

Arsenic in soil, water and plant at contaminated sites and in agricultural soil of Thailand

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Abstract: Arsenic is a very toxic element. It is released and contaminated in agricultural soil by natural weathering, industrial production and mining. In 1987, arsenic contamination was first recognized in Ron phibun District, Nakhon Si Thammarat Province. However, new arsenic contamination area was also found and the related institutes realized to study in these contaminated sites.

Six hundred and thirty four soil samples in agricultural soil that grow economic crop were collected and analyzed for arsenic. The results showed that arsenic concentration ranged from ≤ 0.005 to 64 mg kg^{-1} . Arsenic background concentration of surface soil is estimated from the database as 30 mg kg^{-1} .

Arsenic concentration in soil in Ron phibun District, Nakhon Si Thammarat Province ranged between 2.53 and 151 mg kg^{-1} . Arsenic concentration in water ranged from $\leq 0.007 \text{ ug L}^{-1}$ to 0.036 mg L^{-1} and arsenic concentration in plant ranged from $\leq 0.009 \text{ mg kg}^{-1}$ to 7.70 mg kg^{-1} . Only arsenic concentration in algae sample exceeded the maximum allowable in food of 2 mg As/kg food .

In Ongpra Subdistrict, Dantchaeng District, Supanburi Province, seventeen soil samples were collected and analyzed for arsenic. The results showed that arsenic concentration ranged from 8.96 to 92.35 mg kg^{-1} . Plant samples were also collected and analyzed for arsenic. Arsenic concentration in plant samples range from $\leq 0.009 \text{ mg kg}^{-1}$ to 1.235 mg kg^{-1} . Although none of plant sample exceeded the maximum allowable in food of 2 mg As/kg food but seven plant samples were rather high when compared with database of crop inventory on heavy metals in Taiwan.

Arsenic concentration in plant has tendency to relate to arsenic concentration in soil.

Arsenic contaminated in water is major factor of human health risk. The problem can be solved or relieved by supplying clean water.

Keywords: arsenic, agricultural soil, edible plant, drinking water, soil contamination

1. Introduction

1.1 Background

Arsenic is a very toxic element. Symptoms of arsenic poisoning begin with headaches, confusion and drowsiness. As the poisoning develop, convulsions and change in fingernail pigmentation may occur. When the poisoning becomes acute, symptom may include diarrhea, vomiting, blood in the urine, cramping muscles, hair loss, stomach pain and more convulsions. The organs of the body that are usually affected by arsenic poisoning are the lungs, skin, kidneys and liver. The final results of arsenic poisoning are coma or death [1]. Arsenic can be found naturally in soils and various environmental. It is released by natural weathering, industrial production and mining. In Thailand, arsenic contamination was first recognized in Ron phibun District, Nakhon Si Thammarat Province in 1987. People live near or in old tin mine area were sick, their skin became black and were diagnosed as skin cancer. The Department of Mineral Resources have studied and found that arsenic was weathered from arsenopyrite by both natural and mining activities [2]. To solve and prevent this problem, mining activities were prohibited in February 1994 and clean water was supplied to people in this area. Arsenic contamination was also found in Ongpra Subdistrict, Dantchaeng District, Supanburi Province. People in this small area of two villages need to be take care and prevent them from arsenic sick.

Heavy metal concentration in agricultural soil of Thailand has been studied. The results of this project can be used to calculate background concentration of heavy metal in agricultural soil and can be used as reference database.

1.2 Objectives

- 1) To study arsenic in agricultural soils
- 2) To study arsenic in contaminated sites

2. Materials and Methods

2.1 Study Areas

1) Agricultural soils

Soil samples were collected from soil which grow economic crop such as rice, corn sugar cane, cassava and pineapple. The sampling sites locate in 76 Provinces of Thailand and 634 samples were collected for the study.

2) Contaminated sites

There are two studied areas in contaminated sites. The first area is in Ron phibun District, Nakhon Si Thammarat Province and the second area is in Ongpra Subdistrict, Dantchaeng District, Supanburi Province.

Ron phibun District, Nakhon Si Thammarat Province is in the south of Thailand. The studied site lies between 8° 04' and 8° 14' N latitudes and between 99° 46' and 99° 54' E longitudes. The studied area is 110 km².

The second studied site is small area in Ongpra Subdistrict, Dantchaeng District, Supanburi Province. The location of Dantchaeng District is at 14° 50' N latitude and 99° 42 E longitude.

