Study for the Production of Local Adsorbent from Tea Wastes for Removal of Zinc from an Aqueous Solution

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Abstract:

In this research the production of low-cost adsorbent from tea waste for removal of zinc from an aqueous solution was studied both batch and continuous experiments were conducted in order to investigate the behavior of produced adsorbent kinetic. A noticeable improvement in the surface area and other physical properties were recorded after exposing tea waste to charring process. In the batch experiments different dosage of adsorbent were used and the equilibrium isotherm was of favorable type for adsorbent. While, in continuous system different parameters were conducted such as (bed height, particle size, flow rate). Achieved optimum conditions as follow (bed height=2cm, particle size= 250µm, flow rate =0.25 L/hr). Removal degree efficiency of Zn reach to (99%). Increasing bed height will increase the breakpoint value. While, decreasing flow rate, particle size will increase breakpoint.

Key words: Tea waste; zinc; adsorption

1. Introduction

Environmental pollution and contamination are serious problems in the last few decades because of development in industry. The reduction of contamination must be done either by reduce the origin of pollution or by control methods on these origins. Heavy metals are a toxic substances released to the environment which are a result of several activities such as mining, industrial, agriculture activities **[5].** Zinc is the most common heavy metal in industries, hence when proposed to list 1662 sites of hazardous waste on NPL(list of EPA priorities) that found ,this metal has been specified in 985 site of them **[6].** Zinc is considered as mobile metal in ground water and surface water according to its presence in soluble compound case at acidic pH and neutral. Zinc is able to form complexes

of hydroxides and carbonate at basic values of pH**[4].**

2.Experimental work

This study was made to evaluate the adsorption phenomena by using local adsorbent made from tea waste to remove zinc ions from simulated waste water. The effect of different factors and conditions on adsorption process such as bed height of adsorbents, particle size, flow rate, had been studied.

2.1 Adsorbent preparation

Tea waste collected and washed by boiling water for several times in order to remove mainly the color of this material and dirt. The wetted tea had been dried in oven at 105°C overnight **[7].** The dried tea was grinded and sieved to a size of (250µm, 600µm and 1mm) by using (Sieves, S/N:03007314, Body 200mm×500, Germany); these different sizes was used to study the influence of the adsorption process by changing particle size. Tea waste char produced through charring process proceeded according to burning raw tea waste in furnace to increase the surface area of adsorbent and enhance the capacity of adsorption. The temperature used for burning was 250°C with duration time of 1 hr **[7].**

2.2Adsorbate

Zinc solution of concentration equal to (25 mg/l) had been prepared by dissolving (0.05211gm) of ($Zncl_2$) in (1L) of deionized water to use in batch experiment. For Experiments of continuous system the following concentrations (5, 15,25mg/l) was used through dissolving (0.0208, 0.0625, 0.104 gm) of $ZnCl_2$ respectively each in (2 L) of distilled water. By using equation (1) **[1]:**

$$\boldsymbol{W = C \times V \times \frac{M_{wt}}{A_{wt}}} \qquad \textbf{...(1)}$$

Where :

W: represents weight of metal in(mg)
C: represents concentration needed (mg /L)
V: represents volume of solution (L)
A_{wt}: represents Zinc atomic weight of which equal to(65.38g/mole)
M_{wt}: is the molecular weight of zinc chloride which equal to (136.28g/mole). Table (1) including achieved properties of tea waste char.

Table 1: Properties of tea before and after activation.

Item	Before activation	After activation
Surface area	0.94 m^2/gm	82.56 m^2/gm
Real density	2.9927	2.29701
Bulk density	0.4465	0.4057
Porosity	85.0803	82.3379

2.3 Batch Experiment

Batch experiment of adsorption was made by using different adsorbent mass (0.2, 0.4, 0.6, 0.8, 1, 1.2, 1.4, 1.6, 1.8, 2 gm) of tea. Solution of Zinc was prepared including the needed concentration of Zinc ion which is (25 mg/L) and experimentally measured.

2.4 Continuous System

Glass tube which its length (35cm) was used with internal diameter (4cm). A fine metal mesh was used to prevent any missing of produced adsorbent of tea from bed, then the solution of (Zinc chloride) pass through it. To collect wastewater, container of plastic used. One flow meter used to measure the flow rate which ranged (0.25-0.75 L/hr).

The samples of zinc solution of (100 ml) had been put in the conical flasks (250 ml) which including accurate mass of char of tea. The pH value had been measured equal to (7), also temperature is (28°C). Flakes put in shaker of rotary type (SM- 25, Edmund bühler, Germany) at (100 rpm) and time 1 hour.

2.5Analysis

Concentrations of dissolved metal in aqueous solution were tested by flame atomic absorption spectrophotometer AAS (novAA 400 P, Germany) in lab of Ibn Al-betar Research center.

3. Result and Discussion

3.1 Batch system

Experimental data for batch experiment were fitted to Langmuir, and Freundlich isotherm, founded that Freundlich isotherm was gave best fitting according to R^2 value which equal to (0.98).

