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Adsorption study on Copper (II) ions from aqueous solution using Chemically activated *Couroupita guianensis (*J.K. AUBLET) carbon

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Abstract

In recent years, many researchers uses various natural adsorbent for the removal of heavy metals from the industrial waste water. The heavy metals from the effluents discharge in aqueous stream causes a great hazard to the environment. Adsorption method is the effective technique for the removal of heavy metals from the aqueous solution even in very low concentration. The present adsorption study focuses to evaluate the potential of chemically activated Couropita guianensis carbon for the removal of Copper (II) ions in the aqueous solution. The chemically activated carbon was characterized using standard American Standard Testing Methods. (ASTM). Morphology of carbon particles have been characterized using Scanning Electron Microscopy (SEM). Adsorption studies performed by batch experiments showed that the adsorbent prepared from fruit of Coroupita guianensis has good capacity of copper ions adsorption from aqueous solution The preparation and characterization of activated carbon are listed out and well prepared porous activated carbon was studied under various parameters include contact time, adsorbent dosage, initial concentration, pH. The adsorption process of copper (II) is tested with Langmuir and Freundlich adsorption isotherm models.

Keywords: Adsorption, heavy metal, low cost adsorbent, characterization, copper, isotherms.

Introduction

Many industries releases toxic heavy metals at various concentration into the environment and causes the great havoc to all living beings on earth. The indiscriminate toxic effluents from various industries create a global threat. Particularly the copper toxicity exceeds the permissible limits of 0.5 to 1.5mg/L causes physiologically and biologically many health problems in human beings[1]. Copper is an essential element for the proper functioning of blood vessel and heart. The adult human body contains 100-150 mg/L of cu (II) but present excess in the body can be toxic[2,3]. The WHO recommended a maximum permissible limit of copper in the drinking water of 1.5mg/L[4].

Therefore the removal of heavy metals effluents is the major global issue to reduce the toxic levels. There are various methods to remove heavy metals before discharging into the environment [5]. Adsorption is the cost effective and eco friendly and selective method for the removal of copper ion from the waste waters even at very low concentration[6,7]. The chemically activated carbon are used for the adsorption of copper from the aqueous solution. The copper has the greater affinity towards nitrogen and sulphur donar ligands[8]. The purpose of this work were to investigate the adsorption capacity of chemically prepared activated carbon from Couropita guainesis to remove copper ions from the aqueous solution. The batch experiments were done for studying the effectiveness of adsorbent dosage, pH, contact time, initial concentration, for the maximum removal of copper from aqueous solutions. The Langmuir and Freundlich adsorption isotherms were used to verify the adsorption.

Material and Methods

Adsorbent: Collection and preparation of activated carbon. In this present study, Couropita guainesis was used as a adsorbent for the removal of Cu (II) ions from aqueous solutions. Couropita guainesis were collected from temple campus and washed with distilled water, then cut into small pieces and dried in open air in sunlight for two week. The dried pieces were grounded into a very fine powder in a machine to increase the surface area. The finely grounded material was chemically activated by treating with the calculated amount of 98% conc.Sulphuric acid for 12hours and kept in a hot air oven for 5 hrs then cooled. The carbonized material obtained was washed with double distilled water for several times until the excess acid is removed. The chemically activated carbons were dried in hot air oven for 8 hours at 105^{o}C until it dried. The prepared activated carbon was grounded well and sieved to select particles of less than 0.5 mm (mesh size of 250 µm). The chemically activated carbon, were put in a air tight bottle for further use as a adsorbent in batch studies.

Adsorbent characterization: Scanning electron microscope (SEM) machine was employed to check the surface morphology of activated carbon.

Table-1
Characteristics of adsorbent

Characteristics	Values
Moisture content (%)	9.64
Ash content (%)	1.00
Volatile matter (%)	20.58
Fixed carbon (%)	68.78
Iodine Value (mg/g)	486.75
Decoloursing Power (mg/g)	16.20
pH	4.00 (ASTMD 3838-80)
Conductivity(200µs)	196.90

Fourier Transform-Infrared spectroscopy (FT-IR): FT-IR investigates the surface carbon-oxygen groups. The activated carbon was mixed with KBr, compressed into wafer and FT-IR spectra were recorded by Mattson 5000 FT-IR spectrophotometer

Adsorbate: Synthetic solutions were prepared by dissolving analytical grade(Merck) $CuSO_4.5H_2O$ and 5ml of 1:1 HNO_3 using distilled water. The copper solution was diluted to the required concentration for experiments [9].

