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# Adsorbent from Low-Cost Bio Waste for Treating Municipal Wastewater

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## Abstract

This study looks into the efficacy of using used tea leaves to remove heavy metal ions from wastewater. The effect of mineral ions on adsorbents is investigated by varying contact time, ricin dose, and starting mineral concentration. Researchers are also looking into the adsorption process's sensitivity to pH during the batch method. At a pH of 7 or below, depending on the concentration of heavy metals, metal ion removal is at its maximum; once equilibrium is attained, metal ion removal stops. The results suggest that used paper tea, along with other effective absorbent materials, could be used to treat wastewater containing heavy metal ions.. Additionally, the effects of resin, contact time, and principal mineral concentrations on the percentage of removal are being investigated. Tea has a high rate of absorption,the absorbency and cost effectiveness of using tea leaves to remove lead metal from wastewater have been achieved in this approach. The Freundlich and Langmuir methods of the batch experiment were used to calculate the amount of adsorbent material and the concentration of heavy metal in this investigation. The corresponding equations were uncovered, and their secrets revealed.

**Keywords:** Adsorbents, tea leaves, heavy metals and wastewater treatment.

## 1. Introduction

Global warming is being held responsible for water shortages in dry and semiarid regions of Iraq. This is why recycling wastewater serves an important function. As a result, wastewater reuse is regarded essential for solving these problems. Adsorption is a very advanced treatment method for dealing with synthetic wastewater. The European Union's goals for a circular economy have put an emphasis on the topic of resource recovery. Maximum resource recovery from wastewater and other wastes is the goal of the "waste to product" principle. Inexpensive and beneficial to the environment, ion-exchange and adsorption procedures [1]. Research into adsorption and ion-exchange techniques to recover valuable materials from wastewater shows promise. Because of its efficiency and ease of use, adsorption has become a popular removal method [2]. However, in many industrial applications, the process cost is equally important as the processing cost.

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Options for treating wastewater are examined in terms of their costs to society and the environment. Adsorption improves when a potentially costly precursor is used to create the adsorbent. Agricultural by-products and waste materials are a viable alternative to conventional active carbon [3] due to their low cost, ease of processing, and high metal absorption capability.

Waste collection that doesnot harm the environment is related to economics, ecology, and health. It has been shown in a number of studies [4, 5] that natural and agricultural products can be used as a viable alternative to traditional sorbents for the removal of toxic metals from water. This is the most common type of orange peel seen in trash cans. Orange peel is effective at removing metal ions from aqueous solutions, including cadmium, lead, and copper [6, 7]. Studies have shown that physical and/or chemical activation of orange peel improves adsorption, which is beneficial because of the peel's properties (such as porosity and surface area).There may also be a significant demand for chemical oxygen and biochemistry due to the presence of unprocessed plant waste. Biological oxygen demand (BOD) is the amount of oxygen needed by living organisms in a given volume of water. Marine life can be negatively impacted by low oxygen levels in the ocean [8, 9]. The activation part is eco-friendly and meets the same criteria as harmful chemicals li ke potassium hydroxide and sodium hydroxide [10].

The use of batch adsorption for the removal of Cr (III) from water was investigated by the researchers. OPAPC, or orange peel activated with potassium, was employed. Since potassium carbonate-tonic orange peel had a greater capacity to absorb than either fresh orange peel or orange peel activated with phosphoric acid, it was used as an adsorbent. By adjusting the adsorbent content (2–15 g/l), pH (5-7), temperature (298–318 K), and contact time (0.1–240) min, the optimal adsorption conditions were identified. OPAPC was used to confirm that Cr (III) was removed from water at concentrations between 5 and 50 mg/L. The system's balance data and kinetic data were evaluated with the use of the first and second pseudo-kinetic models [4].The thermodynamics of adsorption in light of the proposed method were also investigated. In order to increase the absorbency of orange peel, a byproduct of the food industry, potassium carbonate was added to it. Through the use of $Cr(NO_3)_3 \cdot 9H_2O$, there were able to produce a Cr (III) stock solution with a concentration of 1000 mg/L.

The adsorbent (OPAPC) was stored in a polyethylene container for further usage.Because it affects the solubility of metal ions, pH is a major determinant of adsorption. Both the intensity of the adsorption and the degree to which the surface can compete for hydrogen ions and mineral ions at their accessible centers are affected by the acidity of the surrounding environment. The effect of solution pH on Cr (III) adsorption onto potassium-activated orange peel was investigated [12],[13] with solutions spanning the range from 5.0 to 8.0. There was 30 mg of Cr (III) per liter in each 20-milliliter solution. Heavier-than-average mineral components are exceedingly uncommon. Atoms with an exceptionally high density and low mass. It moved along really quickly. Numerous manufacturing processes, such as those used to create fertilizers, metals, pulp, plastics, rubber, and batteries, all contribute to the emission of heavy metal pollution. Access to water from nearby lakes and rivers. Heavy metals are carcinogenic and have other negative health effects, even at low exposure levels. It will not break down in the environment. 1 It is extremely dangerous to

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aquatic ecosystems and human health. A buildup of toxic minerals in the body can cause seriou issues like nervous system damage, organ damage, and even death [14].

Adsorbents such as natural materials (fruit peel, eggshell, clay, algae, Serbian clay, etc.), agricultural waste (sugar cane bag, onion skin, bicolor, wheat bran, rice straw), and industrial waste (lignin, saw dust, tea waste, flash, sludge, etc.) were used to extract vital substances (algae, fungi, and bacteria) from these waste streams. Chemical precipitation, chemical oxidation, reverse osmosis, ion exchange, and electrolysis are only a few of the tried-and-true methods for detoxifying water of heavy metals.

All of these procedures produce harmful and expensive waste products. Because of its lower operating costs, adsorption seems to be the ideal solution for heavy metal removal. Even at modest doses, the therapeutic method is effective [15]. It's a poisonous metal that's frequently discovered in sewage. Adsorption is the process by which a gas or liquid is deposited onto a solid or liquid surface (the adsorbent) from the surrounding environment. Heavy metals in liquid industrial waste can be effectively removed using a combination of physical and chemical reactions. Even now, behind water, tea remains the second most commonly consumed beverage worldwide. Heavy metals such as Fe, Cr, Pb, and Ni can be effectively removed from water using absorbent material, which is why tea trash has garnered so much interest in this regard. Tea leaves function as the cell membrane. Cellulose, lignin, and hydroxyl carbohydrates abundant in phenolic groups are all excellent biological sorbents. Untreated sawdust has a higher absorption capacity than Noah-treated fir and poplar. Sawdust from fir and poplar trees absorbs the most $Cu^{+2}$, $Zn^{+2}$, and metal in Noah's lab [16].

