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Adsorption of lead (II) from aqueous solution by fly ash

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Abstract

A Carbon adsorbent derived from Fly Ash was used for the Removal of Pb (II) from aqueous solution. Sorption of Metal ion has been studied as a function of contact time, temperature, PH of the Solution and metal ion concentration these factor have Remarkable positive effect on sorption process. the Adsorption data of Fly Ash at different Initial Concentration was fitted to frendlich & Langmuir adsorptions Isotherms and monolayer's sorption capacity determined was 72 (PH 5.0 temperature 27^0C).

Thermodynamic parameter indicated that the sorption is Exothermic spontaneous with a greater affinity of metal species for the adsorbent.

Keywords: fly ash, PB (II), sorption, metal ion, adsorption isotherm, AAS

Introduction

The Heavy metal plays a vital role in the normal function of living organism the presence of trace metal in the aquatic environment has been of great concern because of their toxicity non-biodegradable nature

Activated Carbon adsorption is a well Known method for the removal of heavy metals [1, 2]. Process including chemical precipitation, Coagulation, solvent extraction electrolysis, membrane separation, Ion Exchange and adsorption are commonly used to solve pollution problem caused by Heavy Metals. For this purpose Activated Carbon Adsorption is well known of activated Carbon and adsorption is well known method for Removal of heavy Metals [3, 4].

The Adsorption capacity of metals on Fly Ash depends on the agitation rate Adsorption increases, Although not in direct proportion by increasing the agitation speed it may be though that or the speed increase Resistance to mass Transfer from bulk to the adsorbents phase decreases, Resulting in Increased adsorption rate. It is noted that by increasing the agitation Speed the percent adsorption increases for all of the solutes but at different extents. This is probably due to the difference in molecular size.

Fly Ash material solidifies while suspended in the exhaust gases and in collected by electrostatic precipitators or filter bags. Since the particles solidify rapidly while suspended in the exhaust gases, Fly Ash particles are generally spherical in shape and range in size from 0.5 μm to 300 μm the metar consequence of rapid cooling is that only few minerals will have time to crystallize and that mainly amorphous, quenched glass remains. Never the less some factory phases in the pulverized cool will not melt (entirely) and remain crystalline in consequence. Fly Ash is a heterogeneous material SiO_2, Al_2O_3, Fe_2O_3, and occasionally CaO are the main chemical Components present in the Fly Ashes.

Experimental

- Preparation of sample: The Fly Ash is prepared by standard novel method.
- Preparation of lead stock Solution: For our analytical purpose we made a stock solution of lead of 1000 PPM from lead nitrate. For this we dissolve 1.30 gm in 100 ml water. All Reagents are AR or GR grade.
- Sorption Studies:- For the study of Removal of Pb (II) metal form aqueous solutions 100 ml of metal solution is taken with 2.5 gm of hybrid precursor in a shaker (100 PPM), After about 45 minutes sample were withdrawn from the shaker, centrifuged and the supernatant solution was Analyzed for Residual metals by AAS.

Result and Discussion

The Results obtained from AAS study is Shown in table-1 and it is evident that the adsorption of Pb (II) is maximum at this concentration and at ph- 5.0 the contact time was 60 minutes.

3.1 Using Batch technique the dependence of adsorption of Pb (II) on contact time was determined at time Intervals of 15 minutes, 30 minutes, 45, 60 75, 90 and 105 minutes at 303 k

The tabel-1 shows the Effluence of contact time on the adsorption of metal by Fly Ash. Effect of contact time was studied by taking 100 PPM solution at PH- 5.0 (adsorbent dose 0.5 gm/Litt.) Rate of up take of Pb (II) was Initially lower and Increases with contact time it Ranges from 18 to 78.5 % at 303 k the Increases in Removal efficiency with contact time is due to Increase in surface area of Absorbent and hence more active sites are available for the adsorption the fig-1 show the dependence of adsorption of metal Ion on contact time and Indicates that contact time plays a vital role in any adsorption Process.

