COLUMN TRACER EXPERIMENT FOR REMOVAL OF CHROMIUM(VI) BY ACTIVATED CARBON DERIVED FROM CASUARINA FRUIT .

Shashikant R Mise
Professor
PDA College of engineering Kalaburagi
Sheetal
Mtech Student
PDA College of Engineering Kalaburagi.

ABSTRACT

The present study deals with removal of Chromium(VI) from the synthetic sample using low cost physically and chemically activated carbon prepared from Casuarina Equestifolia fruit powder. The chemically($CaCl_2$ and $MgCl_2$) activated carbon is prepared with Impregnation Ratio(I.R) of 0.75. A series of column tracer experiments have been performed with Chromium(VI) on the Physically and Chemically activated carbons for obtaining breakthrough and retardation coefficients. Adsorption capacities for physically, chemically activated $CaCl_2$ and $MgCl_2$ carbons are 0.341mg/g, 0.57mg/g and 0.416mg/g respectively.The values of Freundlich coefficient (K_F), Freundlich Isotherm constant (1/n), Distribution Coefficient (K_d^F), Retardation Coefficient (R) for Physically activated carbon are 1.412,0.840,0.976,1.270 respectively and for $CaCl_2$ activated carbon are 1.00,0.994,0.986,1.404 and for $MgCl_2$ activated carbon 1.27,0.869,0.939 and 1.248 respectively.

KEYWORDS: Adsorption, Chromium(VI), Column study, Impregnation ratio, activated carbon, $CaCl_2$ and $MgCl_2$

I. INTRODUCTION

Heavy metals are most common pollutants found in industrial wastewater. Heavy metals enter into the environment due to bioaccumulation. These metals are highly toxic and disturb the ecosystems. The presence of these in the aquatic environment has been of great concern to scientists, engineers because of their increased discharge, toxic nature and other adverse effects on receiving water bodies. These heavy metals are non biodegradable and their presence in streams and lakes leads to bioaccumulation in living organisms, causing health problems in animals, plants and human beings. Heavy metal ions are reported as priority pollutants, due to their mobility in natural water ecosystems and due to their toxicity.

Water pollution by chromium is of considerable concern, as this metal is used in a variety of applications including Steel production, Electroplating, Leather tanning, Nuclear power plant, Textile industries, Wood preservation, Anodising of aluminium, Water-cooling and Chromate preparation.

Chromium is a chemical element having atomic number 24; atomic weight 51.99. It is the first element in Group 6. The characteristics are gray in colour, lustrous, hard and brittle metal which takes a highly shining, resists tarnishing, and has a high melting point.

Chromium exists mostly in two oxidation states; Hexavalent chromium Cr(VI) and trivalent chromium Cr(III).The Chromium(VI) is a very strong oxidizing agent (therefore very fast in reacting, unlike Chromium(III) and likely to form complexes). Chromium(VI) is not very stable state when compared to Cr(III). Hexavalent chromium exists mainly as H_2CrO_4, $HCrO_4$-, $Cr_2O_7^{2-}$ and CrO_4^{2-} in aqueous environment.[1]

II. OBJECTIVE:

1. To study the Break through Curves by Column Tracer Experiments.
2. To find out Frendlich isotherm constants.
3. To find out the Distribution and Retardation coefficients.

III. LITERATURE REVIEW

L.Soundari, A.Agilan, K.Rajarajan (2018) have studied the removal of chromium from industrial wastewater by adsorption using coconut shell and palm shell. The concentration of Cr was determined by atomic absorption spectroscopy (AAS) through absorbance of the solution or sample. Removal of Cr was found to be dependent on pH. The results of this study proved that activated charcoal powder can be used to remove chromium (Cr) from tannery effluent.[2]

N. Gandhi, D. Sirisha and KB. Chandra Sekhar (2014) has studied the removal of Cr(VI) from aqueous solution by using multanimiti. The study is carried out with respect to contact time, concentration, dosage, effect of pH and temperature. The experimental data tested with adsorption isotherm and kinetics studies. Adsorption with multani mitti is not only cheaper but requires less maintenance and supervision.[3]

IV. MATERIAL AND METHODOLOGY

The material used in this research study is Casuarina equisetifolia as an adsorbent. *Casuarina equisetifolia* is an evergreen tree growing to 6-35m tall as shown in fig 1. The foliage consists of slender, much branched green to grey- green twigs 0.5-1mm diameter, bearing minute scale leaves in whorls of 6-8.The fruit is an oval woody structure 10-24mm long and 9-13mm in diameter, superficially resembling a conifer cone made up of numerous carpels each containing a single seed with a small wing 6-8mm long as shown in fig 2.