Fig.1 and 2 represent fitting of data into the Langmuir and Freundlich model.

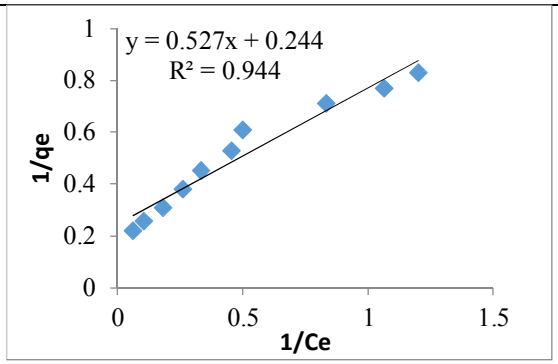

Fig.1 Langmuir model

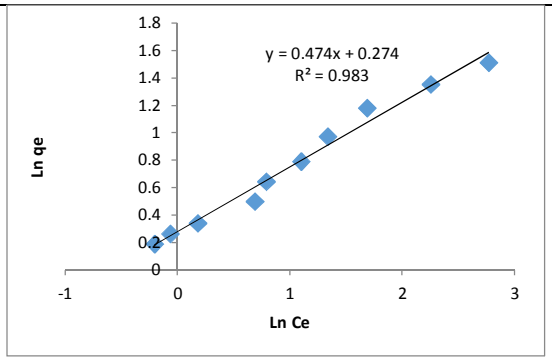

Fig.2 Freundlich mode

3.2 Continuous system

3.2.1Effect of bed height

The effect of varying bed height of adsorbate (1,1.5, 2 cm) were studied by fixing the initial concentration (25 mg/L), flow rate (0.5 L/hr), particle size (600 µm) and pH=7 , and with 28°C The experimental curves had been presented in Fig.3 as C_e/C_o versus time for each bed height .

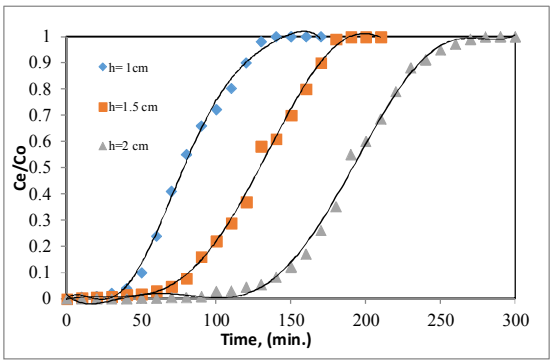

Fig.3: Effect of bed height

From fig.3 it can be noticed that when height of bed increases, the breakpoint increases. At smaller bed height the effluent adsorbate concentration ratio increases more rapidly than higher heights of bed. That mean, the bed with smaller height needs less time for saturation. The bed of smaller height has smaller capacity to adsorb adsorbate from the solution due to lesser amount of adsorbent. AS flow of solution remains constant, then increasing the height of bed will increases the contact time between adsorbate with bed that will enhance adsorption and increase efficiency of removal **[2].**

3.2.2 Effect of particle size

Effect of applying Various particle sizes (250µm, 600µm, 1mm) of tea char adsorbent on the breakthrough curves had been investigated by fixing other parameters which are flow rate (0.5L/min), initial concentration (25 mg/L), bed height is the optimum from previous set of experiments(2 cm) and pH(7) at 28°C.

These breakthrough curves are presented in Fig.4 below that showed the effect of these changing.

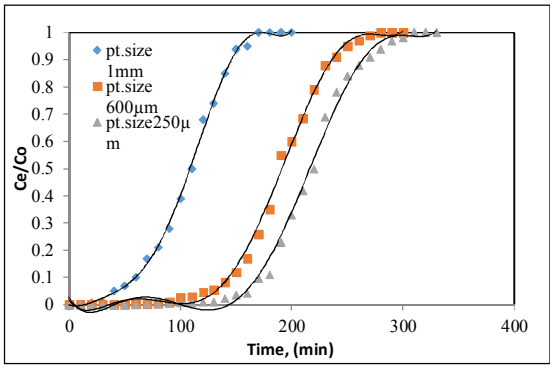

Fig.4: Effect of particle size.

The curves show that the time required to reaching to breakpoint increase when the size of particle decrease. This occur because of that surface area available for adsorption increase with decrease the particle size that means more sites for adsorption and adsorption capacity increase. Therefore when particle size decreases the time required for saturation increase and inside pores the total length of path increase. For these conditions the overall Kinetics of the process is low, because of needed time for solute molecules to attach the adsorption site is more[1].

3.2.3 Effect of the flow rate

The effect of using various flow rates(0.25, 0.5, 0.75 L/hr) of each tea char on the breakthrough curves were studied by keeping other parameters constant which are optimum particle size(250µm), initial concentration (25 mg/L), bed height is the optimum from previous set of experiments(2 cm) and pH(7) at 28°C. These breakthrough curves are presented in Fig.5 that showed the effect of this changing.