## 1.1. Batch systems

There is not much done to treat the effluent. To treat tiny amounts of highly concentrated wastewater streams, batch systems employ cutting-edge flushing technology and water management [17]. The purified water is taken out of the batch after it has been filtered, precipitated, and settled.Regulatory standards and cutting-edge technology dictate that wastewater be purified and filtered before it may enter the sewer system. Waste water with low pollutant concentrations (less than 3 $m^3/h$) is best treated using a batch system. The subsequent surgical options are currently accessible: Complex treatments, neutralisation, and sludge separation are performed with water regeneration and concentration, cyanide, nitrite, and chromium decontamination, and more [18].

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### 1.2. The Aim of the Project

The purpose of this study is to investigate the feasibility of utilising discarded tea as a heavy metal ion removal agent in wastewater treatment. Mineral ion adsorption is studied to learn how contact time, pH, and the principal mineral dose affect the adsorption process. The batch method will also be used to determine if the adsorption process is sensitive to changes in pH. Heavy metal concentration and adsorbent material amount were determined by doing both Freundlich and Langmuir batch experiments. The related equations were found, and each one concealed its own set of solutions.

## 2. Adsorbent materials

Activated alumina, silica gel, activated carbon, zeolites, molecular sieve carbon, and polymeric adsorbents are some of the most common adsorbents. Some adsorbents, like activated carbon, are synthetic while others, like zeolites, are found in nature. Different materials have different adsorbing surface types, porosities, and pore structures. Adsorbents can have quite different pore diameters. Microspore "diameters" range from 50 nm or more down to 2 nm, whereas macrospore "diameters" (also known as transitional pores) range from 2 nm up to 50 nm. Within amorphous adsorbent materials like carbons, silica gels, and alumina, microspores, macrospores, and macrospores all interconnect in complex networks. Zeolite adsorbents, on the other hand, have uniformly sized pores [19].Table (1) represents the typical applications of commercial adsorbents. Table (2) displays the previous studies for types of adsorbent materials in removal of heavy metals.

**Table (1) Typical applications of commercial adsorbens.**

| Adsorbent | Applications |
|---|---|
| Carbons | It is used in the elimination of hydrogen, nitrogen, vinl chloride, desulfurization, and denitrogenation of NOx from gasses, in water treatment, and in the treatment of nuclear waste. |
| Alumina | “It is utilized in drying of gases and adsorption of fluoride, chromium, arsenic, and selenium in water treatment. |
| Zeolites | It helps in drying of gases, water treatment, sweetening and liquids, aids in pollution control of Sox and NOx through desulfurization and dentrogenation, recovery of carbon dioxide in the separation of aromatics from paraffina ets. |
| Silica | It is utilized as a desiccant of gases, maintance of relative humidity, and in desulfurization. |

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**Table (2) The types of adsorbent materials in removal heavy metal.**

| Extractable metals | Applied agricultural waste as a bio- adsorbs | The environment from which toxic metals are extracted | Adsorbent concentration | Concentration of heavy metal used | References |
|---|---|---|---|---|---|
| Cr(III) | orange peel | Waste Water | g\l) 15-2 ( | mg/l)50-5 ( | [20] |
| Cr (VI)( | Orange peel | Waste Water | g 1 | 10 mg\l | [21] |
| Pb | spent tea leaves | aqueous solutions | 0.2 g. | 0.01-2 gm.\l | [22] |
| $Cu^{2+}$, $Co^{2+}$, $Ni^{2+}$, $Zn^{2+}$ and $Pb^{2+}$ | Banana and orange peels | wastes water | 0.1 g | 5-25mg/l | [8] |
| Cd (II), Co (II), Zn(II) | Orange tree leaves | wastewater | 0.1 g (OTL) and 0.07 g | 100mg/l | [19] |
| Cr(IV) | dolochar | Aqueous solution | 20mg/l | (10-50mg/l) | [5] |
| Cu and Ba | Nanoparticles of Origanum (OR) and Lavandula (LV) | Aqueous Solutions | 0.5g | 10 mg/l | [4] |
| methylene blue (MB) and $Pb^{2+}$ | acid-activated Posidonia oceanica waste | | 0.5-3.0g/l | mg/l 20 | [23] |
| Lead ion | Charcoal Originated from Chemical Carbonization of Rubber Wood Sawdust | Aqueous Solution | 10 mg | 30mg/l | [24] |
| Lead ion | Spent paper tea | Aqueous solution | 0.5 mg | 50mg/L | This work |

## 3. Experimental Work and Procedure

In the experiments, sorption was employed to get rid of the metal ions, and the adsorbent was old tea bags. A batch mode experiment was carried out to identify the used tea papers with the highest capacity for chelating metal ions.

### 3.1 Chemicals

The following materials are used: Spent tea papers, Lead (II) sulfate ($PbSO_4$) (Sicma company), Hydrochloric acid (THOMAS company) [1M], Sodium hydroxide pellets (THOMAs company), [1M] and Distilled water .

### 3.2 Equipments

The equipments were used in the experiment part are as the following: An “atomic absorption spectrometer” (AAS; Norwalk, Connecticut, United States). Second, high-speed orbital shaker (Thermolyne, Maxi-Mix III, Type: 65800, USA) operates at speeds between 100 and 2200 revolutions per minute. Inaddition, pH bench metre (Type: HI 250, Bench model, USA). A 210-gram capacity digital indication electrical balance (type: sartorius).

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Also, filter paper was utilized and instruments made of glass (such as pipettes, beakers, and a volumetric flask).

### 3.3. Experimental procedure

#### 3.3.1. Prepation of aqueous solution

Heavy metal-contaminated synthetic waste water was used in this experiment. The procedure resulted in the creation of synthetic waste water that contained heavy metals. In the first round of testing, heavy metals were concentrated to a level of 50 mg/L by dissolving metal salts in distilled water to achieve a concentration of 50 mg/L.

To determine the mass of heavy metal salts that needed to be added to distilled water [19].

