Arsenic contamination in groundwater and residents from Ha Nam and Ha Tay Provinces of Red River Delta, Vietnam

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Abstract To make clear the distribution of As contamination in the Red River Delta, Vietnam, As concentrations were measured in groundwater and human urine from Ha Nam and Ha Tay Provinces. Concentrations of As in groundwater were from 3.0 μg/l to 486 μg/l (median; 256 μg/l) in Ha Nam Province and from 132 μg/l to 344 μg/l (median; 194 μg/l) in Ha Tay Province. Most of groundwater samples had As more than the WHO guideline value (10 μg/) for drinking. These results suggest that human health risk in both provinces is of concern and that As pollution may be widely distributed in the Red River Delta. Dimethylarsinic acid (DMA) was the most predominant compound in almost all the residents. Monomethylarsonic acid (MMA), arsenite (As[III]) and arsenate (As[V]) were also detected in the urine samples. A significant positive correlation between concentrations of As in groundwater and in urine of residents was observed. DMA, As[III] and As[V] concentrations in human urine were also positively correlated with As concentrations in groundwater. These results suggest that residents in Ha Nam and Ha Tay are exposed to As through drinking groundwater and human health risks by As exposure are of great concern.

Keywords: arsenic; groundwater; human urine; Red River Delta; Vietnam

Introduction

Numerous occurrences of As contamination in groundwater and its related health issues have been reported in the world (Nordstrom, 2002). Especially, this problem in Bangladesh and West Bengal, India is known as one of the most serious cases (Nordstrom, 2002). In Vietnam, Berg et al. (2001) reported for the first time that there is As pollution in groundwater collected from Hanoi and its maximum level (up to 3,050 μg/l) was comparable to those in Bengal Delta. A significant positive

correlation between As concentrations in groundwater and human hair in this region was observed, suggesting that people are exposed to As through groundwater consumption (Agusa et al., 2004; Agusa et al., 2006). Because population using groundwater in the Red River Delta is expected over 11 million, As contamination in this region and hence human health risk with As exposure are of great concern. However, there is little information on As contamination in the Red River Delta. This study was conducted to make clear the contamination status of As in groundwater and residents in Ha Nam Province and Ha Tay Province of the Red River Delta, Vietnam.

Materials and Methods

Sampling was conducted in Ha Nam and Ha Tay Provinces in the Red River Delta during December 2004. From these regions, 23 groundwater and 97 human urine samples were collected and all the samples were stored at –20 °C. Informed consent was obtained from all the donors and the samples were collected in an ethical manner.

The groundwater samples were acidified with sulfuric acid. Analysis of As in groundwater was performed with a hydride generation atomic absorption spectrometer (Shimadzu HVG-1 hydride system coupled to a Shimadzu-AA680 AAS) (Agusa et al., 2004). The urine samples were diluted by Milli-Q water without chemical treatment. Arsenic compounds (arsenobetaine (AB), dimethylarsinic acid (DMA), monomethylarsonic acid (MMA), arsenite (As[III]) and arsenate (As[V])) were determined in urine samples with a high performance liquid chromatograph (Shimadzu, LC10A Series) – inductively coupled mass spectrometer (Hewlett-Packard, HP-4500) using an anion exchange column (Shodex Asahipak ES-502N 7C) (Mandal et al., 2001). Total As concentration in urine was represented as sum of As compounds detected.

Results and Discussion

Arsenic was detected in all the groundwater samples and their levels were from 3.0 μg/l to 486 μg/l (median; 256 μg/l) in Ha Nam Province and from 132 μg/l to 344 μg/l (median; 194 μg/l) in Ha Tay Province. There is no significant difference between As concentrations in groundwater of Ha Nam and Ha Tay ($p > 0.05$). Interestingly, As concentrations in most of the groundwater samples (22/23) were over the WHO guideline level (10 μg/l) for drinking (Fig. 1)(WHO, 2004), suggesting possible human health risk in both provinces and that As pollution may be widely distributed in the Red River Delta.

Concentrations of As in groundwater have been reported in other As-contaminated areas in Vietnam (Berg et al., 2001; Agusa et al., 2004; Iwata et al., 2004; Agusa et al., 2006). In the Red River Delta, North Vietnam, high concentrations of As were observed in groundwater of Gia Lam District (up to 3,050 μg/l, mean; 127 μg/l) and Thanh Tri District (up to 3,010 μg/l, mean; 432 μg/l) in Hanoi (Berg et al., 2001). Our preliminary study found high concentrations of As (up to 411 μg/l) in groundwater of the Mekong Delta, South Vietnam (Iwata et al., 2004). Median levels of As in groundwater in the present study were comparable to mean values in the previous study by Berg et al.

