Int. J. Chem. Sci.: 9(2), 2011, 836-844
ISSN 0972-768X
www.sadgurupublications.com

REMOVAL OF LEAD IONS USING FLY ASH AS ADSORBENT

S. K. SRIVASTAVA*, S. K. THAKUR, R. C. TRIPATHI and NAMRATA VERMA

Central Institute of Mining and Fuel Research, P.O. FRI, DHANBAD – 828108 (Jharkhand) INDIA

ABSTRACT

The aim of this work is to find out the effectiveness of fly ash for the removal of lead ions from its aqueous solution. Batch adsorption experiments were done in order to evaluate the efficiency of lignite as well as bituminous fly ashes. The ashes used for the purpose were Neyveli Lignite fly ash from NLC Neyveli, Tamil Nadu & Fluidized Bed Combustion ash or Bituminous ash from Tata Steel, Jamadoba. The effect of the parameters, contact time and pH on adsorption of lead on two flyashes used were studied. The contact time necessary for obtaining equilibrium concentration was found to be approximately one hour in acidic medium and approximately 1.5 hours in alkaline medium for both the ashes. Experimental results show that the value of equilibrium concentration of Pb^{2+} (lead ions) in alkaline medium, at pH 7.80 was less than the corresponding value in acidic medium at pH 5.50. Hence fly ash in alkaline medium was found to be more effective for adsorption of lead than in acidic medium but time taken would be more. It was observed that both the fly ashes were highly effective for removing the concentration of Pb^{2+} (or lead ions) from its aqueous solution.

Key words: Lead ion, Fly ash, Adsorbent.

INTRODUCTION

Environmental contamination by heavy metals is a widespread problem. The removed of these heavy metals which are highly toxic for animals and human beings are of significant importance as they are nonbiodegradable. Once released into the environment, they cannot be destroyed but can be diluted or transformed.

Often human activities affect the natural geological and biological distribution of these heavy metals once released into the environment by altering its chemical form and give rise to bioaccumulation in plants or bioconcentration in food chain and attack specific

*Author for correspondence; E-mail: sukusri1@rediffmail.com

organ in the body. This may give rise to heavy metal pollution. Since the main source of heavy metal are the industrial activities, therefore, they should be removed from industrial wastewater before discharge.

Lead is one of the heavy metals whose pollution is of environmental concern. It may prove to be toxic when present in high concentration. Lead pollution in surface water bodies may occur by mine and smelter discharges or from the use of lead based pipes in water supply systems, coal combustion, use of lead based paints, etc.

Natural waters should not contain more than 5 µg/L of lead. The acute toxic symptoms of lead are anemia, headache, insomnia, dizziness and irritability, weakness of muscles, hallucination and renal damage. In adverse situation it may damage kidney, lever, reproductive system, basic cellular process and brain function.

Present study deals with the effectiveness of fly ash in the removal of lead ions from its aqueous solution.

Fly ash, a waste material generated from pulverized coal based Thermal Power Plants, may pose environmental challenges if not managed well, because every year tones and tones of this ash is generated. More over this fly ash generation is expected to grow further in the coming years as coal would continue to remain as a major source of energy at least for next 25 years.

Thus in order to protect the environment, Fly Ash Utilization Programme (FAUP) was set up. This is a Technology Project in Mission Mode by the Government of India commissioned, to overcome or face this environmental challenge. This mission undertakes projects for creating awareness for safe disposal or safe management & gainful utilization of fly ash.

Fly ash is made up of three types of solids,

(i) Chemically water stable solids (SiO_2, Fe_2O_3, Al_2O_3) which has low reactivity in water but possesses surface electric charge. (The reason for electric charge may be due to zeta potential). It may adsorb metal cations, e.g. Cd, Ni, Pb, etc., or anions. e.g. arsenate. borate, sulfate, etc .

(ii) Relatively water soluble solids (e.g., Metal-SO_4, and Metal-BO_3). These are the group of components present in coal fly ash, which are represented by metals or metalloids adsorbed onto the oxide surfaces.