W=V* Ci*M.wt/At.wt …………… (1)

Where:

W:weight of heavy metal (mg/L)

V:volume of solution (L)

Ci: intial concentration of metal ions in solution (mg)

M. wt: molecular weight (mole).

At.wt: atomic weight of metal ion (g/mole)

The metal ion aqueous solution utilised in this study was prepared in a controlled laboratory environment. A stock solution of Pb (II) ions at a concentration of 1000 mg/L was prepared by dissolving 1.60 g ($PbSO_4$) in 1 L of deionized water. The stock solution was used to create many diluted solutions. To adjust the liquids' pH levels from 3 to 8, we employed 0.1 N HCl and 0.1 N NaOH.

#### 3.3.2. Adsorbent

Trash samples were gathered from the streets using tea towels. Before serving, one tea bag was steeped in filtered water at 90 $^{o}$C for three minutes. After this, it is gathered all the used tea sheets and washed them in distilled water many times to get rid of any leftover soluble or coloured components. The solid was dried in an oven set at 60 degrees Celsius for 24 hours after being rinsed with distilled water. The material was dried at room temperature after being crushed and sieved to generate particles fewer than 500 microns in size[25,26].

### 3.3.4 Batch experiments

The ideal pH, duration, agitation speed, and resin dosage were determined using batch system. The experiment using 250 mL flasks throughout. At first, 50 parts per million (ppm) of a heavy metal ions solution was poured into each flask. The adsorbent dose in each flask was about 0.5 g.

Let the resins and solution settle in the shaker for an hour after dropping them into the flask and mixing at 300 rpm for 30 min. The adsorbent and the solution were separated using filter paper. Across a pH range of 3-8, with resin amounts of 0.5-2 g, and initial heavy metal ion concentrations of 50 ppm, the effect of pH on heavy metal ion removal was investigated [27]. In order to determine how many metal ions could be removed by filtering, AAS was used. The resin concentration was determined using a mass balance.

## 3.5 Absorption capacity

When the equilibrium in the flask was reached, 10 ml samples were taken. Heavy metal ion concentration was determined using ASS after these samples were filtered.

Removal efficiency (%) (eq.2) was calculated using an equation.

$$\% \text{ removal efficiency} = \frac{C_i - C_f}{C_i} \times 100 \text{ ........(2)}$$

Where:
$C_i$ : initial concentration of the metal (mg/L)
$C_f$ : final concentration of the metal (mg/L)

## 3.6 The Kinetic adsorption

In order to illustrate how the adsorption model is interpreted, it is emploied the Langmuir and Freundlich isotherms. The accuracy of adsorption modelling and interpretation relies heavily on the use of adsorption isotherms.

Linear regression analysis is commonly used to analyse fit quality and adsorption performance over a spectrum of adsorption data while nonlinear regression analysis is utilised to bridge the gap between expected and experimental data. Because of this, it is important to investigate the applicability of linear and nonlinear regression analysis in various adsorption systems.

Here, it is evaluated the two models' ability to match the data and explain the adsorption isotherms [23]. The following equations are Langmuir and Freundlich isotherms:

Langmuir isotherm

$$qe = (Q^0 * K * Ce) \text{ ............ } (3)$$

Where:
*Ce* : dye concentration.
*qe* : amount of adsorbate.
*qm* : highest monolayer capability.



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*K*L : constant.

$$1/qe = (1/Q^0) + (1/K*Q^0) * (1/Ce)$$

Freundlich Isotherms:

$$q_e = K_f * C_e^{\frac{1}{n}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where:

*q*e : amount of adsorbate adsorbed per unit mass of solid.

*C*e: equilibrium solution concentration of the adsorbate.

*K*f : Freundlich adsorption constant.

*n* : empirical constant.

*f* and 1/*n* found by linear regression.

Where *KF* and *n* are Freundlich parameters indicating the adsorption capacity (mg/g)(L/mg)1/n and intensity of the adsorption.

$$\log q_e = \log K_f + \frac{1}{n}\log C \ldots\ldots(5)$$

qe : amount of heavy metal ions adsorbed on adsorbent at equilibrium (mg/g) .

$C_0$ : initial concentration of heavy metal ions in solution (mg/L).

Ce :concentration of heavy metal ions in solution at equilibrium (mg/L).

m :mass of adsorbent used (g).

V : volume of heavy metal ions solution (L).

X/M = kC1/n……………(6)

Where:

X/M : loading, is the amount of impurity adsorbed (X) per unit weight of carbon (M).

C : equilibrium concentration after adsorption.

K, n : constants.

## 4.Results and discussion

### 4.1.1 The effect of pH

By measured the effect of pH on pb(II) removal efficiency using a paper tea dose of 0.5mg/L, pb(II) concentration of 50mg/L, contact length of 1hr, and agitation at 180rpm.

The highest clearance efficiency, as shown in Figure (1), was over 88%. Up until an appropriate pH was reached, paper tea was able to more effectively absorb Pb(II) ions. At a pH of 5, hydroxides containing Pb(II) ions begin to precipitate out of solution, preventing true sorption [28,29]. Therefore, pb(II) a desorption is optimal at a pH 5.

PH has been reported as one of the major parameters controlling the adsorption capacity of metals onto adsorption because it affects the solubility of the metal _ions, the degree of ionization of the adsorbent during reaction and the concentration of the functional groups of the adsorbent. The effect of the pH level of (1, 3, 4, 5, 6, 7 and 8) was examined. The pH effects both surface charge of adsorbent and the degree of solution heavy metals, The

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influence of pH level on pb(II) removal efficiency using paper tea dose of 0.5mg/L, pb(II) concentration of 50mg/L, with contact time of 1hr .

The maximum removal efficiency was about (88%) as shown in figure (1) The adsorption capacity of Pub(II) ions on to paper tea was increased as the pH increased till the optimum pH was used, after that the pH decreased. At pH value is 5 Pb (II) ions hydroxides starts precipitate from the solutions making true sorption impossible[30]. Thus, the pH value of 5 was as the optimum value for pb(II) adesorption.

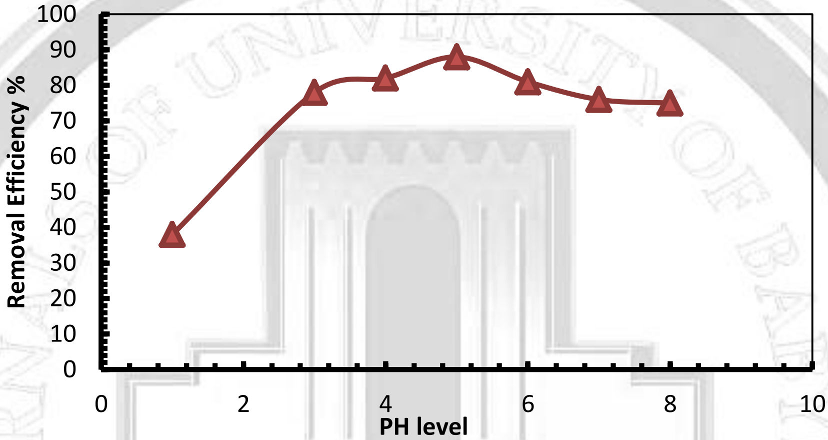


**Figure (1) The effect of pH on pb(II) removal efficiency.**

### 4.1.2 The effect of resin dose

Figure (2) shows that a rise in adsorbent dosage from 0.5 to 3.5 g resulted in a rise in pb(II) removal effectiveness from 85% to 97%. That more paper tea was better than no paper tea at all suggests that hypothesis.

