Removal of Lead and Copper from Textile Wastewater Using Egg Shells

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ABSTRACT

The aim of present study was to investigate the removal of lead and copper from textile wastewater using waste egg shells in a continuous stirred tank reactor. The effect of initial pH, metal concentration, adsorbent dosage and retention time were investigated. Optimum adsorption of lead (80%) was obtained at pH 6, initial metal concentration 20 mg/L, adsorbent dosage 12.5 g/L and retention time 90 minute. Also, optimum adsorption of copper (71%) was obtained at pH 6, initial metal concentration 15 mg/L, adsorbent dosage 15 g/L and retention time 75 minute. Langmuirs, Freundlich and Temkin isotherms were used for the mathematical description of adsorption equilibrium. Langmuir isotherm showed the best fitting to the isotherm equilibrium data, with a maximum adsorption capacity (q_m) of 4.33 mg/g and 3.54 mg/g for lead and copper, respectively. Results revealed that pseudo-second order adsorption kinetic equation fit the data with a high correlation coefficient (R^2 more than 0.97). Based on the results of the present study, egg shells is suitable to be used for the removal of lead and copper from textile wastewater.

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INTRODUCTION

India is one of the major manufacturer of textiles which constitute 197 composite mills and 3244 semi composite processing units (Tiwari et al., 2015). Environmental pollution due to textile wastewater is of major concern because of their high wastewater discharge, toxicity and threat for human and the environment. It discharges up to 1.2 billion liters per day of wastewater (Markandeya et al., 2015). This wastewater is discharged from various operations for instance dyeing, bleaching, printing, finishing and cleaning. The most harmful aspects for the discharge of textile wastewater are the strong color, basic and acidic pH, high chemical oxygen demand (COD), high biochemical oxygen demand (BOD), high suspended solids, chlorinated organic compounds, surfactants and considerable amounts of heavy metals such as Pb, Cu, Cr, Fe, Ni and Zn (Phugare et al., 2011). Dyeing and printing are main sources of heavy metals in textile industries (Verma et al., 2012). These heavy metals which have been discharged into the environment are highly toxic and can bio-accumulate in the human body, natural water-bodies and also possibly trapped in the soil.

Lead and copper selected in the present study exist in the textile wastewater causing several adverse impacts on aquatic system and human health. These metals when enter into the water bodies without proper treatment, they penetrate into the micro-organisms and grazing food chains until saturation is reached. Lead directly interrupts the activity of enzymes, competitively inhibits absorption of trace minerals and deactivates antioxidant (Jomova and Valko, 2011). Copper causes cancer, neurological disorders, diabetes, cardiovascular disease and atherosclerosis in human being (Jomova and Valko, 2011). Removal of these heavy metals from textile wastewater is essential to prevent unacceptable damage to the natural environment and human health.

The treatment technologies available for textile wastewater are ion-exchange, chemical precipitation, ultrafiltration or electrochemical depositions do not seem to be economically feasible as of their relatively high costs. Therefore, one has to look into alternative method which is effective and economic for textile industry. Adsorption is such a process which has advantages over other methods. The design is simple and it is sludge free and can involve low investment. The most popular and widely used adsorbent in wastewater treatment applications throughout the world is undoubtedly activated carbon (Baur et al., 2015; Deng et al., 2015). Despite the versatility of carbon adsorbent in wastewater treatment, it remains costly. In recent years, the use of low-cost materials as alternatives to carbon has been encouraged. Some of the reported adsorbents are clay

materials (Auta and Hameed, 2015), chitosan (Markandeya et al., 2017), vermi-compost (Singh and Kaur, 2015), sawdust (Markandeya, 2015a), rice husk (Leng et al., 2015), coal fly ash (Kisku et al., 2015), tea leaves (Shukla et al., 2014), cenospheres (Tiwari et al., 2013) and egg shells (Ibrahim et al., 2015). Egg shell has pore structure and $CaCO_3$ (Park et al., 2007), which can be used to adsorb heavy metals. Lim and Aris, (2014) proved that egg shells have natural characteristics, which can act as pH adjuster that makes this adsorbent as budgetary and environmental friendly.

