ISSN : 0974 - 7435
Volume 10 Issue 13

2014

BioTechnology
An Indian Journal

FULL PAPER
BTAIJ, 10(13), 2014 [7243-7248]

Monitor arsenic content and health risk assessment of drinking water source in Huayuankou of Yellow Rive

LI Hai-hua[1], Yan Wei-feng[2], XING Jing [2], MENG Rui-jing[2]
[1]Faculty of Environmental & Municipal Eng., North China University of Water Resources and Electric Power, Zhengzhou 450011, (CHINA);
[2] Guangzhou Institute of Standardization, Guangzhou 510050, (CHINA)

ABSTRACT

The pollution and health risks of trace As (Ш) in drinking water remains a longstanding challenge in Yellow River. Toward this objective,we explored trace arsenic (Ш) in water samples using atomic fluorescence spectrometry in Huayuankou of Yellow River. Here,we report that arsenic (Ш)content of all sampling points is less than environment of surface water standards. arsenic (Ш)content of the surface raw water of the Yellow River, the water gate of Huayuankou, Ceramic water filters, the raw water of Zhongfa, groundwater in Zhengzhou city is far less than the sanitary standard for drinking water, water quality is good. However,arsenic (Ш) content of the Yellow River deep lateral seepage water is over much of life drinking water health standards, which exceed the standard rate of 44.7%,66.7%,83% in 2011~2013, it leads that the pressure is higher in post processing. As (Ш)content of drinking water source of Yellow River except the Yellow River deep lateral seepage water is good, but the cancerous risk indexes exceed the acceptable levels recommended by U.S.EPA and it should enhanced preparedness. In view of that,drinking water of Huayuankou Yellow River is safety but with a health risk,especially,we need to pay attention to the treatment of As (Ш) pollution about Yellow River deep lateral seepage water.

KEYWORDS

Yellow river; Drinking water source; As (Ш); Health risk assessment; Monitor.

INTRODUCTION

The Yellow River is the main source of drinking water in China. Arsenic (As) is a well known water contaminant that causes toxicological and carcinogenic effects (Shipley et al., 2010;Lynda et al., 2006). Recently, arsenic contamination of groundwater has been reported in more than ten provinces and municipalities of China, which has been attributed to the development of industry (Ma, 2011; Wang & Lin, 2012). The USEPA has categorized arsenic as a class A human carcinogen and in January 2006, lowered the maximum contaminant level (MCL) from 50 to 10 μg·L^{-1}. Although many countries, including the USA, now face the dilemma of treating their drinking water to achieve regulatory standards.(Bian et al., 2012)To date,arsenic pollution in wetland soils in the Yellow River Delta has been reported.(Bai,et al., 2012). The identification and characterization of associated human health risks are important problems that need to be addressed by environmental and medical geochemistry (Wang,et al., 2011), because arsenic (As) represents one of the most potentially toxic inorganic contaminants of groundwater worldwide, risk assessment studies of As-contaminated drinking water have important consequences worldwide (Stanislav,et al.,2007;Stiihrer,et al.,1991). The pollution and health risks of As (Ш) in the Yellow River have remained elusive. Processes to remove arsenic from drinking water are therefore urgently required (Isabel,et al.,2008; Wu,et al.,2010;Kavcar[a,1],et al.,2009).

To approach this situation of the the Yellow River As (Ш) pollution,monitored 6 sampling points from Huayuankou of the Yellow River,from 2011 to 2013,a sample a month every point. Based on the evaluation the dates,explored environmental health risk assessment of arsenic of the Yellow River, and provided the basis for the risk management of drinking water sources.

MATERIALS AND METHODS

Sampling point

The samples were separately obtained from the raw water of the Yellow River (Huayuankou hydrologic section), inlet sluice of Huayuankou, ceramic water filters (the water intake closing to pumping stations), the raw water of Zhongfa (behind the sand filters), the Yellow River lateral seepage water (take from the intake of the Dongzhou water work and the groundwater (from the wells of village) and tap water.

