ARSENIC REMOVAL FROM DRINKING WATER USING FLYASH AS AN ADSORBENT

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Abstract
Nowadays water pollution has become a major problem that is being faced by the human kind. Among various pollutants present in water, arsenic is gaining much importance because of the toxicity of its compounds. Hence it is very much necessary to find the best suitable technique for removal of arsenic from drinking water. In the present study, the removal of Arsenic from synthetic sample on coated fly ash has been carried out at room temperature $32 \pm 1^{o}C$. Initially raw fly ash was used for the experiment and it was seen that the residual arsenic concentration increased hencebatch tests were conducted for the removal of Arsenic on iron sulphate coated fly ash for optimum parameters such as dosage, pH, time, initial concentration and agitation rate. The maximum removal efficiency was obtained at an optimum dosage of 0.5gms. It was found that 100% removal can be achieved at slightly alkaline pH condition. The optimum time, initial concentration and agitation rate were found to be 15mins, 140µg/l and 150RPM respectively.

Keywords: Arsenic, Adsorption, Iron Sulphate coated Fly Ash.

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1. INTRODUCTION

Arsenic is the 20th most abundant element found in the earth's crust. It occupies nearly 0.00005% of the entire earth's surface [2]. Arsenic occurs naturally and sometimes can be produced by anthropogenic sources such as mining, industrial and agricultural activities. It is found naturally in the geologic substrate and also can be produced during volcanic eruptions. Arsenic occurs in organic and in-organic forms. It is present in the organic form in food in small amount which is required for the body. In natural waters, it is present in the in-organic form namely As (III) and As (V). These two ions namely, arsenic trioxide and arsenic pentoxide are either naturally occurring or byproducts of industrial waste. The predominant species for As (III) are H_3AsO_3 and for As (V) are H_2AsO^{4-} and $HAsO4^{2-.}$ These chemicals can badly affect human health[10]when they are consumed in large amount. The ground water at various locations in Bangladesh, West Bengal, some parts of Bihar& Karnataka in India, has been noticed to be contaminated with Arsenic (As) in excess of its permissible limit. Recently 14 out of 20 villages at Surpur taluq of Yadgir district, Karnataka state (India) has been found to be affected by Arsenic content.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 [4]. 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, ease of operation and efficiency, in comparison with conventional methods especially from economical and environmental points of view. Many attempts have been made to remove arsenic from water using various adsorbents.

Fly ash is a by-product that is produced by coal fired thermal power plant. From literature review it can be concluded that fly ash has sorptive properties with regard to heavy metals [3].And it was also found that iron containing adsorbents were effective in arsenic removal from aqueous solution hencefly ash coated with iron sulphate was used in the present study [5].

2. MATERIALS AND METHODS

2.1 Materials

Fly ash was obtained from Raichur Thermal Power Plant and the chemical properties depend on the source, and method of combustion. The main contents of fly ash are silica and alminosilicates. Particle size should be given due consideration in the process of adsorption hence fly ash used was 300micron passing and 150micron retained. The fly ash was coated with iron sulphate and then used.

The instruments used for the experimental work are Electronic Balance, pH meter, Magnetic Stirrer,Atomic Absorption Spectrophotometer,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

Arsenic stock solutions were prepared in distilled water using arsenic trioxide. Arsenic working solutions were

freshly prepared by diluting arsenic stock solutions with distilled water. H_2SO_4 and NaOH (0.1N) were used for adjusting the pH of the arsenic solution.

2.2 Methods

Initially raw fly ash was used for the removal of arsenic from synthetic solution. 100ml of sample containing 10µg/l arsenic was tested at different adsorbent dosage. After the experimental studies, it was found that arsenic concentration in the effluent increased hence there was a need to coat the fly ash with iron sulphate since iron containing adsorbents were effective in arsenic removal.

2.2.1 Preparation of Coated Fly Ash

100gms of fly ash was mixed with 600ml distilled water containing 156.75gms of ferrous sulphate.The mixture was stirred in a magnetic stirrer for about 1hour, then after 15mins of settling, the solution was decanted and 100ml of distilled water containing 2gms NaOH was added. Again the mixture was stirred for 5mins, then after 15mins of settling, it is again decanted and kept 24hours for drying allowing for oxidation of the iron coating. After 24hours of drying, coated fly ash is obtained which is used for further batch studies [1,8,9].

2.2.2 Determination of Optimum Dosage of Adsorbent

To determine the optimum dosage of coated fly ash, it was added to the beaker in different dosage varying from (0.1gms, 0.2gms, and 0.3gms and up to 2.0gms), containing 100mL solution with arsenic concentration of 100µg/L. The solution in the beaker was subjected to stirring for 30mins, filtered and analyzed for residual arsenic concentration. The dosage which gives minimum residual concentration is chosen as optimum dosage.

