How to Cite:
AL-Hussain, Z. K. A., & Hameed, H. M. A. (2022). Study for the production of local adsorbent from tea and coffee wastes for removal of lead ions from an aqueous solution. *International Journal of Health Sciences*, *6*(S6), 6947–6955.
https://doi.org/10.53730/ijhs.v6nS6.11957

Study for the production of local adsorbent from tea and coffee wastes for removal of lead ions from an aqueous solution

Zahraa Kadhim Abd AL-Hussain
Engineering College –Baghdad University
*Corresponding author email: zahra.hussein2011m@coeng.uobaghdad.edu.iq

Hayder M. Abdul Hameed
Engineering College –Baghdad University
Email: hayderabdul_hameed@yahoo.com

***Abstract*---**In this article, the manufacture of low-cost adsorbents from tea and coffee waste for the removal of lead from an aqueous solution was batch experimental of the created adsorbent. After charring tea and coffee waste, there was a considerable improvement in surface area and other physical parameters such as density, bulk density, and porosity. In the batch studies, different dosages of both adsorbents were utilized, and the equilibrium isotherm was of the very favorable type for adsorbents, and two models (Freundlich and Langmuir) were used, and the data corresponded well with the Freundlich isotherm. a random set of experiments showed a removal degree efficiency of lead reaching (99 percent).

***Keyword*---**production, local adsorbent, wastes, lead ions, aqueous solution.

Introduction

Heavy metal exposure has increased dramatically as a result of industrial activity, which resulted in an increase in environmental contamination and pollution throughout the previous century.(Balali-Mood *et al.*, 2021). Pollution reduction must be done either by reducing the source of pollution or utilizing controlling these sources (Haneen, 2018). Heavy metals are described as metallic elements with a density greater than that of water. Heavy metals are toxic to humans, and their exposure has risen as a consequence of industrial and anthropogenic factors, as well as contemporary industrialization. Toxic metal contamination of water and air is a major environmental hazard that affects hundreds of millions of people throughout the world(Yedjou, Patlolla and Sutton, 2021). Heavy metals are

Manuscript submitted: 9 April 2022, Manuscript revised: 18 June 2022, Accepted for publication: 27 July 2022

represented by three types, toxic, such as lead, precious metals, such as gold, and dangerous ones, such as radium Heavy metals such as (Al, Cu, Zn, Fe, Cd, Pb, Mn, Ni, Na, and Hg)(Kiziloz, 2019).

Heavy metal pollution can be caused by biological, agricultural, or industrial processes, such as mineral processing in refineries, coal combustion in power plants, petroleum combustion, nuclear power plants and high-pressure lines, plastics, textiles, microelectronics, wood preservation, paper processing plants, battery manufacturing, and so on (Arruti, Fernández-Olmo and Irabien, 2010; Tchounwou *et al.*, 2012). Lead is a bluish-gray metal that occurs naturally in trace amounts in the earth's crust. Although lead naturally occurs in the environment, anthropogenic activities such as the combustion of fossil fuels, mining, and manufacturing contribute to the release of high amounts. Lead has several industrial, agricultural, and household applications. It is now utilized in the manufacture of lead-acid batteries, ammunition, metal goods (solder and pipes), and X-ray shielding devices. In 2004, the United States utilized an estimated 1.52 million metric tons of lead for different industrial purposes. Lead-acid battery manufacture accounted for 83 percent of that total, with the remainder used for a variety of items including ammunition (3.5 percent), oxides for paint, glass, pigments, and chemicals (2.6 percent), and sheet lead (1.7 percent) (Abdul-Hameed, 2009). Lead exposure is mostly caused by inhaling lead-contaminated dust. Ingestion of lead-contaminated food, water, and paints, as well as particles or aerosols (Corporation, 1990; Abadin *et al.*, 2007). Lead is the most systemic toxicant that affects several organs in the body including the kidneys, liver, central nervous system, hematopoietic system, endocrine system, and reproductive system (Corporation, 1990).

Experimental work

Materials

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 manufactured from tea and coffee waste. The effect of several parameters and circumstances on the adsorption process, such as sorbent weight, particle size, run-per-minute (RPM), pH, and starting concentration, was investigated.

Preparation of adsorbent

The tea and coffee residues are collected and cleaned with water numerous times (12-15) 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) and may alternatively be dried in the(Furnace 62700).

