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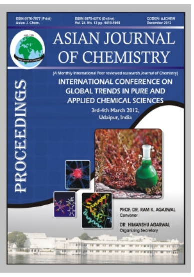


# Evaluation of Coal Based Granular Activated Carbon for Removal of Manganese(II) from Wastewater†

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In present study coal based carbon filtrasorb 816 (F-816) and filtrasorb 300 (F-300) were tested for their efficiency in removing metal ions from aqueous phase. Studies on removal of manganese(II) from aqueous phase by adsorption on granular activated carbon containing adsorbed organic ligand such as resorcinol have been carried at constant temperature 25 ± 0.5 ºC. The present study deals with the determination of manganese(II) removal capacity from synthetically prepared industrial wastewater using these low cost adsorbents. The adsorption isotherms of manganese(II) on Granular activated carbon have been determined at pH in the range of 5 to 6. Freundlich and Langmuir isotherm models were applied to the equilibrium data. The data could be fitted reasonably well to these both isotherms. Experimental results demostrate that the F- 816 has a significant capacity for adsorption of manganese(II) as compared to F-300 from wastewater.

**Key Words: Adsorption, Manganese, GAC F-300, GAC F-816.**

## INTRODUCTION

Toxic metals generally occur in water in low concentration as a result of metal industries and partially through geological process but this causes direct toxicity both human and living beings due to their presence beyond specified limits. Manganese occurs naturally in many surface water and ground water sources and in soils that may erode in to this water in drinking water sources. The secondary maximum contaminant level for manganese[1] must not exceed 0.05 mg/L.

Manganese in surface water is a micro nutrient but elevated concentrations are toxic to aquatic life and humans and impair drinking water quality[2]. Technologies generally used for the removal of heavy metals such as ion-exchange, chemical precipitation, ultra filtration, electrochemical dispersion *etc*. do not seen to be economically feasible because of their high cost.

Adsorption using activated carbon is popular in potable water treatment[3,4]. Activated carbon is effective in removing taste and odour causing compounds and many metals[5]. It has the strongest physical adsorption force or highest volume of adsorbing porosity of any material known to mankind. It is highly porous material; thus it has an extremely high surface area for contaminant adsorption. The equivalent surface area of 1 pound of activated carbon ranges from 60 to 150 acres[6].

In this connection work was initiated in laboratory to scavenge manganese metal using coal based granular activated carbon containing adsorbed ligand which are capable of forming a chelate with the manganese and thus help in its recovery. For this purpose resorcinol has been chosen in present work. Resorcinol is 1,3-dihydroxy benzene, It is acidic and two OH groups make system sufficient polar, so it is soluble in polar solvent water.

## EXPERIMENTAL

In the present investigation commercially available granular activated carbon namely F-816 and F-300 were used as adsorbents. These were first subjected to the size fractionation. Only the particles of size ranging between 1400 micron to 1600 micron were recovered. The granular activated carbon was then washed with boiled distilled water and then dried in an oven at 100-110 ºC and stored in $CaCl_2$ desiccator until use. A stock solution of manganese ions was obtained by using a solution of manganese sulphate (E. Merck, 98 % purity). It

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was standardized volumetrically by EDTA. Spectrophotometrically, Beer's law calibration curve was established for $Mn^{2+}$. For this purpose standardized 0.01 M manganese solution was first prepared. All the chemicals used were of AR grade. A sample of resorcinol was recrystallized by the standard method. The experimental melting point of resorcinol (108 ºC) was compared with the literature value (m.p. 110.8 ºC)[7]. All experiments were carried out in batches of four to six units at a time. For determining the adsorption isotherm of manganese ion on the different grades of carbon containing adsorbed ligand such as resorcinol, it was first essential to fix the amount of the ligand on the granular activated carbon. This process of fixing of ligand on granular activated carbon was denoted as Loading of granular activated carbon. For this purpose 0.5 gm of the granular activated carbon was taken in clean shaking bottles and 200 mL of the ligand solution of a specified concentration was shaken for about 5 h using Remi Stirrers (Type L-157 M/s Remi Udyog, Mumbai, India) in constant temperature bath for 220 rpm. The solution was then filtered off and the carbon was washed thoroughly with distilled water. This carbon was then transferred to a clean shaking bottle and then 200 mL of manganese solution at a pH = 5 was added of a desired concentration and the contents were stirred for 6 h at 25 ± 0.5 ºC. The initial and final concentration of the manganese ion in mg/L was then determined spectrophotometrically (Type 166 Systronics India Ltd.).

## RESULTS AND DISCUSSION

Equilibrium adsorption isotherms for different grades of granular activated carbon are shown in Figs. 1 and 2. The amount of manganese on the ligand adsorbed on the Granular activated carbon was determined using the equation.

$$q_e = (C_o - C_e) \times V/W$$

where, $q_e$ = concentration of manganese ion on the ligand loaded Granular activated carbon in mg/millimoles of ligand; $C_o$ = onitial concentration of manganese ion in solution in mg/L; $C_e$ = final concentration of the manganese in solution in mg/L; V = volume of solution in litres; W = millimoles of the ligand actually present on Granular activated carbon.

