OVERVIEW OF ARSENIC CONTAMINATION IN GROUNDWATER AND HUMAN HEALTH RISK IN VIETNAM

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ABSTRACT
Although arsenic pollution in groundwater is a world wide problem, very few studies have been conducted in Southeast Asian countries. This study presents an overview of arsenic contamination in groundwater and human from Vietnam obtained from our previous studies. Samples of groundwater, hair and urine of residents were collected in Red River and Mekong River Deltas in 2000-2004. Concentrations of As in the groundwater ranged from <0.1 to 486 μg/l, with about 33 % of these exceeding WHO drinking water guideline of 10 μg/l. These levels were comparable to or lower than those of other As contaminated regions. Concentrations of As in hair and urine of residents correlated positively with those in groundwater. This indicates that people in these regions are exposed to As through drinking water and hence potential health risk of As is of great concern for these people.

KEYWORDS
Arsenic, groundwater, human, Mekong River Delta, Red River Delta, Vietnam

INTRODUCTION
Arsenic pollution in groundwater is one of the key environmental issues in the world (Nordstrom, 2002; Smedley and Kinniburgh, 2002). Especially, the pollution status in Bangladesh and West Bengal, India are most serious. (Nordstrom, 2002; Smedley and Kinniburgh, 2002). However, there are only few investigations on As contamination in groudwater from Southeast Asia. Recently, Berg et al. (2001) reported arsenic pollution in groundwater from Hanoi for the first time and the level was up to 3,050 μg/l. Their findings indicate that studies on distribution of As contamination in the Red River Delta and related human heath risk with As exposure are of great concern because more than 11 million people in this region are using groundwater. Furthermore, As contamination in groundwater from Mekong River Delta, South Vietnam is also of concern. In this article, we concisely summarize the findings of arsenic contamination in Vietnam obtained from our previous studies (Agusa et al., 2004, 2005, 2006; Minh et al., 2005; Iwata et al., 2004).

MATERIALS AND METHODS
Groundwater, human hair and urine samples were collected from Gia Lam, Than Tri, Ha Tay and Ha Nam Provinces in Red River Delta and An Giang, Can Tho, Soc Trang, Dong Thap, Ho Chi

Minh, Long An, Tien Giang, Vinh Long and Ben Tre Provinces in Mekong River Delta during 2001 to 2004. The informed consent was obtained from all the donors and the samples were collected in an ethical manner. All samples were transported to Japan and were kept at –20 degree in the Environmental Specimen Bank (*es*-Bank), Center for Marine Environmental Studies (CMES), Ehime University, Japan until chemical analyses.

The groundwater samples were acidified with sulfuric acid. Analysis of As in groundwater was performed with a hydride generation atomic absorption spectrometer (HG-AAS)(Shimadzu HVG-1 hydride system coupled to a Shimadzu-AA680 AAS)(Agusa et al., 2004). The hair samples were washed by polyoxyethylene lauryl ether and were digested with acid mixture (HNO_3, H_2SO_4 and $HClO_4$) by heating. Total As concentrations were measured by HG-AAS (Agusa et al., 2005). The urine samples were diluted by Milli-Q water without chemical treatment. Five arsenic compounds such as 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) (Agusa et al., 2006). Total As concentration in urine was represented as sum of As compounds detected in this procedure.

RESULTS AND DISCUSSION

Arsenic concentrations in the groundwater from Vietnam ranged from < 0.1 to 486 μg/l (Fig. 1). Elevated concentrations of As in groundwater were observed in some locations from Dong Thap (up to 411 μg/l) in the Mekong River Delta and Ha Nam (up to 486 μg/l) in the Red River Delta. Generally, concentrations of As in groundwater from the the Red River Delta in North Vietnam and the Mekong River Delta in South Vietnam were comparable to or lower than those of previous studies in Vietnam (Berg et al., 2001; Trang et al., 2005) and other As contaminated areas such as Bangladesh and West Bengal, India (Nordstorm, 2002; Smedley and Kinniburgh, 2002). About 33 % of groundwater samples had higher concentrations of As than WHO drinking water guideline (10 μg/l) for potential human health risk (WHO, 2004). From these

