Asian Journal of Chemistry Vol. 22, No. 3 (2010), 1885-1888

Estimation of Arsenic(III) by Adsorption and Filtration from Wastewater of Kanti Thermal Power, Muzaffarpur (India)

KALPNA KUMARI
Department of Chemistry, B.P.S. College, Desari-844 505, India

Adsorption process of As^{3+} from effluent of Kanti thermal power was found to be dependent on concentration of adsorbent and adsorbate, pH of solution, temperature, particle size of adsorbent and agitation speed of the system. It is observed that favourable conditions for arsenic removal are: equilibrium time of 50 min, pH of 7.5 and agitation speed of 190 rpm. The removal of As^{3+} has been found in the range of 87-95 %.

Key Words: Arsenic, Adsorption, Alumina, Spectrophotometry.

INTRODUCTION

Arsenic contamination is found[1] in major parts of the World, including Mexico, Argentina, Chile, Taiwan, inner Mongolia, China, Japan, India, Vietnam and Bangladesh. The situation is perhaps more serious in the Ganges river delta regions of India and Bangladesh where arsenic contaminated water from tube wells is major source of drinking water and is affecting the health of millions of people. Leaching of arsenic into the ground water can be associated with natural conditions or the industrial practices of mankind. Natural arsenic is generally associated with sedimentary rocks of marine origin weather volcanic rocks, fossil fuels and geothermal areas[2]. Silicon, iron and aluminum are substituted by arsenic and used in crystal lattice of silicate minerals[3].

Its intake of more than 0.05 ppm/L in drinking water damages the liver, skin and digestive system and causes melanosis (skin cancer)[4], hepatomegaly (liver enlargement), dyspnoea (bronchial asthma) and digestive problem. Acute arsenic problem can arises from ingestion of 100 mg arsenic. Chronic effect can appear its accumulation in the body at low intake levels of prolonged period. World Health Organization (WHO) recommend a provisional guideline for maximum contaminent level (MCL) of arsenic in drinking water[5] to be 0.01 mg/L. Several methods have being investigated and developed for removal of arsenic from contaminated water, including co-precipitation, adsorption[6], membrane technologies, distillation, coagulation, filtration[7] and ion exchange[8]. The selection of removal method is ultimately dependent upon the technology being validated in terms of sustainability, efficiency, adaptation and cost effectiveness. Based on these criteria filtration and adsorption methods are considered to be the most suitable. Efficiency of arsenic removal depends mainly on the effectiveness and efficiency of the adsorbent used in the system. Some of the adsorbents for arsenic, given in the literature are activated alumina[9] granular ferrihydrite, iron oxide coated sand, iron oxide rich soil, clay minerals, iron ores and scrap iron.

Studies on the treatment of effluents bearing arsenic by filteration and adsorption has been found to be the most promising technique because it is highly effective, cheap, easy and ecofriendly method. The present study is carried out for removal of arsenic from effluent of Kanti thermal power (Bihar) which generates about 399.16 million unit of electricity per year utilizing about 0.8350 kg/unit of coal/year and 54.79 mL/unit of furnace oil per year. Present study is carried out by filtration and adsorption techniques using alumina as adsorbents.

EXPERIMENTAL

The adsorbent[4] used is Al_2O_3. 10 L of sample of effluent was collected in dry and clean flask and sample was stored by adding 50 mL concenterated HNO_3 to minimize adsorption of metal on the container wall. For arsenic analysis sample was filtered again through 0.2 μm membrane filter. The filtrate was analyzed for arsenic(III) by silver diethyl thiocarbamate spectrophotometric method[10]. Solution pH was adjusted with $NaHCO_3$ and maintained at the desired value with, constant stirring through out experiment. Now the effluent was filter through arsenic filter containing iron fitting cut in small pieces and sand. Iron were corroded because it absorbe arsenic. About 5 % removal of arsenic observed by this filteration.

Then effluent was fed in to a tank reactor where the molecules of arsenic were held in the surface and known quantity of alumina pores through adsorption completed. Mixture moved to a membrane unit through microfilteration. The particles and arsenic were rejected and returned to the tank so that the alumina can be reused. The solution of $NaHCO_3$ was added to the reactor that causes the arsenic to separate or deabsorb from the alumina. The rejected alumina was regenerated and reused. The initial and equilibrium arsenic concenteration of the solution were determined. Experiments were triplicated and results averaged. All experiments were conducted at room temperature. The arsenic removal from effluent was estimated over a wide range of initial As^{3+} concenteration.