Figure1 Casuarina Equestifolia tree

Figure 2 Casuarina Equestifolia fruit

Adsorption technique was employed using activated carbon prepared from Casuarina fruit shell. There are two methods to prepare activated carbon, namely

i. Physical activation
ii. Chemical activation using $CaCl_2$(Calcium Chloride) and $MgCl_2$(Magnessium Chloride)

4.1 COLUMN TRACER EXPERIMENTS

A series of column tracer experiments have been performed with Chromium(VI) on the physically and chemically(0.75 I.R. $CaCl_2$ and $MgCl_2$) activated carbon obtaining the breakthrough curves and retardation coefficients. To observe the retention and leaching of chromium(VI) through adsorbent, adsorbent columns of length 50cm was used. For the column, Perspex glass columns of 1.54cm diameter were used. The length of the carbon columns are chosen on the basis of carbon texture and compaction. At the bottom, a height 5cm is filled by Coarse gravel of 10mm followed by two layers of sand of size 5mm and 500µ. Then the chosen length of adsorbent is filled. Outlets were made at the top of the columns to collect the leachate as shown in fig 3. First the distilled water was allowed to leach through the column to saturate the carbon and then the Chromium(VI) solution were passed through the saturated carbon, in upward flow. The leachate was collected for every half an hour and tested for Chromium(VI) concentration

Figure 3: Arrangement of Column Tracer Experiment

V. RESULTS AND DISCUSSION

Breakthrough curve for Physically activated carbon for 10 mg/L of initial concentration were performed as shown in fig 4

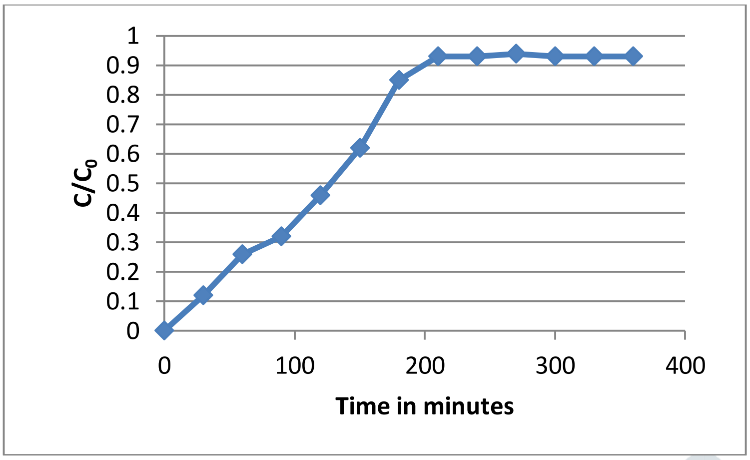

Figure 4: Break through curve for adsorption of Chromium(VI) on physically activated carbon

Breakthrough curve for $CaCl_2$ and $MgCl_2$ activated carbon for I.R 0.75 for concentration of 10mg/L are as shown in fig 5 and 6

