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Research paper

Cadmium Ions Removal Analysis from Wastewater utilizing Salvadora persica Stem's Activated Carbon

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A R T I C l E I N F O

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A B S T R A C T

The heavy metals impressive elimination from industrial wastewater is one of the most significant topics for industrialized nations. Cadmium Removal of aqueous solutions was investigated utilizing activated carbon produced from Salvadora persica stems. Batch adsorption experimentations have been conducted as a pH function, connection time, solute concentration, and absorbing dose. The optimal pH needed for highest absorbing was about five for cadmium. The highest connection time for the stability condition is 180 minute at the absorbing dose rate of 2.5 g. The highest proficiency of cadmium removal by activated carbon has been 81.7 percent. The outcomes have been equipped very well with both Langmuir and Freundlich isotherm.

Introduction

Heavy metals collect in alive materials in the food chains that the human is on their head. These poisonous metals could generate cumulative toxic, brain problems and cancer while found above the toleration level. The cadmium presence in drinking water beyond the acceptable limitation might generate negative effects in health like anemia, encephalopathy, hepatitis and nephritic syndrome. Therefore, it is very essential which it should be terminated from wastewater (Potgieter et al. 2006). The main benefits of sorption technology are its efficacy in decreasing the heavy metal ions concentration to extremely lower levels and the utilization of cheap absorbing materials (Saeed et al. 2005, Singanan et al. 2007, Tien 2002). Absorbing procedures are significantly appropriate for the wastewater purification including lower heavy metals concentration (Feng & Aldrich 2004).

In this investigation, determining the significance of the activated carbon generated from stem of the plant Salvadora persica. It was utilized for removing cadmium from synthetic wastewater and for investigating the method of sorption in activated carbon with executing a set empirical procedure (Hall et al. 1996, Axtell et al. 2003).

Methodologies

Synthetic Wastewater Preparation

Synthetic wastewater model was designed by utilizing analytical grade cadmium nitrate. For pH regulation in the investigation, hydrochloric acid or sodium hydroxide solutions have been utilized as required. The stock solution included 2 g/L of Cd.

Preparation of Carbon

Plant Salvadora persica Stem was gathered and air-dried for 48 hours. Salvadora persica activated carbon has been designed with the purification of the stem pieces by the concentrated sulphuric acid. Also maintained in an oven at 150°C for one day. It was purified and filtered by distilled water frequently for removing sulphuric acid. Ultimately dried in an oven at 300°C, and powered utilizing mortar and pestle. The resultant black production was held in an air-free oven kept at 300°C for 5 hours. The activated carbon particle size among 40 and 60 mesh sizes has been utilized. Batch investigations were conducted at 27°C (Hall et al. 1996). Therefore, models have been mechanically mixed at 100 rpm. The cadmium concentration was calculated.

Discussion and Results

Effect of pH

In heavy metals sorption, pH is one of the critical elements. The cadmium by activated carbon of Salvadora persica sorption in various pH levels is demonstrated in Fig. 1.

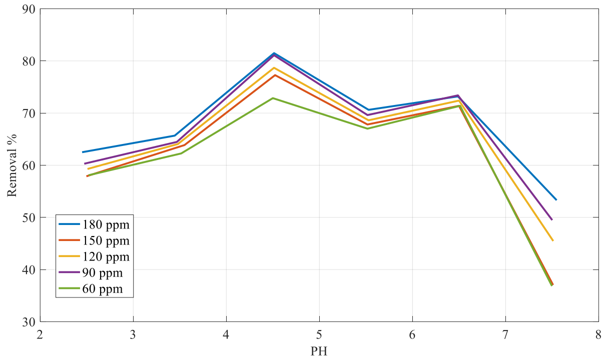

Fig. 1. Influence of pH on Cd ions removal at time 150 minutes and absorbent dose 2.5g.

In this study, the speed of Cd ions removal in synthetic wastewater is mostly governed by solution pH. The optimum pH for Cd removal was five. At pH more than five metal was precipitated according to the formation and removal of the hydroxide considering the absorption was so low. In low pH the protons concentration was high and metal-binding areas evolved positively charged repulsing the Cd cations. By growing in pH (Ho 2005), the negative charge density on the activated carbon grows according to deprotonation of the metal-binding areas, therefore raising metal absorption.