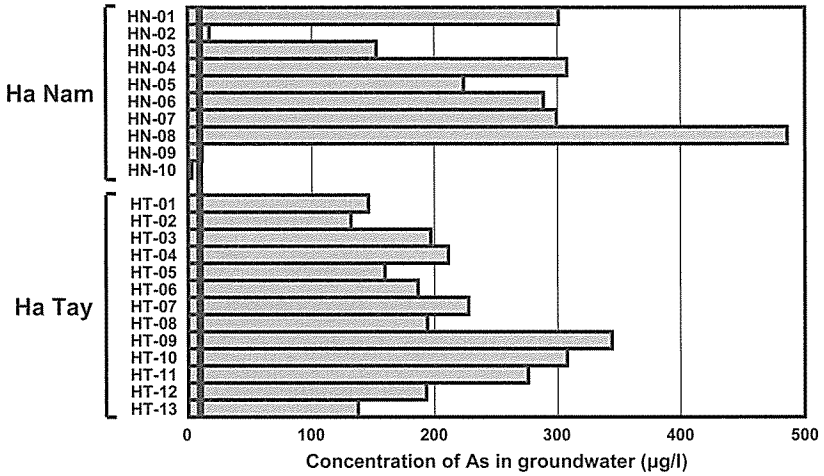

Fig. 1. Concentrations of As in groundwater in Ha Nam and Ha Tay Provinces in Red River Delta, Vietnam. Sample numbers (HN01-10 and HT01-13) indicate the well in each house. The vertical bold line denote the guideline value (10 μg/l) established by WHO (WHO, 2004).

(2001).

To assess the As exposure, concentrations of As compounds in urine of residents in Ha Nam and Ha Tay were quantified. Although high abundance of AB, which may be derived from consumption of seafood, was observed in urine of some donors, DMA was the most predominant compound in almost all the residents. MMA, As[III] and As[V] were also observed in the urine samples. A significant positive correlation between concentrations of As in groundwater and in urine of residents was observed ($p < 0.01$). DMA ($p < 0.01$), As[III] ($p < 0.01$) and As[V] ($p < 0.001$) concentrations in human urine were also positively correlated with As concentrations in groundwater (Fig. 2). On the other hand, no significant correlation was observed between concentrations of As in groundwater and AB in urine ($p > 0.05$) (Fig. 2). These results suggest that residents in Ha Nam and Ha Tay are exposed to As through drinking groundwater and hence human health risks by As exposure

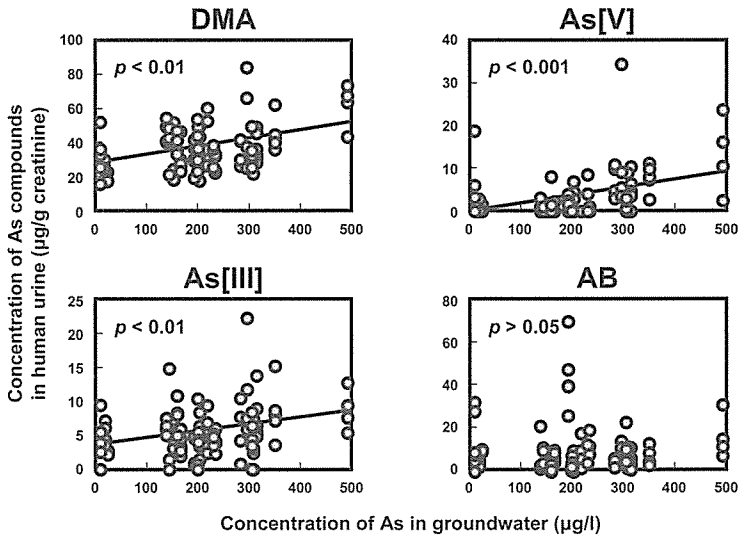

Fig. 2. Relationships between As concentrations in groundwater and concentrations of dimethylarsinic acid (DMA), arsenite (As[III]), arsenate (As[V]) and arsenobetaine (AB) in urine of residents in Ha Nam and Ha Tay Provinces in Red River Delta, Vietnam.

are great concern. Further investigation is needed to evaluate the toxic effects by As to the residents in these areas.

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