(iii) The third group includes highly water reactive components. Generally, this group includes oxides of Ca, Mg, K, Na, Ba, as well as gypsum ($CaSO_4$. $2H_2O$), nearly a neutral salt and sulfite (SO_3).

Also fly ash has got a high porosity or surface area per unit mass, which is the common characteristics of all fly ashes. Hence due to the surface charge and high porosity, fly ash proves to be an effective adsorbent for adsorbing metallic ions from its aqueous solution.

Present work deals with the effectiveness of lignite as well as bituminous fly ash in the removal of lead ions from its aqueous solution.

EXPERIMENTAL

Methods and materials

Adsorption experiment were conducted using two types of fly ashes viz.

(i) Neyveli Lignite fly ash from NLC Neyveli, Tamil Nadu and

(ii) Fluidized bed combustion ash or bituminous ash from Tata Steel, Jamadoba.

The element analyzed for adsorption was lead (Pb^{2+}).

Solution of lead was prepared by dissolving lead nitrate in distilled water. Analysis of lead in aqueous solution was done by Atomic Absorption Spectrophotometer (Model Number 680; Make: Shimadzu AA680). Adsorption experiments were done using Electric Shaker.

The chemical compositions of the two of fly ashes were determined by XRF Model PW2424 Magix X (Make: Philips the Panalytical).

Fly ash was tested following of American Standard of Testing Materials for its water soluble components. Fly ash was mixed with distilled water in the ratio of 1 : 20 and operated in electric shaker for 18 hours. After 18 hours the suspension solution was filtered with Whatman 40 filter paper and the clear liquid obtained was tested for various chemical parameters. The ORION make pH-meter measured the pH. Loss on Ignition (LOI) was determined by heating a pre weighed dry sample (left at 105ºC in an oven and then cooled in a desiccator) to 800ºC, over a period of two hours. The concentration of calcium and magnesium ions were measured by standard EDTA method. Like wise the concentrations of sulphates and chlorides were also measured by the standard methods.

Adsorption experiments

For carrying out the adsorption experiments six stoppered conical flasks were taken and in each conical flask 20 g of fly ash was added followed by mixing it with 250 mL of lead solution prepared. All six conical flasks containing fly ash and the lead solution mixture was kept on an electric shaker. The shaker was kept on for three hours continuously. After each half an hour one conical flask was removed from electric shaker for collection of clear liquid.

The clear liquid was collected by filtering the materials using Whatman 40 filter paper and the same was analyzed for lead ion concentration in AAS. The results showed that the concentration of lead ions was that decreased due to adsorption on the fly ash particles. This experiment was repeated with two different pH values of lead solution or aqueous solution of lead prepared (one in slightly acidic medium and the other in slightly alkaline medium) and the data on decrease in the concentration of the lead ions with time was collected and plotted with respect to time followed by data interpretation.

RESULTS AND DISCUSSION

The chemical composition of Neyveli Lignite Corporation Thermal Power Plant fly ash and Fluidized Bed Combustion Power Plant fly ash of Tata Steel, Jamadoba is presented in the Table 1.

Table 1: Chemical composition of two types of fly ash

Compound/ parameter	Composition of Neyveli lignite fly ash	Composition of FBC ash of TATA Steel, Jamadoba
LOI	4.46	17.15
SiO_2	52.75	46.55
Al_2O_3	22.27	20.99
Fe_2O_5	5.39	5.69
TiO_2	0.40	1.21
P_2O_5	0.60	0.81
SO_3	3.75	1.30
CaO	9.40	3.23

Cont…

Compound/ parameter	Composition of Neyveli lignite fly ash	Composition of FBC ash of TATA Steel, Jamadoba
MgO	0.81	0.58
Na_2O	0.58	0.32
K_2O	0.13	1.65

It can be seen from Table 1 that the fly ash is siliceous in nature. The oxides of silica and aluminum predominate followed by the oxide of iron. These are the insoluble oxides or water stable oxides. Thus the percentage of water stable oxides is much more than the water soluble oxides. That is the reason fly ash when mixed with water do not react much with water to form any other compound.

