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Adsorption study of some inorganic elements on the surface of activated charcoal prepared from ceratonia siliqua

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Abstract

This study included the process of adsorption of some inorganic elements known as environmental risk (Cd, Cr, Cb, Pb) of its water solutions on the surface of activated charcool to ceratonia siliqua . The percentage of adsorption and isothermal adsorption curves were calculated according to equation, as well as the effect of temperature , pH and particle size of adsorbent on the adsorption of these elements. The study included the comparative study of the adsorption with natural ceratonia siliqua powder. The results showed an optimum conditions at PH=5 and the partical size of adsorbent was 500 µm, while the percentage of adsorption ranged from 81% to 93% .

Introduction

Adsorption is a characteristic of many natural materials such as alumina and silica in addition processed materials such as zeolite and activated charcoal, One of the most important problems of adsorption is the pollution [1,2]. Water pollution is one of the problems in current era because of the difficulty of disposal of these components because of their different forms dissolved in water for long time. The trace concentration of heavy metals and the presence of these pollutants as a coliform suspension are associated with organic substances and mineral materials so that these concentrations are dictated to water pollution by trace elements [3]. Hamza and Robert[4,5] sed activated charcoal in removing the pollutants for a large number of surface pores that make a wide surface area in activated charcoal. However the development of the method of studying adsorption on other surfaces like zeolite, kaoline, bentonite and other materials are not less important than carbon. These surfaces include zeolite, kaolin, bentonite surface[6,7] . The presence of metal element ions in the aquatic environment leads to great concern because of high toxicity of these materials if they exceed the permissible limits of non-decomposition and accumulation [8]. There are several different factors affect the adsorption of materials on the surfaces including the concentration of adsorbent material, temperature, polarization and the nature of surface matter [9,10]، As well as the used solvent and pH in the adsorption process[11]. The increasing interest in the process of adsorption is due to its high efficiency in adsorption of toxins, dyes and their low cost [12].

Experimental part

A: used Apparatus

The apparatus used in this research are listed in table (1).

Table (1) The used apparatus

No	The name of apparatus	Company & origin
1-	Atomic absorption Spectrometer(A.A-6200)	Shimadzu,gapan
2-	Sensitive balance (BL 210S)	Sartorius ,Germany
3-	Burning oven	Carbolit , England
4-	pH meter (3310)	Jenway (origin)
5-	Shaker (B5-11)	Lab companion (origin)
6-	Magnetic stiror (Hp-3000)	Lab companion (origin)

B: chemicals

used Chemical are listed in table (2).

Table (2) used chemical

No	Substance	Chemical formula	% purity	Company
1-	Hydrochloric acid	HCl	37%	BDH
2-	Sodium hydroxide	NaOH	97	Fluka
3-	Standard solution for copper, chromium ,cadmium ,lead	Cu ,Cr ,Cu ,Pb	Pure	Fluca

C: standard solution

Ten ppm for each heavy metal (Cd,Cr,Cu,Pb) were prepared from standard solution of 1000 ppm for each one. Hydrochloric acid 0.1M was and sodium hydroxide of 0.1 M was prepared.

D: Collection and preparation of siliqua

The certonia siliqua was collected from samarra which washed with distilled water several times to remove the impurities and some materials such as dust and salts, then they were placed in electric oven in 120 c^o for two and half hours to dry them and dehumidification, figure (1) showed the siliqua after washing and drying.

Figure (1) siliqua after washing and drying

E: process of carbonation

Twenty gm of dried granulated powered of cartonia siliqua was taken and mixed with 20 ml of sodium hydroxide 0.1 M in crucible and mixed then it was put in oven furnace for one hour at 800 C^o , then cooled and the coal crushed [8].

F: process of activation and final washing

The coal was washed several times with distilled water and filtered in a 150 micro filter paper to remove the ash and then added 10ml of hydrochloric acid (0.1 M) to remove chemical residue, the coal was then washed with distilled water for several times and filtered to remove the acid and basic residues, then dried for one hour at 100 C^o , the dried coal was grinded to product and sort with suitable sieves ranging from (150-750) micrometer(10) as showed in figure (2).