Table 1: Removal of Pb (II) by Fly Ash Temp. 303 K Ph 5.0

S.No.	Weight of Adsorbent (gm)	Time min.	Amount Adsorbed Ppm	% Removal of metal ion
1	0.5	15	180	18.0
2	0.5	30	200	20.0
3	0.5	45	560	56.0
4	0.5	60	720	72.0
5	0.5	75	755	75.0
6	0.5	90	780	78.0
7	0.5	105	785	78.5

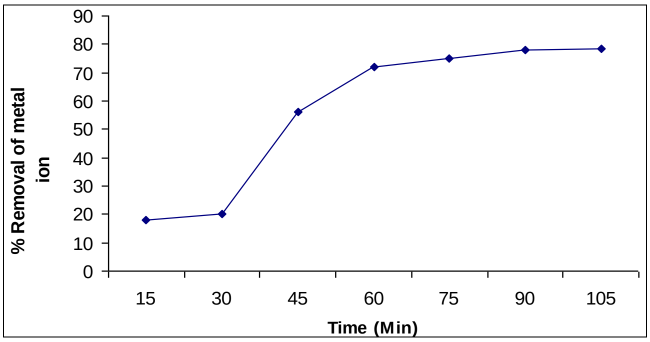

Fig 1: Effect of contact time on adsorption of Pb (II) at 303 k on Fly Ash

3.2 Effect of PH and Pb (II) up take

Aliquots of 100 ml Pb (II) solution of known concentration were poured into beaker (250 ml) containing 0.5 gm of adsorbent.

The beaker was shakes at 200 rpm using an electric shaker for 12 hr at 303k. The solution was centrifuged and adsorbent was then removed by filtration after filtration the solution was analyzed for residual metal content by AAS.

Series of solution of Fly Ash with metals has been prepared and the PH of Adsorbate solution was absorbed by adding HCl or NaOH. The effect of PH on adsorption Process was studied by increasing Ph of the solution 2 to 10 (Initial Metal concentration was 1000 PPM.)

The various Results are shown in table 2 and Represented by figure- 2 the Removal of metal ions from aqueous solution by adsorption is highly dependent on the PH of the solution which effects the surface change of the adsorbent and the degree of Ionization and speciation of the adsorbent and the shows the removal of the metal increased with Increase in ph and Reached Maximum at PH- 5.0 followed by a sharp Increase in Removal Reacting close to 79 % over the PH 8.00 to 10.00 it can be explained as According to stability constant calculations the Increase of So_4 the Predominant species at PH < 4.0 in Pb So_4 (Fig.- 2).

Table 2: Percentage Adsorption of Pb (II) by Fly Ash (Effect of PH) Temp. 303 K Adsorbent weight 0.5 gm Contact time 60min

S.No.	PH	Removed amount of pb(II) in ppm	Removed % pb(II)
1	2	520	52.0
2	4	705	70.5
3	6	730	73.0
4	8	695	69.5
5	10	750	75.5
6	12	790	79.0

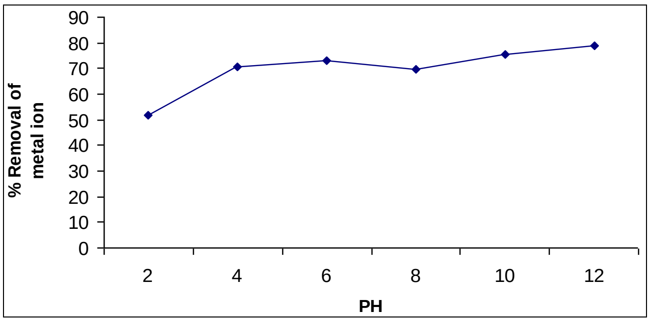

Fig 2: Effect of PH on Adsorption of Pb (II) At 303K Fly Ash

The formation of this has been found to decrease the Pb adsorption at this PH the Increase uptake of Pb Ions at increased PH is due to the fact that at higher PH Concentration of H^+ ion decrease but the concentration of metal ions Remains the same leading to Increase uptake by adsorbent.

3.3 Effect of adsorbent dose on Pb (II) uptake

The effect of adsorbent doses level on sorption of Pb (II) is shown in table- 3 and figure- 3 the study was carried out by taking 1000 ppm solution of metal.

Adsorbent dose varied form 20 gm/ 100 ml to 180 gm/ 100 ml more that 78.5% of Pb Removal occur at dose. level 180gm/100ml so, like the other factors adsorption dose of adsorbent plays a vital role in the study of the percentage removal of pb (II) the higher dose of adsorbent due to increased surface area would have caused the availability of more number of adsorption sites resulting in higher uptake of metal Ions.

