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# Adsorption studies of copper ion by low cost activated carbon

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**ABSTRACT**

*Sorgum Vulcaris dust, a waste from the agricultural farm, was investigated as a replacement for the current expensive methods of removing metal ions from aqueous solutions. The pH of values of solution was adjusted by addition of HCl and NaOH. The batch study indicated that initial pH of aqueous solution affect metal ion removal. While the removal efficiency decreased with increasing initial concentration, it increased with increasing adsorbent concentration. For the linear forms of the Langmuir and Freundlinch models, the results indicated that the Langmuir adsorption isotherm fitted the data better than the Freundlich adsorption isotherm. Adsorption of these metal ions onto Sorgum Vulcaris dust carbon was favorable sorption. Therefore, Sorgum Vulcaris dust, the low-cost agricultural waste, is suitable for use as adsorbent for copper ion under this investigation*

**Key words:** Activated carbon (SVC), Copper ion, Adsorption isotherm, Equilibrium, Kinetic and Thermodynamic parameters, Intraparticle diffusion, Regeneration pattern.

## INTRODUCTION

Due to the discharge of large amount of metal contaminated wastewater, electroplating industry is one of the most hazardous among the chemical industries. Inorganic effluent from the industries contains toxic metals. The heavy metals are of special concern because they are non-

degradable and therefore persistent. Commonly encountered metals of concern include $Pb2^{+}$, $Cu^{2+,}$ $Zn^{2+,}$ $Co^{2+,}$ $Ni^{2+}$ etc. These metals are toxic in both their chemically combined forms as well as the elemental form. Exposure to these contaminants present even in low concentrations in the environment can prove to be harmful to the human health. In order to solve heavy metal pollution in the environment, it is important to bring applicable solutions. Some in place treatment technologies available for the removal of heavy metal ions from aqueous solutions are chemical precipitation, ion exchange, coagulation, and bioremediation and sorption/ adsorption [1,2,3]. Of all these techniques adsorption at solid substrate is preferred because of its high efficiency, easy handling and cost effectiveness as well as availability of different adsorbents.

The present study undertaken to evaluate the efficiency of a carbon adsorbent prepared form acid activated Sorgum Vulcaris dust carbon for the removal of copper ion aqueous solution. In order to design adsorption treatment systems, knowledge of kinetic and mass transfer process is essential. In this paper, the applicability of kinetic and mass-transfer models for the adsorption of copper ion onto activated carbon were reported

## EXPERIMENTAL SECTION

### Materials and methods

#### Sorgum Vulcaris dust collection and adsorbent development

Sorgum Vulcaris dust was collected from local agricultural farms. It was oven dried at $110^{0}$C overnight then it is added with con sulphuric acid in a weight/volume ratio of 1:1. The resulting black product was washed with water until free from excess acid and dried at 150 ± 5°C. The resulting black mass was kept in a furnace maintained at 400°C for 12 hours for activation. The carbon product obtained was ground well to fine powder which is used for all experiments.

#### Equipment

A UV-Visible double beam Spectrophotometer was used for metal ion analysis. The pH measurements were obtained using a digital pH meter Elico-model .An Remi water bath shaker was used for all adsorption experiments

#### Adsorption experiments

Adsorption studies were performed by the batch technique. A series of 50ml conical flasks were used. The flasks were shaken at 30, 40, 50 and 60ºC temperature and the shaking speed was 125 rpm. The pH values of solutions were adjusted by addition of HCl and NaOH. The Following adsorption experiments were carried out:

***Experiment 1.*** **The effect of adsorbent dose**: adsorbent dose ranged from 10 to 250 mg/50 ml at optimum contact time from experiment 3 and optimum initial pH and initial concentrations from Experiment 2.

***Experiment 2.*** **The effect of contact time or shaking time**: Contact time ranged from 10 – 60 minutes, initial concentration was 15initial pH solution was 6.75 and adsorbent does was 25 mg/50 ml.

***Experiment 3*. The effect of initial pH and initial concentrations**: pH ranged from 3 to 10. The initial concentration ranged from 5 to 25 mg/L and adsorbent does is 25 mg/50 ml. This experiment operates at optimum contact time which results from experiment1.

***Experiment 4*. The suitable condition to remove copper ion**. Equilibration time was determined at the optimum initial pH and initial concentrations obtained in experiment 2.

***Experiment 5*. Adsorption isotherms for copper ion onto sorgum vulcaris dust carbon**: Experiment was set at the suitable condition found in the previous experiment. This study used Langmuir and Freundlich isotherms to describe the metal ion adsorption onto Sorgum Vulcaris dust carbon.

***Experiment 6*. Effect of temperature on the adsorption copper ion:** The adsorption experiments were performed at four different temperatures viz., 30, 40, 50 and 60ºC in a thermostated shaker machine (Remi, India). The constancy of the temperature was maintained with an accuracy of ± 0.5º C.

