

Contamination by Trace Elements in Groundwater of Vietnam

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Abstract Although arsenic (As) pollution has been indicated in groundwater of Vietnam, there is no detailed information on pollution by other trace elements in Vietnam. In the present study, concentrations of As and other trace elements were determined in groundwater collected from Gia Lam District and Thanh Tri District, suburban areas of Hanoi, Vietnam in September 2001. Concentrations of As in the groundwater ranged from <0.10 to 330 µg/l. These levels were lower than those in other As-contaminated areas, but about 40 % of these samples exceeded the World Health Organization (WHO) drinking water guideline of 10 µg/l. Interestingly, 76 % and 12 % of groundwater samples had also higher concentrations of manganese (Mn) and barium (Ba) than WHO drinking water guidelines, respectively. To our knowledge, this study indicates for the first time that the people in Red River Delta may be exposed not only to As but also to Mn and Ba from groundwater.

Key words : trace elements, groundwater, Hanoi, Vietnam

Introduction

Arsenic (As) is a naturally occurring element and ubiquitous in the environment, but can cause cancer at low levels [1]. Arsenic pollution in groundwater has been a serious environmental problem over the world during the last decade, particularly in Asian countries such as Bangladesh, India [2-5], and Taiwan [6]. An estimated 36 million people in the Bengal Delta are at risk from As-contaminated water [7]. Moreover, Frisbie et al. [9] revealed that concentrations of manganese (Mn), lead (Pb), nickel (Ni) and chromium (Cr) as well as As were above the drinking water guidelines of World Health Organization (WHO) in some groundwater of Bangladesh, suggesting the need for research on contamination of multiple elements in groundwater and their synergetic effects.

Recently, Berg et al. [8] reported elevated As concentrations (up to 3050 µg/l) in the groundwater of suburban areas of Hanoi, the capital of Vietnam, suggesting a health risk to the people consuming As-contaminated

water in Red River delta [8]. However, very limited data is currently available on the subject. Also, there is no information on other trace element contamination in the groundwater around Red River Delta, Vietnam. In the present study, concentrations of As and other trace elements were determined in groundwater collected from Gia Lam District and Thanh Tri District, suburban areas of Hanoi, Vietnam during September 2001.

Materials and Methods

Groundwater samples were collected from households from Gia Lam and Thanh Tri districts in the suburban areas of Hanoi during September 2001. Rainwater and pond water, which are the two other sources of drinking water to residents in these districts, were also collected. All samples were kept at -20 °C until chemical analysis.

The water samples were acidified with sulfuric acid (H₂SO₄) for As [10] and with nitric acid (HNO₃) for other elements. Analysis of As was performed with a hydride generation atomic absorption spectrometer [10]. Concentrations of 20 elements (vanadium (V), Cr, Mn, cobalt (Co), copper (Cu), zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), molybdenum (Mo), silver (Ag), cadmium (Cd), indium (In), tin (Sn), antimony (Sb),

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cesium (Cs), Ba, thallium (Tl), Pb and bismuth (Bi)) and mercury (Hg) were determined by inductively coupled plasma-mass spectrometry and cold vapor atomic absorption spectrometry, respectively [11]. Iron (Fe) was measured by atomic absorption spectrometry.

Results and Discussion

Concentrations of As in the groundwater ranged from <0.01 to 330 µg/l (Fig. 1). Median concentration in groundwater from Gia Lam (5.0 µg/l) was comparable to that in Thanh Tri (1.5 µg/l) (*p* > 0.05). About 40 % of these samples contained As concentrations exceeding the WHO drinking water guideline of 10 µg/l [12] (Fig. 1). In contrast, low concentrations of As were found in pond water and not detected in rainwater (Fig. 1).

