Adsorption of Chromium (VI) from Aqueous Solution Using Phytoremediation

Huda Hasan Nahar Jasem[1*], Saba. A. Obaid. Al Shiaa[2]

Abstract

The goal of this study is to assess how well sunflower waste can remove chromium (VI) from an under various process settings, an aqueous system is examined. Sunflower stalks were burned to create adsorbents, which were subsequently used to soak up water in a variety of applications. The use of Sunflower (Helianthus annuus L.) It has been investigated as a Cr (VI) reducing agent for the removal of hexavalent chromium from synthetic waste water. Adsorbent properties were determined via the use of ultraviolet (UV), x-ray diffractograms (XRD), infrared (FTIR), and magnetic hysteresis methods. 20 milligrams per liter of hexavalent chromium experiments a study on chromium recovery in batches found that increasing the pH of the aqueous solution enhanced metal recovery. pH = 7, adsorbent dose of 0.03 gr, and 25°C temperature were shown to be optimal for the removal of Cr (VI). Cr (VI) may be removed from synthetic model effluent by using Sunflower, according to the results of this study. The Sunflower plant has successfully cleaned synthetic waste water by rapidly removing Cr (VI) from aqueous solution.

Key Words: $K_2Cr_2O_2$, Sunflower, Chromium Removal, Activated Carbon, Absorption Isotherm.

DOI Number: 10.14704/nq.2022.20.3.NQ22061 **NeuroQuantology 2022; 20(3):204-210**

Introduction

A fatal impact on all forms of long-term life and, these organisms penetrate the food chain response via the channelizing of waste disposal is heavy metallically ionized metal (Makeswari et al, 2014). Among the most poisonous are the metal ions mercury, lead, cadmium, and chromium (VI). Chromium Cr (VI) is amongst the best hazardous heavy metals (Yuan et al, 2010 ; Sun et al, 2011). If a person is poisoned with Cr(VI), the neurological system, blood, living tissue, and bone are all adversely affected. Industrial wastes from leather the processes of magnification, electroplating, and metal polishing all include Cr(VI) (Hu et al, 2009 ; Katz et al 1994). Because of this, removing Cr(VI) from natural waterways and wastewater is a crucial step. Methods for removing Cr(VI) precipitation, ion exchange adsorption, and other processes (IEA), membrane filtering, and solvent extraction (Setshedi et al, 2013 ; Aydın et al, 2009). Adsorption is the most a method that is often used because of its ease of use, high efficiency, and cheap cost (Fan et al, 2012). Many other industries' effluent includes one or more of these harmful heavy metals, including metallurgical, tannery, chemical, mining, and battery manufacture. When metal concentrations in effluents exceed permitted discharge limits, this is a problem (Chen et al, 2011).

If the concentration of these ions is over the pollution level, the discharge of such solutions produces environmental pollution and harms aquatic and human life. Beneficial characteristics include ease of use, minimal processing requirements, high adsorption capacity and selective heavy metal ion absorption, as well as inexpensive costs, free availability and simple regeneration when employing plant wastes for wastewater treatment (Hu et al, 2014).

Corresponding author: Huda Hasan Nahar Jasem

Address: [1*]Department of Physics College of Science, University of Babylon, Iraq; [2]Department of Physics College of Science, University of Babylon, Iraq.

[1*]E-mail: huda.nahar.scihigh89@student.uobabylon.edu.iq

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received: 05 January 2022 **Accepted:** 10 February 2022

As a result, the use of untreated plant wastes as adsorbents may result in various issues, including limited adsorption capacity, excessive COD and BOD (Lovell et al, 2013).
The Asteraceae family includes sunflowers. There are 65 distinct species of Helianthus in the genus (Andrew et al, 2013). There are large, coarsely serrated leaves, a hairy stalk, and a ring of blooms at the top of the plant, which develop into seeds on a receptacle base, all of which characterize it as belonging to this family (Fernández et al, 2014). Researchers are investigating the use of rapid and simple activation of activated carbon nano composites iron salts separation by using sunflower to build an anionic absorbent, as well as the effect of this material on the removal of Chromium (VI) from aqueous solutions.

Methods and Materials

Sunflower Preparation (Helianthus Annuus L.)