The leaching results determinations were made following ASTM standard on Neyveli Lignite Corporation Thermal Power Plant fly ash & Fluidized Bed Combustion Power Plant fly ash from Tata Steel, Jamadoba are presented in Table 2.

Table 2: Leaching result with respect to Neyveli lignite fly ash from NLC Neyveli, Tamil Nadu and fluidized bed combustion ash from Tata Steel, Jamadoba

Parameter	FBC Ash	Neyveli Ash
Ca^{2+}	320 mg/L	400.8 mg/L
Mg^{2+}	43.92 mg/L	179.34 mg/L
SO_4^{2-}	0.18 mg/L	0.0313 mg/L
Cl^-	0.12 mg/L	0.086498 mg/L
LOI	17.15	4.46
pH	10.09	11.61

On careful examination of Table 2, it can be observed that both the ashes are alkaline in nature and the water soluble sulphates is too less. It is believed that most of the heavy metals which are released into the environment as water soluble components are present in the form of sulphates.

Variation in the concentration of lead ions with time

The results of variation in the concentration of Pb^{2+} (lead ions) with time, at different

pH values using both the fly ashes i.e. Neyveli Lignite fly ash of NLC, Tamil Nadu & fluidized bed combustion fly ash of Tata Steel, Jamadoba are shown in figures 1, 2, 3 and 4.

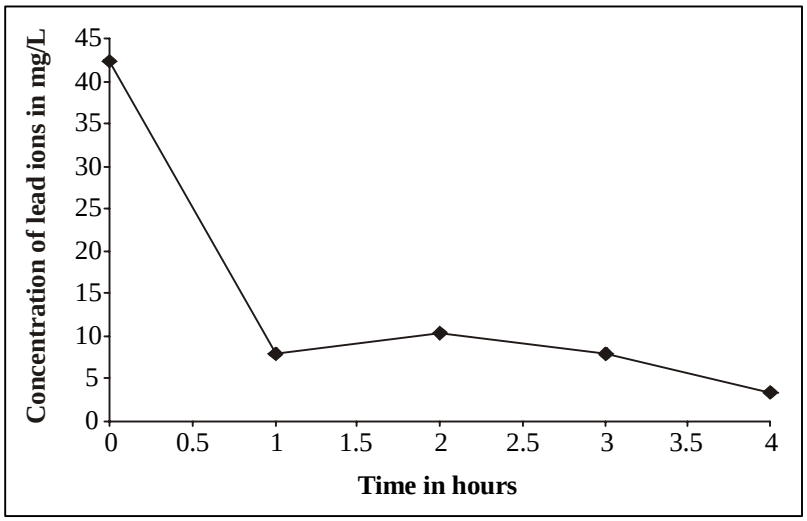

Fig. 1: Variation in the concentration of lead ions with time at pH 5.50 with FBC ash of TATA Steel, Jamadoba

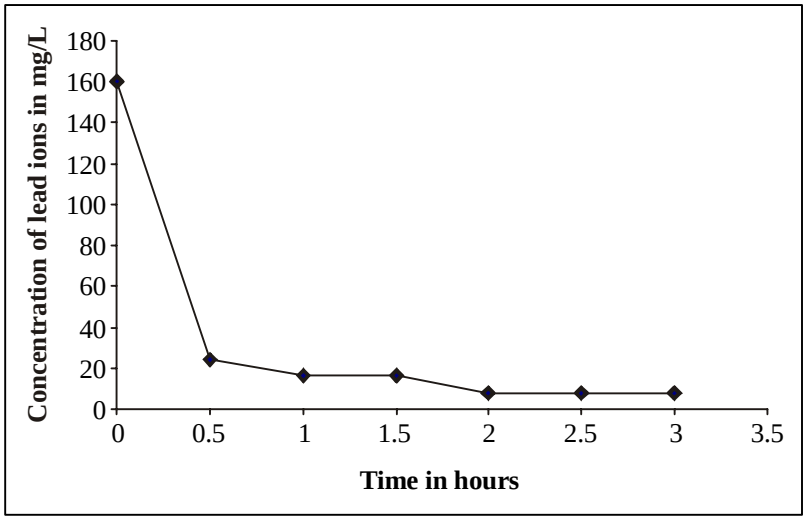

Fig. 2: Variation in the concentration of lead ions with time at pH 5.50 with Neyveli lignite fly ash

