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Biosorptionof chromium ions by using black tealeaveswaste and the effect of some parameters on the removal of ions

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Abstract: Biosorption can be an effective technique for the treatment of heavy metals bearing waste water resulting from human and industrial activities. severalbioadsorbents have the ability to remove the heavy metals and thereby making water contaminant free. In the present study the biosorption of heavy metals using the black tea leaves waste and parameters affecting the biosorption of Cr ion; such as contact time, pH, temperature, dosage and particles size have been investigated. The present study showed that the contact time taken for maximum sorption of Cr ion was 120 min. The maximum percent removal of Cr ions on adsorbent was observed at pH 6 and significantly decreased by reducing the pH values and slightly decreased at higher pH values. The results indicated that the increasing of temperature from 35°C to 50°C induced that the adsorption capacity of Cr ions with highest adsorption capacity at 45°C and the concentration of 2 g was sufficient for maximum biosorption. It was obvious that the adsorption capacity of metal ion on tea wasteincreased by decreasing the particle size and the best particles size was 200 µm. The experiment results showed that maximum removal of Chromium ion by tea waste is 89.5 % at optimum condition.

Key words: Chromium ion,Biosorption,Tea waste.

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الامتصاص الحيوي لايونات الكروم باستخدام مخلفات أوراق الشاي الاسود وتاثير بعض العوامل على ازالة الايون

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الخلاصة:يعتبر الامتصاص الحيوي تقنية فعالة لمعالجة العناصر الثقيلة الناتجة من الفعاليات الصناعية والحيوية وهنالك بعض المواد الحيوية ذات القابلية على ازالة هذه العناصر الثقيلة من المياه الملوثة.

في هذه الدراسة تم استخدام مخلفات اوراق الشاي الاسود كمادة فعالة تستخدم للامتصاص الحيوي وتم دراسة بعض العوامل التي تؤثر على فعالية الامتصاص مثل زمن الاستبقاء,الرقم الهيدروجيني, درجة الحرارة ,كمية المستخدمة, حجم الجزيئات. اظهرت الدراسة ان افضل زمن استبقاء هو 120 ثانية للحصول على افضل امتصاص حيوي وان افضل رقم هيدروجيني هو . انخفاض واضح للامتصاصيةعند خفض الرقم الهيدروجيني بصورة اقل عند الرقم الهيدروجيني العالي وجدت النتائج ان رفع درجة الحرارة من 35 الى 50 سوف يؤدي الى زيادة قابلية الامتصاص الحيوي لأيونات الكروم, كانت الامتصاصية الحيوية 2غم في درجة حرارة 45 م°. من الواضح ان قابلية الامتصاصية للايون تزداد بنقصان حجم الجزيئات وكانت افضل امتصاصية في حجم 200 مايكروميتر.اظهرت نتائج التجربة اعلى نسبة امتصاصية والتي بلغت 89.9% في الظروف المثلى.

Introduction

Rapid industrialization has led to increase disposal of heavy metals into the environment. The tremendous increase in use of heavy metals over the past few decades has inevitably resulted in an increased flux of metallic substances in the aquatic environment. The metals are of special concern because of their persistency.
The metal ions i. e. Cd^{+2}, Zn^{+2}, Ni^{+2} and Pb^{+2} are important heavy metals in the soil water system since they are micronutrients in plants and animal. Mining activities, agricultural runoff, industrial and domestic effluents are mainly responsible for the increase of the metals released into the environment(1). All of the tea beverages, however, are obtained from the same basic tea leaves(*Camellia sinensis*) which, once the beverage has been brewed, become a waste thatmust be disposed of. Like other biomass residues, tea wastes represent an unusedresource and pose increasing disposal problems (2).For these reasons, strategies are being investigated to evaluate their possible use as anenergy source or in other value-added applications (3).The adsorption abilities of a number of lowcostadsorbents (e.g., cheap zeolites, clay, coal fly ash, sewage sludge, agriculture waste and biomass)have been determined for the removal of heavy metals from water. Therefore, there is a need to lookinto alternatives to investigate a low-cost adsorbent which is effective and economic, for potentialapproach is the use of tea waste, Tea is one of the most popular beverages and about 3.5 million tons oftea was consumed annually in the world (4).

