RESEARCH ARTICLE

STUDIES ON ADSORPTION OF CHROMIUM (VI) ONTO FICUS CARICA SEED FROM WASTEWATER

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ABSTRACT

Heavy metal contamination in drinking water has become a more serious environmental problem in the last several decades as a result of its toxicity and insusceptibility to the environment. Adsorption process has been overlooked as one of the best water treatment technologies around the world. The study evaluated the adsorption capacity of chromium from contaminated aqueous solution by using Ficus carica fruit seeds. Our ongoing study on low cost effective heavy metal removal techniques in developing countries have already demonstrated. This paper presents the first reported use of a related species, the common fig, Ficus carica for chromium removal and preliminary investigation of the interaction of the metal with the Ficus carica seeds. The potential of the Ficus carica for chromium removal was tested by means of jar tests. With an initial chromium concentration of 5ppm. Ficus carica seed powder, at doses of 0.50-2.50 mg/ 50ml reduced the concentration of chromium by above 93% respectively. Ficus carica was more effective than activated carbon in removing chromium from water. Parameters such as solution pH, effect of adsorbent of mass, contact time between solution and absorbent. Isotherms, kinetics and desorption were evaluated. The results showed that the biosorbents has advantages owing to its low cost and efficiency in chromium removal from contaminated water.

INTRODUCTION

Heavy metals contamination of aqueous media and industrial effluents is one of the significant environmental problems due to the toxic nature and accumulation of these metal ions in the food chain because they are non- biodegradable. Wastewater contains heavy metals such as Pd, Cd, Cr, Ni, Zn, Cu, and Fe are present in industrial wastewater; these heavy metals in wastewater are not biodegradable(Arunlertaree C et al., 2007). One such pollutant, chromium and its compounds persists in the environment in oxidation state of Cr^{3+} and the more toxic Cr (VI). The maximum permissible limit of Cr (VI) in natural water is 0.05mg/l by the U.S. Environmental production agency. The removal of Cr(VI) from aqueous solution has received the considerable attention in recent year .Traditionally, these removals are made by electrochemical treatment, Chemical precipitation , membrane process(Shih M., 2005) ,reverse osmosis ,ion exchange ,liquid-liquid extraction , electro dialysis ,evaporation and sorption . Recent studies shows that no deleterious effects from low Cr (III) in cells (Mubeena K et al., 2014; SoniyaM et al., 2013). The Cr (VI) compounds are known to be toxic and mutagenic for most living organism. When chromium enters the gastric system, epigastric pain, nausea, vomiting, severe diarrhea, Corrosion of skin, respiratory tract and lung carcinoma were noticed(Collivignarelli C et al., 2008 and Collivignarelli C et al., 2011) . However the application of this treatment processes

has been found to be restricted because of expensive investment, operational costs, potential generation of secondary pollution and its disposal is not ecofriendly (Hu J et al., 2004; Shipley H.J et al.,2009). For instance incomplete removal, high energy requirements and pollution of toxic sludge. Recently numerous approaches have been studied for the development of cheaper and more effective technologies both to decrease the amount of wastewater produced and to improve the quality of the treated effluent (Poyatos J.M et al., 2011; Follett M et al., 2010; Gomez-Lopez M.D et al., 2009). Adsorption has become one of the alternative treatments (Chand S et al., 1994;), in recent years the search for low cost adsorbents that have metal binding capacities has intensified(Muthuraman G et al., 2013; Rane N M et al., 2010; Periasam K et al., 1991; Gamila Ali H et al., 2008) . Ficus carica seed is an important member of genus Ficus. It is ordinarily deciduous and commonly referred to as fig. The fig is an important harvest worldwide for its dry and fresh consumption. Its common edible part is the fruit which is fleshy, hollow and receptacle . The dried fruit of Ficus carica have been reported as an important source of vitamins, minerals, carbohydrates, sugars, organic acids and phenolic acids(Saeed M.A et al., 2002) . The fresh and dried figs also contain high amounts of fiber and polyphenols. Ficus carica seeds belong to the order of utricles and family of Moraceae with over 1400 species classified into about 40 genera. Heavy metal contamination of aqueous media and industrial effluents is one of the significant environmental problems due to toxic

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nature and accumulation of these metal ions in the food chain because they are non-biodegradable. The last few decades have witnessed tremendous interest in development of new sorbents and Modifying the performance of existing ones. As a result different types of sorbent were studied for sorption of heavy metal ions from aqueous solutions. Activated carbon is characterized by important advantages of high porosity and high surface area. In the present study the first reported work we have studied the potential of chromium biosorption. The parameters such as effect of adsorbent dosage, effect of pH, effect of time, isotherms, thermodynamic, kinetics and desorption were evaluated. Results from this study can be used to assess the utility of ficus carica seeds for chromium removal from aqueous solution.

MATERIALS AND METHODS

Materials

All chemicals used were of analytical grade and supplied by Merck (purity >99%). All dilutions and washings were carried out using double distilled water. Muffle furnace was used to carbonize Ficus carica fruit seed. The stock solution of Cr (VI) was prepared at a concentration of 1000 mg/L from potassium dichromate using double distilled water. The pH adjustments were made using 0.1 M NaOH and 0.1 HCl. The ground water samples were collected from west mugapair Chennai.

Preparation of Ficus carica seed powder and activated carbon (FCAC)

Ficus carica fruit was collected and washed with double distilled water to remove the adhered impurities and dried in air. The dried samples were carbonized at $500\,^{\circ}C$ in a muffle furnace. The dried fruit seed was powdered using pest line Mortar.

