

## Removal of Toxic Cr (VI) from Polluted Water for Low-Cost Activated Carbon Using Vernonia Cinneria

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### Keywords

Chromium(VI), adsorption, Vernonia Cinneria activated carbon, Adsorption isotherms and Kinetics, Characterization studies, application.

### Abstract

The main intent of this paper is to assess the biosorption potential of Cr(VI) based on Vernonia Cinneria bark activated carbon. The adsorbent is characterized based on the energy dispersive X-ray spectrometer, X-ray diffraction spectrometer, Fourier Transform Infrared and scanning electron microscope. The variables of biosorption are pH, Initial concentration of Cr (VI), contact time and process temperature. pH level is optimized at 2. The adsorption isotherms express the models of Langmuir, Freundlich, Temkin & D-R adsorption. Effective experimental data is obtained from the Langmuir adsorption model Compared with other models. Kinetic models applied to the adsorption of Cr (VI) ions and compared with pseudo first-order, the pseudo second-order, Elovich and intraparticle diffusion kinetic models. From result it is shown that experimental data is correlated with the pseudo second-order kinetic model.

### Introduction

In the hexavalent and trivalent forms, the contaminants of chromium are present. In human nutrition, Trivalent chromium plays important role in the hexavalent chromium to recognize mutagenic agent. The liquid waste of other metal processing performs refining operations of hexavalent chromium like leather, tannery, metallurgical dyes, paint industries, textile, electroplating, galvanizing, pigment and other considerable amounts which consists of very small and large scale sector. The International Agency for Research were considered by Chromium (VI) on Cancer about the process of DNA transcription which is an powerful agent that modifies on carcinogenic which is caused by some important exposure of long-term chromosome. Cr (VI) compounds cause some skin diseases like sensitization, ulceration, nausea, epigastria pain, severe diarrhea, hemorrhage, ulcer, vomiting, birth defects, tissue necrosis, lung cancer, & kidney damage etc.

The survey of Literature is commonly used as adsorbed activated charcoal that shows carbon; that the adsorption

becomes more dangerous expensive as a result it is increasing from the cost of disposal.

The alternate innovative biosorbents for search the wastage of agricultural had attention on the removal of heavy metals during recent years

the credibility has gained because of low cost, good performance. For the removal of Cr (VI) from aqueous solutions and waste water from industrial at solid some researchers have made different contributions in this area. utilizing a number of natural materials of Solution interface were used for the removal of chromium such as charcoal, peel of banana, seaweed, dead fungal biomass, cyan bacterium, green algae wool, olive cake, sawdust, pine needles, almond shells, cactus leaves, charcoal, used tires, soot, hazelnut shell, coconut shelled etc. There are some agricultural wastes which are mainly composed of structural biopolymers. it is embedded in the cellulose of matrix like other cellulose of heavy, nitrogen-containing substances, minerals, organic acids, lignin, pectin, waxy substances, etc. The highly functionalized linear stiff chain of cellulose is homo polymer, it is characterized by

its biodegradability, hydrophilicity, hilarity, modifying chemical board Capacity.

The natural adsorbents of potential raw material makes heterogeneity for many industrial applications of an absorbed perfect environmental cleaner. The efforts are converted the inexpensive into biomass, to get the absorbed effective. The paper aim is to prepare eco friendly Veronica canneries as a low-cost activated carbon for the de pollution of water effluents contaminated by heavy metals from industry.

To find out the suitability, applicability of the adsorbent prepared from NVCC to uptake Cr (VI) from simulated waste water.

## II. Experimental

### Methods and Materials

#### 2.1 Chemicals and Reagents

The reagents and chemicals which are using in the investigation of present it is purchased from the India Pvt. Ltd of Merck. All the augmented reality grade reagents were prepared by the are Sd. Fine Chemicals is washed by double distilled water. A stock solution of the adsorb ate was prepared by dissolving the exact calculated quantity of Potassium dichromate in doubly distilled water.

#### Adsorbent materials



**Fig.1:** Vernonia cinerea plant

The active carbon prepared from stem of **Vernonia cineria** was used for Chromium (VI) removal from waters. The Vernonia cineria is about 1000 species of a genus in the family asteraceae and it is a flowering plant. Some of the species are known as **Ironweed**. The species are of economic value which is edible. These species flowers are known by having

extreme purple flowers. The name of the genus is kept by the English botanist William Vernon. There are different number of subgenera and subsections in this genus species. The botanists divided the large number no. of species into different genera. For example the *North America* plants recognizes the 20 species, the 17 species are in are in North America of north Mexico, and the other are South America.

#### 2.2. Absorbed Preparation

Activated carbons were prepared from Vernonia cineria plant stem material. For two days the raw material was dried under sunlight and washed with double distilled water. In muffle furnace materials was carbonized for 4 hours and the dried plant in the absence of air at 500°C. By washing with double-distilled water the carbon is dried at the oven air at 110°C . it can be removed in the desired particle sizes after the carbonization. For removing the unwanted materials the materials of carbon was subjected to the oxidation of liquid phase. It was treated with 0.1 nitric acid and it was boiled for 2 to 3 hours. The excess acid of prepared active charcoal to remove and was dried at 110°C for 5 hours in an air oven & the carbon treated acid is thoroughly washed with double-distilled water. The activated charcoal prepared from the stem of Vernonia cineria plant of Nitric acid was named as 'NVCC'.

#### 2.3. Characterization of Adsorbent

By using standard testing methods the parameters were analyzed. The adsorbed activated charcoal is widely used by its capacity of high adsorption, surface area of high, the structure of micro porous has the degree of high surface respectively. The structure of chemical nature pores were usually determines by the activity of sorption. In the Table 1 there are some important physical and chemical characteristics of NVCC were given. The absorbed activated charcoal of pH value was determined by using the meter of Ellice pH, model is LI-120 and the equilibrium method of pH is determined by the pH<sub>ZPC</sub>. The size of the Particle was determined by the Test Method of Sieves by using American Standards. There are other parameters such as density of apparent, Iodine numbers, power of decolorizing, moisture, Ignition loss, Ash, soluble of acid matter. The matter of water soluble by using these standard test methods it is analyzed. The surface area of the prepared activated charcoal buraneur-Emmet-teller is determined by using the analyzer of gas nitrogen at 77k Quanta – Data Acquisition

of Nova chrome and the version of instruments Reduction 10.01 for NOVA. The adsorption of surface area of the equation buraneur-Emmett-teller by applying the BET to the data was obtained. The active charcoal estimates the surface of acidic and basic groups on the Boehm titration method.