Figure (2) activated charcoal from ceratonia siliqua

G : Estimate the acidic function of the prepared activated charcoal

One gram of activated charcoal was added to 10 ml of distilled water and shaked for 30 minutes then filtered and measured by pH-meter

H: the effect of partical size of prepared activated charcoal

Three paritical size: (500,800,1000) µm of activated charcoal were used to study their effect on the adsorption process of heavy metals in experimental conditions

I: adsorption experiments The ceratonia siliqua used as natural state after washing , drying and grinding, as well as the use of activated charcoal prepared from ceratonia siliqua as adsorbed material by taking 0.1 gm of them in conical flask and then adding the standard solution of inorganic element with concentration 10ppm and then shacked by shaker equipped with water bath then filtrated and measured the solution by atomic absorption spectrometry to estimate the inorganic element concentration these steps were returned to four inorganic elements (Cd, Cu ,Cr ,Pb) [9].

Results and discussion

1-results of adsorption of inorganic elements using natural ceratonia siliqua powder

The results showed that the percentage of adsorption was in the range from 75% to 80% as shown in the table (3).

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Table(3) Adsorption percentage using natural ceratonia siliqua powder

No	Concentration before adsorption (ppm)	Concentration after adsorption (ppm)	Elemnts	Adsorption percentage
1	10	2.2	Cu	78%
2	10	2.7	Cr	73%
3	10	2.4	Cd	76%
4	10	2.0	Pb	80%

2-Results of adsorption of inorganic elements using activated charcoal prepared from ceratonia siliqua ,the results showed that the percentage of adsorption was in the range from 81% to93% as shown in the table (4).

Table(4) Adsorption percentage using activated charcoal prepared from ceratonia siliqua

No	Concentration before adsorption (ppm)	Concentration after adsorption (ppm)	Elements	Adsorption percentage
1	10	1.1	Cu	89%
2	10	1.01	Cr	89.9%
3	10	1.9	Cd	81%
4	10	0.7	Pb	93%

The concentration was calculated from calibration curve for each elements as showed in figures (3,4,5,6).

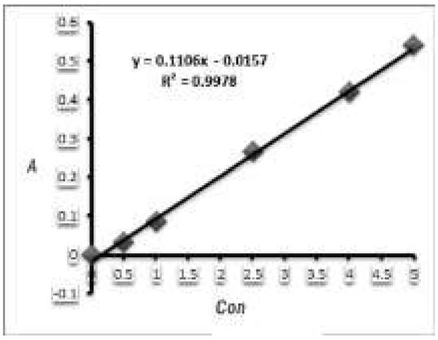
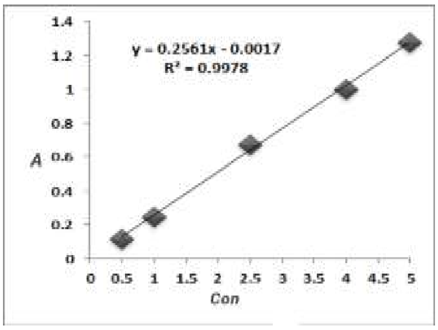


Figure (3) calibration curve of Cu



figure(4) calibration curve of Cr

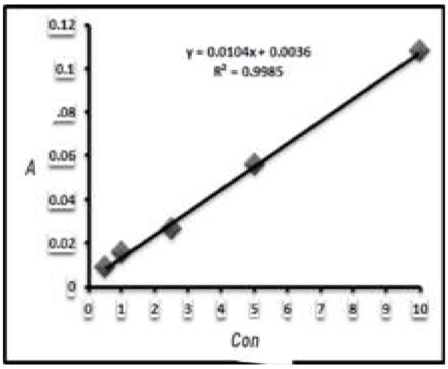


figure (5)calibration curve of Cd

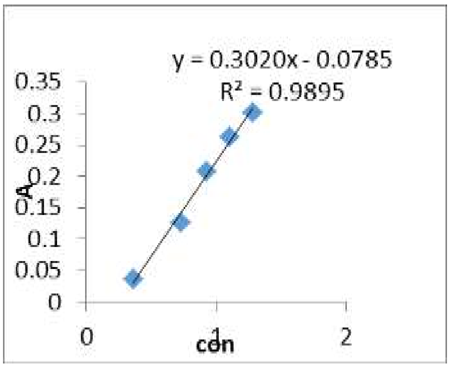


figure (6) calibration curve of pb

the optimum conditions for adsorption was at pH=5 ,partical size was 500 µm and temperature at 283K

3- Calculation of thermodynamic functions of adsorption

Table (5) The values of thermodynamic functions of adsorption of (Cu ,Cd ,Cr ,Pb) ions on the surface of the activated charcoal at the concentration of (10)ppm and at a different temperatures

