Al-Imam Muhammad ibn Saud Islamic University
College of Science
Department of Chemistry

Adsorption of Chromium from aqueous Solutions by Palm tree Waste.

A graduation research project submitted to the Department of Chemistry in partial fulfillment of the requirements for the completion of the degree of

Bachelor of Science in Chemistry

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Abstract

The removal of poisonous Cr VI from aqueous solutions by low-cost abundant adsorbents was investigated. Investigation was using palm tree trunks (stem) to provide in abundance in the Arab world. We produced activated carbon from palm tree waste at 400^{o} C that was used as an adsorbent. It was used to removal of chromium from its solutions. Capacity and Efficiency of adsorption has been investigated.

Acknowledgment

All praise and thanks to Allah (SWT) to reconcile me in completion this work. This project would not be possible with continues help from my supervisor Dr. Abdulrahman Alhamazani in the department of chemistry at Al-Imam University. I would also thank Dr. Mohammad Habib for invaluable help during my work in the laboratory. I really would like to show my deepest gratitude for his guidance, patience, and support. I have learned a lot from him in doing research and solving the problems in the chemical laboratories.

I would also express my thanks to the department of chemistry for supporting me during my project graduation work.

Grateful thank to my parents for their support in my study and their patience.

1. Introduction:

Removal of heavy metal ions from solutions by adsorption using agriculture waste materials has been used by many researchers [1,2,3]. Chromium occurs most frequently as Cr VI or Cr III in aqueous solutions. The two oxidation states have different chemical, biological and environmental properties [4]. Cr(III) is relatively insoluble, and an essential micronutrient [5], while Cr(VI) is a primary contaminant because of its toxicity to humans, animals, plants and microorganisms.

Chromium has widespread industrial applications; hence, large quantities of chromium are discharged into the environment. The major industries that contribute to water pollution by chromium are mining, leather tanning, textile dyeing, electroplating, aluminum conversion coating operations, plants producing industrial inorganic chemicals and pigments, and wood preservatives [6]. Chromium (VI) is highly toxic in nature due to the fact that one of the reduction products of Cr(VI) is Cr(V), which is a known carcinogen and will lodge in any tissue to form cancerous growths. Cr (VI) is a very strong oxidizing agent [7]. The level of chromium in discharged wastewater should be reduced, or recycled if possible.

Several methods are utilized to remove chromium from industrial wastewater. These include: reduction fol-lowed by chemical precipitation [8]; ion exchange [9]; adsorption [10]. Adsorption is an effective and versatile method for removing chromium, particularly when combined with appropriate regeneration steps. This solves the problems of sludge disposal and renders the system more economically viable, especially if low-cost adsorbents are used [11]. However, the literature is still insufficient to cover this problem, and more work and investigations are needed to deal with other locally available and cheap adsorbents to eliminate Cr VI from industrial wastewater samples with different compositions and characteristics. The simultaneous quantitative determination of the micronutrient Cr III and the carcinogenic Cr VI is of great importance in environmental analysis and biological studies.

In this research report palm tree trunk (steam) low-cost locally available adsorbents, was used to determine their efficiency in removing chromium from simulated contaminated samples. The effects of pH, contact time, adsorbent concentration and metal ion/adsorbent ratio were investigated.

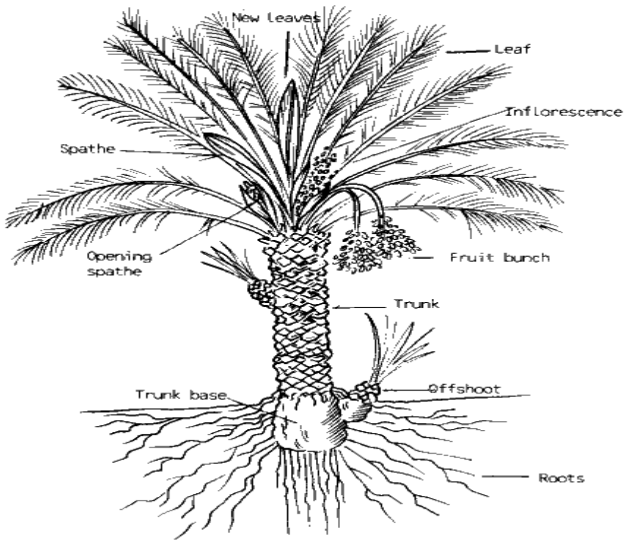


Figure 1. Parts of Palm Tree.