Table 3: Percentage Adsorption of Pb (II) by Fly Ash (Effect of Absorbent dose) Temperature 303 K ph 0.5 gm Contact time 60min

S.No.	Adsorbent dose gm/100 ml	Removed Amount of pb (II) in ppm	Removed % pb II
1	20	450	45.2
2	40	620	62.0
3	60	680	68.0
4	80	710	71.0
5	100	760	76.0
6	120	775	77.5
7	140	780	78.0
8	180	785	78.5

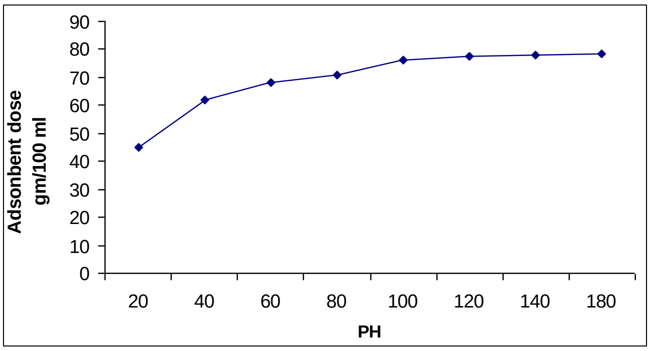

Fig 3: Effect of Adsorbent dose on adsorptions of Pb (II) at 303 k on Fly Ash

3.4 Effect of Initial metal concentration on metal uptake

The effect initial concentration of metal ions on the sorption potential of adsorbent Fly Ash was investigated at ph 5.0 and adsorbent dose 0.5 gm the adsorption data of adsorbent at different initial concentration of Pb (II) is shown in table-4 and 5.

The adsorption increases the percentage removal of metal ion decreases from 72% at 100 mg/ L^{-1} to 66.4% at 250 mg/L^{-1} on case of Pb (II)

The decreases in removal percent may be due to the fact that adsorbent possess a limited number of achieve sites and there sites become saturated at contain concentration.

3.5 Influence of temperature and study of adsorption isotherm

The study on Influence of temperature on metal sorption indicated the adsorption of Pb (II) on Fly Ash in exothermic. The adsorption capacity decreased with an increase in the temperature of the system. This also proves the endothermic nature of the Reaction. Two Isotherms can be written as

$$\text{Log}\frac{x}{m} = \log\ k + \frac{1}{n}\log Ce$$

Frendlich adsorption isotherm and

$$\frac{1}{x\backslash m} = \frac{1}{q_0}\left(\frac{1}{q_0 b}\right)\frac{1}{c_e}$$

Langmuir adsorption isotherm

C_e is the equilibrium concentration (g/l) and x/m is the amount of metal adsorbed at equilibrium (g/g) q_0 and b are Langmuir constants respectively q_0 signifies the adsorption capacity of the adsorbent and b in related to energy of adsorption process. A series of Isotherm were determined at fine different concentration namely.

50, 100, 150, 200, 250 mg/L, keeping all other experimental conditions constant. The value in the Table- 4 at 5 indicates that the uptake of metal ion per unit pass of the adsorbent increased with the increasing concentration of solution. in freundlich adsorption isotherm x/m in the amount of metals adsorbed per unit weight of adsorbent (g/g) C_e in the equilibrium concentration of sorbet k is a content which is a measure of adsorption intensity the liner plots of x/m vs log C_e (Fig- 4 and 5) suggest the applicability of the freundlich model for lead sorption. The values of freundlich constants are given in table- 6 the value of n (1 to 10) suggests the beneficial adsorption of lead by Fly Ash. The sorption data were also analyzed in the light of Langmuir's model. The linear plots of x/m versus $\frac{1}{C_e}$ (fig- 5 and 7) suggest the applicability of the Langmuir model. the liner plots clearly indicate monolayer's coverage of adsorb are at the outer surface of the sorbent langmuir contents and thermodynamics parameters calculated from the adsorption data are shown table- 7 standard monolayer of Gibbs free energy for these process is calculated as

$$\Delta G^0 = RT\ln k$$

And the standard enthalpy change in calculated form the value of k at 303k 313k respectively

$$I_n\frac{K_1}{K_2} = \frac{-\Delta H^0}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

K_1 and K_2 are the respective contents at this temperature are derived from Langmuir plots standard entropy change Δs^0 for the process was calcultated form the equation

$$\Delta G^0 = \Delta H^0 - T\Delta S^0$$

$$\Delta S^0 = \frac{\Delta H^0 - \Delta G^0}{T}$$

From the data shown in Tab- 8 for Pb (II) are value of q_0 (Langmuoir Contants) decreses show the exothermic nature of the adsorption. The value of ΔG^0 are negative which means that reaction are spontaneous. The magnitude of ΔG^0 decreases with rise in tempreture pointing to words spontaneity of the reaction and gradual change in affinity of metal in by Fly Ash. The value of enthalpy can be use to distinguish between chemical and physical adsorption of any adsorption process. The Enthalpy values for Pb (II) come to 1.005 suggest the Endothermic nature of the process and reaction was energically stable.