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 (m^2/g)	0.735	72.857
Real density (g/cm^3)	1.6251	0.8855
Bulk density (g/cm^3)	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 (m^2/gm)	0.81846	67.9071
Real density (g/cm^3)	1.098239	1.098689
Bulk density (g/cm^3)	0.5623118	0.5116324
Porosity (%)	48.79803	53.432300

The dried tea was ground and sieved to different sizes (of 250 m, 600 m, and 1 mm) using (sieves, S/N: 03007314, body 200 mm x 500, Germany); these varied sizes are utilized to evaluate the influence of the adsorption process by modifying the particle size of both tea and coffee residues. The resultant tea and coffee waste grease from the pyrolysis process continued to be burnt in the furnace to expand the surface area of the adsorbent and improve adsorption capacity and efficiency. Because the coffee was oily, the temperature utilized for burning was 200°C for one hour for carbonization of tea and coffee, 350°C for activation of tea, and 250°C for activation of coffee.(Abdul-Hameed and Abdul-Kareem, 2017)

Coffee waste after charring

Tea waste after charring

Adsorbate

A solution of lead with the required concentration (20mg/l) was prepared by dissolving (80ml) of ($Pb(NO_3)_2$) in (4L) of distilled water for the batch experiment. the following initial concentrations (5,10,15,20)mg/l were prepared by dissolving (20,40,60,80)ml respectively each from ($Pb(NO_3)_2$) in (4L) of distilled water. By using equation (1) (Ridha, 2017):

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

Where:
W: is the mass of metal(mg)
C: is the concentration required (mg/L)
V: volume of solution (L)
A_{wt}: is the atomic weight of lead which is equal to(207.2g/mole)
M_{wt}: is the molecular weight of lead nitrate which equal to (331.21g/mole).
………………(2) Dilution Law $N_1 V_1 = N_2 V_2$
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.
In the adsorption experiments, Use of the law of adsorption capacity with different initial concentrations of lead nitrate (2.5, 5.0, 7.5, 10)of adsorbent were mixed

with 4L of (5, 10,15, 20) ppm of Pb^{2+} at pH 7 for 1 h in the shaker and home temperature. The amount of adsorbed metal, qe, was determined using:

$$(Eq\ .3) \quad qe = \left(\frac{(Co-Ce)*Vo}{m}\right)$$

Where Co is the initial concentration of Pb^{2+} in mg L^{-1}, Vo is the initial volume in liters, Ce is the equilibrium concentration of Pb^{2+} in mg L^{-1} and m the mass of adsorbent in grams(Nunez-Hernandez, Colpas-Castillo and Fernandez-Maestre, 2017).

Contact Time

The 20 ppm metal solution was prepared from the initial 1,000 ppm solution; each of the 20 ppm solutions was separated into eight different beakers to study the contact time for one hour. The pH of the solutions in each of the beakers was adjusted to 7 for Lead. 3g of the tea and 4g of coffee (adsorbent) were added to each solution and they were agitated using an er at 200 rpm for tea and 150rpm for coffee and orbital shaker subsequently, the solutions were filtered after 1hr time interval for tea and coffee waste (adsorbent) and samples were subjected to analysis(Iyiola *et al.*, 2019) .

Batch Experiment

The adsorption experiment was performed using different masses of adsorbents (0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4 g) from tea and coffee. A lead solution containing the required concentration (20 mg/L) was prepared from
Lead ion and its experimental measurement.(Abd Ali, 2015) pH= 7, at home temperature. at 250ml of lead solution in flask and put in a shaker for 1 hr at 100rpm.

