National Workshop on Pragmatic Management of Industrial Pollution (PMIP-2004). NIT, Rourkela

Arsenic: Its Hazardous effect and application

H. M. Jena[#] and P. Rout*

#Dept. of Chemical Engineering, NIT, Rourkela-769008, India

*Regional Research Laboratory, Bhubaneswar – 751 013, India

Abstract:

Arsenic is a commonly occurring toxic metal in natural systems and the root cause of manydiseases and disorders. Vast areas of Bangladesh and West Bengal (India) are facing problem with high concentration of arsenic in their ground water that is used for drinking. The International drinking water standards set by Environmental Protection Agency (EPA) with respect to arsenic was 0.05 ppm. Recently, USEPA lowered the maximum contaminated level of arsenic in municipal drinking water from 0.05 ppm to 0.01 ppm. This review paper contains the total idea about the occurrence, toxicity behaviour and application of arsenic.

Keywords: Arsenic; Source; Toxicity; Application

Introduction:

Arsenic is a commonly occurring toxic metal in natural ecosystem. It is one of the most toxic elements in the environment and is of great interest in environmental studies [1,2]. In India, arsenic is found in groundwater in West Bengal, Orissa and Andhra Pradesh. Arsenic-enriched groundwater is also found in other parts of world, e.g. Bangladesh, USA (Arizona) and Korea [3]. The occurrence of geogenic As(III) and As(V) in ground water is a major problem in West Bengal and Bangladesh. Although Arsenic is not the most toxic element specially in pentavalent state yet the same has drawn attention because of its notoriety as a poison both in history and popular literature. Important factors to be considered for a water source to be used for drinking purposes are its bacteriology quality and presence of certain inorganic constituent like fluoride and arsenic. Arsenic enters the aquatic system in the dissolved form through industrial discharge such as metallurgical, glass and ceramic, pesticide manufacturing and petroleum refining industries etc. Arsenic chemistry in aquatic system is quite complicated as the element can be stable in four oxidation states (+5), (+3), (0) and (-3) under different redox condition but in groundwater only two valence states As(+3) and (+5) are common. The toxicity of arsenic varies greatly with its oxidation states as As(+3) is much more toxic and mobile than As(+5). A variety of methods have been used in the past for arsenic removal from drinking water and waste water. Existing methods of arsenic removal include precipitation [4 - 6], adsorption [7-10], ion exchange [11], ultrafiltration [12].

Source and Occurrence:

The main anthropogenic sources are industrial waste, fossil fuel power plants, phosphate, fertilizers, coal, oil, cement, mine tailing, smelting, ore processing, metal extraction, metal purification, chemicals, glass, leather, textiles, alkali, petroleum refineries, acid mines, alloys, pigments, insecticides, herbicides and catalysts.

The occurrence of arsenic is mainly due to two reasons: natural and anthropogenic. Arsenic is widely distributed in nature and principally occurs in the form of inorganic and organic compounds. Inorganic compounds consist of arsenite, the most toxic form and arsenate, the less toxic form [13]. The main ores of arsenic are arsenopyrite, arpiment, realgar and arsenopalledenite. It is present in nature as iron arsenate, iron sulphate and in calcareous soil as calcareous arsenolite, In flood deposits, it is found as arsenite.

The main stages of arsenic are $As^{=5}$, $As^{=3}$, and As^{-3}. It can form hydrides (AsH_3), acids (H_3AsO_3, H_2AsO_3, $HasO_3$, H_3AsO_4, H_2AsO_4,, $HAsO_4$) and also halides (gas AsF_4, solid $AsBr_3$, AsI_3) [14]. It can also form arseno betaing arseno, chlorine and namomethyl arsenate. Arsenic can also form bands with organic sulphur, nitrogen and carbon. Arsenic (III) and (IV) can also be formed by dissolving organic matter in natural environment. This can prevent sorption and co-precipitation with the solid phase organics and inorganic [15]. The most commonly found arsenic compounds in ground water are trivalent arsenite or pentavalent arsenate. Organic forms of arsenic compounds occur primarily in seafood obtained from several marine organisms that extract arsenic from water and methylate the same to an organic compound. The World Health Organization (WHO), the European Union, the United States, and many other countries' governments have established 0.050 mg/L arsenic as the maximum contaminant level for total arsenic in potable water. However, there is evidence of adverse health effects at lower exposure levels, and WHO promoted 0.010 mg/L arsenic as the new guideline value for arsenic in potable water [16].

Correspondance concerning this article should be addressed to P. Rout at puspa@rrlbhu.res.in.