Wheat straw, dried $FeCl_3$, sunflower, and a solution of 99 percent ethanol and $FeCl_3$ were soaked for 24 hours in an oven at 60 degrees Fahrenheit Celsius in an oven-dried. Dilutions were made to meet the study's requirements. As a consequence of the fire, a little bit of straw was incinerated and acquired some powder.

Figure 1. Sunflower powder

Chromium Solution

It was possible to generate different quantities of soluble chromium by combining potassium dichromate ($K_2Cr_2O_7$) salt with distilled water. All A 100 rpm stirrer was used throughout the trials, and the temperature was maintained at room temperature.

Adsorption Studies in a Batch

The majority of trials were conducted in batches. By dissolving and diluting a suitable amount of potassium dichromate ($K_2Cr_2O_7$), a stock solution containing 1000 mg/L Cr (VI) was prepared in deionized water. The Cr (VI) concentrations in all experimental solutions were determined by repeatedly diluting the stock solution with water. Each of our equilibrium adsorption investigations was conducted in a thermostatic shaker rotating at a speed of 200 revolutions per minute (rpm) while maintaining a constant temperature (Bhaumik et al, 2014). Throughout the studies, metal concentrations varied from 10 to 50 mg/L, whereas adsorbent doses ranged from 0.03 to 0.1 g/L. A solution of 1250 mg/L $Kr_2Cr_2O_7$ produced by dissolving the compound in 100 mL of water was used as a reference solution for batch adsorption tests. Cr (VI) concentrations in all experimental solutions were achieved by diluting the stock solution numerous times with water. For all of the equilibrium trials, the temperature was controlled and the rotational speed was 200 revolutions per minute (rpm). A study was conducted to determine the effect of solution pH on Sunflower clearance of Cr (VI) as the flowing of equation (Monika et al, 2009).

$$R\% = \left(\frac{Ci-Ce}{C0}\right) \times 100 \qquad (1)$$

The initial and final concentrations of chromium in the solution were denoted by the letters Ci and Ce, respectively. The most frequent experimental method for determining an adsorbent's adsorption capacity is to do a mass balance on a sorbate in a solution volume V. This experiment is often used to construct experimental adsorption isotherms. This equation (2) was used to calculate the equilibrium adsorption capabilities of all adsorbents for all chromium(VI) ion concentrations in our tests (Monika et al, 2009).

$$qe = \left(\frac{CO-Ce}{M}\right) \times V \qquad (2)$$

M denotes the adsorbent's mass (g) that was employed and the solution's volume is V are given Twenty-five milliliters. The adsorption studies, conducted out at a pH of 2.09, used solutions of 100 mg/L Cr(VI) comprising two concentrations (10-50 mg/L) of each of the principal components. The adsorbent used was 20 milliliters of adsorbent at pH 2.09. The adsorbent was removed from the solution after the adsorption process had achieved an equilibrium. After that, the filtrate was examined for the presence of any residual Cr (VI). In order to test the Sunflower's capacity to remove Cr (VI) from real wastewater samples, a sample from the mining industry was used in batch mode. Sunflower extract was shown to be effective in the elimination and recovery of chromium in this investigation. Batch experiments done with varying amounts of chromium revealed that 5 minutes was sufficient to eliminate 90.18 percent of the chromium.

Table 1. Sunflower's capacity to absorb Cr is strongly influenced by the adsorption conditions used (VI)

Adsorption parameters			
Contact time (min)	pH	Dosage (g L^{-1})	Concentration of Cr (VI)ppm
20	2.09	0.03	10
30	3.04	0.05	20
60	5.16	0.07	30
90	6.02	0.09	40
120	7	0.1	50

Results and Discussion

- *Analysis of Adsorbents Using Fourier Transform Infrared*

The functional groups included in adsorbents undergo change. In order to get the adsorbent spectra, many different wave lengths were used in the experiment (500-4000 cm1). The spectra of all adsorbents were plotted on the transmittance axis using the same scale, and the results were compared. According to the FT-IR spectrograms of the adsorbents, the adsorbents are complex in character. As seen in Fig. 2, the FT-IR spectra of both adsorbents (native and chromium-loaded) reveal a strong absorption peak at 3276.75^{cm1}, indicating the existence of a covalently linked hydroxyl group. This functional group seems to be involved in the binding of metal ions. Adsorption on these adsorbents might occur surface precipitation, ionic exchange, physical adsorption, complexation with functional groups on the surface, or chemical interaction at the locations in plain view. The complexation of Cr (VI) with functional groups in the adsorbents is shown by changes in the FT-IR spectra of the samples. Researchers have linked the precursor's sharp bend at 2852.16–2933.13 to asymmetry and harmony in the C-H group's vibrational modes (Nakanishi et al, 1977).

