Freundlich Isotherm Model of Adsorption of Fe^{2+}, Co^{2+} and Cr^{3+} IonsfromAqueous Solution Using Activated Carbon Prepared from Corn Maize(*Zea mays L.ssp*) Waste.

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Abstract

Chemical and physical properties of Activated Carbon(AC-C) prepared from Corn Maize (*Zea mays L.ssp*) waste were determined and the adsorption characterization of Fe^{2+}, Co^{2+} and Cr^{3+} from aqueous solution with respect to Freundlich isotherm and adsorption kinetics were investigated. AC-C was prepared using chemical activation with Potassium Hydroxide (3M at 600 °C for 1 hr).The characterization of (AC-C) revealed that it has 49.42% carbon, 4.2% ash, bulk density of (0.75 g/ml); porosity (57.08%) and methylene blue of 190.6 mg/g. Kinetic adsorption of metal ions (Fe^{2+}, Cr^{3+} and Co^{2+}) has also been investigated at isotherm container at 30°C. The effect of dose of (AC-C) on the percentage removal of metals indicates that the maximum dose of adsorbent was at concentration of 0.8 g/L in which 10% Fe^{2+} was removed. For Fe^{2+} and Cr^{3+}metal ions, the adsorption decreases as the pH increases. The optimum pH for the adsorption was 6 for both Cr^{3+} and $Co^{2+}$and 7 for Fe^{2+}. The experimental isotherm data was analyzed using Freundlich equations. The adsorption process follows the Freundlich order kinetic, with a correlation coefficient (R^2) of 0.97 for both $Fe^{2+}$and Co^{2+} and 0.96 for Cr^{3+}. Adsorption capacity (K) and the adsorption intensity (1/n) were the highest for Fe^{2+}, with the values of 1.83 and 1.41, respectively.

Other adsorption factors such as detection of inorganic elements and functional groups on the (AC-C) sample were examined by XRF, XRD and FT-IR spectroscopy. The major elements in the sample were: Potassium (0.047%) and Calcium (3.66%). The FT-IR spectra indicate the presence of five functional groups; 2511 cm^{-1}corresponds to a carboxylic O-H stretching, 1794 cm^{-1}corresponds to an acid anhydride C=O stretching, 1454 cm^{-1}corresponds to aromatic C-H stretching,874 $cm^{-1}$is associated with the out of plane C-H wagging and 704 $cm^{-1}$is in plane C=C bending.

Keywords

Activated Carbon, Corn Maize (*Zea mays L.ssp*) waste, adsorption, Freundlich isotherm, FT-IR and XRD.

نموذج فروندليش الحراري لامتزاز ايونات الحديد، الكوبالت والكروم من محاليلها المائية باستخدام الكربون المنشط المحضر من مخلفات الذرة الشامية

تم تقدير الخواص الكيميائية والفيزيائية للكربون النشط المحضر من مخلفات نبات الذرة الشامية كما تمت دراسة حركية الامتزاز لتقييم ملائمة الكربون المنتج في امتزاز ايونات الفلزات (الحديد و الكوبالت و الكروم) من محاليلها المائية. أظهرت نتائج عملية الامتزاز ملائمة نموذج معادلة فروندليش للعينات المنشطة كيميائيا.

تم القيام بعملية التنشيط الكيميائي باستخدام محلول هيدروكسيد البوتاسيم بتركيز (3 مولار) في درجة حرارة 600 درجة مئوية لمدة ساعة.

أظهرت نتائج التحليل الكيميائي أن نسبة الكربون تبلغ (49.42%) ومحتوى الرماد (4.2%) والكثافة الظاهرية (0.75غم/مل). يعتبر تحديد ونوع المسامات الموجودة بالكربون النشط عامل اساسي لتقييم كفاءة الكربون المنتج كمادة امتزاز، نتائج تحديد نسبة المسامات الكلية اظهرت احتواءه على (57.08%). واختبار ازرق الميثيل (190.6ملغم/غم)تم دراسة حركيات الامتزاز لمحاليل ايونات فلزات الحديد والكوبالت والكروم عند درجة حرارة 30 درجة مئوية، كما تم دراسة تاثير جرعة الكربون النشط اللازمة لازالة ألوان محاليل الفلزات وكانت الجرعة المناسبة عند تركيز (0.8 غم/لتر).

وجد ان الرقم الهيدروجيني (6) هو المناسب لعملية الامتزاز لايوني Cr^{+3} و Co^{+2} والرقم هيدروجيني (7) لعنصر Fe^{2+} . تم تحليل البيانات المتحصل عليها من التجارب و التي اظهرت ملائمتها لمعادلة فروندليش ، معامل الارتباط (R^2) يساوي 0.97 و 0.96، سعة الامتزاز (K) وكثافة الامتزاز (1/n) لعنصر Fe^{2+} كانت 1.83 و1.41 على التوالي .

تم دراسة بعض العوامل الاخرى المؤثرة على عملية الامتزاز باستخدام الاشعة السينية والتي بينت احتواء العينات على انواع و كميات مختلفة من العناصر الغير عضوية وغالبية العناصر المتوفرة هي البوتاسيوم (0.047%) و الكالسيوم (3.66%). التحليل الطيفي للكربون النشط باستخدام الاشعة تحت الحمراء اظهر احتوائه على خمسة زمر وظيفية:هيدروكسيل عند $2511cm^{-1}$ زمرة وظيفية لحمض انهيدريد C=O عند $1794\ cm^{-1}$.وتشير الاطياف الى وجودزمر وظيفية عطرية لكربون- هيدروجين C–H عند $1454\ cm^{-1}$ ، وفي الطيف بين ($874-704\ cm^{-1}$) تم التعرف على مجموعة C–H خارج المستوى و اخرى C=C داخل المستوى .

1. Introduction

Conversion of agricultural wastes into carbonaceous adsorbents that can be used in many applications such as sugar refining, wastewater treatments and pharmaceuticals industry would add a value to these agricultural commodities, helps reduce the cost of waste disposal, and provide a potentially cheap alternative to existing commercial carbonaceous adsorbents. Activated Carbon as a porous carbon material, usually chars had been subjected to reaction with gases during or after carbonization in order to increase porosity [1]. Activated Carbon is produced from different precursors such as wood, peat, lignite and various types of hard coal and petrochemical products and polymers [2].

The world production of activated carbon in 1990 was estimated to be 375,000 tons, excluding what is produced by Eastern Europe and China. In 2002, the demand for activated carbon reached 200,000 ton per year in the United States. The demands of activated carbon increased over the years and market growth was estimated at 4.6% per year [3]. The strong market position held by Activated Carbon relates to their unique properties and low cost compared with that of possible competitive inorganic adsorbents like zeolites. Heavy metals are produced in large amounts during industrial activities and contaminate the environment. Metal ions are non-biodegradable and many of them are soluble in aqueous media and easily available for living organisms. Heavy metals account for a number of disorders in plants and animals and their removal from aqueous media is an important and challenging task [4]. Various processes for color removal include physical, chemical and biological schemes such as ion exchange, advanced oxidation, filtration, and adsorption [5]. Adsorption has been found to be more efficient process from other techniques for water reuse in terms of initial cost [6], the simplicity of design, use of operation and insensitivity to toxic substances [7].

