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# ADSORPTIVE REMOVAL OF METAL IONS FROM AQUEOUS SOLUTION USING GAC BY BATCH ADSORPTION TECHNOLOGY

**V. R. KINHIKAR***

G. H. Raisoni Institute of Engineering and Technology for Women, NAGPUR (M.S.) INDIA

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## ABSTRACT

Modified Granular Activated Carbon of grade F300, has been used as an adsorbent material for the removal of nickel (II) from aqueous solutions at different experimental conditions in batch adsorption technique. F 300 GAC was modified with Nitric acid.GAC was characterized by SEM and AAS techniques. The time required to attain equilibrium was found to be 6 hrs. The effects of initial concentration of Ni (II), particle size of adsorbent, adsorbent dose and temperature on removal of nickel (II) have been studied. The $Ni^{2+}$ content of the solution was analyzed by colorimetric. Nitric acid modified GAC shows higher adsorption capacity. Batch adsorption kinetics has been described by the Langmuir equation. Langmuir and Freundlich isotherms were applied and both isotherms were seen to be applicable over the concentration range studied.

**Key words**: Adsorption, GAC, Isotherms, Nickel (II).

## INTRODUCTION

In present day context water pollution is the biggest hazard for all forms of life. The environmental pollution has been the most remarkable side effect of rapid industrialization and growing population of the world. Today, almost all the things, which are most necessary to the human beings, are more or less contaminated by toxic substances. Industries discharge waste water containing various pollutants such as heavy metals organic and inorganic impurities including coloring materials etc. depending on type of industries, raw materials and processing conditions used. The major Indian rivers are polluted due to the input of various types of wastes from different sources. Thus, it is a compelling necessity for the environmentalists to develop appropriate way to check the deterioration of the environment[1].

Nickel is 24$^{th}$ most abundant metal in earth crust. Its ores are basically of two types viz. sulphides and oxides. It is used in electroplating, and in a number of alloys and it is a well known catalyst also[2]. Several environmental and health problems, associated with the metal contamination of the natural systems (soil and water) are arising from mining industries, smelting, brass, metal coating, silver refineries, electroplating and several other industrial activities[3,4]. The main symptoms of nickel causes headache, dizziness, nausea and vomiting, chest pain, tightness of the chest, dry cough and shortness of breath, rapid respiration, cyanosis and extreme weakness[5]. In India the acceptable limit of nickel in drinking water is 0.01 mg dm-3 and for discharge of industrial wastewater[6] it is 2.0 mg $dm^{-3}$. The effective technologies available

Available online at www.sadgurupublications.com
*Author for correspondence; E-mail: kinhikarvrushali@yahoo.com; Mo.: +919823388226, 09665081801

for the removal of metallic pollutants from water and wastewater include chemical precipitation, ion exchange, solvent extraction,reverse osmosis and adsorption[7]. Adsorption has been a very effective and economical method for removal, recovery and recycling of metals from wastewater[8]. Different conventional and non-conventional adsorbents such as red mud, coconut coirpith, sewage sludge[9-11] etc. have been cited in the literature as adsorbents by several workers.

The present communication has been addressed to the removal of nickel from aqueous solutions by using Oxidised Granular Activated carbon. Batch adsorption technique has been adopted in removal and the effect of various important parameters viz. contact time and initial concentration, adsorbent particle size, and temperature on removal of nickel has been discussed. The adsorption and isotherm has also been reported.

## EXPERIMENTAL

### Material and methods

### Apparatus

All absorbance measurements are taken by Digital Spectrophotometer (Type-166, Systronics India Ltd.) with matched cells of 1 cm optical path length.

### Reagents and chemicals

Variety of carbon Calgon Carporation Pittusburg (USA), Filtrasorb used namely Oxidised F-300. All the reagents and chemicals used are of A.R. Grade. Nickel sulphate hepta hydrate (E. Merck India Ltd.) was used for the preparation of standard nickel solution and it was diluted proportionately to prepare the experimental solution. Bromine water, ammonia solution and DMG (Dimethyl glyoxime) used in the experiment were of Analytical Grade $HNO_3$ from E. Merck India Ltd. was also used for oxidizing the carbon surface.

### Surface area

Estimation of the specific surface area of granular activated carbon are based upon measurement of the capacity of the adsorbent expressed in mol/gm of GAC and related to the surface area using Langmuir equation for monomolecular adsorption. The relation relates the surface area to the monolayer capacity factor by the relation:

$$S = N_a.Q^o.A$$

Where, S = Surface area of the adsorbent in $m^2/g$; $N_a$ = Avagadro's number; $Q^o$ = amount adsorbed per unit weight of the adsorbent forming a complex monolayer on the adsorbent surface in mg/g; A = Cross sectional area of the adsorbate molecule in $m^2$.