***Experiment 7*. Effect of other ions on the adsorption of copper ion**: Adsorption studies of a specific metal ion in the presence of chloride and calcium ions were experimentally verified using the adsorbents. This involved the determination of the percentage of metal ion adsorbed from 15 mg/L of initial concentration of the metal ion solution with varying concentration of the added ion keeping all other factors constant.

***Experiment 8*. Zero point charge:** The pH at the potential of zero charge of the carbon (pHzpc) was measured using the pH drift method. The pH of the solution was adjusted by using 0.01 M sodium hydroxide or hydrochloric acid. Nitrogen was bubbled through the solution at $25^0$C to remove the dissolved carbon dioxide. 50 mg of the activated carbon was added to 50 ml of the solution. After stabilization, the final pH was recorded. The graphs of final pH versus initial pH used to determine the zero point charge of the activated carbon[4].

***Experiment 9*. Regeneration studies**: The regeneration of the adsorbed carbon is done by using 0.2 M mineral acids and sodium chloride solutions

## RESULT AND DISCUSSION

**Characterization of the adsorbent:** Activated carbons are a widely used adsorbent due to its high adsorption capacity, high surface area, micro porous structure and high degree of surface respectively. The wide usefulness of carbon is a result of their specific surface area, high chemical and mechanical stability. The chemical nature and pore structure usually determines the sorption activity. The physico chemical properties of the chosen adsorbent are listed in following Table.1

**Effect of contact time and initial copper ion concentration**: The experimental results of adsorptions of copper ion on the activated carbon at various concentrations (5, 10, 15, 20 and 25 mg/L) with contact time are shown in Figure 1. The equilibrium data were collected in Table 2 reveals that, percent adsorption decreased with increase in initial copper ion concentration, but

the actual amount of copper ion adsorbed per unit mass of carbon increased with increase in metal ion concentration. It means that the adsorption is highly dependent on initial concentration of copper ion. It is because of that at lower concentration, the ratio of the initial number of copper ion 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 becomes fewer and hence the percentage removal of copper ion is dependent upon initial concentration. Equilibrium have established at 40 minutes for all concentrations. Figure 1 reveals that the curves are single, smooth, and continuous, leading to saturation, suggesting the possible monolayer coverage of the copper ion on the carbon surface [5,6].

**Table.1 Characteristics of the adsorbent**

| Properties | SVC |
|---|---|
| Particle size (mm) | 0.042 |
| Density (g/cc) | 0.3253 |
| Moisture content (%) | 1.75 |
| Loss on ignition (%) | 92 |
| Acid insoluble matter (%) | 2.10 |
| Water-soluble matter (%) | 0.48 |
| PH of aqueous solution | 6.85 |
| $pH_{zpc}$ | 6.25 |

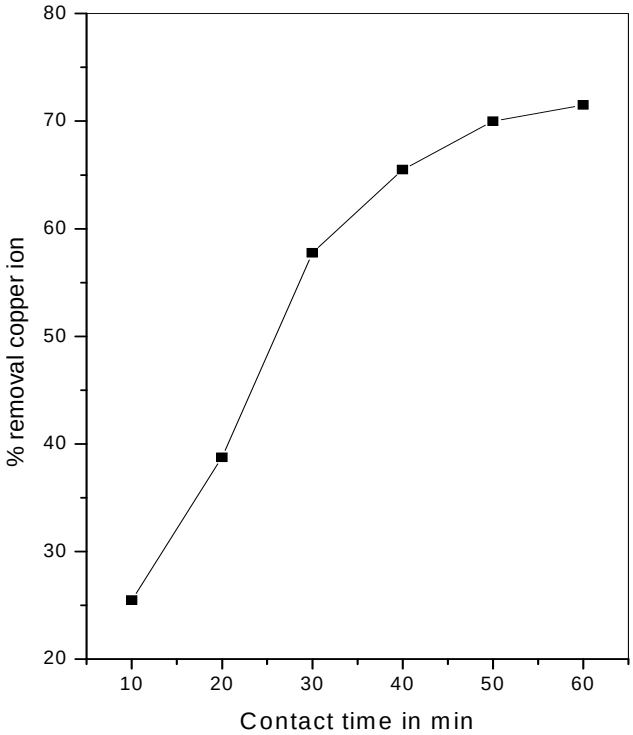


Fig.1-Effect of contact time on the removal of copper ion onto SVC
[M]=15 mg/L;Adsorbent dose=25 mg/50 ml;Temp=30$^0$C

