Using spent tea residue to elimination of chromium in aqueous liquid

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Abstract
In this work, spent red and black tea form leaves were assessed for their ability to doff expel chromium ion from aqueous solutions at various values of PH. Classification adsorption experiments indebted at choice temperature and showed cruise the adsorption of Cr ion decrease more the increase of temperature. In successive lyrics, the adsorption fight is exothermic and the enthalpy is fatal, at long last the unconventional ways and the entropy are positive. The matter copied at equal stat was compared with Langmuir, Freundlich models, and the inference efficiencies for Cr ion higher than 99% and can easily be achieved. It was hinge saunter the brilliant hatch is reform than hyacinthine cause in adsorption of chromium ion.

Keyword: Adsorption, Tea leaves, Chromium ion
Introduction
The potency of the tea waste to remove the serious metals from artificial waste material has been investigated via (“Kumar et al”).(1). Acid of (1.0M) has been accustomed with chemicals activate sample of tea waste. The impact regarding adsorbent dose, hydrogen ion concentrations and the contact time on proportion removal that is related to the serious metals, metallic element and copper were estimated via Spectro-photometric analysis regarding metal’s concentrations in the residue at (312nm) and (540nm). The study discovered a most removal share related to metals to be ninety-one and ninety-four for the copper and metallic element. The same research achieved via (“Thapak et al”).(2) activated tea waste victimisation (1.0M) acid and applied it for taking the copper ions from artificial waste material. The impact related to the contact time, adsorbent dose, and hydrogen ion concentrations on serious metals’ proportion removal has been examined, also the most of removal that is related to copper through tea waste evaluated to be approximately ninetieth on a mean. (“Jeyaseelan and Gupta”)(3)developed such study for upsetting upset the potency regarding un-qualified leaves of waste tea for eliminating metallic element [Cr(VI)] ions from solution related to the Cr(VI) concentrations one thousand mL/L through batch method. In similar way, (“Malakahmad et al”).(4) characterized and estimated the effectiveness of the waste tea (WBT) as inexpensive adsorbent to remove Zn$^{2+}$ and Ni$^{2+}$ ions from the liquid solutions. (“Islam et al”).(5)examined the effect related to variable the activator to precursor the material impregnation magnitude related to surface characteristics of C derived from the factory-rejected tea and its efficiency in removingstain dye from the liquid solutions.During this work, outcomes got once substantial
metal, kind of like metallic element, is placed to bear with red and dark tea deposit square measure presented the expertise has been conducted at center scale with controlled states regarding the starting hydrogen ion concentration, temperature and speak to time. at that time evaluated adsorbent limit regarding dark and red tea buildup to take up metallic element (VI).

**Material and method**

**Preparation of the Adsorbent**

The leaves of spent dark tea in addition to the leaves of red tea have been used in examinations. Dissolvable, also the hued parts have been expelled from leaves through rehashed wash with the bubble water till when filtrate has been for all the purposes and intents vapid. Then, the strong has been washed by the use of refined water and broiler dry at a temperature of sixty Celsius for twenty-four hours. Dried leaves have been grounded and sieved to particles (<500μm) that have been left in the poly-ethylene sacks till use.

**Preparation of the Waste-water Solution**

The waste-water arrangement has been set through dissolving precisely determined amounts of the K₂CrO₄ in the refined water for getting various centralization regarding overwhelming metal particles with regard to the fluid arrangements.

**Batch adsorption tests**

The batch adsorption test has been carried out through mixing identified quantities regarding the tea residue prepared as mentioned-before, also (20mL) solutions related to recognized concentrations of heavy metal. The concentrations of the heavy metal ions for K₂CrO₄ have been ranging between (10 and 70ppm) in respective solutions. Mixer has been utilized for mixing the mixture at speed of (180rpm) for one hour (optimum time for the maximum adsorption), after that the sample have been filtered.
Cr ion’s adsorption to tea residue in aqueous solutions has been evaluated through the use of Spectro-photometer (Perkin Elmer Lambda 25) at (385nm) (the color has been yellow). Experiments have been carried out for determining the impact of PH solutions and temperature on adsorption process’s behavior.