Sample collection and pretreatment

The sampling bottles were soaked overnight in nitric acid, rinsed exhaustively with purified water and dried. Water samples were collected by the pretreated and numbered bottles. Firstly, The samples were immediately saved in low temperature (temperature control in 8ºC or so) and the nitric acid was added (100 mL water sample added 1 mL nitric acid) to make the pH less than 2. PH was measured in the solutions using a glass electrode. Then, 10 mL water sample was taken to the 25 mL colorimetric tube, followed by the addition of 5 mL hydrochloric acid and 5 mL thiourea solution, made up to volume with deionized water and shook it up. The mixture was reacted at least 30 minutes before determination. while arsenic was determined by atomic fluorescence spectrometer. All the experiments were carried out in triplicate.

Arsenic and data analysis

Arsenic (Ш) concentration was measured by atomic fluorescence spectrometer from Beijing Titan instruments Co.Ltd (AFS-8220). The detection limit of this instrument was 0.01μg/L. The arsenic calibration curve was prepared by accurately measuring 1, 5, 10, 20, 40, 60μg·L-1 and 80μg·L-1 standard arsenic solution as the Figure 1.

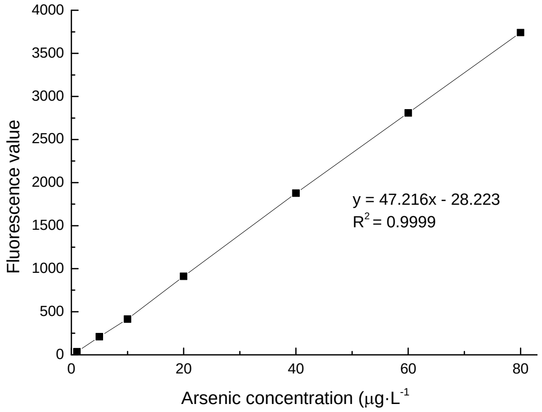

Figure 1 showed that a good linear relation was existed between the arsenic standard solution in the range 0-80μg·L^{-1} and the fluorescence intensity, linear equation was $y = 47.216\ x + 28.223$, correlation coefficient $R^2 = 0.9999$, the correlation was good.

To meet the requirements of the analysis method. In the laboratory, 12 water samples were prepared and determined by 6 parallel determinations; the analysis results were as the TABLE 1.

TABLE 1 : The table of relative standard deviation (n=6)

Samples	Average (mg·L^{-1})	Standard deviation	Relative standard deviation (RSD)%
1	0.196466	0.005006	2.55
2	0.14768	0.001943	1.32
3	0.057383	0.00117	2.04
4	0.049056	0.000592	1.21
5	0.050712	0.001394	2.75
6	0.049965	0.000906	1.81
7	0.025786	0.000548	2.12
8	0.218376	0.004081	1.87
9	0.026222	0.000298	1.14
10	0.12563	0.003293	2.62
11	0.068013	0.00139	2.04
12	0.013309	0.000361	2.71

TABLE 2 showed that the relative standard deviation of the 12 times determination was less than 3%, the relative standard deviation was small, the precision of the instrument characterization was good.

Six water samples was prepared to take the experiment of the adding mark recovery, the experimental results were as TABLE 2. TABLE 2 showed that the labeled recovery was between 96% and 106% and met the water quality analysis standard requirement (recovery results were in the range of 90% ~ 110%), the accuracy of the method was good and met the accuracy requirement of the analysis method. The experiments on precision, accuracy and the recovery of standard substance had been done, and the results were satisfying.

TABLE 2 : Text for recovery of samples

Sample	The determined value of the sample (μg·L^{-1})	Adding standard (μg·L^{-1})	Labeling measured value (μg·L^{-1})	Recovery rate %
1	0.5452	1	1.5252	98
2	3.0125	2	5.1125	105
3	2.855	2	4.8552	100
4	3.4231	2	5.5431	106
5	4.5432	3	7.4232	96
6	4.2356	3	7.3556	104

RESULTS AND DISCUSSION

From January 2011 to December 2013, Samples of each point were collected and prepared once a month to determine and analyzed the content of the concentration As (Ш). They were respectively taken from the six sampling points, the surface raw water of the Yellow River, the water from inlet sluice of Huayuankou, water filtration of Ceramic,the raw water of Zhongfa and groundwater in Zhengzhou city. The determination results were showed in Figure 2, Figure 3 and Figure 4.

