COMPARISION OF THREE DIGESTION METHODS FOR SOIL ARSENIC DETERMINATION. APPLICATION FOR HO CHI MINH CITY SOIL ARSENIC ANALYSIS

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Abstract

For soil arsenic determination, the accuracy is crucial. To attain the accuracy, it is necessary to compare different methods, evaluate their appropriateness and apply them to analyze various local soil types. The results of this study show that: (1) for total soil arsenic determination, the method using microwave with HF has the higher recovery and accuracy rates in comparision with those of normal- and reverse-aqua regia methods.

(2) when applying the method using microwave with HF for soils of Hochiminh City, there are no statistically significant differences in As concentrations resulted from sandy soil sample analysis. But, for clay soil sample, As concentrations are method-dependent and increased following the sequence: normal aqua regia < reversed aqua regia < microwave.
In average, As concentrations in different soil groups, decreased following the sequence: saline acidic sulphate> alluvial> acidic sulphate> regosol >degraded grey> yellowish brown ferrasol. When compared with Vietnamese standards (TCVN 7209:2002) As concentrations in most soil samples are lower.

Keywords: aqua regia, atomic absorption spectrophotometry, arsenic, microwave.

1. Introduction

Arsenic and its health-relating effects are of international concern (4,5,6,8,9). In many locations around the world, high arsenic concentrations and its impact on community health were reported. In Vietnam, some investigators have been conducting studies to provide pertinent information to authority so that they can take appropriate control action (1,2,7). The accuracy of collected data is crucial factor and depends on analytical methods. In this paper, three digestion methods for soil arsenic determination were compared and applied for the analysis of soil samples of Hochiminh City. Anlysis was conducted in the labs of the Research Center for Environmental Technology and Natural Research Management, Nong Lam University, Hochiminh City, Viet Nam and the Center for Marine Environmental Studies, Ehime University, Japan within the scientific cooperation plan of JSPS program.

2. Materials and methods

Soil sampling

Soil samples, 0.5-1 kg each, were taken representing six soil groups (except peat) in suburban areas of Hochiminh City. The geographical distribution of the total 69 soil samples are as follows: Cu Chi District (13), Hoc Mon District (7), Binh Chanh District(13), Nha Be District (8), Can Gio District (13), District 12 (5), Thu Duc District (1), District 9 (6) and, District 2 (3). The sampling sites are depicted in Figure 1.