2.2 Soil, water and plant Sampling

1) Agricultural soils

The project of arsenic database in agricultural soils started from the year 2006 to 2011. Six hundred and thirty four of surface soil samples (0-15 cm depth) were collected, air-dried and ground prior to analysis.

2) Contaminated sites

Thirty six soil samples were collected from Ron phibun District, Nakhon Si Thammarat Province and seventeen soil samples were collected from Ongpra Subdistrict, Dantchaeng District, Supanburi Province. All soil samples were also air-dried and ground prior to analysis.

Thirty three surface water samples were collected from Ron phibun District, Nakhon Si Thammarat Province and preserve with HNO₃ prior to analysis [3].

2.3 Analytical Method

Soil pH was determined using a 1 : 1 ratio of soil to deionized water. Soil texture was measured using the pipette method [4] Organic matter was determined with wet oxidation and titration using the Walkley and Black method [5].

Total soil Arsenic was analyzed by digesting 0.5 g of soil in a 2 : 1 HClO₄ : HNO₃ and measured by using a Hydride Atomic Absorption Spectrophotometer [6].

3. Results and Discussion

3.1 Arsenic in agricultural Soil

The results showed that arsenic concentration from 634 soil samples ranged from ≤ 0.005 to 64 mg kg⁻¹ and the mean value is 5.8 ± 6.5 mg kg⁻¹. All of the data were plotted and presented by geographic information system: GIS (Fig. 1)

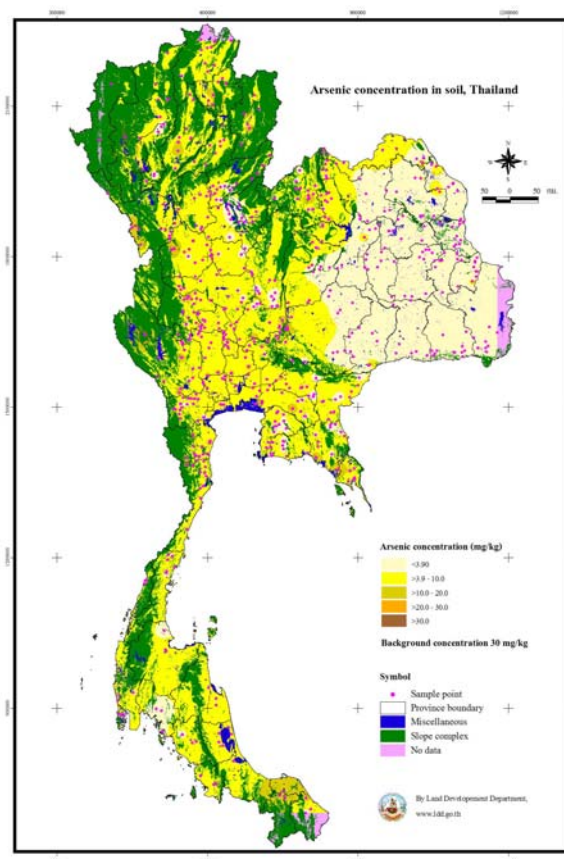


Fig. 1 Arsenic concentration in soil of Thailand

The database of arsenic concentration is propagated at website <http://osd101.ddd.go.th/heavymetal/> and is shown in Fig. 2.

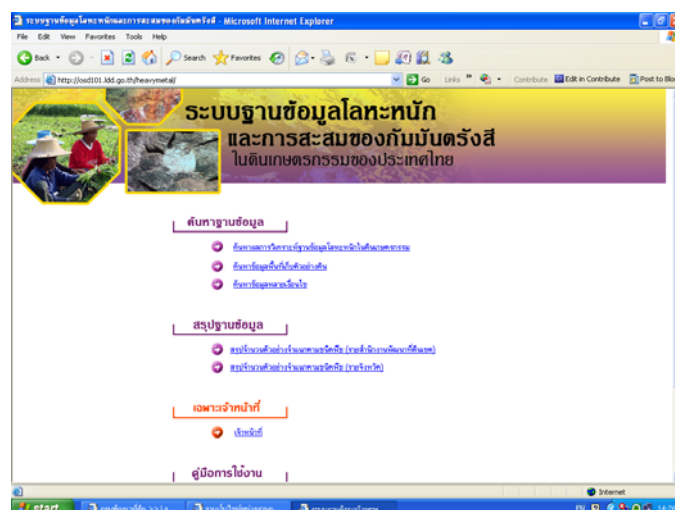


Fig. 2 Web site shows database of heavy metal in soil

The relative % and accumulative % of concentration of arsenic in the surface soil (0-15 cm depth) of database is shown in Fig. 3.