**Table: 1**The NVCC characteristics on Physical and chemical reaction.

**SAMPLE NAME: NVCC**

S. No	Character (Units)	Results
1	Bulk Density in gm/cc	0.273
2	Moisture Content in %	8.123
3	Loss on Ignition in %	83.663
4	Ash Content in %	5.577
5	Particle Size in $\mu\text{m}$	
6	pH	7.813
7	Point of zero charge	7.267
8	Water soluble Matter in %	4.12
9	Acid soluble Matter in %	38.29
10	Iodine Number mg/gms	414.333
11	Decolorizing Power in mg/gms	263.67
12	BET Analysis –surface area, $\text{m}^2/\text{g}$ Before After	462 396
13	Surface Functional Group in %	0.314
13 a	Carboxyl	0.018
13 b	Lactone	0.011
13 c	Phenol	0.698
13d	Total Basic Groups	0.314

### 2.3.1. FTIR analysis

By using Fourier Transform Infrared Spectroscopy the NVCC was examined. by mixing 1 mg of powdered active charcoal sample discs were prepared, in an agate mortar NVCC, with 500 mg of KBr then the mixture is successively resulting pressure for 5 min of 6 tones/ $\text{cm}^2$ ., 10 tones/ $\text{cm}^2$  another vacuum in 5 min,. The measured form of the spectra was 400-4000 $\text{cm}^{-1}$  with HATR Spectrum One Perkin Elmer, USA ID No: SN/LE-735/00735.

### 2.3.2. Microscopy of scanning electron

The most different instruments is scanning electron microscope (SEM) it is available for the analysis and the

examination of the morphology microstructure, the characterizations of chemical composition.

The photographs of micro NVCC were recorded by using the model of Hitachi SEMSu1510 and the voltage beam of magnifications is 500 to 2000V, the resolution to 65,000 is 3nm at 1000V.

### 2.3.3. The spectroscopy of Energy dispersive x-ray (EDX)

The analytical technique used for the elemental analysis is Energy dispersive x-ray spectroscopy in a sample. By allowing the set of peaks each element has its different atomic structure in the spectrum of X-ray and by using the EDX Analyzer it was recorded for NVCC the voltage at 5 kV accelerating, at high vacuum mode.

### 2.4. The Chromium (VI) removal of activated charcoal by using Nitric acid

#### 2.4.1. The procedure of Experimental

The removal of Chromium studies of batch adsorption were adopted the form of water waters. A 50mg/lit of Chromium solution was used in all the experiments. In a 250ml conical flask 100ml or 50mg/lit and the solution of Chromium is pipette out in a room temperature at  $30 \pm 1^\circ\text{C}$  . the quantity of weighed is prepared the absorbed NVAC which is horizontal shaken the conical flask at 120 rpm. It is stand for 2 min after the equilibration time, the settling absorbed by using the filter paper. For residual Chromium concentration the filtrate was analyzed by the methods of SPADNS using the Spectrophotometer of UV- Visible (Model No: Eli co U.V-2600) and the Standard Methods of Water is described in the Analysis of Waste Water at  $\lambda_{\text{max}}$  570 nanometer.

#### 2.4.2. The analysis of Chromium ion

The removal of Cr (VI) ion percentage and the adsorbed amount of (in mg/g) were calculated by using the following relationships:

$$\text{The Percentage Removal of R is} = \frac{C_i - C_e}{C_i} \times 100$$

$$\text{Adsorbed Amount (q}_e) = \frac{(C_i - C_e)}{m} V$$

Where  $C_i$  = the concentration of the Chromium (VI) ion solution in Initial is mg/lit

$C_e$  = the concentration of Equilibrium Chromium (VI) ion solution is in mg/lit



M = the absorbed mass in grams

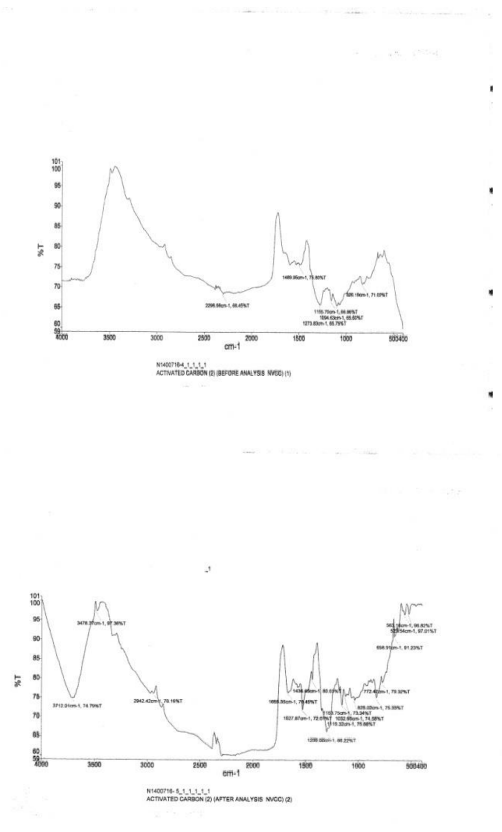
V = the Volume of test solution of Chromium (VI) in liters and the procedures of experiments of parameters has been adopted of physicochemical which is carried out by varying the dosage of absorbed, Chromium (VI) of solution pH, time of agitation, the concentration of Chromium (VI) solution at initial, size of the particle, the presence of foreign ions in temperature.

### III. Results and Discussion

#### 3.1. The Characterization of activated charcoal by using nitric acid

In Table 1 there are some important features of different properties of physical and chemical of the charcoal, and the NVCC, were presented. The absorbed NVCC is favored to the adsorption of  $\text{pH} < \text{pH}_{\text{ZPC}}$ , as a cat ion. The absorbed Chromium (VI) ion adsorption indicates the surface area of brunauer-Emmett-teller. From the Table 1 the functional groups were determined according to Boehm titration methods like oxygen, Phenol, Carbonyl, Hydroxyl and lactones it is declared that the acidic groups were greater than the basic groups.

##### 3.1.1. Analysis of Fourier infrared spectroscopy



**Fig.2:** the adsorption of chromium on Fourier infrared spectroscopy on NVCC

**Table 2:** the before and after analysis of adsorption bands were assigned to the functional groups of NVCC

S.No:	Wave number (cm <sup>-1</sup> )	Bond Stretching
1	NVCC (before) 3688 NVCC (after) 3712	-O-H in Alcohols, Acids Phenols
2	3398 3478	-N-H- in Amines and Amides
3	2925 2942	aliphatic asymmetric C-H Stretching vibration of Ethylene group
4	2359 2343	C=C stretching vibrations
5	1489 1436	COO <sup>-</sup> , C=C C=N stretching vibrations
6	1273 1299	presence of -SO <sub>2</sub> H group
7	826 828	S=O stretching vibrations
8	652 658	C-S stretching vibrations

On the specific functional groups the surface of materials of charcoal the provides evidence for the presence of

Fourier transform infrared (FT-IR) spectroscopy. As shown in the Fig.4 there are several characteristics bands were observed in the spectrum of Fourier infrared spectrum of NVCC shown in each and every band of specific functional group is based on the literature made in the previous assignments. Even though on the surface of the carbon there are many functional groups which were present.