2. Experimental

2.1. Preparation of Activated Carbon

The general process to produce AC-C is based on carbonizing and activating the carbonaceous precursor material. The method of activation used is described previously [8].

2.2. Chemical Activation

The carbonization of the AC-C was done at350°C for three hours and allowed to cool at room temperature according to a previously described method [9]. After sample preparation for the activation, 150 grams was mixed with1000 ml of Potassium Hydroxide (3M). The samples were impregnated in muffle furnace at 600°C for one hour. Washing of the prepared sample was carried out to clean the base content of the prepared AC-C. The washing process was continued until pH7 was attained. The samples were then dried in an oven at 105 °C to remove any moisture content.

2.3. Estimation of Physical and Chemical Properties for AC-C

The pH was measured using a pH meter (HACH 103), for Moisture Content; 0.5g from the AC-C was placed, weighed to the nearest 0.5g and then placed in a preheated oven at 105 °C. After cooling in desiccators to ambient temperature the weight was measured again, according to a previously published work[9].

2.3.1. Iodine Number

The Iodine number of AC-C was determined according to a standard method which is a titrimetric method. 0.5-2.0 g dried carbon was weighed and transferred to a dry, glass Stoppard 250 ml Erlenmeyer flask. Pipette 10ml of 5% HCl acid in the flask, and swirl until the activated carbon is wetted. Place the flask on a hot-plate in a fume hood, bring the constant to the boil, and allow boiling for exactly 30 seconds. Allow the flask and constant to cool to room temperature, and then add by pipette 100ml of 0.10N iodine solutions. Stopper the flask immediately and shake it vigorously for 30sec. Filter by gravity through a filter paper immediately after shaking period. Discard the initial 20-30ml of filtrate and collect the reminder in a clean beaker. Stir the filtrate in the beaker with a glass rod and pipette 50ml into 250ml Erlenmeyer flask. Titer the 50ml of sample with 0.10N sodium thiosulphate solution until the yellow color has most disappeared. Add 1ml of starch solution and continue titration until the blue indicator color just disappeared. Record the volume of sodium thiosulphate solution used.

[10].

2.3.2. Determination of Porosity/ Bulk Density and Carbon Content

Carbon content, Bulk density and Porosity were determined according to the method described earlier [9], [11] For Bulk density and porosity, a cylinder and an aluminum plate were each weighed; a sample of AC-C was placed into the cylinder and weighed again. The sample was transferred into the aluminum plate and put into an oven so as to dry it to a constant weight at a temperature of 105°C for one hour. The weight of the dried samples was taken again after drying. A clean dry well corked density bottle was weighed. The bottle was filled with water, corked and reweighed. A small quantity of activated carbons was taken and ground to powder, sieved using 106μm in diameter and gradually put into the bottles with little amount of water and weighed again. The bulk density and porosity were calculated using the following expressions [9]

$$\text{Bulk density} = \text{Weight of dry sample (g)}/\text{Volume of tube packed dry AC-C (cm}^3\text{)} \quad (1)$$

Porosity = Vv/Vt (2)

Where Vv = volume of sample, Vt = total volume.

2.3.3.1 Calculation of Decoloring Efficiency DE (%)

The decoloring efficiency DE (%) was used to determine the decoloring capacity of AC-C. The following equation was employed to quantify the DE (%). The absorbance of original liquor was taken as A0 and that of filtrate was taken as A [12].

$$DE (\%) = (A_0-A)/A_0 \times 100 \%(3)$$

2.3.3.2 Calibration curve

For the determination of metals (Fe^{2+}, Cr^{3+},and Co^{2+}), a calibration standard curve was constructed. A 1% stock solution of (Co^{+2}), Cobalt nitrate ($Co (NO_3)_2\cdot 6H_2O$), (Fe^{+2}), Ferrous sulphate hydrous ($FeSO_4\cdot 7H_2O$) and (Cr^{+3}), Chromium chloride ($CrCl_3$) was prepared. Then a serial dilution of various concentrations ranging from 0.2-1.0 % was done. The absorbance of the different solution was read using UV spectrophotometer (Model no: C07500E)with the appropriate wavelength (for Cr^{3+} , wave length 600 ± 20 nm, Fe^{2+} wave length 490 ± 20 nm, and Co^{2+} wave length 500 ± 20 nm).the device was operated according to manufacturer instructions.

2.4. Effect of Variable Parameters on the Adsorption Properties

2.4.1.1 Effect of Adsorption Conditions

All equilibrium and kinetic studies of adsorption were carried out according to methods mentioned previously [13, 14].

2.4.2Doses of the Adsorbent

Different doses of the adsorbent ranging from 0.1-1.0 g were mixed with the metal ion and the mixture was agitated in a water bath with a mechanical shaker. The percentage of different adsorption doses was determined by keeping all other factors constant [14].

2.4.3Contact Time

The effect of period of contact linking the adsorbent and adsorbate on the removal of the metal ion in a single cycle was determined, where 0.1-1.0 g of AC-C was shaken with 1% of each metal ion (Fe^{2+},Cr^{3+} and Co^{2+}) at intervals of 20,30,40,50,60,80 and 100 min, respectively .All samples were filtered through a 0.45 µm filter paper to remove the carbon fines and then the concentration of each metal was measured using a UV-VIS spectrophotometer at different wavelengths. Initial concentrations of metals were employed for the study of the effect of initial concentration on adsorption process.

The amount of adsorption (*qt)* at time (*t*), was calculated using formula[14]:

$$qt = (C_0 - C_t)V/W \quad (4)$$

Where C_0-C_t (mg/l) are the liquid phase concentration of metals at initially and at equilibrium, respectively. V is volume of solution (Liter) and W is mass of AC-C used (g). The experiments were carried out at a range of pH 1.0-10.0. The adsorption experiments were carried out at constant temperatures of (30 °C) in a water bath mechanical shaker machine.

2.4.4 pH

Adsorption experiments were carried out at a range of pH 1-10. The acidic and alkaline pH of the medium has been maintained by adding the necessary amounts of hydrochloric acid and sodium hydroxide solutions.

2.4.5 Temperature

The adsorption experiments were carried out at constant temperatures, 30 ºC in a water bath mechanical shaker machine (Remi, India). The constancy of the temperature was maintained with an accuracy of ± 0.5º C.

2.5. XRFAnalysis: The prepared AC-Cwas analyzed using X-ray fluorescence (XRF).AC-C first was crushed into fine powder and then pressed into a pellet form using a15-tonpressing machine. The diameter of each pellet was about 2.5 cm and a mass about 1.0g. The pellets were subjected to the XRF spectrometer system were each of them was measured for 2000 sec. The spectra obtained as a result of X-ray excitation using Cd-109 X-ray source were transferred to a computer. The absorption spectra were then analyzed and concentration of the elements present in the samples was obtained using AX1L –XRF software.