**Table 2-Equilibrium Parameters for the adsorption copper ion onto SVC**

| Copper ion | $C_e$ (mg /L) | | | | $Q_e$ (mg/g) | | | | Metal ions Removed (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| | 30° | 40° | 50° | 60° | 30° | 40° | 50° | 60° | 30° | 40° | 50° | 60° |
| 5 | 0.5215 | 0.4728 | 0.4312 | 0.4054 | 8.957 | 9.0544 | 9.1376 | 9.1892 | 89.57 | 90.544 | 91.376 | 91.892 |
| 10 | 1.9587 | 1.7525 | 1.4747 | 1.2756 | 16.0826 | 16.495 | 17.0506 | 17.4488 | 80.413 | 82.475 | 85.253 | 87.244 |
| 15 | 4.2849 | 3.8254 | 3.3841 | 2.9944 | 21.4302 | 22.3492 | 23.2318 | 24.0112 | 71.434 | 74.49733 | 77.43933 | 80.03733 |
| 20 | 8.3546 | 7.7721 | 7.1599 | 6.5529 | 23.2908 | 24.4558 | 25.6802 | 26.8942 | 58.227 | 61.1395 | 64.2005 | 67.2355 |
| 25 | 13.3945 | 12.6572 | 11.9160 | 11.2435 | 23.211 | 24.6856 | 26.168 | 27.513 | 46.422 | 49.3712 | 52.336 | 55.026 |

**Effect of carbon concentration**: The adsorption of the copper ion on carbon was studied by varying the carbon concentration (10-250mg/50ml) for copper ion concentration of 15 mg/L. The percentage of adsorption increased with increase in the carbon concentration (Figure 2). This was attributed to increased carbon surface area and availability of more adsorption sites [5,6].

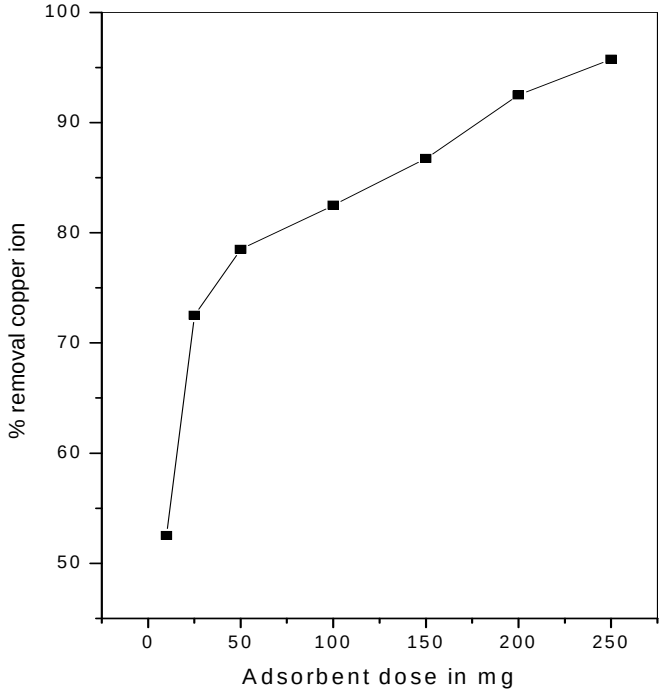


Fig.2-Effect of adsorbent dose on the adsorption of copper ion onto SVC
[M]=15 mg/L;Contact time=60 min;Temp=30$^0$C

**Adsorption isotherm:** The experimental data analyzed according to the linear form of the Langmuir[7] and Freundlich[8] isotherms.
The Langmuir isotherm represented by the following equation

$C_e/Q_e = 1/Q_m b + C_e/Q_m$……..(1)

Where $C_e$ is the equilibrium concentration (mg/L), $Q_e$ is the amount adsorbed at equilibrium (mg /g) and $Q_m$ and b is Langmuir constants related to adsorption efficiency and energy of adsorption, respectively. The linear plots of $C_e/Q_e$ versus $C_e$ suggest the applicability of the

Langmuir isotherms. Values of $Q_m$ and b were determined from slope and intercepts of the plots (Fig.3) and are presented in Table 3. From the results, it is clear that the value of adsorption efficiency $Q_m$ and adsorption energy b of the carbon increases on increasing the temperature. From the values we can conclude that the maximum adsorption corresponds to a saturated monolayer of adsorbate molecules on adsorbent surface with constant energy and no transmission of adsorbate in the plane of the adsorbent surface[9,10]. The trend shows that the adsorbent prefers to bind acidic ions and that speciation predominates on sorbent characteristics, when ion exchange is the predominant mechanism. Further, it confirms the endothermic nature of the processes involved in the system. To confirm the adorability of the adsorption process, the separation factor ($R_L$) has calculated and presented in Table 4. The values were found to be between 0 and 1 and confirm that the ongoing adsorption process is favourable[1,11]