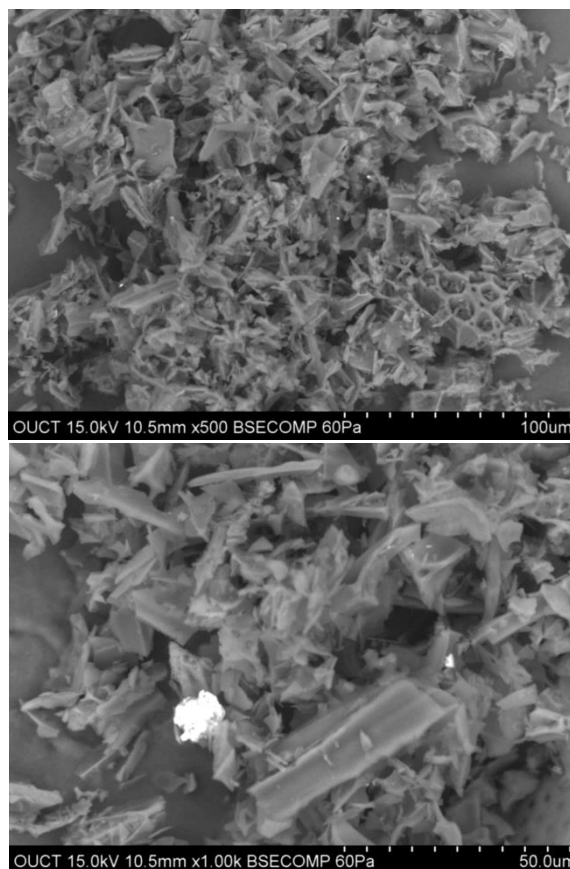
The before and after analysis of Fourier infrared spectroscopy of NVCC confirmed the Chromium(VI) occurrence & there were some changes of adsorption on the active charcoal as it shifted. It decreases the percentage of transmittance in Fourier infrared spectroscopy on the surface of the solid in the range  $400-4000\text{cm}^{-1}$ . The charcoal was subjected by the oxidation of the concentrated nitric acid; the prominent among them were a sharp and intense band at  $3688\text{cm}^{-1}$  which was attributed to the O-H stretching vibration of acids, alcohols & phenols. In the addition of an intense broad of the observed band range of  $3200 - 3600\text{cm}^{-1}$  and centered at  $3478\text{cm}^{-1}$ , the vibration of N-H stretching Amines, Amides to the spectral peaks at  $2942\text{cm}^{-1}$ . It is due to the asymmetric of aliphatic and the stretching vibration of C-H ethylene group.

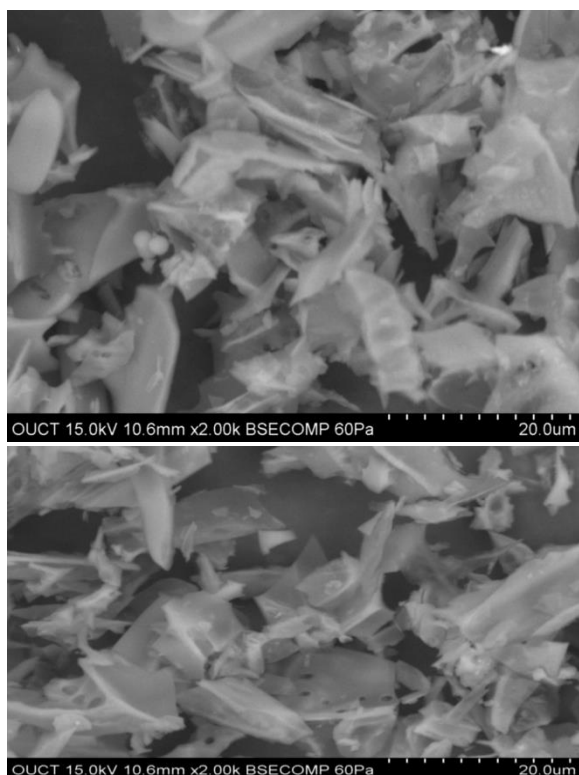
The peaks at  $2361\text{cm}^{-1}$  was due to the presence of  $\text{C}=\text{C}$  stretching vibration. A wide band range is  $1489-1436\text{cm}^{-1}$  and it is due to aromatic and stretching vibrations of aliphatic  $\text{C}=\text{C}$ . A band at  $1273\text{cm}^{-1} - 1299\text{cm}^{-1}$  are due to the presence of  $-\text{SO}_3\text{H}$  group, indicates the favorable for ion exchange mechanism. The stretching vibrations range peaks is  $\text{S}=\text{O}$  due phenols, alcohols, acids, ethers and esters is the  $826-828\text{cm}^{-1}$ . A peak at  $658\text{cm}^{-1}$  is due to C-S stretching vibrations. The peak pertains the absence of specific C-Cr, suggested that the process of adsorption is 'physisorption' but not chemisorption.

### 3.1.2. The Search engineer marketing Analysis (Vide Fig.3)

The search engineer marketing have studied the Photo Graphs about the characteristics of features such as of surface pore, the particles shape & size and the carbons surface (morphology), the activated charcoal of relative amounts is composed of elements and the arranged atoms composition are in the information of crystallographic. In the graphs of micro the areas of dark indicates the small holes and the grey colors of areas indicate the matrix of carbon. In the carbon matrix the small areas of activated charcoal indicates the electrons of zero density.

The surface area of adsorption through out the particle posses the distribution which vary the shapes, sizes of the volume constitute the elements. The graphs of micro indicates the grey surface area contains the micro particles of which indicates the carbon surface of activate sites of functional groups. The search engineer marketing features of make the instruments of different potent and the surface chemistry of the activated charcoal. The search engineer marketing of the images of NVCC surfaces shows the charcoal externally after the reaction with Chromium (VI), the surface of morphology on the NVCC changed and smoothened surface occurred. The coverage of Chromium (VI) ions of the surface area of NVCC of adsorption of Chromium (VI) may be due to the presence of small holes and the active groups on the micrographs of search engineer marketing proved the adsorption of Chromium (VI).