The aim of this study is to investigate the use of dried black tea leaveswaste in the removal of heavy metals from aqueous solutions.

Materials and Methods

Bioadsorbent

10 g of tea leaves waste were purchasedfrom Iraqi local market. The collected leaves were washed with distilled water, then thewashed samples drenched in 3M NaOH solution for 24 hrs. After 24 hours the drenched samples were washed withdistilled water until the dye will remove. The washed samples were kept in hot air oven for overnight at 60 ºC.Thenthe sample crushed with ball mill. The crushed samples were separated into different mesh size 52, 72, 100, 150, 200,240 respectively using the sieve shaker.

Stock Solution Preparation

Different metal concentrations were prepared by dissolving potassium dichromate in double distilled water to getdifferent metal concentrations. The metal solutionwas prepared in sterilized glassware. Prior to experiment all the glass were treated with0.1 M HCL before and after the biosorptionexperiments to avoid binding of metals to it.

General Procedure for Optimization

Carryout batch adsorption for chromiumconcentration (50mg/l) with teawaste powder (0.5-3g) at pH (2-9)using series withIrlenmair flask (50ml),at temperature (30-60°C) and shaking different labeled flask(for 30-

120min).Finally the concentration of chromium ions were measured afteradsorption by flam atomic spectrophotometric (Shimadzu AA-6200) ,calculatedvalues of percentage removal .

Optimum Conditions

In order to obtain maximum removal of chromium ionsoptimum conditions have to be used. Such studies are described as follows: (5)

1-Effect of Contact Time: 50 mg/L of chromium solution (50mL) was added to (1g)of adsorbent into different labeled flask, at fixedpH6 for all measurement.All flasks were kept at constant temperature 25°C fordifferent times(30,60,90,120,150,180min). After each agitation time, the content of each flask wasthen filter, the equilibrium concentration of metal in each of the filtrate wasdetermined by using Flame AtomicAdsorption Spectrophotometer toobtain the time at which removal of chromium ions accrue.

2-Effect of pH: Different solutions were prepared containing fixed amounts of chromiumions (50mg/l). The volume (50mL),adsorbent (1g) and time(90mins)were fixed with variablepH values(2,3,4,5,6,7,8,9) using of waste solution of the metal which transferred intodifferent 50 ml Erlenmeyer flask, corked and labeled. 1.0g each of the adsorbent wasweighed into the different labeled flasks and in shaker for different pH (2-6)using0.1N (HCl orNaOH) to adjust the pH. The concentration was determined afteradsorption and thepH was obtained at which maximum adsorption occur.

3-Effect of Temperature: Same procedure maintained previously used (time,concentration of chromium, pH, and particle size), but with variable temperature (30,35,40,,45,50,55,60 ºC).The concentration of chromium ions was measured after adsorption in maximumtemperature.

4-Effect of Adsorbent weight: Series of solutions containing fixed (time,temperature, pH, and particle size), with variable amounts of natural were preparedwith modifiedadsorbent (0.5-3g). The concentration of chromium ions was measured after adsorption andin maximum adsorbent weight.

5-Effect of particle size:Different solutions containing fixed (time,temperature, pH, and weight of adsorbent) with variable of particle size of natural were obtained withmodified adsorbent(200-700µm). The concentration of chromium ions afteradsorption in maximum percentage removal was measured.The percent chromium removal efficiency wasexpressed as:

$$R\% = \frac{C_o - C_f}{C_o} \times 100$$

where, $C_o$and C_f are the initial and final concentrationsof chromium (mg L–1) in the aqueous solution(6).

Results and Discussion

The results for the effect of contact time on adsorption of Cr ions are shown in figure1.It was observed that sorption percentage increased with the increase of timeup to 120 min.

