

ARSENIC REMOVAL FROM WATER USING ACTIVATED CARBON DERIVED FROM PELTOPHORUM PTEROCARPUM (COPPER POD)

Shashikant.R.Mise¹, Indrale Divyarani²

¹Professor, Department of Civil Engineering, ²M-Tech Scholar, Department of Environmental Engineering, PDA College of Engineering, Gulbarga
srmise45@yahoo.com, indrale26@gmail.com

Abstract

The removal of Arsenic from synthetic sample by adsorption on chemical activated carbon prepared from *Peltophorum Pterocarpum* (Copper pod) fruit have been carried out at room temperature $32 \pm 1^\circ\text{C}$. Batch tests were conducted for the removal of Arsenic on chemically activated (Calcium chloride) carbon with Impregnation ratio's (I.R) 0.25, 0.50 and 0.75 for optimum time, optimum dosage and optimum pH. The maximum removal efficiency was obtained at an I.R. ratio of 0.75 and hence an I.R. of 0.75 has been taken for all the batch and column adsorption tests conducted. The optimum contact time, adsorbent dose and pH for carbon with I.R-0.75 was 10min, 75mg and 8.75, respectively, with arsenic removal efficiency of 97.32%, 99.33% and 99.33% respectively has been observed. Further, results of adsorption column studies data showed best fit with Freundlich Isotherm.

Keywords: Arsenic, Activated carbon, *Peltophorum Pterocarpum*, Calcium chloride, and Freundlich Isotherm.

1. INTRODUCTION

Arsenic and other heavy metals occur naturally in geological structures or sometimes caused by mining, industrial and agricultural activities^[1]. These chemicals can badly affect human health when they are consumed in large amount. The ground water at various locations in Bangladesh, States of West Bengal & Karnataka in India, has been noticed to be contaminated with Arsenic (As) in excess of its permissible value. Recently 14 out of 20 villages at Surpur taluq of Yadgir district, Karnataka state (India) has been found to be affected by Arsenic content. The determination of Arsenic has been of importance to public health agencies for many years because of the toxicity of Arsenic compounds. Several incidents have demonstrated that Arsenic in water may be carcinogenic. Acute poisoning by Arsenic involves the central nervous system leading to coma and for doses of 70-80 mg to death. The gastro-intestinal tract, nervous system, the respiratory tract, and the skin can be severely affected^[2]. It is recommended that, when water is found to contain Arsenic in excess of 0.01 mg/L (W.H.O), the water is considered to be unfit for drinking. Arsenic can be removed by many conventional and non-conventional methods. Adsorption is used widely to remove Arsenic metal from water and industrial wastewater. Adsorption offers significant advantages like low cost, availability, profitability, easy of operation and efficiency, in comparison with conventional methods (such as membrane filtration or ion exchange) especially from economical and environmental points of view. There have been several studies of arsenic removal using activated carbon obtained from agricultural wastes like saw dust^[1], jute stick^[3], rice husk^[4] etc. Activated carbon made

from easily available agricultural wastes can serve as an economically available alternative. As reported in a prior study saw dust was used as an adsorbent for arsenic removal and the effect of pH was studied. It was found that the optimum pH was 6.0. The adsorption properties of some other activated carbons obtained from jute stick using H_3PO_4 and rice husk have been studied^[3]. It was found that the properties of the activated carbon in removing arsenic can be different for different materials used for preparing carbon and that the adsorption of anions was affected more compared to that of cations. In this research fruit of *Peltophorum Pterocarpum* (Copper pod) is used as an adsorbent, which is a waste material causing litter. So far there has been little study of arsenic adsorption using chemically activated carbon, despite the existence of many such investigations using activated carbon. This study was to evaluate the preparation of chemically activated carbon using calcium chloride as an activating agent and detection of arsenic removal on prepared carbon as a function of contact time, adsorbent dosage and pH. Therefore this study would contribute to the understanding of arsenic removal by adsorption on chemically activated carbon.

2. MATERIALS AND METHODS

2.1 Materials

The material used for preparing carbon was fruit of *Peltophorum Pterocarpum* (Copper Pod). The scientific name of this tree is *Peltophorum Pterocarpum*, from family Leguminosae^[2]. Activated carbon made from copper pod does not impart any colour, taste and odour to water, when it is

added to it. So it is a suitable adsorbent for treatment of Arsenic contaminated water.

The instruments used for the experimental work are Electronic Balance, pH meter, Spectrophotometer, Gutzeit apparatus and Gyro shaker which were used from the college laboratory and all the glass wares used were made up of Borosilicate.

2.1.1 Chemicals:

Stock solutions of arsenic were prepared in reverse deionized (DI) water using arsenic trioxide. Arsenic working solutions were freshly prepared by diluting arsenic stock solutions with DI water. H_2SO_4 and NaOH (0.1N) were used for adjusting the pH of the arsenic solution.