Impact of activated carbon amount

Fixing the activated carbon amount of the adsorbent for designing the optimal treating techniques and for a fast reaction of the research. For achieving this purpose, a set of investigations have been performed with the absorbent dose of 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 g per 100 mL for the examination solution. While the absorbent dose addition grew, the metal ions percentage removal grew too. The highest cadmium removal of 81.7 percent has been gained at 2.5 g of the activated carbon. It could be observed from Fig. 2, which, an adsorbent dose of 2.5 g is adequate for optimum metal removal in aqueous solutions. Additional growth in the activated carbon dose quantity wouldn't have any important impact on the cadmium ions removal from the solution.

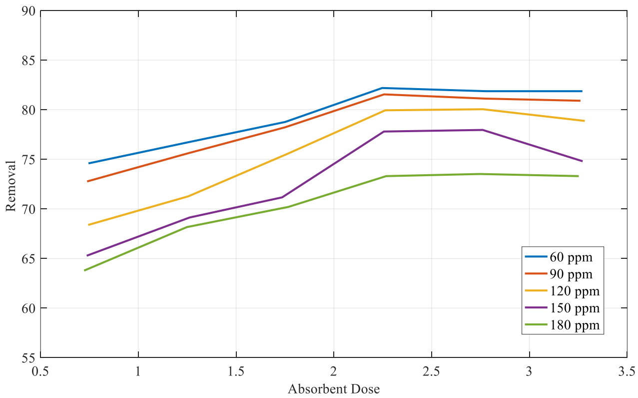

Fig. 2. Influence of absorbent dose on Cd ions removal at PH 5 and connecting time 150 minutes

Contact Times Effect

By optimizing the absorbent dose at 2.5 g per 100 mL examination solution and the pH at five for cadmium ion solution, the impact of contact time for the metal ions' impressive removal was investigated. The metal indicated a constant speed growth of absorption in the sorbate absorbent contact procedure and the removal speed evolved to negligible according to rapid fatigue of the absorption areas. The speed of metal removal is increased in the start according to a bigger surface region of the absorbent existing for the metal absorption. In this investigation, 81.7 percent cadmium removal has been attained at 150 minutes. Additionally, according to Fig 3, no considerable modifications have been seen in the metal ions removal from the resolution after 24 hours of equilibration.

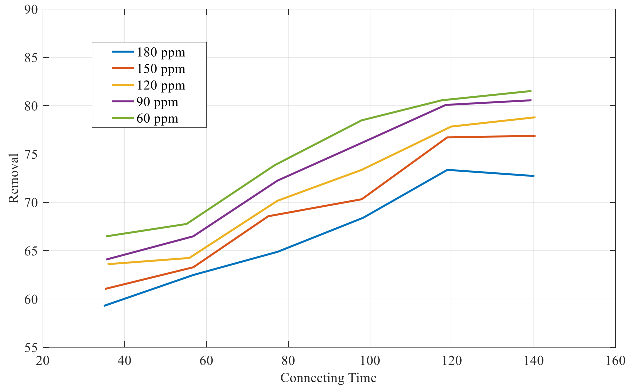

Fig. 3. Influence of connecting time on Cd ions removal at PH 5 and absorbent dose of 2.5 g

Metal ions concentration Effect

The metal absorption technique is mainly dependent on the heavy metal concentration. The initial concentration of 60 mg/L of metal ions has been chosen for Cd. according to Fig. 4, the impact of metal ion concentration on the cadmium ions removal. At the concentration of the metal ion of 60 mg/L and the optimal dose of 2.5 g of the activated carbon, the highest Cadmium removal has been accomplished within 150 minutes. This statement obviously signifies that the metal ions removal relies on the values of absorbent and connection time. The heavy metals are absorbed by special areas delivered by the acidic functional sets on the activated carbon when by growing metal concentrations, the special areas are saturate and the business areas according to the extreme surface area of the activated carbon are supplied. It is obvious that by growing primary concentrations, the metal removal reduces.