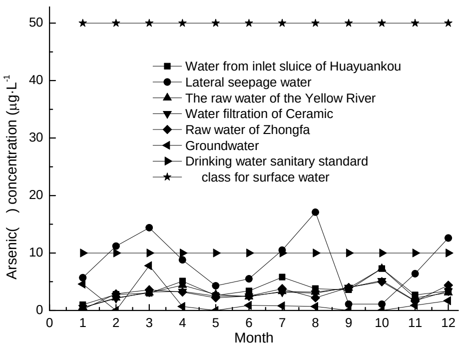

Figure 2 : The concentration trace As (Ⅲ) 2011

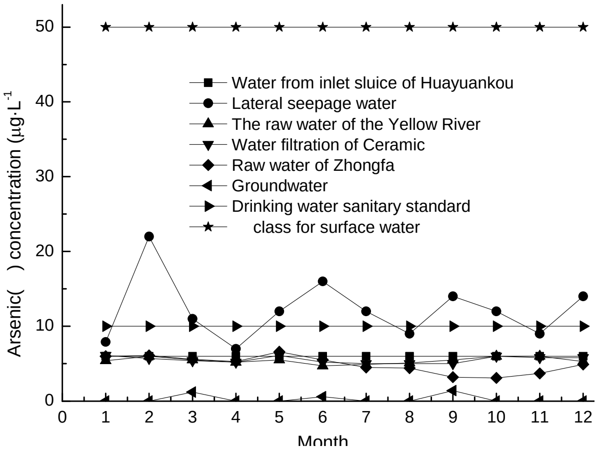

Figure 3 : The concentration trace As (Ⅲ) 2012

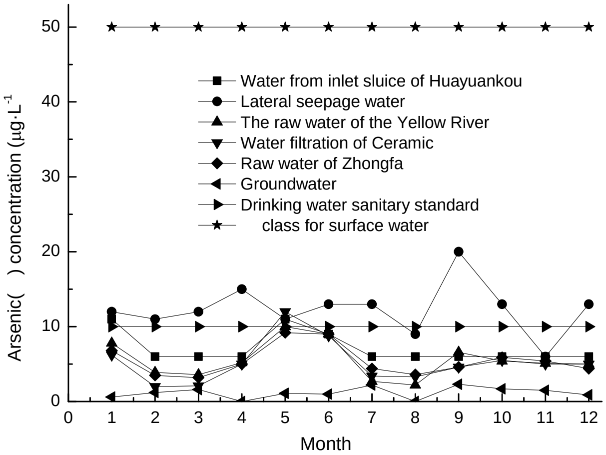

Figure 4 : The concentration trace As (Ш) 2013

Figure 2,3 and 4 showed the content of arsenic (Ш) concentration of the six sampling points,from 2011 to 2013. The results about the arsenic (Ш) concentration of the six sampling points were less than the environment Ш class standard (0.05 mg·L^{-1}) of the surface water. Among them, the arsenic (Ш) concentration of the entrance gate, the Yellow River raw water, ceramic filter water, zhongfa raw water and groundwater were less than the sanitary standard for drinking water GB5749-2006 (0.01 mg·L^{-1}). And the arsenic (Ш) concentration of lateral seepage water mostly exceeded the sanitary standard for drinking water. In 2013, only the arsenic (Ш) concentration of August and November was below the sanitary standard for drinking water, lateral seepage water exceeded 83%. In 2012, only the arsenic (Ш) concentration of January, April, August and November was below the sanitary standard for drinking water, lateral seepage raw water exceeded 66.7%. Whereas in 2011 only the arsenic (Ш) concentration of February, march, July, August and December was above the sanitary standard for drinking water, lateral seepage raw water exceeded 41.7%. Among the six water points, the arsenic (Ш) concentration change of the lateral seepage raw water fluctuated strongly, the other five sampling points were respectively stable, in 2012 the stability was the best of all. In May and June of 2012, there was a certain fluctuation. In February 2012 and September 2013, the arsenic (Ш) concentration of the lateral seepage raw water reached the peak of 0.022 mg/L and 0.02 mg/L. The of arsenic (Ш) concentration of the Yellow River deep lateral seepage water mostly exceeded the sanitary standard for drinking water, the possible reason may be the Yellow River bed sediment content is high, and the sediment had a complex adsorption - analytic function to the heavy metal. This might lead to the arsenic (Ш) concentration of the seepage water, which went though the side of the river,was much higher than the arsenic (Ш) concentration of the raw Yellow River water and added pressure in the follow-up process.