Equilibrium experiments

Equilibrium studies at different metal ions concentrations were investigated using the batch adsorption process as described earlier. Batch adsorption studies were conducted in a set of 250 ml glass stopper Erlenmeyer flasks containing appropriate dose (0.5 g) of adsorbent and 50 ml of metal ion solution. This mixture solution was agitated at a speed of 500 rpm in a thermo shaker until the equilibrium was attained. After equilibrium, supernatant was filtered and the equilibrium concentration of Cr (VI) was analyzed, respectively, using UV–Visible spectrophotometer. The percentage metal ion removal (R) was calculated using the following equations:

$$\% \ Removal \ of \ Cr(VI) = \frac{C_i - C_e}{C_i} \ X \ 100$$

Where C_0 and Ce are the initial and equilibrium concentrations of the metal ion solution (mg/L), V is the volume of the solution (L), and M is the mass of the adsorbent used (g). The obtained data were fitted into adsorption isotherms, Pseudo-first-order, pseudo-second-order and intra particle diffusion models.

Desorption studies

The adsorbent of known quantity (50 mg) that was used for the adsorption of 0.25 to 0.250mg/L of Cr(VI) solution was separated from the solution by filtration using What man filter paper No. 41 and washed gently with distilled water three times for 15 min to remove the unadsorbed Cr(VI). The water was immediately removed. Then the adsorbent was mixed with 50mL of distilled water, adjusted to a pH value in the range of 2.0–10.0 using dilute HCl/NaOH and agitated at time interval longer than the equilibrium time (1 h). The desorbed chromium was estimated as before. The adsorbent after desorption of the ion was checked for further adsorption capacity.

RESULT AND DISCUSSION

Effect of pH

The effect of pH on the adsorption of Cr (VI) is presented in Fig.1. The pH of the aqueous solution is an important operational parameters in the adsorption process because it affects the solubility of the metal ions, concentration of the counter ions on the functional groups of the adsorbent and the degree of ions on the functional groups of the adsorbent and the degree of ionization of the adsorbate during the reaction. The percentage of adsorption increases with pH to attain a maximum at pH 5 and thereafter it decreases with further increasing in pH. The maximum adsorption at pH 6 may be attributed to the partial hydrolysis of M^+, resulting in the formation of MOH^+ and $M(OH)_2$ would be adsorbed to a greater extend on the non-polar adsorbent surface compare to MOH^+ with increase the pH from 2 to 6 the metal exists as $M(OH)_2$ in the medium and surface protonation of adsorbent is minimum, leading to be enhancement of metal adsorption. At higher pH that is optimum pH of 6, increasing in OH- ions cause a decrease in adsorption of metal ion at adsorbent-adsorbate interface. The maximum adsorption found in Ficus carica fruit seeds and activated carbon at pH 5.
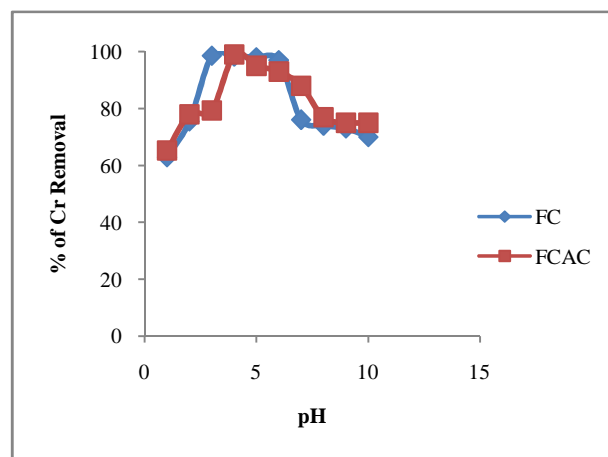

Fig.1 Effect of pH (Experimental conditions: Initial Chromium solution concentration-5ppm, Ficus carica seed powder dosage activated carbon - 0.250mg, Time-120 min^{-1} pH 2-12).

Effect of Adsorbent dose

In studying the effect of dosage the pH of each beaker was fixed at Ph 5. Where the maximum chromium removal had been shown in the previous experiments. The initial chromium

concentration was set at 5ppm. The Ficus carica seed powder and activated carbon dosage was varied between 0.025mg/l to 0.250mg/l. For coagulant dosage of 0.250mg/l the achieved percentage reduction of chromium was more than 95% is shown in Fig 2.
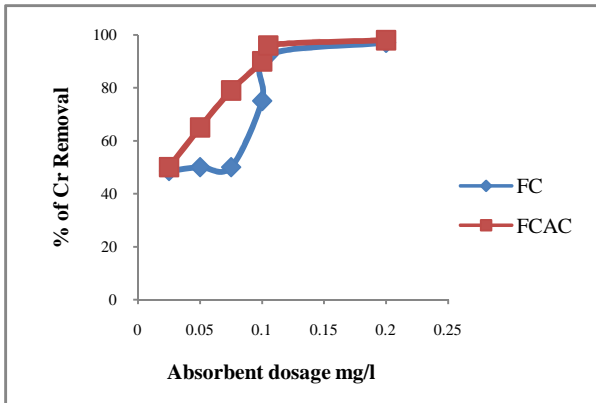

Fig.2 Effect of Ficus carica seed powder and activated carbon dosage (Experimental conditions: Initial Chromium solution concentration-5ppm, Ficus carica seed powder dosage activated carbon -0.025 to 0.250g)

Effect of Initial Chromium Concentration

The effect of initial concentration on the percentage removal of chromium by Ficus carica seed is shown in Fig. 3. It can be seen from the figure that the percentage removal is 95%.The chromium ion concentrations were between 5ppm to 40ppm the pH of the solutions was adjusted to 5.0, the experiments were performed at room temperature and the chromium concentration was measured after 180min of contact. It was found that an increase in chromium concentration leads to a decrease in adsorption capacity of chromium by adsorbents. The percentage removal of the Cr (VI) was found to decrease with the increase in initial Cr (VI) concentration. At lower concentration, the ratio of initial number of Cr (VI) to the available surface area is low. Subsequently, the fractional adsorption becomes independent of initial concentration. However, at high concentration the available sites of adsorption become fewer and hence the percentage removal of Cr (VI) is dependent upon the initial concentration.
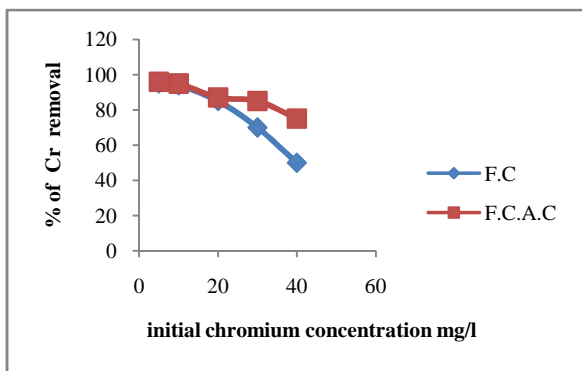

Fig.3 Effect initial chromium concentration (Experimental conditions: Initial Chromium solution concentration-2 to 10ppm, Ficus carica seed powder dosage activated carbon -0.250mg, Time-120 min[-1,] pH 5).