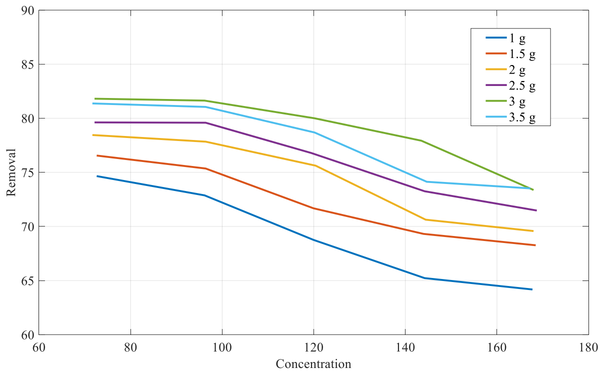

Fig. 4. Influence of metal ion concentration on Cd ions removal at PH 5 and 150 minutes

Absorption Isotherms

The absorption isotherms are very crucial in defining the absorption solutes' behavior on the special absorbent. Two significant isotherm samples Langmuir and Freundlich have been established and analyzed.

Langmuir isotherm

The Langmuir isotherm (Langmuir 1916) assumes a hypothesis, which, the absorption happens at special homogeneous areas within the absorbent.

The following equation is belong to Langmuir equation:

$$qe = \frac{q_0 bCe}{1} + bCe$$

The linear form for the isotherm equation is as follows:

$$\frac{Ce}{q_e} = \frac{1}{q_0 b} + \frac{Ce}{q_0}$$

where, q_0 is the highest metal uptake related to the adsorbent saturation degree b is absorption energy qe = the of metal adsorbed amount in the activated carbon and Ce is the equilibrium metal concentration in the solution.

q_0 and b are the elements of the Langmuir isotherm and could be chosen from the last equation. So, a fig of Ce/q_0 against Ce shows a direct line of slope $1/\,q_0$ and intercept $1/bq_0$. The data fitting the Langmuir isotherms nicely for Cd ions. The amounts of Langmuir elements for the Cadmium metal ions removal are shown in Table 1. The plot linearity in Fig. 5 demonstrates the Langmuir equation application, sustaining a mono-layer shape on the absorbent surface.

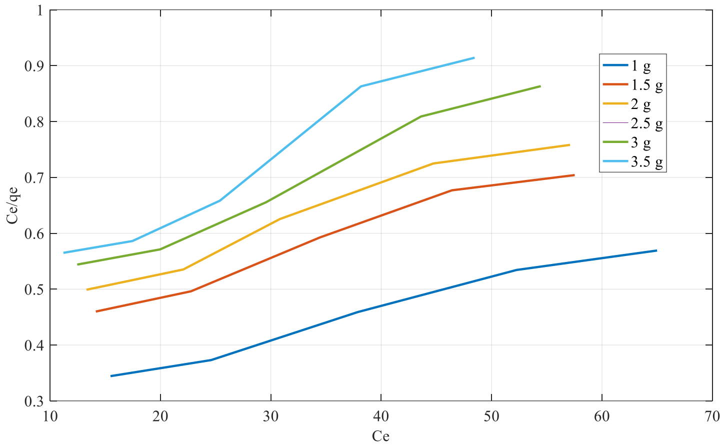

Fig. 4. Langmuir absorption isotherm for Cd ions

Table. 1. Langmuir isotherm

m	$Q_0 = \frac{1}{m}$	C=intercept	$Q_0 * C$	b	bC_o	$1 + bC_0$	$R1 = \frac{1}{(1 + bC_0)}$
0.004	250	0.272	6 8	0.0147	0.882	1.882	0.53134
0.006	166.66	0.379	63.164	0.01583	0.9498	1.9498	0.51287
0.008	125	0.421	52.625	0.019	1.14	2.14	0.46728
0.009	111.11	0.668	74.22	0.013473	0.80838	1.80838	0.553
0.011	90.9	0.513	46.631	0.02144	1.2864	2.2864	0.4373
0.01	100	0.434	43.4	0.02304	1.3824	2.3824	0.4197

Table. 2. Freundlich isotherm

$m = \frac{1}{n}$	n	$C = \log Kf$	Kf	r	r^2
0.635	1.574	0.908	8.09	0.994	0.990
0.686	1.457	0.704	5.05	0.995	0.991
0.654	1.529	0.669	4.67	0.990	0.981
0.673	1.485	0.478	3.01	0.982	0.966
0.684	1.461	0.527	3.36	0.984	0.969
0.649	1.540	0.637	4.33	0.9899	0.980

The amounts of b and q_0 demonstrate the absorption of the metal ions is concentration and pH related. The separation factor term (RL) in the dimensionless shape of the Langmuir isotherm is as follow:

$$RL = \frac{1}{(1 + bC_0)}$$

where, C_0 is the primary metal ion concentration and b demonstrates the Langmuir constant. The separation element (RL) could be utilized for predicting the relationship among the sorbate and absorbent in the absorption procedure. The features of the RL amount demonstrate the adsorption nature:

$$Unfavorable\ while\ RL > 1$$

$$Linear\ while\ RL = 1$$

$$Favorable\ while\ 0 < RL < 1$$

$$Irreversible\ while\ RL = 0$$

It is seen that, in all the chosen metal ion concentrations, the split factor (RL) is smaller than one demonstrating the favorable absorption situation.