Adsorption experiment: Adsorption process was taken place in a magnetic stirrer, at regular interval of time after equilibrium was achieved the solution was filtered with what man paper No 42. The filtrate was analyzed complexo metrically, to evaluate the concentration of copper (II) ions in the solution.

To study the adsorption of adsorbent dosage, the experiments were conducted in different dosages from 0.05 to 0 .5 mg. the effect of initial concentration of copper(II) from 10 mg/L to 60 mg/L and the pH of the solution from 2 to 8.The pH were adjusted using 0.1M HCl and NaOH solution. The adsorption isotherm experiments were conducted at room temperature with the initial concentration of 50mg/L and pH 5.0**.**

The removal of copper from the aqueous solution were calculated according to the following equation: % Removal (mg/L) = (Cinitial-C final) X 100/C initial
The amount of copper ions adsorption were calculated using qe (mg/g)= {Cinitial-C final X V} / m

Adsorption isotherm Models: To find the relationship between the equilibrium of adsorbate concentration in the solid and aqueous phase. The most used model are Langmuir and Freundlich isotherms[10].

Langmuir model: Once the adsorbate occupies the active site of adsorbent no further adsorption takes place, the monolayer of adsorbent formed on the surface[11].
Langmuir model is given by the equation: C/qe+ 1/bQo+C/Qo

Where Qo and b are the Langmuir constants. C = equilibrium concentration (L), qe = equilibrium amount of adsorbate onto the adsorbent (mg/g)

Freundlich model: The data has been used for analyzing the Freundlich isotherm an empirical method by the following equation[12]. Log qe = log K + 1/n log Ce

Where qe = amount of metal ion adsorbed,(mg/g) Ce = equilibrium concentration of adsorb ate(L) K and n are Freundlich constants which represent adsorption capacity and adsorption intensity respectively.