Effect of shaking time

Shaking time is an important factor in the process of evaluation of the Ficus carica seed powder. The batch experiments were carried out at different contact times 5 to 180min using mechanical shaker with a fixed sorbent mass (0.250mg). Chromium concentration 5ppm at a pH of 5 and 50ml of contact solution. Result of percentage oextraction of Cr(VI) as a function of shaking time intervals is represented in Fig 4. The equilibrium is reached within the first 180min of contact and reached a saturation level. In the beginning, the ion adsorbed occupied selectively the active sites on Ficus carica seed and activated carbon. As the contact time increased the active sites on the sorbent were filled. Clearly indicate that the equilibrium for Cr(VI) is attained in 150min of contact (94.5%). These results of percentage extraction and time of attained equilibrium are higher and faster, respectively.
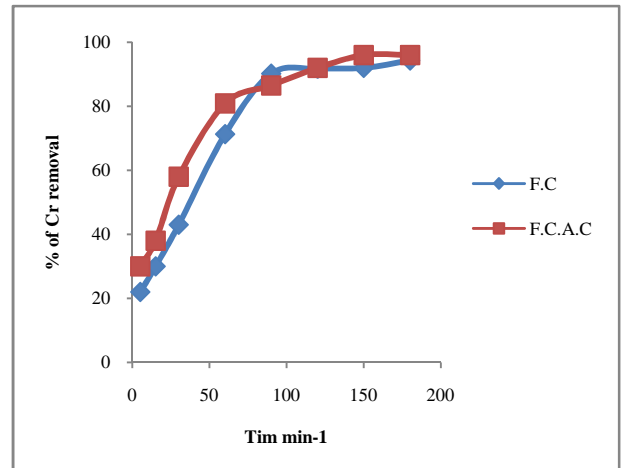

Fig.4 Effect of contact time (Experimental conditions: Initial Chromium solution concentration-5ppm, Ficus caricaseed powder dosage activated carbon dosage-0.250mg, Time-30 to150min^{-1})

Effect of Temperature

It has been observed that adsorption of chromium onto Ficus carica seed powder and activated carbon increased with temperature from 40 to 100 ^{o}C is shown in Fig 5. It may be due to various factors such as enhancement of inter reaction between adsorbent and adsorbate, creation of new adsorption sites and increased rate of intra-particle diffusion at higher temperatures . The increase in adsorption efficiency with temperature indicated that the reaction follows the endothermic pathway.
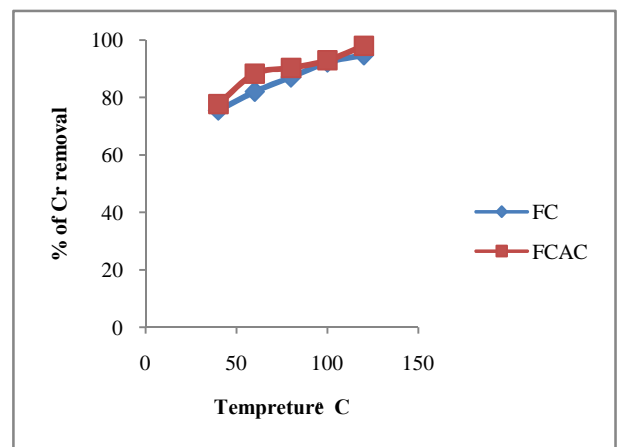

Fig.5 Effect of Temperature (Experimental conditions: Initial Chromium solution concentration- 5ppm, Ficus caricaseed powder dosage activated carbon-0.250mg, Time-120 min[-1,] pH 5, Temperature 20 to 100°C)

Adsorption isotherms

Langmuir and Freundlich isotherm

Adsorption isotherm was assayed by studying the adsorption of Cr (VI) with wide concentration range in aqueous solutions onto Ficus carica seed and activated carbon. The amount adsorbed of metal ion onto carbon adsorbent (mg/g) was represented against the equilibrium concentration of metal ion in aqueous solution. Langmuir isotherm model is based on the assumption that maximum adsorption corresponds to a saturated monolayer of adsorbate molecules on the adsorbent surface that the energy of adsorption is constant and that there is no transmigration of adsorbate in the plane of the surface. Adsorption isotherm was obtained by shaking the adsorbent of fixed doses and the adsorbate solution containing varied concentrations of metal ion for 1 h. The Langmuir isotherm model represents the equilibrium distribution of metal ions between the solid and liquid phases. The following equation can be used to describe adsorption isotherm according to Langmuir:

$$\frac{C_e}{Q_e} = \frac{1}{Q_m K_L} + \frac{C_e}{Q_m}$$

Where Ce is the equilibrium concentration of metal ion in solution (mg/L), Qe is the amount adsorbed at equilibrium on adsorbent (mg/g), Q_0 is the maximum metal ions uptake per unit mass of adsorbent (mg/g), which is related to adsorption capacity and K_L is Langmuir constant (L/mol) which is exponentially proportional to the heat of adsorption and related to the adsorption intensity. Thus, a plot of Ce/Qe vs. Ce should be linear if Langmuir adsorption were applicable; consequently the Langmuir constants could be calculated. The results in Fig. 6&7 shows the equilibrium adsorption isotherm of metal ions in water samples, using Ficus carica seed powder and activated carbon sample as an adsorbent. The isotherm rises sharply in the initial stages for low Ce and Qe values. This indicates that there are plenty of radial accessible sites. Eventually a plateau is reached, indicating that the adsorbent is saturated at this level. The decreases in the curvature of the isotherm are tending to a monolayer adsorption. Considerably increasing the Ce values with slight increase in Qe, is possibly due to less active sites being available at the end of the adsorption process and/or the difficulty of the edge molecules in penetrating the adsorbent, while metal ions partially covering the surface sites. In order to optimize the design of sorption system for removal metal ions from water sample, it is important to establish the most appropriate correlation for the equilibrium curve. The linearized Langmuir plot is shown in Fig. 6&7, and the Langmuir parameters were calculated and recorded in Table 1. The essential feature of Langmuir isotherm can be expressed by means of dimensionless constant referred to as the separation factor or equilibrium parameter, R_L, which is defined by the following equation:

$$R_L = \frac{1}{1 + K_L C_i}$$

Where C_i is the initial metal concentration (mg L^{-1}). The value of separation factor R_L, indicates the nature of the adsorption process as given below:

R_L value	Nature of adsorption process
$R_L > 1$	Unfavorable
$R_L = 1$	Linear
$0 < R_L < 1$	Favorable
$R_L = 0$	Irreversible

The values of R_L values calculated for this study are given in Table 2. The adsorption process will be favorable if the R_L values lie between 0 and 1. The R_L values given in Table 2 very well lie in this range and hence the adsorption process is favorable.

The Freundlich model was chosen to estimate the adsorption intensity of the metal ions on the carbon adsorbent surface. The Freundlich equation is presented as:

$$Q_e = K_F C_e^{\frac{1}{n}}$$

This expression can be linearized to give the following equation:

$$\log Q_e = \log K_F + \frac{1}{n} \log C_e$$

where Kf (mg/g) and n are Freundlich constants incorporating all factors affecting the adsorption process such as adsorption capacity and intensity of adsorption. These constants are determined from the intercept and slope of linear plot of log qe versus log Ce, Fig. 8&9 listed in Table 3. Although the correlation coefficients are greater than 95%, they do not correlate the data as well as the Langmuir isotherm, which has consistently higher correlation coefficients.
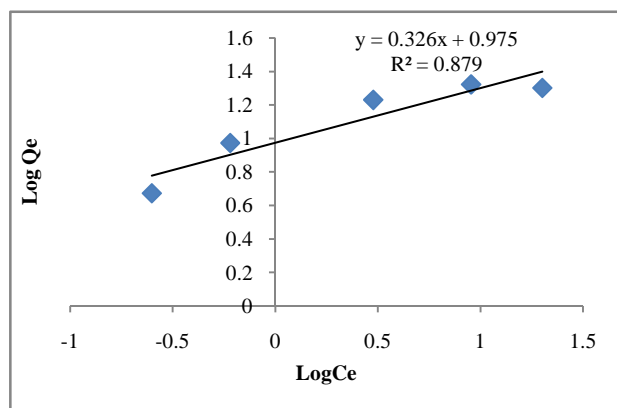

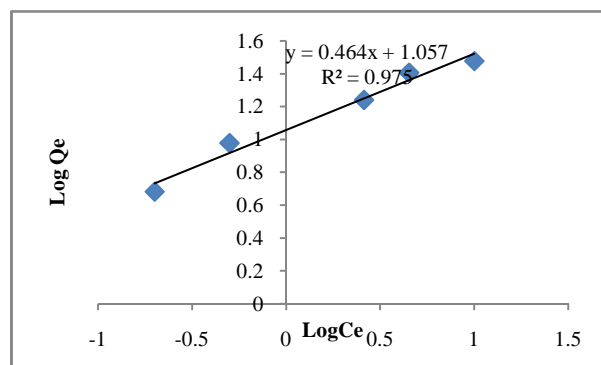**Fig. 6** Langmuir isotherm for the adsorption of Cr (VI) on Ficus carica seed powder adsorbent.

Fig. 7 Langmuir isotherm for the adsorption of Cr (VI) on Ficus carica activated carbon adsorbent.
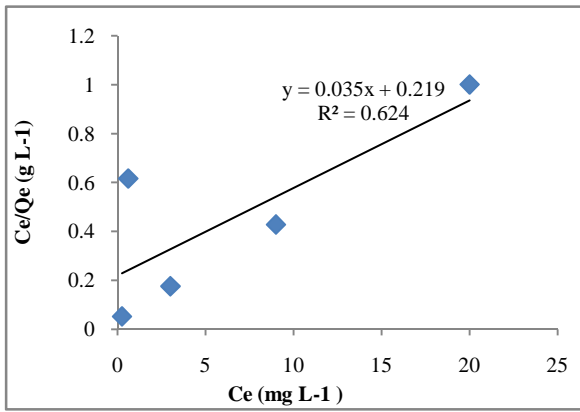
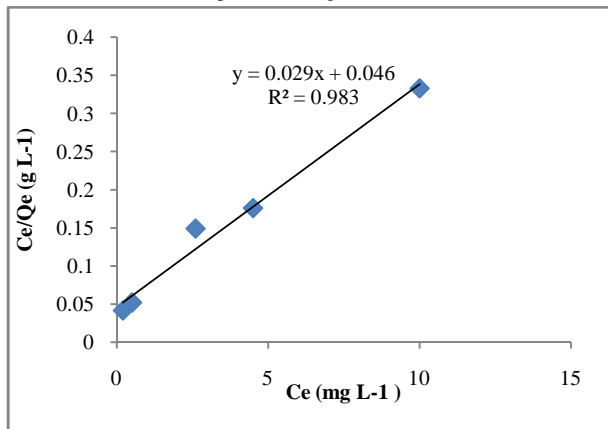**Fig. 8** Freundlich isotherm for the adsorption of Cr (VI) on Ficus carica seed powder dosage adsorbent.

