

## ARSENIC CONTAMINATION OF DOMESTIC WATER IN DAKNONG PROVINCE, VIETNAM: SITUATION AND HUMAN HEALTH CONCERNS

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**Abstract:** Arsenic (As) is listed as a human carcinogen, and As groundwater contamination is a significant health problem in many regions of the world. In the past few years, high concentrations of As in ground water have been discovered in some areas in Vietnam. In 2017, a report of Preventive Medicine Center of Daknong showed that the high As concentrations were found in both treated and untreated ground water samples in some areas belonged to this province. In this study, a total of 651 water samples (83 treated water, 114 surface water, and 455 ground water samples) and 100 duplicate samples were collected in Daknong. All samples were measured pH before preservation by 2% HNO<sub>3</sub> acid until analyzing As by inductively coupled plasma mass spectrometry. According to the results, the high As concentrations, which exceeded the Vietnamese drinking water and domestic water limit for As (10 µg/L) were found in 19 samples. Moreover, one treated water sample from a water supply center presented a high As concentration (greater than 10 µg/L). Three hazard quotient values presented greater than 1 suggested that the water from those wells should not be used for drinking without proper treatment measures.

**Keywords:** Arsenic; Ground water; Domestic water; Daknong.

### 1. INTRODUCTION

Arsenic is a toxic metal present in different environmental and biological systems, which is listed as a human carcinogen (class A), causing skin, lungs, and bladder cancers [1]. The World Health Organization (WHO) suggested that As concentration in drinking water should not exceed 10 µg/L [2]. In India, China, Myanmar, Pakistan, Nepal, Cambodia, and Vietnam, people exposed to an unsafe level of As in drinking water was estimated at about 100 million [3]. In recent past years, high concentrations of As in ground water have been discovered in some areas in Vietnam [4, 5]. Moreover, about 13 million Vietnamese people use ground water directly from tube-wells for domestic purposes (National Environment Agency, 2002).

In Daknong, the As contamination in ground water was reported one time in 2008. The As concentrations in 374 was determined using quick test kits (Hach) ranged between 0.25 and 85 ppb (Daknong DONRE, 2007-2008). However, there was no ground water samples had been detected As in Daknong until 2017 (report from 31 ground water wells at Daknong by Environmental Monitoring Central, 2016-2017). In 2017, a report of Preventive Medicine Center of Daknong showed that the high As concentrations were found in treated ground water from a water supply center and untreated ground water samples around Krongno area.

This study aims to understand the As contamination in domestic water in Daknong province and estimate the human health risks for local people.

## 2. MATERIAL AND METHOD

### 2.1. Sampling and analysis methods

Total 651 water samples (83 treated water, 114 surface water, and 455 ground water samples) and 100 duplicate samples were collected randomly in all seven districts and one town of Daknong province (fig. 1 shows the sampling area and high As concentration sampling points). All samples were measured pH using pH meter (Horiba U52) on-site, and then they were preserved by 2% HNO<sub>3</sub> (Merck, Suprapur®) acid before transferring to the laboratory. Finally, the samples were analyzed As concentration by inductively coupled plasma mass spectrometry following method 3125B:2012 of the standard methods for water and wastewater. The method detection limit for As in the water sample was 0.07 µg/L.

The results of 100 duplicate samples were used to calculate the relative percent difference (RPD) values as below:

$$RPD = \frac{|LD1 - LD2|}{[(LD1 + LD2)/2]} * 100 \quad (1)$$

where LD1 is the sample result, and LD2 is the duplicate result.

The average of RPD in this study was 5.04%, and all RPD values were controlled under 30% indicating that the results of this study were in high precision.



**Figure 1.** Study area and sampling locations of high Arsenic concentration samples.

### 2.2. Human health risk assessment

The hazard quotient (HQ) was used to estimate the health risk to local people for the drinking of As contaminated water. The HQ was suggested by U.S.EPA [6] and calculated by the equation as follows:

$$HQ = \frac{EDI}{RfD} = \frac{C * \frac{dc}{bw}}{RfD} \quad (2)$$

where *bw* is body weight (kg). The average body weight of local people was used in this study was 60 kg, which similar to Asian body weight 57.7 kg or Japanese body weight 58.8 kg [7]; *EDI* is the estimated daily intake (µg/kg\_bw/day); *C* is As concentration in drinking water (µg/L); *dc* is daily water consumption = 2 L/capita/day; *RfD* = 3 µg/kg\_bw/day is reference dose for Arsenic. According to the inorganic As benchmark dose modeling, that value was suggested by FAO/WHO for a 0.5% increased incidence of lung cancer [8]. U.S.EPA. suggested that a HQ value greater than 1 indicate potential health risk for human.

