Removal of Sulfate from Waste Water by Activated Carbon

Mohammed Sadeq Salman
Computer Centre/ University of Baghdad

Abstract

Activated carbon was Produced from coconut shell and was used for removing sulfate from industrial waste water in batch Processes. The influence of various parameter were studied such as pH (4.5 – 9.) , agitation time (0 – 120)min and adsorbent dose (2 – 10) gm.

The Langmuir and frandlich adsorption capacity models were been investigated where showed there are fitting with langmmuir model with squre regression value (0.76). The percent of removal of sulfate (22% - 38%) at (PH=7) in the isotherm experiment increased with adsorbent mass increasing. The maximum removal value of sulfate at different pH experiments is (43%) at pH=7.

1. Introduction

Water pollution by anions is not only a public health concern ; therefore removal of these ions from waste water before the process of discharging is very important .

Sulfate (SO_4^-) is widely distributed in natural water or industrial waste water for example waste water of charging process in manufacturing of batteries. This practice often produces a waste water containing sulfuric acid that is usually neutralized by addition of sodium hydroxide or sometime quick lime (CaO) prior to release to a receiving stream which could contain high sulfate and other ions.(Namasivayam and Sangeetha 2007).

There are several technologies for sulfate treatment like chemical precipitation in order to sediment the sulfate as undissolved salt as evaporation , which reduce the volume of waste water with high concentration of sulfate or ion exchange and reverse osmosis.(Minnesota D. of health 2008)

Adsorption is a demonstrated waste water treatment that use solid adsorbent to remove dissolved pollutants from waste water.(John and Barry 1998)

One of the well known adsorbent is activated carbon which is made from many carbonaceous source including coal, coke, pest, wood and coconut shell.

The carbon source material is activated by treating it with an oxidizing gas to form a highly porous structure with a large internal surface area. The forms of activated carbon are granular activated carbon (GAC) or powdered activated carbon (PAC).

The carbon adsorption mechanism is complicated and although the attraction is primarily physical is a combination of physical , chemical and electrostatic interaction between the activated carbon and the pollutant (Essam 1995).

During the process of adsorption there many parameter affect on the adsorption capacity such as pH number which represented the [H] concentration , contact time where increasing of contact time will increase of adsorption capacity , mass of adsorbed , temperature and concentration of adsorbate (pollutant) .(Namasivayam and Sangeetha 2007).

The use of activated carbon to remove inorganic pollutants from waters is widely extended , because of their high surface area, micro porous character and the chemical nature of their surface (Zhimang et al. 2005).

Langimuir model is used to fit the any result with the any model according to the equation(1) by plotting Ce Vs Ce/qe . (John, 1995)

$$\frac{Ce}{qe} = \frac{1}{ab} + \frac{Ce}{a} \qquad ...(1)$$

where Ce is the concentration of sulfate at equilibrium (mg/l) ,
a is constant monolayer adsorption capacity (mg/g)
b is constant related to energy of adsorption (l/g)
qe is adsorption capacity (mg/g).
Frandich model is expressed to fit the result as shown is equation (2) by plotting log qe Vs log Ce . (John, 1995)

$$qe = k \ Ce^{\frac{1}{n}} \qquad ...(2)$$

linearization of (eq 2) gives:

$$\log qe = \log k + 1/n \log Ce \qquad ...(3)$$

Where n and k are constants, qe is adsorption capacity(mg/g) and Ce is sulfate concentration at equilibrium (mg/l).
The aim of this study is investigating of sulfate removal from waste water by using activated carbon in batch experiment and the result of equilibrium have been detected with above modeling equation (1 , 2).

2. Experimental procedure
2.1 Material and method

Adsorbent is activated carbon is produced from coconut shell by (unicarbo. Company Italia) with properties are shown in table 1

Table 1,
Characteristic of Activated Carbon

Item	Characteristic
Specific surface area (m^2/g)	1000 – 1100
Ash content %	3.2 - 5%
Specific gravity	1.29
Bulk density Kg/m^3	0.12
Porosity %	92%

Adsorbate is waste water was obtained from Batteries factory – waste water from charging unit

with concentration (500-600) ppm which had been diluted to desired concentration with distilled water.
Analysis of stock and samples had been investigated by colorimetric type (color spec, UK) at wave length (420)nm Soaad and Mohammed 1990).