Fig. 9 Freundlich isotherm for the adsorption of Cr(VI) on Ficus carica activated carbon adsorbent. Table 1
Langmuir isotherm

Table 2

Natural coagulants	Qm (mg g-1) (10-2)	KL (L mg-1) (10-3)	R2
Ficuscarica seed powder	27.93	0.1632	0.6248
Ficuscarica activated carbon	34.246	0.6309	0.9831

The R_L Value

Table 3

Cr(VI) concentration (mg L^{-1})		The R_L Value
	Ficus carica seed powder	Ficus carica activated carbon
5	0.5506	0.2407
10	0.3799	0.1368
20	0.2345	0.0734
30	0.1696	0.0531
40	0.1328	0.0381

Freundlich isothem

Natural coagulants	1/n	K_F (mg g^{-1})	R^2
Ficuscarica seed powder	0.886	2.404	0.997
Ficuscarica activated carbon	0.887	2.148	0.998

Tempkin isotherm model

Tempkin isotherm contains a factor that explicitly takes into account adsorbing species-adsorbate interactions. This isotherm assumes that the heat of adsorption of all molecules in the layer decreases linearly with coverage due to adsorbate-adsorbent interaction and adsorption is characterized by a uniform distribution of binding energies, up to some maximum binding energy. Tempkin isotherm has generally been used in the linearized and rearranged form as following:

$$Q = \beta \, lnK_T + \beta \ln C_e$$

where, K_T is an equilibrium constant of binding corresponding to the maximum energy of binding (mg L^{-1}) and the β is related to the heat of adsorption. Fig.10&11 shows a plot of Q_e versus ln C_e, which enables the determination of the isotherm constants K_T and β. The values of K_T, β and correlation coefficient, R^2 for Tempkin isotherm model are given in Table 4.
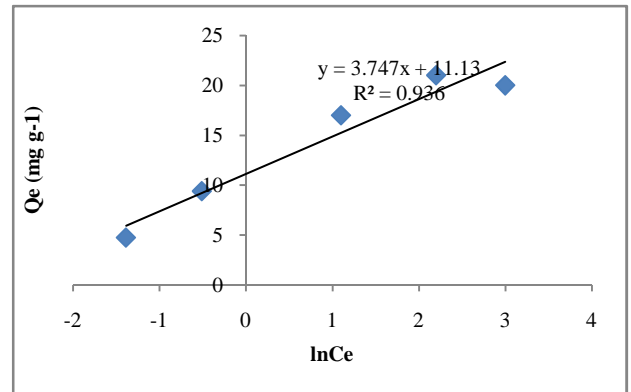

Fig. 10 Tempkin isotherm for the adsorption of Cr (VI) on Ficus carica seed powder adsorbent.
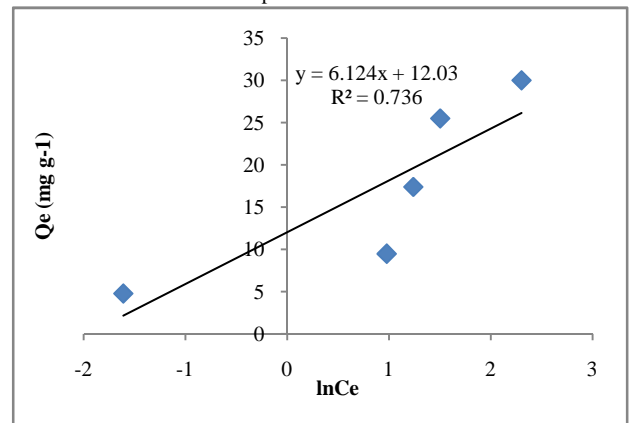

Fig. 11 Tempkin isotherm for the adsorption of Cr(VI) on Ficus carica activated carbon adsorbent.

Tempkin isotherm

Table 4

Natural coagulants	β	K_T (mg L^{-1})	R^2
Ficuscarica seed powder	3.747	6.844	0.9362
Ficuscarica activated carbon	6.1242	4.5249	0.7362

Adsorption Kinetics

Lagergren's first-order kinetic model

The pseudo-first-order kinetic model of Lagergren is more suitable for lower concentration of solute and its linear form is:

$$\log(Q_e - Q_t) = \log Q_e - \frac{k_1}{2.303} t$$

where, Q_t (mg g^{-1}) is the amount of adsorb ate adsorbed at time t (min); Q_e (mg g^{-1}) is the adsorption capacity in the

equilibrium; k_1 (min^{-1}) is the rate constant of pseudo-first-order model. The values of k_1 and Q_e for the adsorption of Cr (VI) onto adsorbent were determined from the plot of log (Q_e-Q_t) vs. time, which is shown in Fig.12. The results obtained for R2 (0.993) and qe 87.9 mg/g revealed that the kinetics of Cr (VI) adsorption onto FC &FCAC does not follow the pseudo first-order.
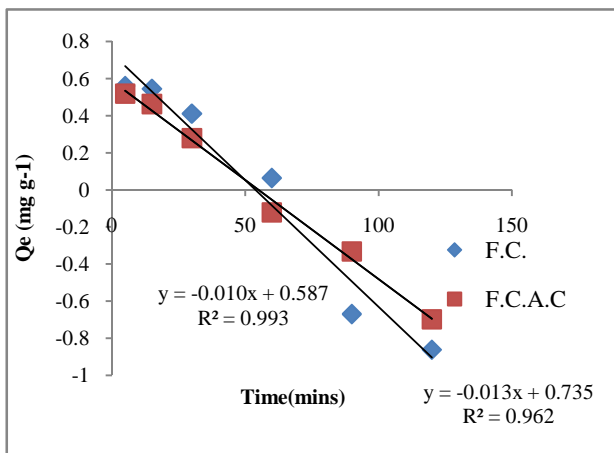

Fig. 12 Lagergren first-order-kinetic model of Cr(VI) adsorption onto 1g L^{-1} adsorbent, initial Cr(VI) concentration 5mg L^{-1}, pH 5.

