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Research Article

A NOVEL OXIDATION-ADSORPTION METHOD FOR THE REMOVAL OF ARSENIC FROM AQUEOUS SOLUTION

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ABSTRACT

We report here the use of chalk powder for the removal of arsenic from aqueous solutions, as such as well as upon oxidation with $KMnO_4$, by adsorption. The adsorption process was studied as a function of pH (3-8), contact time (20-180 min), initial concentration (10 ppb to 100 ppb) and doses of chalk powder (0.5-3 g). It was observed that maximum removal of arsenic takes place at pH 6.5. It was also observed that maximum removal of arsenic occurs after a contact time of 120 minutes. % removal of arsenic decreases with increase in the initial concentration of solution whereas it increases with the increase in the dosages of the adsorbent. Removal was only about 10% when observed as such but increased up to 70% when oxidized with $KMnO_4$.

Keywords: Arsenic removal, Chalk powder, $KMnO_4$, Adsorption.

INTRODUCTION

In typical ground water environments, arsenic may be present in both As (III) and As (V) states. As (III) (arsenite) is generally more mobile in water than As (V) (arsenate), and has higher toxicity[1]. Due to the withdrawal of excessive amounts of groundwater, problems of increased iron, fluoride and arsenic contamination have been reported in different parts of India[2-4]. A recent study on cancer risks from arsenic in drinking water indicates that it could cause liver, lung, kidney and bladder cancers besides skin cancer[5].

In some of our studies, we have observed that quite a few of the ground water samples in the BudhiGandak river belt in Muzaffarpur town have arsenic contamination and exceeded the maximum permissible limit of 10 ppb set by WHO[6,7]. Various techniques[8-24] have been reported for the removal of arsenic from drinking water and waste water.

Ofthe two predominant forms of arsenic in water, arsenate and arsenite, most treatment processes are effective at removing arsenate, but not arsenite, since arsenite is typically non-charged below pH 9.2. Therefore, treatment for the removal of arsenic often includes an oxidation step to convert arsenite to arsenate. Co-occuring iron can oxidize arsenic which precipitates as $FeAsO_4$; aeration partly oxidises arsenic. Other possible oxidants include chlorine, hypochlorite, ozone, permanganate, hydrogen peroxide and Fenton's reagent (H_2O_2/Fe^{2+}). We have, in our present study, investigated the utility of chalk powder and found this as good adsorbent for the removal of arsenic from aqueous solutiontreated first with permanganate to oxidisearsenite to arsenate. Removal was only about 10% when aqueous solution was taken as such but increased up to 70% when oxidized with $KMnO_4$.This study has been influenced by our earlier finding regarding the use of chalk powder for the removal of Copper(II) from aqueous solutions[25].

MATERIALS AND METHODS

Preparation of Adsorbent

The adsorbent, powdered chalk, was primarily heated in an oven at 105^0C for 24 hours and cooled in a dessicator before use in the adsorption process.

Reagents

All the chemicals used were of analytical grade. Stock solution of 1000mg/L of Arsenic trioxide was prepared by dissolving required amount in distilled water. Solutions of required

concentrations were prepared by diluting the stock solutions. The pH of the solution was adjusted using 0.1 N HCl and 0.1NNaOH solutions.

Instrumentations

A UV-Visible Spectrophotometer (Systronics, model no. 2201) was used for analysis. A high precision digital balance was used for weighing and a digital pH meter (Systronics, model no. 361) was used for pH measurement.