2.6.FTIR analysis: The samples were grinded and milled with 100 mg KBr to form a fine powder. This powder was then compressed into a thin pellet under 7 tons weight for 5 minutes. The sample was then analyzed using Fourier Transform Infrared spectrometer (Shimadzu8300) and the spectrum was recorded in a spectral range of 400-4000 cm $^{-1}$.For Software Operation method of FTIR-8400S analyzer was open firstly then a computer software , where a double click IR solution on the program then press insert background holder , wait for few minutes till spectrum appears in the two windows program ,click manipulation and select peak table and then choose calculation measurement on the function tabs.

2.7XRD analysis: The sample was prepared using bulk mineralogy method given in Fauziguide on XRD diffraction mineralogy of sedimentary rock. The water was chilled at a temperature of 20^{O}C and a pressure of 400 PSI. The XRD diffractometer was switched on at initialization power 15 kV and 5mA. The sample was then analyzed using the xpert -pro system.

2.8 Data Analysis: The results were analyzed using Statistical Packages for Social Sciences (SPSS) program.Comparison between adsorbents and other parameters was completed by oneand two-factor ANOVA. Percent relative standard deviations were computed for all replicate samples. All graphs were analyzed using graph PASW statistic software vervison18.

3. Result and Discussion

3.1. Proximate Analysis of AC-C:

AC-C sample had carbon content of (49.42%).The results indicated that the bulk density of AC-C was (0.75g/m), while the porosity of the sample was found to be (57.08%).Pore sizes affect the capacity for molecules of different shapes and sizes, and this is one of the criteria by which carbons are selected for a specific application. [3,15]. To gain further knowledge of the porous structure of activated carbon, the adsorption of aqueous I_2 is considered a simple and quick test for evaluating the surface area of activated carbons. The iodine value, defined astheamountofiodineadsorbedpergramofactivatedcarbonatanequilibriumconcentrationof 0.02N, was measured according to the procedure established by the American Society for Testing and Materials [10]. Amount of carbon content is related to the raw materials [13]. Material consists of plant and extractives are known to vary in chemical structure and initial carbon content. The cellulose is a linear polymer of glucose with a theoretical carbon content of 44.4 %. Lignin is a three-dimensional polymer of aromatic alcohols with a carbon content of 60 – 63%. As a result, the carbon content of a lignocellulosic material is dependent on the relative abundance of its constituents. Thus, the yield of carbon from each component is directly related to the carbon content of the respective components [13]. The power of activated carbon to remove the color as measured in terms of Decoloring Efficiency and expressed as percentage. AC-C has a bulk density of 0.75 g/ml measuring bulk density (BD) give useful data for the estimation of storage and packing volume. Many principles explain the concept of measuring (BD)[16].Powdered carbons used for decolorization usually have a bulk density in the range 0.25-0.75 g/cm^2[7]. A moisture content of AC-C was 2.80%there is a relationship between moisture content and other parameter of activated carbon, presence of carbon-oxygen groups on the surface of carbon and the presence of even small amounts of water vapor increase moisture of activated carbon [5].Other adsorption factors are listed in Table (1). Decoloring efficiency (DE %) of AC-C was 95.7 % for Fe^{2+} (Table 2) ion.

Table 1. Proximate analysis of the activated carbon prepared from Corn maizewaste materials (AC-C) compared to standard activated Carbon.

Parameters	**AC-C***	**AC****
pH	7.60	7.37-8.30
Bulk Density g/ml	0.75	0.50-0.60
Moisture%	2.80	2.0-10.0
Ash%	4.20	4.0-9.00
Iodine Number	13.00	12.8-18.0
Porosity %	57.08	
Volatile Matter %	23.80	
Carbon Content%	49.42	

**An average of triplicate sample , **Standard Activated Carbon(parameter of porosity, volatile matter and Carbon content are depends on nature of the raw material used)*

3.2 Calibration Curves for metal ions Fe^{2+}, Cr^{3+} and Co^{2+}

In order to study the adsorption process of activated carbon prepared from the Corn maize (ACC1) the determination of metals concentration a standard curve was constructed for three metals Fe^{2+},$Cr^{3+}$and Co^{2+}.For plotting the calibration curve different concentrations were used for the UV spectrophotometer measurements. The plot of concentration versus absorbance is shown in Figures (1, 2 and 3). Straight line was obtained. The result indicates that higher absorbance attends at higher concentration of the metals.