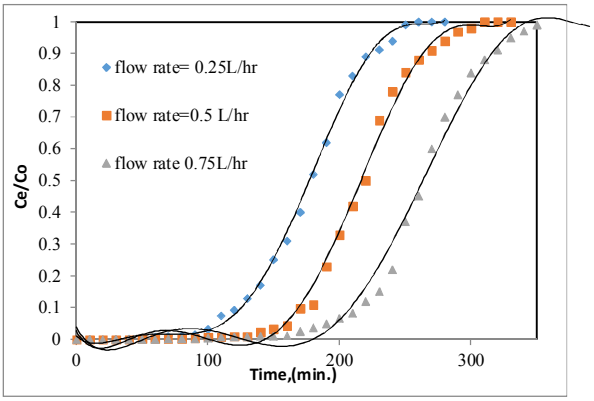

Fig.5: Effect of flow rate.

The figure shows that the breakthrough curves become steeper when inlet flow rate increasing, which is depending upon detention time for adsorbate in the bed, the breakpoint decreases, which is no long to reach for equilibrium. Therefore, for higher flow rate the solution leaves the bed before equilibrium because of reduction in the contact time**[1]**. The thickness of the film around surface of particle reduce due to higher flow rate. This film considers as resistance to mass transfer, so mass transfer increase at higher flow rate. In addition, increasing flow will causes additional mixing that will make penetration of

molecules of adsorbate easier through the solid particles **[5].**

However, capacity of the adsorbent increasing with decreasing flow rate because of good available contact time. That mean for low flow rate, there is sufficient time for adsorbate molecules to reach spaces within particle surface **[3].**

4.Conclusion

Tea wastes offering a good recyclable alternative to be as a cheap adsorbent for removal of zinc from aqueous solution. Producing a local adsorbent by charring process revealed a noticeable improvement in the extending and improving the surface area of produced adsorbent by 98% to the tea waste.

References

[1] Abed, I. N. (2016). " Removal of Copper Ions from Simulated Wastewater by Applying Electromagnatic-Adsorption Using Banana Peel Adsorbent. University of Baghdad, College of Engineering, M.Sc.,Thesis.

[2]Abdul-Hameed, H. M. (2009). "Competitive Adsorption of Heavy Metals onto Activated Carbon in Fixed Bed Column" . University of Baghdad, College of Engineering, ph.D. Thesis.

[3] Abdul-Kareem, R. (2014). "Sustainable Production of Local Adsorbent Material from Waste Tires for Removal of Lead from Aqueous Solution". Unversity pf Baghdad, College of Engineering, M.Sc. Thesis.

[4] Evanko and Dzombak, C. D. (1997). Remediation of metals-contaminated soils and groundwater. Technology evaluation report, TE-97-01. Gound-Water Remediation Technologies Analysis Center, Pittsburgh University, EPA.

[5] Hamadi, N. J. (2014). "Selection of Natural Adsorbent for Removal of Metal Ions from Simulated Wastewater". Unversity of Baghdad, College of Engineering, M.Sc. Thesis.

[6] HazDat. (2005). Agency for Toxic Substances and Disease Registry's Hazardous Substance Release/Health Effects Database.

[7] Jutharat K., J. C. (April , 2010). Adsorption of Zn (II) Metal Ion from an Aqueous Solution Using Tea Waste Char. The Eighth PSU Engineering Conference , (pp. 157- 161).

دراسة أنتاج مادة مازة محلية من مخلفات الشاي لغرض أزالة الزنك من المحلول المائي

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الخلاصة

في هذا البحث يتم دراسة أنتاج مواد رخيصة من مخلفات الشاي لأزالة آيونات الزنك من المحلول المائي ويتم دراستها بنظام التجارب المتقطع والمستمر لمعرفة تصرف المادة المازة. لوحظ أن عملية التفحيم التي خضعت لها مخلفات الشاي لتحويلها الى مادة مازة قد عززت المساحة السطحية لها وكذلك الخواص الفيزيائية الاخرى. في نظام التجارب المتقطع تم أستخدام أوزان مختلفة للمادة المازة ولايجاد علاقة التوازن ووجد أنها من النوع المفضل (favorable). بينما في النظام المستمر تم دراسة عوامل مختلفة وتأثيرها على عملية الأمتزاز ومن هذه العوامل (أرتفاع المادة المازة, حجم جزيئات المادة, تدفق السائل الملوث). وتم الحصول على أفضل الظروف لهكذا تجارب وهي كالتالي (الارتفاع =2سم, الحجم=250مايكروميتر, اما التدفق = 0.25لتر/ساعة. حيث وصلت كفاءة العملية الى(99%). حيث أن زيادة أرتفاع المادة يزيد قيمة ال breakpoint بينما تقليل الحجم والتدفق يقلل من الbreakpoint.

الكلمات الرئيسية: مخلفات الشاي, الزنك, الامتزاز