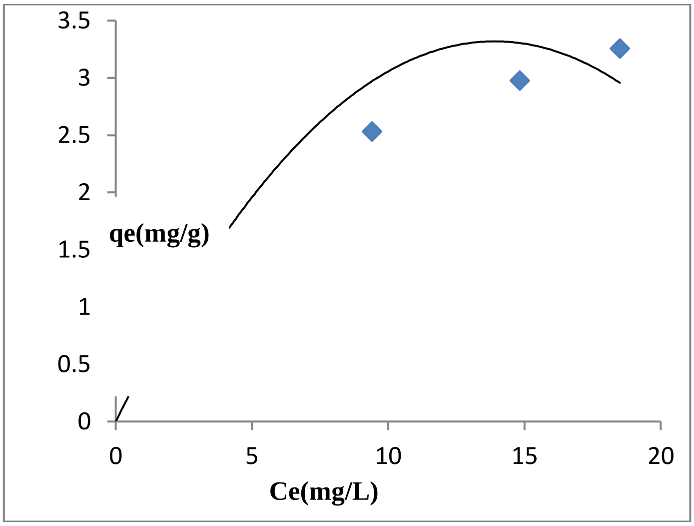

Figure 1. Adsorption isotherms for Pb onto tea waste at home temperature ◦C

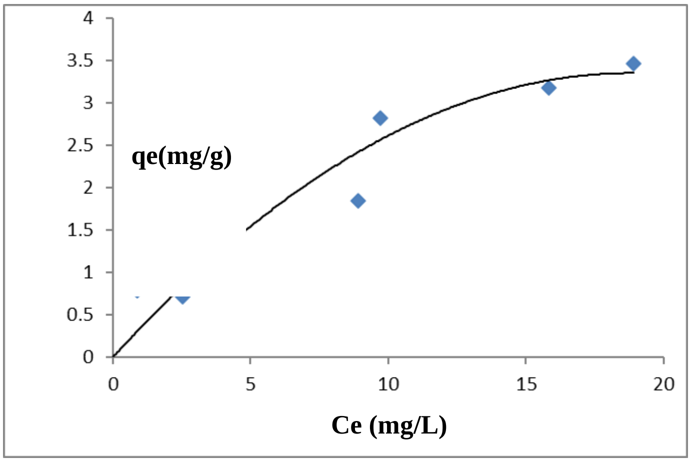

Figure 2. Adsorption isotherms for Pb onto coffee waste at home temperature ◦C

Samples (250 ml) of lead solution were taken and placed in conical flasks (250 ml) containing a fine mass of carbon produced from tea and coffee. pH (7) and room temperature were measured. The chips are then placed in a shaker (SM-25, Edmund Bühler, Germany) and stirred at (100 rpm) continuously for 1 hour. At this point, the focus is on equilibrium. Figure 3,4,5and 6 represents the fit of the data in the Langmuir and Freundlich model for tea and coffee waste. whose equations are described by formulas (4) and (5).

$$a = \frac{a_m Kc}{1+Kc} \quad \text{... (Eq.4)}$$

$$a = kc1/\ n \quad \text{... (Eq. 5)}$$

In the equations (4) and (5), *a* is adsorption, mmol/g; *am* is limiting adsorption in a monolayer, mmol/g; *K* is sorption equilibrium constant, *k*is empirical constant associated with sorption capacity of the sorbent, mg(1−1/*n*)l1/*n*/g, *n* is an empirical parameter associated with surface heterogeneity(Sharov *et al.*, 2019).