2.2 Methods

2.2.1 Preparation of Activated Carbon using $CaCl_2$ as

Activating Agent:

The known quantity of washed and dried Peltophorum Pterocarpum (Copper pod) fruit powder was mixed with the activating agent ($CaCl_2$), in required quantity, depending upon the impregnation ratio (I.R).

$$\text{Impregnation ratio (I.R)} = \frac{\text{Weight of the active agent added}}{\text{Weight of carbonizing material}}$$

The mixture was mixed with required quantity of distilled water and boiled on hot plate till most of the water evaporated and slurry like mixture was retained. The mixture was oven dried in a clean tray for 24 hours maintained at $105 \pm 5^\circ C$ which helps in evaporation of moisture from the mixture. Preheated carbonizing material was filled in small container in three layers, by compacting each layer without any air space. The small container was then placed into a big container, such that sand surrounded the small container completely, the lid of the big container was tightly fitted. Pin hole has been made on the lids of the containers. The container set-up was kept in Muffle furnace and heated at steady rate to attain the temperature of $800^\circ C$. The container was taken out after allowing 10 hours for cooling. Activated carbon thus prepared was washed with 0.1N HCl to remove the activating agent, followed by hot distilled water for about 8 times to remove the excess HCl present in the activated carbon. The activated carbon was dried at $105 \pm 5^\circ C$ and packed in polythene bags and kept in desiccator.

2.2.2 Selection of Optimum Contact Time:

The adsorption is strongly influenced by the contact time. To study the effect of contact time, 100mL of $10\mu g/L$ arsenic solution was mixed with 0.1g of activated carbon, stirred at different contact times varying from (5mins, 10mins up-to 60mins). Then filtrate was analyzed for arsenic concentration using uv visible spectrophotometer.

2.2.3 Determination of Optimum Dosage of

Adsorbent:

To determine the optimum dosage of activated carbon, it was added to the conical flask in different dosage varying from (25mg, 50mg, and 75mg up to 300mg), containing 100mL concentration of arsenic solution ($10\mu g/L$). The solution in the conical flask was subjected to stirring for optimum contact time, filtered and analyzed for residual arsenic concentration. The dosage which gives minimum residual concentration is chosen as optimum dosage.

2.2.4 Selection of Optimum pH on Arsenic:

The extent of adsorption is strongly influenced by the pH at which adsorption is carried out. The effect of pH on arsenic adsorption was studied by performing equilibrium adsorption tests at different initial pH values. i.e. from 6.75 to 9.25. The pH of solution was adjusted by using 0.1N H_2SO_4 or 0.1N NaOH. The pH which gives minimum residual concentration is chosen as optimum pH.

2.2.5 Column Tracer Experiments:

In the column experiment, a column of 1.54 cm diameter was used. At the bottom, a height of 3cm is filled by gravels, a layer of sand of height 3cm is filled above the gravels. Activated carbon of height 11.05cm was laid in the column above the sand layer. First the distilled water was allowed to leach through the column from bottom to top (up-flow) to saturate the carbon bed and then the arsenic solution of concentration $10\mu g/l$ were passed through the saturated carbon, in single flow. The leachate was collected and tested for arsenic concentration.

Procedure for Determining Arsenic by Zinc-Stannous Chloride Reduction Method using Gutzeit Apparatus:

The procedure for determining arsenic was followed according to the standard methods.

3. RESULTS AND DISCUSSIONS

3.1 Effect of Contact Time

Effect of contact time was studied and graph of percentage of arsenic removal versus time in minutes was plotted as shown in Fig.1. From the graph it is evident that the extent of arsenic adsorption increases with increase in time. The adsorption curves are characterized by sharp rise in initial stage and decreases near equilibrium. The removal efficiency on arsenic by using chemically activated carbon ($CaCl_2$) with different I.R. 0.25, 0.50, and 0.75 was found to be 73.3%, 79.33%, and 97.32% with an optimum time of 15min, 10min, and 20min respectively.

3.2 Effect of Adsorbent Dosage

Effect of adsorbent dosage was studied and graph of percentage of arsenic removal versus dosage was plotted as shown in Fig.2. From the graph it is observed that, as the dosage of carbon increases, amount of arsenic decreases, sharply in the beginning and attains maximum later. This is mainly due to the large contact surface area and adsorption sites available for adsorption. Later the carbon gets saturated and the removal efficiency of the adsorbent decreases. The dosage, at which maximum removal is attained, is taken as maximum dosage. The removal efficiency on arsenic by using chemically activated carbon (CaCl₂) with different I.R. 0.25, 0.50, and 0.75 was found to be 86.6%, 94.64%, and 99.33% with an optimum dosage of 175mg, 100mg, and 75mg respectively.