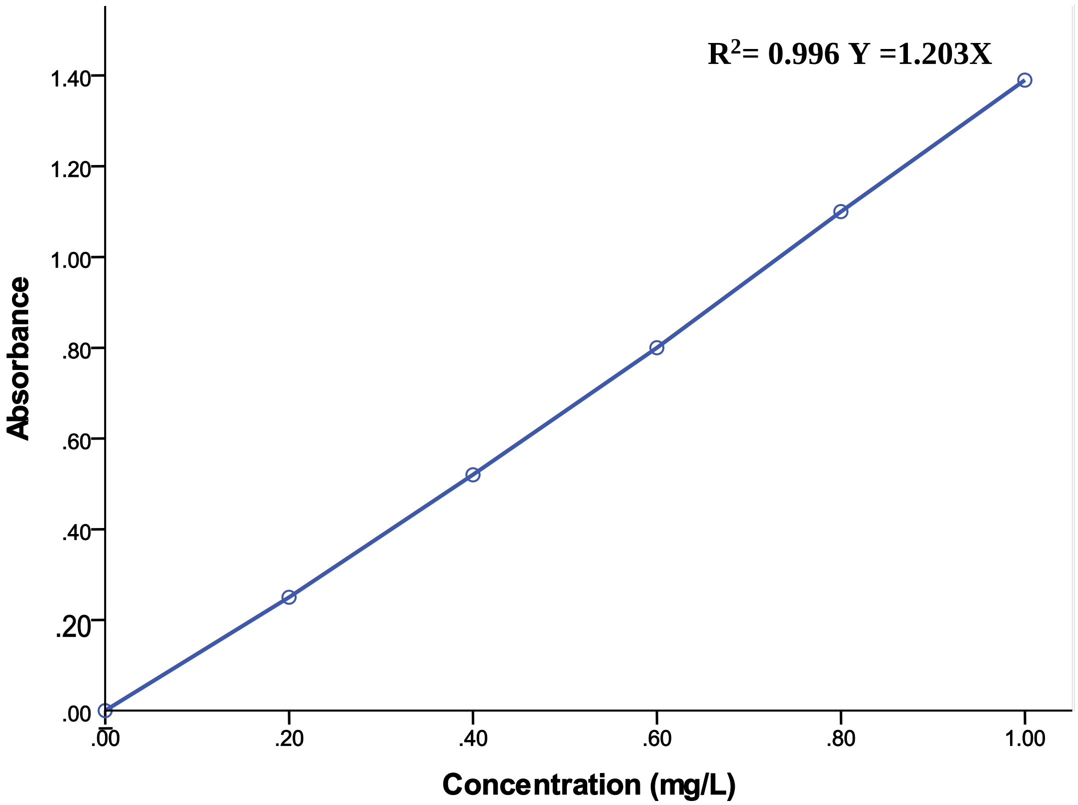

Figure 1. Calibration curve of Fe^{2+}

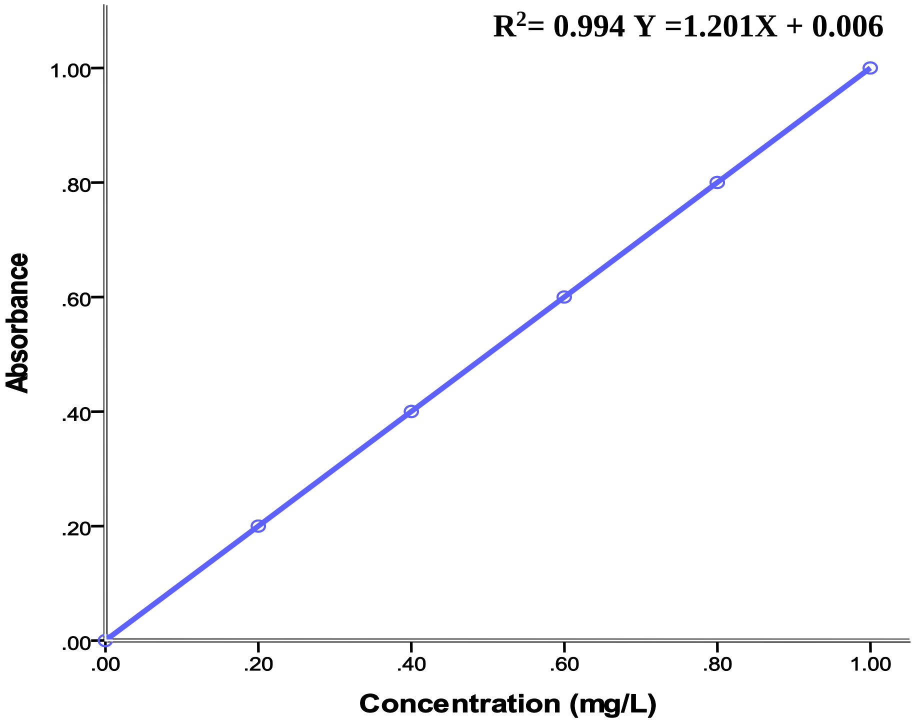

Figure 2. Calibration curve of Cr^{3+}

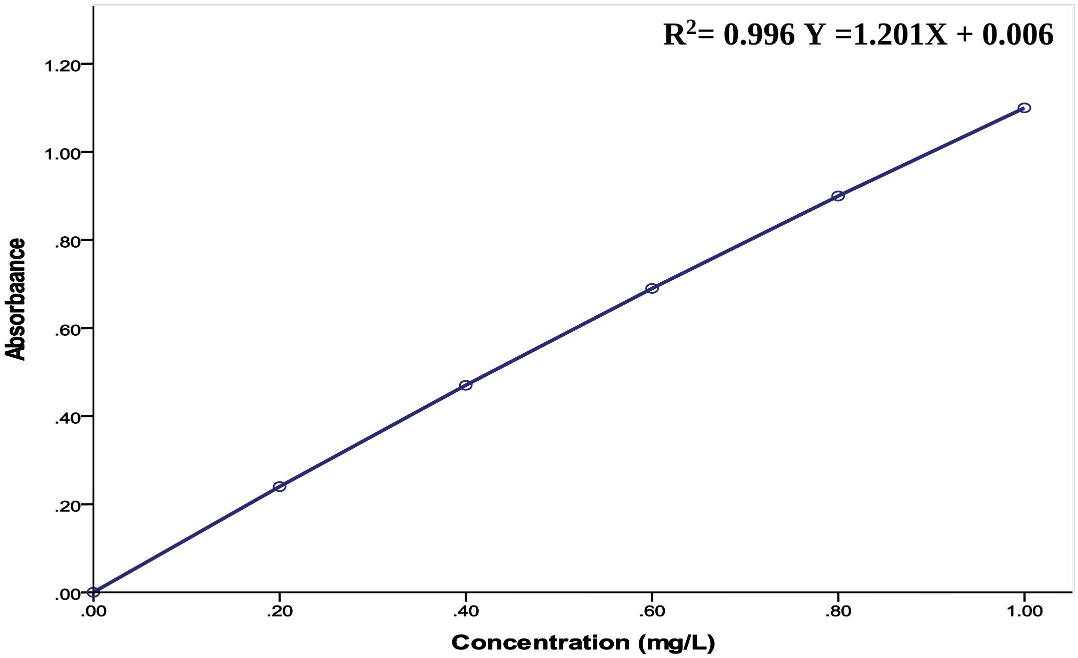

Figure 3. Calibration curve of Co^{2+}

Table 2. Decoloring Efficiency% DE of AC-C:

Metals ion	Fe^{2+}	Cr^{3+}	Co^{2+}
Decoloring Efficiency (% DE)	95.7	90.2	88.9

The effect of pH on adsorption of metal ions was investigated and the results are presented in Figure (4). The optimum pH for the maximum uptake of all metals ions was found to be 6 forCr^{3+} and Co^{2+}**.** The electrostatic attraction between the adsorbent and ions very high at lower pH, but it decreases at higher pH; our result is similar to that mention by [17] but different to that mention by[4]. Thus, the adsorption of metal ions mainly involves electrostatic attractive and repulsive interactions between metal ionic species in the solution and the negative sites on the carbon surface produced by the ionization of acidic groups.

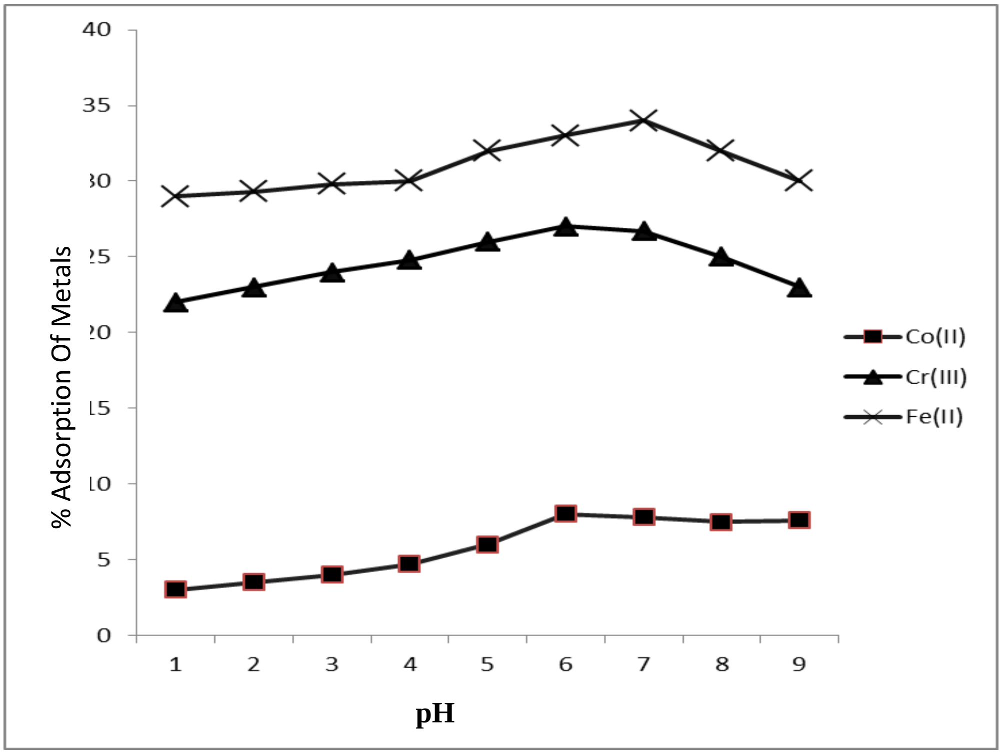

Figure 4. pH Adsorption of metal ions Fe^{2+},$Cr^{3+}$and Co^{2+}versus the % of Adsorption on the AC-C.

