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EFFICIENT ADSORPTION OF LEAD ION FROM AQUEOUS SOLUTION TO EXPLOIT FABRIC FLY ASH AS ADSORBENT

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ABSTRACT

Adsorption performance by fabric fly ash for removal of lead ion from aqueous solution was analyzed. As forces of attraction between lead and fly ash exist and due to this heat energy released. Batch experiments were conducted included various influence of parameters like initial metal ion concentration, ph, and adsorbent dose under different conditions. Kinetic study were explained by pseudo second order reaction and high rate of adsorption explained by well fitted weber morris model at two temperatures 35° C and 45° C. Equilibrium study well explained by Temkin isotherm. Thermodynamic study revealed spontaneity and endothermic behavior for the process.

Keywords: Adsorption, Kinetic, Fly Ash, Heavy Metal.

I. INTRODUCTION

To make better safe and eco-friendly environment, water pollution [1, 2] should be decreased from industrial point of view. As many industrial sectors use heavy metals for processing and their waste effluent contains those heavy metals contaminates used in processing [3-5]. A toxic metal are lead, manganese, chromium, copper, mercury, nickel and cadmium etc. consummated by human bodies as well as animals and also causes chronicle diseases as kidney, liver, blood pressure problems. So to overcome from these problems should maintain the balance of environment [6, 7].

From literature it is clear that many techniques available for removal of heavy metals. Techniques as precipitation, titration, electro dialysis, ion exchange and adsorption. Adsorption is efficient and reliable method for removal of heavy metals and also gives high adsorption capacity and inexpensive method.

As many adsorbents have been exploited by many researchers and they have also introduced better and efficient adsorption capacity as activated charcoal, biochar, zeolites, ashes etc[8-13]. Presented paper introduces the fabric fly ash as low cost adsorbent. Waste fabric used to make fly ash in presence of air. Main aim of study to find out a cheap adsorbent that give better sorption characteristics of Lead metal ion with respect to parameter influence, equilibrium study and kinetic study.

II. EXPERIMENTAL

Materials

Waste fabric fly ash is used as adsorbent for adsorption of lead ions. Firstly waste fabric collected and then dried fabrics in sunlight for 4 to 5 days and completely burned in open atmosphere. After cooling by one night collected this fly ash in container. Stock solution of Lead (25ppm) was prepared by dissolving calculated amount of $PbNO_3$ in distill water. This stock solution was used for preparing different working solutions to know effect of parameters effect of temperature and effect of residence time.

Method

Batch Adsorption set up was used for all parameter study. Adsorption is like very efficient technique to remove heavy metals. Effects of initial metal ion concentration, effect of pH, effect of adsorbent dose were studied. Effect of metal ion concentration by varying only concentration 5, 10, 15, 20 ppm all other factors fixed. Effect of pH by adjusting pH 2, 4, 6, 8, and 10 by 0.1 N HCl and 0.1N NaOH while all others fixed. Likewise, effect of adsorbent dose by 0.1g, 0.2g and 0.3g of adsorbent quantity. All these parameters were evaluated to know the optimum range of these parameters [14].

III. RESULTS AND DISCUSSION

3.1 Effect of initial metal ion concentration

To analyse the result of initial metal ion concentration, varying concentration from 5 to 25 ppm and by adding 0.2g of adsorbent per 20ml of the solution. After 2 hr constant stirring at room temperature on rotary shaker then analysed by uv vis spectrophotometer ultra 3660. From figure observations as concentration is varying from 5 to 25ppm, amount adsorbed per gram of the adsorbent is also increasing for 20 ppm amount adsorbed was 3.25 mg/g and for 25ppm amount adsorbed was 3.82 mg/g due to effect of more active sites present initially then on high concentration all active sites are completely occupied by adsorbate. Similar type of behavior reported in literature.[15, 16]

