# FACTORS RELATED TO URINARY ARSENIC CONCENTRATION AMONG FARMERS IN ONGPHRA SUBDISTRICT, DANCHANG DISTRICT, SUPHANBURI PROVINCE, THAILAND

**Yaowaret Suanboon[1], Sara Arphorn[2,*]**

[1] Master Degree of Science Student, Industrial Hygiene and Safety, Faculty of Public Health, Mahidol University, Center of Excellence on Environmental Health and Toxicology, CHE, Ministry of Education, Bangkok, Thailand
[2] Department of Industrial Hygiene and Safety, Faculty of Public Health, Mahidol University, Center of Excellence on Environmental Health and Toxicology, CHE, Ministry of Education, Bangkok, Thailand

**ABSTRACT:** The objective of the study was to determine the arsenic contamination in environment and to investigate factors related to the urinary arsenic level among farmers in Aongphra Subdistrict, Danchang District, Suphanburi Province. Forty four farmers were selected for study group while 10 household residents were baseline group. The collecting data protocols were divided into 2 parts 1) the interview using questionnaires 2) the arsenic analysis using Atomic Absorption Spectroscopy Hydride Generator. The descriptive statistic used number, percentage, median, and inter quartile range (IQR) while the Mann-Whitney U test statistic was used to determine the factors related to urinary arsenic level and used to compare the difference of arsenic concentration in environment. The Spearman's rho correlation test was used to investigate the relationship of urinary arsenic level with arsenic contamination in environment and behavioral factors. The results showed that arsenic contamination in soil was higher than limit value (Median of house hold resident soil, farmer farm soil and house soil were 56.4, 42.3 and 25.3 mg/kg, respectively). The Mann-Whitney U test statistic at significant *p-value*< 0.05 showed that females had higher urinary arsenic level than males and resident soil had higher arsenic level than farm soil at significant *p-value* 0.049 and 0.002, respectively. Meanwhile, urinary arsenic contamination among famers was higher than household resident at significant *p-value* 0.019. The hygiene behavior of farmers should be improved such as using personal protective equipment properly to avoid the arsenic exposure risk during farming activity. The results of the study showed that the high level of arsenic contamination in soil was above normal limit value and arsenic contamination in resident soil was higher than farm soil then it could be implied that the farmers and resident were living in a high risk area. The factors affecting to urinary arsenic level among farmers were gender and their occupation.

**Keyword:** Urinary arsenic concentration, Farmer, Thailand

## INTRODUCTION

Arsenic has a metalloid property that has four different valence states: -3, 0, +3 and +5 and widely distributed on earth's crust. It presents approximate 2 mg/kg of soil in environment. The majority of arsenic was used in timber treatment which comprises 70% and 22% was used in agricultural chemicals, and the remainder in glass, pharmaceuticals and non-ferrous alloys [1]. Arsenic has been classified as human carcinogen from many institutes such as American Conference of Industrial Hygienists: ACGIH, United States Environmental Protection Agency: US EPA and, International Agency for Research on Cancer: IARC [2-4]. Arsenic can be acquired to human by