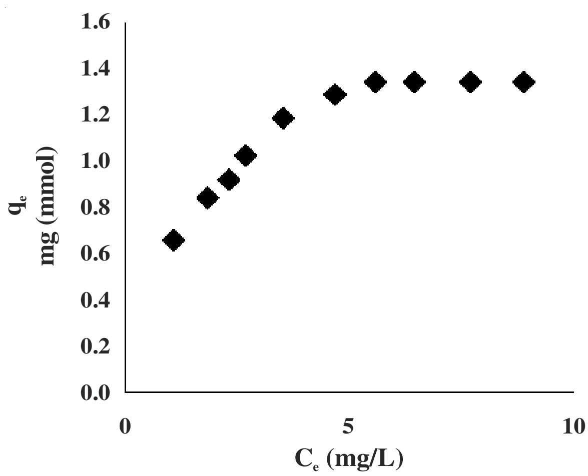


Fig. 1. Adsorption isotherm; system: F-300-resorcinol-$Mn^{2+}$ at 298 K

Data of equilibrium isotherms was tested for adherence to both Langmuir and Freundlich models. As per Langmuir

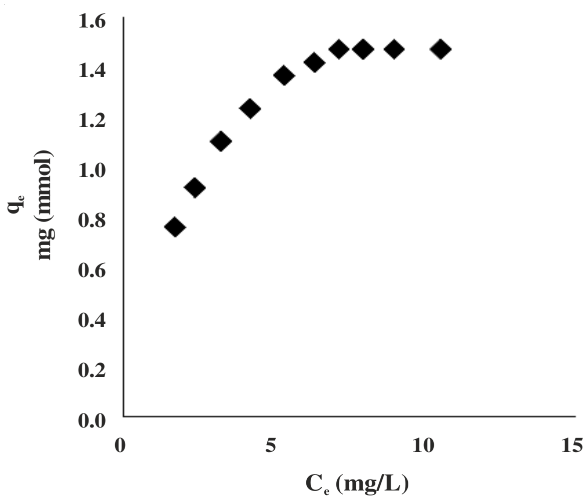


Fig. 2. Adsorption isotherm; system: F-816-resorcinol-$Mn^{2+}$ at 298 K

theory, the saturated value is that beyond which no further sorption can takes place (Table-1). The saturated monolayer can then be represented by:

$$q_e = \frac{Q^o bC_e}{1 + bC_e}$$

TABLE-1
VALUES OF $q_e$ max (mg/mmol), LANGMUIR EQUATION AND $R^2$ FOR ADSORPTION OF MANGANESE ION FROM SOLUTION BY GAC CONTAINING ADSORBED LIGAND (RESORCINOL)

| S.No. | System | F-300-resorcinol-$Mn^{2+}$ | F-816-resorcinol-$Mn^{2+}$ |
|---|---|---|---|
| 1 | $q_e$ max | 1.3421 | 1.4736 |
| 2 | Stat. parameters $R^2$ | 0.983 | 0.988 |

The linearized form of Langmuir isotherm is:

$$\frac{1}{q_e} = \frac{1}{Q^o b} \times \frac{1}{C_e} + \frac{1}{Q^o}$$

where, $Q^o$ and b are Langmuir constants.

Freundlich equation is on the other hand represented by:

$$q_e = k_f . C_e^{1/n}$$

The equation may be linearized as:

$$\log q_e = \log k_f + 1/n \log C_e$$

where, $k_f$ and 1/n are Freundlich constants.

Figs. 3-6 illustrate the plot of Langmuir and Frendlich isotherms for granular activated carbon F-300 and F-816. The plots of $1/q_e$ *versus* $1/C_e$ were found to be linear indicating the applicability of Langmuir model. The parameters $Q^o$ and b are Langmuir constants given in Table-2, relating to the sorption capacity and adsorption energy respectively.

The comparative adsorption capacities (saturation values of $q_e$) of manganese ion on different grades of granular activated carbon used in the present work can be assessed from Figs. 1 and 2.

The trend in the qe values at the saturation level are in the order F-816 > F-300.