Table 5 Largergern's first order kinetic model

Natural coagulants	$Q_{e\ (exp)}$	$Q_{e\ (cal)}$ (mg g^{-1})	K_1x 10^{-2}	R^2
Ficuscarica seed powder	2.340	0.984	2.303	0.931
Ficuscarica activated carbon	2.260	2.051	9.673	0.982

Pseudo-second-order kinetic model

Adsorption kinetics was explained by the pseudo-second-order model expressed as following linear equation:

$$\frac{t}{Q_t} = \frac{1}{k_2 Q_e^2} + \frac{t}{Q_e}$$

Where, k_2 is the second order rate constant (g mg^{-1}min^{-1}). The values of k_2 for Cr (VI) on adsorbent were calculated from the slopes of the respective linear plots of t/Q_t vs. t . The correlation coefficients, R^2 were 0.962 and 0.993 for Cr(VI) respectively suggest a strong relationship between the parameters and also explain that the process follows pseudo second order kinetics is shown in Fig 13 .
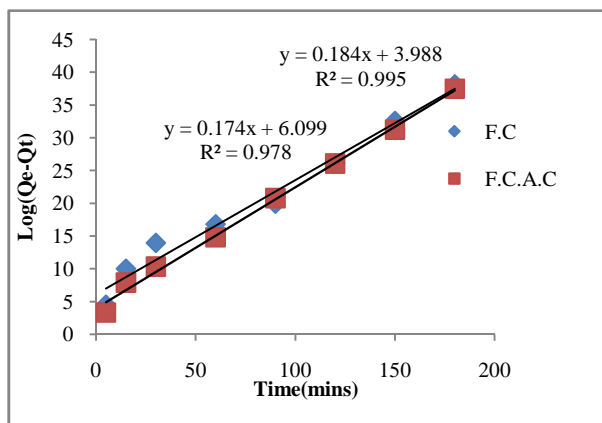

Fig.13. Pseudo-second-order kinetic model for the adsorption of Cr (VI) onto1 g L^{-1} of adsorbent with initial Cr(VI) concentration of 5mg L^{-1} at pH 5.

Pseudo second order kinetic model

Table 6

Natural coagulants	$Q_{e\ (exp)}$	$Q_{e\ (cal)}$ (mg g^{-1})	K_2 x 10^{-2}	R^2
Ficuscarica seed powder	2.340	2.433	5.771	0.998
Ficuscarica activated carbon	2.260	2.369	5.591	0.999

Elovich kinetic model

Elovich model suggests that the chemisorptions, i.e. a chemical reaction, is probably the Mechanism that controls the rate of adsorption. This model can be applied with success in liquid solution and the linear form of the Elovich equation is

$$Q_t = \frac{1}{\beta}\ln\alpha\beta + \frac{1}{\beta}\ln t$$

Where, α (mg g^{-1}) is the initial sorption rate and β (g mg^{-1}) is the desorption constant. The values of α and β can be calculated from the slope and intercept of the plot of Q_t versus ln t (Fig.14).

As can be seen from the table 6, the values of R^2 are closer to unity for pseudo second order model than pseudo first order model and Elovich model. Thus, adsorption of chromium onto adsorbent follows the pseudo second order model. Furthermore, values of $Q_{e\ (cal)}$ calculated from pseudo second order model were in good agreement with experimental values, $Q_{e\ (exp)}$ than those calculated from pseudo first order. The values of R^2 for pseudo first order and Elovich model are lower than the pseudo second order model and thus indicate that pseudo first order and Elovich model cannot be adequate to describe the kinetic of adsorption of chromium metal onto activated carbon prepared from Ficus carica seed powder and activated carbon.
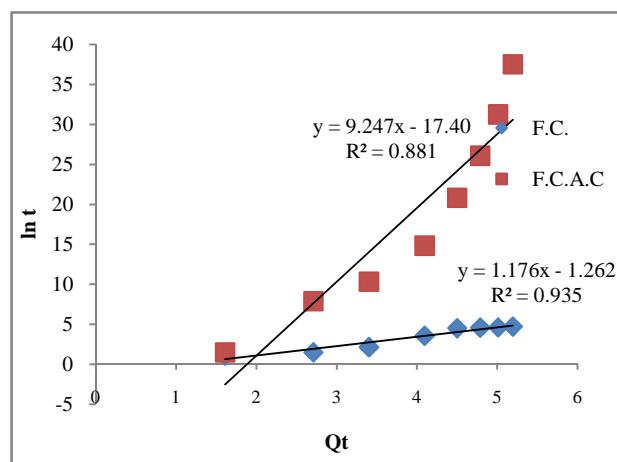

Fig.14 Elovich kinetic model for the adsorption of Cr (VI) onto 1g L^{-1} of adsorbent with initial Cr(VI) concentration 5mg L^{-1} at pH 5.

Natural coagulants	α	β	R^2
Ficuscarica seed powder	5.521	3.358	0.975
Ficuscarica activated carbon	1.574	2.717	0.917

Sample characterization

Scanning Electron Microscope (SEM)