* *Correspondence to: Sara Arphorn*
*E-mail: phsao@mahidol.ac.th*

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dermal exposure, ingestion, and inhalation. The effect of arsenic exposure has been divided into two types: acute exposure and chronic exposure. The acute exposure can cause skin irritation, nausea, vomiting and muscle cramps that affect various human body systems such as gastrointestinal, nervous, cardiovascular system and eventually cause death [1, 5, 6]. Chronic exposure can cause skin symptoms like rash, blister and black spot. Thus, concurrent and repetitive exposure can cause greater impact and in bone marrow then eventually caused damage of erythrocytes and more severe when the organs are involve such as liver, kidney and heart disorder. Furthermore, long term for about 20 years or more arsenic exposure increase cancer risk of skin, lung, bladder and kidney [6, 7]. Chronic arsenic toxic was dependent on arsenic type, concentration, human intake path way, exposure time, behavior and personal factors [1, 5, 6]. From the survey of Environmental Research and Training center (ERTC) of Thailand has high soil arsenic contamination in Danchang district has been found. In Ongphra and Wangkhan Subdistrict has soil arsenic contamination range from 22.5 to 380.1 and 5.3-340.7 mg/kg, respectively [8]. It was higher than limit value of National Environment Board (NEB), Thailand at 3.9 mg/kg [9]. The result of risk assessment of ERTC showed that the resident in Ongpha Subdistrict had higher health risk than resident in Wangkhan Subdistrict at the possibility for 5 cancer cases and 2 cancer cases among 100 people, respectively [10]. The previous study of ERTC did not identify the sources of arsenic distribution. It has been presumed that the source of arsenic contamination could be from the old tin mine. Therefore, arsenic can spread to the environment. Another source could be from the utilization of arsenic content fertilizes in this agricultural area [1, 11]. The farmers are the major population group found in Danchang district, 61.2%. It was higher than in Wangkhan Subdistrict about 20% [8]. Moreover, there are 2 old tin mines in eastern of villages which consisted Moo 1, Moo 5 and Moo 7 [10]. Therefore, the researcher was interested in studying the occupational exposure among farmers in Ong-phra Subdistrict because they might be directly exposed to arsenic contaminated soil in their work life.

## MATERIALS AND METHODS

This cross sectional study among farmers and household resident in Aongphra Subdistrict was performed. The calculation of sample showed that 44 farmers were subjects and selected of 10 household residents for baseline group. The subjects were selected by systematic random sampling with proportion; were age between 18 to 70 years, stayed and worked in area more than 7 years. It was mentioned that the abnormal symptom might developed after 7-20 years of exposure [6, 7]. The subjects were agreed to give a written informed consent, avoid sea food consumption within 3 days prior to urinary collection and who were not pregnant.

The study tool composed of two parts 1) questionnaire was developed from Environment Research and Training Centre, Department of Environmental Quality Promotion. The content of questionnaire was validated by three specialists and the reliability test represented by the Cronbach's alpha coefficient. This questionnaire was composed of 2 parts: personal characteristics and behavior. Personal characteristic question was with choices and 12 open ended questions. The behavior questions were 11 hygiene behavior question with alpha=0.85, and 14 working behavior question with alpha=0.79. All questions were rating scale with 4 levels: regularly, frequently, rarely and never. 2) Atomic Absorption Spectroscopy Hydride Generator (AASHG) Perkin Elmer® AA analyst 300 was used to analyze arsenic contamination in soils, water and urine.

Soil samples were collected following the method from Department of Agricultural Extension of Thailand [12] and Minnesota Department of Agriculture [13]. Water samples were collected following the method by Bureau of Research Development and Hydrology of Department of Water Resources [14] and USEPA Region 9 Laboratory Richmond California Field Sampling Guidance Document #1225 Surface Water Sampling [15]. Urines were collected following the method of ACGIH, TLVs and BEIs Arsenic Element (7440-38-2) and Soluble Inorganic Compounds, Inorganic arsenic plus methylated metabolites in urine [2]. Sample were prepared and analyzed with AAS HG model Perkin Elmer® AA analyst 300 followed the Canadian Society of Soil Science Method which was modified by ERTC [16].

*Soil preparation:* First, the chemical reagents for digestion one sample were nitric acid ($HNO_3$) 40 ml, sulfuric acid (H2SO$_4$) 2 ml, perchloric acid ($HClO_4$) 3 ml, hydrochloric acid (HCl 1:1) 20 ml. Second, soil samples were dried, milled and filtered before extracted. Third, the sample was weighed to 0.1 g into 50 ml glass beaker and added nitric acid 20 ml, and closed for overnight. Fourth, after heating up the samples to 120-150 ˚C until volumes