The effect of the adsorbent dose (Figure.5) was studied at a temperature of 30°Cby varying the sorbent amounts from 0.20 to 1.20 g/L. For all these runs, initial concentration of Fe^{2+},$Cr^{3+}$and $Co^{2+}$was fixed as 1.0 %w/v. Figure(5) shows that the adsorption of Fe^{2+},Cr^{3+} and Co^{2+}increases rapidly with the increase in the amount of AC due to greater availability of the surface area at higher concentration of the adsorbent. For AC-C the significant increase in uptake was observed when the dose was increased from 0.2 to 0.8 g/L. Any further addition of the adsorbent beyond this did not cause any significant change in the adsorption. This may be due to overlapping of adsorption sites as a result of overcrowding of adsorbent particles [12].One of the Factors affecting the adsorption of metals on to activated carbon is contact time, which is the time required for the liquid or vapor to pass through a carbon column, the contact time results are in Figure 6. The time of the adsorbent-adsorbate is of great importance in adsorption, because it depends on the nature of the system used. The effects of time for the adsorption of Fe^{2+},Cr^{3+} and Co^{2+} ions were studied between 20 and 100 minutes. it's clear that as the time increase from 20 -100 min the amount of adsorption increase maximum adsorption of 10.7 mg/L was reported at 80 min for Fe(II).

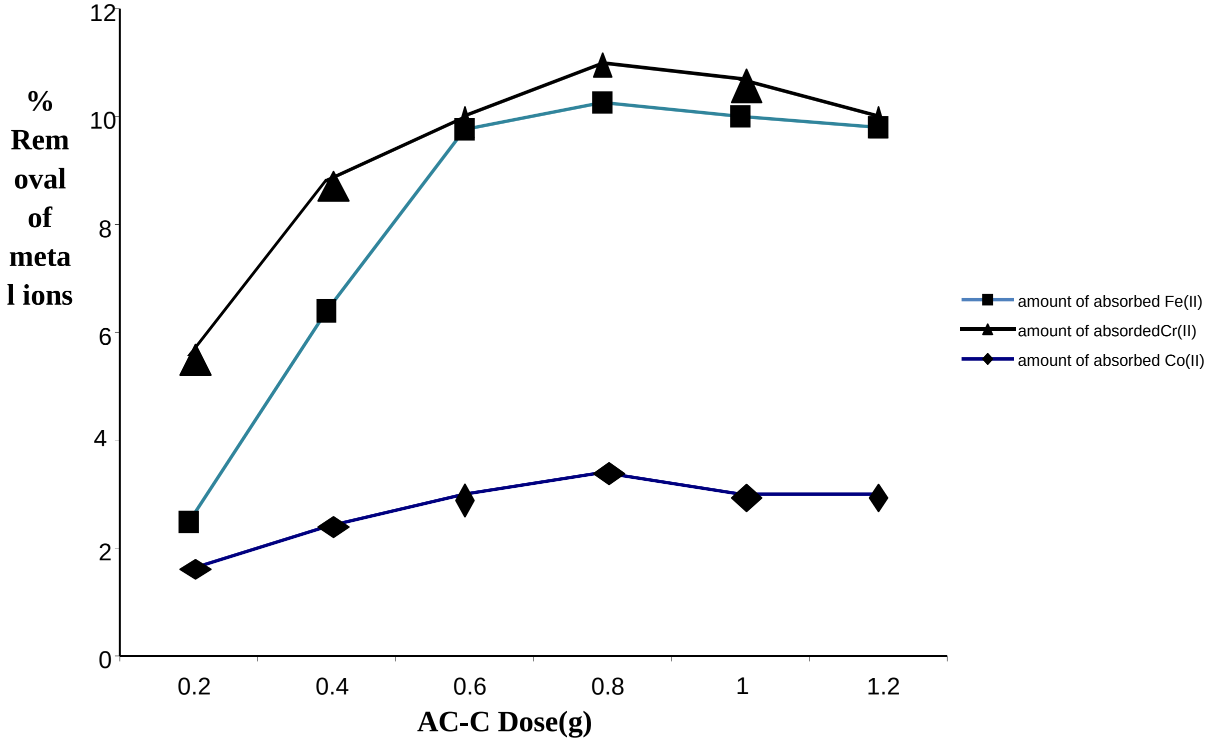

Figure 5. Effect of Adsorbent (AC-C) Dose on Removal of Fe^{2+},Cr^{+2} and Co^{+3}.

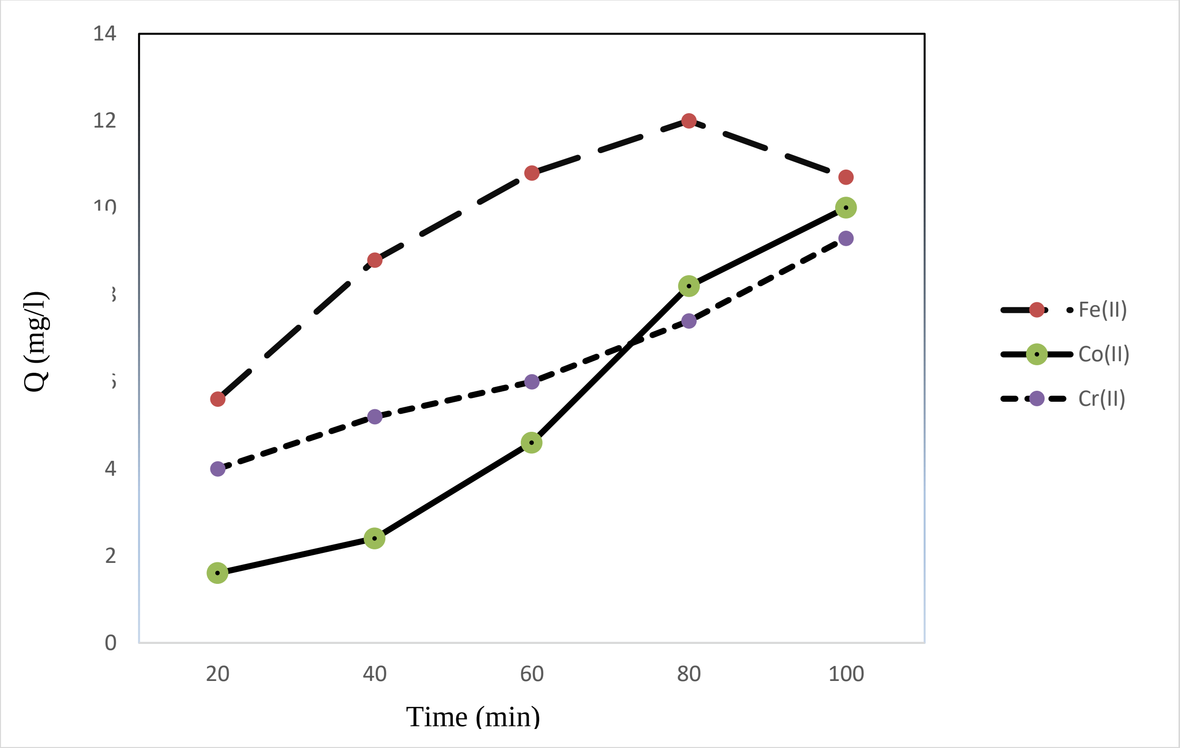

Figure 6. Effect of Contact Time For AC-C.

