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Adsorption Studies of Arsenic Removal on Activated Carbon Derived From Delonix Regia (Gulmohar Sees Pods)

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Abstracts

Arsenic content in groundwater imposes a great threat to people worldwide. As (III) which is toxic element and creates adverse effect to the human health .The present study deals with removal of arsenic from aqueous solution using low cost activated carbon prepared from Delonix regia (gulmohar seed pods).In adsorption solute present in dilute concentration in liquid or gas phase is removed by contacting with suitable solid adsorbent so that the transfer of component first takes place on the surface of the solid and then into pore of the solid. Batch adsorption study were conducted by varying the contact time, adsorbent dosage & pH.

Keywords: Activated Carbon, Adsorption, Arsenic.

Introduction

The presence of heavy metals in the aquatic environment has been of great concern to Scientists and Engineers because of their increased discharge, toxic nature and other adverse effects on receiving water bodies. These heavy metals are non-bio-degradable and their presence in streams and lakes leads to bio-accumulation 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.

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. The toxicity of arsenic compounds depends on the chemical and physical form of the compounds and the route by which it enters the body. 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. Adequate evaluation of toxicity hazards requires arsenic estimation in the micro-gram range. It is recommended that, when water is found to contain arsenic at level of 0.05 mg/l, an attempt should be made to ascertain the valence and chemical forms of the elements.[1]

'ADSORPTION' is one of the effective methods for removing heavy metals from waste water. But the standard adsorbents like silica gel etc are costly. So activated carbon made from easily available agricultural wastes can serve as an economically available alternative.

This work presents the study to evaluate the performance of activated carbon derived from fruit of Delonix regia (gulmohar seed pods) in removing arsenic from its synthetic solution.

Materials and methods

Adsorbent

The material used in this research study is Delonix regia as an adsorbent. For removal of arsenic from aqueous solution, adsorption technique was employed using activated carbon prepared from Delonix regia (gulmohar seed pods). There are two methods to prepare activated carbon, namely

i. Physically activation (taking three sieve sizes 75,150,300 microns)
ii. Chemical activation, using sodium carbonate (Na_2CO_3) taking sieve size 150 microns.

Impregnation Ratio

In chemical activation the degree of I.R. play an important role. It is the ratio of weight of anhydrous activating salt to the dry carbonizing material. The effect of the degree of impregnation ratio on the porosity of the resulting product is apparent from the fact that volume

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of pores increases with I.R. When degree of impregnation is further raised the number of pores with large diameter increases and the volume of the smallest decreases. In this study 0.25, 0.50 and 0.75 I.R'S. are used.

Batch Sorption Experiment

In batch sorption, a pre-determined amount of adsorbent is mixed with the sample, stirred for a given contact time and subsequently separated by filtration. Powder adsorbent is more suitable for the batch type of adsorption.

Selection of Optimum Contact Time

The adsorption is strongly influenced by the contact time. To study the effect of contact time, 100mL of 10µg/L arsenic solution of pH 7.0 ± 0.02, was mixed with 0.1g of activated carbon, stirred at different contact times varying from (5mins, 10mins, 15mins up to 60mins). Then filtrate was analyzed for residual arsenic(III) concentration using spectrophotometer.

Determination of Optimum Dosage

To determine the optimum dosage of activated carbon, carbon was added to the conical flask in varying amount (25mg, 50mg, and 75mg up to 300mg), containing 100mL concentration of arsenic (III) solution (10µg/L) and adjusted pH 7.0±0.02. 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.

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 9.50. The pH of solution was adjusted by using 0.1N H_2SO_4 or 0.1N NaOH. The pH at which maximum Arsenic(III) removal forms optimum pH.

Results and discussions

This chapter deals with the efficiency of prepared carbon for removing Arsenic for:

1. Effect of contact time
2. Effect of dosage
3. Effect of pH

Effect of Contact Time

Contact time has greater influence in the adsorption process. The effect of contact time on removal of arsenic from synthetic sample at pH 7.0±0.02 using physically and chemically activated (Na_2CO_3) carbons prepared from gulmohar seed pods powder with I.R. 0.25, 0.50 and 0.75 are shown in figure 3.1 and figure 3.2.