3. Adsorption Studies
3.1 Effect of Adsorbent Mass

Adsorption experiment was carried out by different weight of adsorbent (2 , 4 , 6 , 8 , 10) gm of activated carbon in 5 flasks each one size 250 ml contains 100 ml of waste water with (520 mg/l) of sulfate concentration after shaking for 4 hours at pH 7 – 8 and 25 C^0 by using shaker type (HT, Infors, TRM, GER), at speed 350 rpm . the sample of each flask was filtrated by paper filter and analysis for sulfate concentration by colorimetric method. (Soad and Mohammed, 1990).

3.2 Effect of pH and Time Contact

Three experiments were carried at different pH (5– 4.5) , (7) and (9) by agitating 600 ml of adsorbate at 150 gm/l sulfate concentration with 10 gm of activated carbon at 25 C^0 and 350 rpm and for 3 hour to express the effect of pH on the adsorption capacity . Adjusting of pH by using diluted HCL and NaOH . With pH meter Type (Metrdlm, 650,Swiss)
The sampling were obtain with time internal (15, 30, 60, 90, 120) min and analyses for sulfate concentration.

4. Result and Discussion
4.1 Adsorption Isotherm.

Fig. (1) show the decreasing equilibrium concentration for experiment of different weight of adsorbent due to the increasing of surface of adsorption (Martin and albahrani 1978).
Fig. (2) shows the adsorption capacity (eq 4) according to equilibrium concentration plotting by qe Vs Ce which show low capacity value due to the surface of carbon is effected by other ions in the waste water.

$$qe = \frac{C - Ce}{m} \times \frac{V}{1000} \qquad \ldots(4)$$

where
C: Initial Conc.   (mg/l)
Ce: Equilibrium Conc. (mg/l)
m : mass of activated carbon (g)
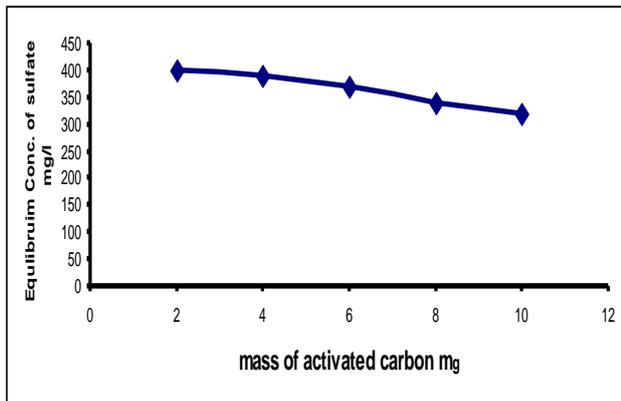qe : adsorption capacity (mg/g)
V : volume of Sample (ml)

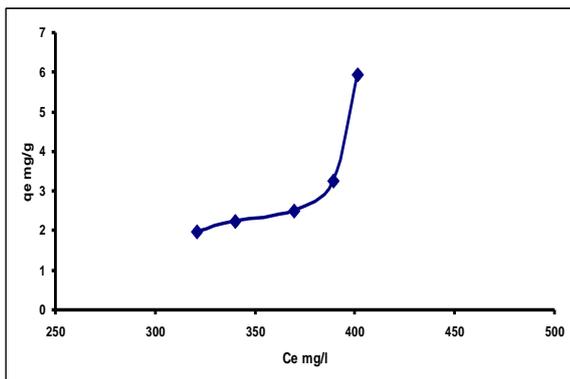**Fig.1. Equilibrium Concentration of Sulfate at Different Adsorbent Mass.**

Fig.2. Equilibrium Isotherm Curve.