3.2 FreundlichIsothermStudy forAC-C

Freundlich isotherm is obtained using the empirical equation:

$$q_e = K_F \text{ X } C_e^{1/n} (5)$$

Where qe isamount of metals adsorbed per unit mass of adsorbent at equilibrium, (mg/g), C_e Equilibrium concentration of Fe^{2+}, Cr^{+2} and Co^{+3} mg/L solution. K and 1/n is Freundlich constants, K is an indicator of adsorption capacity. The higher the maximum capacity, the higher the K value. The value of 1/n is a measure of intensity of adsorption. The higher the 1/n value, the more favorable is the adsorption. Figures (7,8, and9), show the data obtained from this study and was used to plot a curve of log q and logC_f for Fe^{2+}, Cr^{+2} and Co^{+3}, respectively. The values of K and 1/n were calculated from the curves are listed in Table 3.

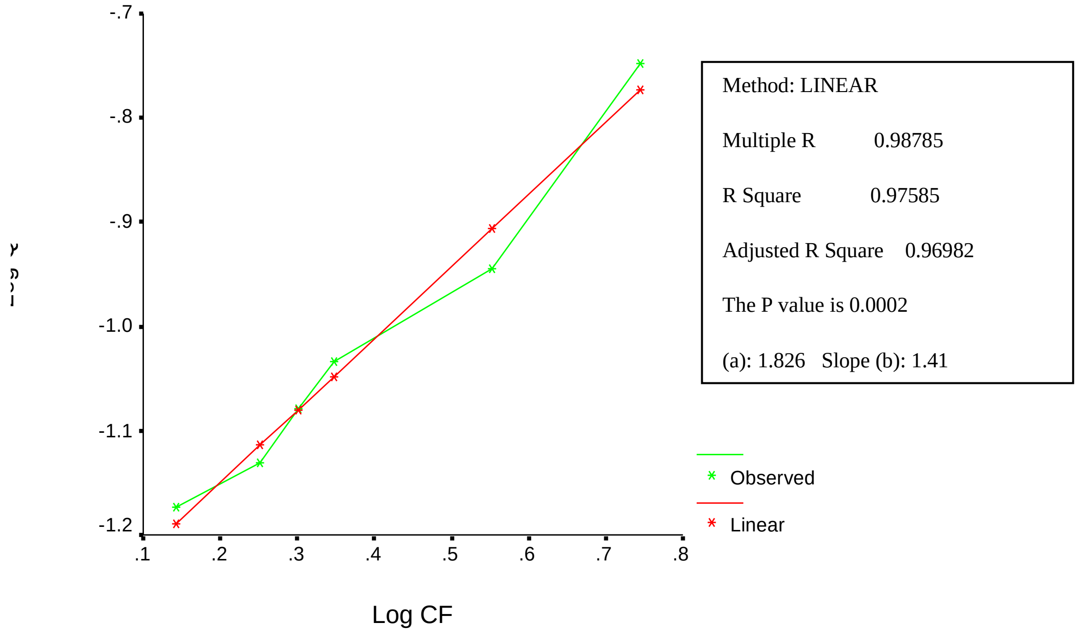

Figure 7 FreundlichIsotherm for the Adsorption of Metal Ion Fe^{2+} onto AC-C.

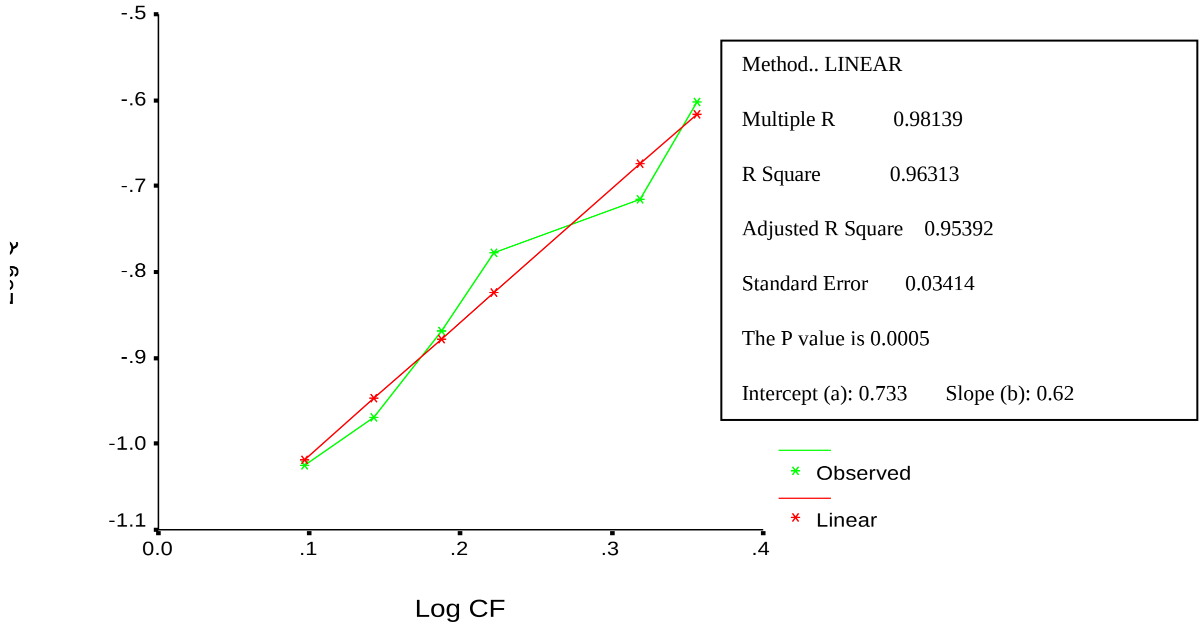

Figure 8. FreundlichIsotherm for the Adsorption of Metal Ion Cr^{3+} onto AC-C.

