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ORIGINAL ARTICLE

Removal Lead Ions from Aqueous Solutions by Production of Local Natural Materials from Waste Tea and Coffee as an Adsorbent Material (Comparative Study)

ZAHRAA KADHIM ABD AL-HUSSAIN[1], HAYDER M. ABDUL HAMEED[2]
[1]College of engineering, University of Baghdad, Babel, Iraq
[2]College of engineering, University of Baghdad, Baghdad, Iraq
Correspondence to: Zahraa Kadhim Abd AL-Hussain, Email: zahra.hussein2011m@coeng.uobaghdad.edu.iq, Cell: +964 7816110517

ABSTRACT
In this article, the production of low-cost adsorbents removal of lead from an aqueous solution from tea and coffee waste and a comparison study between them was investigated utilizing a continuous process to explore the kinetic behavior of the created adsorbent. After charring tea and coffee waste, there was a considerable improvement in surface area and other physical properties such as porosity, density, and bulk density.
In the continuous system, several parameters such as (bed height, particle size, and flow rate) were tested, and the optimal circumstances (for each experiment) were held constant for the subsequent sets of tests. The optimal circumstances were achieved as follows (bed height=8cm, particle size=250µm, and flow rate 0.5L/hr)and a random set of experiments showed a removal degree efficiency of lead reaching (99 %). As a result, raising bed height and pH will raise the breakpoint value. While reducing the flow rate, initial concentration, and particle size). Increasing the bed height increases the breakpoint value. Particle size will increase the breakpoint as the flow rate decreases.
Keywords: Adsorption, Heavy metals , Continuous system, , Lead ions

INTRODUCTION
Contamination of water and air by toxic metals is an environmental concern and hundreds of millions of people are being affected around the world. A new emphasis on agricultural and food sector wastes like coffee grounds, Banana peel, orange peel, rice hull[1], and other materials like sawdust and fly ash as alternatives to synthetic resins or activated carbon as adsorbents for metal-containing solutions in sewage systems[2].

The presence of heavy metals in the environment is a major concern due to their hazardous impact[3].

Heavy metals, such as arsenic, lead, cadmium, nickel, mercury, chromium, cobalt, zinc, and selenium, are very poisonous even at low concentrations and are

Heavy metal poisoning can impair mental functioning and produce central nervous system malfunction, reduced energy levels, as well as harm to the blood composition, lungs, kidneys, liver, and other essential organs. The presence of metals in water streams and seawater poses a considerable health risk to the aquatic ecosystem, the most prevalent of which is fish gill injury [4].

The removal of heavy metal ions from wastewater is an effective approach for reducing environmental pollution and water treatment, and several methods for removing heavy metal pollution have been developed [5].

Pb^{+2} is one of the heavy metals that may create several difficulties for humans and their surroundings. The usage of Pb+2 in service pipes may result in Pb+2 contamination. Other causes of Pb^{+2} contamination include the battery sector, motor exhaust, paints, munitions, and the ceramic glass industries [6].

Chemical precipitation, adsorption, electrolytic recovery, ion exchange, chelation, and solvent extraction or liquid membrane separation are traditional methods for extracting dissolved heavy metals from wastewater. Adsorption is one of the most frequent ways of removing heavy metal ions from aqueous solutions. Adsorption effectiveness is determined by the adsorbent's capacity to adsorb metal ions from solutions onto its surfaces[7]. Adsorption is one of the most efficient methods for the removal of metals due to its high efficiency, easy operation, and low cost[4].

Adsorption performance is mainly dependent on the type of adsorbent used.

METHODS
The purpose of this study was to examine the adsorption process of removing lead ions from simulated wastewater using an affordable and ecologically acceptable natural sorbent material production from tea and coffee waste. The effect of several parameters and circumstances on the adsorption process, such as sorbent bed height, particle size, and the flow rate was investigated.

Literature search strategy: The tea and coffee residues are collected and cleaned with water numerous times (15) to remove the color and dirt and prepare them for use as an adsorbent. The tea and coffee were dried for two days (48 hours).


Tea waste before charring


Coffee waste before charring

Table 1: properties of tea waste before and after activation process.

Item	Before activation	After activation
Surface area (m2/g)	0.735	72.857
Real density (g/cm3)	1.6251	0.8855
Bulk density (g/cm3)	0.7249	0.4331
Porosity (%)	55.3935	51.0897

Table 2: properties of coffee waste before and after activation process.