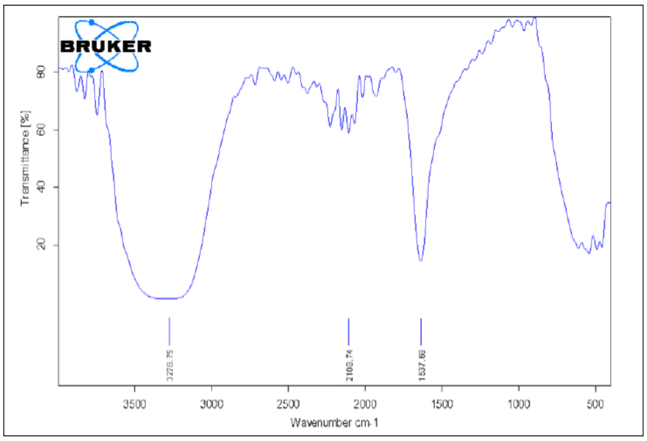

Figure 2. FTIR spectra of native sunflower

Additionally, after being treated with Cr, the magnetic characteristics of the magnetic composites were determined (VI). As seen in Figs. 3a and 3b, the predicted magnetic composition of the composite after treatment with Cr (VI) is 46.74 emu/g and increases to 79.09 emu/g with increasing concentration of Cr (VI). Observations of zero Oe coercivity (coercive force, Hc) superparamagnetic behavior may be seen in both samples and in a normal S curve. The magnetic composite may still be drawn to after being treated with Cr (VI), a permanent magnet (Qiu et al, 2015). 206

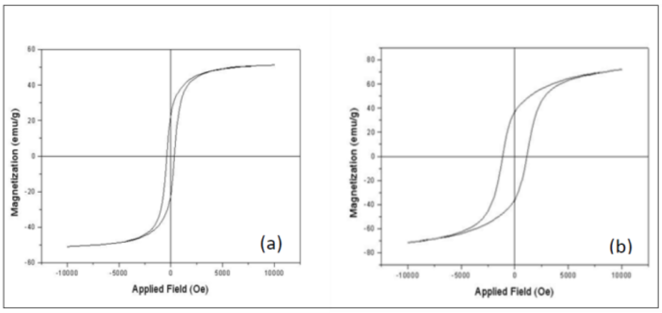

Figure 3 (a, b). Diagram of activated hysteresis nanocomposites

- *Diffraction of Light in the form of x-rays*

It is a non-destructive and adaptable approach for categorizing materials that may be used to determine their composition (Gan et al, 2015). Examples of such characteristics include the study of crystalline phases seen in dense materials as well as the structural aspects of these states, which include parameters like as stress, grain size, phase structure, crystal orientation, and defects. As shown in Figures 4a, 4b, 4c, and 4d, XRD investigations indicated that the produced nano-composite was magnetite (Fe_2Cl_3). Two-dimensional (two-dimensional) diffraction peak at 2 = 40.331 demonstrates strong crystallinity of Fe_2O_3 nanoparticles, and the crystallite size decreases with increasing concentration of Fe_2O_3 nanoparticles This phenomenon may be explained by the fact that the solution has a crystal defect and then becomes well-arranged and increasingly crystalline, eventually reaching the nanoscale. The Debye – Scherrer equation (Zhao et al, 2013; Villaescusa et al, 2004). was used to determine the average dimension of the crystallites. This equation is as follows:

$$D = K \lambda_{cu}\text{-}K_{\alpha} / \cos \theta \ FWHM$$

$$D = 0.9 \lambda / \beta \cos \theta$$

Where:

D: crystallites size, The a coefficient (0.89), the wavelength of light produced by the diffraction tube (cu-K), and the full width at half maximum (FWHM) of diffraction are all shown on a two-dimensional scale (rad)

θ: The Bragg angle of diffraction.