**Table 1** Personal characteristic of farmer and household resident

| Variables | farmer (n=44) | | household resident (n=10) | |
|---|---|---|---|---|
| | Number | Percentage | Number | Percentage |
| **Gender** | | | | |
| Male | 15 | 34.1 | 1 | 10 |
| Female | 29 | 65.9 | 9 | 90 |
| **Age (Years)** | | | | |
| 18 - 31 | 2 | 4.5 | 1 | 10 |
| 32 - 44 | 16 | 36.4 | 3 | 30 |
| 45 - 57 | 14 | 31.8 | 3 | 30 |
| 58 - 70 | 12 | 27.3 | 3 | 30 |
| | ($\bar{x}$ ± SD = 48.0 ±13, range = 20 - 70) | | ($\bar{x}$ ± SD = 48 ±14, range = 27 - 70) | |
| **BMI (kg/m$^2$)** | | | | |
| Underweight <18.5 | 3 | 6.8 | 3 | 30.0 |
| Normal 18.5 - 22.9 | 13 | 29.5 | 4 | 40.0 |
| Overweight 23.0 - 24.9 | 9 | 20.5 | 1 | 10.0 |
| Obese >= 25 | 19 | 43.2 | 2 | 20.0 |
| | ($\bar{x}$ ± SD = 24.3±4.5, range = 15.6 - 35.8) | | ($\bar{x}$ ± SD = 20.9±4.6, range = 13.8 - 27.2) | |
| **Marital status** | | | | |
| Single | 7 | 15.9 | 3 | 30 |
| Couple | 37 | 84.1 | 7 | 70 |
| **Education level** | | | | |
| ≤ Prathom 6 | 31 | 70.5 | 8 | 80 |
| > Prathom 6 | 13 | 29.5 | 2 | 20 |
| **Alcohol drinking** | | | | |
| Yes | 16 | 36.4 | 2 | 20 |
| No | 28 | 63.6 | 8 | 80 |
| **Smoking** | | | | |
| Yes | 9 | 20.5 | 2 | 20 |
| No | 35 | 79.5 | 8 | 80 |
| **Chemical spraying** | | | | |
| Yes | 26 | 59.1 | - | - |
| No | 18 | 40.9 | - | - |
| **Chronic disease** | | | | |
| Yes | 19 | 45.5 | - | - |
| No | 25 | 54.4 | - | - |

reduce to 2-3 ml then cools down and add 10 ml of nitric acid and 3 ml of perchloric acid. Fifth, repeat the fourth procedure but after it cools down add 10 ml of nitric acid and 2 ml of sulfuric acid. Sixth, repeat the fourth then after it cools down add 20 ml of hydrochloric acid. Then, heat up sample up to 90 ˚C for 60 minute and filter it using filter paper. Next, adjust the volume to 50 ml by adding distilled water. Water and urines samples were filtered by filter paper then all of samples were analyzed by AAS HG.

*Samples analysis:* Chemical reagents were 10% of hydrochloric acid (HCl) for carrier solution and 0.2% of sodium borohydide ($NaBH_4$) in 0.05% sodium hydroxide (NaOH) for reducing agent. After preparing the reagents then add 5% potassium iodide (KI) and add 5% ascorbic acid to convert As (V) to As (III) before analysis because AAS HG is analyze the compound element in gas form. The arsenic in As (III) valence is easily to transform to arsine gas. Next, standard solution was prepared from stock standard solutions of 100 ppb arsenic, and then kept 1 ml dilution with 100 ml distilled water and prepared 5 levels of concentration for the calibration curve (0, 1, 3, 5, and 10 µg/l).The samples would be analyzed for arsenic contamination and it should be prepared prior to the analysis. 1 ml of sample solution would be added with 1 ml of conc. HCl, 1 ml 5% KI and 5% ascorbic acid. Then, the prepared sample would be kept for 45 minutes at ambient temperature and be diluted with 10 ml distilled water. It was done at Environment Research and Training Centre. The data sampling was collected during February 21$^{st}$-26$^{th}$, 2011 by interview subjects with 54 questionnaires meanwhile 54 urine, 54 resident soil, 54 resident water (surface water), 44 farm soil, and 44 farm water (tube water) was collected at the same period. The study protocols were certified and approved by the "Ethics Committee for Human