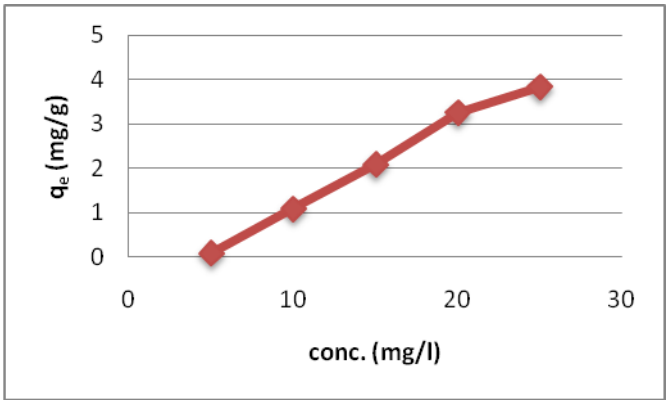

Figure 1. Effect of initial metal ion concentration on adsorption of lead ion

3.2 Effect of pH

To know the optimum value of pH test analysis was done. On adjusting pH by 0.1N acid /base solution per 20ml of solution with respect to varying pH and adding 0.2g of adsorbent constant stirring for 2hr gives values upon analysis. From figure at low pH 2, number of negative charged ion release less and high value of pH 8 and pH 10 negative charged ion release more which totally favors the adsorption. Adsorption capacity is increasing at high pH as comparison to low pH values due to surface negative charged ion present. Therefore optimum pH range is 6.5.[17, 18]

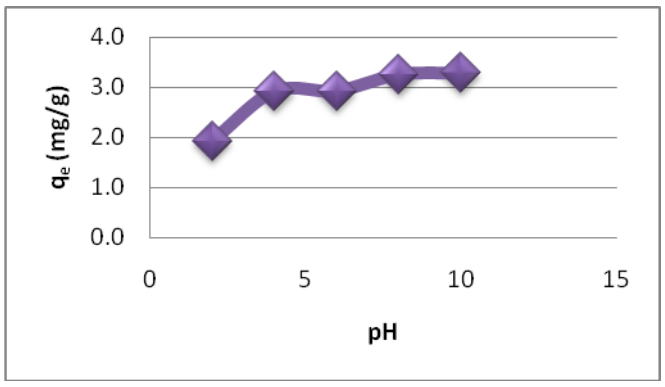

Figure 2. Effect of pH on adsorption of Lead ion

3.3 Effect of adsorbent dose

Adsorbent dose plays a key role in adsorption of heavy metals. Adsorbent dose decide the optimum quanity of adsorbent required for efficient adsorption. Experiment was done by three quantities 0.1g, 0.2g and 0.3g of adsorbent while other parameters fixed. On analysis results shows that for 0.1g amount adsorbed was 2.27mg/g and

then for 0.2g amount adsorbent increased and for 0.3g amount adsorbed was decreased. It revealed that for 0.1g and 0.2g more surface active sites present to adsorb but for 0.3g layer after layer formation found that shows blocking of active sites as active sites more but adsorbate was less.

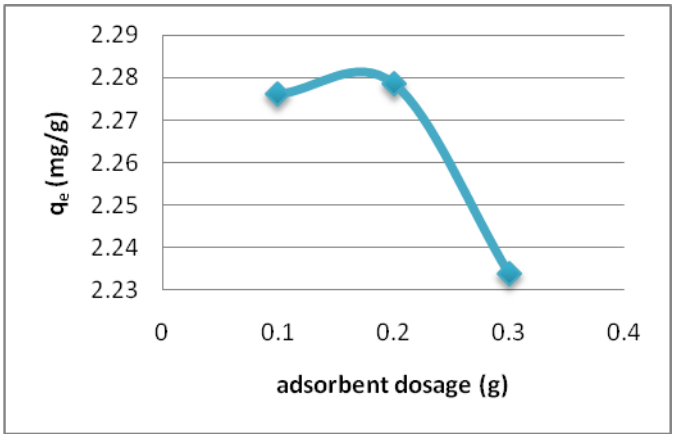

Figure 3. Effect of adsorbent dose on adsorption of lead ion

Kinetic study

3.3 Effect of contact time

The role of contact time was studied using 50 mg/l lead ion concentration and by adding adsorbent dose. At different interval of time samples were collected and analysed. Contact time basically decides the order of reaction and time variation adsorption shows. Results revealed that as the residence time increased adsorption capacity also increased. From initial, rapid adsorption takes place then after 120 min adsorption attained equilibrium. This is all because of all surface reaction changes occurs and time variation and residence time.[19]