The Freundlich equation have also employed for the adsorption of copper ion on the adsorbent. The Freundlich isotherm have represented as

$$\log Q_e = \log K_f + 1/n \log C_e \text{.....(2)}$$

Where $Q_e$ is the amount of copper ion adsorbed (mg/ g), $C_e$ is the equilibrium concentration of metal ion in solution (mg/L) and $K_f$ and n are constants incorporating all factors affecting the adsorption capacity and intensity of adsorption, respectively. Linear plot of log $Q_e$ versus log $C_e$ shows that the adsorption of copper ion follows the Freundlich isotherm (Fig.4). Values of $K_f$ and n were found and given in the Table 5, shows the increase of negative charge on the surface that enhances the electrostatic force like Vanderwaal's between the carbon surface and metal ion, which increases the adsorption of copper ion.

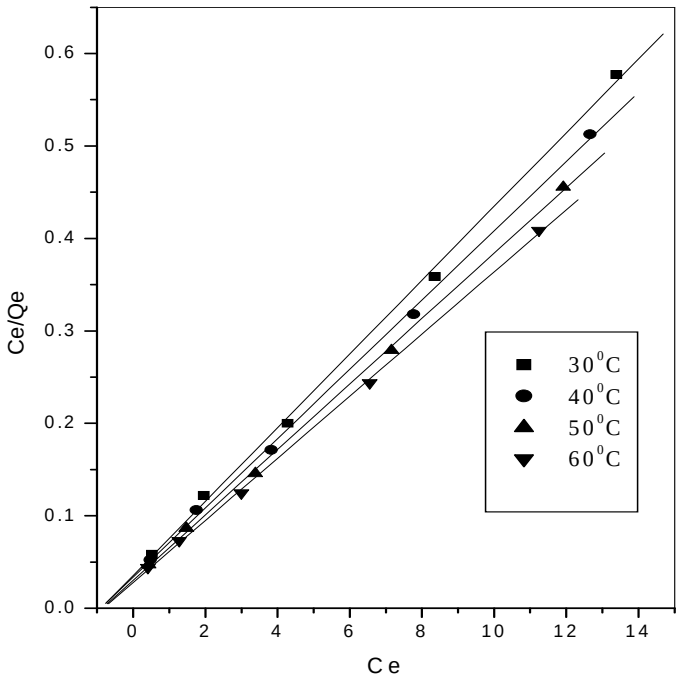


Fig.3-Linear Langmuir isotherm for the adsorption of copper ion

The values clearly show that dominance in adsorption capacity. The intensity of adsorption is an indicative of the bond energies between copper ion and adsorbent and the possibility of slight chemisorptions rather than physisorption [10,11]. The possibility of multilayer adsorption of metal ion through the percolation process cannot be ruled out. However, the values of n is greater than one indicating the adsorption is much more favourable[12,13].

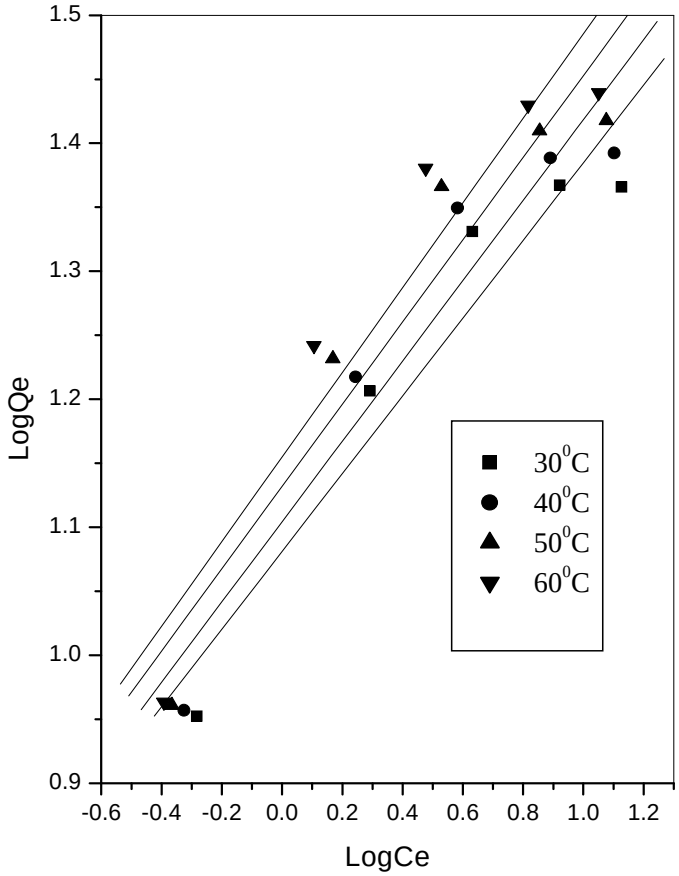


Fig.4-Linear Freundich isotherm for the adsorption of copper ion onto SVC

**Table 3- Langmuir isotherm Results**

| **(metal ion)** | **Temp** | **Statistical parameters/Constants** | | |
|---|---|---|---|---|
| | **(°C)** | $r^2$ | **$Q_m$** | **b** |
| Copper ion adsorption | 30° | 0.9955 | 25.062 | 1.1145 |
| | 40° | 0.9962 | 26.737 | 1.1098 |
| | 50° | 0.9999 | 28.248 | 1.1683 |
| | 60° | 0.9998 | 29.761 | 1.2043 |