Experimental methods

Estimation of arsenic was carried out experimentally by silver diethyldithiocarbamate (SDDC) method[26]. In batch study, effect of different parameters (i.e., pH, contact time, initial concentration and doses of adsorbents) on adsorption of arsenic was studied. For the effect of pH,the contact time was uniformly taken as 120 minutes taking 50 ppb initial concentration and 6 g of adsorbent dosage. For the effect of contact time, 50 ml metal ion solution of 50 ppb concentration was placed with a fixed mass of powdered chalk (i.e., 2 g) at pH 6.5 at varying contact times of 20 min, 40 min, 60 min, 80 min, 100 min, 120 min, 150 min and 180 min. For the study of the effect of initial concentration, 50 ml metal ion solution of different concentrations (10 ppb, 20 ppb, 30 ppb, 40 ppb, 50 ppb, 60 ppb, 70 ppb, 80 ppb, 90 ppb and 100 ppb) were placed together with a fixed mass of powdered chalk (i.e., 2 g) at pH 6.5. For the study of the effect of adsorbent dosage, 50 ml metal ion solution of 50 ppb concentration was placed with varying masses of powdered chalk (0.5 g, 1 g, 1.5 g, 2 g, 2.5 g, 3 g) at pH 6.5. The experiments were carried out at room temperature (about 35^0C).). The same set of experiments were carried out using 50 ml of metal ion solutions of the aforesaid concentrations oxidised with 1 ml of 0.3% $KMnO_4$ solution.

RESULTS AND DISCUSSION

The adsorption of metal ions is influenced by various factors including pH, contact time, initial concentration and amount of adsorbent.

Effect of pH

pH is the key factor for the control of the adsorption of metal ions on the adsorbent. The effect of pH on removal of arsenic is shown in Fig. 1. The study was done in the pH range of 3 to 8. It was found that the adsorption of arsenic ion gradually increases as the initial pH of the solution is raised from 3 to 6.5. The maximum removal of arsenic from the oxidized solution of arsenic was 70% at pH6.5. Hence, pH of the arsenic solution was maintained at 6.5 for further study.

Effect of contact time

% removal was recorded at contact time of 20 min to 180 min. The results are shown in Fig. 2. Evidently, 25 % arsenic removalfrom the oxidized solution of arsenic occurred within 20 min showing that initially the rate of uptake of arsenic is very fast and gradually increases attaining a steady value after reaching the equilibrium at about 120 min. Hence, 120 min contact time was fixed for further study.

Effect of initial metal ion concentration

Experiments were performed by taking different initial concentrations of arsenic solution (10 ppb to 100 ppb) at pH 6.5 for a contact time of 120 min, taking 2 g of powdered chalk as bioadsorbent. The results (Fig. 3) show that % removal of arsenic ions decreased with increasing initial concentration. This is because the adsorption sites become more saturated as the metal ion concentration increases.

Effect of adsorbent dosage

The adsorbent doses were varied from 0.5 g to 3 g. It was observed that the removal of metal ion increased with the increase in dosage of the adsorbentattaining a maximum at 2 g of adsorbent dosage (Fig. 4). Obviously, higher dose of adsorbent results in higher surface area providing greater number of binding sites for the metal ions.

CONCLUSION

Chalk powder was found to be effective natural adsorbent for the removal of arsenic from aqueous solutions, once these were oxidised with $KMnO_4$. The effects of process parameters like pH, contact time, initial metal ion concentration and adsorbent dosage on equilibrium were studied and it was observed that maximum adsorption (70%) takes place with pH 6.5, contact time 120 min., initial metal ion concentration 50 ppb and adsorbent dosage 2 g.

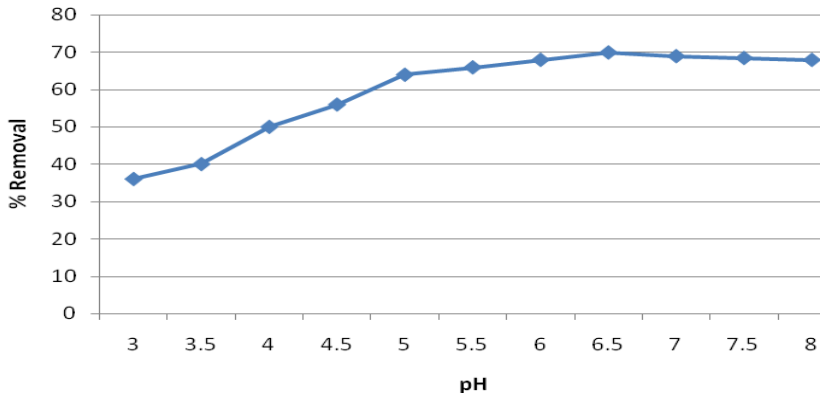

Fig. 1: Effect of pH on adsorption of arsenic on chalk powder (contact time: 120 min., arsenic ion concentration: 50 ppb, biomass dosage: 2 g)