Based on the analysis, it was shown that the greater quantity of resin, the greater number of sorption sites. The removal efficiency increased and the sorption density decreased as the adsorbent dose is increased. Some ion exchange occurred during sorption process, but as orient increased, the number of sites climbs resulting in an increase in removal efficiency.

It is readily understood that the number of available sorption sites increases by increasing the resin amount. It can be concluded that by increasing the adsorbent dose, the removal efficiency increase but sorption density decreases. The decrease in sorption density can be attributed to the fact that some of ion exchange remains unsaturated during the sorption process; whereas the numbers of sites increase by an increase in Orient and this result in increase in removal efficiency [31].

The removal efficiency of pb(II) were Increased from 85% to 97% as increasing the adsorbent dose as shown in the figure(2) This means that a slight improvement was achieved with increasing dose of paper tea. Thus, the optimum dose of sorbent of 1 gm. was selected as the optimum dose.

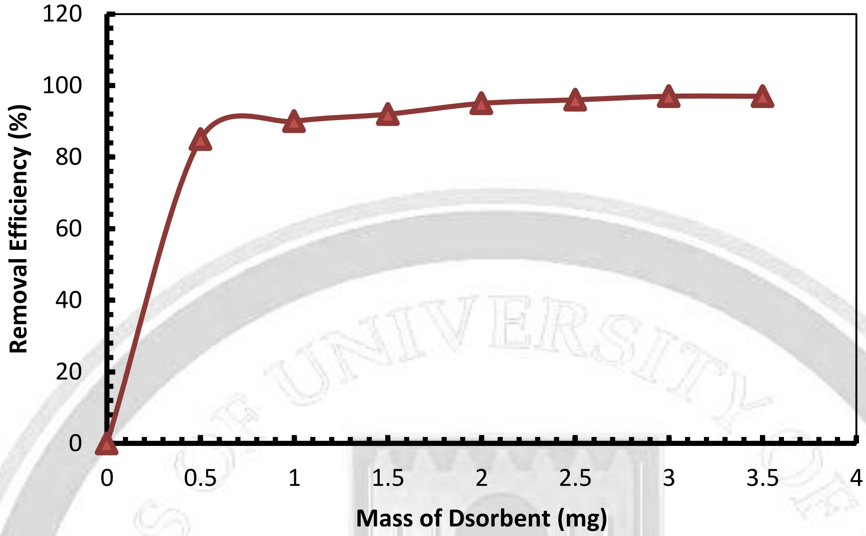


**Figure (2) The effect of resin dose on pb(II) removal efficiency.**

### 4.1.3 The effect of contact time

The influence of contact time on pb(II) removal efficiency using paper tea (pb(II) concentration=50mg/L, contact time=1hr, and paper tea dose=0.5mg) was investigated. Figure (3) displays that as contact duration was increased, paper tea's equilibrium adsorption capacity for pb(II) rised.

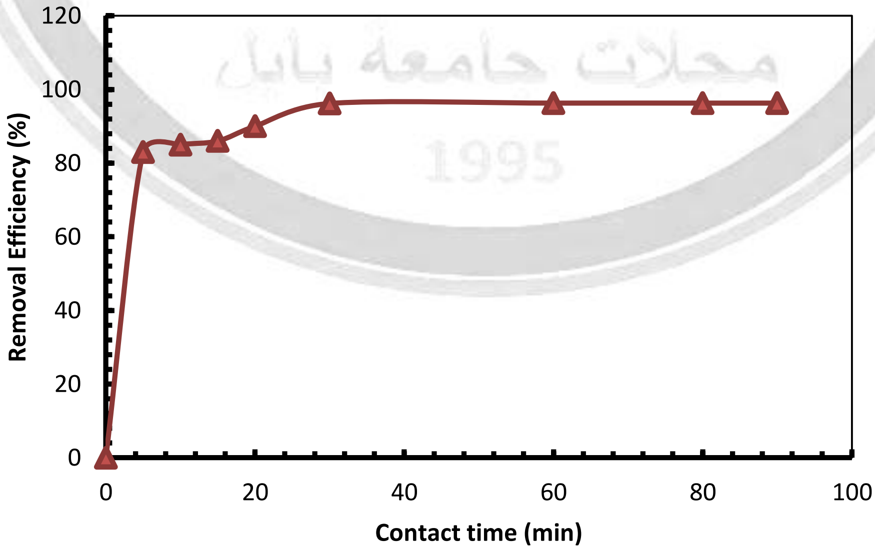


**Figure (3) The effect of contact time on pb(II) removal efficiency.**

The removal efficiency of 96.3% for pb(II) was the same for contact times of 30, 60, 80, and 90 minutes. This indicates that contact periods beyond 30 minutes may somewhat enhance removal efficiency.

Lead (pb) was removed from solution using an adsorbent made from discarded tea leaves. It was determined that pretreatment of the leaves, adsorption contact time, and adsorbent



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dosage all have a role in the effectiveness of used tea leaves as an adsorbent for lead removal. Lead adsorption on the used tea leaf was found to follow pseudo-second kinetics upon closer inspection.

An adsorbent was prepared using spent tea leaf and was used to remove lead (pb(II)) from solution. The pb(II) removal by the spent tea leaf adsorbent depended on pretreatment of spent tea leaf, adsorption contact time and adsorbent dosage.

**4.1.4 The effect of initial metal concentrations**

The influence of initial pb(II) concentration of on adsorption process using paper tea (contact time=1hr, paper tea dose=0.5 mg, pH=5) was investigated.
Effects of low initial metal doses was studied in the figure (4). The metal ion concentrations ranged from 50 to 250 mg/L. With a focus on how initial lead concentration affected adsorption processes, the following certieria of paper tea was utilized (contact time =1hr., paper tea dose =0.5 gm, and pH= 5).