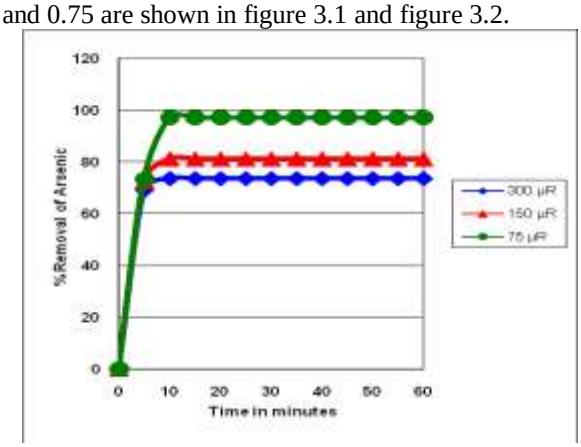

Fig.3.1 Effect of Contact Time on Arsenic Removal by Physically Activated Carbon

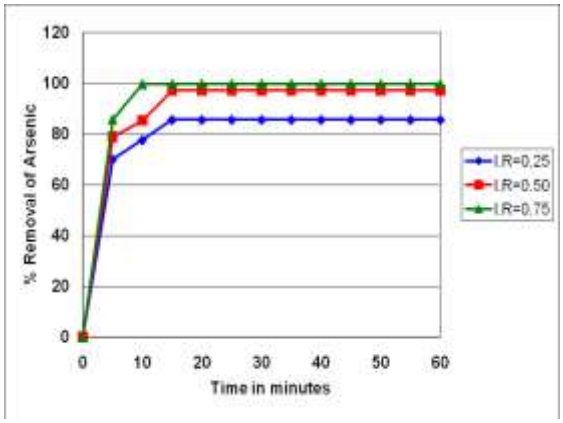

Fig.3.2 Effect of Contact Time on Arsenic Removal by Chemically (Na_2CO_3) Activated Carbon

Effect of Adsorbent Dosage:

Adsorption is a process in which continues transfer of solute from solution to adsorption occurs, until residual concentration of solution maintains an equilibrium with what adsorbed by the surface of adsorbent at constant contact time. Effect of adsorbent dosage is studied and graph of percentage of arsenic removal versus dosage is plotted as shown in figure 3.3 and 3.4.

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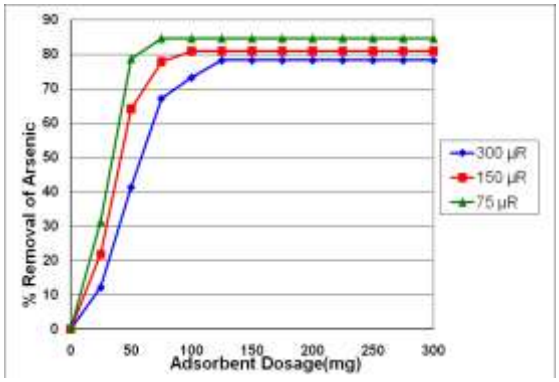

Fig.3.3 Effect of Adsorbent Dosage on Arsenic Removal by physically Activated Carbon.

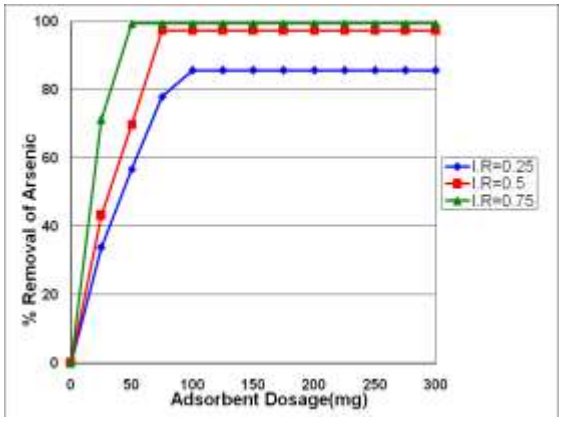

Fig.3.4 Effect of Adsorbent Dosage on Arsenic Removal by Chemically (Na_2CO_3) Activated Carbon

Effect of pH on Arsenic Removal:
The pH of solution has influence on the extent of adsorption removal efficiencies of arsenic by prepared activated carbon at different pH values are shown in figure 3.5 and 3.6. The amount of As(III) not only depends on the surface area, optimum time and optimum dosage but also depends on pH.