EPA HEALTH RISK ASSESSMENT

The carcinogenic risk rate

Health risk assessment is generally based on a quantification of risk level in relation to two types of adverse effects: chronic (noncarcinogenic) and carcinogenic. In general case, in low dose of chemical carcinogen exposure conditions, the common body exposure dose has a linear function of the human carcinogenic risk while exposure dose has a linear function of the human carcinogenic risk while has the exponential function in a high dose. The risk of cancer Risk is used to describe the risk value, calculated as:

$$Risk < 0.01, Risk = SF \times E,$$
$$Risk \geq 0.01, Risk = 1\text{-}\exp(-SF \times E) \quad \textbf{(1)}$$

Where, Risk is risk value,the probability of human lifetime excess cancer; SF is Chemical carcinogen slope coefficient (kg·d /mg),which can be checked from international Risk information system (IRIS)and Health effect evaluation summary table (HEAST); E is rate of exposure dose (mg /kg·d).

Long term daily doses

The level of health risk was calculated using software developed in accordance with the U.S.EPA approach (1989) – RISC WORKBENCH. It is based on the assumption of the long-term ingestion of groundwaters contaminated with As and used for drinking purposes by the adult population.

Long term daily doses which intake from drinking can be calculated as (U·S·EPA):

$$E = \frac{C \times IR \times EF \times ED}{BW \times AT} \quad \textbf{(2)}$$

Where,C is concentration of drinking water (mg /L) ; IR is drinking rate (L /d); EF is Frequency of exposure (d/a),which means the average days of drinking water an year;ED is exposure duration (a),which means the years of drinking water lifetime; BW is the average body weight (kg,can use 60kg in China);AT is average time (d).

RESULT OF EPA HEALTH RISK ASSESSMENT

TABLE 3 shows the result of As (Ш) EPA Health risk assessment of Tap water and groundwater in 2012.

TABLE 3 : Result of As (Ш) EPA Health risk assessment

month	*SF*	*IR* (L/d)	*ED* (a)	Groundwater risk	tap water risk
1	1.5	2	30	1.29E-05	1.71E-04
2	1.5	2	30	2.57E-05	1.50E-04
3	1.5	2	30	3.43E-05	1.07E-04
4	1.5	2	30	0.00E+00	1.29E-04
5	1.5	2	30	2.36E-05	1.71E-04
6	1.5	2	30	2.14E-05	1.50E-04
7	1.5	2	30	4.71E-05	2.08E-04
8	1.5	2	30	0.00E+00	1.61E-04
9	1.5	2	30	4.93E-05	1.07E-04
10	1.5	2	30	3.64E-05	1.29E-04
11	1.5	2	30	3.21E-05	1.71E-04
12	1.5	2	30	1.93E-05	1.93E-04

TABLE 3 showed that arsenic as the carcinogenic pollutant of water sources,according to the classified information of EPA integrated risk information system IRIS,arsenic belongs to class A carcinogenic pollutants (EPA suggest a risk control to 1×10^{-6}),the health risk of groundwater arsenic exceed the standard,exceed the standard up to 12~47 times,and tap water 107~207 times,but compared with the limit of arsenic 0.01 mg/L in state promulgated the drinking water health standards,the concentration of arsenic in the water source is slightly lower than this limit. So you can basically determine the source of water supply will not produce toxic effects on people drinking, but because the health risk indicators have exceed the standard,so the need to strengthen the monitoring of arsenic pollution, ensure its compliance.