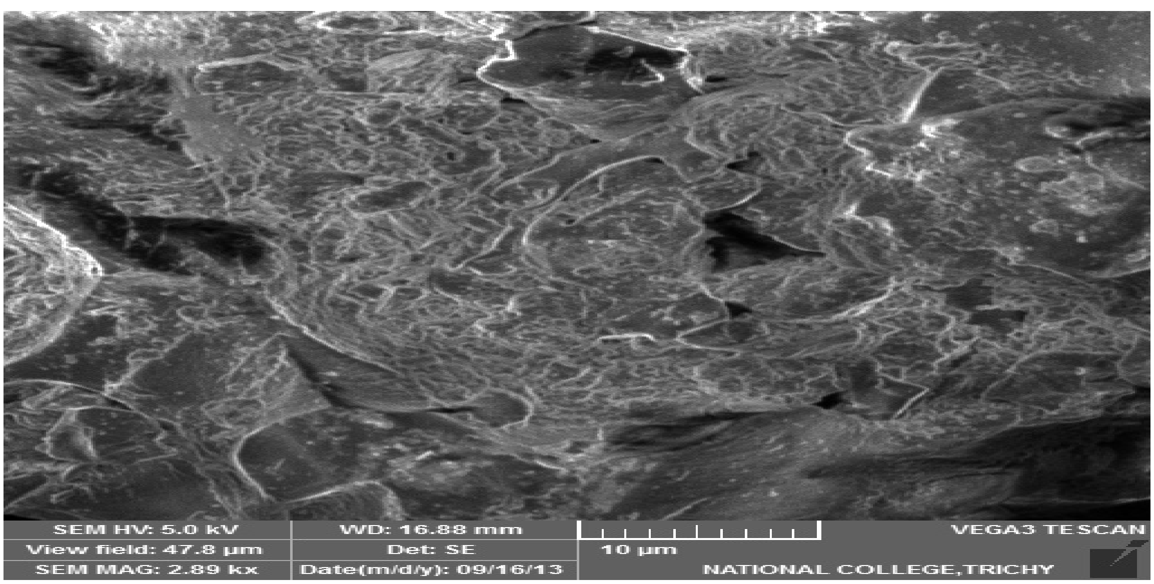

Figure-1
The SEM image shows that the activated carbon surfaces are porous

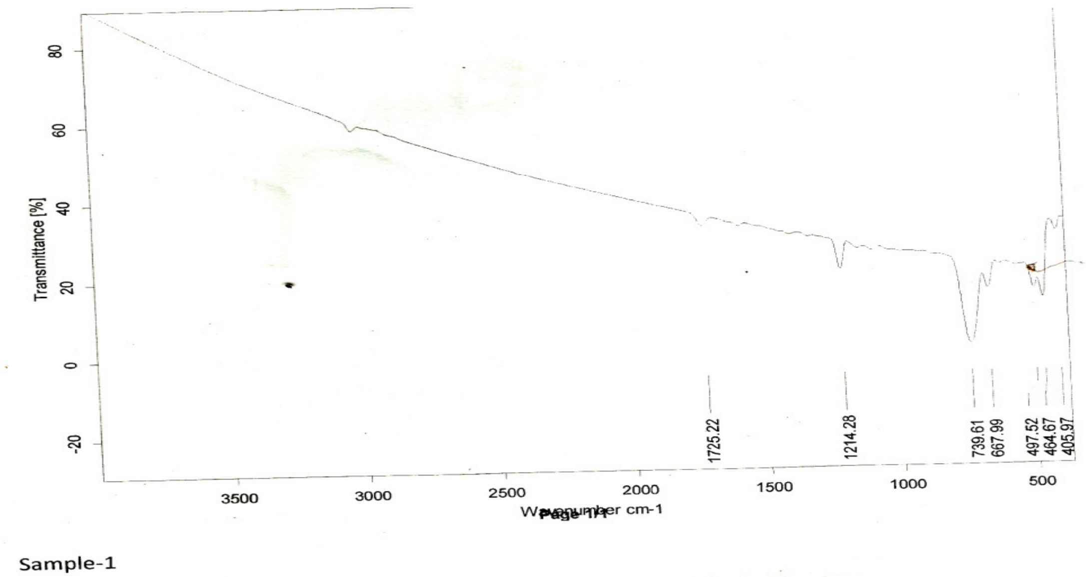

Figure-2
The FTIR spectra showed the presence of functional groups which are responsible for the increase of adsorption of heavy metals from the aqueous solutions

Results and Discussion

Effect of contact time: An activated carbon sample must reach adsorption equilibrium to measure its total adsorptive capacity. In adsorption system, the contact time plays an important role irrespective of the other experimental parameters, affecting the adsorption kinetics. Figure -3 depicts that there was an appreciable increase in percentage removal of Cu (II) up to 30 minutes, due to the presence of number of sites present for the adsorption of copper ions is more, thereafter further increase in contact time the increase in removal of copper was very small (at 50min) due to the saturation of sites. Thus the effective contact time (equilibrium time) taken as 30 min. and it is independent of initial concentration of 50ppm. The amount of heavy metal ion increases as time increases the same is recorded[13,14] .

Effect of adsorbent dosage: The adsorption of copper by activated carbon at different dosages 0.05 to0 .5 mg for the copper concentration was investigated. The figure-4 showed that the copper removal increases with the increase in adsorbent dosage, this is mainly due to the greater availability of adsorbent. Percentage of Cu(II) removal from 40 % –98% acquired by the increase of adsorbent dosage. The adsorption capacity increases with the increase of adsorbent dosage because of more surface area the report was same as[14, 15].

Effect of initial concentration: The initial concentration of copper provides and important forces to overcome all mass transfer resistance of metal ions between the aqueous and solid phases. Figure- 5 The initial concentration from 5mg/L to 50 mg/L the removal of copper adsorption decreased from 95% to 65%. The curve is constant after 50mg/L shown that the availability of adsorption sites were saturated .Increasing uptake of copper ion in the solution by increasing the adsorbent dosage is mainly due to the availability of adsorbent sites up to 50mg/L by increasing the concentration above 50mg/L there is no increase in uptake of copper by adsorbent. It forms a layer there is no sites existing further. Earlier studies[16,17] showed the similar results.

Effect of pH: The pH of the solution is the important controlling factor for the adsorption of copper from the aqueous solution. The removal of Cu (II) increases from 70% at pH2 to 95.6% at pH5.5. Figure – 6 Copper adsorption is noted to be maximum at pH 5 with 95.6%. After that the adsorption capacity decreases from 6 to 9. The adsorption at pH2 observed low due to the higher concentration and mobility of $[H^+]$ ions present. [18] .At pH6 there is a decrease in the adsorption capacity due to the precipitation of copper. At pH6 there are three species present, Cu^{2+} in very small quantities, $Cu(OH)^+$, $Cu(OH)_2$ in large quantities. It has significant effect on adsorption of metal [19]. Copper removed at higher pH using Coroupita guianensis was supported by the investigation [20].