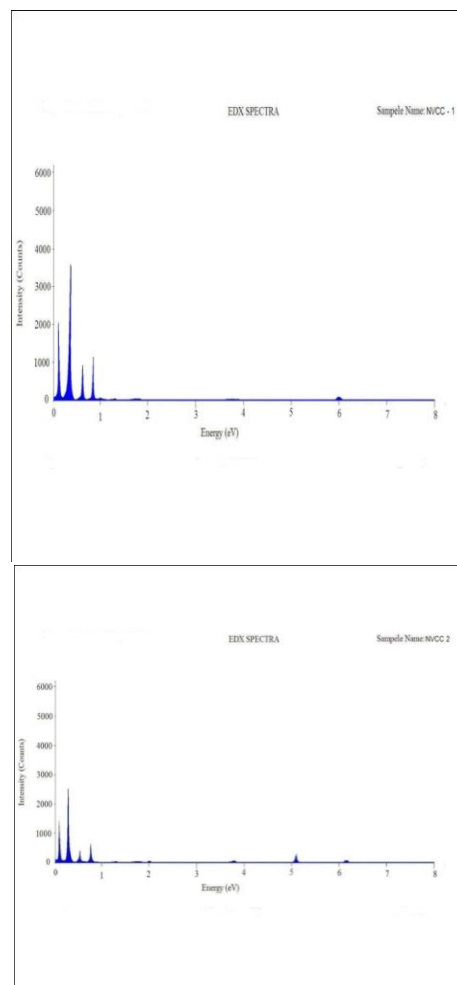




**Fig.3:** The left and right magnifications at X100 and X50 analysis of NVCC of the search engineer marketing

### 3.1.3. The Elemental Analysis of energy dispersive x-rays

When search engineer marketing of energy-dispersive X-ray's spectroscopy is equipped with the (EDX) and the composition of the element is possible to get information about the surface of the charcoal of activated. The analysis of Energy- dispersive X- rays of Carbon and Oxygen ions was highlighted the in the presence of Chromium (VI) as shown in the fig.4. The samples of untreated and treated principle elements other than the Nitrogen is present in a small content and the amount of Carbon and Oxygen is small. The Nitrogen activation is prepared with Nitric acid of carbon. It is concluded that the concentration element of Oxygen has reduced and the concentration of Chromium (VI) is simultaneously the process increased the Chromium ion replace adsorption and the Oxygen atom (OH<sup>-</sup>) containing on the absorbed surface. The energy dispersive x-rays provide the direct evidence that the Chromium (VI) on the surface of NVCC has been adsorbed.



**Fig.4:** The spectra of EDX on NVCC after and before analysis

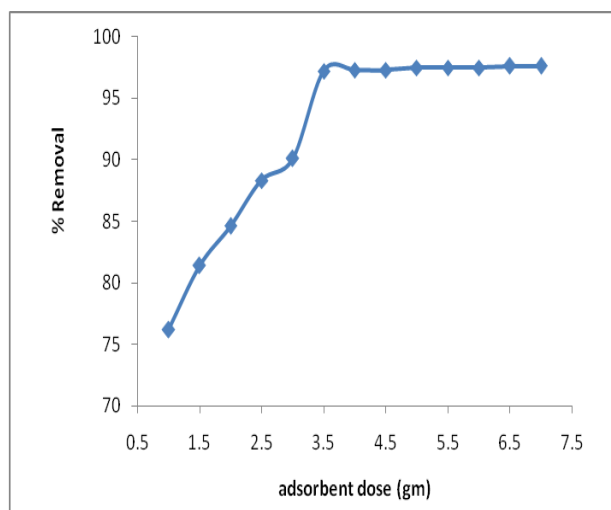
**Table 3:** The analysis of Elemental on NVCC after and before analysis

EDX - Elemental Analysis (before)						EDX- Elemental Analysis (after)				
Composition	CK	NK	OK	CrK	Total	CK	NK	OK	CrK	Total
Energy (eV)	0.3	0.5	0.7	5.2		0.3	0.5	0.7	5.2	
Wt%	62.3	14.3	23.4	--	100	60.1	13.3	16.5	10.1	100
<b>(Mass ratios)</b>										
At%	59.1	15.0	25.9	--	100	62.3	12.7	15.9	9.1	100
<b>(Atomic Percentages)</b>										



### 3.2. The absorbed dosage Effect:

The removal of Chromium (VI) ion effect of absorbed dosage from the waste waters and it was studied. Varying the concentration of adsorbent from 1.0g-3.5g/lit, the extraction of initial concentration of Chromium at optimum conditions is: 50mg/L; and the time contact is: 100 min at 50°C in the fig.5 the results were depicted.



**Fig.5:** The absorbed amount of removal of Chromium (VI) ion percentage plotted and the function of adsorbent dose

The removal of Cr (VI) ions percentage was found to be increasing with increase in the adsorbent dosage. It is found that the fact of dosage increases the active sites and the availability number of the results increases the percentage removal of Chromium (VI) ions.

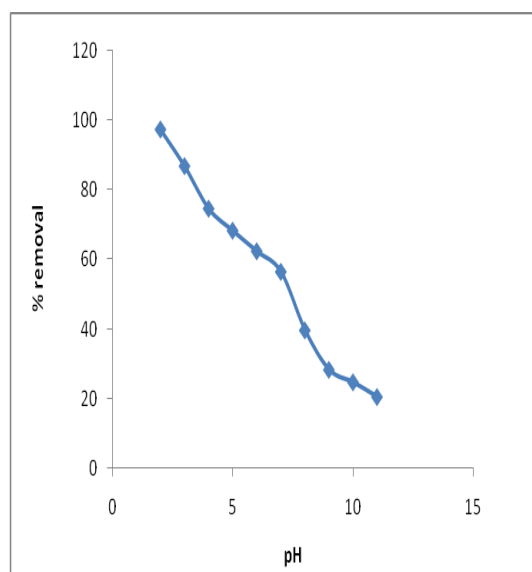
### 3.3. The pH Effect:

The effect of pH solution is affected by the strong process of adsorption. The effect of pH changes was studied by the adsorption changing the pH contents from 2-10, the metal solution of dilute HCL and NaOH.

In the fig.6 that adsorption is maximum, when the metal takes place in the acidic media. The adsorption of Maximum Cr (VI) was observed at the level of PH. The literature of Published shows the level pH value that is very high and very low and the surface of adsorption is surrounded by mainly cations and anions(  $H^+$ ,  $OH^-$ ). The process of adsorption decreases when the metal ions compete with the positively and negatively charged ions. This is the reason that the metal pH show very high and low level of adsorption. The, precipitation of hydroxide

metal ions also occurs at pH values of high basic, It is not good for adsorption.

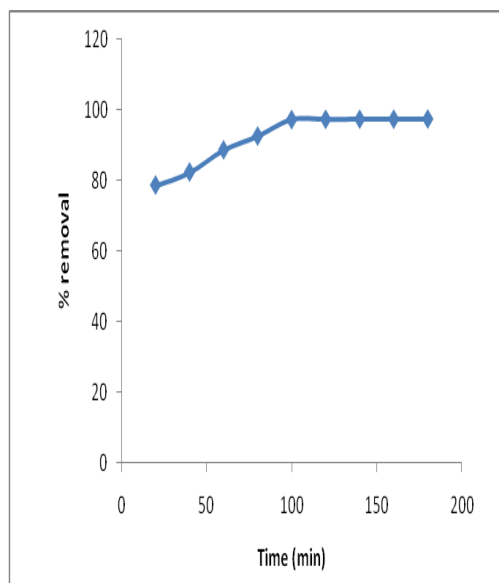
The adsorption phenomenon is related with the functional groups of pH which is also present on the adsorbent. The potential binding sites of on the adsorbent are amino groups, hydroxide groups and carboxylic groups, carbohydrates. At different pH values the functional groups might ionize or dissociate. In the adsorption process functional groups of the surface chemistry also plays an important role.