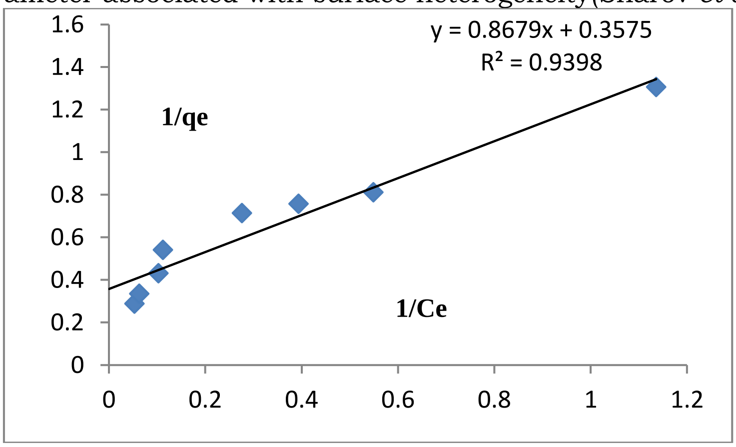

Figure 3. Langmuir model for tea

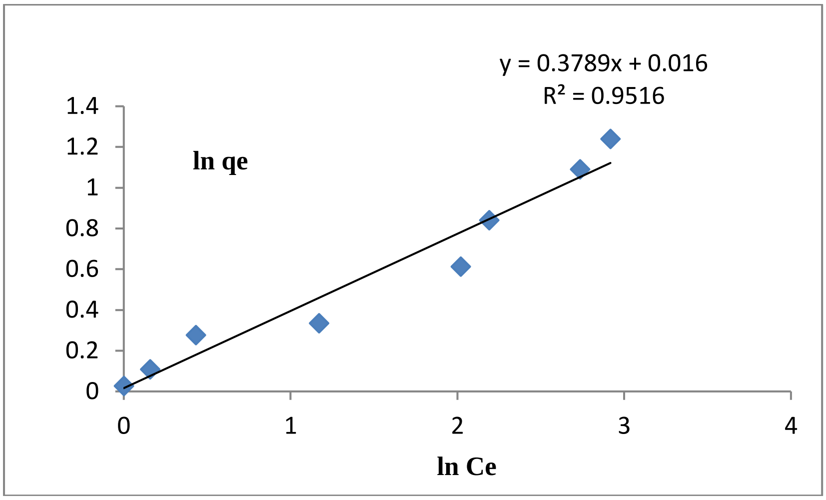

Figure 4. Frenudlich isotherm for tea

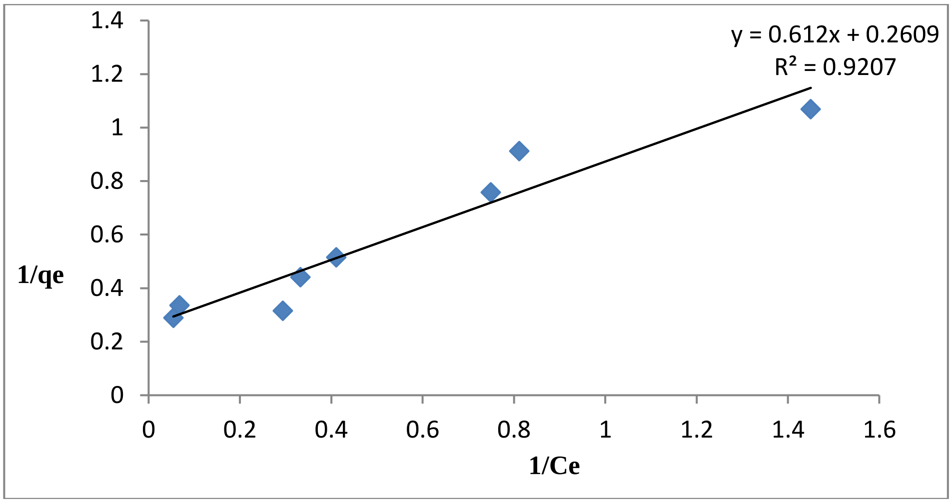

Figure 5. Langmuir model for coffee

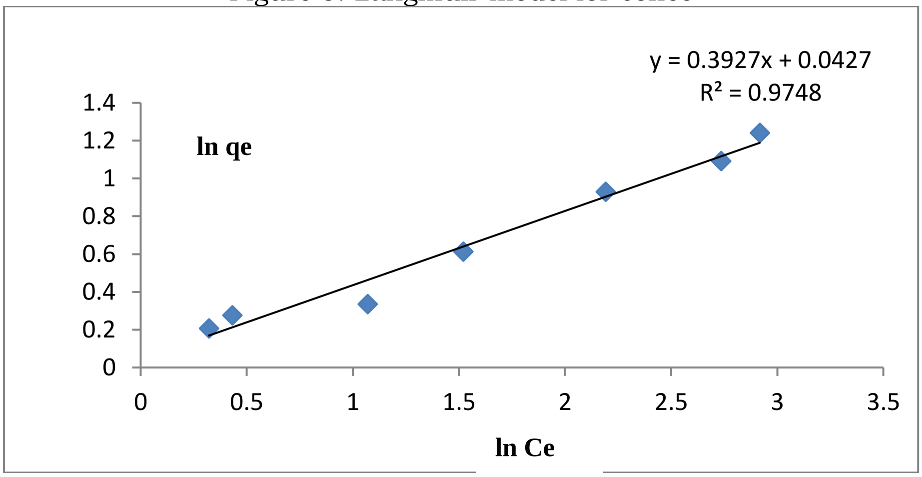

Figure 6. Freundlich isotherm for coffee

Conclusion

Tea and coffee wastes is a good adsorbent for the removal of Pb from wastewater. Pb showed higher adsorption capacity with coffee and rate compared to tea. The adsorption rate was rapid over an initial time and then decreases gradually[13]. In many parts of the world where tea and coffee wastes are available at low or no cost ,regeneration is not required and the metal-laden biomass can be disposed of by incineration[14].