**Table 5 - Freundlich isotherm Results**

| (metal ion) | Temp | Statistical parameters/Constants | | |
|---|---|---|---|---|
| | (°C) | $r^2$ | $k_f$ | n |
| Copper ion adsorption | 30° | 0.9680 | 2.9476 | 3.2916 |
| | 40° | 0.9718 | 3.0171 | 3.1847 |
| | 50° | 0.9770 | 3.1012 | 3.1142 |
| | 60° | 0.9850 | 3.1737 | 3.0238 |

**Table 4: Dimensionless separation factor ($R_L$)**

| Copper ion (mg/L) | Temperature (°C) | | | |
|---|---|---|---|---|
| | 30° | 40° | 50° | 60° |
| **5** | 0.152 | 0.153 | 0.145 | 0.142 |
| **10** | 0.082 | 0.083 | 0.078 | 0.076 |
| **15** | 0.056 | 0.057 | 0.054 | 0.052 |
| **20** | 0.042 | 0.043 | 0.041 | 0.039 |
| **25** | 0.034 | 0.035 | 0.033 | 0.032 |

**Kinetics of adsorption:** Kinetics of sorption describes the solute uptake rate, which in turn governs the residence time of sorption reaction. It is one of the important characteristics in defining the efficiency of sorption. In the present study, the kinetics of the copper ion removal has carried out to understand the behaviour of this low cost carbon adsorbent. The adsorption of copper ion from an aqueous solution follows reversible first order kinetics, when a single species considered on a heterogeneous surface. The heterogeneous equilibrium between the copper ion solution and the activated carbon have expressed as

$$A \underset{k_2}{\overset{k_1}{\rightleftharpoons}} B$$

Where $k_1$ is the forward rate constant and $k_2$ is the backward rate constant. A represents copper ion remaining in the aqueous solution and B represents copper ion adsorbed on the surface of activated carbon. The rate constants calculated as earlier[11,12,13]. The data furnished in Table 7, is evident that the forward rate constant is much higher than the backward rate constant suggesting that the rate of adsorption is clearly dominant. At equilibrium, the rate is the ratio of the concentration of adsorbate in adsorbent and concentration of adsorbate in aqueous solution given by $K_0$. The calculated values presented in the Table 6. The results indicates that $K_0$ values decreases with increase in the concentration of the copper ion and increases with increase in temperature

A clear examination of the effect of copper ion concentrations on the rate constant $K_{ad}$ (Table 7), the values help to describe the mechanism of metal ion removal taking place .In cases of strict surface adsorption a variation of rate should be proportional to the first power of concentration. However, when pore diffusion limits the adsorption process, the relationship between initial copper ion concentration and rate of reaction will not be linear. It shows that pore diffusion limits the overall rate of copper ion adsorption [12,13]

The contact-time experimental results can be used to study the rate-limiting step in the adsorption process, as shown by Weber and Morris [13,14]. Since the particles are vigorously

agitated during the adsorption period, it is probably reasonable to assume that the rate is not limited by mass transfer from the bulk liquid to the particle external surface, one might then postulate that the rate-limiting step may be either film or intraparticle diffusion. As they act in series, the slower of the two will be the rate-determining step [13].

The rate constant for intraparticle diffusion is obtained using the equation

$$Q = K_p t^{½} + C \text{……(3)}$$

Here, $K_p$ (mg/g/min) is the intraparticle diffusion rate constant. The $K_p$ values obtained from the slope of the linear portions of the curves at metal ion concentration (Fig.5). The $K_p$ values increased with increase in the copper ion concentration, which reveals that the rate of adsorption is governed by the diffusion of adsorbed copper ion within the pores of the adsorbent [1,14].