**Fig.6:** Plot of percent removal of Chromium (VI) as a function of pH

### 3.4. The Effect of time contact

The adsorbed Chromium (VI) ion between the contact time and the percentage removal of Chromium (VI) ion had founded the effect. The experiments of adsorption at optimum conditions were conducted the pH level is: 2.0, and the Chromium (VI) concentration is: 50 mg/lit, the dosage of adsorption is: 3.5g/lit and the temperature is 50°C and it is varying between the contact time from 100 to 10 min. The percentage of results were obtained which is plotted in as shown in Fig.7 the removal of Chromium (VI) ion Vs contact time (min)



**Fig.7:** The Plot percentage of removal of Chromium (VI) and the function of contact time (min)

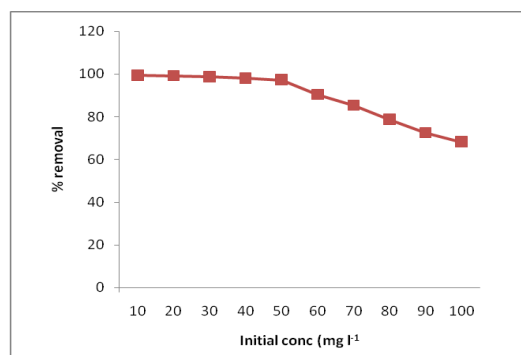
The percentage removal of Chromium(VI) is increasing with the time almost attained the condition of equilibrium is about 100 minutes. The adsorption rate of solute is equal to the desorption rate. The removal of Chromium (VI) ion decrease, particularly towards the monolayer of Chromium (VI) which indicates a possible activated charcoal outer interface from the intra particle diffusion on the surface of inner the particles of absorbed during the experiments through different agitations maintained.

The Chromium (VI) removal by the absorbed samples from the initial periods at rapid with the time it is slowed down of 100 and the stagnated minutes contact time. The removal of Chromium (VI) increases relatively in to some extent after 100 minutes it was lowed from the contact time substantially at the optimum active charcoal is fixed. It is indicated that the removal of Chromium (VI) is in the higher stages the availability of surface area is initial due to the adequate of the absorbed. The contact time is increasing, the adsorption process was attributed and decreased in the active sites. The curves are single, smooth and continuous indicating the removal of was the Chromium (VI) ion coverage on the absorbed monolayer surface.

### 3.5. The initial Effect of concentration adsorb ate

The Chromium (VI) initial concentration effect on the extent removal of ion in terms adsorbed amount of the Chromium (VI) on the absorbed NVCC and it was studied with a fixed amount of absorbed: 3.5g/L, and time of

constant agitation is 100 min and temperature: 50°C, the initial concentration of Chromium (VI) is varying between 10.0 to 50.0mg/L. And initial concentration of the Chromium (VI) will be decreased. This is due to absorbed surface of available active sites on the lack of sufficient number of relatively large number of active sites required for the high initial concentrations of Chromium (VI) ions adsorption.



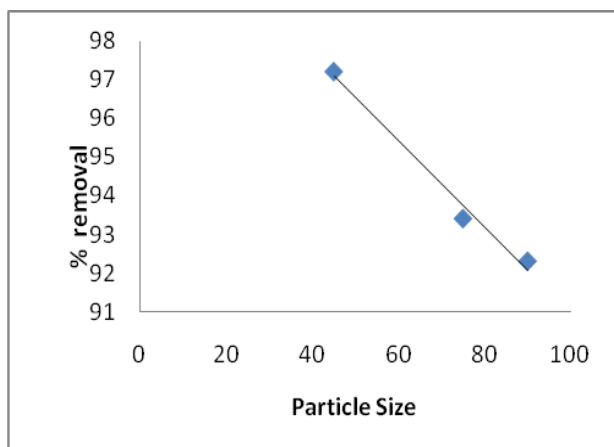
**Fig.8:** The percentage removal of Chromium (VI) and the function of concentration of Chromium (VI) ion solution

The concentration of Chromium from increased 100.0 mg/L to 10.0, and percentage of removal of Chromium is observed that as decreased from 99.4 to 68.10. it was noted that the adsorbed amount of Chromium (VI) on the absorbed NVCC, exponentially increased with the increasing the Chromium (VI) at initial concentration. The fixed amount of Chromium (VI) adsorption changed the concentration of Chromium from 1.0g/L to 3.5g/L and increased from 10 to 100 mg/L.

### 3.6. The Particle Size Effect

The studying percentage of removal of Chromium (VI) ion and the particle size effect was explored at optimum conditions the removal of particle size from 90 $\mu$  to 45  $\mu$  mesh which is namely extraction at 2.0: pH time of contact: 100min, dosage of absorbed: 3.5g/lit, Chromium (VI) ion solution concentration is: 50.0mg/lit, temperature at : 50°C. In Fig.9 the percentage of removal of Chromium (VI) ion Vs Particle size results were obtained.





**Fig.9:** the percentage removal of Chromium (VI) ion and the Particle Size function

The percentage removal of Chromium (VI) ion increases and the size particle decrease in absorbed activated charcoal and the graph shows that the particle size will be lesser and the surface of active sites will be available. But in the large sized particles, the surface number of sites will be insufficient, the Chromium (VI) ion removal of percentage had been decreased. the absorbed particles of charcoal at optimum size were 45 $\mu$ .

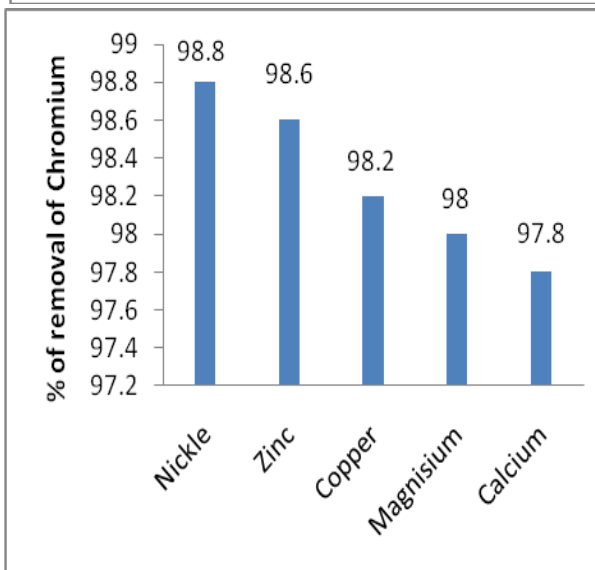
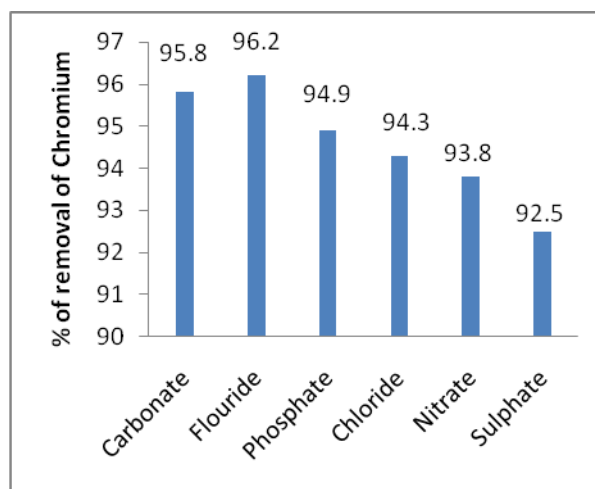
### 3.7. The adsorption of Chromium (VI) on the Effect of co-ion