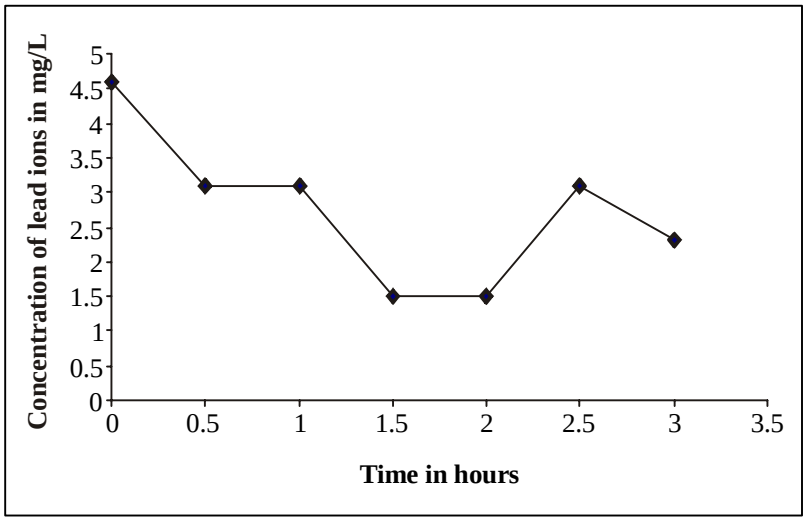

Fig. 3: Variation in the concentration of lead ions with time at pH 7.80 with FBC ash of TATA Steel, Jamadoba

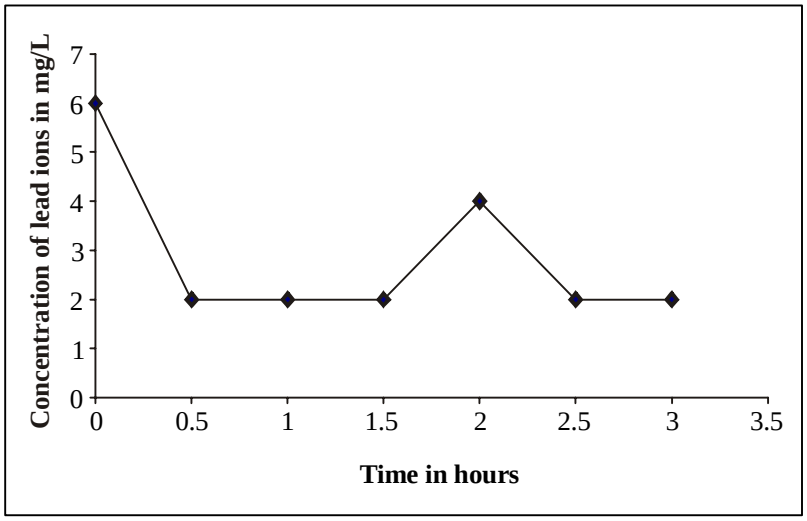

Fig. 4: Variation in the concentration of lead ions with time at pH 7.80 with Neyveli lignite fly ash

Figs. 1, 2, 3 and 4 reveal that as the time of shaking (fly ash and aqueous solution of lead prepared) increases, the concentration of lead ions in the solution decreases. After a certain period of time the concentration of Pb^{2+} (lead ions) in the suspension solution becomes almost constant. This is the time for reaching the equilibrium concentration.