The SEM images before and after adsorption of Ficus carica seed powder and activated carbon were obtained and presented in Fig.15a-c. Ficus carica exhibit an adsorption superior to its

bulk counterpart because of its fibrous and colloidal structures and higher specific surface area. The SEM images clearly indicated that the surface structure of Ficus carica was greatly changed from the activated carbon samples. Surface morphology structure of Ficus carica seed powder having fibrous and bulkier particles present in the surface of the fibre than in the case of Cr (VI) adsorption. Surface morphology structure of activated carbon showed very porous is very unevenly distributed on the surface. The SEM images of Ficus carica and activated carbon different from each other. This observation conformed by the Cr (VI) molecules were filled by the porous.
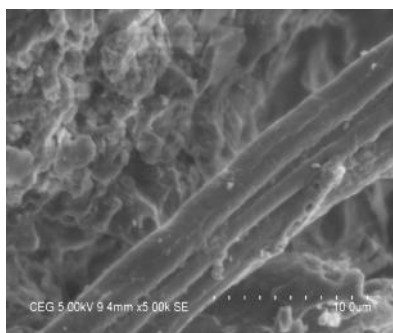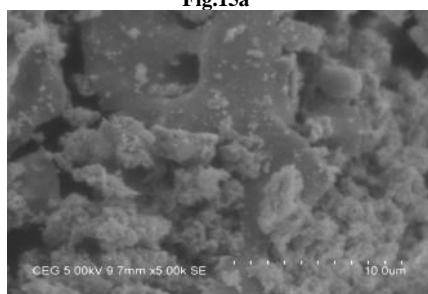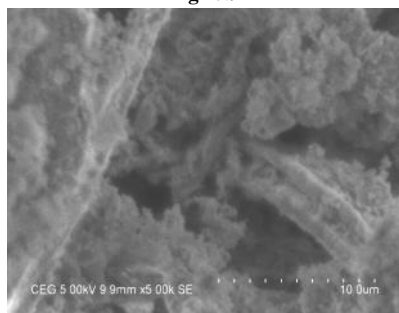

Fig.15
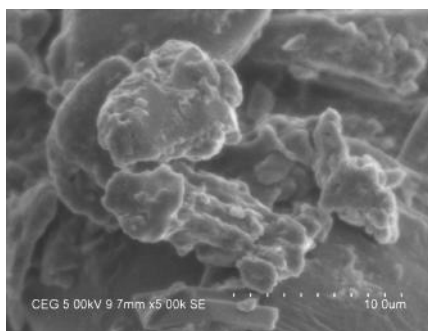
Fig.15a

Fig 15b

Fig.15d

Fig.15 SEM micrography of activated carbons Ficus carica seed powder before adsorption 15a) Ficus carica seed powder after adsorption of Cr (VI) and 15b) Activated carbon before adsorption 15c) activated carbon after adsorption.

FT-IR and XRD Analysis

The XRD pattern for crushed seeds due to high amount of proteins and amino acids present in the composition of the Ficus carica seed powder and activated carbon. For this reason intact seeds are analyzed constituting a complex matrix comprised of a wide variation of substances including proteins, lipid structures and to a lesser extent carbohydrates. It was possible separate a broad peak at around 2Θ equals to for ficus carica seed powder before adsorption. After adsorption it gives broad peak at 25 ° .The XRD pattern of activated carbon indicates the amorphous nature of the material lacking any crystallinity. The amorphous nature of the Ficus carica seed powder penetrate the Cr (VI) biosorption is shown in Fig 16a-c. FT-IR Spectroscopy was also used to identify the changes on before and after adsorption of Ficus carica seed powder and activated carbon correspondence with Cr(VI) reduction is shown in 17a-c. Upon reaction with Cr(VI) the peak at 1739 cm^{-1} assigned to the C=O stretching of carbonyl groups , Significantly decreased. Similarly the peaks at 1220 and 1300-1450 cm^{-1} attributed to C-O stretching of aryl ethers/ O-H bending deformation of Carbonyl groups and CO-CH$_3$ groups respectively decreased with addition of Cr (VI). 1250-1340 peaks indicate that Amine group present in the Ficus carica seed powder. N-H amide group present in 3300-3500 become remarkable Ficus carica treated with Cr (VI). In the present study confirm that oxygen containing group responsible for Cr (VI) reduction.
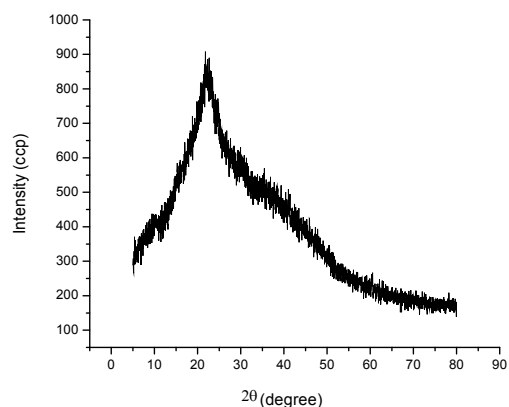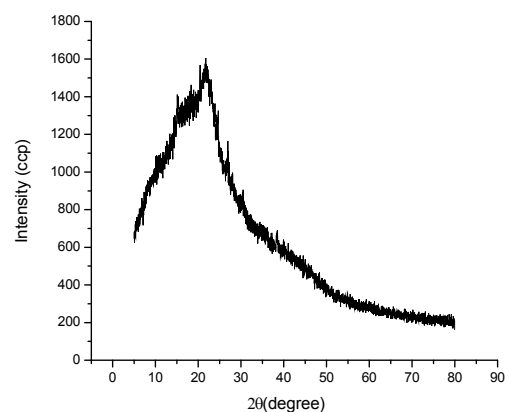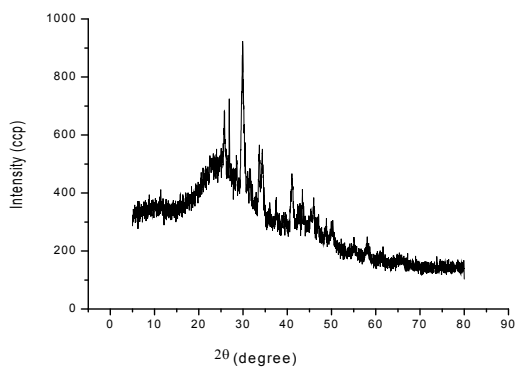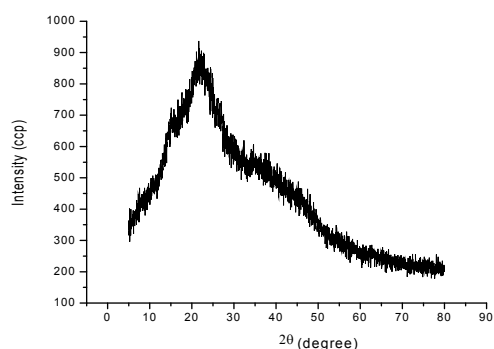

Fig 16

Fig 16a

Fig .16 b

Fig 16 c

Fig.16 XRD spectrum of Ficus carica seed powder and activated carbon Ficus carica seed powder before adsorption 16a) Ficus carica seed powder after adsorption of Cr (VI) 16b) Activated carbon before adsorption 16c)Activated carbon after adsorption of Cr(VI).