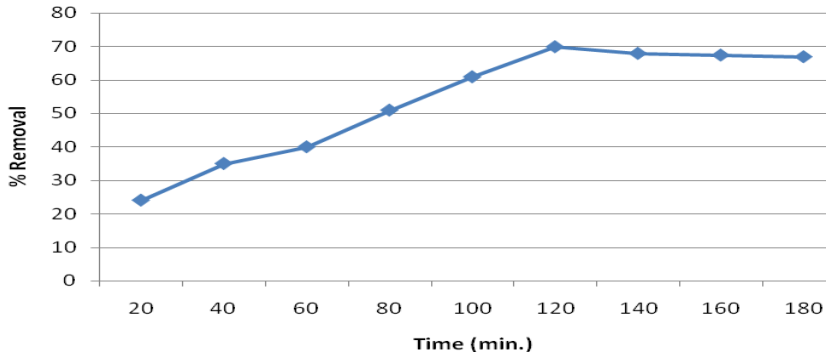

Fig. 2: Effect of contact time on adsorption of arsenic on chalk powder at 308 K (pH: 6.5, arsenic ion concentration: 50 ppb, biomass dosage: 2 g)

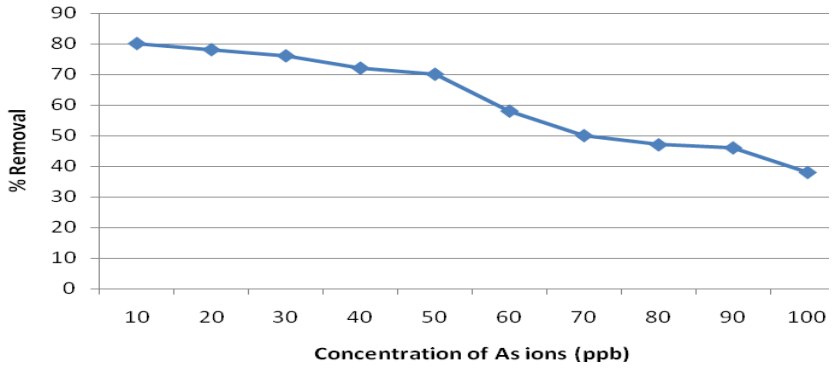

Fig. 3: Effect of arsenic ion concentration on adsorption on chalk powder at 308 K (pH: 6.5, time: 120 min., biomass dosage: 2 g)

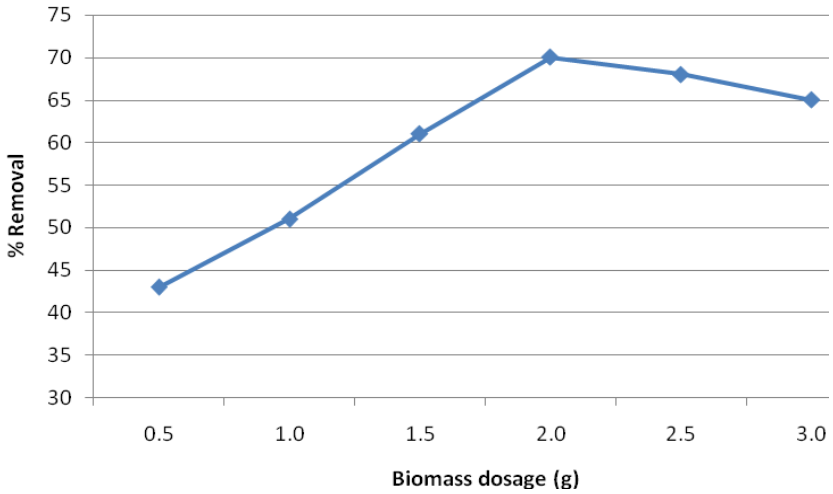

Fig. 4: Effect of biomass dosage on adsorption on chalk powder at 308 K (pH: 6.5, time: 120 min., arsenic ion concentration: 50 ppb)

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