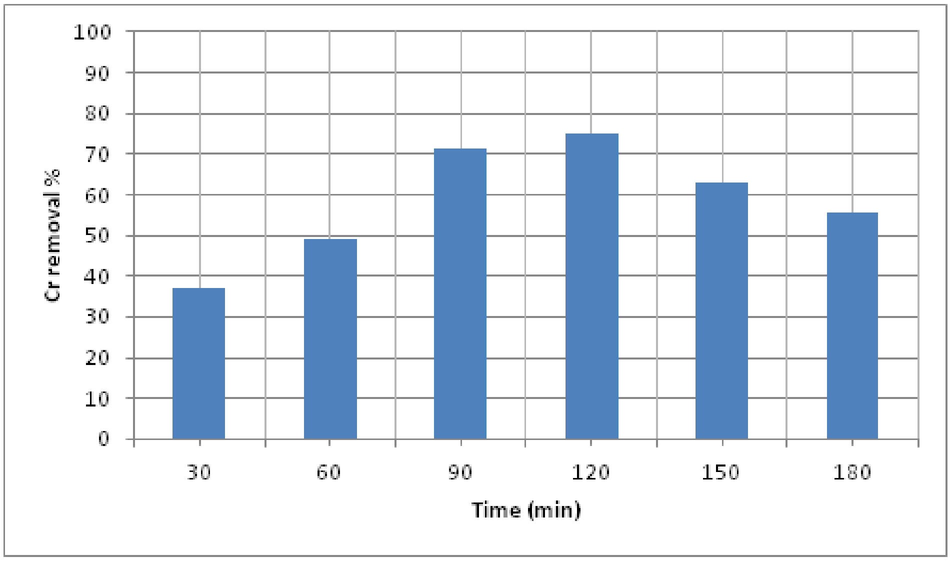

Figure 1: The effect of contact time on adsorption of Cr ions by tea leaves waste

The rapid initial rate increase followed by a slow rate at later period could be due to availability of excess adsorption sites on the adsorbent (7). The initial high adsorption rate might possibly be due to ion exchange followed by a slow chemical reaction of the metal ions with active groups on the sample (8).

In order to establish the effect of pH on adsorption of chromium ions a function of hydrogen ion concentration was determined and batch experiments were carried out at pH values2-9**.** Figure 2 showed that the maximum percent removal of Cr ions on adsorbent was observed at pH 6 and significantly decreased by reducing the pH values and slightly decreased at higher pH values.At higher H^+concentration the adsorbent surface becomes more positively charged hence reduces the attraction between metal ionsand adsorbent.Chromium adsorption was very low at pH<4 and at pH>7, metal removal wasdue to precipitation caused when OH^- ions formed complex with copper.The increase in metal removal as the pH increases can be explainedon the basis of a decrease in competition between proton and metal cations for the same functional groupsand by the decrease in positive surface charge, which results in a lower electrostatic repulsion between thesurface and the metal ions. Decrease in adsorption at higher pH (above pH6) is due to the formation ofsoluble hydroxy complexes (9).