Recently, egg shells has been used as an adsorbent for the removal of heavy metals (Ibrahim et al., 2015; Ahmad et al., 2012; Park et al., 2007). However, study of egg shells as an adsorbent to remove heavy metals from textile industry wastewater using continuous stirred tank reactor has got least attention of researchers and needs to be investigated. Therefore, this study was conducted to investigate removal efficiency of lead and copper from textile wastewater using egg shells and to model the process of adsorption for heavy metal removal using egg shells.

MATERIAL AND METHODS

Preparation of adsorbent
Egg shells were collected from local market and washed with distilled water several times to remove impurities then air-dried and incubated in hot air oven at 50°C for 5 days (Ahmad et al., 2012). Consequently, egg shells were ground in a grinder and sieved with sieve of 150 and 75 microns to obtain homogeneous particle size. The prepared adsorbent was then stored in a desiccators until further experimentations. 250 g of prepared egg shells were mixed in distilled water having volume of 1 L and sonicated for 5 h to obtain homogeneous suspension. The adsorbent loadings were changed by varying the flow rate and hydraulic retention time (HRT).

Preparation of textile wastewater
All chemicals used were of analytical grade. Textile wastewater was simulated as per method reported by Balapure et al. (2015). The malachite green dye (300 mg/L) was accompanied with the chemicals NH_4Cl: 200 mg/L, K_2HPO_4: 250 mg/L, NaCl: 1000 mg/L, Na_2CO_3: 1500 mg/L, $NaHCO_3$: 1000 mg/L, starch: 200 mg/L, glucose: 100 mg/L and 5 mL/L of a trace element solution containing $Pb(NO_3)_2$: 1000 mg/L, $Cu(NO_3)_2.3H_2O$: 1000 mg/L. pH of the simulated wastewater was adjusted to 7 by using sodium hydroxide solution (0.1 M). Characteristics of simulated wastewater are depicted in Table 1 and compared with textile wastewater characteristics as mentioned by Sarayu and Sandhya (2010).

TABLE 1. Characteristics of simulated wastewater and textile wastewater

Parameters	Simulated wastewater	Textile wastewater
pH	7.0	5.5 – 11.0
COD (mg/L)	674	600 – 1400
BOD$_5$ (mg/L)	486	350 – 600
Total suspended solids (mg/L)	458	300 – 500
Chloride (mg/L)	713	700 – 1200
Sulfate (mg/L)	422	300 – 700
Color	Darkish color	Darkish color
Temperature	31ºC	30-39ºC

Experimental setup
Experimental setup was arranged according to Chen et al. (2012) with some modifications. Experiments were conducted using a 7 L working volume of CSTR (made of Acrylic transparent sheet) equipped with an electrically driven stirrer using a DC-motor (12V, 200 rpm) as shown in Fig. 1. The specifications of the reactor are depicted in Table 2. Two inlet lines were installed below the stirrer and one outlet line is installed at 0.3 m height of CSTR. Aqueous adsorbent and textile wastewater were premixed in two different equalization vessels and fed to the CSTR below the stirrer. Vessels were kept at height of 1 m above CSTR. Separate flow controllers were used to control the flow rates of adsorbent and textile wastewater.
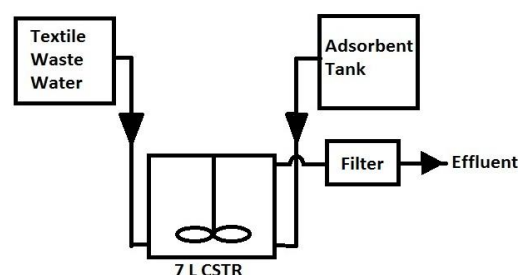

Figure 1. Schematic diagram of the adsorption process using CSTR

TABLE 2. Dimensional details of the CSTR

Specification	Value
Length (m)	0.15
Width (m)	0.15
Height (m)	0.60
Total volume (L)	14.00
Working Volume (L)	7.00
Tanks Location	0.3 m above CSTR
Material	Acrylic Sheet
HRT (min)	15 to 120

Adsorption studies
Experiment started when valves of both vessels were switched on. Textile wastewater and adsorbent suspension starts flowing from vessels to reactor through two inlet pipes which were connected below the stirrer at pre adjusted flow rates. To study the effects of parameters, retention time was varied from 15 to 120

min, adsorbent dosage was varied from 2.5 to 20 g/L, adsorbate amount was varied from 5 to 40 mg/L and pH was varied from 3 to 8. While varying one parameter (retention time, pH, adsorbate concentration and adsorbent dose) other three parameters were kept constant. Thereafter the mixture was stirred at 200 rpm and was filtered using Whatman no. 42 filter paper to determine metal concentration in the filtrate. The metal concentration of each sample was analyzed by Atomic absorption spectroscopy (AAS-1909, Manufacturer: Labman scientific instruments) to determine metal concentration as per method APHA (2012). After each experiment, reactor and pipes were washed thoroughly and then mechanically connected again to the system.

