ARSENIC POLLUTION IN TUBE WELL WATER AT HANOI SUBURB VILLAGES

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Abstract

Arsenic contaminations at tube well water from two villages in suburb Hanoi were investigated. Average As concentration was 132μg/L and in the range from 1 to 357μg/L. Elevated As levels at these places were recognised as having connected with presence of reducing environment and high dissolved content of iron and ammonium. Inhabitants living in high As contamination villages accumulated As in their hair of 0.5mg/kg and in urine of 14.56μg/L are 2.5 and 1.5 times higher than those in no contamination villages with normal level from literature of 0.2 mg/kg and 10μg/L, respectively. Data indicated that people at investigated areas at Red river delta using tube well water for cooking and irrigation could be exposed to As chronically and get adverse effect for health.

Introduction

Arsenic pollution calamity in groundwater at Bangladesh and West Bengal, India became major concerned issue worldwide because ground water is major drinking water source for many parts over the world. The similar situation was supposed to happen at other deltaic areas that included Red river and Mekong river deltas in Vietnam. Few primary reports had confirmed that ground water extracted through tube wells at some places in Red river alluvial delta included Hanoi capital contained quite high arsenic concentration. The average measured arsenic concentration was 159μg/L (WHO guideline value and Vietnamese standard is 10μg/L of As in drinking water). People at rural and suburb area of Hanoi still have to use ground water for cooking purpose, so their health can get risks what have connecting to arsenic toxicity. Yet, the mechanism of the arsenic pollution and its effects to the environment and people's health still has not known here. Hence a research on situation of arsenic pollution and primary body accumulation aspect has been carried out at two Hanoi suburb villages, Thuongcat at Northern part and Vanphuc at Southern part. The research results could be used as evident for arsenic contamination in ground water and adverse health effects as well as providing the background data for development of suitable arsenic removal technology.

Methodology

Two villages with 40 water samples from tube wells were designed in the study, 50 people were recruited for hair and urine samples. Water samples from tube well at family scale was collected in to acid washed clean plastic bottles after filtering through 0.45 m filter paper, the samples were acidified to pH<2 by HNO_3 concentrated and kept in cool place less than two weeks before determination of arsenic and other relevant chemical elements. Arsenic in water, hair and urine was analysed by hydride vapor generator-atomic absorption spectrometer AAS-6800. Other metals as Fe, Mn were determined by flame AAS. Anions in ground water were separated and measured by HPLC 10Avp instrument equipped with anion exchange column and conductivity detector. UV-VIS PC 3100 was used to analyse phosphate and ammonia.

Hair and urine samples were collected from 50 people living at surveyed villages then stored in clean plastic bags and bottles. Hair samples were washed carefully by neutral detergent then drying, a digestion procedure by closed Teflon bomb and microwave oven using a mixture of HNO_3 concentrated (65%) and H_2O_2 30% was used, amido sulfonic acid was added to eliminate NO_2^- before As(V) reducing reaction. Urine samples were digested by the same way as hair sample except a mixture of HCl concentrated and

H_2O_2 30% was used. All analytical instruments used in the research are equipped by Shimadzu cooperation, Japan.

Results and discussion

Arsenic distribution in tube well water at Thuongcat and Vanphuc villages

These villages are located at western bank of Red river but Thuongcat is northern and Vanphuc is southern part of Hanoi city. Samples at Thuongcat are mainly collected inside Red river dyke while Vanphuc samples collected outside. Arsenic and some other chemical parameters as redox potential, dissolved iron, manganese and ammonia are presented on table 1 for Vanphuc and Thuongcat. Among 20 samples collected randomly from each village, arsenic distribution is very different at these places. In Vanphuc, arsenic concentrations are in the range of less than 1 to near 400 μg/L with average value at 132 ppb, among them more than 70% samples are higher than 100μg/L (10 times higher than WHO and Vietnamese standards for As in drinking water) but in Thuongcat, there are only one sample (5%) what is contaminated by As as same as in Vanphuc (figure 1). Average arsenic concentration at Thuongcat is 9.6μg/L, so it seems to be quite safe to use that source of water for drinking but requirement for manganese is not met, average concentration of manganese at Thuongcat is 1.6mg/L (0.2-5.8 mg/L) while the Vietnamese standard for Mn in drinking water is 1mg/L. It is clear that ground water at Vanphuc generally can not be used directly as cooking or drinking water, clean water should be provided for people here by using official water treatment station as well as family scale filter systems. At Thuongcat, concerning other toxic metal as Mn should be addressed.