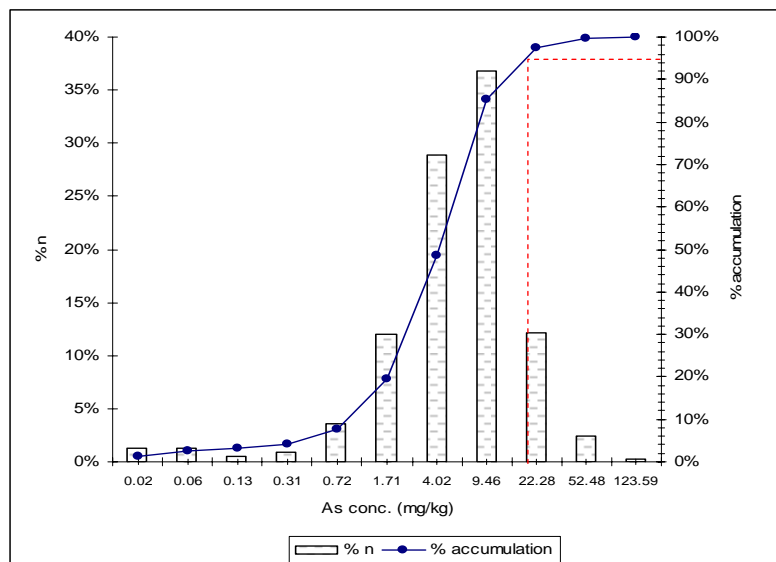


Fig. 3 Arsenic concentration in soil

The upper level of background concentration of surface soil (0-15 cm depth) is estimated as 30 mg kg^{-1} . Arsenic concentration at every sampling point was compared to the background concentration and found that soil sample from 9 sampling points or 1.05 % were exceed background concentration. The area around sampling sites and adjacent area will be monitored and assessed of environmental impact and health risk.

1.2 Arsenic concentration at contaminated sites

1) Ron phibun District site

Thirty six soil samples were collected from Ron phibun District and analyzed for arsenic. The results showed that arsenic concentration in soil ranged from 2.53 to 151 mg kg⁻¹. Soil sample from 9 sampling points or 19.44 % was exceeded arsenic background concentration of 30 mg kg⁻¹ (Fig. 4).