The amount of adsorbed metal was calculated using equation 1 and the removal efficiency was determined by computing the percentage adsorption using equation 2.

$$\text{The amount of adsorbed metal (q}_0) = \frac{(C_0 - C_e) \times V}{m} \qquad (1)$$

$$\text{Percentage removal} = \frac{(C_0 - C_e) \times 100}{C_0} \qquad (2)$$

where, q_e is the adsorption capacity at equilibrium (mg of ions/g of egg shell). V is the volume of the aqueous solution (mL), C_0 is the concentration before adsorption (mg/L), C_e is the equilibrium concentration after adsorption (mg/L) and m is the mass in gram of the adsorbent.

Adsorption isotherms

Several adsorption isotherms are available and three commonly used are Langmuir, Freundlich and Temkin isotherms. The data obtained from experiments were tested for applicability of these isotherms. Langmuir isotherm assumes that the adsorption takes place at specific homogeneous sites within the adsorbent. It assumes monolayer adsorption on the adsorbent surface. It is presented by following equation (Langmuir, 1918):

$$q_e = \frac{q_m K_{ads} C_e}{1 + K_{ads} C_e} \qquad (3)$$

where, q_e is adsorbed concentration at equilibrium (mg/g), q_m is maximum capacity of adsorbent for adsorbate (mg/g), C_e is concentration at equilibrium (mg/L) and K_{ads} is Langmuir isotherm constant. Linear form of the Langmuir isotherm is expressed as follows:

$$\frac{1}{q_e} = \frac{1}{q_m K_{ads}} \left(\frac{1}{C_e}\right) + \left(\frac{1}{q_m}\right) \qquad (4)$$

The equilibrium data obtained from the experiment were plotted for $1/q_e$ vs. $1/C_e$ will give the values of intercept $(1/q_m)$, slope $(1/q_m K_{ads})$ and constant K_{ads}. In order to find efficiency of adsorption process, separation factor (R_L) was calculated by following equation:

$$R_L = \frac{1}{1 + K_{ads} C_0} \qquad (5)$$

The value of R_L confirms whether the adsorption is linear ($R_L=1$), unfavorable ($R_L>1$), favorable ($0<R_L<1$) or irreversible ($R_L=0$).

Freundlich isotherm model explains the relationship between reversible and non-ideal adsorption. This is applied to heterogeneous surface with the interaction between adsorbed molecules. The discussed isotherm is an empirical equation as follow (Freundlich and Heller, 1939):

$$q_e = K_f C_e^{1/n} \qquad (6)$$

where, K_f is Freundlich constant related to adsorption intensity of adsorbents (mg/g), n = heterogeneity factor. Linear form of Freundlich isotherm is expressed as follows:

$$\log q_e = \log K_f + \left(\frac{1}{n}\right) \times \log C_e \qquad (7)$$

A linear plot between $\log q_e$ vs. $\log C_e$ will give the intercept ($\log K_f$) and slope ($1/n$). The slope (value of $1/n$) ranges between 0 and 1 is measure of adsorption intensity. If $1/n = 1$ then the partition between the two phases are independent of the concentration. If value of $1/n$ is below one it indicates a normal adsorption (adsorption is chemical process). On the other hand, $1/n$ being above one indicates cooperative adsorption (adsorption is physical process) (Matouq et al., 2015). If n lies between one and ten, this indicates a favorable adsorption process.