**Results and discussion**

Many models related to describing the correlation of the adsorption isotherm. The model of Langmuir, that is on the basis of the indication that adsorption is considered to be independent from the interactions between adsorbate molecules, has been utilized for gases’ adsorption onto the solids. With regard to these conditions, the adsorption has been is maximized in the case when adsorbing surface is totally covered through adsorbent’s single layer, utilizing Langmuir model, adsorption isotherm has been determined through this relationship:

\[
\frac{1}{q_e} = \frac{1}{bq_0C_0} + \frac{1}{q_0} \tag{1}
\]

Furthermore, depending on Freundlich model it is in the following way:

\[
\log q_e = \log k + \frac{1}{n} \log C_e \tag{2}
\]

Removal (\%) = \( \frac{C_0 - C_e}{C_0} \) \tag{3}

In which \( q_e \) represent concentration of the Cr(IV) which is adsorbed per-unit-mass of the adsorbent (mg/g).

\( q_0 \) represent amount which is related to solute which is adsorbed for each unit mass regarding adsorbent in the case of covering all available sites.

\( C_0 \) represent initial liquid phase.

b represents adsorption coefficient.
Ce represent residual liquid phase at the equilibrium.

n represent adsorption intensity

k defined as capacity of the.

Based on Langmuir and Freundlich, these equations could be presented as:

\[ q_e = \frac{(C_0 - C_e)V}{W} \]  \hspace{1cm} (4)

In which V represent volume (mL); q_e represent quantity related to solute which is adsorbed for each unit weight of the adsorbent, and W represent adsorbent weight (g).

Figure 1 and Figure 2 display adsorption isotherms for Cr (VI) on red and residue of the black tea at a temperature of twenty-five Celsius respectively.

![Figure (1): Langmuir isotherm for adsorption of Cr (IV) ion onto black and red tea residues](image-url)
The Impact of the pH of the solution on the adsorption

The impact of the value of the pH on the Cr (VI) adsorption has been examined through mixing (0.5g) regarding the adsorbent in twenty mL related to identified concentration related to reference heavy metal ions at a temperature of twenty-five Celsius and different pH values that has range (2.2-12) that is displayed in figure 3 and 4.
The pH related to the feed solution is significant control parameter in the process of the adsorption of the heavy metal and therefore hydrogen ion’s role. It has been indicated that pH, in addition to different physicochemical impact, is significant variable in exchanging ions which is governed process of adsorption, through which the charges of the surface could be altered (8), maximum of the adsorption of Cr(VI) on the residues of the tea happens at a value of the pH which is equal to 2.2, also, it has been indicated that dominant form related to Cr(VI) at such value of pH is species of acid chromate ion (HCrO-) and increase in pH is going to shift concentrations that are related to HCrO- to the other forms, CrO$_2^-$ and Cr$_2$O$_2^{-}$. At extremely low pH values, adsorbent’s surface might be surrounded via ions of hydrogen that improve Cr(VI) interactions with the sites of binding regarding adsorbent through higher forces of attraction. With the increase in the value of the pH, overall surface charge on adsorbent will be negative and adsorption will be reduced (9,10).
Impact of the temperature

The impact which is related to temperature on adsorption regarding the ions of the Cr(VI) has been examined on red and black tea residue from temperatures of twenty-five Celsius to forty-five Celsius. The temperature’s impact is typical and increase the mobility related to metal cation. Also, the increase in the temperatures could create swelling impact in tea residue’s internal structure which will enable metal cation for penetrating even more\(^\text{10}\). It has been known that the capacity of the adsorption which is related to Cr(VI) on black and red tea increase with the increase in temperature at twenty-five Celsius to forty-five Celsius. The increase regarding adsorption capacity and adsorption yield at elevated temperatures show that adsorption related to Cr(VI) ions through waste tea could include not just physical, yet chemical sorption. This impact could be because of that at high temperatures, the increase in the active sites happens because of bond rupture, the result regarding percentage of the removal of the Cr(VI) at temperatures of twenty-five Celsius, thirty-five Celsius and forty-five Celsius through red and black tea have been shown in table 1 and figure 5 and figure 6.

**Table 1: The removal efficiency (R%) for Cr ions by tea wastes**

| Waste material     | 25°C   | 35°C   | 45°C   |
|--------------------|--------|--------|--------|
| Black tea waste    | %99.83 | %99.86 | %99.89 |
| Red tea waste      | %99.93 | %99.96 | %99.96 |
Figure 5: Effect of temperature on adsorption of Cr ion on red tea

Figure (6): Effect of temperature on adsorption of Cr ion on black tea
On the basis of basic thermodynamic ideas, it has been supposed that in the isolated systems, the energy can’t be obtained or lost and the variation in entropy is just the motive power in the practices of environmental engineering, entropy and energy factors should be taken into account for the purpose of determining that process that will happen spontaneously\(^{(10)}\).