Since the values of $Q^o$ can be obtained from Langmuir plots of $1/q_e$ versus $1/C_e$, the value of S for any particular GAC sample can be calculated. Here, $q_e$ is the concentration of metal ion on GAC in mg/g of Carbon and $C_e$ is equilibrium concentration of adsorbate in solution in mg/L. The occupied surface area of adsorbent by Nickel ion due is calculated from the following expression.

$$A = 4 \times 0.866 [M / (4\sqrt{2}. Na .d)]^{2/3}$$

Where, M = Atomic weight of nickel, Na = The Avagadro number, d = the density of Nickel Using M = 58.70, $N_a = 6.023 \times 10^{23}$ and d = 9.0

### Modification of granular activated carbon

In the present work an effort has been made to modify the carbon surface by using oxidizing agents

called as chemical modification of the surface. This acid treatment oxidizes the porous carbon surface, enhanced the acidic property, removes the mineral elements and improved the hydrophilic of surface[12].

### Preparation of nickel solution

A standard Nickel stock solution was prepared by dissolving 1.401 gm of Nickel Sulphate (E. Merck India Ltd.) in 500 mL of distilled water. The Nickel solution used for the preparation of standard Beer's law was estimated with UV Visible spectrophotometer and was found that 1 mL = 0.586 mg. A standard calibration curve was plotted using standard procedure. 10 mL of each stock solution was titrated against standard 0.01 M EDTA solution following the standard procedure for the estimation of nickel. Working standard solutions were prepared by appropriate dilution of stock solution. The dilute nickel stock solution of the concentration range of $10^{-4}$ M was used for standard Beer's law plot. The amount of nickel in solution was determined colorimetrically using the standard Beer's law plot[13].

### Adsorption experiments

For determining the adsorption isotherm of nickel ion on F300 grade of oxidized granular activated carbon varying weight of GAC was taken into a 1 liter round bottom flask and placed carefully in thermostat for each set of experiment. A fixed concentration of 200 mL of nickel ion in solution was then introduced. The stirrer was placed in position and the contents were stirred for six hours at ± 28°C. Aliquots of 5 mL of nickel ion solution were then withdrawn from the flask and analyzed calorimetrically for nickel ion concentration. The initial and final concentration of nickel ion in mg/lit was then determined spectrophotometrically. Usually equilibrium was reached with the period of shaking for six hours. Using both values $C_o$ and $C_e$, the value of $q_e$, the amount of nickel adsorbed on the GAC was determined by following expression.

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

Where, $q_e$ = Concentration of nickel ion on GAC in mg/g of carbon; $C_o$ = Initial concentration of nickel ions in solution in mg/L; $C_e$ = Equilibrium concentration of nickel ions in solution in mg/L; V = Volume of solution taken in liters; W = Weight of carbon taken in g.

## RESULTS AND DISCUSSION

### Characterization of adsorbent

In the present work, carbon namely Oxidised Filtrasorb F-300 was used for isotherm study. A plot of qe versus $C_e$ represented an adsorption isotherm with F-300 Oxidised GAC is given in Fig. 1(a). A remarkable increase in adsorption capacity is observed in Fig. 1(a) F-300 Oxidised GAC.

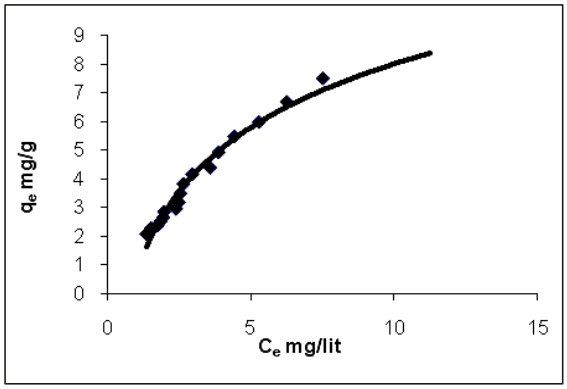


**Fig. 1: Adsorption isotherm system: F-300-oxidised carbon-$Ni^{2+}$**

## CONCLUSION

Adsorption by Oxidised granular activated carbon is a very effective technique for the removal of heavy metals from wastewater as seen from literature in recent years. F-300, grade of Oxidised carbon used are very good adsorbents & it is also useful for the recovery of nickel from wastewater.

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