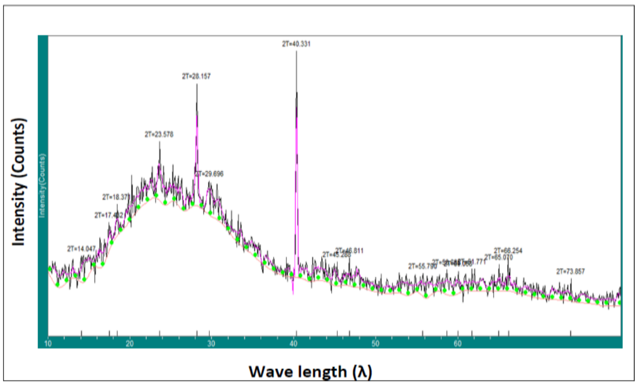

Figure 4 (a). Scheme of XRD with concentration 0.7 gr of sunflower nanocomposite

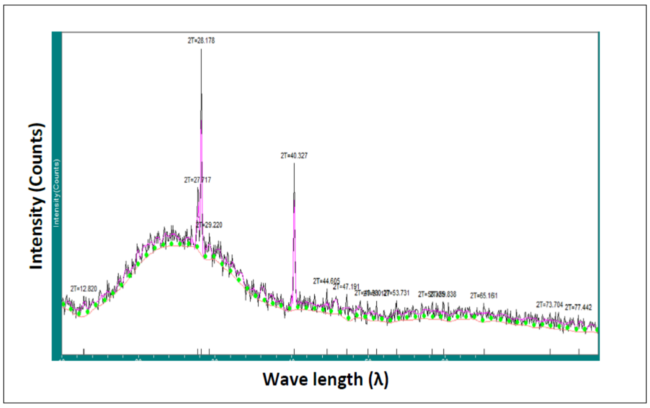

Figure 4 (b). Scheme of XRD with concentration 1 gr of sunflower nanocomposite

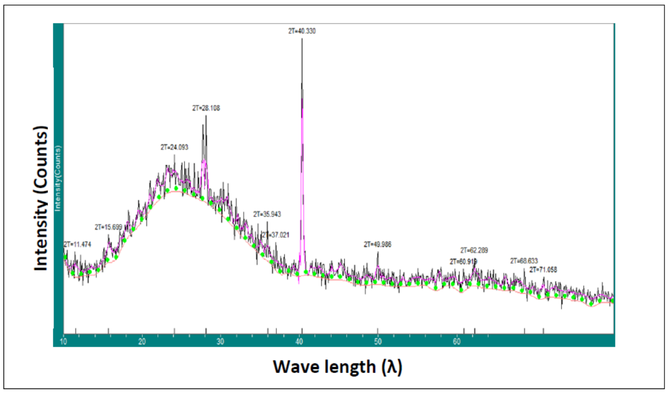

Figure 4 (c). Scheme of XRD with concentration 1.5 gr of sunflower nanocomposite

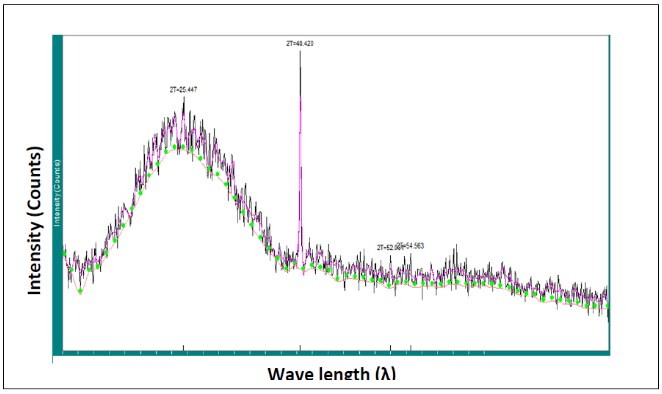

Figure 4 (d). Scheme of XRD with concentration 2 gr of sunflower nanocomposite

- *Effect Concentration of Chromium (VI)*

Cr (VI) removal from sunflower in relation to concentration was studied at a fixed temperature while all other variables remained constant (25 C). The Cr (VI) concentrations were varied between 10 and 50 mg L-1 while all other parameters were kept constant. Figure 8 depicts the results of the adsorption of Cr (VI) by the sunflower. For constant contact time and higher ionic strength, removal percentages declined with rising concentrations of Cr (VI). For constant contact time and lower concentrations, the removal percentages dropped to 10% to 50% at 10 to 50 mg L-1 and 10% to 20% at 10 to 50 mg L-1, respectively. The adsorption percentage dropped from 80% to 10% when the concentration was raised from 10 - 50 mg L-1. As Cr (VI) concentrations increase, the adsorption percentage decreases, most likely owing to the saturation of active sites on the sunflower surface. Increased Cr (VI) concentration, on the other hand, increased the amount of Cr (VI) adsorbable per sunflower mass. To get through the mass transfer barrier, the higher initial concentration of Cr (VI) serves as a forceful pushing force for Cr (VI) transfer

eISSN 1303-5150

from solution to sunflower surface. The researchers' results (Lv et al, 2014). are equivalent to those of this study.

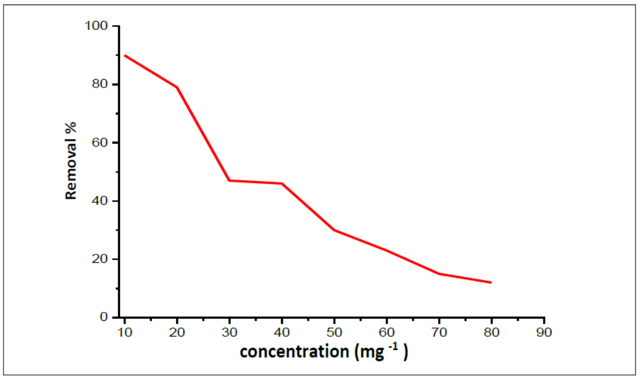

Figure 8. Diagram percent absorbed by different concentrations solution of Chromium

- *The pH of a Solution Affects Chromium Solution Absorption (VI)*