Toxicity:

Occurrence of arsenic contaminated water is also reported from several other countries like Taiwan, Chile, Argentina, Mexico and Thailand. In West Bengal about 80 million people in 59 districts out of 64 districts are facing serious health threat due to arsenic contaminated drinking water [17]. Numerous recent investigations indicated that arsenic constitutes a serious health risk at different places and it was also confirmed by the medical studies [18]. Ingestion via food or water is the main pathway of this metalloid in the organism where its absorption takes place in the stomach and intestines, followed by its release into the blood stream. It gets deposited on or bound to tissues. Arsenic is then converted by the liver to a less toxic form, which is eventually largely excreted in the urine [19]. It was estimated that more than two lakh people in West Bengal have arsenical skin lesions. Arsenic toxicity develops insidiously after six to twenty-four months of drinking arsenic contaminated water. In the initial period the skin of the body or palm becomes dark (diffuse melanosis) followed by spotted melanosis usually on chest, back or limbs. Leucomelanosis is common in persons who stopped arsenic contaminated water, but had spotted melanosis earlier. The other symptoms are conjunctival congestion, non-pitting swelling of feet, complications like liver and spleen enlargement and fluid in abdomen. Prolonged use of arsenic contaminated water results in carcinoma affecting lungs, bladder and other sites.

Applications:

Studies on removal of arsenic ions from aqueous systems are important because the highly toxic compounds of this element are still widely used in many applications. Among others they are used for the

(i) Production of ceramics
(ii) Semiconductors
(iii) Pesticides
(iv) Fertilizers
(v) Pigments
(vi) Glass Industry
(vii) Textiles
(viii) Paper Industry
(ix) Wood preservation
(x) Ammunition and
(xi) Metal adhesive.

References:

1. P.L. Smedly and D.G. Kinniburgh, Appl. Geochem., 17, 2002, 517.
2. F.R. Siegeal, "Environmental geochemistry of potentially toxic metals", 2002, Springer, Berlin.
3. PHED, UNICEF, Joint plan of action to address arsenic contamination of drinking water. Govt. of West Bengal and UNICEF, Public Health Engineering Department, Govt. of West Bengal, (1999).
4. W. Chow, Removing Traces Elements from Power Plant Waste water, Pollut. Eng., 19(1997) 54 – 55.
5. T.R. Harper and N.W. Kingham, Removal of Arsenic from waste water by Chemical Precipitation Methods, Wat. Env. Res., 64 (1992) 200 – 203.
6. A. Ramana and A.K. Sengupta, Removing Selenium and Arsenic (+5) Oxi-anion with Tailored Chelating polymers, J.Env. Engg., 118 (1992) 755 – 775.
7. M.P. Elizalde et al, Sorption on natural solids for arsenic removal, Chem. Engg. J., 81 (2001) 187-195.
8. J. Gregor, Arsenic removal during conventional aluminium based drinking water treatment, Water. Res., 35(7) (2001) 1659-1664.
9. S.K. Gupta, and K.Y. Chen, Arsenic Removal by Adsorption, J. Water. Poll. Cont. Fed., 50 (1978) 493.

10. C.P. Huang, and P.L.K. Fu, Treatment of Arsenic (5) containing water by the Activated Carbon Process, J. Water Poll. Cont. Fed., 56 (1984) 233-242.
11. D.Clifford and C.C. Lin, Arsenic (+3) and Arsenic (+5) removal from Drinking water in San Ysidro, New Mexico, EPA/600/S2-91/011 (1991).
12. E. Bellack, Arsenic Removal from Potable water, J. Amm. Wat. Works Assoc., 63 (1971) 454-458.
13. World Health Organization, Guidelines for Drinking Water Quality, volume 1 : Recommendations, WHO, Geneva, 2nd edn, 1993.
14. H.L. James, Chemistry, Chemistry of the iron-rich sedimentary rocks, Data of geochemistry, USGS Prof. Pap. 440-W, 1996.
15. W.R. Cullen and K.J. Reimer, Arsenic speciation in the environment, Chem. Rev. , 1989, 89, 713-764.
16. M. Williams, Environ. Geol. 40(2001) 267-278.
17. British Geological Survey, 1999, Ground water studies for arsenic contamination in Bangladesh.
18. J.C. Saha, 1999, ph.D. Thesis, Removal of Arsenic from water Environment by New Adsorbent.
19. F. Carroli, LA Torre, F. Petrucci, and N. Violante, 1996, Element specification in Bioionorganic Chemistry, edited by Sergio Caroli, Chemical Analysis Series, 135, pp.445-463.