after the water had circulated through the clay beds. The adsorptive removal of such poisonous metals Pb (II), Cu (II), Mn (II), Hg (II), and CN–was studied (Baghel *et al*. 1999) from water by using adsorbents such as active carbon, impregnated carbon and bentonite loaded fabric strip. Pb is the metal of most interest due to its occurrence in waste water from storage battery manufacturing (Santos *et al.* 2003). The removal of heavy metals from waste water without prior treatment was studied. After the adsorption process, the Pb concentration as well as that of Cd, Ni, Cr and Cu was below the detection limit. The effect of concentration on removal of toxic heavy metal Pb from water and waste water by adsorption technique was studied (Asthana *et al.* 1997). The std. stock solution of Pb was prepared by dissolving a known amount of Pb $(NO_3)_2$ in de-ionized water. It was observed that at temp 30^{O}C and pH 6.0 and particle size < 0.53 µm china clay gives 100% adsorption at 2.0 ppm concentration. The sorption of Pb and Cd was observed (Barbick *et al.* 2000) from aqueous soln. to the montmorillonite/H_2O) interface as a function of pH for three concentrations. Adsorption increases with pH and Pb is retained more than Cd. The removal of Pb, Cd, Cu and Zn from aqueous solutions using the adsorption process on bentonite was investigated (Berket *et al.* 1997). In order to find out the effect of temperature on adsorption the experiments were conducted at 20, 30, 35 and 50 ^{O}C. For all the metals max adsorption was observed at 20 ^{O}C. The adsorption of Pb on 3 clay minerals (Guo 1997) was studied. The results showed that the adsorbing ability of these clay minerals follows the order montmorillonite> kaolinite> illite. The adsorption of Pb^{2+} on montmorillonite is affected greatly by pH. Higher pH is favorable to Pb^{2+} adsorption. Complex organic materials are unfavorable to the adsorption of pb^{2+}. The present work describes the removal of lead in water by adsorption process using alumina. The main objective was to develop a cost-effective technique for water purification.

Materials and Methods

Reagents

All the reagents used were of analytical grade. Lead nitrate was used to make standards for lead determination. The fol-

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lowing chemicals were used. 1000 ppm $(NO_3)_2.3H_2O$ stock solution, 1% Hcl 1% $CaC1_2$ and 1% NaOH. Various spiked standard solutions of 10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm, 60 ppm, 70 ppm and 80 ppm 100 ppm were prepared by taking a known aliquot of the stock solution in borosilicate 250 ml measuring flasks, making the volume up to the mark with deionized water. The ratio of solution to α- $A1_2O_3$ (Alumina) was 50:1

Instrumentation

Atomic absorption spectrometer "Hitachi Polarized Zeeman AAS" equipped with standard burner and air-acetylene flame was used to determine the concentration of lead in each filtrate. The hollow-cathode lamp of lead metal was used.

Procedure

The adsorption of Pb^{+2} on α-$A1_2O_3$ (alumina) was studied by batch-technique (Saad *et. al*.,1994). α- Alumina (E.MERCK)^{TM}, with a BET area of 100$\pm$=30m^2g^{-1}, density 3.970g/cm^3 and a mean particle size 20 nm was used as an adsorbent without any heat and chemical tretment. The amount of adsorbent used was one gram and time taken for adsorption was 30 minutes. The solution to adsorbent ratio was 50:1. All adsorption experiments except variable pH were done at pH 7. 0 and room temperature (32 ^{O}C). pH was measured by using pH meter (Model: 8417 Hanna Instruments). The pH of the suspension in one set of experiments was adjusted by using NaOH / NH_4OH and HNO_3. Low temperature i.e., 15 ^{O}C was obtained by refrigeration. After equilibrium the suspension was centrifuged in a stoppered tube for 5 minutes at 4500 rpm, was then filtered through Whatman 41 filter paper. The concentration of lead persent in the filtrate was determined by AAS and the quantity of lead adsorbed was calculated by difference. Adsorption of Pb^{+2} on α-$A1_2O_3$ (alumina) was determined in terms of percentage cxtraction.

Results and Discussion

For the adsorption studies of lead on alumina, different parameters i.e. effect of adsorbate, time, temperature and pH were studied which are as follows;

1 Effect of adsorbate dose on adsorption

Effect of adsorbate dose on adsorption of Pb^{2+} using lg α-alumina was studied by varying the initial concentration of lead solutions (10-100 ppm). Percent of adsorption values decreases with increasing metal concentration which suggest that at least two types of phenomena (i.e. adsorption as well exchange) taking place in the range of metal concentration studied, in addition less favorable lattice positions or exchange sites become involved with increasing metal concentration.