Analysis

Concentrations of lead metals dissolved in an aqueous solution were tested by flame atomic absorption spectrophotometer AAS (novAA 400 P, Germany) at the Market Research and Consumer Protection Center, University of Baghdad.

References

Abadin, H. et al. (2007) 'Agency for toxic substances and disease registry (ATSDR) toxicological profiles', Toxicological Profile for Lead. Atlanta (GA): Agency for Toxic Substances and Disease Registry (US) [Preprint].

Abd Ali, Z.T. (2015) 'A comparative Isothermal and Kinetic Study of the Adsorption of Lead (II) from Solution by Activated Carbon and Bentonite', Journal of Engineering, 21(7), pp. 45–58.

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 [Preprint].

Abdul-Hameed, H.M. and Abdul-Kareem, R. (2017) 'Studying the Adsorption of lead from aqueous solution using local adsorbent material produced from waste tires by pyrolysis', Journal of engineering, 23(2), pp. 95–108.

Amarasinghe, B. and Williams, R.A. (2007) 'Tea waste as a low cost adsorbent for the removal of Cu and Pb from wastewater', Chemical engineering journal, 132(1–3), pp. 299–309.

Arruti, A., Fernández-Olmo, I. and Irabien, Á. (2010) 'Evaluation of the contribution of local sources to trace metals levels in urban PM2. 5 and PM10 in the Cantabria region (Northern Spain)', Journal of environmental monitoring, 12(7), pp. 1451–1458.

Balali-Mood, M. et al. (2021) 'Toxic mechanisms of five heavy metals: mercury, lead, chromium, cadmium, and arsenic', Frontiers in pharmacology, 12.

Corporation, A. for T.S. and D.R.S.R. (1990) Toxicological profile for lead. Agency for Toxic Substances and Disease Registry, Syracuse Research Corporation.

Exposto, L. A. S., & Januraga, P. P. (2021). Domestic waste characteristics and the management systematic review. International Journal of Health & Medical Sciences, 4(2), 253-259. https://doi.org/10.31295/ijhms.v4n2.1731

Haneen, M.R. (2018) 'Environmental impact of heavy metal pollution in natural aquatic systems'.

Iyiola, E.A. et al. (2019) 'Efficiency of sawdust from selected African indigenous wood spp. as a low-cost adsorbent for removal of copper ion from contaminated water', Int Res J Pure Appl Chem, 19, pp. 1–9.

Kiziloz, B. (2019) 'Investigation Of Some Hazardous Agents And Trace Elements In Drinking Water Of Kocaeli Region', Periodico Tche Quimica, 16(31), pp. 381–389.

Nunez-Hernandez, J.E., Colpas-Castillo, F. and Fernandez-Maestre, R. (2017) 'Xanthation of sawdust waste for adsorption of lead ions from aqueous solutions', Periodico Tche Quimica, 14(27), pp. 131–138.

Ridha, A.M. (2017) 'Removal of lead (II) from aqueous solution using chitosan impregnated granular activated carbon', Journal of Engineering, 23(3), pp. 46–60.

Sharov, A. V et al. (2019) 'Toxicological properties of heavy metals adsorbed on the surface of activated carbon', Periodico Tche Quimica, 16 (32), pp. 516–528.

Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2022). Post-pandemic health and its sustainability: Educational situation. International Journal of Health Sciences, 6(1), i-v. https://doi.org/10.53730/ijhs.v6n1.5949

Tchounwou, P.B. et al. (2012) 'Heavy metal toxicity and the environment', Molecular, clinical and environmental toxicology, pp. 133–164.

Tunali, S., Çabuk, A. and Akar, T. (2006) 'Removal of lead and copper ions from aqueous solutions by bacterial strain isolated from soil', Chemical Engineering Journal, 115(3), pp. 203–211.

Yedjou, C.G., Patlolla, A.K. and Sutton, D.J. (2021) 'Heavy Metals Toxicity and the Environment Paul B Tchounwou', Published in final edited form as: EXS, 101, pp. 133–164.