The % removal of Chromium (VI) on the effect of co-ions was studied by NVCC of concentrated co-ions with 50 mg/lit and it is found commonly in waters such as sulphate, phosphate, chloride, fluoride, nitrate, carbonate, calcium, magnesium, copper, zinc and nickel. In Table 4 the results were obtained under extraction of optimum conditions namely pH: 2.0, time of contact: 100min, dosage of adsorbed: 3.5g/lit, Chromium (VI) ion solution concentration is: 50.0mg/lit, temperature: 30<sup>0</sup>C and size of the particle: 45 $\mu$  mesh.

**Table 4:** the removal of Chromium (VI) ion from aqueous solution on the Effect of co-ions by the activated charcoal: NVCC

S.No	Adsorbent	Maximum Extractability at Optimum conditions	Extractability of Chromium (VI) ion in presence of 50mg/lit of interfering ions at optimum (PHS)
1	NVCC	97.2%	92.5 96.2 93.8 94.3 94.9 95.8 97.8 98.0 98.2 98.6 98.8

1 NVCC 97.2% 92.5 96.2 93.8  
 94.3 94.9 95.8 97.8 98.0 98.2 98.6 98.8  
 pH:2 pH:2 pH:2 pH:2 pH:2 pH:2 pH:2  
 pH:2 pH:2 pH:2 pH:2 pH:2 pH:2 pH:2  
 100 min



**Fig.10:** The (%R) of Chromium (VI) ion on the Effect of co-ions onto NVCC

### 3.8. Effect of Temperature

QQZ

$$\Delta G = -RT \ln K_d$$

$$\ln K_D = \Delta S/R - \Delta H/RT$$

$$K_d = q_e/C_e \text{ and}$$

$$\Delta G = \Delta H - T\Delta S$$

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Where  $K_d$  is the adsorption coefficient for distribution, and

$q_e$  is the adsorbed activated charcoal on the amount of fluoride ion

Equilibrium solution is the absorbed per liter,

In equilibrium the concentration ion solution of fluoride is  $C_e$ ,

Kelvin is the absolute temperature in T

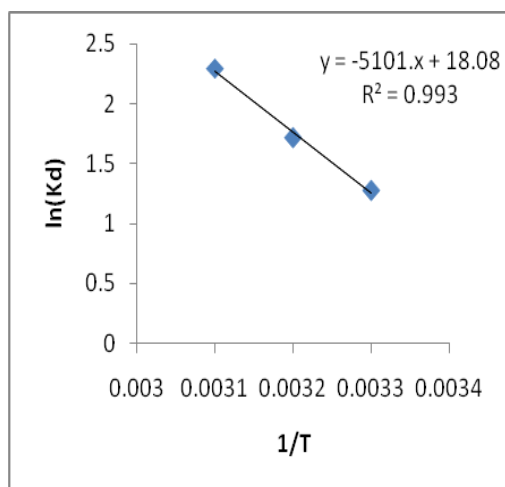
The gas constant is R.

$\Delta G$  is change in free energy

$\Delta H$  is the enthalpy Change

$\Delta S$  is entropy Change

The  $\Delta H$  and  $\Delta S$  were obtained from the slope values of intercept there is a plot between were obtained from the equation  $\Delta G = \Delta H - T\Delta S$   $\ln K_d$  and  $1/T$  and  $\Delta G$  values were tabulated



**Fig.11:** The (%R) of Chromium (VI) ion increases on the Effect of temperature of NVCC

**Table 5:** The Chromium (VI) ion adsorption on NVCC and the parameters of thermodynamics

Parameter	$\Delta H$ (KJ/mol)	$\Delta S$ (KJ/mol)	$\Delta G$ (KJ/mol)
$R^2$			
Temperature (K)	303	313	323
NVCC	35.93	137.84	-41.7295 -43.1079 -44.4863
			0.989

The percentage removal of Chromium (VI) ion increases from 99.1 to 99.4% from NVCC. the temperature increases from 303 to 323K. The outer surface of the thickness of the activated absorbed charcoal temperature increases. The diffusion rate of chromium increases the ion the kinetic energy decreases from the external boundary layer of Chromium (VI) ion increases and the charcoal holes are absorbed.

In the Table 5,  $\Delta H$  values are positive, it physisorption indicates the endothermic nature of adsorption. The value of  $R^2$  (0.989) indicates the process of adsorption, it is endothermic in nature. The values  $\Delta S$  indicate that they are positive & increased the randomness and disorder of the adsorbed interface of solid solution in fluoride ions.  $\Delta G$  indicates the adsorption process of negative values and the spontaneous nature i.e. the adsorptive forces are strong. it is overcome the potential barrier.

The most extensively employed method for representing the equilibrium states of an adsorption system is adsorption isotherm. the isotherm adsorption purpose is the relation of bulk concentration solution and the adsorbate amount of interface solid is adsorbed. accurately developing of an equation of isotherm data is important and it can be used for design purpose represents the results. For water and wastewater treatment application the Langmuir and Freundlich adsorption isotherm equations are used commonly describe the adsorption isotherms at the temperature constant the Freundlich equation in Linear form is  $\text{Log}(q_e) = \log K_f + (1/n) \log C_e$

The equation of Langmuir in Linear form  $(C_e/q_e) = (aL/kL) C_e + 1/kL$

The nature of adsorption process is unfavorable according to Hall et al, ( $RL > 1$ ), it is in the form of linear ( $RL = 1$ ), favorable ( $0 < RL < 1$ ) and irreversible ( $RL = 0$ ) and the features of significant and the separation factor of the isothermal Langmuir model of dimensionless can be defined by the,

$$RL = 1 / (1 + aLC_i)$$

In the Fig.12 the two adsorption isotherms of linear plots were shown and the constants of isothermal along coefficient correlated values were presented in Table 6.