Ce/qe Vs Ce curve was plotted to determine Langmuir constants (a, b) in Fig. (3).
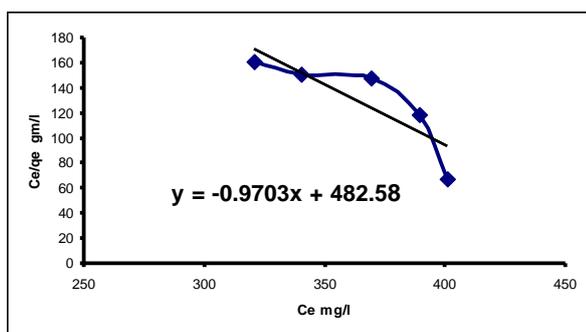

Fig.3. Langmuir Equilibrium Isotherm.

When plotting of log Ce Vs log qe   to determine Frandlich constant constants n and K adsorption coefficient in Fig. (4) which   show unfitting results because n value   less than (>1).(Abood 2005).
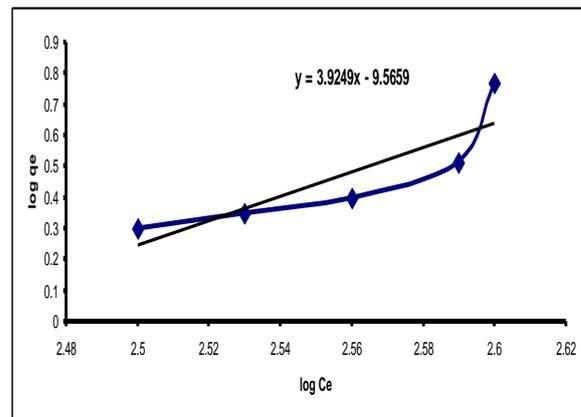

Fig.4. Frandlich Equilibrium Isotherm.

4.2 pH and Contact Time Effect

Fig. (5) Shows percent of removal of sulfate for each pH value at different time. which show the critical value and the best value of removing at pH(7) after (30) min.
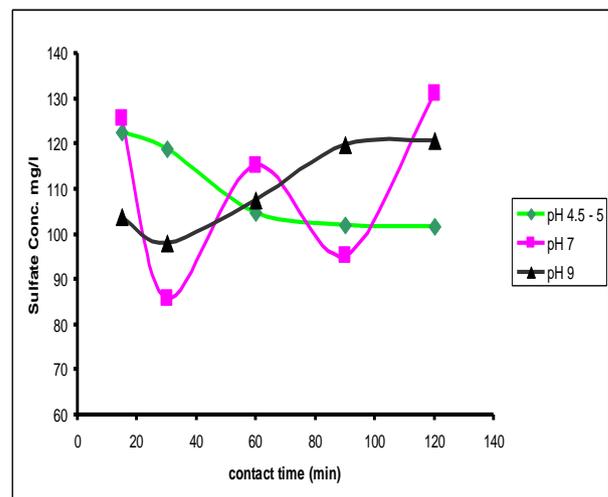

Fig.5. Effect of pH on Sulfate Cons.

Fig.(6)   shows   the   comparing   among experimental isotherm and theoretical isotherm (Langmuir and Frandlich models) with error percent value for each models. (Abood 2005) equation (5).

$$\% E = \frac{1}{n} \sum_{1}^{\wedge} \frac{\left| qe_{\exp} - qe_{Cal} \right|}{qe_{\exp}} \qquad \dots(5)$$

