Arsenic and antimony concentrations in Chinese typical farmland soils

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ABSTRACT: The pollution extent by heavy metals in soils is dependent on their total contents, chemical speciation, sources, and some soil physicochemical factors affected their geochemical behaviors. The difficulty in characterization of soil, and current lack of ecological risk assessment methods for heavy metals in farmland soils in China are to be addressed. This study aimed are to investigate the distribution of Arsenic (As) and Antimony (Sb) in different soils collected from 21 provinces of China, and to assess the total content of As and Sb in the soil samples. The present study evaluates the understanding of differences in soil bio-toxicity effects against different heavy metals. The total content of As and Sb in different soils was extracted by double acid digestion (HNO₃ and HCl). The concentration was measured using HG-AFS technique. It provides the basic information about the presence of these toxic metals in different types of soils around China.

1 INTRODUCTION

Arsenic is a commonly encountered contaminant in the environments because of its release during industrial, mining, and agricultural activities (Smedley & Kinniburgh, 2002). The toxicity and mobility of arsenic in soil environments is a function of its oxidation state and its sorption to soil minerals and organic matter (Charlet *et al.*, 2011). Antimony is a toxic element, and excess intake results in many diseases in humans, such as cancers, cardiovascular disease, liver disease and respiratory disease (WHO, 2003). China has the most abundant Sb resources of any country in the World (He *et al.*, 2012). Soil contamination by As and Sb is suspected to cause health problems in some regions in China. For example, residents of antimony mining area in the south Guizhou province in China are subjected to long-term Sb exposure, and liver cirrhosis is the primary cause of death (Cen *et al.*, 2007).

2 EXPERIMENTAL METHODS

2.1 Soil sampling and extraction method

Soil samples from 21 provinces of China were air-dried, sifted to remove stone and debris, then ground to pass through a 20-mesh sieve (0.99 mm in particle size). Approximately 0.1 g of this fine powder from each sample was accurately weighed into a glass tube (25 mL) containing 3 mL concentrated HNO₃ and 1 mL HCl and left overnight. Samples will be digested

for 2 h in a water bath at 90°C, after which the supernatants were obtained via centrifugation and filtration. As and Sb was measured using a hydride generation atomic fluorescence spectrometer (HG-AFS) (Wei *et al.*, 2011). Blanks, duplicated samples and soil standard reference materials (Centre for Reference Materials, China) were used to verify the accuracy of the analysis.

2.2 Analytical technique

Numerous analytical techniques and experimental approaches have been proposed in the last two decades to identify and measure As and Sb aimed at obtaining reliable results and correct evaluations in the field of environmental chemistry. Atomic fluorescence spectroscopy coupled to HG has received increasing attention because its suitability for As and Sb determination at trace levels due to its high sensitivity, wide dynamic range (4–6 orders of magnitude), simplicity and very low instrumental cost (Chen *et al.*, 2003; Miravet *et al.*, 2005; Zhang *et al.*, 2005).

The QA/QC included the calibration, blanks and using the reference materials. Initial calibration was performed before all the samples. The calibration curve yielded correlation coefficient of 0.998. QC samples were prepared and analyzed with each set of soil samples for As and Sb detection. The samples were gone through the same sample preparation method in the same manner to ensure the evaluation of extraction procedure. The recovery percentage for reference materials ranged from 88% to 97%.

3 RESULTS AND DISCUSSION

3.1 Arsenic

The concentrations of As are in the range of 1.688 and 10.28 mg kg⁻¹ (mean 5.575 mg kg⁻¹). The soil of Xinjiang soil is presenting a highest concentration of As (10.28 mg kg⁻¹) among the different farmland soils of China. The minimum amount of As is found in the sample of Jilin soil (1.688 mg kg⁻¹). The binding of As via ternary complexes and mobile colloids has been considered the most important but not the sole driver of As mobility in soils. The total content of As gives the information about the presence of As concentration as a whole. However, the environmental availability and toxicological effects of As depend on its speciation, the knowledge of the oxidation state of As in soils is essential for the risk assessment.

3.2 Antimony

Soil is the main plant-developing medium; it is also a major contaminant sink in various ways: fertilizers and amendments inputs, aerial deposition, and water percolation. Therefore, the concentration of Sb is varying in different provinces of China (0.091–0.521 mg kg⁻¹). The highest concentration of Sb was found in the soil of Anhui province (0.521 mg kg⁻¹). The soil of Chongqing city showed the minimum concentration of Sb as shown in Table 1.

Table 1. Concentration of arsenic and antimony in different soils (mg kg⁻¹).

Province	Sb	As
Hainan	0.100	8.560
Guangdong	0.274	6.770
Hunan	0.266	3.779
Yunnan	0.331	4.735
Jiangsu	0.207	3.746
Zhejiang	0.128	5.290
Anhui	0.521	2.267
Jiangxi	0.260	6.052
Sichuan	0.211	4.393
Chongqing	0.091	6.119
Shanxi	0.224	4.427
Shandong	0.140	6.431
Shanxi	0.372	9.809
Hubei	0.309	7.140
Henan	0.170	5.898
Hebei	0.173	7.420
Beijing	0.351	3.734
Ningxia	0.252	3.295
Xinjiang	0.150	10.28
Jilin	0.179	1.688
Heilongjiang	0.213	5.245

4 CONCLUSIONS

The present study gathers the current state of knowledge on As and Sb concentrations in farmland soils of China. The concentration may vary according to the difference in physico-chemical properties of soil. The study helped to develop the soil heavy metal risk assessment methods that will contribute to China's farmland soil protection and food safety. It has an important social value, which can provide technical guidance for farmland soil remediation.

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