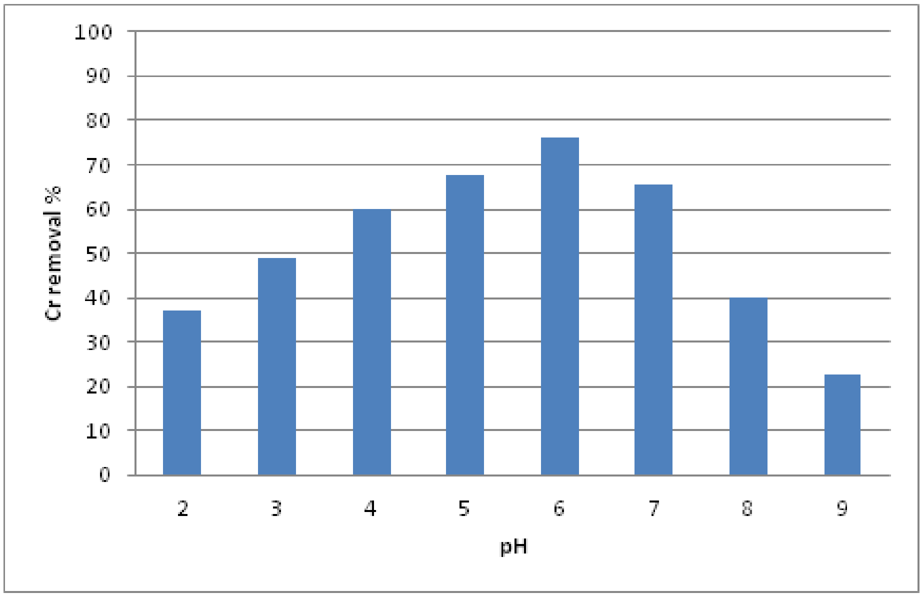

Figure 2:The effect of pH on adsorption of Cr ions by tea leaves waste

The effect of temperature on the Cr ions by tea leaves waste (figure 3), the results indicated that the increasing of temperature from 35°C to 50°C induced theadsorption capacity of Cr ions with highest adsorption capacity at 45°C. The effect of temperature on the adsorption of Ni(II) ions was presented by (10) for the adsorption of Ni onto tea factory waste indicated that increasing the temperature caused increasing the mobility of the metal cation.The increase of the adsorption yield and adsorption capacity at increased temperature indicated that the adsorption of nickel(II) ions by waste tea may involve not only physical but also chemical sorption. This effect may be due to the fact that at higher temperature an increase in active sites occurs due to bond rupture.The decrease in adsorption with increasing temperature above 50°C,suggest weak adsorption interaction between biomasssurface and the metal ion, which supports physisorption. According (11)the attractive forcesbetween biomass surface and metal ions are weakened andthe sorption decreases during temperature increasing.

Effect of the amount of adsorbent on metal adsorption was studied at fixed pH by various authors. The results of effect of adsorbent dose on the adsorption of chromiumby tea leaves waste are summarized in figure 4. The results showed that the concentration of 2 g was sufficient for maximum biosorption. The percentageremoval of heavy metal is seen to increase with adsorbent dose.