There was a negative correlation between the initial metal ion concentration and the amount of pb(II) absorbed by paper tea. This indicated that the adsorption is highly sensitive to the initial concentration of metal ions. The concentration dependence of the fraction of adsorption sites disappeared at low concentrations, where there were few metal ions in relation to the available surface area [32]. The figure shows the relation between concentration of pb(II) in mg/L with the removal effieency (%).

It can be noticed that the adsorption capacity of pb(II) ions onto paper tea increased with decrease in initial concentration of metal ions. It means that the adsorption is highly dependent on initial concentration of metal ions. This is because at lower concentration, the ratio of initial number of metal ions to the available surface area is low; subsequently the fractional adsorption sites become independent of initial concentration.

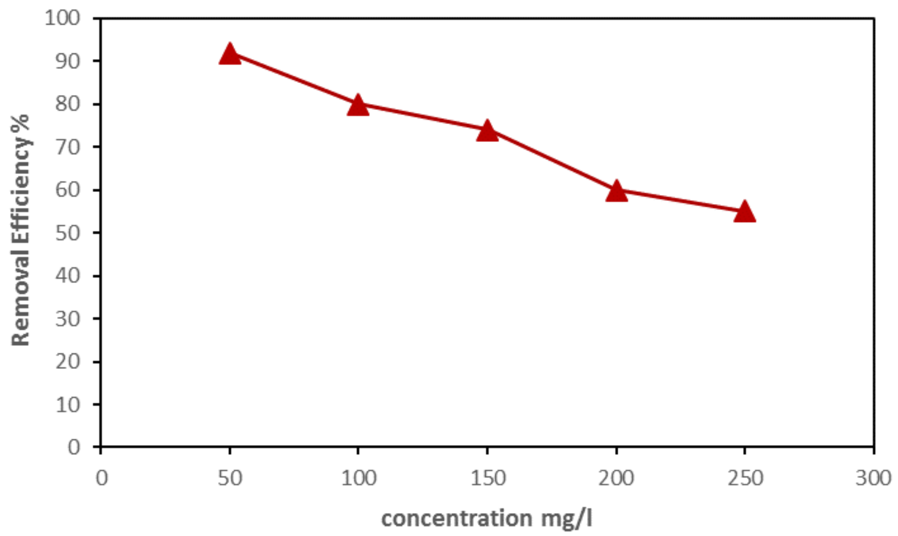


**Figure (4) The effect of initial metal concentrations on pb(II) removal efficiency.**

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## 4.2 Langmuir Adsorption Isotherm

The Langmuir isotherm was utilized in this investigation in a semi-empirical isotherm. The dynamic equilibrium between adsorbed and free gaseous molecules is one of the numerous assumptions underlying this isotherm. It rests on the four premises listed below:

The strength of the adsorption sites on the surface of the adsorbent is uniform across the board. Adsorbate molecules do not interact with one another.

All types of adsorption are accomplished in the same way. At the peak of adsorption, when a monolayer is formed, molecules of the sorbed species do not deposit on other, already adsorbed, sorbed species but rather exclusively on the free surface of the adsorbent [24].

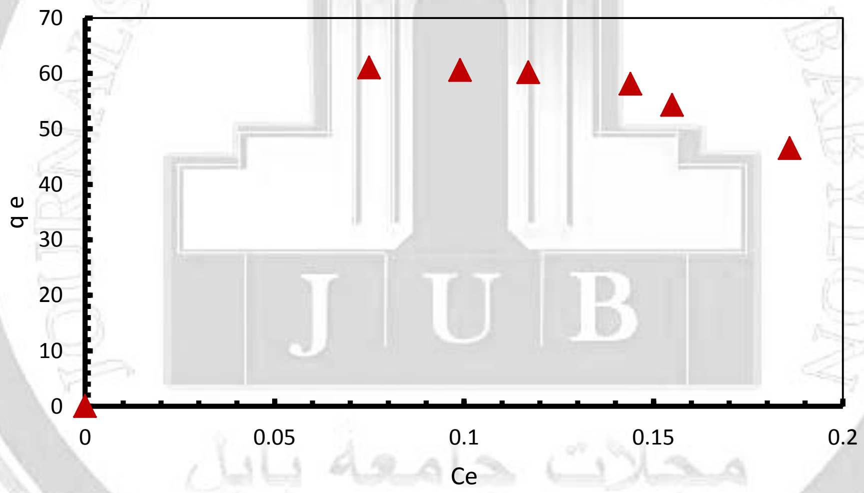


**Figure (5) The relation between qe and Ce.**

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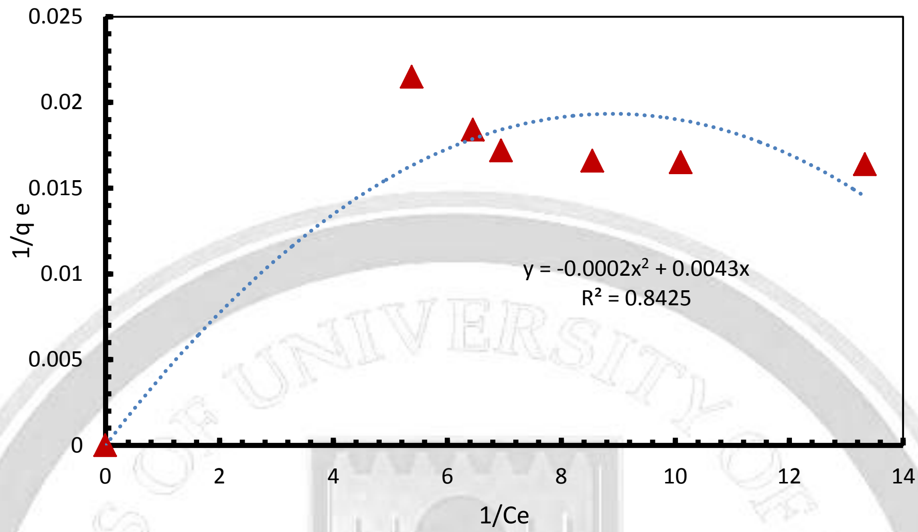


**Figure (6) The relation between 1/qe and 1/Ce.**

Based on the figures (5,6) above, the following data are calculated:
The intercept = 1/K = 1.5 K= 1/1.5 = 0.666
Calculate slope = (13.333-5.376) / (0.0164-0.0215) = 792.7
(1/K Q^0) = 792.7 so Q^0= 1.894*10^-3
The Langmuir Equation = 1/qe = (1/0.666)+1/ (1.894*10^-3) *0.666*Ce