where
n= Number of Samples
$qe_{\exp}$= Experimental adsorption Capacity (mg/g)
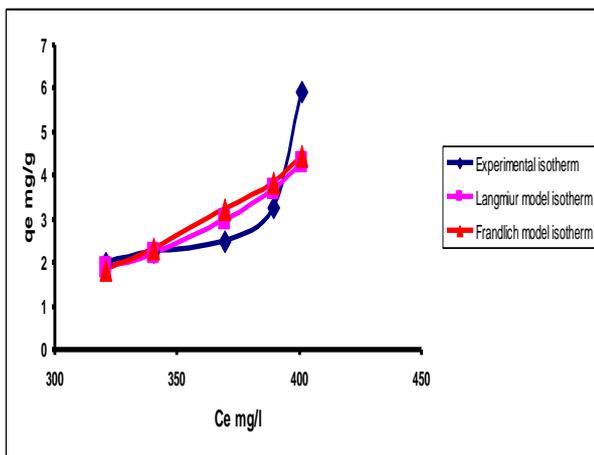qe_{Cal}= calculated adsorption capacity by models (mg/g)

Fig.6. Experimental and Theoretical Isotherms.

The models constants are showed in table (2) with E value for both models.

Table 2,
Langmuir and Frandlich Constant

Models	a (mg/g)	b (l/g)×10^{-3}	K (mg/g)	1/n	%E
Langmuir	1.03	2			13.6
Frandlich			1.47	3.925	27.4

5. Conclusions

- The effect of pH value showed the adsorption of sulfate is like ion exchange process due to the activated carbon particles is considered with positive charge and SO_4 ion is a negative charge therefore the adsorption will be caused by the different charges.
- Adsorption followed Langmuir isotherm more than Frandlich isotherm with error percent (%E) values were in Langmuir model less than in Frandlich model.
- Adsorption of sulfate with activated carbon is higher at low concentration than the high concentration .

Nomenclature

a   Langumir constant (eq. 1) (mg/g)

b   Langumir constant (eq. 1) (l/g)

Ce   Equilibrium concentration (mg/l)

E   Error value among experimental and theoretical

k   Frandlich constant (eq. 2) (mg/g)

m   mass of activated carbon (gm)

n   Frandlich constant (eq. 2)

qe   adsorption capacity at equilibrium (mg/g)

6. References

[1] Abood W. thesis. "Removal of furfural by activated carbon" Baghdad university. College of engineering , 2005.

[2] Essam almajid ,"Environment Engineering" Jordan 1995.

[3] John G "Adsorption technology and design " Wiley series , UK,1995.

[4] Martin R. and Albahrrani K., "Experimental of factor influencing adsorption", Water research, vol. 12 , pp 879-888 , 1978.

[5] Minnesota Dept. of health report "sulfate in well water" 2008.

[6] Namasivayam , D. Sangeetha, "coconut coir pith for the removal of sulfate", J. of Desalination, Vol. 219 , pp 1 – 13 , 2008.

[7] Soaad A .Abaawy and Mohammed S. Hussn , "water tests" Al Musel university, Iraq, 1990

[8] John and Barry C. "Adsorption technology and design", Oxford, UK, 1998.

[9] Zhimang g. ,Jun F. and Baolin deng , "Preparation and Evaluation of GAC Based Iron Contain Adsorbent for Arsenic Removal" Environ. Sci. technol ,vol 39, pp. 3833 – 3843 , 2005.

إزالة الكبريتات من المياه المخلفة باستخدام الفحم المنشط

محمد صادق سلمان

مركز الحاسبة الالكترونية، جامعة بغداد

الخلاصة

تم استخدام الفحم المنشط مجهز محليا من أصل قشور جوز الهند في عملية   إزالة الكبريتات من المياه الصناعية في تجارب البحث. المتغيرات في التجربة هي وزن الفحم (2 – 10) غم والدالة الحامضية (4.5 – 9) وزمن التلامس (0 – 120) دقيقة.

تمت المطابقة مع موديلين لانكمير وفراندلش ولوحظ ان منحني التوازن يتطابق مع موديل لانكمير بـ ($R^2=0.76$) ولا يتطابق مع فراندلش. وان نسبة الإزالة عندما تكون (pH=7) هي من (22%) الى (38%) مع زيادة وزن الفحم المستخدم في عملية تجربة منحني التوازن. فأن أفضل إزالة عند (pH=7) في حالة تغيير زمن التلامس هو (43%).