2. **Experimental Part:**

Collecting sample

The waste pods of palm tree trunk were collected from side products of local farm. Then, they were cleaned, crushed to small particles, and dried in open air and sun for several times. The good materials have been grinded by using mixer for several times until desirable particle size and dried in an oven at 70o C for 7 hours.

Figure 2. Material after grinded.

Preparation of activated carbon:

The grinded materials were dried in an oven at 100 °C for 2 hours. The dried materials were burned at 400º C for 2 hours in a furnace. The obtained sample were cooled at room temperature, then soaked with concentrated *ortho-phosphoric acid* for 2 hours in a ratio of 2:1 (H_3PO_4 solution /sample, W/W). Then, the material was washed with excess of water to remove the acid till the pH become 7.0. The washed material was dried at room temperature for 90 minutes, and dried in an oven at 200 ^{o}C for 90 min. Thermal activation was carried out at 650^{o} C for 20 min.

Figure 3. Picture of burned Material.

The obtained activated carbon was used for adsorption of Cr(VI) from aqueous solutions.

Scanning Electron Microscopy of the prepared sample before adsorption which indicates there is pores of the activated sample (see figure ??)

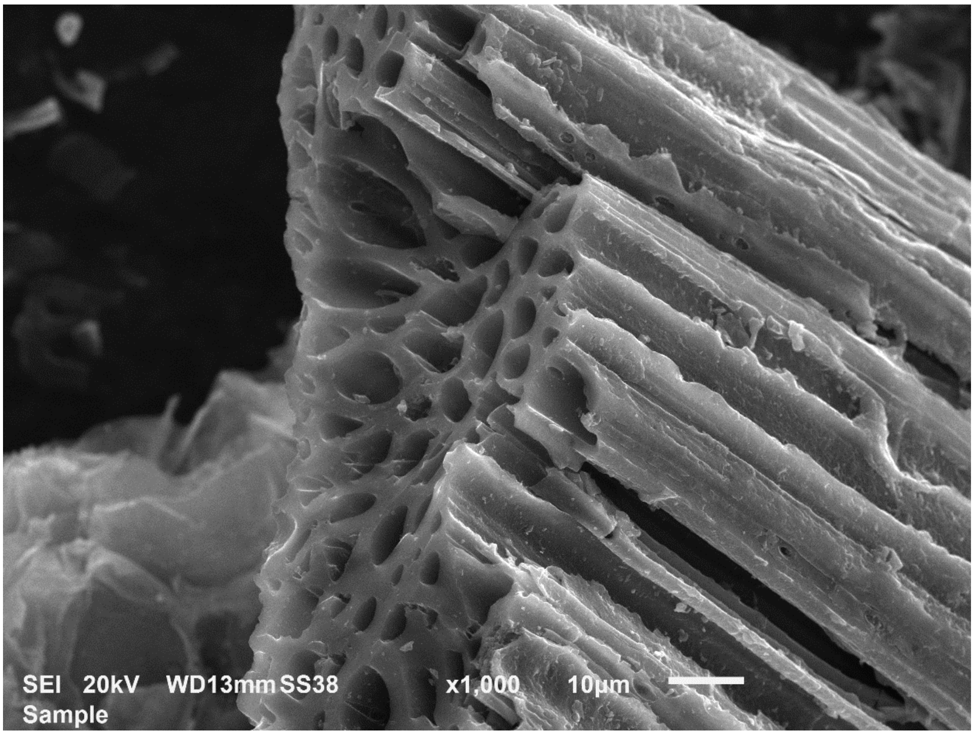


Figure ??. SEM of sample before adsorption

Results and discussions:

First amount of activated carbon was added to Cr(VI) solution, $K_2Cr_2O_7$, then shacked for 7 hours. The color of the solution diminished, which means that adsorption of Chromium was happened.