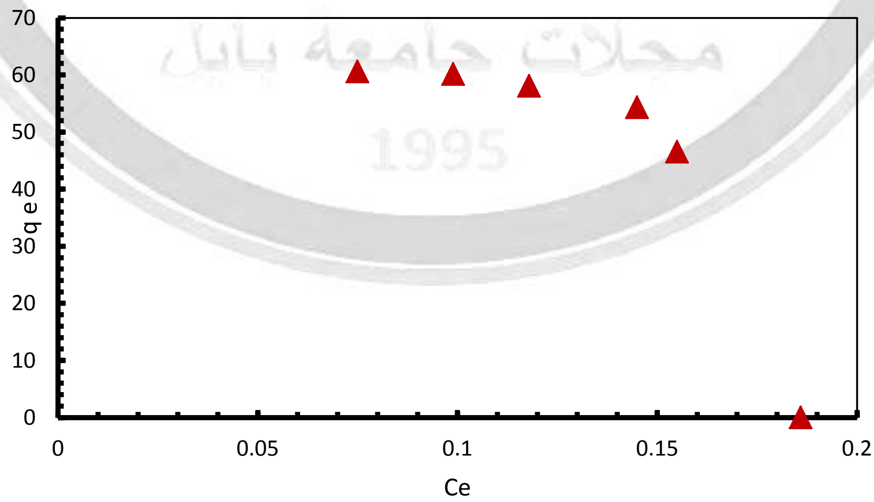


**Figure (7) The relation between qe and Ce by Freundlich.**

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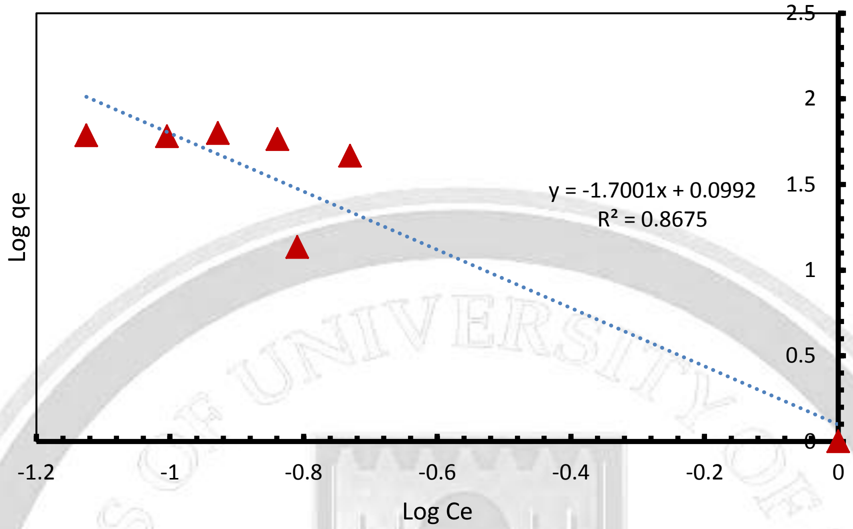


**Figure (8) The relation between log qe and log Ce.**

Based on the figure (7,8) Freundlich Isotherms are calculated
As following :

$$q_e = K_f * C_e^{\frac{1}{n}}$$

$$\log q_e = \log K_f + \frac{1}{n}\log C$$

$$\frac{1}{n} = \frac{\log 0.6 - \log 0.4}{\log 1.1 - \log 0.53} = 0.555$$

$$slope = \frac{1}{n} = 0.555 \Rightarrow n = 1.803$$

$$intercept = \log k_f = -0.025 \Rightarrow K_{f=}0.944$$

$$q_e = 0.944 * C_e^{\frac{1}{1.803}}$$

The concentration of a solute on the surface of an adsorbent and the concentration of the same solute in the liquid it is contacting are empirically related via a relation known as an adsorption isotherm.

The Freundlich isotherm provides a mathematical representation of the equilibrium of adsorption between a liquid (or gas) and a solid medium. The Freundlich equation is used to express, empirically, the isothermal variation of liquid or gas adsorption onto the surface of a material [24]. As showen in figures (7,8)

Amount adsorbed (x), mass of adsorbent (m), partial pressure of adsorbate in gas (P), and constants for the adsorbent-adsorbate pair (k, n) at different temperatures (T).

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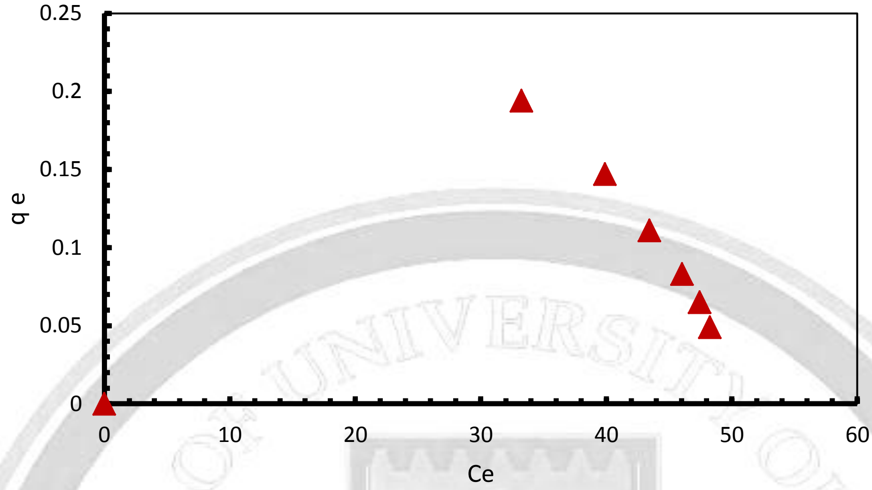