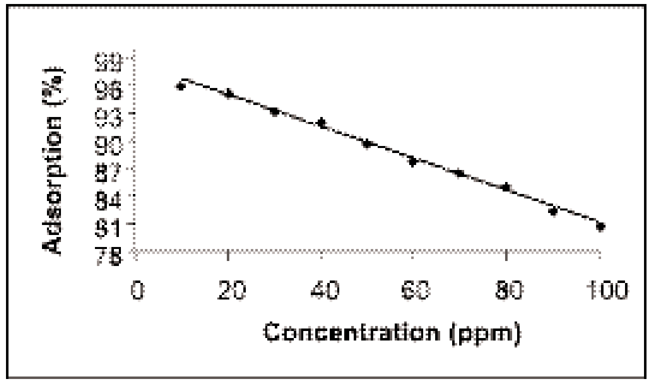

Fig. 1: Effect of adsorbate dose on adsorption.

2 Effect of time on adsorption

Effect of time on adsorption of Pb^{2+} (60ppm) using 1 gram-α-alumina was studied by varying the time intervals taken for adsorption. Adsorption of lead was varied by varying the time for adsorption. Maximum adsorption was observed after 30min. Decrease in adsorption indicates that surface precipitation as well as ion exchange may be possible adsorption mechanism.

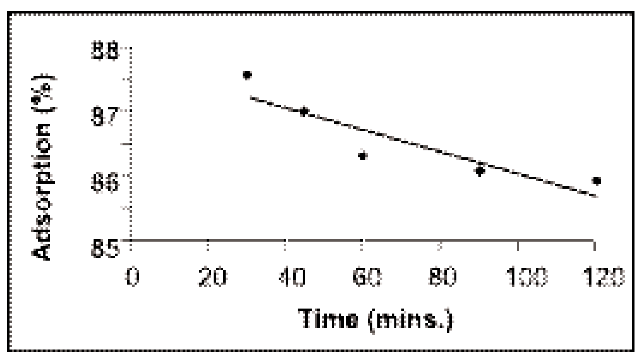

Fig. 2: Effect of time on adsorption.

3 Effect of temperature on adsorption

Effect of temperature on Pb^{2+} adsorption on α-alumina was studied at various temperature ranges i.e. 15, 32, 50, 65 and 80 ^{O}C. Effect of temperature on 50 ppm, 60 ppm and 70 ppm lead standards was studied. Maximum adsorption was noted at 32 ^{O}C. At higher temperature the adsorption decreases because there may be breakdown of the forces by which lead were adsorbed on bentonite.

