CONTAMINATION BY ARSENIC AND LEAD IN RESIDENTS FROM VIETNAM

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ABSTRACT

In this review, we summarized the contamination status of As and Pb in residents from Vietnam obtained in our previous studies. Concentrations of As in groundwater from the Red River Delta and the Mekong River Delta were <0.1 - 486 μg/l and about 33 % of these samples had concentrations exceeding the WHO drinking water guideline value of 10 μg/l. Significant positive correlations were observed between concentrations of As in groundwater and human hair and urine of residents, indicating that people are exposed to As through drinking water and hence potential health risk of As is of great concern for these people. Concentrations of blood Pb in Vietnam were 2.42 - 27.4 μg/dl, with some donors having levels exceeding threshold concentrations of blood Pb for toxic effects. Blood Pb levels showed negative correlation with δ-aminolevulinic acid dehydratase activities, indicating suppression of heme synthesis by Pb. Air dusts showed high Pb concentrations and those Pb isotope ratios were similar to human blood. Thus, air dust may be one of the exposure sources of Pb to Vietnamese.

KEYWORDS

Air dust, arsenic, groundwater, human, lead, Vietnam

INTRODUCTION

Contamination by arsenic (As) in groundwater has caused environmental health issues in the world, especially in Bangladesh and West Bengal in India (Nordstrom, 2002; Smedley and Kinniburgh, 2002). Around the Red River Delta in Vietnam, Berg et al. (2001) found elevated As concentrations (up to 3050 μg/l) in the groundwater, far exceeding the WHO drinking water guideline (10 μg/l). Furthermore, As contamination in groundwater from Mekong River Delta, South Vietnam was reported recently (Nga et al., 2003; Trang et al., 2005; Shinkai et al., 2007). These results attract great concern on contamination status and health risk in the residents exposed to high levels of As through the consumption of groundwater.

Since economic growth and population have remarkably increased in many Asian developing countries, environmental pollution is also becoming serious problem, especially in urban areas. Lead (Pb) is widely distributed in the environment and is toxic even at low exposure levels, especially to fetuses and children (ATSDR, 1998). On the other hand, there are very few information on the contamination status by Pb in Asian developing countries. Furthermore, reports on the assessment of toxics effect by Pb exposure in humans are not available from Asian developing countries.

We have investigated contamination by As and Pb in Vietnam since 2001. This study summarizes recent results on As and Pb pollution in Vietnam obtained in our previous studies

(Agusa et al., 2004, 2005, 2006a, 2006b, 2007; Iwata et al., 2007).

MATERIALS AND METHODS

Groundwater, human hair and urine samples were collected from Gia Lam, Than Tri, Ha Tay and Ha Nam Provinces in the Red River Delta and An Giang, Ben Tre, Can Tho, Dong Thap, Ho Chi Minh, Long An, Soc Trang, Tien Giang and Vinh Long Provinces in the Mekong River Delta during 2001 to 2004. Human blood and air dust samples were collected from downtown and farming village in Hanoi in 2003 and 2004. The informed consent was obtained from all the donors and the samples were collected in an ethical manner. Collected samples were kept at –20 °C and 4 °C in the Environmental Specimen Bank for Global Monitoring (*es*-BANK), Center for Marine Environmental Studies (CMES), Ehime University, Japan (Tanabe, 2006) for elemental and δ-aminolevulinic acid dehydratase (ALAD) analyses, respectively.

Total As concentrations in groundwater and human hair were measured with a hydride generation atomic absorption spectrometer (HG-AAS)(Shimadzu HVG-1 hydride system coupled to a Shimadzu-AA680 AAS)(Agusa et al., 2004). Five arsenicals, dimethylarsinic acid (DMA[V]), monomethylarsonic acid (MMA[V]), arsenite (As[III]), arsenate (As[V]) and arsenobetaine (AB) were determined in urine samples with a high performance liquid chromatograph (Shimadzu, LC10A Series) – inductively coupled mass spectrometer (Hewlett-Packard, HP-4500). Total As concentration in urine was represented as the sum of As compounds detected by this procedure. Analyses of lead concentrations and isotope ratios in human blood and air dust were performed by ICP-MS. Activities of ALAD in blood were determined at the Occupational Poisoning Center, Tokyo Rosai Hospital, Japan (Ushio et al., 1975).

RESULTS AND DISCUSSION

Arsenic contamination

Arsenic concentrations in groundwater were in the range of < 0.1 – 486 μg/l (Table 1). The levels in groundwater collected from the Red River Delta were relatively higher than those from the Mekong River Delta. Concentrations of As in our studies (Agusa et al., 2005, 2006; Inoue et al., in preparation) were comparable to or lower than those of other studies in Vietnam (Berg et al., 2001; Nga et al., 2003; Shinkai et al., 2007; Trang et al., 2005)(Table 1). Arsenic levels in about 33 % of groundwater samples exceeded over WHO drinking water guideline (10 μg/l) of As for human health risk (WHO, 2004). A significant positive correlation between As concentrations in groundwater and hair of residents in Gia Lam and Thanh Tri was observed ($p < 0.001$). Since ingested inorganic As is methylated and excreted through the urine in humans (Styblo et al., 2002), analysis of As compounds is needed to assess exposure status and metabolic capacity of As in human. Although AB, which may be derived from consumption of seafood, was detected in the urine of some donors, DMA[V] was the most predominant compound in almost all the residents from Ha Nam and Ha Tay. Furthermore,

Table 1. Concentrations (μg/l) of As in groudnwater from the Red River and the ekong River Deltas in Vietnam.