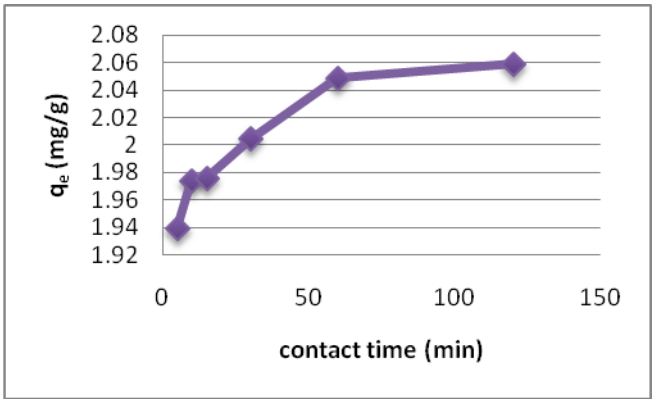

Figure 4. Effect of contact time on adsorption of lead ion

Pseudo Second order reaction

Langregen pseudo second order behavior is given by equation

$t/q_t = 1/(K_2 q_e^2) + t/q_e$

Where K_2 second order rate constant (g mg^{-1} min^{-1}).

Second order behavior is followed by chemisorption process. When plot between time and t/q_t this type of behavior is revealed that correlation coefficient gives value exactly equal to 1. Linearity gives that adsorption of lead by fabric fly ash followed second order reaction.

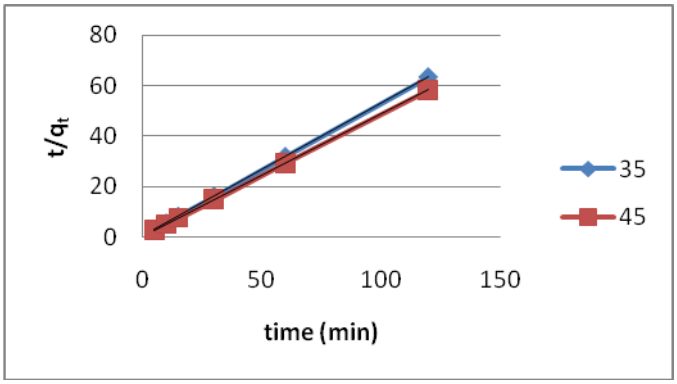

Figure 5. Pseudo second order behavior of lead ion

Weber morris model

Weber morris model also known as intra-particle diffusion model which gives value of intra particle diffusion constant. [20, 21]

$q_t = K_i * t^{0.5}$

Where K_i intra diffusion rate constant (mg g^{-1} $min^{-1/2}$)

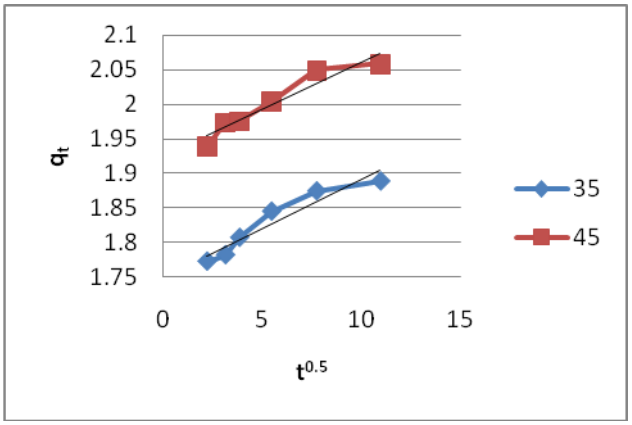

Figure 6. Intra-particle diffusion behavior of lead ion

On plotting results revealed that it gives a linear relationship and these curves don't cross the origin due to boundary effect. Higher values of K gives high rate of adsorption.

Table 1. Constants evaluated by second order equation and Weber Morris model.

model	Pseuo second order		Weber Morris model
paramters	qe (mg/g)	K (g mg^{-1} min^{-1})	K (mg g^{-1} $min^{-1/2}$)
35° C	2.070	15.040	1.749
45° C	1.897	10.528	1.924

3.4 Effect of temperature

Effect of temperature were studied on three different temperatures 35° C 45° C and 55° C. Varying concentration 5, 10, 15, 20 mg/l were used with respect to different temperature behavior. Maximum adsorption capacity was found to be 1.300 for temperature 35° C , 1.470 for temperature 45° C and 1.518 for 55° C. Highest adsorption capacity increased as concentration increased.