**Table 2** Behavior factors of farmer

| Behavior (n=44) | Regularly n (%) | Frequently n (%) | Rarely n (%) | Never n (%) |
|---|---|---|---|---|
| **Hygiene behavior** | | | | |
| Hand washing after soil exposure | 33(75.0) | 11(25.0) | - | - |
| Hand washing before meal in farm | 38(86.4) | 6(13.6) | - | - |
| Meal in farm | 19(43.2) | 7(15.9) | 15(34.1) | 3(6.8) |
| Smoking during chemical spraying | 1(2.3) | - | 40(90.9) | 3(6.8) |
| Immediately washing after chemical spraying | 39(88.6) | 4(9.1) | 1(2.3) | - |
| Do others activities after remove gloves | 13(29.5) | 6(13.6) | 25(56.8) | - |
| Cleaning and drying equipment | 25(56.8) | 10(22.7) | 2(4.5) | 7(15.9) |
| Reused equipment without cleaning | 8(18.2) | 9(20.4) | 3(6.8) | 24(54.5) |
| Discarded equipment immediately if damaged | 18(41.0) | 3(6.8) | 1(2.3) | 22(50.0) |
| Used chemical container for food package | 2(4.5) | 1(2.3) | 41(93.2) | - |
| Burn or bury chemical bottle | 13(29.5) | - | - | 31(70.5) |
| **Working behavior** | | | | |
| Instruction reading before chemical mixing | 38(86.4) | 5(11.3) | - | 1(2.3) |
| Work according chemical instruction | 33(75.0) | 9(20.4) | 1(2.3) | 1(2.3) |
| Mixing chemical out door | 39(88.6) | 1(2.3) | - | 4(9.1) |
| Chemical spraying during windy or raining | 2(4.5) | 2(4.5) | 40(90.9) | - |
| Stay downwind during chemical spraying | 3(6.8) | 12(27.3) | 3(6.8) | 26(59.1) |
| Blowing injection spray by mouth | 1(2.3) | - | 43(97.7) | - |
| Scratching during chemical spraying | 1(2.3) | 2(4.5) | 73(84.1) | 4(9.1) |
| Wear mask during chemical spraying | 29(65.9) | - | 2(4.5) | 13(29.6) |
| Wear gloves during chemical spraying | 28(63.6) | 2(4.5) | 2(4.5) | 12(27.3) |
| Wear boots during chemical spraying | 37(84.1) | 3(6.8) | - | 4(9.1) |
| Wear glass during chemical spraying | 16(36.4) | - | - | 28(63.6) |
| Wear hat during chemical spraying | 41(93.2) | - | - | 3(6.8) |
| Wear shirt during chemical spraying | 44(100.0) | - | - | - |
| Wear pant during chemical spraying | 43(97.7) | - | - | 1(2.3) |

Research Faculty of Public health", Mahidol University, Bangkok. With COA No MUPH 2011-207.

**STATISTICAL**

This study was used software SPSS v.18 for the descriptive and inferential data analysis. Descriptive statistics were number and percentage to describe the personal characteristic such as age and body mass index. The arsenic contamination in soil, water and urine didn't show in mean value because max and min value of the contamination was very different and did not show normal distributions. So the median and inter quartile range (IQR) were used to describe the arsenic contamination in soil, water and urine [17]. Inferential statistic was the Mann-Whitney U test statistic for comparing the difference of arsenic in urine and environment between two groups. Spearman's rho correlation test was used to compare and describe the relationship of urinary arsenic level with arsenic contamination in environment and behavioral factors.

**RESULTS**

The general characteristic of the samples in farmer group had overweight body mass index (BMI) average of 24.3 kg/m$^2$ [18]. Most of them were female 65.9%, no alcohol drinking 63.6%, no smoking 79.5% but 59.1% of them chemical spraying and 43.5% had a chronic disease. The farmers had education lower or equal to primary school 70.4% and most of them were married 84.1%. And the most baseline group (household resident) was female with normal BMI average of 20.9 kg/m$^2$ and 30% of them had a chronic disease. Most of them had education level lower or equal to primary school and married status. The average ages both of farmers and household residents were 48.0 years old (Table 1).

According to Table 2, the behavior factors of farmers were hygiene behavior and working behavior. The hygiene behavior showed that farmers performed regularly hand washing after soil exposure (75%), hand washing before meal (86.4%), meal in farm (43.2%), immediately washing after chemical spraying (88.6%), cleaning and drying equipment (56.8%), meanwhile they rarely do others activities after remove gloves (56.8%), used chemical container for food package (93.2%), and they never reused equipment without cleaning (54.5%), discarded equipment immediately