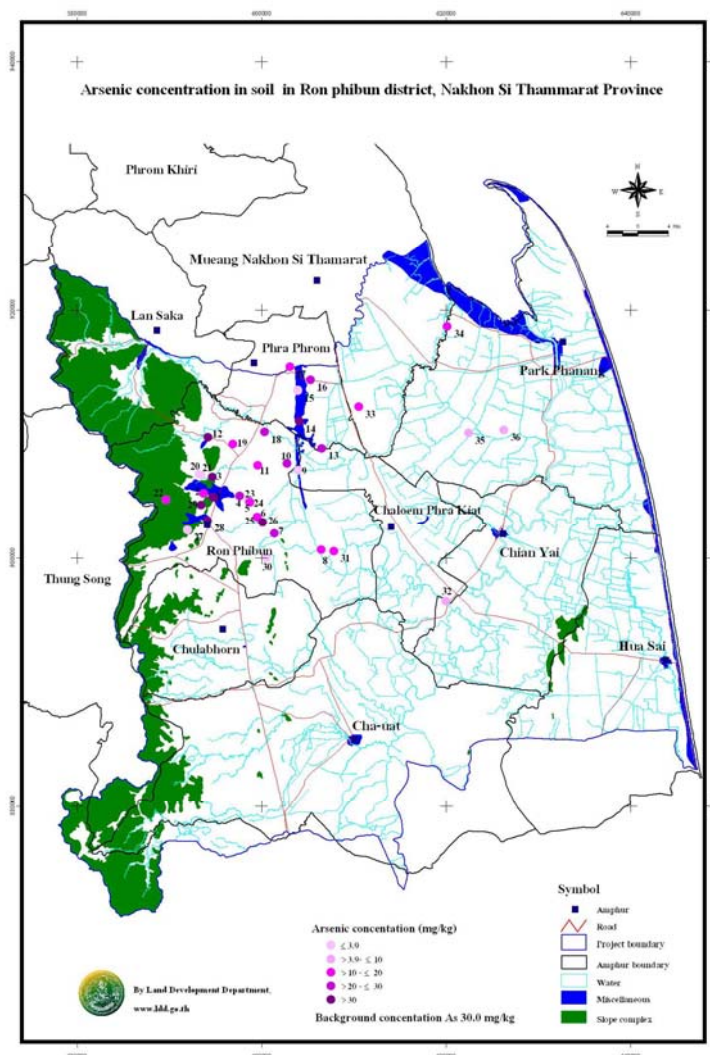


Fig. 4 Arsenic concentration in soil in Ron phibun District, Nakhon Si Thammarat Province.

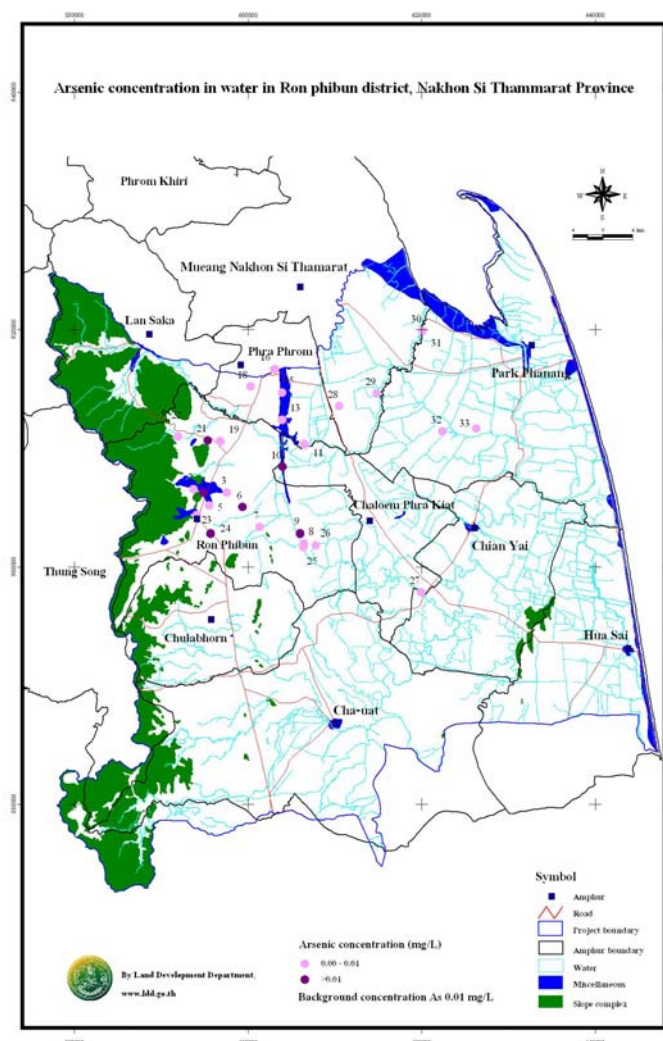


Fig. 5 Arsenic concentration in water in Ron phibun District, Nakhon Si Thammarat Province.

Thirty three water samples in Ron phibun District and adjacent area were collected and analyzed for arsenic. The results showed that arsenic concentration in water ranged between $\leq 0.007 \text{ ug L}^{-1}$ and 0.036 mg L^{-1} . Water sample from 6 sampling points or 18.18 % were exceeded drinking water standard of 0.1 mg L^{-1} . Arsenic concentration in water in Ron phibun District, Nakhon Si Thammarat Province is shown in Fig. 5.

Plant samples were also collected at soil sampling points. Arsenic concentration in range is illustrated in Fig. 6.

