HEALTH RISKS OF ARSENIC EXPOSURE VIA SHALLOW WELL WATER USE IN RON PHI BUL, SOUTHERN THAILAND

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Abstract- This study investigated arsenic concentration in shallow wells water and evaluated the public health risk level from arsenic exposure via this water consumption in Ron phi bul sub district, Ron phi bul district, Nakorn Sri Thammarat province in southern of Thailand. This area was contaminated with arsenic because of the tin mining since 1987. Until present, there is founding of arsenic contamination in environmental samples taken from this area, moreover the population still use the water from shallows well water continuously. The 165 water samples were collected randomly from shallow wells in 15 villages. The water used behaviours was also studied by questionnaire among 226 household numbers. The results found the shallow wells in 7 villages has exceeded drinking water standard for arsenic (0.01 mg/L). Their average arsenic concentrations were 0.05 0.14 0.02 0.09 0.97 0.09 and 0.04 mg/L. The maximum concentration found in water samples was 1.60 mg/L. The health risk of household who used the shallow well water as drinking water still was acceptable level but the arsenic concentration in some wells exceed the maximal recommendation value for daily life activities.

Keywords- Arsenic, Carcinogen, Risk Assessment, Shallow Well Water.

I. INTRODUCTION

Ron phi bul sub district, Nakorn Sri Thammarat province in southern of Thailand is one of major area where has tin mining activities since 30 years ago. Presently there are no more mining activities in this area but the arsenic was still found in the environment. This problem caused by the tin mining type vein mineral that form Arsenopyrite (FeAsS) and Arsenopyrite spreader in the area. Arsenopyrite would be decomposed to be arsenites and arsenates that were distributed into water soil and air. The continuous exposure to arsenic can be the cause of health problems including skin lesions, change of skin pigmentation, hands and feet keratosis. Moreover arsenic is classified as a human carcinogen.

Although there is arsenic contamination in water sources reported in Ron phi bul sub-district over 20 years passed but the surveying data showed that residents in this area still used water from shallow wells for their daily life such as drinking, bathing, cooking, washing activities as washing clothes and utensils, brushing teeth. This area located in rural area that some village still lack tap water therefore the use of shallow well water is necessary. So the purpose of this study was to determine the arsenic concentration in shallow wells water and the health risk level among this area resident. The result obtained will be used as the baseline data to find the appropriate and acceptable technology for these residents in arsenic pre-treatment before using.

II. PROCEDURE

A. Area of study
15 villages in Ron phi bul sub-district was used as area of study. In this area, there are 550 households who still use water from shallow well water in the daily life activities. The number of sample was calculated by using Taro Yamane's formula and randomly selected from total population.

B. Arsenic concentration determination
Arsenic in shallow well water samples were analysed by Hydride Generation Atomic Absorbance Spectrometer (Hg-AAs) follow Standard Methods for the Examination of Water and Wastewater, Part 3112B (APPHA, 2012).

C. Water use behaviour study
The data of water use behavior was acquired. The behaviour in water consumption of the household samples was considered as 3 groups. The first was households who use the water from shallow well only for washing (washing cloth, utensils, food, and body). The second group was households who use that water for washing and cooking. The last group was households who use that water for washing, cooking and drinking. This was set for considering the exposure pathway.

D. Health risk assessment
The method of health risk assessment followed the United State Environmental Protection Agency (U.S. EPA) guideline.

E. Exposure assessment
Although arsenic can enter through body via several pathways, inhalation, dermal contact and ingestion but inhalation and dermal contact pathway are negligible. So exposure assessment arsenic was done for ingestion (drink water) exposure in term of milligram. body weight per day units (mg.kg/day). The arsenic concentration in environment obtained from method in 2.2 and some data including sex, age, body weight,

duration exposure obtained from questionnaires. The chronic daily intake (CDI) was calculated by equation (1). Some exposure parameter needs to be used as default values obtained from scientific literatures (Table I).

$$CDI = \frac{(CW(CR)(ER)(ED)}{(BW)(AT)} \quad (1)$$

When CW is concentration of arsenic oxidation state +3 (mg/1000L),
CR is contact rate (mL/day),
EF is exposure frequency (days/year),
ED is the exposure duration (years),
AT is the estimate time for cancer effect (days),
BW is bodyweight (Kg).

Table I The estimate time for calculating an exposure dosage.

Age rang	EF (days/year)	AT (days)
ResAdult (C)	330	21,170
ResAdult (NC)	330	25,550
JobAdult (C)	360	21,170
JobAdult (NC)	360	25,550

ResAdult(C), JobAdult(C) = Cancer risk of Resident adult, Cancer risk of job adult. ResAdult(NC), JobAdult(NC) = Non cancer risk of Resident adult, Non cancer risk of job adult.

F. Risk Characterize

The risks level from arsenic exposure was calculated as both cancer and non-cancer risk. The cancer risk value canbe calculated by the equation (2) and the hazard quotient (HQ) was expressed for non-cancer risk level that can be calculated by the equation (3).

$$Cancerrisk = (CDI)(SF). \quad (2)$$

That accepted in safety rang 10^{-4}-10^{-6}.

$$HQ = \frac{CDI}{RfD} \quad (3)$$

That accepted in safety is equal to or less than 1(When slope factor (SF) in term kg.day/mg unite = 1.5 and Reference Dose in term mg/kg/day unite = 0.0003) [3]