Temkin isotherm contains a factor that explicitly taking into the account of adsorbent–adsorbate interactions. By ignoring the extremely low and large value of concentrations, the model assumes that heat of adsorption (function of temperature) of all molecules in the layer would decrease linearly rather than logarithmic with coverage.

$$q_e = \frac{RT}{b_T} \ln(K_T C_e) \qquad (8)$$

where, K_T is Temkin isotherm constant (L/g), R is ideal gas constant (8.314 J/mol K), T is temperature in (K) and b_t is constant related to heat of adsorption (J/mol). Linear form of the Temkin isotherm (Temkin and Pyzhev, 1940) is expressed as follows:

$$q_e = \frac{RT}{b_T} \ln(K_T) + \frac{RT}{b_T} \ln(C_e) \qquad (9)$$

$$q_e = B_t \ln K_T + B_t \ln C_e \qquad (10)$$

A linear plot between q_e vs. $\ln C_e$ gives a straight line from which the slope (B_t) and intercept ($B_t \ln K_T$) can be evaluated.

Adsorption kinetics

Prediction of kinetics is necessary for the design of adsorption systems and to control reaction rate. The nature of adsorption process depends on physicochemical characteristic of the adsorbent. The kinetics of adsorption of lead and copper on egg shells has been studied by Lagrange pseudo-first order and pseudo-second order. The Lagrange pseudo-first order equation is generally expressed as follows (Markandeya et al., 2015; Farhan et al., 2012):

$$\frac{dq_t}{dt} = K_1(q_e - q_t) \qquad (11)$$

After integration and applying the boundary conditions $q_t=0$ to $q_t=q_t$ at $t=0$ to $t=t$, the integrated equation becomes

$$\log (q_e - q_t) = \log q_e - \left(\frac{K_1}{2.303}\right) \times t \qquad (12)$$

A plot $\log (q_e-q_t)$ vs. t gives a straight line from which K_1 and q_e can be evaluated from slope and intercept. The pseudo-second order kinetics of Lagrange is based on adsorption capacity of solid phases, which has been applied for analyzing chemisorptions kinetics rate. It is given by the following equation:

$$\frac{dq_t}{dt} = K_2(q_e - q_t)^2 \qquad (13)$$

The boundary conditions $q_t=0$ and $q_t=q_t$ at $t=0$ to $t=t$. The integrated form of equation becomes:

$$\frac{t}{q_t} = \frac{1}{(K_2 q_e^2)} + \left(\frac{1}{q_e}\right)t \qquad (14)$$

A plot t/q_t vs. t gives a straight line from which K_2 and q_e can be evaluated.

RESULTS AND DISCUSSION

Effect of adsorbent dosage
Adsorbent dosage plays a crucial role to affect adsorption process. To achieve maximum adsorption capacity, the optimum dose of egg shell must be determined. In such, different amounts of adsorbent had been used, varying from 2.5 to 20 g. The effect of adsorbent dose on heavy metal removal is shown in Fig. 2. The adsorption increased as the adsorbent dosage of egg shell increased. With the increasing amount of adsorbent, the active or available surface for adsorption increases that is increasing of adsorbent surface area, lead to the increasing of metal removal efficiency. It is elaborated that maximum adsorption attained at adsorbent dose of 12.5 g/L (71%) for lead and 15 g/L (80.08%) for copper. If adsorbent dose is increased beyond optimum dose, no significant change in the removal of lead and copper is observed. Zheng et al. (2007) investigated that the adsorption of copper and cadmium on hydroxy-apatite extracted from the egg shell and found that removal efficiency increases with the increase of adsorbent dosages which is similar to present findings.

Effect of initial metal concentration
As the initial metal concentration increases, the removal percentage decreases for a fixed adsorbent dose and retention time. This behavior can be explained due to limitation of active site on the adsorbent surface. At higher concentration, the metal ions are relatively higher than the available sites, hence, decreasing the removal
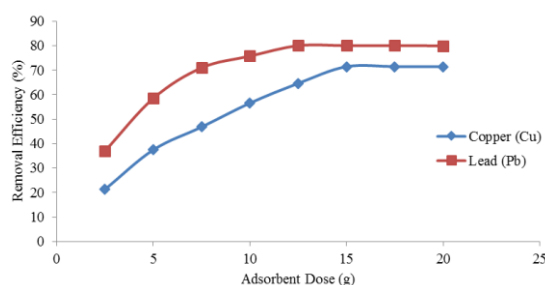