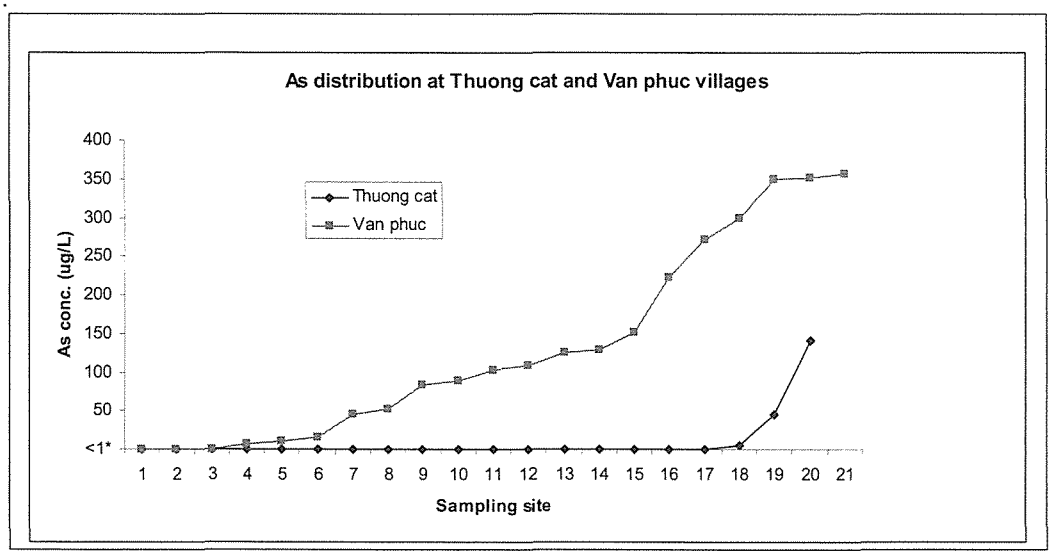


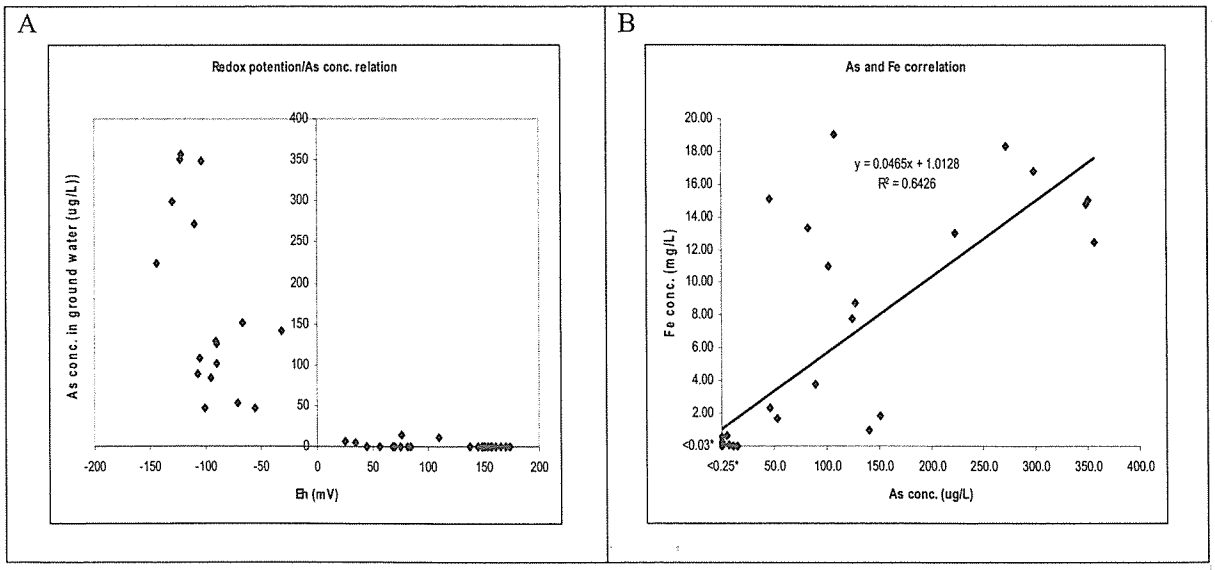
Figure 1: Arsenic distribution among samples collected from Thuongcat and Vanphuc village.