**Figure (9) The relation between qe and Ce by Langmuir.**

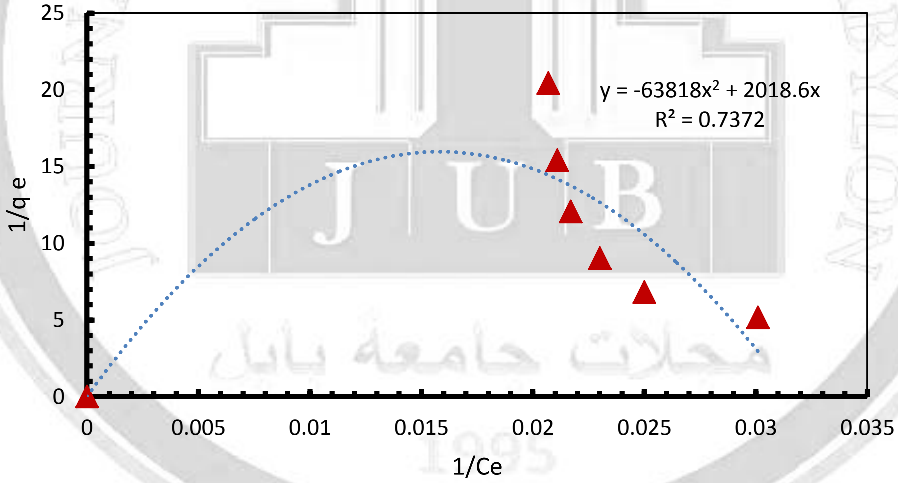


**Figure (10) The relation between 1/qe and 1/Ce by Langmuir.**

As shown in figures (9,10) Langmuir isotherm analysis based on the data are:
The intercept = 1/K = 4.5          K= 1/4.5 = 0.222
Calculate slope = (20.408-0) / (0.0207-0) = 985.8
(1/K Q^0) = 985.8          so          Q^0= 4.569*10^-3
The Langmuir Equation = 1/qe = (1/0.222)+1/( 4.569*10^-3) *0.222*Ce

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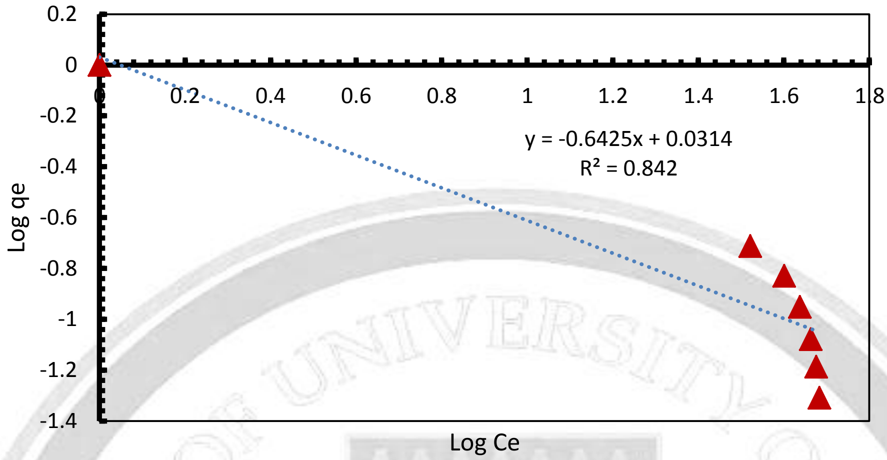


**Figure (11) The relation between log qe and log Ce by Freundlich**

Based on the figure (11) Freundlich Isotherms are calculated
As following :

$$q_e = K_f * C_e^{\frac{1}{n}}$$

$$\log q_e = \log K_f + \frac{1}{n} \log C$$

$$\frac{1}{n} = \frac{\log 0.84 - \log 0.6}{\log 1.4 - \log 0.88} = 0.725$$

$$slope = \frac{1}{n} = 0.725 \Rightarrow n = 1.379$$

$$intercept = \log k_f = 0.01 \Rightarrow K_f = 1.023$$

$$q_e = 1.023 * C_e^{\frac{1}{1.379}}$$

There are major differences between the two theories. The Freundlich isotherm is based on experiment, while Langmuir's model is theoretical. According to the Langmuir model, when coverage is maximized, there should be only a single monomolecular layer present at the surface.

Ce values and qe values were used to build relationships, and as can be seen in the relationship figure (5), the results indicate that the amount of lead decreases as the amount of adsorbed material increases. There are a total of 14 dirty water samples between the two data sets. Both models demonstrate that the adsorbent material significantly affects the lead concentration in the sample through relationship No. 1, which indicates that a lower adsorbent mass results in a higher lead concentration in the sample, and through the logarithmic relationship between Ce and qe. Tea leaves act as an adsorbent, soaking up lead from the samples and lowering their overall concentration. As can be seen below, the Batch Experiment made use of both the Langmuir and Freundlich isotherms[33].

1-qe= (Q^0 * K * Ce)

2-$q_e = K_f * C_e^{\frac{1}{n}}$

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Moreover, the values of constants were found, and for both methods, k and n where the values of k*f* were relative to the Langmuir isotherm as follows:

K= 0.666 for data1
K= 0.222 for data2
Where kf and n as follows:
K*f*= 0.944 , n=1.803 for data1
K*f*=1.023 , n=1.379 for data2

As a result, the final equation was obtained for both methods and as follows:

For data1:

1-The Langmuir Equation: 1/qe = (1/0.666)+1/( 1.894*10^-3) *0.666*Ce

2-The Freundlich Equation: $q_e = 0.944 * C_e^{\frac{1}{1.803}}$

For data2:

1-The Langmuir Equation: 1/qe = (1/0.222)+1/( 4.569*10^-3) *0.222*Ce

2- The Freundlich Equation: $q_e = 1.023 * C_e^{\frac{1}{1.379}}$

The relationship between qe and Ce for Langmuir Equation is depicted in Figure (5) for a range of qe values from 61.075 to zero, qe decreases from its initial value of 0.075 all the way to zero as Ce grows. Figure (6) depicts values for 1/qe from 0.0164 to infinity, whereas values for 1/Ce range from 13.333 to infinity.

The relationship between qe and Ce for Freundlich Equation is depicted in Figure (7) for a range of qe values from 61.075 to zero, qe decreases from its initial value of 0.075 to 0.18 .

In Figure (8) for the Freundlich isotherm, it is expressed the logarithmic relationship between Ce and qe, and also the logarithmic value of the removed metal decreases as the logarithmic value of the adsorbed material grows .

Ce values start at 48.25 and decrease to zero in Figure (9) while qe values start at 0.049 and increase to zero in the Langmuir isotherm.

Figure (10) depicts the relationship between (1/Ce and 1/qe), where it is obvious that the value of 1/qe decreases as the value of 1/Ce increases.

In Figure (11), it is showed that as log qe increases, log Ce decreases for the Freundlich isotherm.

In the case of tea leaves, the Langmuir model predicts a decrease in lead concentration with increasing adsorbent mass, but the Freundlich batch experiment approach also works well for applying the isotherm. In addition, the mass of the adsorbent material in the tea leaves was found to correlate positively with the observed drop in metal concentration, virtually reaching zero. The pictures make it evident that the Freundlich model is the most effective model; the curve for this approach nearly touches zero.