RESULTS AND DISCUSSION

The experimental parameters which were used for evaluation of the unit performance are given in Table-1. Typical results of the various test runs of the demonstration unit are given in Table-2. The residual arsenic in the treated effluent was lowered to below the WHO and EPA limit (0.01 mg/L) in the pH range 6.5-8.5 within 50 min of treatment time. The results suggested that within 5 h of shaking, As^{3+} were removed 95-98 %. The selected geometric mean size of the adsorbate particle was 0.164 mm and the shaking speed was 190 rpm. To obtain the optimal adsorbent dose, the experiments were carried out using various adsorbent doses 0-30 g/L. It was observed that at dose of 25 g/L 98 % of total arsenic from the sample could be removed with an agitation time of 50 min. Hence the dose 25 g/L and the equilibrium time 50 min were chosen for the entire study. It was observed that arsenic removal increases with the increase of adsorbent dose shown in (Fig. 2) and maximum removal at pH 7.5 shown in (Fig. 1). It was observed that 25 g/L of adsorbent dose was efficient to remove 95 % of total arsenic from the effluent with an agitation time 50 min and at an agitation speed of 190 rpm.

TABLE-1

Total volume	10 L
pH range	6.5-8.5 (Adjusted by addition of $NaHCO_3$)
Medium	Acidic
Initial arsenic(III) concentration	2 mg/L
Adsorbent	Al_2O_3

TABLE-2
TYPICAL RESULTS OF THE EFFLUENT TREATMENT TEST RUNS

Test	Contact time (min)	pH	As (mg/L)
1	30	7.0	< 0.01
2	40	7.0	< 0.01
3	60	7.0	< 0.01
4	30	6.5	< 0.01
5	30	7.5	< 0.01
6	30	8.0	< 0.01

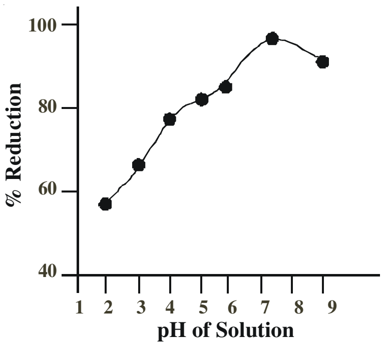

Fig. 1. Removal of % As at different pH value of initial concenteration 2 mg/L, sorbent dose 25 g/L, contact time 5 h, temperature 25 °C and 190 rpm

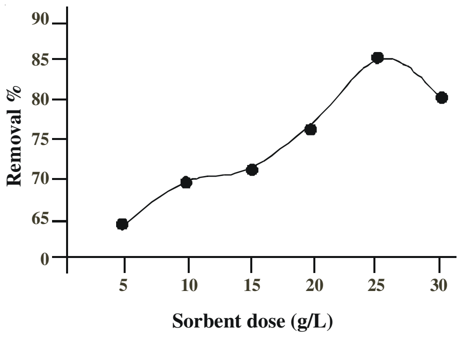

Fig. 2. Removal of % As at different sorbent doses and at initial conceteration 2 mg/L, pH 7.5, contact time 5 h, temperature 25 °C and 190 rpm

ACKNOWLEDGEMENTS

The author is thankful to Head of Department of Chemistry, B.R.A. Bihar University, Muzaffarpur for providing laboratory facilities and also to Prof. H.C. Rai and Dr. Mumtazuddin for their support and encouragement.

REFERENCES

1. The World Bank, Arsenic Contamination of Groundwater in South in East Asia, Towards a More Operational Response Report no. 31303 Environment and Social Unit South Asia Region Water Sanitation Programme South and East Asia (2005).
2. N.E. Korte and Q.A. Fernando, *Crit. Riv. Env. Conrib.*, **21**, 1 (1991).
3. T.S. Singh and K.K. Pant, *Sep. Purif. Technol.*, **48**, 288 (2006).
4. K.S. Squibb and B.A. Powler, in ed.: B.A. Powler, The Toxicity of Arsenic and its Compounds in Bilogical and Environmental Effects of Arsenic, Elsevier Science Publisher, Amsterdam, Ch.7, pp. 233-369 (1983).
5. WHO, Guideline for Drinking Water Quality World Health Organization, Geneva (1993).
6. S. Kundu, S.S. Kavalakatt, A. Pal, S.K. Ghosh, M. Mandal and T. Pal, *Water Res*. **38**, 3780 (2004).
7. Y. Sato, M. Kang, T. Kamei and Y. Magara, *Water Res.*, **36**, 3371 (2002).
8. E. Korngold, N. Belayev and L. Aronov, *Desalination*, **141**, 81 (2001).
9. M.A. Jalil and F. Ahmed, Development of an Activated Alumina Based Household Arsenic Removal Unit, In M.F. Ahmad, M.A. Al and A. Dul, Technology for Arsenic Removal from Drinking Water, Bangladesh University of Engineering and Technolgy and the United Nation University, Tokyo, Japan, Dkhaka, Bangladesh, edn. 2 (2001).
10. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis Longman (1995).

(*Received*: 13 April 2009; *Accepted*: 25 November 2009) AJC-8071