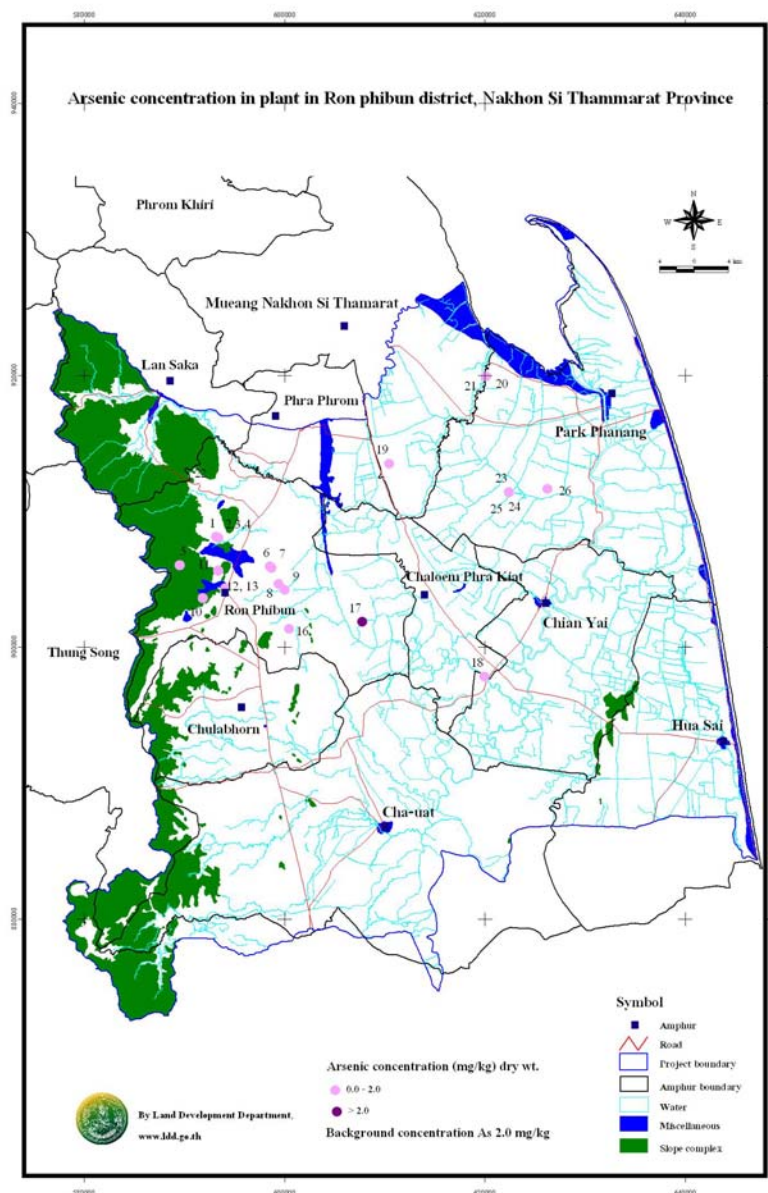


Fig. 6 Arsenic concentration in plant in Ron phibun District, Nakhon Si Thammarat Province. Plotted from data of Department of Agriculture, 2008.

Thirty six plant samples in Ron phibun District and adjacent area were collected and analyzed for arsenic. The results showed that arsenic concentration in plant ranged from $\leq 0.009 \text{ mg kg}^{-1}$ to 7.70 mg kg^{-1} . Only algae sample contains high arsenic concentration of 7.70 mg kg^{-1} and exceeded the maximum allowable in food of 2 mg As/kg food which established by Ministry of Public health (1986). Turmeric which is root crop, elephant ear and two samples of water mimosa which are grown in water also contain high arsenic. Arsenic concentrations in these crops were 0.295 , 0.119 and 0.183 mg kg^{-1} , respectively.

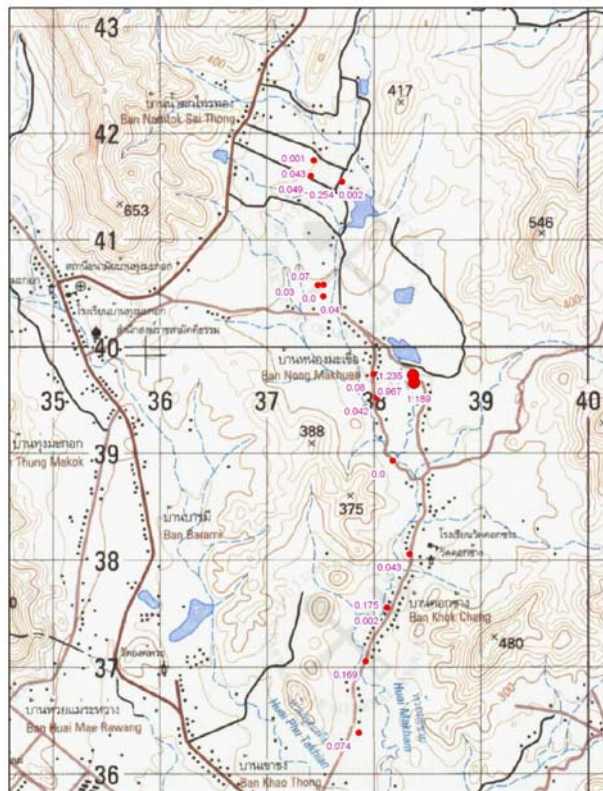


Fig. 8 Plant sampling points in Ongpra Subdistrict, Dantchaeng District, Supanburi Province
(Cited from Department of Primary Industries and Mines, 2009)