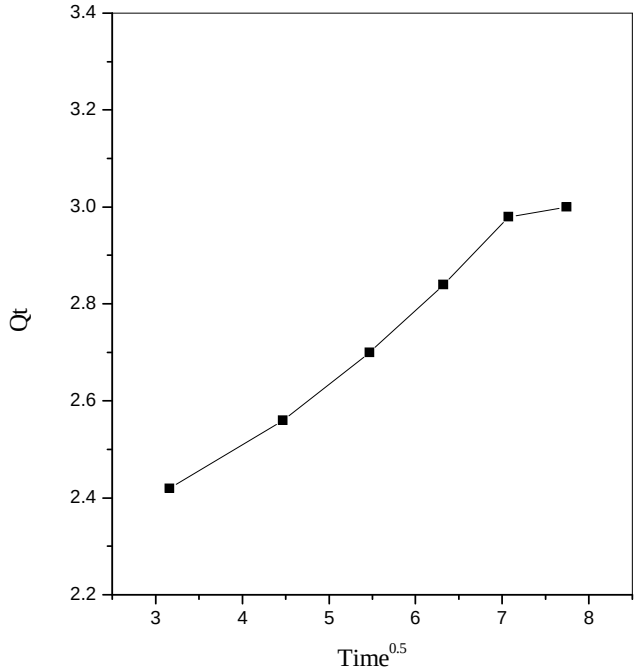


Fig.5-Effect of intraparticle diffusion on the adsorption of copper ion
[Cu]=15 mg/L;Adsorbent dose=25 mg/50 ml;Temp=$30^0$C

**Effect of temperature:** The adsorption capacity of the carbon increased with increase in the temperature of the system from 30°- 60°C. Thermodynamic parameters such as change in free energy (ΔG°), enthalpy (ΔH°) and entropy (ΔS°) were determined using the following equations [11,12,15,16]

$$K_0 = C_{solid}/C_{liquid} \text{……...(4)}$$
$$\Delta G° = -RT \ln K_O \text{…… ……. (5)}$$
$$\log K_0 = \Delta S°/ (2.303RT) - \Delta H°/(2.303RT) \text{…..(6)}$$

Where Ko is the equilibrium constant, $C_{solid}$ is the solid phase concentration at equilibrium (mg/ L), $C_{liquid}$ is the liquid phase concentration at equilibrium (mg/L), T is the temperature in Kelvin

and R is the gas constant. The ΔH° and ΔS° values obtained from the slope and intercept of Van't Hoff plots have presented in Table 5. The values are with in the range of 1 to 93 KJ/mol indicates the favourability of physisorption. From the order we could make out physisorption is much more favourable for copper ion. The positive values of ΔH° show the endothermic nature of adsorption and it governs the possibility of physical adsorption. Because in the case of physical adsorption, while increasing the temperature of the system, the extent of copper ion adsorption increases, this rules out the possibility of chemisorptions. However, the very low ΔH° value depicts copper ion is physisorbed onto adsorbent [12,13,15]

The negative values of ΔG° (Table 6) shows the adsorption is highly favourable for nickel ion. However, it indicates that the copper ion adsorption was spontaneous. The positive values of ΔS° (Table 6) shows the increased disorder and randomness at the solid solution interface of with adsorbent. While the adsorption there are some structural changes in the copper ion and the adsorbent occur. The adsorbed water molecules, which have displaced by the adsorbate species, gain more translational entropy than is lost by the adsorbate molecules, thus allowing the prevalence of randomness in the system [5,12,18]. The results show that more efficient physisorption. Enhancement of adsorption capacity of the activated carbon at higher temperatures has attributed to the enlargement of pore size and activation of the adsorbent surface [11,12,13].

**Table 6- Equilibrium constant and thermodynamic parameters for the adsorption of metal ions onto acid activated carbon Temperature (°C)**

| Copper ion(mg/L) | $K_o$ | ΔG° | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30° | 40° | 50° | 60° | 30° | 40° | 50° | 60° | ΔH° | ΔS° |
| 5 | 8.58 | 9.57 | 10.59 | 11.33 | -5417 | -5879 | -6338. | -6721 | 5.27 | 43.82 |
| 10 | 4.10 | 4.70 | 5.78 | 6.83 | -3557 | -4030 | -4711 | -5323 | 7.16 | 59.59 |
| 15 | 2.50 | 2.92 | 3.43 | 4.00 | -2308 | -2789 | -3311 | -3844 | 6.16 | 51.22 |
| 20 | 1.39 | 1.57 | 1.79 | 2.05 | -836 | -1179 | -1568 | -1990 | 4.61 | 38.40 |
| 25 | 0.86 | 0.97 | 1.09 | 1.22 | 361 | 65 | -251 | -558 | 3.69 | 30.73 |