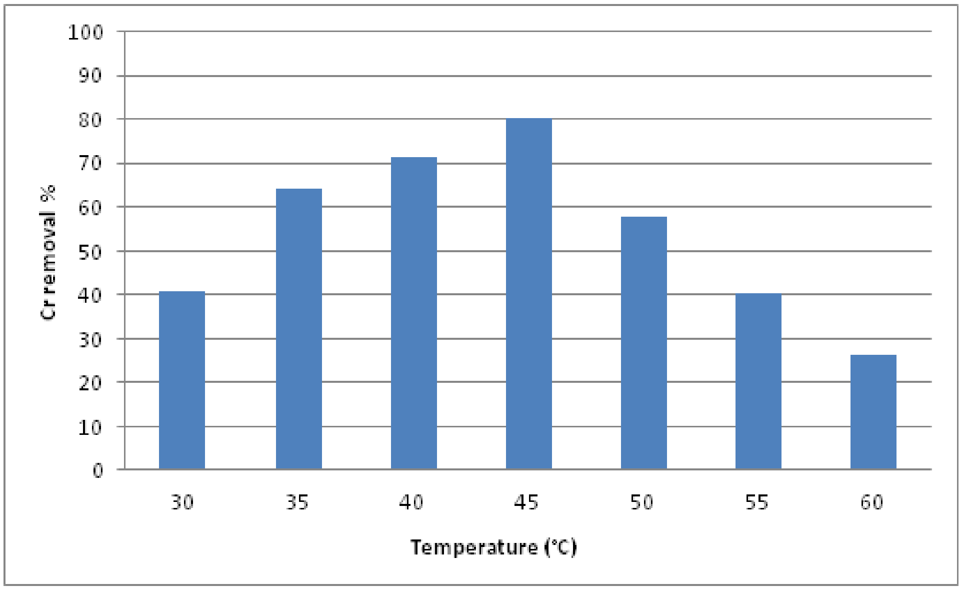

Figure 3: The effect of temperature on adsorption of Cr ions by tea leaves waste

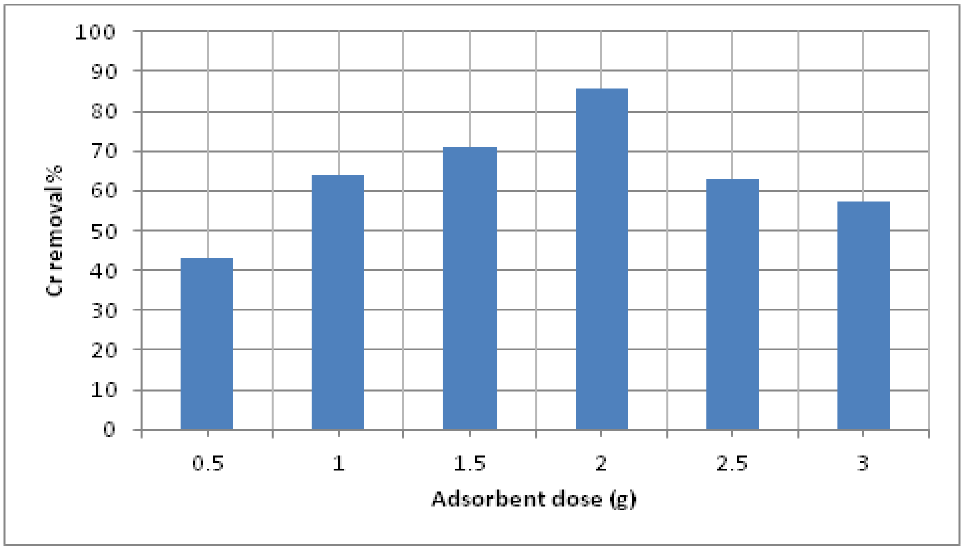

Figure 4: The effect of adsorbent dose on adsorption of Cr ions by tea leaves waste

The total amount of metal ions removed from the solutions increases by the amount of adsorbent. This is an expected result because as the adsorbent concentration increases, the number of adsorbent particles surrounding the metal ions or ratio of adsorbent particles to metal ions increases, therefore, these particles attach more ions to their surfaces. Increase in adsorption with adsorbent dose can be attributed to increased adsorbent surface area and availability of more adsorption sites. (12,13).

The average particle size was changed from 200 to 700 µm keeping the other variables set constant.The adsorptioncapacity of metal ion on tea wasteincreased by decreasing the particle size (figure 5).This results can beattributed to the relationship between the effective specific area of the adsorbent particles and their sizes. This can beexplained by the fact that for small particle a large external surface area results in a power driving force per unitsurface area for mass transfer (14). The increase in the uptake by smaller particles was due to the greateraccessibility topores and to the greater surface area for bulk adsorption per unit mass of theadsorbent.Similar trend had been observed on removal of Cr(VI) by using *Pitchellobiumdulce*Benth – A kinetic study (15).

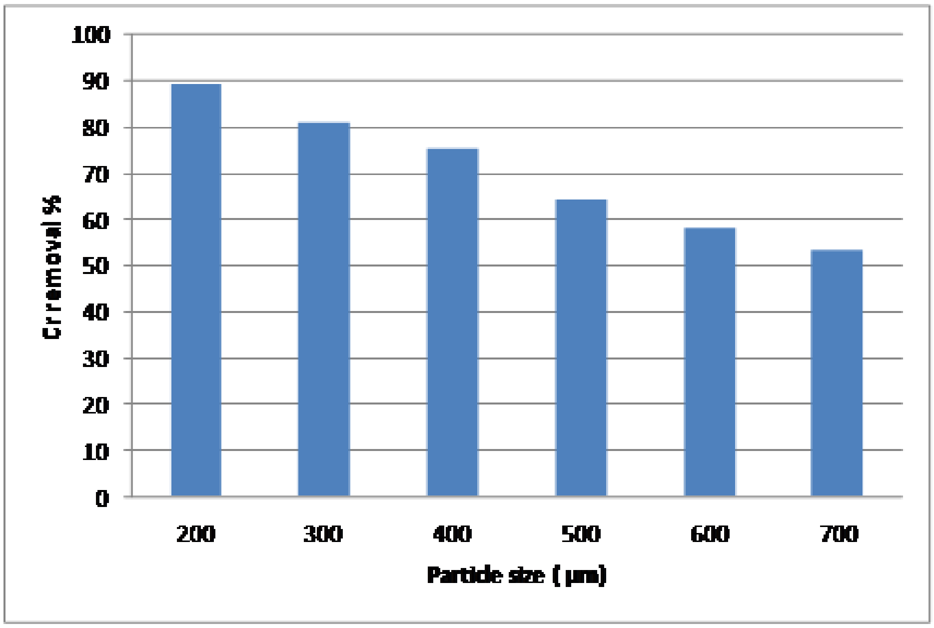

Figure 5: The effect of particle size on adsorption of Cr ions by tea leaves waste

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