Speciation of arsenic in sediment and groundwater

W.T. Luo, X.B. Gao, Y. Li, X. Zhang & P.L. Gong

School of Environmental Studies, China University of Geosciences, Wuhan, P.R. China

ABSTRACT: Yuncheng basin is an area contaminated by arsenic (As). The species of As present in the study area need to be better characterized. In this study, species of As in sediment was investigated using sequential extraction method. Ion Chromatography – Hydride Generation – Atomic fluorescence Spectrometry (IC-HG-AFS) was used to determine the species of As in aquifer sediments and surrounding shallow groundwater. The instrumental system of ion chromatography(IC) couples with HG-AFS proved to be an effective method for analysis of the total As and the As speciation in sediments.

1 INTRODUCTION

Arsenic (As) is a toxic trace element presents in soils and groundwaters throughout the world (Javed *et al.*, 2014; Korte, 1991; Huang *et al.*, 2008). As one of the areas contaminated by As, Yuncheng basin shows a slightly higher As in surface soils than the background values of soils in China (Wei *et al.*, 1991). It belongs to the typical basin-derived high As groundwater with As contents in groundwater up to $50 \mu\text{g L}^{-1}$. The toxicity of As varies with different species (e.g. As(III), As(V), monomethylarsonic acid (MMA) and dimethylarsenic acid (DMA)). The inorganic As species are believed to be more toxic than organic species. The forms of As present in the study area need to be better characterized. This study analyzed the species of As in groundwater and bore-drilling sediments in high-As groundwater area in Qiji County, Yuncheng basin.

2 METHODS/EXPERIMENTAL

Sediment samples were collected from one borehole in the Yuncheng Basin, Shanxi Province in 2015. Thirty one groundwater samples were collected from domestic water wells with depth between 40 and 65 m. Sequential extraction was performed to speciate As in sediment samples to get the six As fractions (Water-soluble fraction, Exchangeable fraction, Bound to carbonates or specifically adsorbed fraction, Bound to Iron and Manganese Oxide fraction, Bound to Organic Matter, Residue fraction). Different species of As were determined by IC-HG-AFS (ICS2100, Thermo Scientific, USA; RGF-6300, Bohui, Beijing, China) method (Fig. 1).

Figure 1. Chromatogram of IC-HG-AFS analyses for a standard solution of four arsenic species at $10 \mu\text{g L}^{-1}$ concentration for each species. Intensity counts per second. The retention times of As(III), DMA, MMA, and As(V) is 2.54, 3.26, 3.73, and 7.07 min, respectively.

3 RESULTS AND DISCUSSION

3.1 Speciation of arsenic in sediment

The chromatogram of the species analysis (Fig. 2) showed that As(V) and As(III) were detected in all As fractures, while organic As (DMA and MMA) was not found in fractions 1, 3 and 4. Exchangeable fraction is the loosely bound state. Only a little organic As (DMA and MMA) was found in fraction 2. The weight percent of As(III) and As(V) was 74.66% and 7.75% respectively, indicating that the migration of As(III) is stronger than As(V) in loosely bound state. The contents of these two fractions in the sediments were limited, accounting for a less impact on groundwater As pollution. Inorganic As remained dominant in fractions 3 and 4. Moreover, obviously increasing content of As(V) was observed in fraction 3, while the proportion of As(III) reduced relatively.

Figure 2. The chromatogram of the arsenic species in sediment samples.

The As(V) content reached its maximum in fraction 4. The weight percentage of As(V) in fraction 4 was 75.94%. The results showed that bounding to carbonates or specifically adsorbed fraction and

bounding to iron and manganese oxide fraction are mainly related to As(V). In other words, the dominant species of As in the strongly bound state was As(V). Strongly bound As influenced the groundwater mainly through reductive dissolution and adsorption/desorption. Organic As (DMA and MMA) with a relatively low content was detected in fraction 5. Inorganic As remained dominant in this fraction.

3.2 Speciation of arsenic in groundwater

Total As contents in groundwater samples were above the World Health Organization's standard of $10 \mu\text{g L}^{-1}$, except for the QJ05 ($8.59 \mu\text{g L}^{-1}$). The content of As in groundwater ranged from $8.59 \mu\text{g L}^{-1}$ to $19.40 \mu\text{g L}^{-1}$. Arsenic species analysis revealed that organic As is very low in groundwater and inorganic As is the dominate part. As to the inorganic As, As(V) was abundant, whereas As(III) was relatively low in all samples.

4 CONCLUSIONS

The instrumental system of ion chromatography (IC) couples with HG-AFS proves to be an effective method to analyze the As speciation in sediments and groundwater.

REFERENCES

- Huang, C.L., Zheng, P. & Chen, Y.L. 2008. Change of the arsenic content in soils of the Linfen – Yuncheng basin, Shanxi, China. *Geol. Bull. China* 27(2):246–251.
- Javed, M.B., Kachanoski, G. & Siddique, T. 2014. Arsenic fractionation and mineralogical characterization of sediments in the Cold Lake area of Alberta, Canada. *Sci. Total Environ.* 500–501: 181–190.
- Korte, N. 1991. Naturally-occurring Arsenic in groundwaters of the mid western United State. *Environ. Geol. Water Sci.* 18(2): 137–141.
- Wei, F.S., Chen, J.S. & Wu, Y.Y. 1991. Research of the soil environmental background value in China. *Environ. Sci.* 12(4): 12–19.