*ΔH° (kJ/mol),ΔS° (J/K/mol), ΔG° (J/mol)*

**Table 7- Rate constants for the adsorption of copper ions ($10^3$ $k_{ad}$, $min^{-1}$) and the constants for forward ($10^3$ $K_1$, $min^{-1}$) and reverse ($10^3$ $K_2$, $min^{-1}$) process**

| Copper ion (mg/L) | Temperature (°C) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $k_{ad}$ | | | | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ | $k_1$ | $k_2$ |
| | 30° | 40° | 50° | 60° | 30° | | 40° | | 50° | | 60° | |
| 5 | 41.60 | 42.27 | 43.35 | 45.21 | 36.77 | 4.28 | 38.27 | 3.99 | 39.61 | 3.73 | 41.54 | 3.66 |
| 10 | 26.57 | 28.56 | 31.46 | 35.01 | 21.36 | 5.20 | 23.55 | 5.00 | 26.82 | 4.64 | 30.54 | 4.46 |
| 15 | 20.31 | 21.75 | 23.82 | 25.66 | 14.51 | 5.80 | 16.20 | 5.54 | 18.44 | 5.37 | 20.53 | 5.12 |
| 20 | 15.20 | 15.96 | 17.01 | 17.88 | 8.85 | 6.35 | 9.76 | 6.20 | 10.92 | 6.09 | 12.02 | 5.86 |
| 25 | 12.17 | 12.94 | 14.11 | 14.42 | 5.65 | 6.52 | 6.38 | 6.55 | 7.38 | 6.73 | 7.94 | 6.48 |

**Effect of pH**: The solution pH plays a major role in determining the amount of copper ions absorbed. Adsorption was studied over the range of pH ~ 3-10 and the results are shown in Fig.6. The initial metal ion concentrations were kept constant. Adsorption of copper ions increased appreciably (1-2 times) with increase of pH from 3 to 10 and consistent with results

obtained by others. The increase is partly attributed to the formation of different hydroxo species with rise in solution pH. Based on the hydrolysis constants of metal ions as defined in

$$M^{2+} + nH_2O \rightleftharpoons M(OH)_n^{2-n} + nH^+$$

and taking only primary metal species expected to be formed in the working pH range into consideration, the species distribution diagrams for copper ion is constructed and given in Fig. 4, It is evident that $Cu^{2+}$ and its monohydroxo species are the predominating species up to pH ~ 9, while dihydroxo species are also formed to a significant extent above pH ~ 7.5 for copper ion. Since maximum adsorption copper ion was achieved at pH ~ 6.25, it may safely be stated that the removal of copper ion was mostly due to adsorption and not precipitation. However, precipitation of small fractions of $Cu^{2+}$ even at pH ~ 6.25 on the surface by nucleation cannot be neglected. At still higher pH (>7), however, part of $Cu^{2+}$ may be precipitated as dihydroxo species, which also depend upon the initial metal ion concentration. The other important factor, which might contribute to the higher adsorption of metal ions with increased pH, is the $pH_{pzc}$ of SVC. At any pH below $pH_{pzc}$ the surface of metal oxides/ oxyhydroxides is positively charged and at pH above $pH_{pzc}$ the surface is negative. When the solution pH exceeded pHzpc, the metal species are more easily attracted by the negatively charged surface of adsorbent, favoring accumulation of metal species on the surface and thus promoting adsorption [17,19].

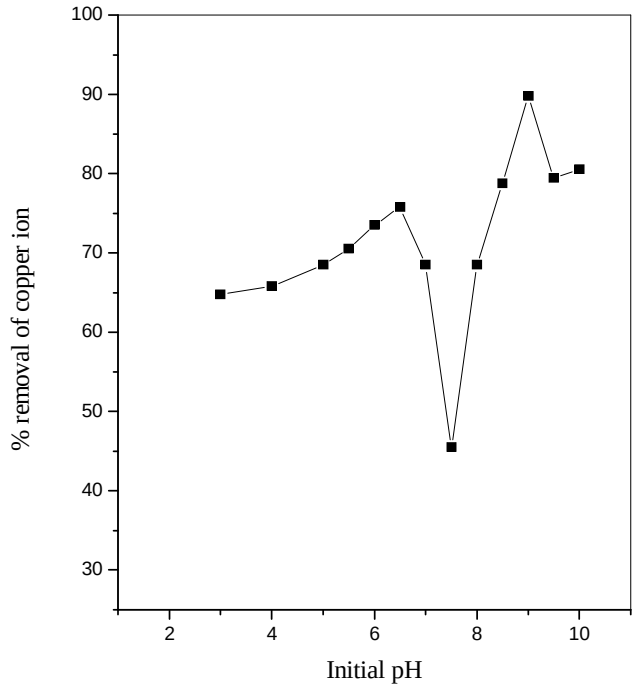


Fig.6-Effect of initial pH on the adsorption of Copper ion
[Cu]=15 mg/L; Adsorbent dose=25 mg/50 ml;Contact time=60 min

**Effect of other ions:** Till now all the adsorption results discussed above were obtained by taking a single cation as adsorbate (e.g. $Cu^{2+}$) however, in reality the contaminated water contains several other ions (both cations and anions), which can affect the adsorption of heavy metals. Therefore, it was thought worthwhile to study the effect of some commonly occurring ions on adsorption behavior of copper ion under present study. A typical water sample containing