Further the essential characteristics of the Langmuir isotherm can be describe by separation factor $R_L$; which is defined as:

$$R_L = \frac{1}{(1 + bCi)}$$

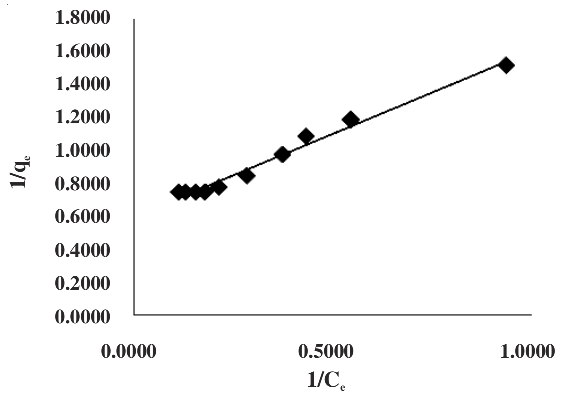


Fig. 3. Langmuir adsorption isotherm at 298 K; System: GAC-F-300-resorcinol-$Mn^{2+}$

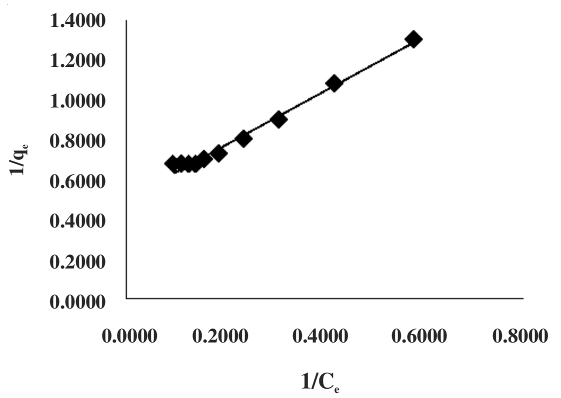


Fig. 4. Langmuir adsorption isotherm at 298 K; System: GAC-F-816-resorcinol-$Mn^{2+}$

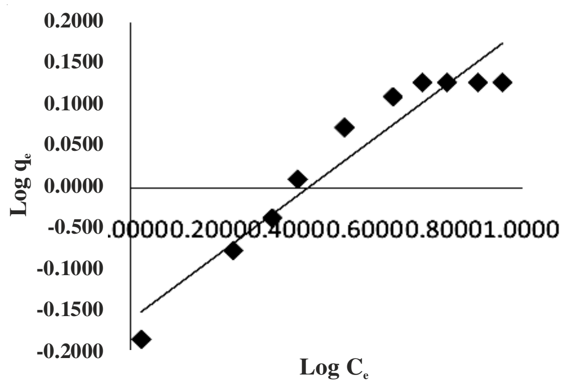


Fig. 5. Freundlich adsorption isotherm at 298 K; System: GAC-F-300-resorcinol-$Mn^{2+}$

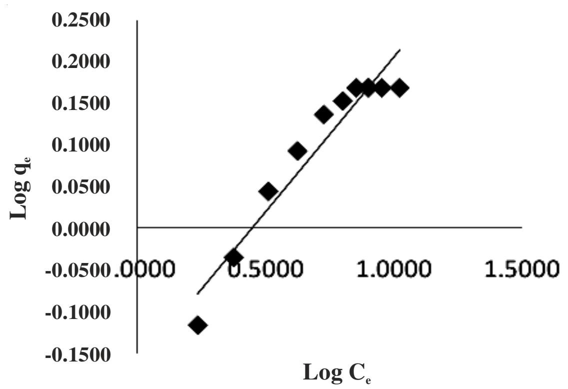


Fig. 6. Freundlich adsorption isotherm at 298 K; System: GAC-F-816-resorcinol-$Mn^{2+}$

TABLE-2

| S. No. | System | Langmuir $Q^o$ | Constant b | Freundlich k | Constant 1/n |
|---|---|---|---|---|---|
| 1. | F-300-Resorcinol-$Mn^{2+}$ | 1.6778 | 0.5901 | 0.6950 | 0.351 |
| 2. | F-816-Resorcinol-$Mn^{2+}$ | 1.9841 | 0.3700 | 0.6807 | 0.373 |

where, Ci is the initial concentration of manganese(II) (mg/L) and b is the Langmuir constant (gm/L). The value of separation factor $R_L$, indicates the nature of the adsorption process as given below:

| $R_L$ Value | Nature of adsorption process |
|---|---|
| $R_L > 1$ | Unfavourable |
| $R_L = 1$ | Linear |
| $0 < R_L < 1$ | Favourable |
| $R_L = 0$ | Irreversible |

The values of $R_L$ in the present study are found to be in between 0 and 1, showing favourability of adsorption process.

## Conclusion

The present work was carried out keeping in view that the presence of toxic metals in industrial waste could lead to serious consequence. It concludes that Granular activated carbon in the presence of ligand could function very effectively in scavenging manganese ion from aqueous solution. The adsorption isotherms of the manganese on different grades of carbon loaded with resorcinol clearly shows that F-816 adsorbs manganese to a greater proportion as compared to F-300. Adsorption was found to be in good agreements with Langmuir isotherm which indicates monolayer adsorption. Application of the Freundlich and Langmuir isotherm models gave good representations of the experimental data for manganese sorption by granular activated carbon. The adsorption isotherms obtained from the present work could play a significant role in designing industrial adsorption columns.

## ACKNOWLEDGEMENTS

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