Freundlich isotherm

The Freundlich term is a practical equation according to a heterogeneous level. The general shape of the Freundlich equation is as follows:

$$q_e = K_f C_e^{1/n}$$

The linear form of this is as following equation:

$$logq_e = \log K_f + 1/n\ logCe$$

where, $logq_e$ is the interrupt , adsorption capability measure, $1/n$ is the slope of absorption intensity, q_e is metal ion absorbed amount, and Ce is concentration of a metal ion in solution in equilibrium

The n must include amounts between 1 and 10 for the category as favorable absorption.

The Freundlich adsorption model is shown in Fig. 6. According to this Fig, the Freundlich isotherm is nicely fitted to the metal ions.

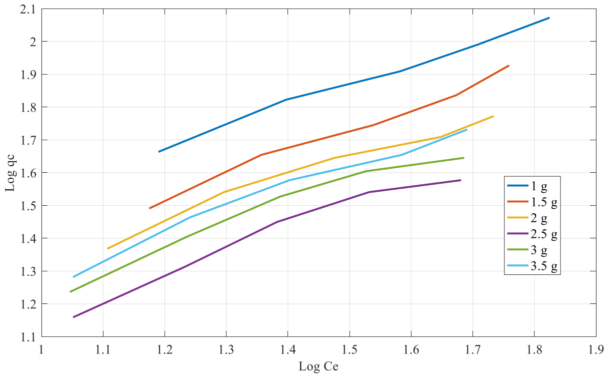

Fig. 4. Freundlich isotherm for Cd absorption

Conflict of interest

The authors declare that they have no conflict of interest.

References

Aksu, Z. 2001. Equilibrium and kinetic modelling of cadmium (II) biosorption by C. vulgaris in a batch system: Effect of temperature. Separ. Purif. Tech., 21: 285-94.

Axtell, N.R., Sternberg, S.P.K. and Claussen, K. 2003. Lead and cadmium removal using Microspora and Lemna minor. Bioresource Tech., 89: 41-8.

Feng, D. and Aldrich, C. 2004. Adsorption of heavy metals by biomaterials derived from the marine alga Ecklonia maxima. Hydrometallurgy, 73: 1-10.

Hall, K.R., Eagleton, L.C., Acrivos, A. and Vermeulen, T. 1996. Pore and solid diffusion kinetics in fixed-bed adsorption under constant pattern conditions. Industrial & Engineering Chemistry Fundamentals, 5(2): 212-223.

Ho, Y.S. 2005. Effect of pH on heavy metal removal from water using tree fern as the sorbent. Bioresource Tech., 96: 1292-1296.

Langmuir, I. 1916. The constitution and fundamentals properties of solids and liquids. Part I: Solids. J. Am. Chem. Soc., 38: 2221- 2295.

Padmavathy, V., Vasudevan, P. and Dhingra, S.C. 2003. Biosorption of cadmium (II) ions on Baker's yeast. Process Biochem., 38: 1389-1395.

Potgieter, J.H., Potgieter-Vermaak, S.S. and Kalibantonga, P.D. 2006.

Heavy metal removal from solution by palygorskite clay. Minerals Engineering, 19(5): 463-470.

Saeed, A., Akhter, M.W. and Iqbal, M. 2005. Removal and recovery of heavy metals from aqueous solution using papaya wood as a new biosorbent. Separ. Purif. Tech., 45: 25-31.

Singanan, M., Abebaw, A. and Vinodhini, S. 2007. Studies on the removal of hexavalent chromium from industrial wastewater by using biomaterials. Electron. J. Environ. Agr. Food Chem., 6: 2557-2564.

Tien, C.J. 2002. Biosorption of metal ions by freshwater algae with different surface characteristics. Process Biochem., 38(4): 605-613.