The ionic forms of metal ions in solution and the adsorbent's surface characteristics are both altered by pH, making it an important factor in the adsorption process. As a result, pH has an effect on a solution's adsorption capability. Chromium concentration was set at 50 mg/L, and adsorbent dose was set at 0.03 g; the mixture was left to agitate for two hours before the experiment was completed at pH 2.09–7.0. The greatest absorption occurs in liquids with a pH of 7:2, which is acidic. CrO^{4-} and $HCrO^{4-}$ions reveal that absorption is often seen at acidic pH values in the presence of these ions (Fig 9). Adsorption of Cr (VI) ions from water by Cu-Zn particles showed a similar phenomenon (Kaprara et al, 2013). Which was previously described.

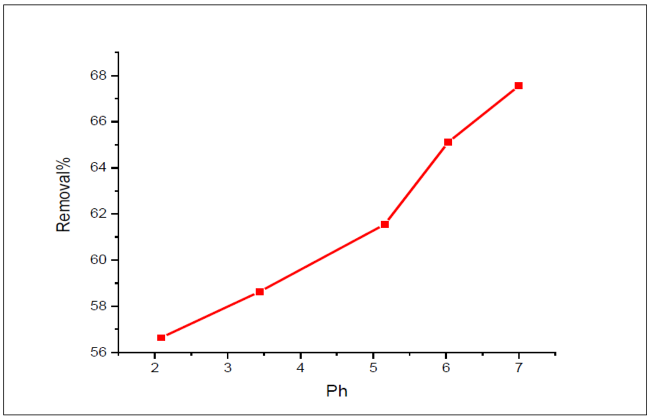

Figure 9. Curve the percentage of amounts solution pH

- *The Influence of Contact Time*

Considered to be crucial factors to consider design is a big part of making sure that wastewater treatment systems work well. The equilibrium period between adsorbate and adsorbent (the time it takes for the adsorbate and adsorbent to reach equilibrium) (Fig. 10). This figure depicts the influence of contact time on the proportion of Cr (VI) removed from solution onto Sunflower. To remove the Cr (VI) more effectively, the contact time between the Cr (VI) and the sunflower was increased from 20 minutes to 120 minutes, which made it more effective by 12% to 82%. Because of the huge number of available unoccupied sites, an equilibrium adsorption of Cr (VI) ions may be detected within 120 minutes after the start of the experiment. Because of the decreased availability of the remaining active sites as well as the reduction in driving power, the adsorption process becomes more time-consuming. As a result, the optimal contact time for Sunflower adsorbent at the 50 mg L-1 concentration was 120 minutes. The findings of this study are consistent with the findings of the researchers (Chen et al, 2009).