3.3 Effect of pH

Effect of pH was studied and graph of percentage of arsenic removal versus pH was plotted as shown in Fig.3. From the graph it is observed that, arsenic is removed more effectively in slight alkaline range. The removal efficiency of arsenic by using chemically activated carbon (CaCl₂) at I.R 0.25, 0.50 and 0.75 was found to be 93.33%, 97.99% and 99.33% at a pH of 8.5, 8.75 and 8.75 respectively. The observations of the pH effect on the arsenic adsorption using chemically activated carbon were generally similar to most of those obtained by using different types of activated carbon. From the earlier studies the maximum adsorption of arsenic was obtained at a pH range of 7-9 and therefore the explanations of how pH affects arsenic adsorption can be applied to this adsorbent.

3.4 Column Tracer Experiments

A series of column tracer experiments have been performed with Arsenic on the chemically activated carbon with I.R 0.75 obtaining the breakthrough curve and retardation coefficients. Results obtained by Column tracer method were interpreted

using Freundlich, linear formulas describing the adsorption isotherms. In all cases of Arsenic adsorption, the best fit was obtained for the Freundlich isotherm, described by the formula:

$$C_{ads} = K^F \times C_{aq}^{1/n}$$

Where,

C_{ads} = balance concentration of the studied compound in the ground;

C_{aq} = balance concentration of the studied compound in the water;

K^F and n = coefficients of the Freundlich adsorption isotherm. Table.1. shows the values of Freundlich coefficients.

Substitute distribution coefficient (determined using the Freundlich isotherm) K_d^F for a given value of balance concentration of ion adsorbed in the bed (solution) equals.

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

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

$$R = 1 + \frac{\rho_d}{n} K_d^F$$

Where,

η = Porosity

ρ_d = Bulk Density Kg/m³

Table.1: Values of Freundlich Coefficients for column tracer experiments.

Type of carbon	K^F (Coefficient of Freundlich Isotherm)	1/n (Coefficient of Freundlich Isotherm)	K_d^F (Distribution coefficient)	R (Retardation)
Chemically(CaCl ₂ , I.R=0.75) activated carbon	1	0.841	0.693	1.383