Figure 2. Effect of adsorbent dosage

percentage. The results as depicted in Fig. 3 reveals that the amount of metal ions adsorbed per unit mass of adsorbent decrease with increase in concentration from 20 to 40 mg/L for lead and 15 to 40 mg/L for copper. The rate of removal of both metals follows similar trend. Lead showed maximum removal at 20 mg/L (80%), while copper showed at 15 mg/L (71%). Wan et al., (2010) investigated adsorption of copper on chitosan coated sand and found that by increasing the initial concentration of the copper, the rate of adsorption is reduced.
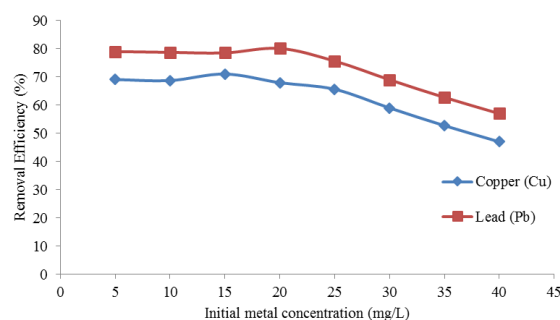

Figure 3. Effect of adsorbate concentration

Effect of retention time
The effect of retention times (from 15 min to 120 min) on metal removal of lead and copper is shown in Fig. 4. From the obtained results, it is observed that the percentage of removal of heavy metal ions increases sharply with increase in retention time in first 90 min for lead and in first 75 min for copper. This is due to the presence of large number of vacant sites. As the time proceeds, the removal efficiency decreases due to the accumulation of metal ions on the vacant sites until it approaches equilibrium. Therefore, further increase in retention time did not enhance the metal removal and the optimum retention time is 90 min for lead and 75 min for copper. Chen et al. (2012) also used CSTR to adsorb strontium using montmorillonie and found to be optimum retention time of 52 min.
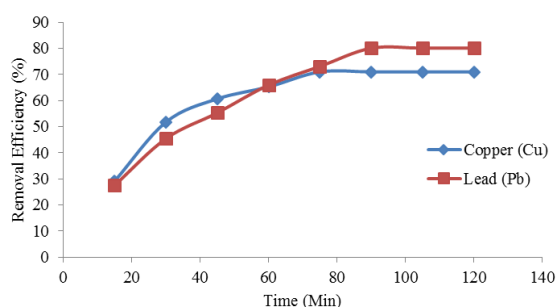
Figure 4. Effect of retention time

Effect of pH

For the adsorption process, the pH is one of the main variable parameters. The pH may affect on the ionization degree of the adsorbate and the surface property of the adsorbent. The influence of pH in the range of 3–9 was studied. The pH of the solution was adjusted using NaOH/HNO$_3$ solutions. It is evident from Fig. 5, that percentage removal of both metals was increased with an increase in pH from 3 to 6. While increasing pH from 6 to 9 it starts decreasing. It may be due to active adsorption sites remain protonated at low pH, and become less available for metal adsorption. As pH increases, the concentration of H$^+$ ions decreases, hence they do not compete with metal ions on the adsorption sites. Our results are in agreement with those of Tran et al. (2010) and Hossain et al (2012), who reported that optimum pH was 6 to remove lead and copper using chitosan composites and garden grass, respectively.
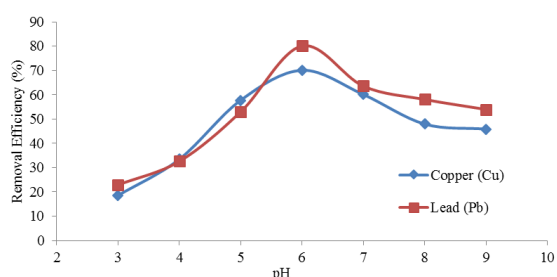

Figure 5. Effect of pH

Isotherms

For Langmuir isotherm, the equilibrium data obtained from the experiment was plotted for 1/q$_e$ vs. 1/C$_e$. Constants q$_m$ and K$_{ads}$ were calculated by using Eq. 4 and results have been tabulated in Table 3. In order to find efficiency of adsorption process, separation factor (R$_L$) was calculated by Eq. 5. In the present study, R$_L$ values for lead and copper was 0.280 and 0.371, respectively, which were greater than zero and less than unity, indicating that the equilibrium adsorption was favorable for both metal ions. A list for the comparison of maximum monolayer adsorption capacities (q$_m$) of copper and lead metal ions on different adsorbents is given in Table 4.