Item	Before activation	After activation
Surface area (m2/g)	0.81846	67.9071
Real density (g/cm3)	1.098239	1.098689
Bulk density (g/cm3)	0.5623118	0.5116324
Porosity (%)	48.79803	53.432300

The waste tea was ground and sieved to various sizes (250 m, 600 m, and 1 mm) using (sieves, S/N: 03007314, body 200 mm x 500, Germany); these different sizes are used to evaluate the effect of the adsorption process by varying the particle size of both tea and coffee residues. The pyrolysis waste tea and coffee grease was burned in the furnace to increase the surface area of the adsorbent and improve adsorption capacity and efficiency. Because the coffee was oily, the temperature for carbonization of tea and coffee was 200°C for one hour, 350°C for tea activation, and 250°C for coffee activation [8].


Tea waste after charring　　　　Coffee waste after charring

Adsorbate: For the continuous experiment, a solution of lead with the appropriate concentration (20mg/l) was generated by dissolving (800ml) of (Pb(NO3)2) in (40L) of distilled water. the following starting concentrations (5,10,15,20)mg/l were generated by dissolving (200,400,600,800)ml correspondingly each from ($Pb(NO_3)_2$) in (40L) of distilled water. By applying equation (1) [9]:

W=C*V*M_wt/A_wt　　　　...(1)

Where:

W　is the mass of metal(mg)

C　is the concentration required (mg/L)

V　volume of solution (L)

Awt　is the atomic weight of lead which is equal to (207.2g/mole)

Mwt is the molecular weight of lead nitrate which equal to (331.21g/mole).

N1 V1= N2V2　　Dilution Law　　...(2)

N1　normality of solution of lead nitrate equal to 1000ppm (standard).

N2　normality Prepare a dilute solution for the experiment in ppm.

V1　volume of a dilute solution of lead nitrate in ml.

V2　The volume of distilled water required for the experiment in ml.

Continuous System: A stainless steel transparent tube of length (35cm) was used and diameter and inner diameter (5cm). A mesh was used to prevent any losses of produced adsorbent of tea and coffee from the bed, The mesh above was placed to distribute the water and homogeneously spray the water adsorbent. The mesh at the bottom of the filling was placed to prevent the adsorbent from coming out so that the treatment would take place with the best possible efficiency and then the (lead nitrate) solution would pass.) Through it.

Wastewater was contained in a plastic container. A single rotameter was used to measure the flow rate (0.5-1.5 L/hr). The solution of lead nitrate was fed into the bed using a pump.

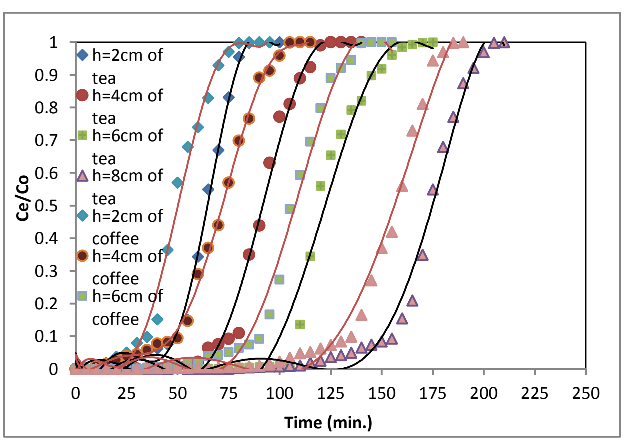

Figure 1: Breakthrough curves of lead ions adsorption onto char of tea and coffee wastes at different bed heights.

Effect of bed height: The effect of several heights of the adsorbent layer was studied where the heights were (2, 4, 6, and 8 cm) by fixing the initial concentration (20 mg/L), the constant flow rate at (0.5 L/h), pH = 7, and volume The particles, that is, after roasting, charring and using

A　sieve, have a size (600 micrometers) at 25°C temperature. The experimental curves in (Fig. 1) are presented as Ce/Co versus time for both tea and coffee.

Figure (1) demonstrates that at bed height (2 cm), the behavior of two adsorbents is identical owing to quick diffusion of the bulk solute (since this process is rapid), but as layer heights increase, another mechanism, inter particle diffusion, takes over. The method is a rate-setting process (control process) that differs for each adsorbent based on the texture and available surface area [3]. As may be observed, the coffee stopping point is reached first, followed by the waste tea good. It's also worth noting that the ideal bed height for both tea and coffee is 8cm.

Effect of particle size: The adsorbent's surface area is an essential adsorption property. Adsorbent sites are more reactive to metal ion interaction when the surface area of the adsorbent is large. The greater the surface area per unit weight, the smaller the particle size. Adsorbent, resulting in a greater proportion of metal removal expected.