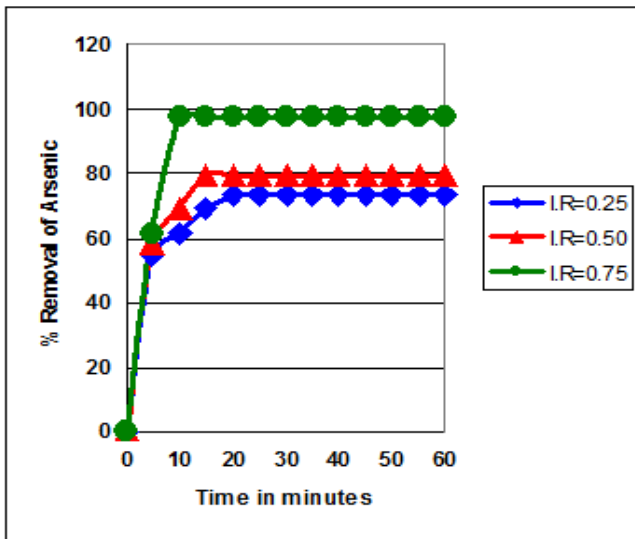


Fig1 Effect of contact time

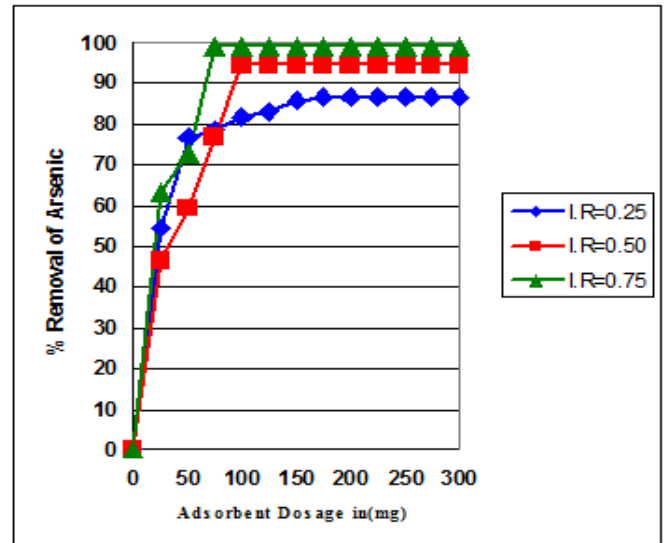


Fig2 Effect of adsorbent dosage

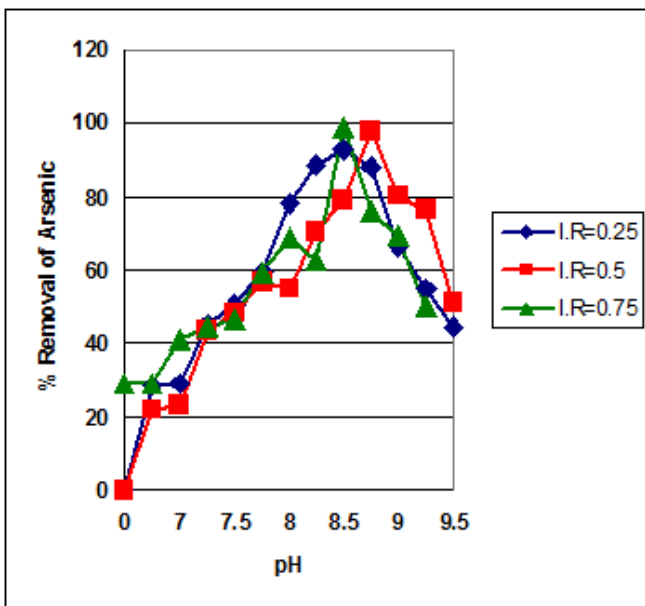


Fig.3 Effect of pH

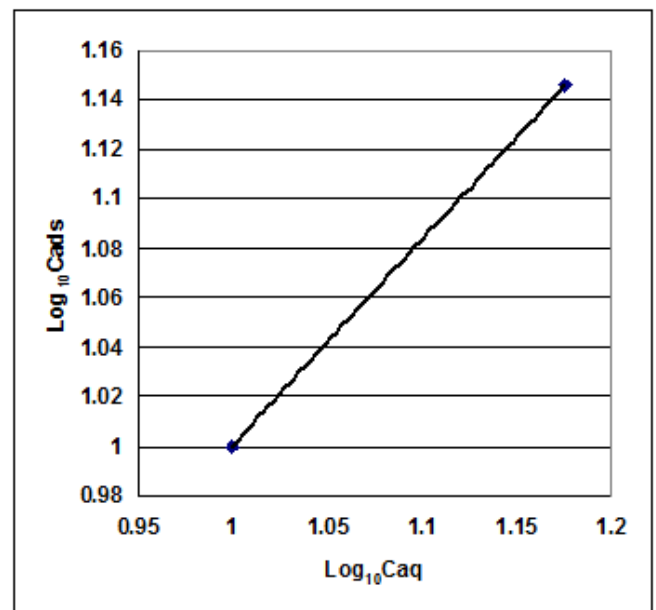


Fig.4 Plot of Freundlich Isotherm for column adsorption

CONCLUSIONS

Arsenic adsorption on CaCl₂ activated carbon was studied in batch and column adsorption experiments. With an initial arsenic concentration of 10µg/l for effect of contact time, adsorbent dosage and pH

From the experimental results it was found that the optimum contact time for carbon at I.R's 0.25, 0.50 and 0.75 were

20min, 15min and 10min with removal efficiency of 73.33%, 79.33% and 97.32% respectively.

The result of experiment on optimization of dosage of adsorbent revealed that, increase in amount of dosage added, increased the removal of Arsenic from the solution. Hence, the optimum dosage for carbon at I.R's 0.25, 0.50 and 0.75 were 175mg, 100mg and 75mg with removal efficiency of 86.60%, 94.64% and 99.33% respectively.

The adsorption of Arsenic is mainly pH dependent. The removal efficiency of adsorbent increased with increase in pH value. The optimum pH for I.R-0.25, 0.50 and 0.75 was found to be 8.5, 8.75 and 8.75 respectively.

The result of the column experiments were fitted to Freundlich isotherms as $1/n$ value was less than 1.

REFERENCES

- [1]. Arun kumar, Dinesh Pandey, Ratnesh Anand and Nandlal Choudhary, "Study of Adsorption of Arsenic Metal from Aqueous Solution Through Local Adsorbent Saw Dust", Indian Journal, Science Research, 2 (4), 73-78, 2011.
- [2]. Le Zeng, "Arsenic Adsorption from Aqueous Solutions on an Fe(III)-Si Binary Oxide Adsorbent", Water Qual. Res. J. Canada, Volume 39, No. 3, 267-275, 2004.
- [3]. M Israt Jahan, M Abdul Motin, M Moniuzzan and M Asadullah, "Arsenic removal from water using activated carbon obtained from chemical activation of Jute stick" Indian Journal of Chemical Technology, vol. 15, pp 413-416, 2008.
- [4]. M.N. Amin., Kaneco, T. Kitagawa, A. Begum, H. Katsumata, T.Suzuki, K. Ohta, "Removal of arsenic in aqueous solutions by adsorption onto waste rice husk", Ind. Eng. Chem. Res. (ACS) 45, 8105-8110, 2006.