Table 1: Parameters presented for Arsenic and some others at Vanphuc and Thuongcat

Place ID	Eh (mV)		As (µg/L)		Fe (mg/L)		Mn (mg/L)		NH4 (mg/L)	
	Van phuc	Thuong cat	Van phuc	Thuong cat	Van phuc	Thuong cat	Van phuc	Thuong cat	Van phuc	Thuong cat
1	75	-55	<1	46	<0.05	2.3	0.5	0.3	0.6	2.51
2	85	35	<1	5	<0.05	0.6	0.5	2.8	0.3	6.09
3	-144	166	223	<1	13.0	<0.05	0.2	3.6	18.3	9.26
4	76	170	15	<1	<0.05	<0.05	1.2	2.6	3.6	7.22
5	110	-31	11	141	<0.05	1.0	1.7	0.4	7.3	0.42
6	-123	145	351	<1	15.1	0.1	0.2	0.6	13.1	3.50
7	-110	150	272	<1	18.3	0.1	0.6	4.3	4.1	4.32
8	-121	174	357	<1	12.4	0.1	0.7	1.9	6.9	4.13
9	-95	45	83	<1	13.4	0.2	0.4	1.1	3.5	0.88
10	-103	161	349	<1	14.8	0.1	0.3	1.1	36.5	4.77
11	-90	158	125	<1	7.8	0.2	0.6	0.7	7.4	2.30
12	26	68	7	<1	0.1	0.1	1.1	2.8	5.6	3.09
13	-107	152	89	<1	3.8	0.2	0.9	5.8	13.8	1.97
14	-66	138	151	<1	1.8	0.2	1.3	0.35	13.3	1.47
15	-101	157	46	<1	15.1	0.2	1.8	0.5	5.2	0.33
16	-91	70	128	<1	8.7	0.2	2.5	0.4	9.6	0.16
17	56	154	<1	<1	<0.05	0.2	1.3	0.2	5.1	1.61
18	-90	150	102	<1	11.0	0.2	1.0	0.2	7.2	0.12
19	-105	82	108	<1	19.0	0.2	0.2	2.5	6.1	0.24
20	-130	148	299	<1	16.8	0.6	0.5	0.5	12.0	<0.03
21	-71		53		1.7		0.6		9.0	
Min	-144	-55	<1	<1	<0.05	<0.05	0.2	0.2	0.3	<0.03
Max	110	174	357	141	19.0	2.29	2.5	5.8	36.5	9.26
Average	-53	112	132	9.6	8.2	0.3325	0.9	1.6	9.0	2.72

Relation between As and other chemical parameters of ground water

Arsenic rich minerals as pyrite or hydroxy iron oxide were known as major source for arsenic pollution in ground water at many places in the world while the second one is prominent at alluvia delta area as Bangladesh, West Bengal and Vietnam. At these areas an anoxic reduction of buried organic material by microbial organisms has been a trigger for arsenic increased level.