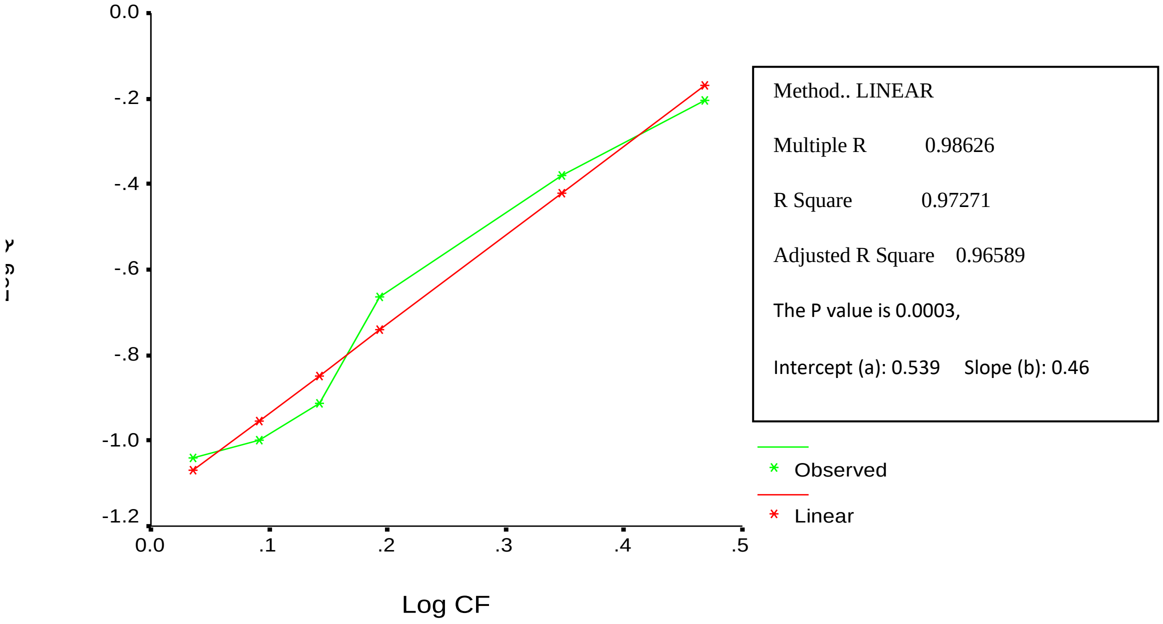

Figure 9.FreundlichIsotherm for the Adsorption of Metal Ion Co^{2+} ontoAC-C

The data in Table (3)showed higher value of K for Fe^{2+}which indicate a good adsorption capacity to form a monolayer while moderate adsorption capacities were obtained in the sample that have K value range from 0.54-0.73.Likewise, 1/n value of Fe^{2+} indicates good adsorption intensity. Value of R^2 is very important since it gives information about the goodness of fit of a model,(Table 3).In general, the data conform well to the Freundlich equation. The essential models could be described fitting the adsorption phenomena with R^2 value between 0-1. The level of fitness indicate as follows; When R^2 =1 Perfect fit, R^2 = (0.5–0.9) good fit, and R^2 = (0–0.4) poor fit [18].Our results are similar to that mentioned previously [19].

Table (3).Freundlich isotherm constants for AC-C sample.

Metals Ion	K	1/n	R^2
Fe^{2+}	1.83	1.41	0.97
Cr^{3+}	0.73	0.62	0.96
Co^{2+}	0.54	0.64	0.97

3.3. XRF, FT-IR and XRD Analysis:

3.3.1 XRF analysis

XRF of AC-C analysis is shown in in Figure 10. XRF analysis indicated that the percentage of Calcium was 4.24%; other elements that were found in the sample are Iron, copper and strontium. The presence of the inorganic elements in all samples play an important role in adsorption process. Variation in elemental concentrations in AC-C may be attributed to the nature of raw materials used and adsorption study. These elements play an important role in the field of catalysis by transition metals and their compounds, due to their ability to change the oxidation states and to adsorb other substances on their surface as catalyst.

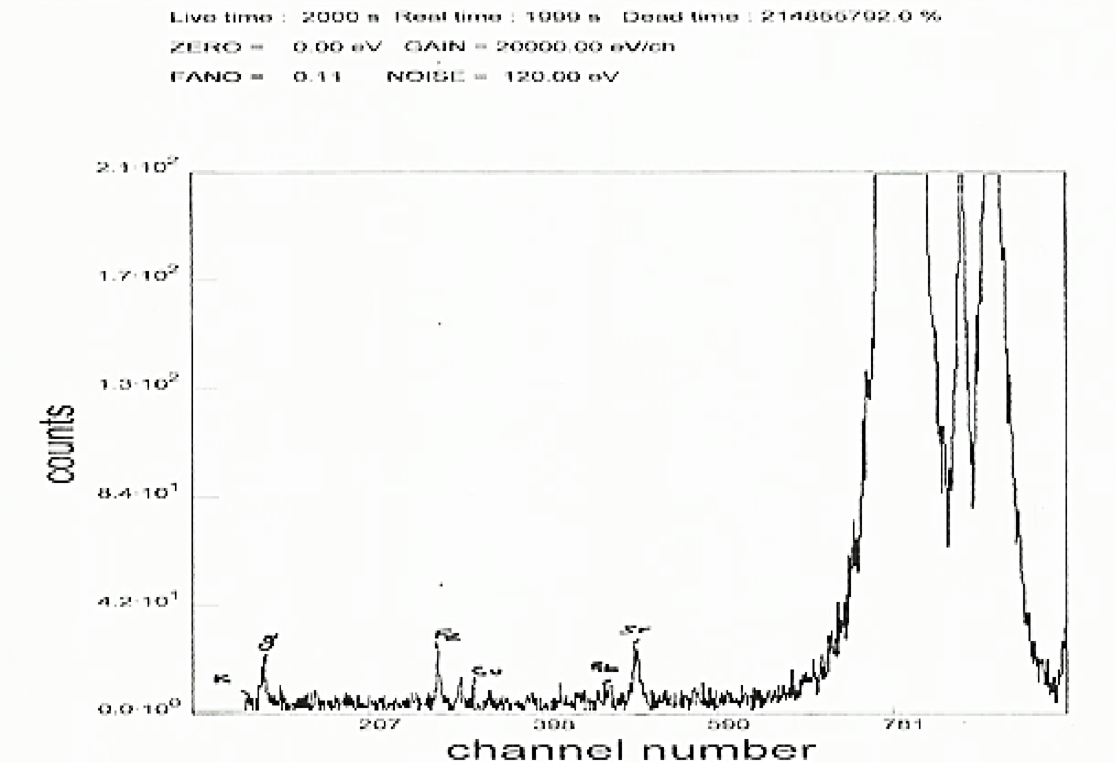

Figure 10. XRF for AC-Csample.

3.3.2FT-IR analysis:

FT-IR is used to identify the functional group on AC-C sample since these functional groups play a significant role in adsorption system. The FT-IR spectra of AC-C are shown in Figure (11).