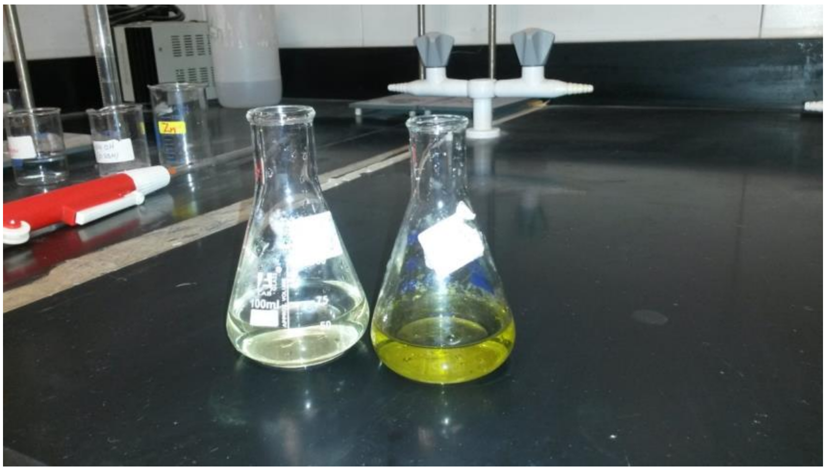


Figure 4. Cr Solution before and after adsorption.

Different concentrations of $K_2Cr_2O_7$ solution (10, 20, 30, and 40 mg/L) have been prepared to be used for adsorption process. Absorbance has been measured using UV/VIS spectrophotometer at λ = 440 nm.

Table 1. Data of adsorption Process at different concentrations.

Concentration of Cr,[C_i] ($mg.L^{-1}$)	Absorbance		Concentration After Adsorption [C_e]	q_e	E%
	Before Adsorption	After Adsorption			
10	0.057	0.050	6.25	0.93	37.5
20	0. 142	0.080	10	2.50	50
30	0.232	0.170	21.25	2.18	29.16
40	0.328	0.290	36.25	0.93	9.38

The adsorption capacity of the activated carbon was evaluated using Chromium solutions as adsorbent using the following equation:

$$qe = \frac{(Ci-Ce)*V}{m}$$

where, q_e is the adsorption capacity (mg/g), C_i is the initial concentration of Chromium, C_e is the equilibrium concentration of Cr, V is the volume of the solution in L, and m is the mass of the adsorbent in g.

The relationship between the absorbance and concentration is shown below for both before treatment and after treatment.

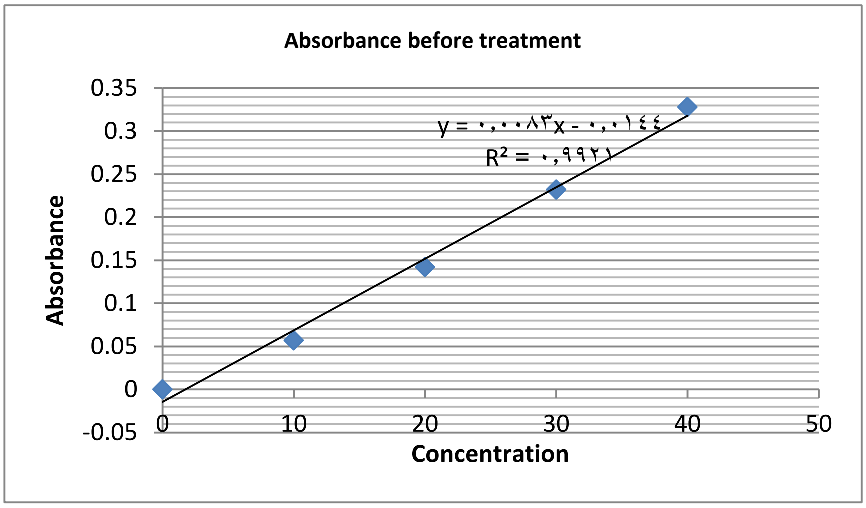


Figure 5. Absorbance data for different concentrations of Cr Solutions before treatment.