2.2.3 Selection of Optimum Contact Time

Contact time is an important parameter which strongly influences the adsorption. To study the effect of contact time, 100mL of 100µg/L arsenic solution was mixed with 0.5gms of coated fly ash, stirred in a rotary shaker at different contact times varying from (2mins, 4mins up-to 30mins). Then filtrate was analyzed for arsenic concentration using Atomic Absorption Spectrophotometer. The lowest contact time at which maximum arsenic removal takes place was taken as optimum contact time.

2.2.4 Selection of Optimum pH

pH is another important parameter on which the adsorption is strongly dependent. The effect of pH on arsenic adsorption was studied by performing adsorption tests at different initial pH values. i.e. from 2.0 to 10. The pH of solution was adjusted by using HNO_3 or 0.1N NaOH. The pH which gives maximum removal of arsenic was chose as optimum pH.

2.2.5 Selection of Optimum Initial Concentration

The rate of adsorption also varies with respect to initial concentration of arsenic in the water. To find the optimum initial concentration, studies were conducted by varying the initial concentration from (10µg/L, 20µg/L and up-to 300µg/L). 0.5gms of coated fly ash was added in 100ml solution at pH of 10 and the contact time maintained was 15mins. Then the filtrate was used to find the residual arsenic.

2.2.6 Selection of Optimum Agitation Rate

To find the optimum agitation rate, 0.5gms of coated fly ash was added in 100ml of solution containing 140µg/l and it was stirred in a rotary shaker at different agitation rate. Later the solution was filtered and analyzed for the residual arsenic concentration. The minimal agitation rate at which higher percentage of arsenic was removed is chose as optimum agitation rate.

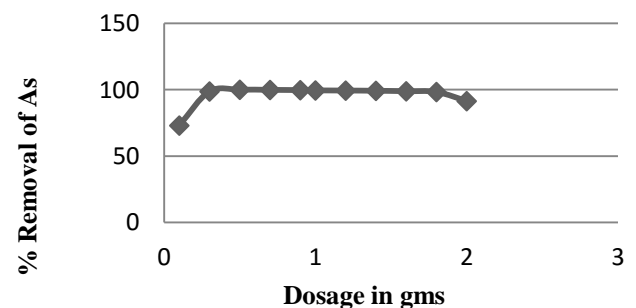## 3. RESULTS AND DISCUSSIONS

3.1 Effect of Adsorbent Dosage

Fig –1: Effect of adsorbent dosage

The Effect of dosage of adsorbent was studied and graph of percentage of arsenic removal versus dosage was plotted as shown in Fig.1. From the graph it is observed that, as the dosage of coated fly ash increases, arsenic removal increases and attains maximum later. This is mainly due to the large contact surface area and adsorption sites available for adsorption.Later the coated fly ash gets saturated and the removal efficiency of the adsorbent decreases. Another reason is as the dosage increases, there are chances of aggregation of fly ash molecules which leads to lesser surface area resulting in reduction of removal efficiency. The dosage, at which maximum removal is attained, is taken as maximum dosage. The removal efficiency was just 70% at a dosage of 0.1gms and it increased to 100% at a dosage of 0.5gms.

3.2 Effect of pH

Effect of pH was studied and graph of percentage of arsenic removal versus pH was plotted as shown in Fig.2.
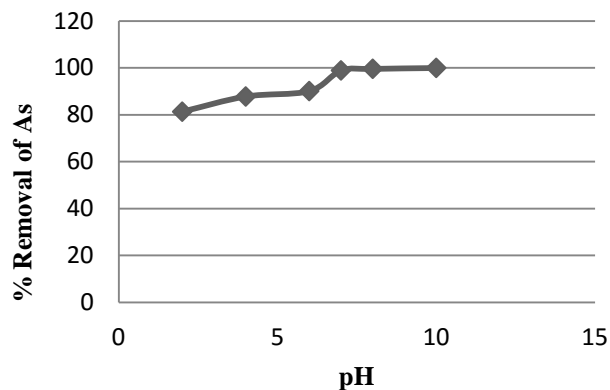
Fig – 2: Effect of pH