For Freundlich isotherm, the equilibrium data obtained was plotted between log q$_e$ vs. log C$_e$. Constants K$_f$ and 1/n were calculated by using Eq. 7 and results have been tabulated in Table 3. In order to find nature of adsorption process, heterogeneity factor was calculated. In the present study, the value of n for lead and copper was 1.633 and 1.567, respectively, which were greater than one and less than ten which shows a normal favorable chemical adsorption. For Temkin isotherm, the equilibrium data obtained was plotted between q$_e$ vs. lnC$_e$. Constants K$_T$ and B$_t$ were calculated by using Eq. 10 and results have been tabulated in Table 3.

Results showed the higher correlation coefficient (R^2) values for the Langmuir model, which confirmed better fitting of this model to the experimental data. Due to the lower value of correlation coefficient for the Freundlich and Temkin isotherm model, these models did not accurately described the correlation between the amounts of adsorbed metal ions and their equilibrium concentrations in the solutions. Hemandez-Montoya et al. (2012) investigated removal of fluoride using egg shells as an adsorbent and found Langmuir isotherm suitable for it. Ibrahim et al. (2015) studied adsorption of lead by hydroxyapatite with high surface area and pore volume from egg shells and found Langmuir isotherm suitable for it. Fitting of data to Langmuir isotherm model indicates that the adsorbent surface is uniform and homogeneous and that the adsorption reaction results in the formation of a monolayer of adsorbed molecules.

TABLE 3. Langmuir, Freundlich and Temkin constants for Lead and Copper

	Langmuir		Lead Freundlich		Temkin		Langmuir		Copper Freundlich		Temkin	
q$_m$	4.330	1/n	0.612	B$_t$	0.560	q$_m$	3.544	1/n	0.6381	B$_t$	0.422
K$_{ads}$	0.077	K$_f$	0.406	A$_t$	1.640	K$_{ds}$	0.046	K$_f$	0.229	A$_t$	1.194
R^2	0.982	R^2	0.886	R^2	0.970	R^2	0.977	R^2	0.882	R^2	0.950

Adsorption kinetics

Pseudo-first order: The values of k$_1$ were obtained from the slopes of the plot of log (q$_e$−q$_t$) vs. t as per Eq 12 and depicted in Tables 5 and 6. For the pseudo-first order kinetic model, the values of correlation coefficients (R^2) were low, which suggested that the adsorption of both metal departed significantly from the pseudo-first order kinetic model and could not explain the adsorption mechanism of lead and copper onto egg shells.

Pseudo-second order: The values of k$_2$ were obtained from the intercepts of the plot t/q$_t$ vs. t (Tables 5 and 6). The obtained values of the correlation coefficients (R^2) for pseudo-second order kinetic model were more than 0.97 for all the studied concentrations for both metal ions which is more than pseudo-first order kinetic model. These results indicated that the adsorption system studied followed the pseudo-second order kinetic model for both

metals. Naushad et al. (2015) also found pseudo-second order on the basis of compared correlation coefficients

TABLE 4. Comparison of adsorption capacity for copper and lead with other adsorbents

Metal ion	Adsorbents	Maximum capacity (mg/g)	References
Copper			
	Coconut Husk	3.07	Low et al., 1995
	Orange Peel	3.65	Annadurai et al., 2003
	Activated carbon	3.56	Machida et al., 2005
	Oak sawdust	3.22	Argun et al., 2007
	Moringa oleifera	2.09	Farrokhzadeh et al., 2013
	Rice husk ash	3.27	Johan et al., 2011
	Egg shells	3.54	Present work
Lead			
	Chitosan	0.13	Ng et al., 2003
	Natural duck egg shell	1.64	Arunlertaree et al., 2007
	Boiled duck egg shell	1.23	Arunlertaree et al., 2007
	Maganese oxide coated sand	1.90	Han et al., 2006
	Mature pods of Moring Oleifera	19.20	Nadeem et al., 2006
	Apricot stone	22.85	Kobya et al., 2005
	Egg shells	4.33	Present work