Adsorption isotherm Models Isotherms models give the mathematical relationship used to describe the adsorbent and adsorbate adsorption behaviors and adsorption capacity[21]. The graph is drawn by plotting the values Ce/Qe Vs Ce gave a straight line figure-7 shows that the linearity is due to the formation of monolayer of Cu (II) on the surface of the Coroupita guianensis. It can be seen from the graph , copper adsorption is best represented by Langmuir isotherm (highest R^2 value) The Freundlich isotherm is empirical and heterogeneous layer is formed by plotting the values, graph log Qe Vs log Ce figure-8 gives slope and intercept.

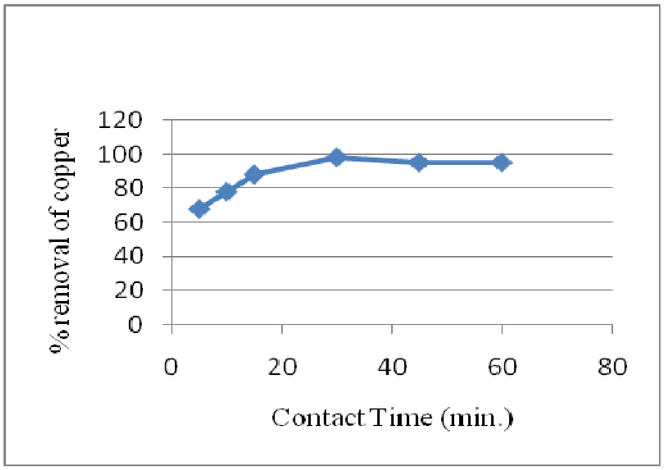

Figure-3
Effect of contact time

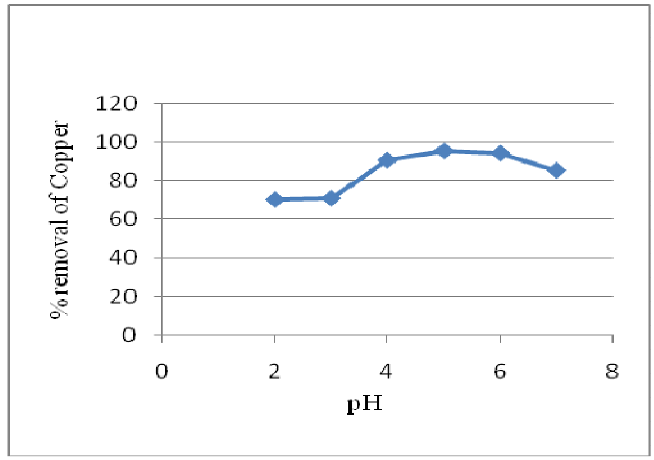

Figure-6
Effect of pH

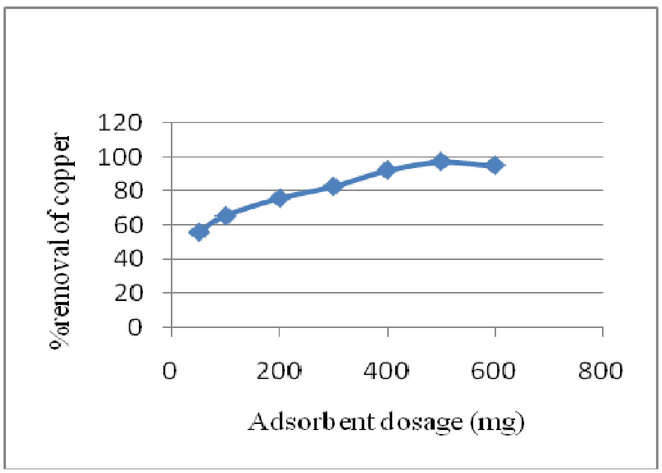

Figure-4
Effect of adsorbent dosage

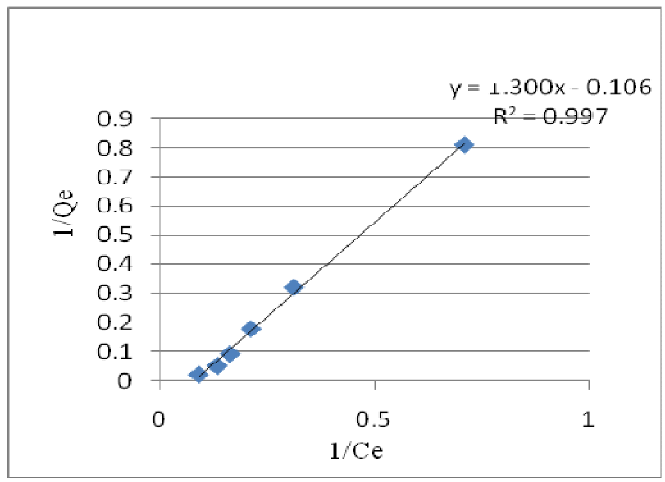

Figure-7
Langmuir isotherm

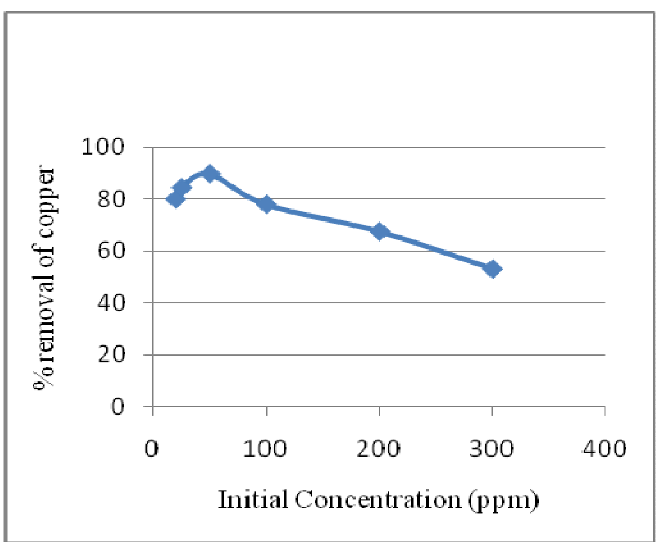

Figure-5
Initial concentration

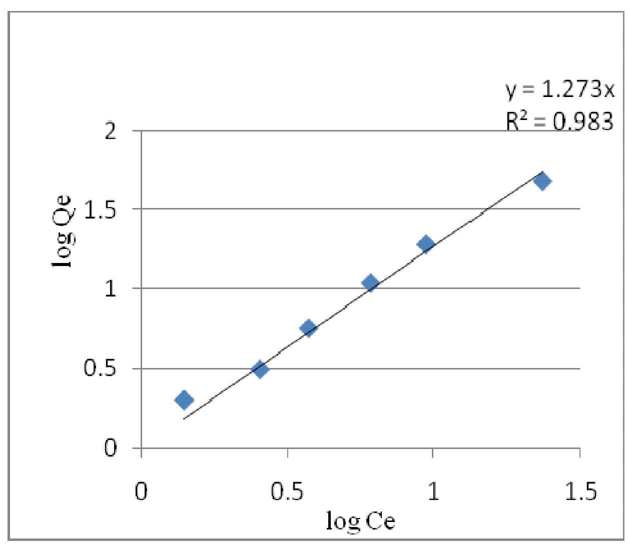

Figure-8
Freundlich isotherm

Equilibrium Adsorption Isotherms: Langmuir and Freundlich isotherms models were used in this work. These isotherms model results are best fitted with an equilibrium data. Langmuir model in terms of R^2 value gives 0.991 this indicates the monolayer of copper on the surface of adsorbent. A value of slope indicates normal Langmuir adsorption. The values of Freundlich exponent n,value is greater than unity showed the favourability of adsorption by Couropita guanesis[21] while 1/n is above 1 is indicative of cooperative adsorption[22].

Conclusion

The chemically prepared activated Couropita guainesis carbon can be used as a best adsorbent material for the removal of copper from the industrial waste water. The condition for the removal of copper obtained from this study are the required contact time is maximum 30 minutes, at the initial concentration of 50 mg/L and the adsorbent dosage of 500 mg/L. at pH 5.5. The maximum adsorption capacity of prepared carbon is found to be 95.6 mg/g. Langmuir and Freundlich isotherms models were significant correlation with adsorption equilibrium data. Langmuir model has a better fitting model than Freundlich isotherm.

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