From the graph it is observed that, arsenic is removed more effectively in slight alkaline range. The removal efficiency of arsenic using coated fly ash was 100% at a pH range of 8-10. From the earlier studies the maximum adsorption of arsenic was obtained at a pH range of 7-9[3] and therefore the explanations of how pH affects arsenic adsorption can be applied to this adsorbent [6,7].
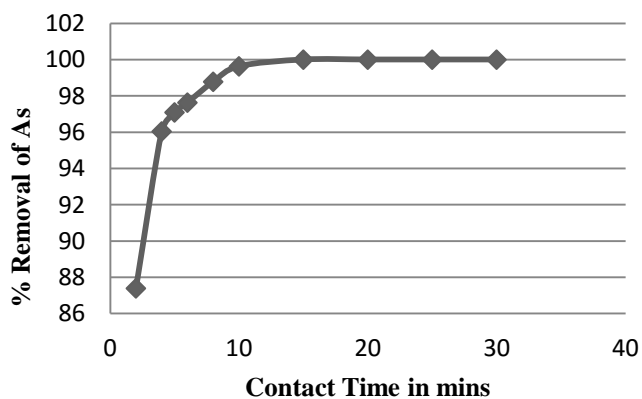
3.3 Effect of Contact Time

Fig – 3: Effect of Contact Time

Effect of contact time was studied and graph of percentage of arsenic removal versus contact time in minutes was plotted as shown in Figure.3. 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 of arsenic by using coated fly ash was 100% for a contact time of 15mins.
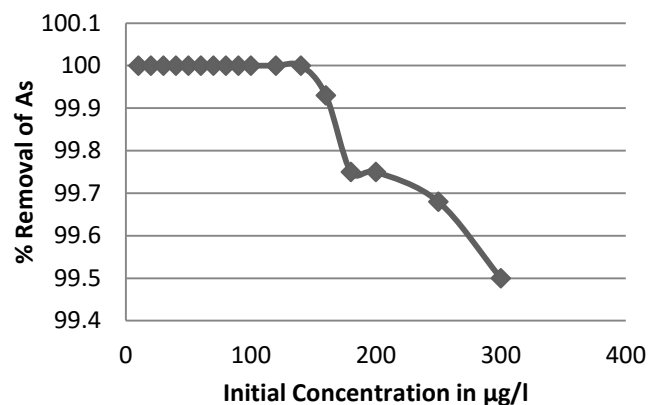
3.4 Effect of Initial Concentration

Fig – 4: Effect of Initial Concentration

The effect of initial concentration was studied and a graph was plotted as shown in the figure 4. From the graph, we can observe that 100% removal was there for 10μg/l which is the maximum allowable concentration for arsenic in drinking water. As the concentration of arsenic increased, 100% removal was observed till an initial concentration of 140μg/l.

3.5 Effect of Agitation Rate

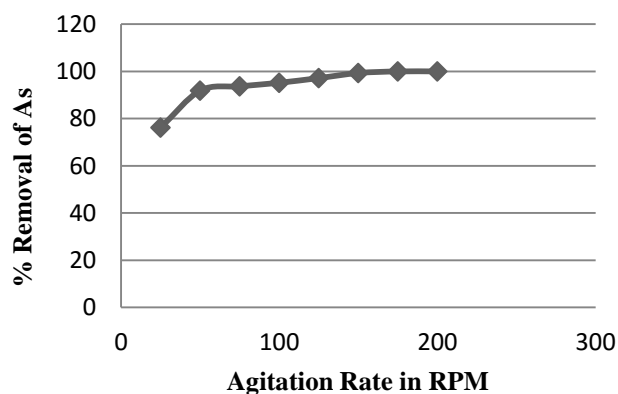The rate of adsorption was also studied with respect to agitation rate.

Fig – 5: Effect of Agitation Rate

After the experimental studies, a graph of percentage removal of arsenic versus agitation rate was plotted as shown in the figure.5. From the graph, it was clear that as the agitation rate increases, removal percentage also increases. The optimum agitation rate was found to be 150RPM.

4. CONCLUSION

- The trial study using raw fly ash showed that arsenic concentration increased in the effluent due to the presence of arsenic in the fly ash.
- Arsenic adsorption on coated fly ash was studied in batch adsorption experiments. With an initial arsenic concentration of 100μg/l, the effect of adsorbent

dosage, pH, contact time, and agitation rate were studied.

- From the experimental data, it was found that the optimum parameters were as follows:
  - ➢ Optimum dosage – 0.5gms
  - ➢ Optimum pH – 8-10
  - ➢ Optimum contact time – 15minutes
  - ➢ Optimum initial concentration – 140µg/l
  - ➢ Optimum agitation rate – 150RPM
- Initially rate of adsorption increases with the increase in the adsorbent dosage and later decreases on further addition of adsorbent.
- Removal efficiency increases with increase in the pH of the solution and it was found that 80-100% removal was achieved in the pH range 0f 3-10. Maximum percentage removal was observed at pH 8-10.
- Percentage removal of arsenic increased with the increase in the contact time and further increase in contact time had no effect on removal efficiency.
- As the concentration of the arsenic in the sample increases, the removal efficiency decreases.
- As the agitation rate increased, removal efficiency increased. The optimum agitation rate was found to be 150RPM.

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