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Model Fitting and Kinetic Approach To Sorption of Lead Ion Using Plum Stone Powder

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Abstract:- **Adsorption of lead ion from aqueous solution on adsorbent is studied. Adsorbent used after chemical treatment for all study at room temperature. Study describe influence of various parameters initial metal ion concentration, pH. Kinetics behavior studied by pseudo second order and Elovich equation. According to pseudo second order process follows chemisorptions. Isotherm adsorption studied by Temkin adsorption isotherm that shows adsorbate-adsorbent bonding.**

***Index Terms*—Adsorption, Elovich, Lead, plum stone**

I. INTRODUCTION

Water pollution day by day crossing the permissible limits. Water pollution is comprised of few chemicals, organic and inorganic salt ions released by industrial sectors[1-3]. Salt ions as in the form of aromatics, pesticides, precious metals and toxic metals.

As concerned with toxic heavy metal ions like mercury, lead, chromium, zinc, nickel, copper and cobalt, if used or consumed beyond their permissible designed by WHO limit can cause dangerous diseases cancer, blood pressure problems, kidney failure, liver damage, migrane, paralysis and vomiting problems [4-7].

Many techniques used in past for removal of these toxic heavy metals like ion exchange, filtration, membrane separation and some nano technology that proven better method for removal but obstacles they used large space and high maintaince, these factors down their demand in market. Researchers found a new efficient and cost effective method to overcome these problems that is adsorption [8-10]. Adsorption is basically a surface contamination process and its mechanism given by physical and chemical adsorption. It also uses a solid adsorbent for removal of heavy metal ions. Adsorbent used activated charcoal, silica gel, zeolites and fly ash [11]. Researchers concerned for low cost adsorbent agriculture waste like shells of many fruits and peels, leaves of plants and seeds etc.

Main objective of this paper to exploit a new low cost adsorbent plum stone activated powder. As adsorbent it used for optimizing parameters, equilibrium study and kinetic study approach by batch adsorption process.

II.EXPERIMENTAL

A. Adsorbent preparation

Plum purchased from local market and its stone collected into a carry bag. Then these collected stone dried in sunlight for 2 days and then washed with distill water. Dry overnight in an oven to remove moisture and grind into fine grinder to increase surface area and sieved through sieve shaker. After sieving material treated by H3PO4 acid for 12 hr and over time washed with distill water to neutralize pH. Finally heated in muffle furnace for 2hr and upon cooling used as adsorbent for analysis.

B. Batch adsorption process

Batch adsorption process approach was used to optimize the initial metal ion concentration and pH. These all tests were analyzed by an instrument uv-vis spectrophotometer at room temperature.

Prepared 25 ppm of stock solution by adding a known amount of lead nitrate. 0.1N HCl and 0.1N NaOH solution made to adjust pH balance.

C. Model fitting approach

Equilibrium study was used to know mechanism of adsorption process. Temkin adsorption isotherm equation was used that showing interaction between adsorbate and adsorbent.

D. Kinetic approach

Kinetic term describe efficiency for particular adsorbent and indicate speed of molecules responsible for adsorption. Rate of adsorption also noticed in terms of kinetics and rate of arrival of an adsorbate molecule at adsorbent surface.

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III.RESULTS AND DISCUSSION

A. Initial metal ion concentration

Initial metal ion concentration with 5, 10, 15, 20 and 25 ppm used with 0.1g activated adsorbent. The results revealed that on increasing the lead ion concentration % removal increasing around highest 66 % on concentration changing from 20 to 25 ppm. These two concentrations decides the equilibrium point after that no change occurs. This variation in removal efficiency due to more active sites availability on surface of adsorbent. But on equilibrium point all sites already fixed by adsorbate indicate no more allowability of adsorbate molecules on surface of adsorbent.

Analysis results plotted on graph shown below from Figure.

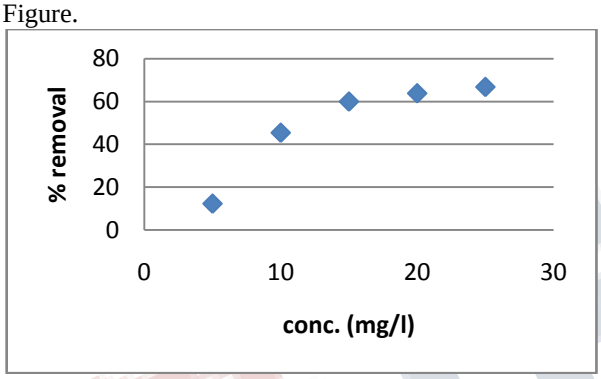

Fig. 1. Influence of initial metal ion concentration

B. pH

One of key factor on which adsorption dependent. One solution with low pH noticed high range of hydrogen ion or vice-versa. As from Figure, by variate pH from 2, 4, 6, 8 and 10, remains other parameters fixed clearly indicate high removal percentage noticed in between 6 or 8 that is nearly equal to neutral pH value. It means optimize value for adsorption is neutral.