In the Fig.12 the applicability of Freundlich isotherm model is confirmed and found to be linear from the work plots at different Chromium (VI) ion concentrations of  $\log(C_e)$  Vs  $\log(q_e)$ . In the fig.12 when the  $C_e$  is plotted

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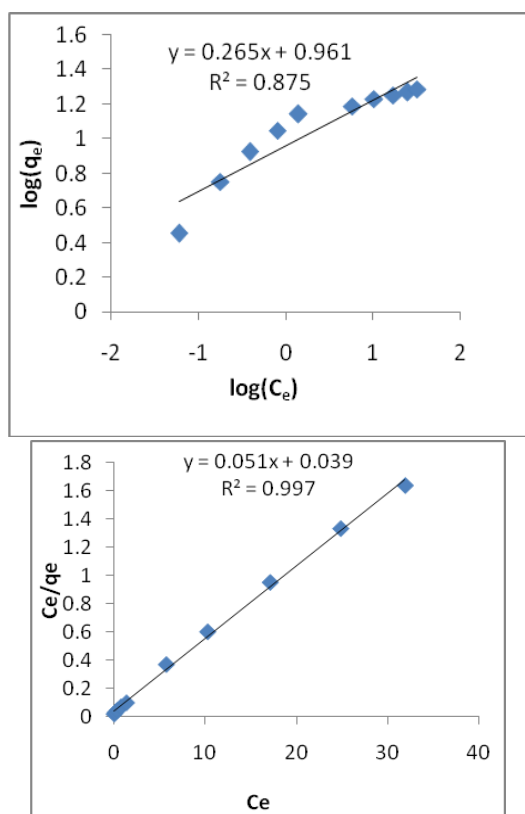
against  $C_e/q_e$ , a slope of  $1/b_a$  with straight line is showed and obtained and the isotherm of following Langmuir was confirmed. On the Y-axis constants of 'b' and 'a' Langmuir is calculated from the intercept of slope. In Table 6 presented the values of adsorption of Langmuir and Freundlich constants of correlation coefficients together. The linear relationships of significant statistically were evidenced from the correlated coefficients from the r-values where unity to close, and the isotherms indicated the applicability the coverage monolayer of two adsorption on the surface of active charcoal and the species of Chromium (VI) ion. The slope of the plots and the magnitudes  $K_f$  and  $1/n$  were calculated from the intercept.

S.No:	Adsorption isotherms	Slope	Intercept	R <sup>2</sup>
1	Freundlich Isotherm	0.265	0.961	0.875
2	Langmuir Isotherm $R_L=0.0148$	0.051	0.039	0.997

The equation Temkin in Linear form is  $q_e = B \ln A + B \ln C_e$  where  $B = RT/b$

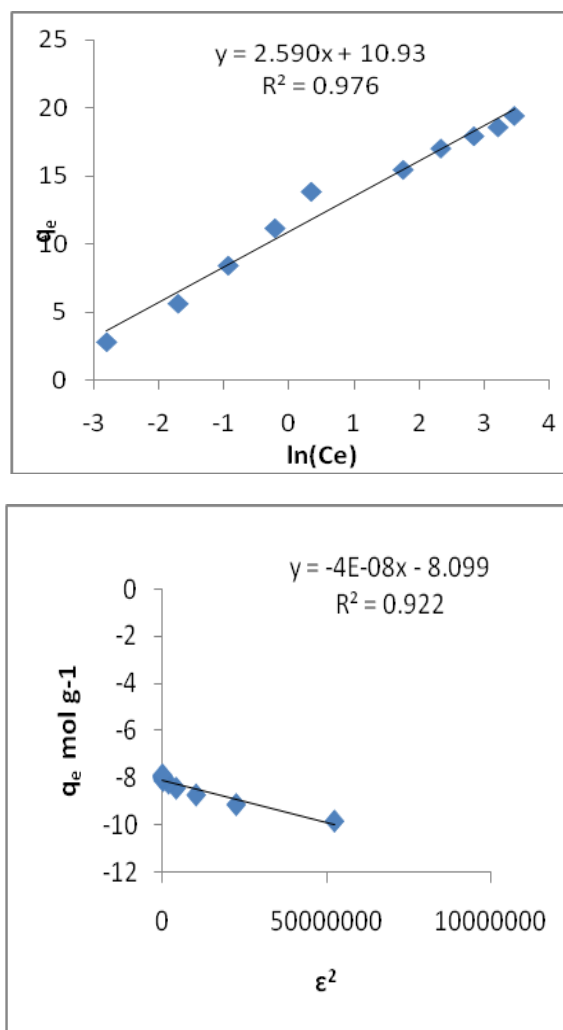
The Linear form of Dubinin –Radushkevich equation is  $\ln q_e = -\beta \epsilon^2 + \ln q_m$  where  $\epsilon = RT \ln (1 + 1/C_e)$

As shown in Fig.13 the two adsorption isotherms of linear plots were and the constants of isothermal coefficient correlated values were presented in Table 7.



**Fig.12:** The left isotherm of Freundlich and the Right isotherm of Langmuir

**Table 6:** the parameters of Freundlich and Langmuir plots of isothermal Adsorption



**Fig. 13:** The left Isotherm of Temkin and the right isotherm of Dubinin –Radushkevich



**Table 7:** The parameters of isothermal Adsorption of Temkin and Dubinin- Radushkevich plots

S.No:	Adsorption isotherms		Slope	Intercept	R <sup>2</sup>
1	Temkin Isotherm	B=2.590J/mol	2.590	10.93	0.976
2	Dubinin-Radushkevich Isotherm	E=3.53KJ/mol	-4E-08	-8.099	0.922

The values of coefficients correlated (R<sup>2</sup>) are unity to close, these two adsorption isotherms are applicable indicate the extraction system of present confirmed that the absorbed heterogeneous surface.

The absorbed heat of Temkin, B=2.590 joule/mole and the Temkin of linear was calculated from the slope of plot, the mean free energy of Dubinin-Radushkevich, E = 1/√2β, is found in the activated charcoal be 3.535 kJ/mol for, NVCC. It is an indication of ‘physisorption’ [146] when the E < 8 kJ/mol, the chemisorptions dominating the exchange ions etc. In study of present system extraction of nonspecific adsorption it is also called as “Physisorption” weak Vander Waals forces between Chromium (VI) ions and adsorbed the long range result. According to the Atkins [147], the mean free energy (E) from the characteristics for “physisorption” and also the adsorption values of are less than B= 20kJ/mol. the values of B 2.590 J/mol confirm the nature of ‘physisorption’ for the further present adsorbent system.

#### 4. Kinetics of Adsorption

The adsorption rate of kinetics of Chromium (VI) ion for the absorbed activated charcoal NVCC and study model of pseudo first-order reaction [125,148], the model of second-order pseudo reaction[148-149], Morris and Weber intraparticle diffusion model [150], model of Bang ham’s pore diffusion [151], Elovich equations [152-153].