**Table 3** Arsenic contamination in soils, water and urine of farmer and household resident

| Sample | Standard [a] | Arsenic concentration | | |
|---|---|---|---|---|
| | | Min - Max | Median | IQR [b] |
| **Farmer (n=44)** | | | | |
| Resident soil (mg/kg) | 3.9 mg/kg | 3.3 - 123.9 | 42.3 | 42.7 |
| Farm soil (mg/kg) | 3.9 mg/kg | 3.3 - 164.6 | 25.3 | 23.2 |
| Resident water (µg/L) | 10 µg/L | 0.3 - 82.8 | 2.7 | 18.6 |
| Farm water (µg/L) | 10 µg/L | 0.9 - 84.8 | 3.8 | 16.6 |
| Urine (µg/L) | 35 µg/L | 1.2 - 80.8 | 4.5 | 11.8 |
| **Household resident (n=10)** | | | | |
| Resident soil (mg/kg) | 3.9 mg/kg | 25.7 - 113.4 | 56.4 | 46.8 |
| Resident water (µg/L) | 10 µg/L | 0.7 - 37.0 | 4.3 | 50.9 |
| Urine (µg/L) | 35 µg/L | 1.6 - 8.2 | 2.1 | 0.61 |

[a] Soil from National Environment Board (NEB) 2004 [9], Water from National Environment Board (NEB) 1992 [14], Urine from American Conference of Industrial Hygienists (ACGIH), 2009 [2]

**Table 4** Comparison urinary arsenic level between two independent variables

| Factors | | Number | Urinary arsenic level | | *P-value* |
|---|---|---|---|---|---|
| | | | Median | IQR | |
| **Gender** | Male | 15 | 6.8 | 10.2 | 0.049* |
| | Female | 29 | 1.7 | 13.0 | |
| **Smoking** | Yes | 9 | 6.1 | 12.4 | 0.142 |
| | No | 35 | 1.7 | 8.7 | |
| **Alcohol drinking** | Yes | 16 | 3.6 | 12.4 | 0.845 |
| | No | 28 | 5.5 | 11.8 | |
| **Marital status** | Single | 7 | 3.4 | 7.6 | 0.760 |
| | Couple | 37 | 5.0 | 13.2 | |
| **Educational level** | ≤ Primary school | 31 | 4.6 | 23.0 | 0.563 |
| | > Primary school | 13 | 4.5 | 8.7 | |
| **Chemical spraying** | Yes | 26 | 4.7 | 9.9 | 0.867 |
| | No | 18 | 3.1 | 15.2 | |
| **Chronic disease** | Yes | 19 | 5.0 | 13.2 | 0.530 |
| | No | 25 | 3.9 | 8.6 | |
| **Occupational** | Farmer group | 44 | 4.5 | 11.8 | 0.019* |
| | Household group | 10 | 1.7 | 0.61 | |

All factors were not normal distributions curve; it was significantly at p- value < 0.05 (test by Shapiro-Wilk test)
*significant at *p-value*< 0.05

if damaged (50%), burn or bury chemical bottle (70.5%). The working behavior showed that farmers performed their work with regularly instruction reading before chemical mixing (86.4%), work according chemical instruction (75%), and mixing chemical out door (88.6%). While they regularly used personal protective equipment such as mask (65.9%), gloves (63.6%), boot (84.1%), hat (93.2%), shirt (100%), and pant (99.7%). Meanwhile they performed rarely with chemical spraying during windy or raining (90.9%), blowing injection spray by mouth (99.7%), and scratching during chemical spraying (84.1%). They also performed their work by never stay downwind during chemical spraying (59.1%) and never wearing glass during chemical spraying (63.3%).

The results of arsenic contamination in environment of farmer group was found in resident soil between 3.3-123.9 mg/kg with median 42.3 mg/kg (IQR 42.7) while in farm soil between 3.3-164.6 mg/kg with median 25.3 mg/kg (IQR 23.2). Arsenic contamination in resident water was between 0.3-82.8 µg/L with median 2.7 µg/L (IQR 18.6), and in farm water between 0.9-84.8 µg/L with median 3.8 µg/L (IQR 16.6). The arsenic level in environment of household resident group was found in resident soil 25.7-113.4 mg/kg with median 56.4 mg/kg (IQR 46.0) and in resident water between 0.7-37.0 µg/L with median 4.3 µg/L (IQR 50.9). The farmer urinary arsenic varied between 1.2-80.8 µg/L with median 4.5 µg/L (IQR 11.8). The household resident urinary arsenic content varied between 1.6-8.2 µg/L with median 2.1 µg/L (IQR 5.2), Table 3.