The next equations could be used to obtain thermodynamic data\(^{(11)}\):

\[
\log X_m = -\frac{\Delta H}{2.303} \frac{1}{RT} + \text{Constant} \tag{5}
\]

Where \(X_m\) is the maximum amount of adsorbate.

\[
\Delta G = -RT \ln \frac{Q_e}{C_e} \tag{6}
\]

\[
\Delta S = \frac{\Delta G - \Delta H}{T} \tag{7}
\]

Thermo-dynamic adsorption parameters that are related to Cr ion on residues of the tea have been shown in figure (7) and table 2.
Negative value related to $\Delta H$ show the process of exothermic adsorption, and positive values that are related to $\Delta G$ at all the temperatures examined are because of the fact that the procedure of the adsorption process is spontaneous, also the negative values related to $\Delta S$ show reduced randomness at solid / solution interface throughout this procedure. Which suggest that more optimum adsorption happen at low temperatures on red tea in comparison to the black tea at low temperatures.

Table 2: The thermodynamic parameters for the adsorption of Cr ion onto tea residues

| surface     | T(K) | $\Delta G$(KJ/mol) | $\Delta S$(J/mol) | $\Delta H$(KJ/mol) |
|-------------|------|--------------------|-------------------|--------------------|
| Red tea     | 298  | +9.002×10^3        | -93.73            | -1.9×10^{-4}       |
|             | 308  | +10.285×10^3       | -94.8             |                    |
|             | 318  | +11.016×10^3       | -94.17            |                    |
| Black tea   | 298  | +6.222×10^3        | -20.88            | -1.89×10^{4}       |
|             | 308  | +7.381×10^3        | -23.96            |                    |
|             | 318  | +8.457×10^3        | -26.59            |                    |

Conclusion

The present work display that the waste tea leaves is an effective adsorbent for elimination of Cr (VI) ions from aqueous solutions. The rate of adsorption is relatively fast, and most of the adsorption takes place within 60 minutes. The data obtained using Langmuir and Freundlich models at equilibrium stat showed the removal efficiencies of Cr ion are 99% and can easily be achieved. It was found that the red tea is better than black tea in adsorption of chromium ion.
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Reference

1. Kumar H, Sumint T, Trivedia S, Pandey LK, Tea waste adsorbent for the removal of chromium and copper from synthetic wastewater. IJIRST Int J Innov Res Sci Technol, (2015), 2(2), 70–74
2. Thapak HK, Sharma J, Boudh B, Banger N, Dwivedia P., Adsorption of copper ions in aqueous media using tea waste and sawdust as an adsorbent. IJIRST Int J Innov Res Sci Technol, (2015), 2(3), 52–57
3. Jeyaseelan C, Gupta A., Green tea leaves as a natural adsorbent for the removal of Cr(VI) from aqueous solutions. Air, Soil Water Res. (2016), https://doi.org/10.4137/ASWr.S35227
4. Malakahmad A, Tan S, Yavari S., Valorization of wasted black tea as a low-cost adsorbent for nickel and zinc removal from aqueous solution. J Chem., (2016), https://doi.org/10.1155/2016/5680983
5. Islam MA, Benhouria A, Asif M, Hameed BH., Methylene blue adsorption on factory-rejected tea activated carbon prepared by conjunction of hydrothermal carbonization and sodium hydroxide activation processes. J Taiwan Inst Chem Eng., (2015), https://doi.org/10.1016/j.jtice.2015.02.010
6. Mehrdad Cheraghi, Soheil Sobhanardakani, Raziyeh Zandipak, Bahareh Lorestani, Hajar Merrikhpour, Removal of Pb (II) from Aqueous Solutions Using Waste Tea Leaves, Iranian Journal of Toxicology, 2015, 9(28).
7. Bindra Shrestha, Jagjit Kour and Kedar Nath Ghimire, Adsorptive Removal of Heavy Metals from Aqueous Solution with Environmental Friendly Material—Exhausted Tea Leaves, ACES, 6 (4), 2016

8. Mähler, J.; Persson, I. A study of the hydration of the alkali metal ions in aqueous solution. Inorg. Chem., 2012, 51, 425–438.

9. Dan Yu, Shintaro Morisada, Hidetaka Kawakita, Keisuke Ohto Katsutoshi Inoue, Ximing Song and Guolin Zhang, Selective Cesium Adsorptive Removal on Using Crosslinked Tea Leaves, Processes 2019, 7, 412, 1-15.

10. Kailas L.W., Adsorption of Metals onto Tea Factory Waste: A review, In IJRRAS, 2010,3 (3)

11. Bshaer J.K., Dyes removal from aqueous solution using egg shell powder, university of al-Kofa, Msc thesis, 2015.