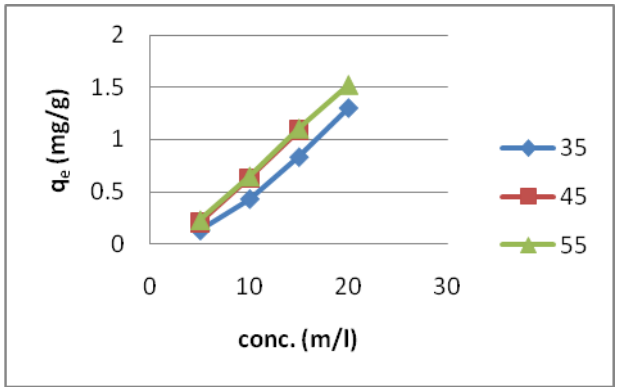

Figure 7. Effect of temperature with initial concentration at different temperatures

Temkin isotherm

Temkin isotherm contains a factor that explicitly takes into the account of adsorbent-adsorbate interactions. If plot between q_e and ln C_e then this plot gives the value of slope and intercept and this slope and intercept values further gives the parameters. The parameters heat of adsorption evaluated are 1.168, 1.315, and 1.580 with varying temperature.

The equation is

$$q_e = \frac{RT}{b_t} \ln(A_t C_e)$$

$$q_e = \frac{RT}{b_t} \ln A_t + \frac{RT}{b_t} \ln C_e$$

$$q_e = B \ln A_t + B \ln C_e$$

Where $B = \frac{RT}{b_t}$

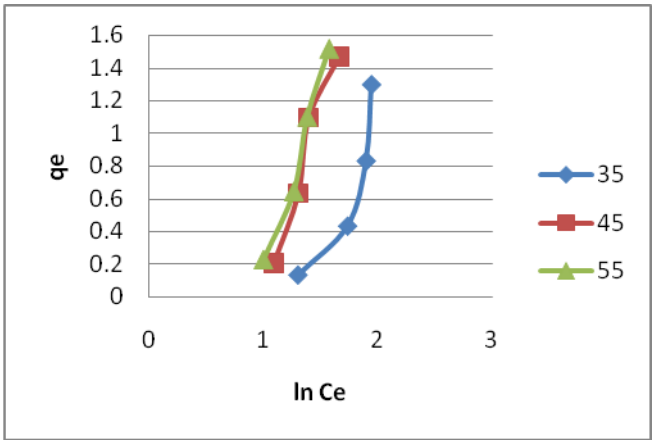

Figure 8. Temkin isotherm plot of lead metal ion at different temperatures

Thermodynamic study

Thermodynamic study tells the feasibility, nature and spontaneity of the reaction. All parameters calculated by thermodynamic equation decide the process behavior. Each parameter change in gibbs free energy, change in enthalpy, change in entropy gives a constant value with respect to adsorption of lead ion. Equation is

$\Delta G° = -RT \ln K_o$

Where K_o is equilibrium constant. Gibbs free energy change is directly related to change in enthalpy and change in entropy. Three temperatures 35°C 45°C and 55°C gives different value for each parameter presented in Table 2. Negative value of gibbs free energy change describe the endothermic behavior process.

Table 2. Thermodynamic constant for lead metal ion at different temperatures.

Temperature	Δ G° (cal/mol)	Δ H° (cal/mol)	Δ S° (cal/mol.K)
35° C	-1385.76	40697.03	146.8252
45° C	-2278.00		
55° C	-2692.38		

IV. CONCLUSION

1. Fabric fly ash proved as low cost adsorbent for adsorption of lead ion.
2. Adsorption is a reliable and inexpensive method. It gives high adsorption capacity.

3. Effect of parameters on adsorption of lead ion decides the optimum range for each of parameter.

4. Kinetic study gives second order behavior followed and Weber Morris model also gives satisfied result in terms of diffusion constant.

5. Equilibrium study followed by Temkin isotherm and Thermodynamic study proves spontaneity and endothermic behavior of the process.

REFERENCES

[1] S. Shahmohammadi-Kalalagh, Isotherm And Kinetic Studies On Adsorption Of Pb, Zn And Cu By Kaolinite, Caspian Journal Of Environmental Sciences, 9(2), 2011, 243-255.

[2] D. Adie, C. Okuofu, And C. Osakwe, Comparative Analysis Of The Adsorption Of Heavy Metals In Wastewater Using Borrassus Aethiopium And Cocos Nucifera, International Journal Of Applied Science And Technology, 2(7), 2012, 1-9.

[3] W. Kong, Et Al., Adsorption Behavior And Mechanism Of Heavy Metal Ions By Chicken Feather Protein-Based Semi-Interpenetrating Polymer Networks Super Absorbent Resin, Rsc Advances, 6(86), 2016, 83234-83243.