The factors related to urinary arsenic level of

**Table 5** Comparison arsenic contamination in environment

| Factors | | Arsenic concentration | | *P-value* |
|---|---|---|---|---|
| | | Median | IQR | |
| Resident water (μg/L) | Farmer group | 2.7 | 18.6 | 0 .197 |
| | Household group | 4.3 | 50.9 | |
| Resident soil (mg/kg) | Farmer group | 42.3 | 42.7 | 0.275 |
| | Household group | 56.4 | 46.8 | |
| Farmer water (μg/L) | Resident water | 2.7 | 18.6 | 0.570 |
| | Farm water | 3.84 | 16.6 | |
| Farmer soil (mg/kg) | Resident soil | 42.3 | 42.7 | 0.002* |
| | Farm soil | 25.3 | 23.2 | |

All factors were not normal distributions curve; it was significantly at p - value< 0.05 (test by Shapiro-Wilk test)
*significant at *p-value*< 0.05

**Table 6** Correlation between arsenic contamination in environment and urinary arsenic level of farmers

| Arsenic contamination in environment | **Urinary arsenic level** (μg/L) | |
|---|---|---|
| | r | *P-value* |
| Resident soil (mg/kg) | -0.206 | 0.062 |
| Resident water (μg/L) | 0.040 | 0.797 |
| Farm soil (mg/kg) | 0.216 | 0.159 |
| Farm water (μg/L) | -0.043 | 0.784 |

All factors were not normal distributions curve; it was significantly at *p-value*< 0.05 (test by Shapiro-Wilk test)
*significant at *p-value*< 0.05

**Table 7** Correlation between behavior level score and urinary arsenic level of farmers

| Behavior | Total Score | Level Score | | | Urinary arsenic level | |
|---|---|---|---|---|---|---|
| | | Fair n (%) | Good n (%) | Very Good n (%) | r | *P-value* |
| Hygiene behavior | 33 | 18 (40.9) | 14 (31.8) | 12 (27.3) | 0.156 | 0.313 |
| Working behavior | 42 | 9 (20.5) | 16 (36.4) | 19 (43.2) | 0.154 | 0.319 |

**The level of score:** Fair< 70.0%, Good= 70.0% - 79.9%, Very good≥ 80.0%
All factors were not normal distributions curve; it was significantly at *p-value*< 0.05 (test by Shapiro-Wilk test)
*significant at *p-value*< 0.05

farmers was gender and occupational; females had higher urinary arsenic concentrations than males and farmers had higher urinary arsenic level than household resident with the *p-value* 0.049 and 0.019, respectively (Table 4). The comparison of arsenic level in soil and water between farmer and household group had no significant. But in farmer group the result showed resident soil has higher arsenic level than farm soil at *p-value* 0.002 (Table 5).

The hygiene behavior level score of farmers was very good (27.3%) good (31.8%) and fair (40.9%). The working behavior was very good (43.2%) meanwhile good and fair was 36.4% and 20.5%, respectively. The correlation test showed that had no significant between arsenic contamination in environment and urinary arsenic level and, had no significant between behaviors level score and urinary arsenic level (Table 6, Table 7).

## DISCUSSIONS

In this study the soil arsenic contamination both of household resident and farmers was higher than limit value of Nation Environment Board (NEB), Thailand at 3.9 mg/kg [9]. The median of soil arsenic contamination in household resident soil, farmer resident soil, and farm soil was 56.4, 42.3 and 25.3 mg/kg, respectively. The farmers and household resident were living in high soil arsenic contamination area. This result was agreed with the survey of ERTC, Thailand that arsenic concentration in soil was higher than limit value (NEB) at 380.1 mg/kg [8]. Arsenic compound might be the natural background of soil in this area. It was supported by the geology and mineral resources survey of S.A.P company ltd that Ongphra Subdistrict was rich of tin ore and there were two tins mine located. The consequence of mining operation was arsenic contamination that was found high level in soil [19]. But the level of arsenic contamination in soil of ERTC, Thailand was higher than this study with the value of 380.1 mg/kg, and the difference was caused by different sampling point and different period. The duration of the data collecting has a difference of 2 years. The environment changed and flooding causes the reduction of soil arsenic contamination [20, 21]. The median of arsenic concentration both of resident water and farm water were lower than standard limit value of NEB, Thailand at 10 µg/L. It showed that farmers and household resident were safe with water consumption.