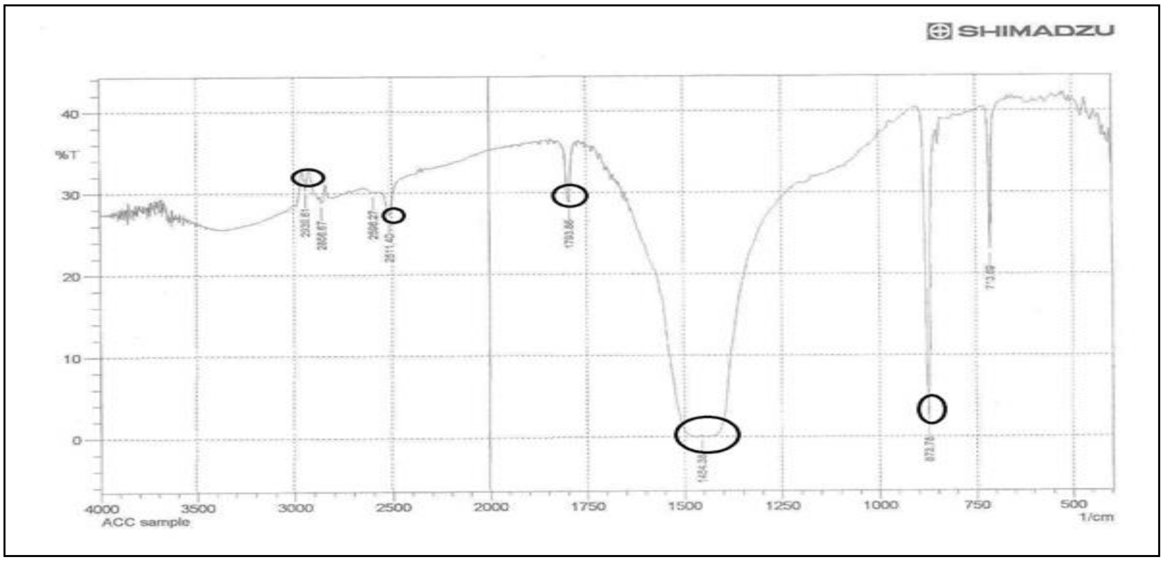

Figure 11. FT-IR spectrumfor AC-C

The FT-IR spectra indicate the presence of five functional groups; at frequency of 2511 cm^{-1} a carboxylic O-H stretching which is in agreement with the vibration stretching range (3300-2500 cm^{-1}) reported previously [20], this could be due to the absorption of water molecules during the process of treatment as result of an O-H stretching mode of hydroxyl groups and adsorbed water [21]. 1794 cm^{-1} corresponds to an acid anhydride C=O stretching which is in agreement with the vibration stretching range (1800-1775 cm^{-1}) reported previously [20]. 1454 cm^{-1} corresponds to an aromatic C-H stretching which is in agreement with the vibration stretching range (1400-1500 cm^{-1}), 874 cm^{-1}, 874 $cm^{-1}$is associated with the out of plane C-H wagging and 704 $cm^{-1}$is in plane C=C bending reported previously [21]. The chemical structure of activated carbon reported previously [22] explains the functional groups shown in Figure 11.

Functional groups are indicated to more important parameters that influence and determine the adsorption of metal ions from aqueous solutions are the carbon-oxygen functional groups present on the carbon surface. Although all of these surface groups influence the adsorption of inorganics from aqueous phase, the carbon oxygen surface groups are the most influencing and important [20, 21].

3.3.3 XRD analysis

XRD analysis wasused to identify the crystallographic structure of the samples using ICCD standard. The results obtained in this study showed that the sample AC-C contain one crystal system of potassium carbonate and chlorine oxide figure (12).

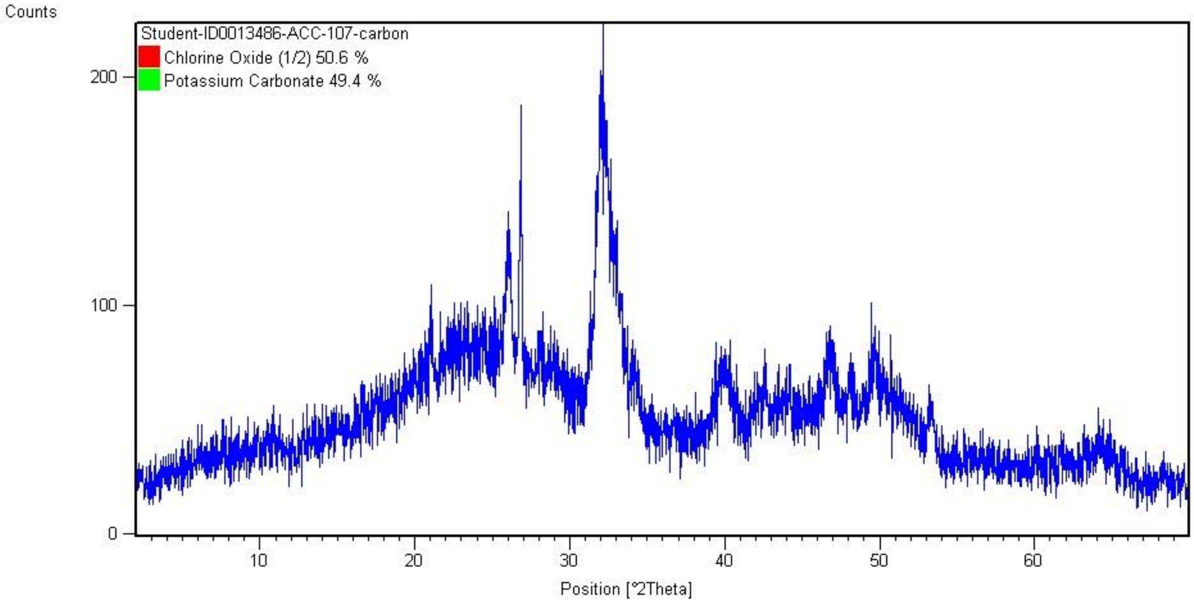

Figure 12.XRD Analysis for AC-C Sample.

The presence of minerals inthe prepared activated carbon (AC-C) were further tested by XRD studies. The activated carbon shows two peaks at around 2θ = 27° and 33° which contribute to chlorineoxide and potassium carbonate.[22]

XRD was used to determine the mineralogical and crystal composition of the raw material components as well as qualitative and quantitative phase analysis of multiphase mixtures. The occurrences of minerals in samples were identified by comparing ‘D’ values (peak intensity and position). It could be supposed that during the KOH activation process, various reactions can be considered with such products as H_2, K^+, K_2CO_3, K_2O and $K(HCO_3)$.At higher temperature, the formation of K_2O is thermodynamically the most stable. The increase of KOH ratios on samples containing a large amount of potassium suggests that the high ratio of KOH may give more K_2CO_3 and K_2O during pyrolysis [7], [22] different minerals were occurred at 002 which indicating different crystalline structure. In this study XRD analysis is associated with ash content since ash content is the starting point for analysis of minerals, thus lower ash content yield low minerals.

4. Conclusion

The present study shows that Corn maizewaste is an effective adsorbent forthe removal of metals ions Fe^{2+}, Cr^{3+} and $Co^{2+}$from aqueous solutions. From the kinetic studies, it is observed that adsorption of metals ion increase as the dose of the prepared activated carbon increase .The various properties of the studied indicates the applicability of corn maize waste as an effective low cost adsorbent The adsorption process was highly dependent on solution pH and adsorbent dose, also the results showed that the adsorption capacity and intensity are metal dependent; the higher capacity and intensity were for Fe^{2+} ions.

5. References

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