T(K)	1/T K^{-1}	Ce (mg/L)	Qe (mg/g)	K	ln K
283.00	0.00353	0.092	0.19908	2.163	0.77
293.00	0.00341	0.085	0.19915	2.342	0.85
298.00	0.00338	0.083	0.19917	2.399	0.87
303.00	0.00335	0.082	0.19918	2.429	0.88
313.00	0.00329	0.080	0.19920	2.490	0.91

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Table (6) The values of the thermodynamic functions of adsorption of (Cd) ions on the surface of the activated charcoal at the concentration of (10)ppm and at a different temperatures

T(K)	1/T K^{-1}	Ce (mg/L)	Qe (mg/g)	K	ln K
283.00	0.00353	0.078	0.19922	2.554	0.937
293.00	0.00341	0.075	0.19925	2.656	0.976
298.00	0.00338	0.072	0.19928	2,767	1.017
303.00	0.00335	0.070	0.19930	2.847	1.046
313.00	0.00329	0.068	0.19932	2.931	1.075

Table (7) The values of the thermodynamic functions of adsorption of (Cr) ions on the surface of the activated charcoal at the concentration of (10) ppm and at a different temperatures

T(K)	1/T K^{-1}	Ce (mg/L)	Qe (mg/g)	K	Ln k
283.00	0.00353	0.093	0.19907	2.140	0.760
293.00	0.00341	0.091	0.19909	2.187	0.782
298.00	0.00338	0.088	0.19912	2.262	0.816
303.00	0.00335	0.084	0.19916	2.370	0.862
313.00	0.00329	0.078	0.19922	2.554	0.937

Table (8) The values of the thermodynamic functions of adsorption of (Pb) ions on the surface of the activated charcoal at the concentration of (10) ppm and at a different temperatures

T)(K	1/T K^{-1}	Ce (mg/L)	Qe (mg/g)	K	ln K
283.00	0.00353	0.089	0.19911	2.237	0.805
293.00	0.00341	0.079	0.19921	2.521	0.924
298.00	0.00338	0.077	0.19923	2.587	0.950
303.00	0.00335	0.075	0.19925	2.656	0.976
313.00	0.00329	0.069	0.19931	2.888	1.060

Ce: remained concentration
Qe: adsorbed concentration

The values that were found in the previous tables indicated that there was a fluctuation in the values of the thermodynamic equilibrium constant of the adsorption process in the case of using 313K low temperature followed by an increase.

Table (9) Values of the thermodynamic functions of adsorption of copper ions on the surface of activated charcoal at a concentration of (10) ppm and different temperatures

T (K°)	ΔG ^{o} $J.mole^{-1}$	ΔH ^{o} $J.mole^{-1}$	Δ S^{o} $J.mole^{-1}.K^{-1}$
283	-1811.70	2817.94	16.3591
293	-2070.60		16.6844
298	-2155.48		16.6893
303	-2216.84		16.6164
313	-2368.07		16.5687

Table (10) Values of the thermodynamic functions of adsorption of (cd) ions on the surface of activated charcoal at a concentration of (10) ppm and different temperatures

T (K°)	ΔG ^{o} $J.mole^{-1}$	ΔH ^{o} $J.mole^{-1}$	Δ S^{o} $J.mole^{-1}.K^{-1}$
283	2204.63-	5014.83	18.4433
293	2377.53-		25.2298
298	2519.69-		25.2836
303	2635.02-		25.2471
313	2797.45-		24.9593

Table (11) Values of the thermodynamic functions of adsorption of copper(cr) ions on the surface of activated charcoal at a concentration of (10) ppm and different temperatures

T (K°)	ΔG ^{o} $J.mole^{-1}$	ΔH ^{o} $J.mole^{-1}$	Δ S^{o} $J.mole^{-1}.K^{-1}$
283	1788.17-	6549.02	29.4600
293	1904.95-		28.8531
298	2021.69-		28.7607
303	2171.50-		28.7805
313	2438.33-		28.7135

Table (12) Values of the thermodynamic functions of adsorption of(Pb) ions on the surface of activated charcoal at a concentration of (10) ppm and different temperatures

T (K°)	ΔG ^{o} $J.mole^{-1}$	ΔH ^{o} $J.mole^{-1}$	Δ S^{o} $J.mole^{-1}.K^{-1}$
283	1999.93-	7553.26	33.7568
293	2250.86-		33.4611
298	2353.69-		33.2447
303	2458.68-		33.0427
313	2758.41-		32.9446