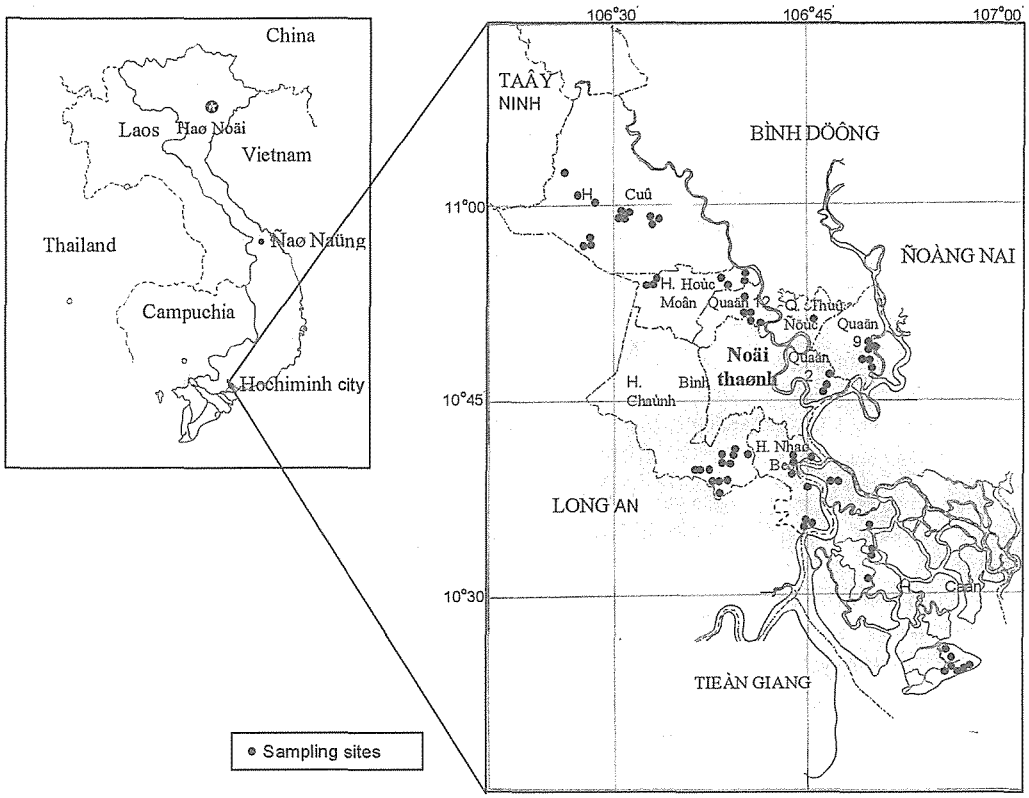

Figure 1. Sampling plan of 69 soil samples

Determination of soil parameters

Total P, total Al, total Fe, total Mn, total Carbon, pH, mechanical characteristics of collected soils were determined.

For arsenic, the method applied was HG–AAS. This is the most common method for organic As analysis. This method improves the detection limit and reduces the impact of interference substances (3,5,11). Pure chemicals and ultra-pure distilled water were used in the analysis.

Equipment

Atomic Absorption Spectrophotometer SHIMADZU AA680 connecting with SHIMADZU HVG 1 was used. Operating conditions are as follows:

- Wave length: 193,7 nm.
- Slit width: 0,7 nm.
- Flame : air and acetylene.
- Carrier gas: Argon.
- Measuring time: 15 seconds.

3. Results and discussion

The method using microwave with HF has the higher recovery and accuracy rates in comparision with those of normal- and reversed-aqua regia methods (Table 1). It is selected to analyze soil samples in Hochiminh City

Table 1. As concentrations (average ± standard deviation) in standard as analyzed by three methods

	As (mg/kg)	Recovery (%)*	Accuracy (%)
Normal aqua regia	7.40 ± 0.97	61.6 ± 8.1a	13.1
Reserved aqua regia	7.82 ± 0.94	65.2 ± 7.8a	12.0
Microwave	10.2 ± 0.65	84.2 ± 1.7b	2.1
Standard	12 ± 2		

Note: * Recovery (%), values with the same symbol have non-significant difference (P > 0.05).

Physical and chemical characteristics of 69 soil samples taken from Hochiminh City were determined and described in the Table 2

Table 2 Physical and chemical characteristics of soil samples taken from Hochiminh City, Vietnam

Soil group	Quantity Of samples	Total P (%)	Total Fe (%)	Total Al (%)	Total Mn (%)	Total Carbon (%)
Ferralitic yellowish brown	5	0.036 ± 0.022a	0.19 ± 0.14a	3.0 ± 2.9b	0.33 ± 0.19a	2.3 ± 2.5b
Grey	11	0.051 ± 0.026ab	0.32 ± 0.15ab	3.1 ± 2.1b	0.39 ± 0.16a	1.8 ± 1.2b
Alluvial	26	0.088 ± 0.040ab	1.1 ± 0. 55bc	13 ± 2.5c	3.4 ± 4.6b	2.9 ± 1.3b
Acidic sulphate	13	0.12 ± 0.10b	0.74 ± 0.80abc	14 ± 3,8c	1,1 ± 0,7ab	6,1 ± 3,1c
Salty acidic sulphate	10	0.065 ± 0.014ab	1.4 ± 0.92c	9.2 ± 3.3c	3.7 ± 3.0b	4.0 ± 2.2b
Sandy dune	4	0.067 ± 0.031ab	0.82 ± 0.59bc	1.1 ± 0.47a	3.1 ± 2.0b	0.51 ± 0.21a
Soil group	**Quantity Of samples**	**Sand (%)**	**Clay(%)**	**Loam (%)**	**pH-H2O**	**pH-KCl**
Ferralitic yellowish brown	5	52 ± 26c	22 ±18b	26 ±13b	5.3 ± 0.59a	4.2 ± 0.47b
Grey	11	56 ± 14cd	16 ± 8ab	28 ± 8b	5,4 ± 0.54ab	4.3 ± 0.48b
Alluvial	26	11 ± 3a	51 ± 7c	37 ± 7b	5.0 ± 0.73a	4.1 ± 0.67b
Acidic sulphate	13	25 ± 11b	43 ± 7c	32 ± 7b	4.2 ± 0.73a	3.5 ± 0.43c
Salty acidic sulphate	10	16 ± 7ab	48 ± 14c	36 ± 9b	5.1 ± 1.1a	4.5 ± 1.1b
Sandy dune	4	87 ± 3d	9 ± 1a	5 ± 3a	6.7 ± 0.53b	5.7 ± 1.2a

Note: * Concentration = Average conc. ± standard deviation.