A positive entropy value for Pb (II) reflect infinite of adsorbent material (Fly Ash) for pb (II) the positive values of entropy also suggest a high degree of disorderedness ate the solid solution interface during the adsorption of metal ions on to Fly Ash.

The essential characterizations of the Langmuir equation can be described by a dimensionless equilibrium parameter $R_{L,}$ which is defined by Hall *et al.*

$$R_L = \frac{1}{(1+b\,c_0)}$$

Where b is the Langmuir constant and c_0 is the insital metal ion concentration the value of R_L indicates the shape of the Iso therm to be Iso therm is favourable i.e. R_L value $0 < R_L < 1$ (table-7)

Table 4: Percentage Adsorption of Pb (II) by Fly Ash (Effect of PH) Temperature 303 K Adsorbent weight 0.5 gm Contact time 60min

Intial Con. mg/L	c_e	X	X/M	Log C_e	Log X/M	$\frac{1}{C_e}$	$1/\frac{x}{m}$
50	1.25	48.70	0.0974	0.0969	-1.6143	0.80	10.26
100	1.58	96.50	0.1939	0.4116	-0.7104	0.38	5.15
150	6.38	143.59	0.2871	0.8042	-0.5419	0.15	3.48
200	10.38	189.58	0.3791	1.0161	-0.4212	0.09	2.63
250	15.90	234.00	0.4680	1.2013	-0.3297	0.06	2.13

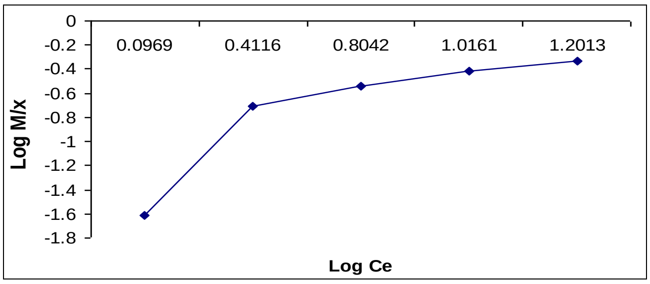

Fig 4: Freundlich adsorption isotherm of Pb (II) at 303 K on Fly Ash

Table 5: Value of Freundlich Constants for Pb (II)

Metal Ion	**Log**		**1/n**		**r(Corr. coefficient)**	
	303k	313k	303k	313k	303k	313k
Pb (II)	-1.4614	-1.0337	1.045	0.587	0.907	0.985

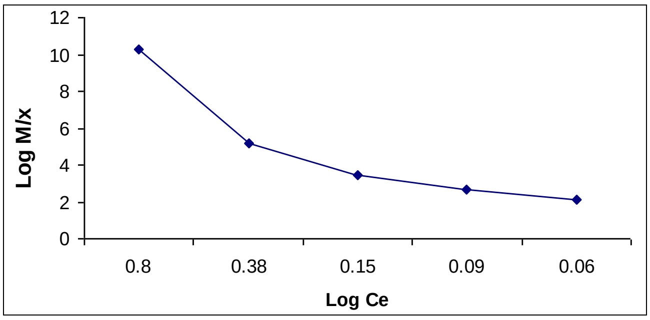

Fig 5: Langmuir adsorption of Pb (II) at 303 K on Fly Ash

Table 6: Values of Langmuir Constants and thermodynamics parameter

Metal Ion	**q value related to the equilibrium constant (Lmole^{-1})**		**b (lng^{-1})**		**ΔG^0 K. Cal mole^{-1}**		**Mean ΔH^0 K. Cal mole^{-1}**	**Mean ΔS^0 K. Cal mole^{-1}**
	303K	313K	303K	313k	303k	313k		
pb (II)	1.5787	1.5978	10.646	11.249	-1.369	-1.447	1.005	0.00783

Table 7: Equilibrium Parameters R_L Calculated from Langmuir adsorption Isotherm

Metal Ion Concentration (mg/L)	**Pb (II)**	
	303k	313k
50	0.00187	0.00177
100	0.00093	0.00088
150	0.00062	0.00059
200	0.00046	0.00044
250	0.00037	0.00035

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