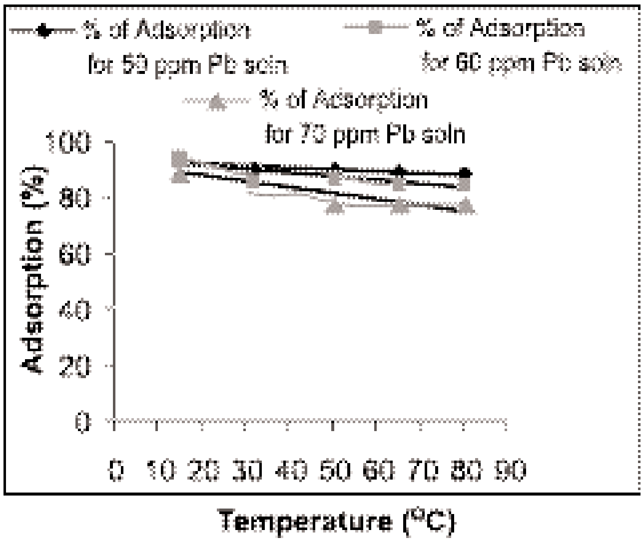

Fig. 3. Effect of Temperature on Adsorption at pH 7

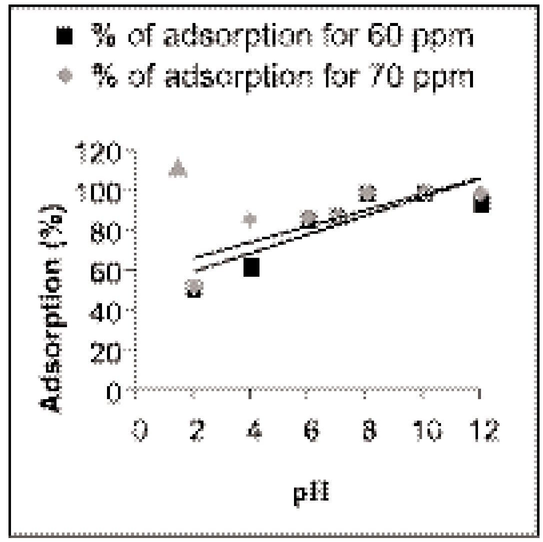

Fig. 5. Effect of pH on adsorption of 60 and 70 ppm pb solution

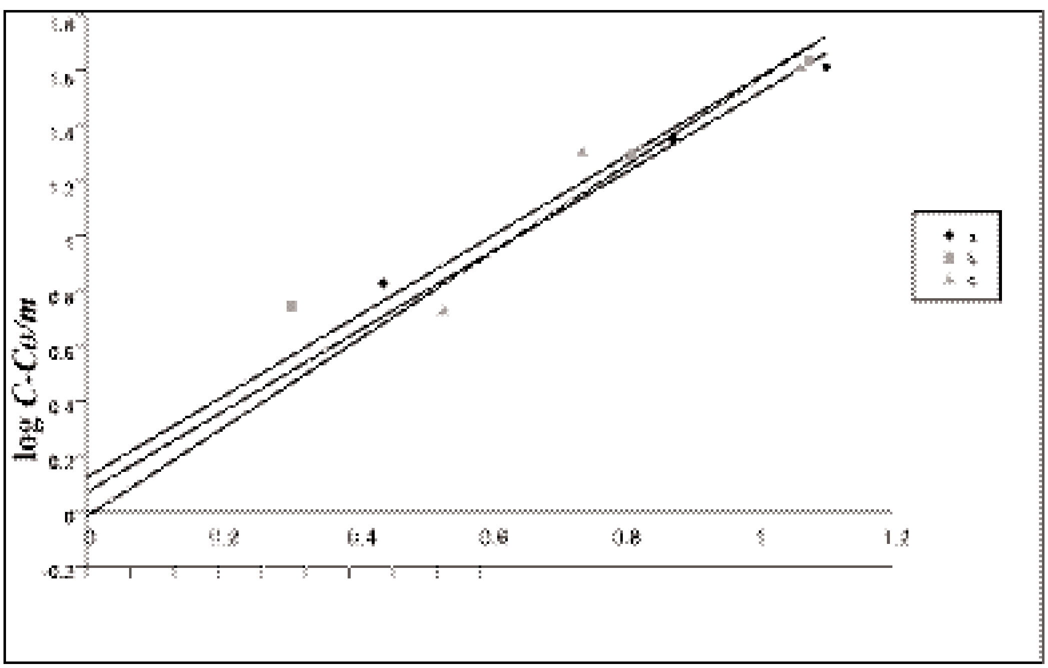

Fig. 4: Freundlich plot of Pb adsorption on α-alumina at different temperatures

The adsorption isotherms at three different temperatures (15$\pm$ 0.5^{O}C, 32$\pm$ 0.5^{O}C and 50$\pm$ 0.5^{O}C) were constructed keeping the working pH constant. The Freundlich isotherm (Saad *et al.* 1994, Sarwar *et al.* 1994) describes the adsorption according to the following relationship:

$$(C_0-C)/m = KC^{1/n}$$

Where, C_0 = the initial conc. of lead ions in solution; C = the conc. of lead ions were the equilibrium was reach m = the amount of alumina used (g/100 ml); k and n = empirical constants. When log $(C_0-C)/m$ was plotted against log C, a straight line was found, showing that the Freundlich equation is satisfied.

4 Effect of pH on adsorption of lead

pH is an important parameter for adsorption of metal ions from aqueous solution because it affects the solubility of the metal ions, concentration of the counter ions on the functional groups of the adsorbent and the degree of ionization of the adsorbate during reaction.

Effect of pH on adsorption of pb^{2+} using lg α-alumina was studied at different pH ranges. 60 ppm and 70 ppm lead standard were used for this purpose. pH of the each of lead standards was maintained at 2, 4, 6, 7, 8, 10, and 12. For 60 ppm and 70 ppm lead solutions, the adsorption of Pb^{2+} was maximum at pH 10. With increase in pH or decrease in acidity of solution, adsorption also increases (Guo 1997).

Conclusion

From this study it was concluded that α -alumina is cheap, easily available, enviornment friendly and good adsorbent. The batch adsorption technique is the best for the removal of lead from water because it is simple, time saving and inexpensive. About 99% lead removal is possible by this technique using α -alumina.

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