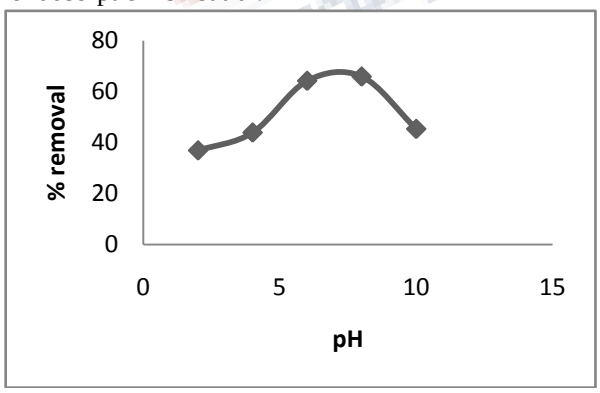

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Fig. 2. Effect of pH on adsorption of lead metal ion

C. Model fitting

Temkin adsorption isotherm [12]

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

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

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

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

A_t = temkin isotherm equilibrium binding constant (l/g)

b_t = temkin isotherm constant

R = universal gas constant (8.314 J/mol.K)

T = temperature (K)

B = constant related to heat of sorption (J/mol)

By graph analysis correlation coefficient shows well fitting by this isotherm. Bonding between adsorbate and adsorbent clearly noticed and also coverage of adsorbate around the adsorbent surface. As linearity in equilibrium concentration increasing amount adsorbed per gram of adsorbent increased.

All parameters evaluated from slope and intercept value figerized in Table 1. All are positive and figure out a constant value as heat of adsorption 6.375 J/mol and binding constant value 0.229 l/g.

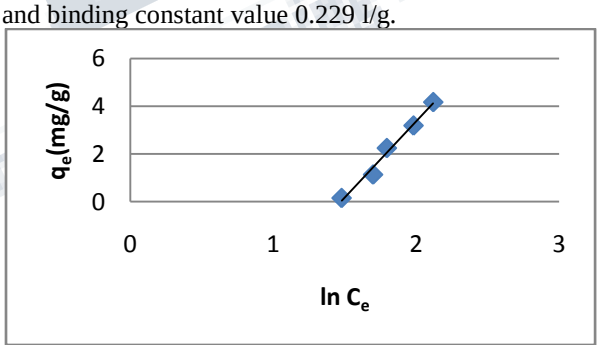

Fig. 3. Temkin adsorption isotherm fitted for lead metal ion.

Table 1. Expansion of paramters calculated from temkin adsorption isotherm.

Temp.	Temkin isotherm parameters		
	B	b_t	A_t
35°C	6.375	356.230	0.229

D.Kinetics

As kinetics decides the bahviour of adsorbent by models. Diffusion speed and rate, order of reaction all factors decide by kinetics. Behavior of adsorbent

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analyzed by two models pseudo second order and elovich equation [13-15].

Pseudo second order $t/q_t = 1/(k_2 q_e^2) + t/q_e$

Elovich equation $q_t = 1/\beta\ [\ln(\alpha\beta)] + \ln t/\beta$

Where,

qt = amount adsorbed at time t

qe = amount adsorbed at equilibrium

α = initial rate of constant

β = desorption constant

Second order

Chemisorption process related by second order kinetics in terms of second order kinetics is only one describe the chemical adsorption. If second order kinetic equation linearly fitted then it clearly indicates that process undergoes chemical adsorption rather than physical adsorption.

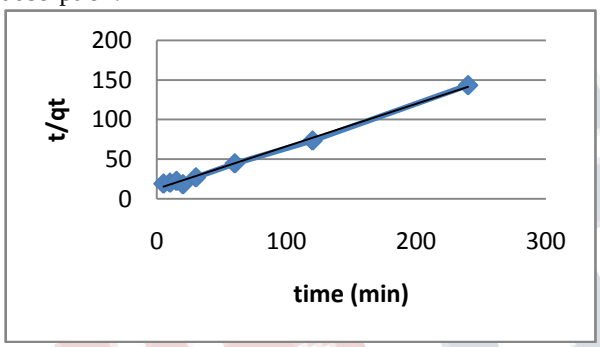

Fig. 4. Pseudo second order plot

Elovich equation theory tells about heterogenity of solid surface. With graph analysis it is understood there is continous increment in curve with time and correlation coefficient also truly defined its linearity with positive value of both constant. Rate of adsorption found to be high and desorption constant value also positive. This proves quite well fit by Elovich equation.

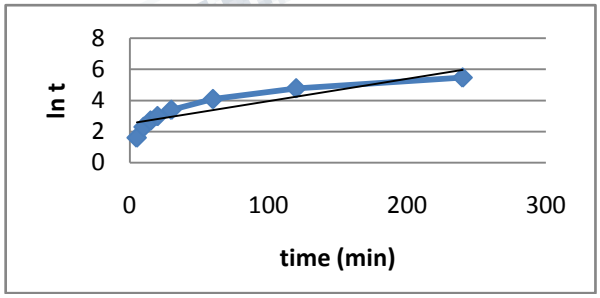

Fig. 5. Elovich model fitting

Parameters calculated from second order and Elovich equation with help of slope and intercept shown in Table 2.

Table 2. Kinetic models parameters evaluation.

Temp.	Second order		Elovich	
	qe	K	α	β
35°C	1.869	0.274	3.6924E+76	71.428

IV. CONCLUSION

Influence of parameters easily understable to optimize the value. Batch process gives high adsorption capacity. This process of adsorption comes under Pseudo Second order kinetics and well fitted by Elovich equation. Equilibrium isotherm well fitted by Temkin adsorption isotherm. Activated plum stone powder proved as low cost adsorbent.

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