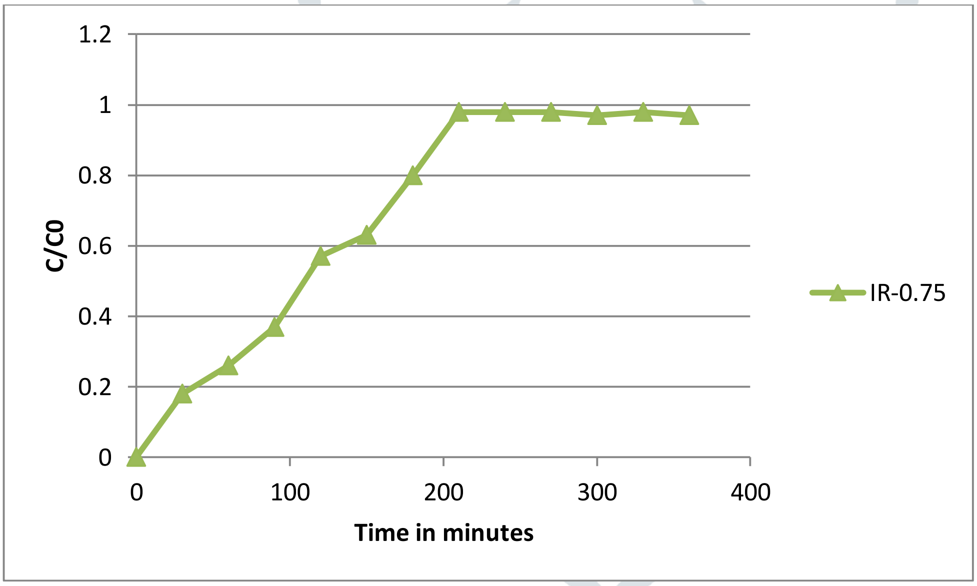

Figure 5: Break through curve for adsorption of Chromium(VI) on chemically($CaCl_2$) activated carbon

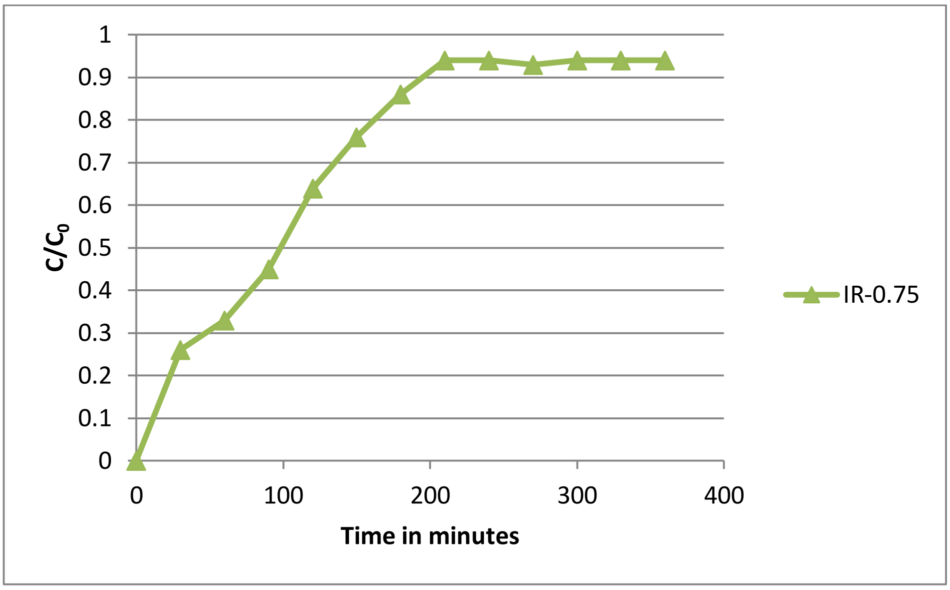

Figure 6: Break through curve for adsorption of Chromium(VI) on chemically($MgCl_2$) activated carbon

5.1 DISTRIBUTION AND RETARDATION COEFFICIENT

The standard form of freundlich Isotherm is

$Cads = K^F \times C_{aq}^{1/n}$ ---(1)

Where,
Cads = balance concentration of the studied compound in the carbon bed;
Caq = balance concentration of the studied compound in the water;
K^F and n = coefficients of the Freundlich adsorption isotherm.

$K_d^F = \frac{KFC_{aq}^{\frac{1}{n}}}{Caq}$ $K^F C_{aq}^{(1/n-1)}$ ------------------(2)

For the distribution coefficient determined on the basis of the adsorption isotherm, the retardation has been defined as

$R = 1 + \frac{\rho d}{\eta} K^F_d$ ---------------------(3)

Where,
Ƞ= Porosity
ρ_d = Bulk density Kg/m^3

The calculated values of Caq and Cads are as shown in table 1 and the corresponding graph is as shown in fig 5.