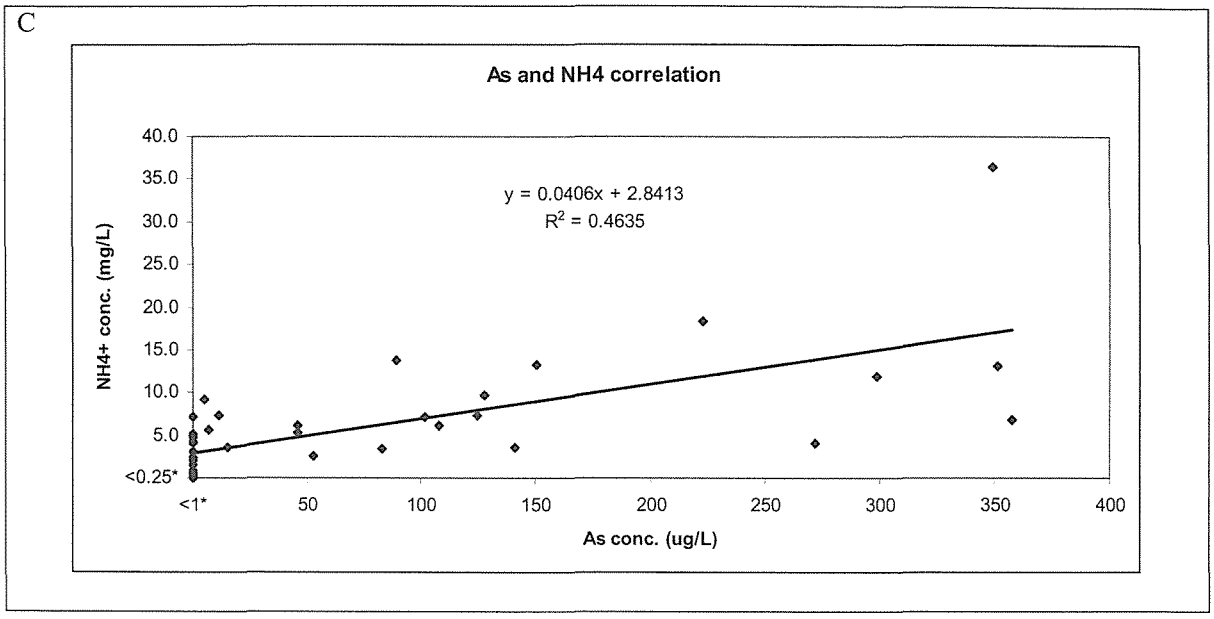


Figure 2: Relation between arsenic concentration and redox potential (A), iron (B) and ammonia (C) from samples at Thuongcat and Vanphuc

It could be reason for arsenic concentrations being different at Thuongcat and Vanphuc, or even the patchy picture at Vanphuc. It is observed that Thuongcat's samples collected almost inside the dyke, where have not been very frequently affected by flood. It is contract to Vanphuc's samples, which collected at area where flooded almost every year for a short period during rainy duration. So it can be understood that strata out side and in side the dyke are different for arsenic mobilization. At near by river bank area, flood can bring silt with organic matter and build up there by time then aquifer is depleted oxygen and induce strong reducing environment. Arsenic concentration in ground water at alluvia delta is assumed to be controlled by some other factors what have influence to reducing media there. The layers of clay and silt restricted entry of air to the aquifer, it can develop a highly reducing aquifer condition which favour the mobilisation of arsenic released from sediment into ground water. Under anoxic condition (reducing environment) electron donators can be reduced by microbial in presence of organic matter. This hypothesis seems to be matched quite well at the study areas. So it means that at arsenic high concentration sites, subsurface water has negligible dissolved oxygen, low redox potential and can contain higher iron, ammonia and less SO_4^{2-}. Relation between As and Fe, Eh and NH_4 from the samples are shown on figure 2.

So at least at these areas, arsenic mobilisation can be understood as results of sequence of reduction reactions occurring when sediments and aquifer become anaerobic. At high arsenic contaminated sites redox potentials are low (about -100mV) as presented on figure 2 (A).The processes causing changes in Fe redox chemistry are particularly important since they can directly affect the mobility of As. One of the principle causes of high As concentration in subsurface water is the reductive dissolution of hydrous Fe oxides and release of absorbed arsenic, As (III) is expected to be less strongly absorbed than As (V) and some desorption of As may occur as result of the onset of strongly reducing condition following sediment burial. Most of the ground water samples containing high concentrations of arsenic have high dissolved iron and ammonium concentration (B, C from figure 2).

Arsenic accumulation in hair and excretion in urine

Arsenic is toxicant with many serious affect, people intake water with high content of As for long time would be dead by cancer at skin, lung or kidney as reported in Bangladesh, Taiwan. Exposure to low concentration of As for a long time can get illness with several diseases as hypertension, diabetes etc. or more specific with skin manifestation. The clinical manifestations of chronic arsenic intoxification are dependent on host susceptibility, the dose and the time course of expose. In this study about 50 people from

Thuongcat and Vanphuc village have been asked to provide their tube well water, hair and urine samples for total arsenic determination and results are presented in table 2.