Location	*n*	Mean and range	Median	References
Red River Delta				
Gia Lam	11	10.8 (<0.1 - 38.2)	5.0	Agusa et al., 2006
Ha Nam	10	209 (3.0 - 486)	256	Agusa et al., 2005
Ha Tay	13	209 (132 - 344)	194	Agusa et al., 2005
Thanh Tri	14	44.0 (<0.1 - 330)	1.5	Agusa et al., 2006
Dong Anh	48	31 (<1 - 220)		Berg et al., 2001
Gia Lam	55	127 (2 - 3050)		Berg et al., 2001
Thanh Tri	45	432 (9 - 3010)		Berg et al., 2001
Tu Liem	48	67 (1 - 230)		Berg et al., 2001
Ha Dinh	5	92.6		Nga et al., 2003
Luong Yen	6	22.8		Nga et al., 2003
Mai Dich	3	1.1		Nga et al., 2003
Ngoc Ha	3	1.6		Nga et al., 2003
Ngoc Si Lien	3	1.4		Nga et al., 2003
Phap Van	5	67.3		Nga et al., 2003
Tuong Mai	4	44.5		Nga et al., 2003
Yen Phu	7	40.5		Nga et al., 2003
Red River Delta	83	140 (1.3 - 460)		Trang et al., 2005
Mekong River Delta				
An Giang	24	5.4 (<0.1 - 71.2)	1.3	Inoue et al., in preparation
Ben Tre	2	66.6 (47.0, 86.1)	66.6	Inoue et al., in preparation
Can Tho	42	3.7 (<0.1 - 23.0)	2.0	Inoue et al., in preparation
Dong Thap	12	96.5 (<0.1 - 411)	0.8	Inoue et al., in preparation
Ho Chi Minh	10	5.5 (<0.1 - 32.7)	0.5	Inoue et al., in preparation
Long An	6	13.5 (<0.1 - 30.4)	13.3	Inoue et al., in preparation
Soc Trang	2	6.0 (<0.1 - 12.0)	6.0	Inoue et al., in preparation
Tien Giang	10	7.7 (<0.1 - 29.5)	5.6	Inoue et al., in preparation
Vinh Long	10	1.5 (<0.1 - 4.5)	0.8	Inoue et al., in preparation
Dong Thap	8	(1.6 - 321)		Shinkai et al., 2007
Tien Giang	6	(0.9 - 8.8)		Shinkai et al., 2007
Mekong River Delta	111	39 (<1 - 850)		Trang et al., 2005

inorganic arsenicals (As[III] and As[V]) were also found in the urine samples. Similar to the results on human hair, there was a significant positive correlation ($p < 0.01$) between As concentrations in groundwater and urine. Moreover, urinary DMA[V] ($p < 0.01$), MMA[V] ($p < 0.01$), As[III] ($p < 0.01$) and As[V] ($p < 0.001$) concentrations were also positively correlated with As concentrations in groundwater. These results suggest that As contamination in groundwater may be present not only in certain areas but also widely distributed in both Red River and Mekong River Deltas and residents in these regions are exposed to As through drinking water.

Lead contamination

Lead was detected in all human blood samples and the levels were from 2.42 μg/dl to 27.4 μg/dl. Blood Pb concentrations of residents from urban site were slightly higher than those from control site although significant difference was not noticed. Lead levels in blood in this study were comparable to or higher than other Asian countries and developed countries. Concentrations in blood of some residents exceeded the levels associated with toxic effects of lead such as hypertension in adult (10 μg/dl) (Occupational Safety and Health Reporter) and development of inhibition for intelligence in fetus (20-30 μg/dl) (Silberbeld et al., 2000). Significant negative correlation between Pb concentrations and ALAD activities in blood were observed in the residents from Vietnam ($R^2 = 0.73$, $p<0.001$) (Fig. 1), suggesting suppression of heme biosynthesis in these residents. Concentrations of Pb in some air dust samples were over WHO guideline value (400 ng/m^3) for Pb of air (WHO, 2000). This result showing that lead isotopic ratios in human blood were similar to those in air dust indicates that air dust may be one of the sources for Pb exposure to these populations.

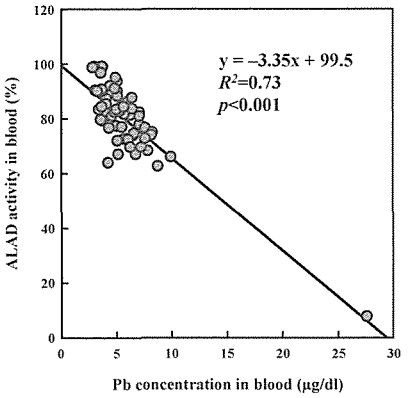

Fig. 1. Relationship between Pb concentration and δ-aminolevulinic acid dehydratase in blood of sidents from Vietnam.

CONCLUSIONS

Our results on As and Pb contamination in Vietnam lead following conclusions; 1) high contaminations by As and Pb may be present in Vietnam and 2) people may be exposed to high concentrations of As and Pb through drinking water and air dust, respectively. To understand health effects in these population, further research on toxicological assessment is required. International technical and financial assistances are also needed to improve the contamination by these elements.

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