** Different symbols in the same column depict the significant difference at P < 0.05

The distribution of accumulating probabilities of As concentrations in soils of Hochiminh City are depicted in Fig. 2

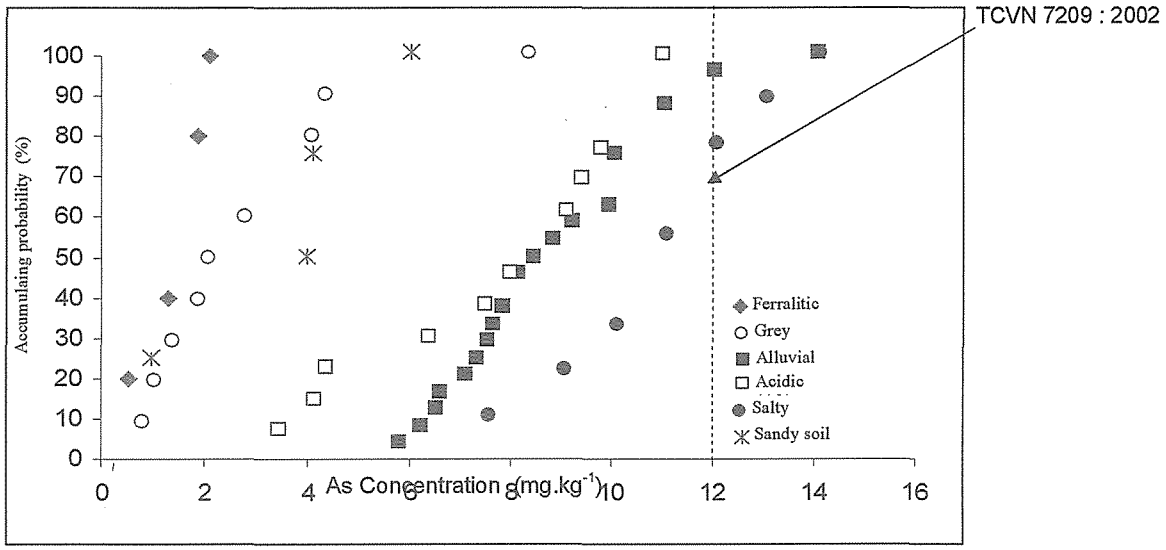

Fig. 2 Acccumulating probability curves and As concentration in soils of Hochiminh City

The As concentrations (as mg/kg dry weight) in different soil types of Hochiminh City are depicted in Table 3

Table 3 As concentrations(mg/kg dry weight) in different soil types of Hochiminh City

Soil group		Concerntration*	Range	TCVN 7209 : 2002 (Vietnamese standards)
Yellowish brown ferrasol	5	1.5 ± 0.64a**	0.54 – 2.1	12
Degraded grey soil	11	2.9 ± 2.3ab	0.59 – 8.1	
Alluvial soil	26	9.0 ± 2.1c	5.8 – 14	
Acidic sulphate soil	13	8.0 ± 2.7c	3.5 – 11	
Saline acidic sulphate soil	10	11 ± 1.9c	7.5 – 14	
Regosol	4	3.8 ± 2.1b	1.0 – 6.0	
All samples	69	7.2 ± 3.7	0.54 – 14	

Note: * Concentration = Average conc. ± standard deviation.

** Different symbols in the same column depict the significant difference at $P < 0.05$

4. Conclusions

For soil total arsenic determination, the method using microwave with HF has the higher recovery and accuracy rates in comparision with those of normal- and reversed-aqua regia methods.

Using the standard NIES SRM 2, microwave method has the higher recovery and accuracy rates (with the average of 84.2% and 2.1%, respectively), in comparision with two aqua regia methods (with the average <65% and >12, respectively).

When applying the microwave method for soil of Hochiminh City, there are no statistically significant differences in As concentrations of the sandy soil samples. But, for clay soil samples, the increment of As concerntrations are as follows: normal aqua regia < reversed aqua regia < microwave.

For different soil groups, As concentrations decrease following the sequence: saline acidic sulphate> alluvial> acidic sulphate> regosol>degraded grey>yellowish brown ferrasol.

The As concentrations detected in most soil types of Hochiminh City are lower than Vietnamese standard.

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