The pseudo first-order equation is  $\log(q_e - q_t) = \log q_e - k_1 t / 2.303$

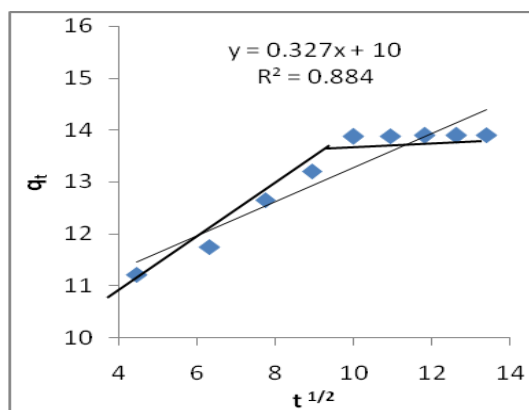
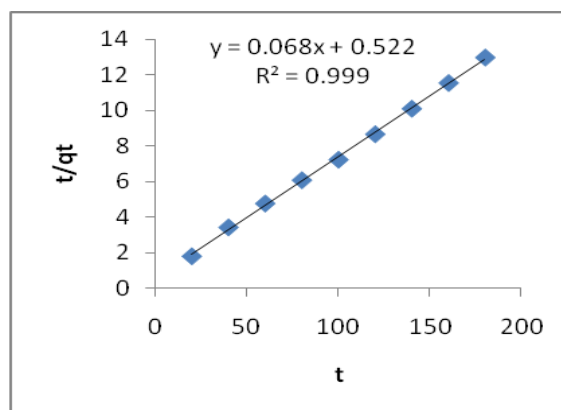
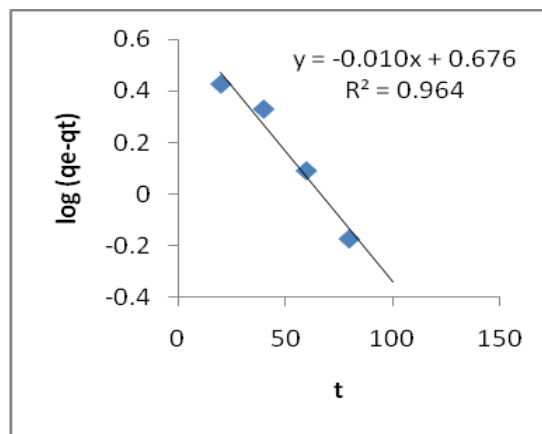
The pseudo first-order equation is  $t/q_t = 1/k_2 q_e^2 - (1/q_e) t$

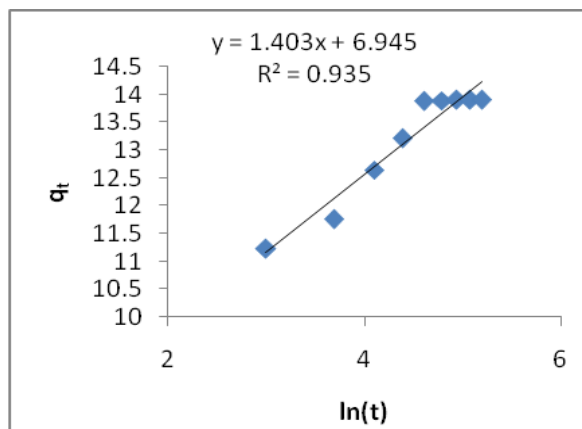
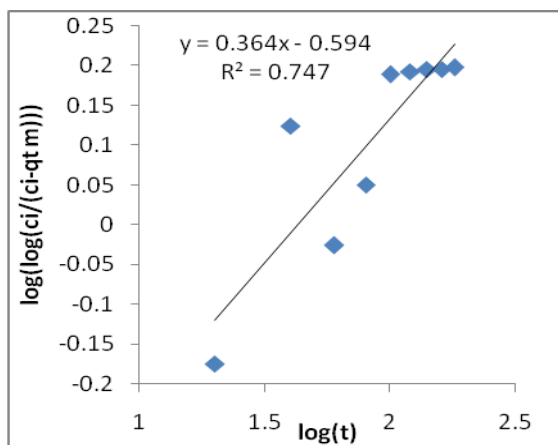
The equation of Weber and Morris intraparticle diffusion is  $q_t = k_i t^{1/2} + c$

Bang ham’s pore diffusion equation is  $\log [(C_i/C_i - q_{tm})] = \log (k_0/2.303V) + a \log (t)$

$q_t$  is the equation of Elovich =  $1/\beta \ln(\alpha\beta) + 1/\beta \ln(t)$

all these five kinetic models of linear plots is shown the correlation of coefficient rate constants the values was presented in Table 8.





**Fig.14:** model of Elovich, diffusion of Weber and Morris intra particle, Pseudo first-order reaction Bang ham's pore diffusion, Pseudo second-order

**Table 8:** Kinetic parameters

S.No:	Adsorption Kinetics	Slope	Intercept	R <sup>2</sup>
1	pseudo first-order	-0.010	0.676	0.964
2	pseudo second-order	0.068	0.522	0.999
3	Weber and Morris intraparticle diffusion	0.327	10.00	0.884
4	Bangham's pore diffusion	0.655	-1.042	0.277
5	Elovich model	1.403	6.945	0.935

The kinetic equations of applicability are compared with the coefficient correlation (R<sup>2</sup>). these models of five kinetics, the model of pseudo second-order of coefficient correlation value is greater than the pseudo second-order

models of kinetics that indicates the experimental data from the adsorption system in present studies. The other best model is pseudo first-order model (R<sup>2</sup>=0.875) followed by Bang ham's pore diffusion model (R<sup>2</sup>=0.854), Eolith model (R<sup>2</sup>=0.730), least is Weber and Morris intra particle diffusion model (R<sup>2</sup>=0.589).

#### IV. Conclusion

In this study the activated charcoal of inexpensive has been developed from the plant stems of Vernonia cinerria from polluted waters for removal of Chromium (VI). The maximum Chromium (VI) results indicate and the adsorption takes place at the pH: 2.0 and adsorbed dose: 3.5g/lit time of equilibrium: 80 min, size of the Particle: 45μ, temperature: 30 °C. The Langmuir adsorption isotherm is an adsorption process it has well relation which is a monolayer of coefficient value indicating adsorption. The sorption of Temin heat, B=2.764 J/mol, and E = 5.00 kJ/mol of Dubinin-Radushkevich, mean free energy, the physisorption' process of activated adsorbed charcoal indication is NVCC. In studies of kinetics to identify the rate of adsorption process some equations have been applied they are:

1. Kinetic pseudo-first-order reaction
2. pseudo-second-order reaction
3. Intraparticle diffusion of Weber and Morris
4. Bang ham's diffusion pore and Elovich equations .

The pseudo-second-order model has good correlation coefficient values with the adsorption process. The search engineer marketing of energy dispersive x-rays have a morphological change on the active carbon on the surface of adsorption in the studies of Fourier transform infrared spectroscopy indicate some surface functional groups of involvement in Chromium (VI) adsorption. These methods have developed the work which is applied to samples of water to real polluted Chromium (VI) and it is successful remarkably contaminated.

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