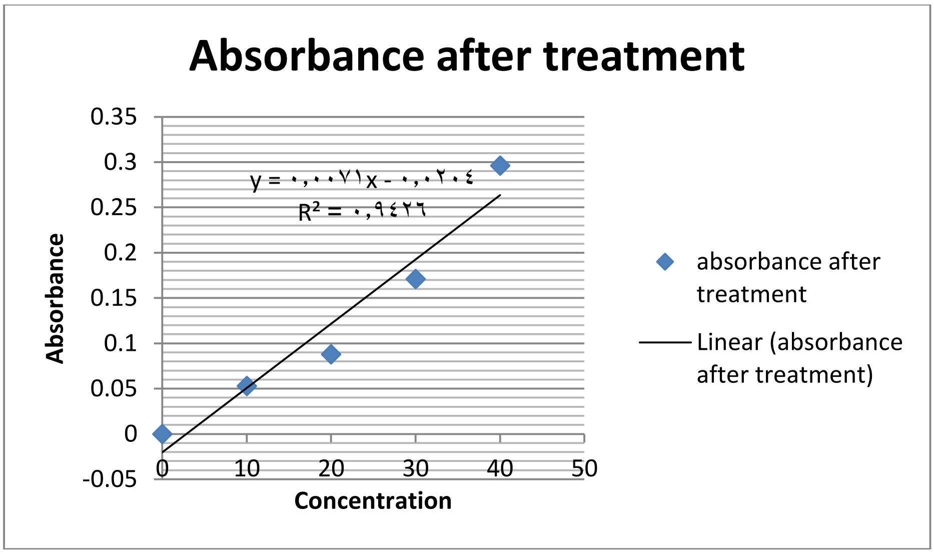


Figure 6. Absorbance data for different concentrations of Cr Solutions after treatment.

The highest adsorption capacity, 2.5, and highest efficiency, 50%, were observed at concentration of 20 mg/L. The following figures (7 and 8) show the relationship between adsorption capacity and efficiency vs concentrations.

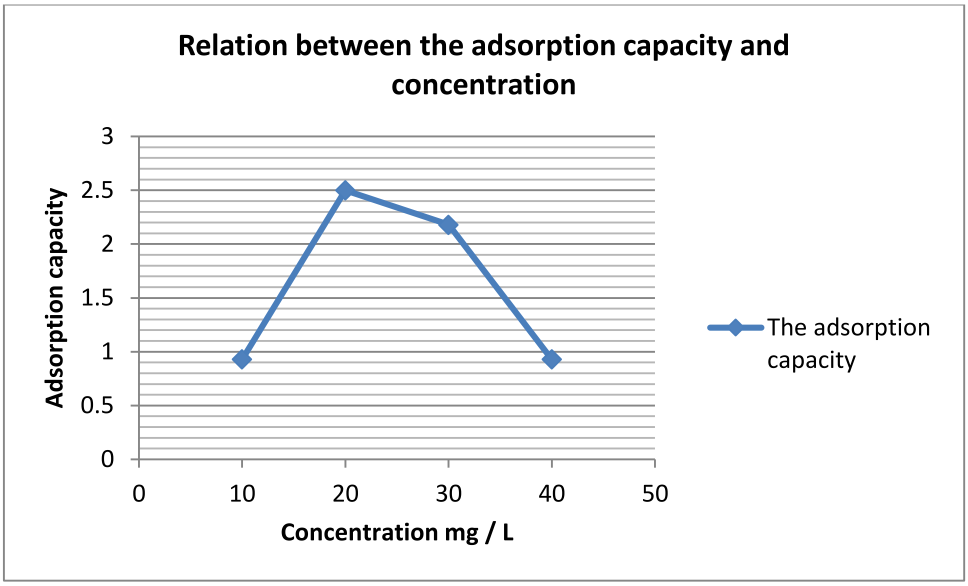


Figure 7. Relationship between adsorption Capacity vs. concentrations.