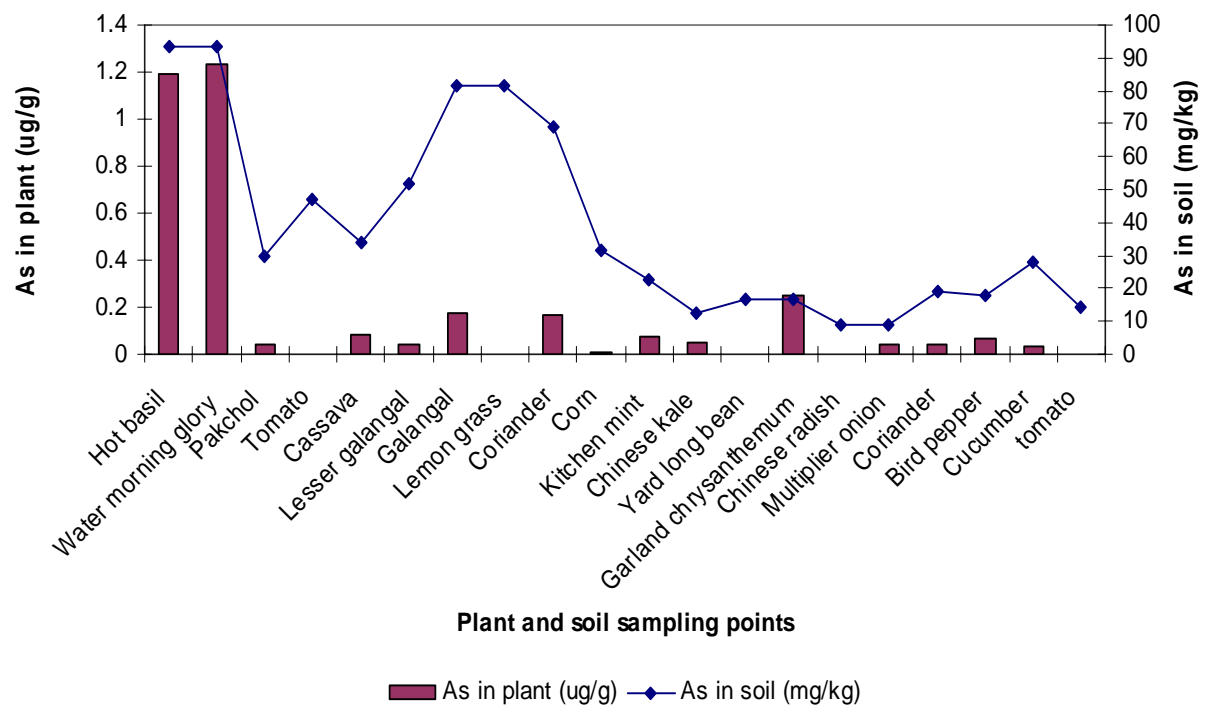


Fig. 9 Arsenic in plant and soil in Ongpra Subdistrict, Dantchaeng District, Supanburi Province (Plotted from data of Land Development Department and Department of Primary Industries and Mines, 2009)

4. Conclusions and Recommendations

Six hundred and thirty four soil samples in agricultural soil that grow economic crop were collected and analyzed for arsenic. The results showed that arsenic concentration ranged from ≤ 0.005 to 64 mg kg^{-1} . Arsenic background concentration of surface soil is estimated from the database as 30 mg kg^{-1} .

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Aknowledgements

The authors wish to thank Prof. Zueng-Sang Chen, Department of Agricultural Chemistry, National Taiwan University for his guidance and valuable advice. They also thanks the Department of Disease Control, Ministry of Public health for soil sampling in Ongpra Subdistrict, Dantchaeng District, Supanburi Province.

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