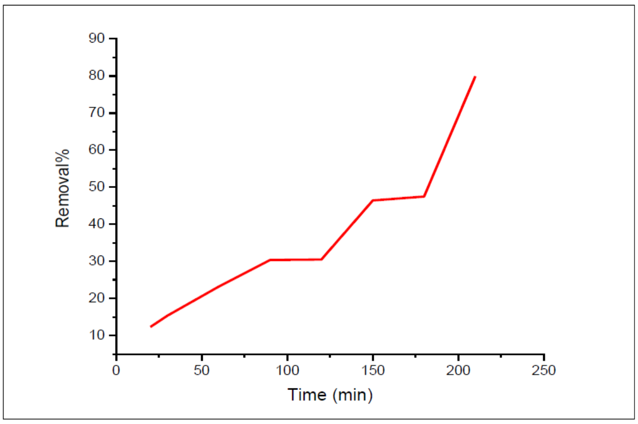

Figure 10. Curve the percentage of absorption of various time duration

- *The Effects of Adsorbent Dosage Include*

By examining the effects of magnetic activated carbon adsorbent on the removal of chromium, the researchers discovered Sunflower extracts of 0.03, 0.05, 0.07, 0.09, and 0.1 g were tested for their purity. The specific absorption rate and the total volume level of porous matter are dependent on each other in this investigation. At different phases of testing, a total of 25 ml of solutions with a constant concentration of chromium of 30 ppm were added to the mixture. The solutions were agitated for 120 minutes while containing adsorbent. The largest amount of sunflower oil absorbed at 0.03 gr of sunflower oil is adsorbent (see Fig 11). As the absorbent dosages of 0.03 gm are increased, it is shown that the absorbent of composite nanoparticles glomerate diminishes as a consequence of the reduction in free surface area available for absorption. As a result, even when the absorbent dosage increases, the absorption rate remains constant and will not increase (Obaid et al, 2019).

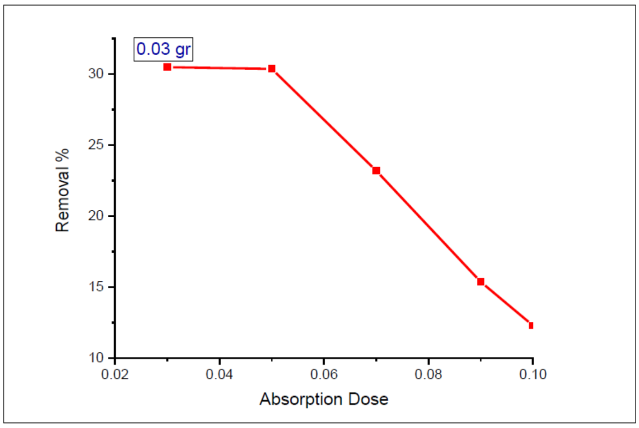

Figure 11. Show increasing the absorption rate is fixed and will not increase the dose adsorbent

Conclusions

The current investigation is concerned with the adsorption of Cr (VI) to be dissolved in water solution utilizing as an efficient toxic. It was discovered that as the concentration of Cr (VI) increased, the percentage adsorption of Cr (VI) dropped. In light of the fact that, for a constant adsorbent dose, the total number of adsorption sites was restricted, the percentage removal of the adsorbate decreased in response to a rise in the concentration of the adsorbate, as was predicted. The pH of the reaction mixture has an enormous influence on Cr (VI) efficacy reduction, with rising pH resulting in a decrease in Cr (VI) concentration. By increasing the strength of diffraction peaks, X-ray diffraction investigations verified that the produced nano-composite was magnetite (Fe_2Cl_3), indicating that the material was magnetite.

Sunflower, an abundant agricultural waste from biodiesel production, has been used for the removal of Cr (VI) from aqueous solutions, according to the findings of the current research. This has resulted in the development of new and more ecologically friendly cleansing methods.

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