To understand the magnitude of As contamination, concentrations of As in groundwater in the present study were compared with those in other As-contaminated areas [2-6, 8]. Median values in groundwater in Gia Lam and Thanh Tri were lower than those in other As-contaminated areas. However, the maximum value (330 µg/l) was comparable to the levels in other As-contaminated areas. In a previous report, high concentrations of As were observed in groundwater of Gia Lam (2-3,050 µg/l) and Thanh Tri (9-3,010 µg/l) [8]. In the present study, however, lower concentrations of As were observed in groundwater though these samples were collected from the same area. Because As level in groundwater varied considerably between tube wells (2-3,050 µg/l) [8], the difference in As concentration between the present and previous studies might be related to the sampling points even within the same area. Various trace elements in the groundwater, pond water and rainwater were also measured in the present study. Concentrations of Fe and Mn in groundwater were higher than those of other elements, followed by alkaline earth metals such as Sr and Ba. On the other hand, concentrations of Ag, In, Sn, Sb, Cs, Hg, Tl and Bi were very low. Concentrations in pond water and rainwater were lower than those in groundwater for most of

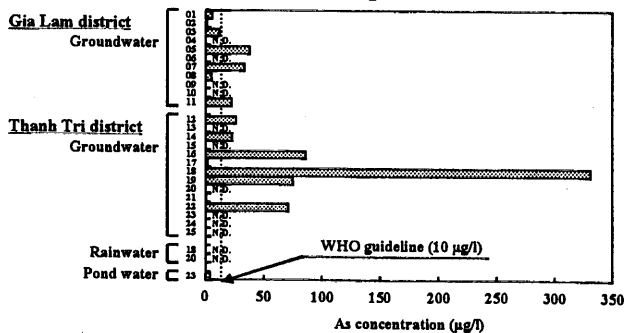


Fig. 1. Concentrations of arsenic in groundwater, rainwater and pond water in the suburban areas of Hanoi. N.D. means below detection limit (< 0.1 µg/l)

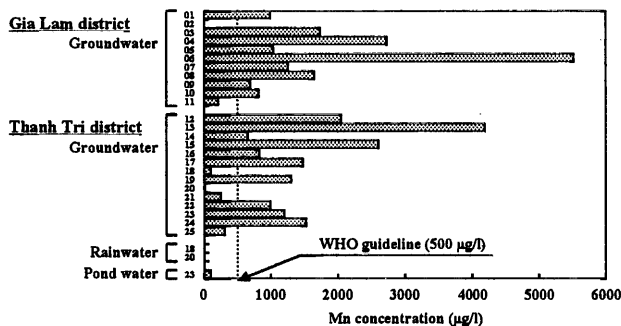


Fig. 2. Concentrations of manganese in groundwater, rainwater and pond water in the suburban areas of Hanoi.

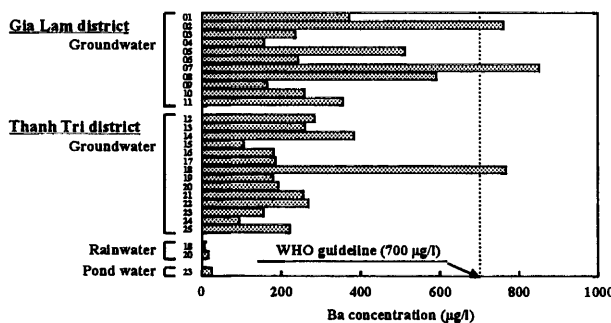


Fig. 3. Concentrations of barium in groundwater, rainwater and pond water in the suburban areas of Hanoi.

the elements.

Concentrations over the WHO drinking water guideline were also found for Mn (500 µg/l) and Ba (700 µg/l) [12] in some groundwater samples from Gia Lam and Thanh Tri (Figs. 2 and 3). Particularly, median value of Mn concentration in groundwater in both Gia Lam and Thanh Tri was higher than 1,000 µg/l and about 76 % of the samples exceed the WHO guideline of 500 µg/l (Fig. 2). Similarly, about 50 % area of Bangladesh contains groundwater with Mn concentrations greater than the WHO drinking water guideline [9]. Our study indicates that Ba concentrations in 3 samples of groundwater were also higher than WHO drinking water guideline (700 µg/l) (Fig. 3).

Depth of well and pH were not related with As concentrations in groundwater (data not shown). However, a significant positive correlation was found between As and Fe concentrations in the groundwater (*p* < 0.001). Hence, the As levels in groundwater may be the result of reductive dissolution of Fe oxyhydroxides adsorbed with As in the Red River alluvial tract, as suggested by Berg et al. [8].

In conclusion, the present study indicates that the groundwater in Red River Delta is contaminated not only by As but also by Mn and Ba. Hence, their possible adverse effects are of concern for the residents around Red River Delta (about 11 million people), and further work is needed for the more accurate risk assessment of these

elements for the residents.

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