

## **Arsenic Speciation and Chemistry in Groundwater of Vietnam**

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### **ABSTRACT**

Naturally occurring arsenic in groundwater has been identified as one of the most significant environmental problems in many regions around the world. Arsenic contamination of groundwater has been reported in Vietnam since late 1990s. Only total arsenic concentrations have been determined and used to calculate the risk assessment to humans because separation of arsenic speciation has not been conducted before. Since As(III) is approximately 50 times as toxic as As(V) and is more difficult to remove from groundwater than As(V), arsenic speciation analysis from groundwater may be useful to understand the mobility of arsenic and toxicological implications. Naturally occurring arsenic is commonly found as arsenite [As(III)] and arsenate [As(V)] species in groundwater. As(III) is present in groundwater as the uncharged form,  $\text{H}_3\text{AsO}_3$ , whereas As(V) is found in the negatively charged species,  $\text{H}_2\text{AsO}_4^-$  or  $\text{HAsO}_4^{2-}$ . Thermodynamically, As(III) predominates under reducing conditions at neutral pH. On the other hand, As(V) exists generally under oxidizing conditions. The concentrations of arsenic and other elements in groundwater (n=52) were analyzed and the properties of groundwater were measured in four villages (VT: Vinh Tru, ND: Nhan Dao, BD: Bo De, and HH: Hoa Hau) of Ha Nam province in Vietnam during April 2005. As(III) and As(V) species in groundwater were separated with disposable arsenic speciation cartridge in the field. Total arsenic concentrations and As(III):As(V) ratio obtained from groundwater samples were summarized in Table 1. The arsenic concentrations of all samples collected from groundwater in VT, BD, and HH villages and approximately 27% of groundwater sample in ND village exceeded in 10  $\mu\text{g/L}$  of Vietnamese drinking water standard. Also greater than 70% of total arsenic was found in As(III) species. ORP (oxidation-reduction potential) and pH values obtained from groundwater samples were

presented in the pE-pH diagram (Figure 1). The results showed that most samples were in the  $H_3AsO_3$  region except five samples of ND village. Elevated concentrations of As(III) and Fe(II) were observed from samples in the  $H_3AsO_3$  region. On the other hand, low concentrations of As(V) and Fe(II) were detected in the  $H_2AsO_4^-$  region. These results indicate that reducing conditions of groundwater play an important role in arsenic mobility and toxicity.

Key words: Arsenic, Speciation, Groundwater, Contamination, Vietnam

Table 1. Arsenic concentrations and speciation of groundwater in four villages, Vietnam

	Vinh Tru (VT)	Nhan Dao (ND)	Bo De (BD)	Hoa Hau (HH)
Range	74-445 $\mu\text{g/L}$	ND-101.8 $\mu\text{g/L}$	27-246 $\mu\text{g/L}$	108-323 $\mu\text{g/L}$
Mean	280 $\mu\text{g/L}$	18 $\mu\text{g/L}$	154 $\mu\text{g/L}$	205 $\mu\text{g/L}$
Median	283 $\mu\text{g/L}$	1 $\mu\text{g/L}$	143 $\mu\text{g/L}$	208 $\mu\text{g/L}$
Mean As(III):As(V) ratio	84.6:15.4	78.6:21.4	70.2:29.8	85.4:14.6

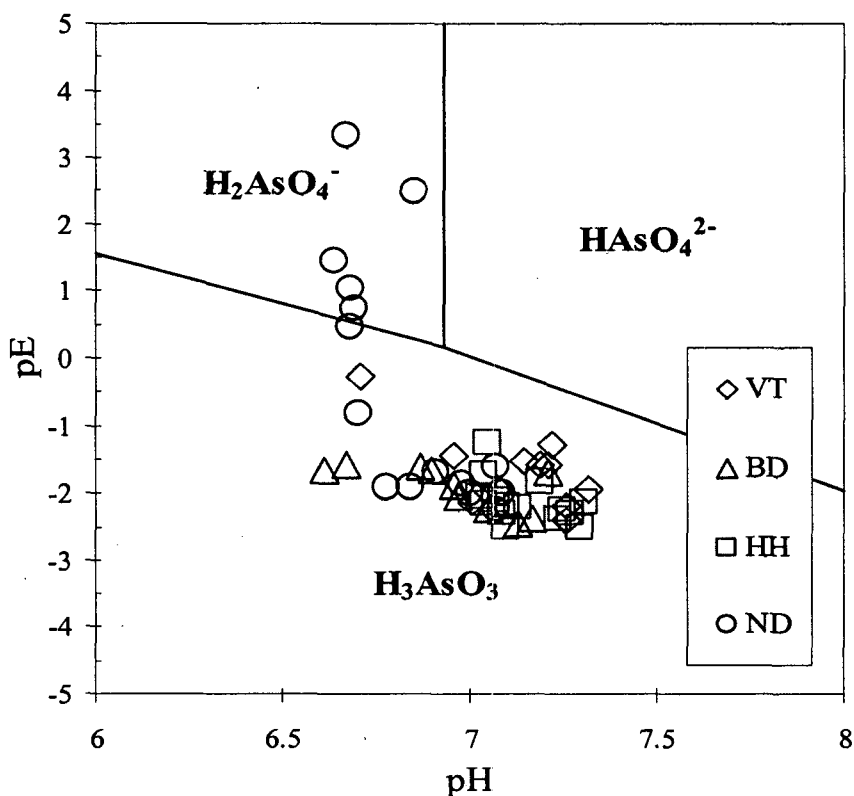


Figure 1. pE-pH diagram for arsenic showing pE-pH data collected from groundwater.