III. RESULT AND DISCUSSION

G. Contamination of arsenic in shallow well water

The result of arsenic concentration analysis showed the shallow well water was contaminated by arsenic in the levelhigher than 0.01 mg/L in 7 villages from 15 villages. (Hu Dan, Ron Na, Hnong Kok, Kok Yang, Tahlad Ron, Sala Keehleng and Ton Muang). The average arsenic concentration in these areas were 0.05 0.14 0.02 0.09 0.97 0.09 and 0.04 mg/L respectively. The rest 9 villages found arsenic concentration equal or lower than or equal to 0.01 mg/L (Ta hleng, Huey Rak Mai, Don Klang, Wung Sai, Ton Koe, Muang Hgam, Huey Mai Kan, Na Poe and Tung Nam Jan). The highest concentration was found at 1.60 mg/L in Tahlad Ron village. The number of shallow wells water which their water sample were contaminated by arsenic over 0.01 mg/L was 65 wells or 39.39 % and that less than 0.01 mg/L was 100 wells or 60.61%.The water which contaminated by arsenic over 0.05 was recommended to stop using it for drinking or food preparation and 0.50 mg/L was recommended to stop using it.

H. Water use behaviour

The result of water use behaviour showed the number of households who used water that contaminated the arsenic level rang >0.01-0.05 mg/L for activities in group 1, 2 and 3 were 15.49%, 3.98% and 0.44% respectively. The households who used water that was contaminated by in rang >0.05-0.50 for activities in group 1 and 2 were 15.04% and 1.33% respectively. Finally the household who used water that contaminated arsenic level over 0.50 for activities in group 1 was 2.65 % (Table II and Fig I.)

Table II Percentage of household who use arsenic contaminated water for activities in daily life

As level (mg/L)	Number of household		
	Washing	Washing Cooking	Washing, Cooking, Drinking
≤ 0.01	87 38.50%	37 16.37%	14 6.20%
>0.01-0.05	35 15.49%	9 3.98%	1 0.44%
>0.05-0.5	34 15.04%	3 1.33%	0 0.00%
>0.5	6 2.65%	0 0.00%	0 0.00%

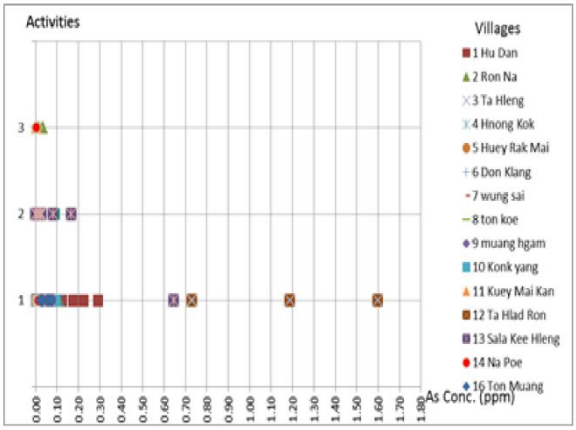

Fig.I Relationship between the arsenic concentration (mg/L) and using activities in fifteen villages.

1 Washing activities as washing clothes and utensils, bathing and food
2 Cooking and all of activities in 1
3 Drinking and all of activities in 1 and 2

I. Health risk assessment

The result of using water behavior data show the amount of households that is drinking water from shallow wells was 37 peoples in 15 household from total 226 households. They are living in the villages, Ron Na 2 households, Don Klang 3 households, Ton Koe 2 households, Huey Mai Kan 6 households and Na Poe 2 households. The result of risk following by age rang found that the risk level of sample groups, resident adult and job adult, was acceptable (Table III). When consider the result of risk following by village zoning found the cancer risk was in range of 9.22 x 10-6 to 1.37x10-4. (In term of 1.37x10-4 means 1 in 10,000 people could possibly suffer from cancer and term 9.22 x 10-6 has means same). The risk characterization of non-cancer was also in safety level. The results of non-cancer and cancer risk are presented in the Table IV.

Table III

Age rang	Number of people	Risk level
ResAdult (C)	28	$1.37x10^{-5}$ - $9.23x10^{-6}$
ResAdult (NC)	28	0.01-0.41
JobAdult (C)	9	$1.84x10^{-5}$ - $4.36x10^{-6}$
JobAdult (NC)	9	0.01-0.21

Table VI the outputs of risk characterization

Villages	As concentration (mg/L)	Cancer risk	Non-Cancer
Ron Na	0.01-0.11	$1.72x10^{-5}$ - $8.81x10^{-6}$	0.01- 0.58
DonKlang	0.00-0.01	$1.83x10^{-5}$ - $9.22x10^{-6}$	0.02 - 0.27
Ton Koe	0.00-0.01	$5.37x10^{-5}$ - $4.98x10^{-5}$	0.11- 0.14
Huey Mai Kan	0.00-0.02	$1.37x10^{-4}$ - $7.92x10^{-5}$	0.04 - 0.42
Na Poe	0.00-0.02	$2.56x10^{-5}$ - $3.38x10^{-5}$	0.07 - 0.90

CONCLUSION

Even though the arsenic concentration in some hallow wells water exceeded the recommendation values for using in daily life activities (0.5 mg/L) for food preparation (0.05) and for drinking water (0.01 mg/L)[6] but the residents in the area of study still use this water for in their life. The risk assessment showed that the risk level still was acceptable level but when arsenic is carcinogen, it should be concerned and risk management is necessary. The result of consumption behavior show households who have to be worrisome was 1 household that use water contaminated by arsenic over 0.01 mg/L for activities in group 3 (washing, cooking and drinking) and 3 households that are using water contaminated by arsenic over 0.05 mg/L for activities in group 2 (cooking and washing) and 6 households that are using water contaminated by arsenic over 0.5 mg/L for washing activities. The result of this study will be inform to the residents in this sub-district and the focus group and brain storming technique among stakeholders will be used to find the appropriate technology for arsenic pretreatment.

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