CONCLUSION AND RECOMMENDATION

The present investigation indicated that arsenic (Ш) concentrations of Yellow River are all below drinking water standard. Just enough to meet the need for drinking. About the 6 sampling points, The results show that excepting the lateral seepage water,the other arsenic (Ш) concentrations are lower than the Ш arsenic standard of GB3838-2002 (Surface Water Environment Quality Standard). Excepting the lateral seepage water,the arsenic (Ш) content of other points are far less than the sanitary standard for drinking water, which proves that the water quality of is good. The arsenic (Ш) concentration of lateral seepage water mostly exceeded the sanitary standard for drinking water. From 2010 to 2012, the over standard rate is 41.7%, 66.7%, and 83%. More effective controls should be focused on As to reduce pollution in the lateral seepage water,and further treatment technology is needed to deeply studied how trace arsenic could be removed from water,which bringing great pressure for the subsequent processing.

Results of EPA Health risk assessment showed that risk assessment is an effective tool for risk management, and the permissible content of arsenic in source water is suitable for China at present, although the risk index has more than EPA index, but less than the "drinking water health standards", it will not produce toxic to people, but need to strengthen its monitoring.

ACKNOWLEDGMENTS

This work was financially supported by the Major Research plan of the National Natural Science Foundation of China (Grant No. 51190093), the National Natural Science Foundation of China (Grant No. 51179149).

REFERENCES

[1] Heather J. Shipley, Sujin Yean, Amy T. Kan, et al; A sorption kinetics model for arsenic adsorption to magnetite nanoparticles, Environmental Science and Pollution Research, **17**, 1053–1062 **(2010)**.

[2] L.Ma, S.X.Tu; Removal of arsenic from aqueous solution by two types of nanoTiO2 crystals, Environmental Chemistry Letters, **9**, 465–472 **(2011)**.

[3] S.L.Wang, C.Y.LIN; Arsenic content, fractionation, and ecological risk in the surface sediments of lake, International Journal of Environmental Science and Technology, **9**, 31-40 **(2012)**.

[4] Bai Junhong, Xiao Rong; Arsenicand heavy metal pollution in wetland soils from tidal freshwater and salt marshes before and after the flow-sediment regulation regime in the Yellow River Delta, China Journal of Hydrology, **450**, 244-253 **(2012)**.

[5] Stanislav Rapant, Katarı´na Krcˇmova; Health risk assessment maps for arsenic groundwater content: application of national geochemical databases, Environ Geochem Health , **29**, 131–141 **(2007)**.

[6] Isabel Villaescusa Jean-Claude Bollinger; Arsenic in drinking water: sources, occurrence and health effects (a review). Rev Environ Sci Biotechnol, **7**, 307–323 **(2008)**.

[7] M.Lynda, K.Knobeloch, M.Zierold, H.A.Anderson; Association of arsenic contaminated drinking water with prevalence of skin cancer in Wisconsin's Fox river valley, Journal of Health, Population and Nutrition, **24**, 206–213 **(2006)**.

[8] Bian Zhan-qiang, Xie Li, Tian Xiang-hong, et al; Adsorption of As (Ш) and As () in Water by Nano-MnO_2 with Three Kinds of Crystal Structures, Journal of Environment and Health, **29(7)**, 645-648 **(2012)**.

[9] Wu Jun, Wu Shun-hua, Ma Yan, et al; Determination of arsenic species in urine by high performance liquid chromatography and hydrid genesis atomic fluorescence spectroscopy, Journal of Environment and Health, **27(4)**, 371-372 **(2010)**.

[10] Environmental quality standards for surface water **(GB3838-2002)**.

[11] Zhenxing Wang, Liyuan Chai, Yunyan Wang, Zhihui Yang, Haiying Wang, XieWu; Potential health risk of arsenic and cadmium in groundwater near Xiangjiang River, China: a case study for risk assessment and management of toxic substances, Environ Monit Assess, **175,** 167–173 **(2011)**.

[12] Pınar Kavcar[a,1], AysunSofuoglu[b], SaitC.Sofuoglu[b]; A health risk assessment for exposure to trace metals via drinking water ingestion pathway.P. Kavcar et al. / Int. J. Hyg. Environ, Health 212, 216–227 **(2009)**.

[13] Gerhard Stiihrer.Arsenic:opportunity for risk assessment.Arch Toxicol, **65**, 525-531 **(1991)**.