It was observed that the time of reaching the equilibrium concentration is different in all the cases. In acidic medium, i.e. pH 5.50 it was around one hour for both the fly ashes and in alkaline medium i.e. pH 7.80 it was around 1.5 hours for both the fly ashes.

On comparing the data of equilibrium concentration of Pb^{2+} (lead ions) from initial stage, to a period of three hours of experiment, it was found that effective removal or reduction of Pb^{2+} (lead ions) concentration has positively occurred which proves that the two the fly ashes are effective adsorbents.

In case of FBC ash of Tata Steel, Jamadoba; the value of equilibrium concentration at pH 5.50 is 7 mg/L of Pb^{2+} (lead ions), while in case of Neyveli Lignite fly ash it is 5 mg/L of Pb^{2+} (lead ions).

Similarly in case of FBC ash of Tata Steel, Jamadoba the value of equilibrium concentration at pH 7.80 is 1.5 mg/L of Pb^{2+} (lead ion), while in case of Neyveli Lignite fly ash also the value is 1.5 mg/L of Pb^{2+} (lead ion).

When the values of equilibrium concentrations obtained at pH 5.50 and 7.80, (irrespective of the values of the initial concentration) are compared it can be seen that the value of equilibrium concentration is less in case of alkaline medium than in acidic medium. Hence the adsorption is favored more in case of alkaline medium, rather than in acidic medium.

The plausible explanation would be at low pH value the H^+ ions predominate and at high pH value OH^- ions predominate. Hence at low pH value, most of the adsorption sites are neutralized by the H^+ ions, giving rise to hindrance to the adsorption process. Whereas at high pH values, the negative charge of the fly ash particle is increased due to the predominance of OH^- ions enhancing the adsorption process.

CONCLUSION

The data on chemical composition of the two ashes clearly indicate that the percentage of water stable oxides are more (e.g. SiO_2, Al_2O_3, Fe_2O_3) than the water soluble oxides (e.g. CaO, K_2O, MgO, etc.). These fly ashes proved to be an effective adsorbent for the removal or reduction of lead ions from its aqueous solution.

Adsorption of lead ion from its aqueous solution is more effective in alkaline medium than in acidic medium.

The data obtained in this study clearly demonstrated the potential use of both the fly ashes viz. Neyveli Lignite Corporation Thermal Power Plant fly ash & Fluidized Bed Combustion Power Plant fly ash or Bituminous fly ash from Tata Steel, Jamadoba for the removal of Pb^{2+} (lead ions) from its aqueous solution.

REFERENCES

1. T. A. Albanis, D. G. Hela, T. M. Sakellarides, T. G. Danis, Global Nest : The Int. J., **2 (3)**, 237-244 (2000).
2. J. Y. Hwang and X Sun Z. Li, J. Min. Mat. Char. Engg., **1**, **(1)**, 39-60 (2002).
3. A. Ansari, F. Raofie, E. J. Chem., B, **10**, 49-59 (2006).
4. S. Shanmugav Alli, P. S. Sayed Shabudeen, R. Venckatesh, K. Kadirvelu, S. Madhavakrishnan and S. P. Oattabhi, E. J. Chem., **3(3)**, 218-229 (2006).
5. Belgin Bayat, Water, Air and Soil Poll., **136**, 69-92 (2002).
6. Bably Prasad, Namrata Verma, Adesh Srivastava and Kajal Kumar Mondal, National Seminar on Status of Environmental Management in Mining Industry, 2003, BHU, (2003) pp. 421-428.
7. S. K. Srivastava, N. Verma, T. B. Das and Rupa Das, Indian J. Envir. Prot., **27(6),** 502-507 (2007).
8. X. Querol, J. C. Umana, F. Plana, A. Alastuey, A. Lopez- Soler, A. Lopez – Soler, A. Medinaceli, A. Valero, M. J. Domingo and E. Garcia – Rojo, Fuel, **80**, 857-865 (2001).

Revised : 05.12.2010 *Accepted : 07.12.2010*