[4] H.N. Muhammad Ekramul Mahmud, A.K.O. Huq, And R.B. Yahya, The Removal Of Heavy Metal Ions From Wastewater/Aqueous Solution Using Polypyrrole-Based Adsorbents: A Review, Rsc Advances, 6(18), 2016, 14778-14791.

[5] R. Wang Et Al., Adsorption Of Heavy Metals And Organic Contaminants From Aqueous Stream With Chemically Enhanced Kapok Fibers, Environmental Earth Sciences, 75(4), 2016, 338.

[6] A. Guijarro-Aldaco, Et Al., Improving The Adsorption Of Heavy Metals From Water Using Commercial Carbons Modified With Egg Shell Wastes, Industrial & Engineering Chemistry Research, 50(15), 2011, 9354-9362.

[7] A.T. Ojedokun, And O.S. Bello, Sequestering Heavy Metals From Wastewater Using Cow Dung, Water Resources And Industry, 13, 2016, 7-13.

[8] M. Karnib, Et Al., Heavy Metals Removal Using Activated Carbon, Silica And Silica Activated Carbon Composite, Energy Procedia, 50, 2014, 113-120.

[9] M. Kobya, Et Al., Adsorption Of Heavy Metal Ions From Aqueous Solutions By Activated Carbon Prepared From Apricot Stone, Bioresource Technology, 96(13), 2005, 1518-1521.

[10] M.A. Al-Omair, And E.A. El-Sharkawy, Removal Of Heavy Metals Via Adsorption On Activated Carbon Synthesized From Solid Wastes, Environ Technol, 28(4), 2007, 443-51.

[11] M.A. Al-Omair, And E.A. El-Sharkawy, Removal Of Heavy Metals Via Adsorption On Activated Carbon Synthesized From Solid Wastes, Environmental Technology, 28(4), 2007, 443-451.

[12] I.J. Alinnor, Adsorption Of Heavy Metal Ions From Aqueous Solution By Fly Ash, Fuel, 86(5–6), 2007, 853-857.

[13] M. Nascimento, P.S.M. Soares, And V.P.D. Souza, Adsorption Of Heavy Metal Cations Using Coal Fly Ash Modified By Hydrothermal Method, Fuel, 88(9), 2009, 1714-1719.

[14] O.E. Abdel Salam, N.A. Reiad, And M.M. Elshafei, A Study Of The Removal Characteristics Of Heavy Metals From Wastewater By Low-Cost Adsorbents, Journal Of Advanced Research, 2(4), 2011, 297-303.

[15] I. Agbozu, And F. Emoruwa, Batch Adsorption Of Heavy Metals (Cu, Pb, Fe, Cr And Cd) From Aqueous Solutions Using Coconut Husk, African Journal Of Environmental Science And Technology, 8(4), 2014, 239-246.

[16] S.V Yadla, V. Sridevi, And M.C. Lakshmi, Adsorption Performance Of Fly Ash For The Removal Of Lead, International Journal Of Engineering Research And Technology. Ijert, 1(7), 2012, 1-7.

[17] J.M. Unagolla, And S.U. Adikary, Adsorption Of Cadmium And Lead Heavy Metals By Chitosan Biopolymer: A Study On Equilibrium Isotherms And Kinetics In 2015, Moratuwa Engineering Research Conference (Mercon), 2015.

[18] U.I. Gaya, E. Otene, And A.H. Abdullah, Adsorption Of Aqueous Cd(Ii) And Pb(Ii) On Activated Carbon Nanopores Prepared By Chemical Activation Of Doum Palm Shell, Springerplus, 4(1), 2015, 458.

[19] M. Inyang, Et Al., Removal Of Heavy Metals From Aqueous Solution By Biochars Derived From Anaerobically Digested Biomass, Bioresource Technology, 110, 2012, 50-56.

[20] A.A. Farghali, Et Al., Adsorption Of Pb(Ii) Ions From Aqueous Solutions Using Copper Oxide Nanostructures, Beni-Suef University Journal Of Basic And Applied Sciences, 2(2), 2013, 61-71.

[21] M.S. Rahman, And K.V. Sathasivam, Heavy Metal Adsorption Onto Kappaphycus Sp. From Aqueous Solutions: The Use Of Error Functions For Validation Of Isotherm And Kinetics Models, Biomed Research International, 2015, 2015, 126298.