Table 1: Adsorption of chromium(VI) for selected concentrations on different carbon to fit freundlich isotherm

Type of carbon	**Initial concentration, Caq(mg/L)**	**Effluent Concentration of Chromium(VI) Cads(mg/L)**	**$Log_{10}Caq$**	**$Log_{10}Cads$**
Physically activated	10	9.8	1.0	0.991
	15	13.80	1.176	1.139
Chemically activated $CaCl_2$(I.R.=0.75)	10	9.97	1.0	0.998
	15	14.9	1.176	1.173
Chemically activated $MgCl_2$(I.R.=0.75)	10	9.5	1.0	0.977
	15	13.52	1.176	1.130

In the above table the values of LogCaq and LogCads are calculated for the adsorption of 10mg/L and 15mg/L Chromium(VI) concentrations on Physically and Chemically activated carbons and are shown in figure 7.

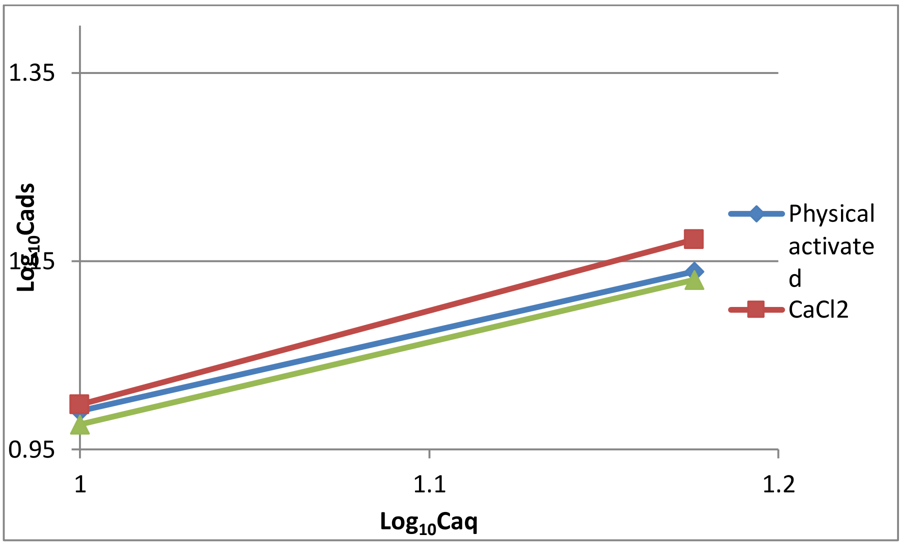

Figure 7: Freundlich Isotherm of adsorption of Chromium(VI) on Physically and Chemically activated Carbon.

From the figure 7 the values Freundlich isotherm constants K_F and 1/n are obtained and are presented in table 2.By substituting these values in equation 2 and 3 the values of distribution coefficient K_D^F and retardation coefficient R are calculated and are shown in table 2.

Table 2 Data showing the value of Freundlich Coefficients

Type of carbon	**K^F(Coefficient of Freundlich Isotherm)**	**1/n (Coefficient of Freunlich Isotherm)**	**K^F_d (Distribution coefficient)**	**R(Retardation coefficient)**
Physically activated carbon	1.412	0.840	0.976	1.270
Chemically activated carbon($CaCl_2$-0.75I.R)	1.00	0.994	0.986	1.404
Chemically activated carbon $MgCl_2$– 0.75I.R	1.27	0.869	0.939	1.248

From the above table values of 1/n(1/n<1) and K_F (K_F = 1 to 10) it fits Freundlich isotherm as the values are within the specified ranges.

VI. CONCLUSIONS

1. From the break through curve for physically, chemically activated $CaCl_2$ and $MgCl_2$ carbons the adsorption capacities are 0.341mg/g, 0.57mg/g and 0.416mg/g respectively.
2. The values of Freundlich coefficient K_F, Freundlich Isotherm constant 1/n, Distribution Coefficient K_d^F, Retardation Coefficient R for Physically activated carbon are 1.412,0.840,0.976,1.270 respectively and for $CaCl_2$ activated carbon are 1.00,0.994,0.986,1.404 and for $MgCl_2$ activated carbon 1.27,0.869,0.939 and 1.248 respectively.
3. The result of the Column tracer Experiment follows Freundlich isotherm .
4. The activated carbon prepared from Casuarina fruit suits for removal of Chromium(VI) for column studies.

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