Since the limit value for urinary arsenic level has not been set in Thailand yet. Therefore the urinary arsenic level in this study used the value recommended by American Conference of Industrial Hygienists (ACGIH) as limit value at< 35 µg/L; it would be the occupational safety and health standard approached. It was a guideline to assist in control of health hazard for 8 hour [2]. Most of farmers work 8 hours per day and every day in farm. If the recommendation of limit value was safe for the worker it should be safe for subjects or farmers who work under similar conditions. The farmer urinary arsenic level (4.5 µg/L) was higher than household resident (2.1 µg/L). There was one of the studies which were similar with this study that arsenic contamination in subject was higher than control group [22].But, it was different from the study of Gebel [23], which found the higher urinary arsenic level in control group. It is remarkably the study consumed traditional food such as seafood, tea and wine 3 days before urinary collection.

The factors might relate to urinary arsenic level of farmers was gender and occupational. The females had higher urinary arsenic level than male at *p-value* 0.049. This result was consistent with Lindberg et al. [24] that the gender and age were major factors influencing arsenic metabolism in this population with a median of 77 µg/L of arsenic in urine and women had higher arsenic methylation efficiency than men, but only in childbearing age, supporting an influence of sex hormones. Moreover, it also supported with previous study of Sudo et al. [25] and Tseng et al. [26], which state that the better methylation efficiency in female. Therefore, women trended to have higher urinary arsenic than men even though have same arsenic exposure level. On the other hand, Liu et al. [21] and Fillol et al. [27] who found significantly higher urinary arsenic level in men cause of smoking habit. Most of volunteers in this study were female who had no smoking habit.

The arsenic contaminations in soil showed both of resident group were living in high arsenic contamination area. The farmers had urinary arsenic level higher than household resident group even though arsenic contamination in farm soil was lower than household resident. So, the difference of urinary arsenic level might be from behavior factors such as hygiene and working behavior of farmers. Thus, 43% of farmers had regularly meals in farm and 29.5% of them regularly performed other activities after removed gloves. The farmers more than 50% did not used glasses and 30% of them did not use mask and gloves during farming activities. In addition, 50% of farmers still used damage equipment. The person who working without using personal protective devices (masks, gloves and waterproof clothes) considering that pesticides could be absorbed through the skin and inhaled between the spraying intervals [28]. But the most level score of working behavior was very good and both of hygiene and working behaviors was not correlated to urinary arsenic levels. The possibility of contamination should be come from the PPE of farmers such as shirt, pant, and mask were not appropriate as standard which this study was not evaluate. The pathway of arsenic can be taken into human body via inhalation as arsenic in ambient air, ingestion and skin absorption which absorbed 2% from low water arsenic concentration and 1% from soil [29, 30]. World Health Organization presented that major of residues arsenic in farmland was generated from pesticides using activities [1]. The arsenic contamination in farm soil of this study was lower than resident it may be caused of flooding area. However, both of farmer and household resident groups had urinary arsenic level lower than ACGIH limit value.

There was found slight significance between arsenic contamination of resident soil and urinary arsenic level at *p-value* 0.062, but all of arsenic level in environment was not correlate with urinary arsenic level of farmer. There was one of the studies which were similar with this study that the correlation of total urinary arsenic with soil arsenic level was weaker and no significant correlations found [31].

**CONCLUSION**

The overall results showed arsenic contamination in soil was higher than limit value. The factors related to urinary arsenic level among farmers were gender and occupational. The personal characteristic such as smoking, alcohol drinking, marital status, education level, chemical spraying, and chronic disease had no effect with urinary arsenic level. All residents who are farmer and non-farmer living in high risk area should have knowledge and awareness to protect themselves from arsenic exposure. Especially, the farmers should strictly good perform standard agriculture practice and PPE for reducing the exposure during farming activities.

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