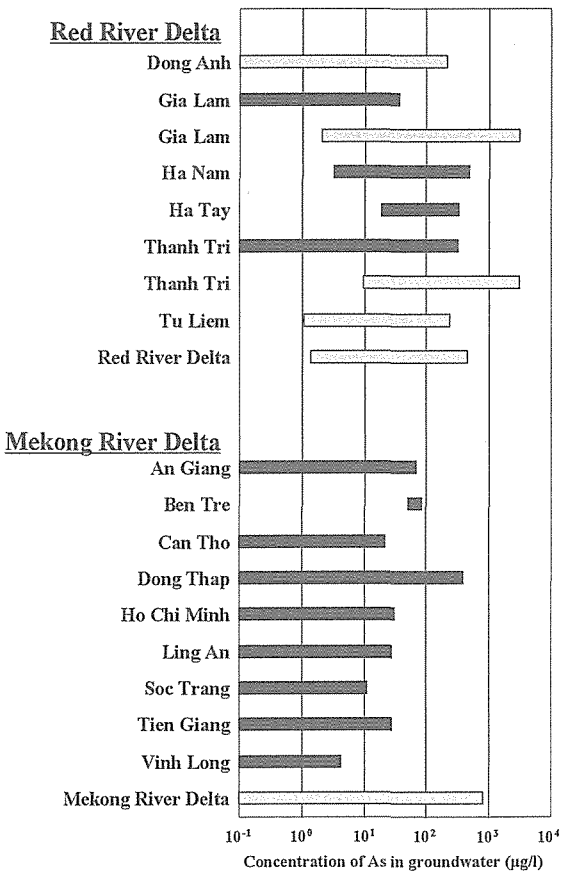

Fig. 1. Concentrations of As in groundwater from Red River and Mekong River Deltas in Vietnam. Black and grey bars indicate data from this study and references (Berg et al., 2001; Trang et al., 2004), respectively.

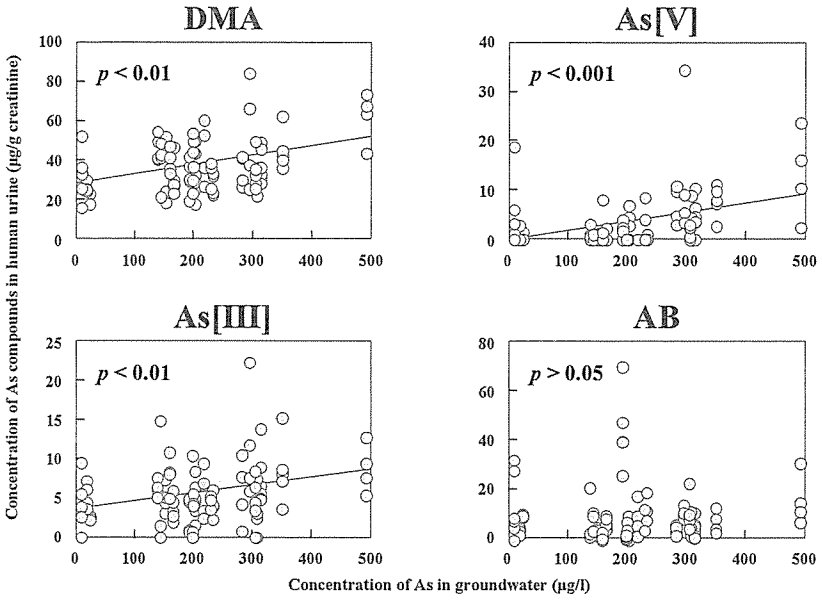

Fig. 2. Relationships between As concentrations in groundwater and concentrations of dimethylarsinic acid (DMA), arsenite (As[III]), arsenate (As[V]) and arsenobetaine (AB) in urine of residents in Ha Nam and Ha Tay Provinces in Red River Delta, Vietnam.

findings, it seems that contamination by As in groundwater may be widely present in both Red River and Mekong River Deltas, Vietnam.

A significant positive correlation between As concentrations in groundwater and hair of residents in Gia Lam and Thanh Tri was observed ($p < 0.001$). This result suggests that groundwater is probably the main source of As exposure for these people. To assess the human As exposure in detail, analysis of individual As compounds is required because toxicity or accumulation potential of As depend on chemical speciation. Hence, we analyzed individual As compounds in human urine samples from Ha Nam and Ha Tay. Although AB, which may be derived from consumption of seafood, was predominant in the urine of some donors, high concentrations of DMA was present in almost all the residents. Additionally, MMA, As[III] and As[V] were observed in the urine samples. Concentrations of total As in groundwater and in urine of residents showed a significant positive correlation ($p < 0.01$). Moreover, urinary DMA ($p < 0.01$), As[III] ($p < 0.01$) and As[V] ($p < 0.001$) concentrations were also positively correlated with As concentrations in groundwater (Fig. 2). On the other hand, there was no significant relationship between concentrations of As in groundwater and AB in urine (Fig. 2). These results suggest that residents in Ha Nam and Ha Tay are exposed to As through drinking water.

CONCLUSIONS

The present study indicates the widespread As contamination in groundwater in Red River and Mekong River Deltas, Vietnam. Also, people in these regions are exposed to high As through consumption of groundwater and might be at risk of toxic effects of As. Further work is needed for more accurate toxicological assessment to As exposure of the residents.

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