It is evident by the drawings that the isotherm can be well applied by the two methods of the batch experiment Langmuir and Freundlich where for the Langmuir model to observe a decrease in the concentration of the heavy metal lead with an increase in the mass of the adsorbent material for the tea leaves. Moreover, for the Freundlich model we observe a significant decrease in the metal concentration the lead almost reaches zero with the increase in the mass of the adsorbent material in the tea leaves and in the end it becomes clear to us through the drawings that the Freundlich model is the best model in terms of results and this indicates the shape of the curve for this method which almost reaches zero and this indicates the possibility of using this model in removing lead metal for wastewater treatment.

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In conclusion, we note that by increasing the value of the concentration of lead, the value of the adsorbent decreases, and this means that the adsorbent is consumed in water by the lead metal, which indicates the possibility of using tea leaves in the currency of removing lead metal because of its effective removal effect on this toxic metal.

To sum up, it was seen that the value of the adsorbent decreased with increasing lead concentration, indicating that lead metal consumed the adsorbent in water, suggesting that tea leaves could be used as a currency for lead removal due to their efficient removal effect on this toxic metal.

Prevention of heavy metal pollution is especially important in today's polluted world because of the direct impact water has on our lives and the hazards that its contamination poses to both individuals and the environment. This investigation focuses mostly on strategies for treating wastewater that has been tainted by lead. The most cost-efficient strategy for avoiding tea leaf consumption and heavy metal contamination of water is to reduce discharge to the riverbed.

The accuracy of the adsorption isotherm was also studied by comparing it to the results obtained using the Langumiar method and the Frendich isotherm, both of which are considered to be quite reliable. Understanding the generated adsorption isotherms is crucial for making meaningful comparisons between the adsorption performances of different models.

Also, there are two methods of excellence, which are the method of Langmuir and Freundlich isotherm were examined too in order to investigate the accuracy of adsorption isotherm. Both successful modeling and the interpretation of adsorption isotherms are dependent parameters in order to observe which model are better than other in the adsorption performance and quality of fits.

In the end, it can be concluded that tea leaves are considered an excellent and economical material due to the large availability of them in nature, as they are considered a material for removing heavy metals from polluted water. In some studies, tea leaf is a biological sorbent material for production from activated carbon using conventional physical activation. The active carbon derived from waste tea can have features fit with the commercially available type.

The level of accuracy obtained from adsorption processes is greatly dependent on the successful modelling and interpretation of adsorption isotherms.

While linear regression analysis has been frequently used in accessing the quality of fits and adsorption performance because of its wide applicability in a variety of adsorption data, nonlinear regression analysis has also been widely used by a number of researchers in a bid to close the gap between predicted and experimental data. Therefore, there is the need to identify and clarify the usefulness of both linear and nonlinear regression analysis in various adsorption systems.

## 6. Conclusion and Recommendation

Finally, tea leaves are utilised to remove heavy metals from polluted water. This practise shows that these leaves, which are abundant in nature, could be a spectacular and cost-effective resource. There has been a significant amount of research conducted on tea leaves to investigate the possibility that they could be utilised in the conventional physical activation process as a biological sorbent material. There is a possibility that activated carbon made from used tea leaves will have some characteristics of carbon that is already offered for sale

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in the marketplace. The reliability of adsorption data is directly proportional to the quality of the isotherm models and interpretations that were utilised to generate them. In spite of the extensive utilisation of linear regression analysis for the purpose of assessing fit quality and adsorption performance, numerous research have turned to nonlinear regression analysis in order to bridge the gap that exists between predicted and experimental results. As a consequence of this, it is of the utmost importance to determine and make clear the roles that linear and nonlinear regression analysis play in a variety of different adsorption systems.

**Recommendations:**

1. It is considered to use other adsorbents such as Orange tree leaves, it is considered to be adsorbent for the removal of Cd (II) Co (II) and Zn (II) from wastewater. This study indicates that the developed Method based on orange tree leaves is very simple, low-cost, fast and Trusty for the removal of heavy metal ions from water and wastewater samples.
2. It might be tried another heavy metal such as Nickel from aqueous solution by using low cost adsorbents
3. It might be considered the removal of heavy metals from emerging cellulosic low-cost.
4. It might be considered the removal of Cr (VI7), orange peel is used as an adsorbent in which the material used as an adsorbent for the removal of Chromium (VI).
5. It might be considered the adsorption of heavy metals from water using banana and orange peels is considered to be an adsorbent. Finally, removal of lead from aqueous solutions by spent tea leave.
6. Using different other adsorbents might be useful for the removal of heavy metal ions from aqueous solution.

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# أستخدام مادة ماصة منخفضة الكلفة من المخلفات الحيوية لمعالجة مياه الصرف

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**الخلاصة**

تبحث هذه الدراسة فعالية استخدام أوراق الشاي المستهلك لإزالة أيونات المعادن الثقيلة من مياه الصرف. يتم التحقيق في تأثير أيونات المعادن على الممتزات من خلال تغيير وقت التلامس، والجرعات وكذلك تركيز المعادن. يتم البحث أيضًا عن حساسية عملية الامتصاص للأس الهيدروجيني أثناء طريقة الدُفعات. عند درجة حموضة ٧ أو أقل، اعتمادًا على تركيز المعادن الثقيلة، تكون إزالة أيونات المعدن في أقصى حد لها؛ بمجرد تحقيق التوازن تتوقف إزالة أيونات المعدن. تشير النتائج إلى أنه يمكن استخدام اوراق الشاي المستهلكة إلى جانب مواد ماصة فعالة أخرى، لمعالجة مياه الصرف التي تحتوي على أيونات المعادن الثقيلة . يتم التحقيق في آثار الممتزات ووقت التلامس وتركيزات المعادن الرئيسية على النسبة المئوية للإزالة. يتمتع الشاي بمعدل امتصاص مرتفع، وقد تم تحقيق القدرة على الامتصاص والفعالية من حيث التكلفة لاستخدام أوراق الشاي لإزالة معدن الرصاص من مياه الصرف في هذا النهج. تم استخدام طريقتي Freundlich و Langmuir للتجربة الدفعية لحساب كمية المادة الممتزة وتركيز المعدن الثقيل.

**الكلمات الدالة** امتصاص , أوراق الشاي ,معادن ثقيلة , معالجة مياه الصرف.