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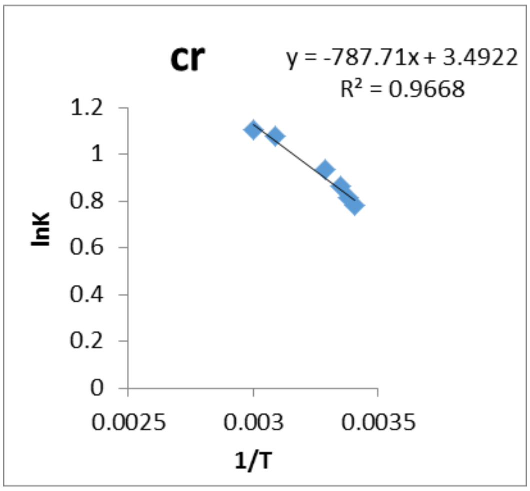
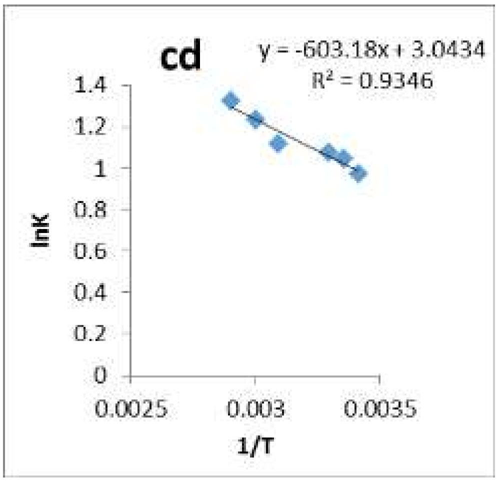
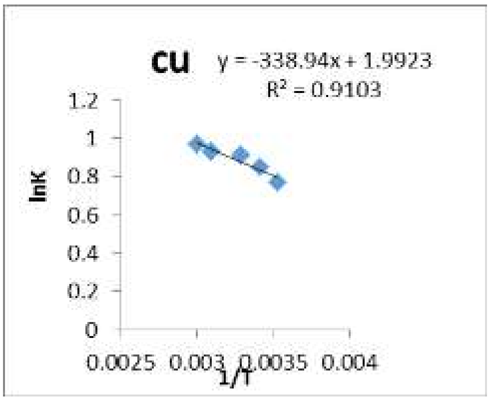


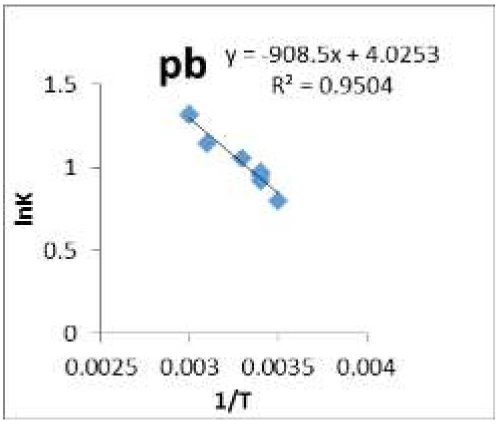
figure(7)Vant Huff curve (Cr)



Figure(8)Vant Huff curve (Cd)



figure(9) Vant Huff curve of (Cu)



Figure(10)Vant Huff curve of (Pb)

from the above values it was concluded that the value of adsorption temperature was positive for the studied ions on activated coal surface when measured at a concentration of 10ppm ,this indicates that adsorption was an exothermic process. This value also indicated that the absorption process was accompanied with adsorption and both process occurred to gethar inside the porous solid phase and the diffusion rate of adsorbed molecules increase as temperature increase .

It is well known that the dependence of adsorption on temperature measured at maximum concentration includes all binding energies of the particles at various sites on surface.

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دراسة امتزاز بعض العناصر اللاعضوية على سطح الفحم المنشط المحضر من الخرنوب

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الملخص

تضمنت الدراسة عملية االامتزاز لبعض العناصر اللاعضوية المعروفة بخطرها البيئي (Pb، Cb ،Cr،Cd) من محاليلها المائية على سطح الفحم المنشط للخرنوب، والنسبة المئوية للامتزاز الايزوثيرمي. وكذلك تاثير درجة الحرارة والأس الهيدروجيني وحجم الدقائق على امتزاز العناصر، وكذلك دراسة مقارنة للأمتزاز باستخدام مسحوق الخرنوب الطبيعي وبينت النتائج الظروف المثلى باستخدام pH=5 وحجم الدقائق للمادة المازة كان 500 μm، وان النسبة المئوية للأمتزاز كانت 81% الى 93%