The effect of using molecular sieves (250m, 600m, and 1mm) for each tea and coffee char adsorbent on the breakthrough curves was investigated while maintaining other parameters constant, such as flow rate (0.5L/min), initial concentration (20 mg/L), bed height (8cm), which was the best from the previous set of experiments, and pH (7) at 25°C temperature.

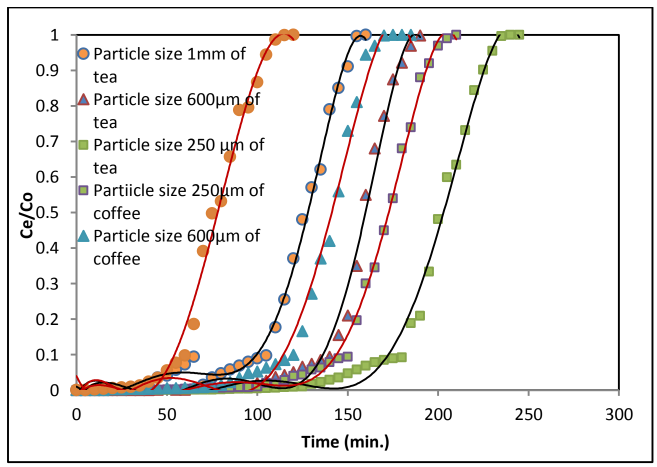

Figure 2: Breakthrough curves of lead ions adsorption onto char of tea and coffee waste at different particle sizes.

The above thought shows that the stopping point of the curve at 250 µm coffee waste is faster than that of tea waste, and we note that the treatment is better the smaller the sorbent material. The breakthrough curves illustrate that as particle size decreases, the time required to reach the breakpoint increases. This happens because the surface area accessible for adsorption increases as particle size decreases, resulting in more adsorption sites and increased adsorption capacity. As a result, as particle size drops, the time required for saturation increases, and the overall length of the journey inside pores increases. The overall Kinetics of the process is low under these conditions because the time for adsorbate molecules to reach the adsorption site is longer since the diffusion path via pores is longer[10].

Effect of the flow rate: The impact of utilizing different flow rates (0.5, 1, 1.5 L/hr) of each tea and coffee char adsorbent on the breakthrough curves was evaluated while maintaining other parameters constant, such as ideal particle size (250m), starting concentration (20 mg/L), bed height (8cm), and pH(7) at 25°C temperature. (Figure 3) depicts the consequence of this adjustment by displaying these breakthrough curves.

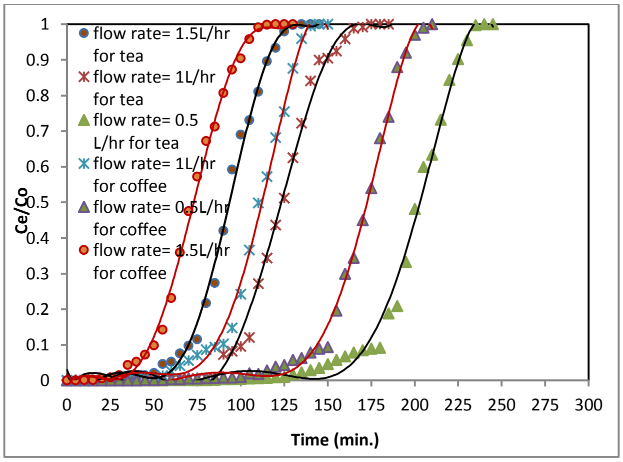

Figure 3: Breakthrough curves of lead ion adsorption onto char of coffee waste at different flow rates.

The figure shows that the breakthrough curves become steeper when the inlet flow rate increases. Because of the pollutant's residence period in the bed, the breakpoint lowers and no longer reaches equilibrium for a high flow rate. As a result, at high flow rates, the solution exits the bed before reaching equilibrium due to a decrease in contact time As the flow rate increases, the thickness of the film around the particle's surface decreases. Because this film takes resistance to mass transfer into account, mass transfer rises as the flow rate increases. Furthermore, when the flow increases, extra mixing occurs, allowing adsorbate molecules to pass more easily through the solid particles[4,11].

CONCLUSION

Tea and coffee wastes are effective adsorbents for removing Pb^{+2} from wastewater. When compared to tea, Pb^{+2} had a greater adsorption capability and rate with coffee. The adsorption rate was fast at first and then progressively decreased4 .In many places of the globe where tea and coffee waste are cheap or free, regeneration is unnecessary, and the metal-laden biomass can be burned[12].

Analysis: Concentrations of lead metals dissolved in an aqueous solution were tested by flame atomic absorption spectrometer model AA-7000 of Japanese origin from Shimadzu Corporation at the Market Research and Consumer Protection Center, University of Baghdad.

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