Table 2. Arsenic concentrations in water, urine and hair samples collected from Thuongcat and Vanphuc, Ha noi.

Parameters	Ground water (μg/L)		Hair (mg/kg)		Urine (μg/L)	
	Thuongcat	Vanphuc	Thuongcat	Vanphuc	Thuongcat	Vanphuc
No. Samples	20	21	21	29	20	30
Maximum	141	357	0.47	2.75	25.36	56.02
Minimum	<1	<1	0.06	0.01	0.25	1.32
Average	9.6	132	0.25	0.50	9.19	14.56

At Thuongcat, tube well water have meet the standard for As (average is smaller than 10 μg/L) while water from Vanphuc were highly contaminated (average is 132 μg/L). Definitive correlation between As concentrations in water, hair and urines samples can not be deducted because number of samples still limited as well as depending on other host related factors as exposure duration, age, sex, food consumption, etc. The data shown that people from Vanphuc have intaken more arsenic into their body than people from Thuongcat so their hair and urine samples have about two time arsenic contents compared with people from Thuongcat (figure 3).

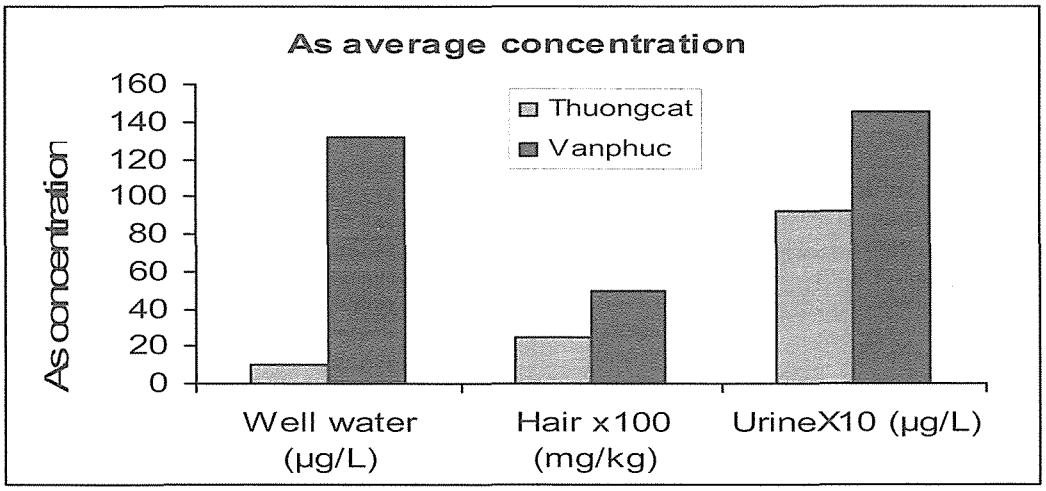


Figure 3: Arsenic concentration in water, hair and urine samples from Thuongcat and Vanphuc, Hanoi

Arsenic is normally found in higher concentrations in human hair and nail than other parts of the body and high As excretion in urine is indicative of continued As exposure. As accumulation in hair and excretion via urine from people at Vanphuc are about two times higher than people from Thuongcat. In study area people have used the water from tube well for about 2-10 years but not always for drinking and cooking. In Vietnam people at rural area often collect and store rain water during rainy season, that source of clean water were used for drink and prepare meal. But during the end of dry season when no more rain water left in tank people have to temporally use ground water directly or after simple filtering. It means that it is not easy to calculate dose and exposure time for each individual. According to reference from WHO document arsenic concentration in urine generally below 10μg/L in Europe. Drinking well water with an As content exceeding 100μg/l gave an average urinary total As concentration of 178 μg/L. In people with no exposure to As the concentration of As in hair generally is 0.02-0.2 mg/kg, it is in range of 3-10 mg/kg are reportedly common in people in areas in West Bengal that suffer from getting high As concentration in drinking water. So from received data people from Vanphuc village have accumulated As about 0.5 mg/kg in their hair and 14.56 μg/L in urine. The results indicated that their health might be effected by chronic As exposure.

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