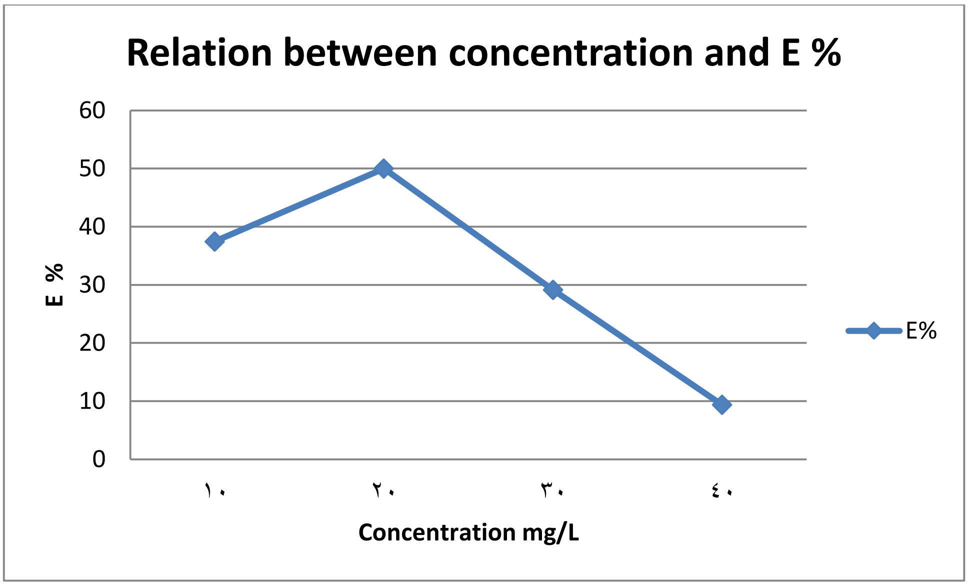
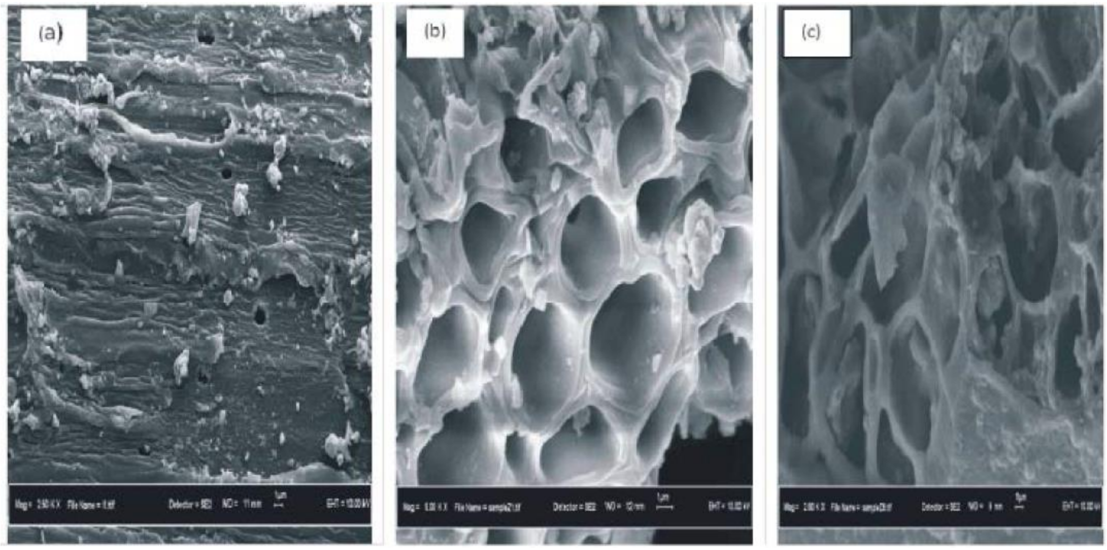


Figure 8. Relationship between Efficiency and concentrations.

Conclusion:

Adsorption of the Chromium has been done. The capacity and efficiency of adsorption was observed. Trunks of palm tree is found to be low-cost material for removing heavy metal such as Chromium from solutions.


(a)
(b)
(c)

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