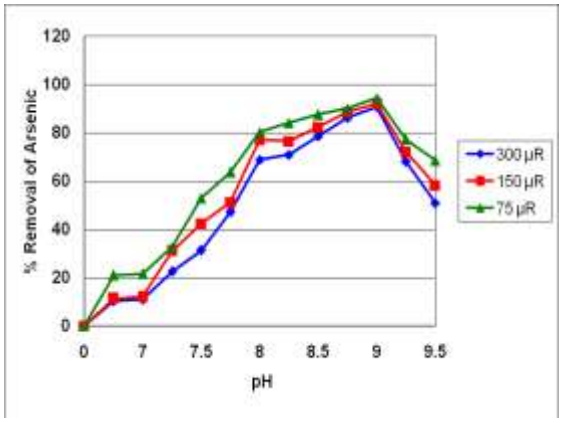

Fig.3.5 Effect of pH on Arsenic Removal by Physically Activated carbon

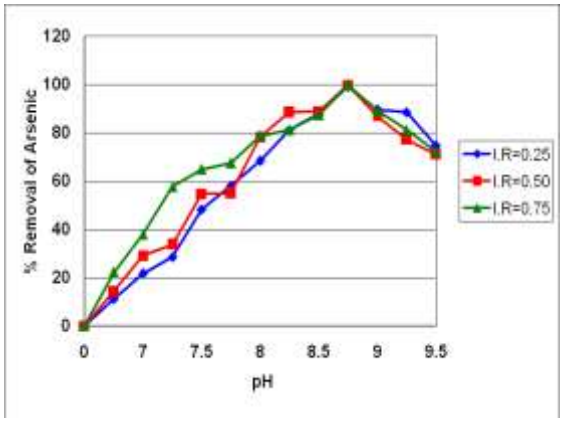

Fig.3.6 Effect of pH on Arsenic Removal by Chemically (Na_2CO_3) Activated Carbon

Table-3.1: Optimum Contact Time, Optimum Dosage And Optimum pH For Prepared Carbons

Type Of Carbon		Optimum Time (min)	Optimum Dosage (mg)	Optimum pH
1.Physically activated carbon	Sieve size	25	125	9.0
	300 µR	20	100	9.0
	150 µR	15	75	9.0
	75 µR	25	125	9.0
2.Chemically activated (Na_2CO_3)	I.R	15	100	8.75
	0.25	15	75	8.75
	0.50	10	50	8.75
	0.75	15	100	8.75

Conclusion

1. The Experimental results shows good removal efficiency of As(III) from synthetic solution by using activated carbon derived from Delonix regia.
2. The kinetics of adsorption of As(III) with Physically and Chemically activated carbon were studied by estimating the effect of contact time on the percentage removal of arsenic. The data and results from the experiment reveal that removal of arsenic increases with increase in contact time and attains equilibrium at particular time. Hence optimum contact time for physically activated carbon at different sizes 300 µ, 150 µ, 75 µ retained are 25min, 20min, 15min with removal efficiency of 78.20%, 82.9%, 88.66%. For Na_2CO_3 activated carbon at

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different I.R.-0.25, 0.50, and 0.75 are 15min, 15min, and 10min with removal efficiency of 85.67%, 97.36% and 99.87% respectively.

3. The result of experiment on optimization of dosage of adsorbent reveals that, increase in amount of dosage added, increases the removal arsenic from the solution. Hence Optimum dosage for physically activated carbon at different sizes 300 µ, 150 µ, 75 µ retained are 125mg,100mg,75mg with removal efficiency of 78.24%,82.91%, 88.60%. For Na_2CO_3 activated carbon at different I.R.-0.25, 0.50, and 0.75 are 100mg, 75mg, and 50mg with removal efficiency of 85.63%, 97.32% and 99.86% respectively.
4. The adsorption of arsenic is mainly pH dependent. The removal efficiency of adsorbent increases with increase in pH value. It has been observed that maximum adsorption takes place in slight alkaline medium around pH-9 for physically activated carbon at size 75 µ retained with removal efficiency of 92.38% and pH-8.75 for chemically activated (Na_2CO_3)carbon (for I.R. 0.75) respectively. Batch experiment results showed a different behaviour for the chemically activated carbon used. Chemically activated carbon by calcium sodium carbonate has shown the maximum removal efficiency as compared to carbon activated with sodium dipottasium anhydrous orthophosphate.

Scope for future study

1. Adsorption studies can be further continued on various other heavy metals like chromium, lead, zinc etc.
2. Experiment can also be conducted with adsorbent of different varying sizes so as to choose the best size of the adsorbent.
3. Experiment can also be conducted by varying temperature.
4. Experiment may also be conducted to know the effect of various arsenic concentrations on removal efficiency of adsorbents.
5. Regeneration and reuse after adsorption can be carried out.

Acknowledgements

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References

1. Santosh Kumar Garg, "Water Supply Engineering", 19th edition, 2008