Chloride ions and Calcium ions was doped with known quantities of adsorbate metal ions and they were used as the simulated water matrix for adsorption. A fixed amount SVC was dispersed in this water matrix containing adsorbate. The other adsorption parameters were kept constant, as stated earlier. The results are collected in Fig.7. It is evident that the presence of the above-mentioned ions in the adsorbate solution practically did not affect the extent of adsorption. It may be noted that almost the whole iron content in the adsorbate solution is removed after adsorption. The concentration of other ions, however, marginally decreased (within 10% of initial concentration) after adsorption. A higher concentration level of interfering ions may, however, adversely affect the adsorption capacity of SVC. Adsorption of different heavy metal from a simulated water matrix containing a high back ground level of different ions is being carried out to assess its future applicability to removal of toxic metals from industrial effluents [16,17,19].

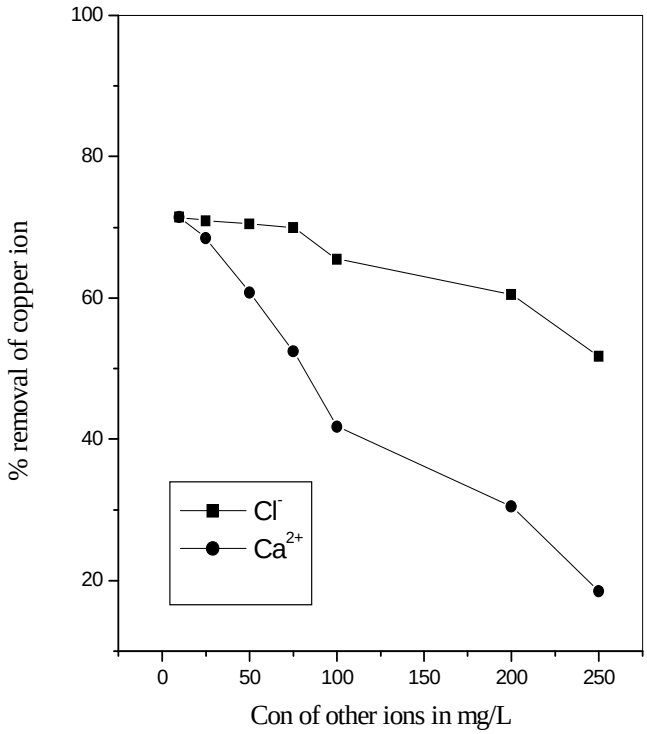


Fig.7-Effect of other ions on the adsorption of copper ion
[Cu]=15 mg/L;Adsorbent dose=25 mg/50 ml;Contact time=60 min

**Desorption studies:** Desorption studies help to elucidate the nature of adsorption and recycling of the spent adsorbent and the copper ion. If the adsorbed copper ion can be desorbed using neutral pH water, then the attachment of the copper ion of the adsorbent is by weak bonds. If sulphuric acid or alkaline water desorp the copper ion, then the adsorption is by ion exchange. If organic acids, like acetic acid can desorp the copper ion, then the metal ion has held by the adsorbent through chemisorption. The effect of various reagents used for desorption studies indicate that hydrochloric acid is a better reagent for desorption, because we could get more than 85% removal of adsorbed copper ion. The reversibility of adsorbed metal ion in mineral acid or base is in agreement with the pH dependent results obtained. The desorption of metal ion by

mineral acids and alkaline medium indicates that the copper ion was adsorbed onto the activated carbon through by physisorption mechanisms[11,12,17,18].

## CONCLUSION

The objective of this paper was utilization of sorgum vulcaris dust carbon as adsorbent material for copper ion removal. The following conclusions have been drawn from the above investigations**:**

1. The removal efficiencies of copper ion through adsorption onto sorgum vulcaris dust carbon were found to be between 25.062, 26.637, 28.248, 29.761 at 30, 40, 50 and 60ºC temperatures respectively.
2. The initial pH's of aqueous solutions affect the copper ion removal. On the other hand percent removal .of copper ion decreased with increasing initial concentration but increased with increasing adsorbent concentration.
3. The best adsorptions were obtained under the condition of 25mg/50 ml copper ion concentration and original pH solution .The suitable contact time was 40, 50 and 60 minutes.
4. Adsorption isotherm can be described by Langmuir and Freundlich isotherm equations ,
5. The values of $\Delta H°$, $\Delta S°$ and $\Delta G°$ results shows that the carbon employed has a considerable potential as an adsorbent for the removal of copper ion.
6. Sorgum vulcaris dust carbon has the potential for use as an adsorbent for the removal copper ion from wastewater

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