Table 5. Pseudo 1st and 2nd order adsorption kinetic constants for Lead

Lead (mg/L)	Pseudo 1st order Kinetic Model			Pseudo 2nd order Kinetic Model		
	K_1	q_e	R^2	K_2	q_e	R^2
5	0.042	0.389	0.959	0.081	0.408	0.985
10	0.039	0.721	0.945	0.040	0.816	0.985
15	0.031	0.846	0.975	0.032	1.173	0.995
20	0.032	1.501	0.978	0.011	1.836	0.989
25	0.029	1.289	0.943	0.020	1.863	0.992
30	0.040	1.677	0.931	0.026	1.953	0.997
35	0.044	1.902	0.885	0.027	2.050	0.996
40	0.038	1.511	0.972	0.030	2.091	0.998

Table 6. Pseudo 1st and 2nd order adsorption kinetic constants for Copper

Copper (mg/L)	Pseudo 1st order Kinetic Model			Pseudo 2nd order Kinetic Model		
	K_1	q_e	R^2	K_2	q_e	R^2
5	0.110	1.152	0.855	0.201	0.274	0.981
10	0.076	0.887	0.997	0.107	0.541	0.98
15	0.069	1.364	0.954	0.057	0.860	0.981
20	0.079	2.288	0.972	0.041	1.144	0.974
25	0.079	2.288	0.972	0.031	1.363	0.973
30	0.077	2.711	0.969	0.027	1.477	0.981
35	0.058	1.918	0.980	0.028	1.525	0.981
40	0.049	1.759	0.952	0.025	1.569	0.986

(R^2) between pseudo-first order and pseudo-second order. Matouq et al. (2015) investigated adsorption

kinetics and modeling for heavy metal removals and found pseudo-second order fit for it on basis of higher R^2.

CONCLUSION

Present study revealed that low cost waste egg shells were an effective adsorbent for the removal of heavy metals from textile wastewater. Optimum adsorption of lead (80%) was observed at pH 6, initial metal concentration 20 mg/L, adsorbent dosage of 12.5 g/L and retention time 90 minutes where as optimum adsorption of copper (71%) was observed at pH 6, initial metal concentration 15 mg/L, adsorbent dosage of 15 g/L and retention time 75 minutes. The results of adsorption isotherms suggest that Langmuir model was best for both metal ions. Kinetic test demonstrated that pseudo-second order model was best to describe the adsorption behavior for both metal ions with high correlation coefficient (R^2 more than 0.97). From the results, egg shells are considered as an effective, low cost and environmental friendly method for the removal of metal ions from textile wastewater. It could be used as an alternative to the expensive commercial adsorbents for the removal of heavy metals.

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Persian Abstract

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چکیده

هدف از انجام این مطالعه بررسی حذف سرب و مس از فاضلاب نساجی با استفاده از پوسته تخم مرغی در CSTR است. اثر pH اولیه، غلظت فلز، دوز جاذب و مدت زمان نگهداری مورد بررسی قرار گرفت. جذب بهینه جذب سرب (۸۰٪) در pH 6، غلظت فلزات اولیه ۲۰ میلی گرم در لیتر، دوز جذب ۱۲٫۵ گرم در لیتر و زمان احتباس ۹۰ دقیقه بدست آمد. همچنین جذب مطلوب مس (۷۱٪) در pH 6، غلظت ۱۵ میلی لیتر در لیتر اولیه، مقدار جذب ۱۵ گرم در لیتر و زمان ریزش ۷۵ دقیقه بدست آمد. لانگمویرز، ایزوترم Freundlich و Temkin برای توصیف ریاضی تعادل جذب استفاده شد. ایزوترم لانگمویر بهترین اتصالات را برای داده های تعادلی ایزوترم نشان می دهد که با حداکثر ظرفیت جذب (qm) 4.33 میلی گرم بر گرم و ۳٫۵۴ میلی گرم بر گرم برای سرب و مس به ترتیب. نتایج نشان داد که معادله جنبشی جذب مرتبه مرتبه دوم با یک ضریب همبستگی بالا (R2 بیش از ۰٫۹۷) مناسب است. بر اساس نتایج مطالعه حاضر پوسته های تخم مرغ مناسب برای حذف سرب و مس از پساب های نساجی مناسب است.