Fig .17

17a

Fig .17b

17c

Fig.17 FT-IR spectrum of Ficus carica seed powder and activated carbon Ficus carica seed powder before adsorption 17a) Ficus carica seed powder after adsorption of Cr (VI) 17b) Activated carbon before adsorption 17c)Activated carbon after adsorption of Cr(VI).
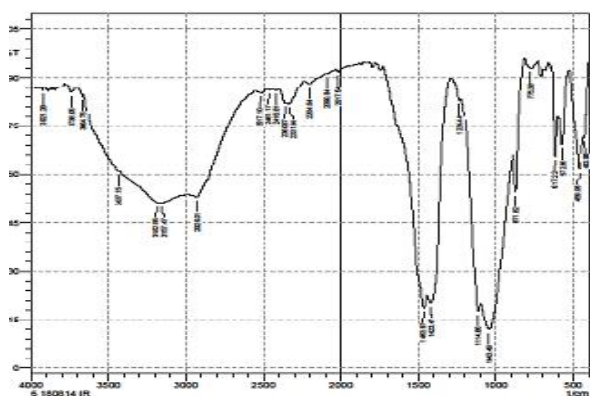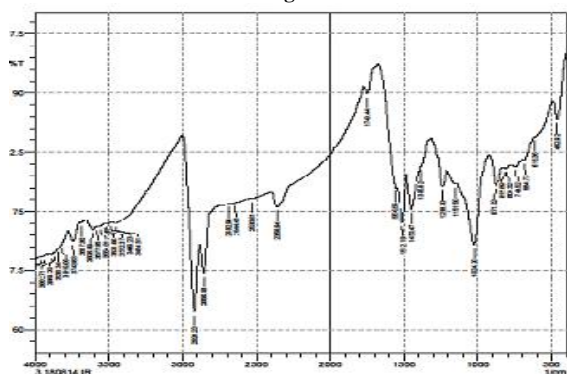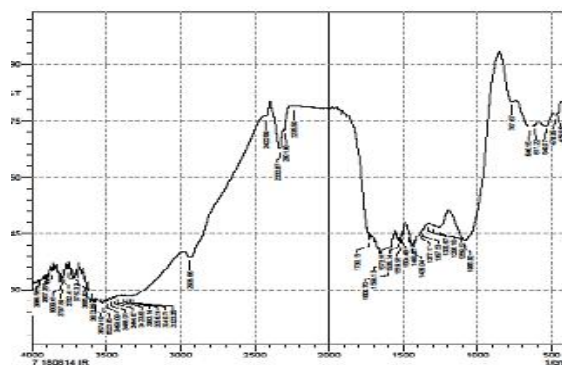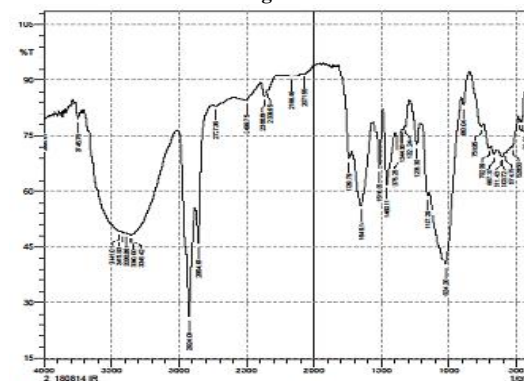
Desorption

Reversibility of the adsorption known as desorption Corresponds to the removal of metal binding sites on the surface of the adsorbent whereby H^+ ions are expected to replace cations adsorbed by the ion exchange mechanism. This process Gains importance when the employed adsorbent material has high costs relative to the lower costs generated by the process. For Ficus carica seed powder and activated carbon the average percentage of adsorption was 94.6% of which approximately 6.4% was desorbed, indicating the occurrence of a strong interaction between the metal and adsorbent.

CONCLUSION

Ficus carica seed powder and activated carbon is an effective adsorbent for the removal of Cr (VI) from aqueous solution. The adsorption is metal ion concentration and pH dependent. Increasing the concentration of chromium showed an decreasing of the uptake capacity of the composite. The adsorption Data fitted the langumuir isotherm well with 0.9. Adsorption Kinetics followed the pseudo- second-order demonstrating that chemisorptions is the rate-controlling the determining step. A Comparison of maximum adsorption capacity of the Ficus carica seed powder and activated carbon gives the similar results used for the removal of the metal ions was made. The Ficus carica seed is a natural adsorbent reveal its remarkable efficiency over the treated and untreated synthetic adsorbent. Due to high surface area and short diffusion route of the ficus carica seed powder and activated carbon high adsorption capacities can be obtained in a very

short time. The cost for formulating adsorbent and operating the treatment systems are generally low. Natural adsorbent are basically biodegradable that consists mainly of degradable organic matter. The adsorption of metal ions is strongly affected by the properties of water to be treated , Such as pH, effect of time, adsorbent dosage, Initial concentration of the metal ions were studied. Optimal pH for adsorptions of metal cations is generally around neutral, and their adsorbed amounts would decrease as solution pH is lowered because of diminishing of negatively charged sites on the sorbents due the protonation. On the other hand acidic pH favors adsorption of the metal ions. Ficus carica seed has good potential to remove the chromium from aqueous solutions.

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