### 3. RESULTS AND DISCUSSION

#### 3.1. Arsenic contamination in domestic water

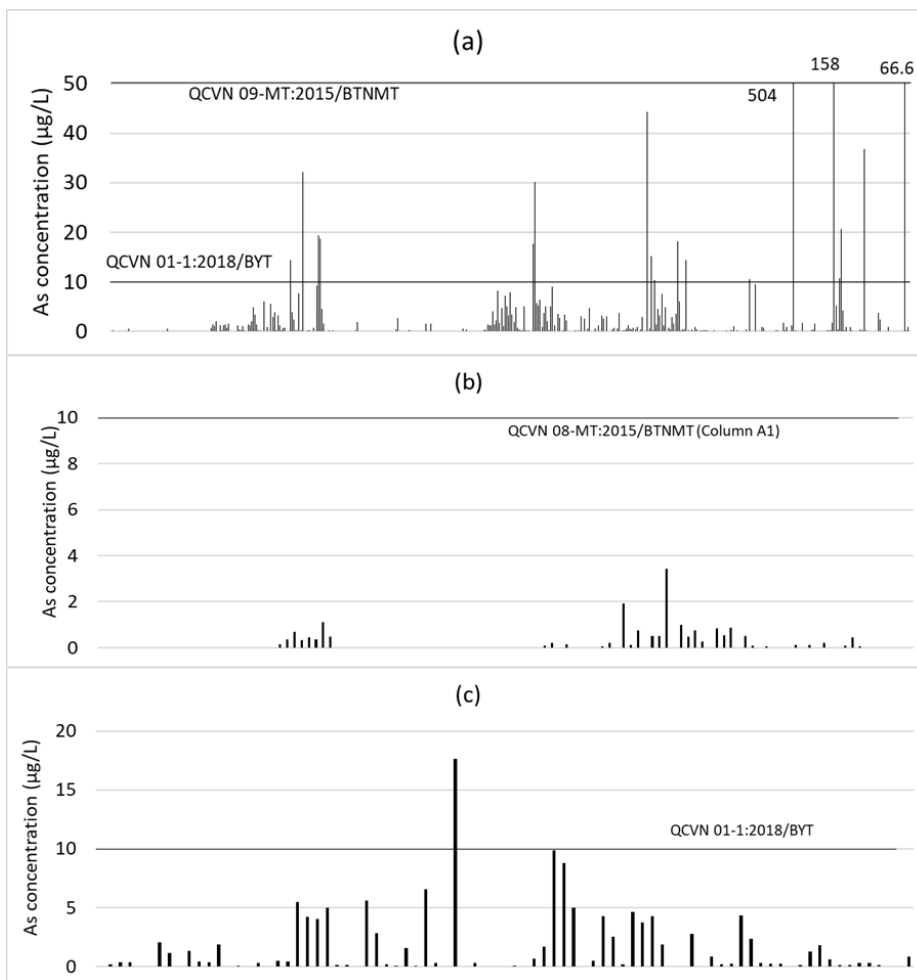
According to the results, the high As concentrations that exceeded the Vietnamese drinking water and domestic water limit for As (10 µg/L) were found in 19 samples at Krongno, Cujut, Dakglong, Dakmil, and Gianghia (see more details in fig 1 and table 1). The highest As concentration, 504 µg/L, was presented in one ground water sample at Krongno (fig. 2a). The As concentrations in surface water samples ranged from ND (Not detected) to 3.4 µg/L (fig. 2b). Especially, beside the water supply center at Krongno, one more treated water from other water supply centers at Dakmil also presented a high As concentration (17.7 µg/L) (fig. 2c).

**Table 1.** As distribution in domestic water at Daknong.

| Sampling area | Number of samples |               |            |
|---------------|-------------------|---------------|------------|
|               | As<10 µg/L        | As 10-50 µg/L | As>50 µg/L |
| Gianghia      | 58                | 2             | 1          |
| Krongno       | 113               | 7             | 1          |
| Daksong       | 76                | 0             | 0          |
| Dakmil        | 62                | 3             | 0          |
| Dakglong      | 98                | 2             | 1          |
| Cujut         | 127               | 2             | 0          |
| Tuyduc        | 25                | 0             | 0          |
| DakR'Lap      | 72                | 0             | 0          |
| <b>Total</b>  | <b>632</b>        | <b>16</b>     | <b>3</b>   |

Base on the distribution of As in ground water, the high As concentration samples were found in three areas. The first one, three samples at Gianghia town had been detected As from 10.5 to 66.6 µg/L. The second one, in ten samples with As concentration from 10-50 µg/L at Dakmil and Krongno, eight samples were found around the border of those provinces. Among them, two wells were supplying for one local rural water supply center. Finally, the last high As concentration in the ground water area was found at some places along the Serepok River.

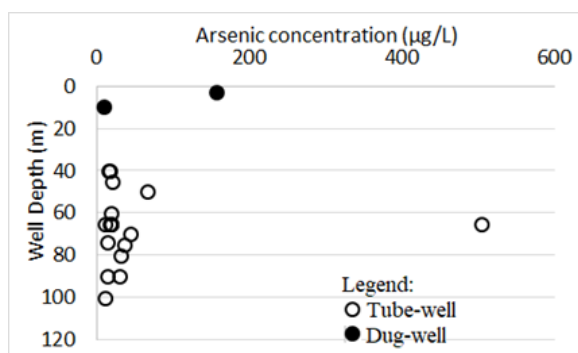
The As contamination in surface water is depend on the composition of surface recharge or the characteristics of bedrock lithology. Typically, the As concentrations in river water are in the low range [9, 10]. The high concentrations of As in river water might found in some areas, which was influenced by high As contaminated ground water, As pollution wastewater, or river baseflow around arid areas. The lower As concentration found in surface water on account of oxidation and adsorption of As on to the sediment and dilution by other water sources [9].



**Figure 2.** As concentrations in (a) ground water; (b) surface water; and (c) treated water at Daknong.

Note:

- QCVN 08-MT:2015/BTNMT column A1 is Vietnamese National technical regulation on surface water quality in case the water is considered to use as supply water.
- QCVN 09-MT:2015/BTNMT is Vietnamese National technical regulation on ground water quality.
- QCVN 01-1:2018/BYT is Vietnamese National technical regulation on domestic water quality.

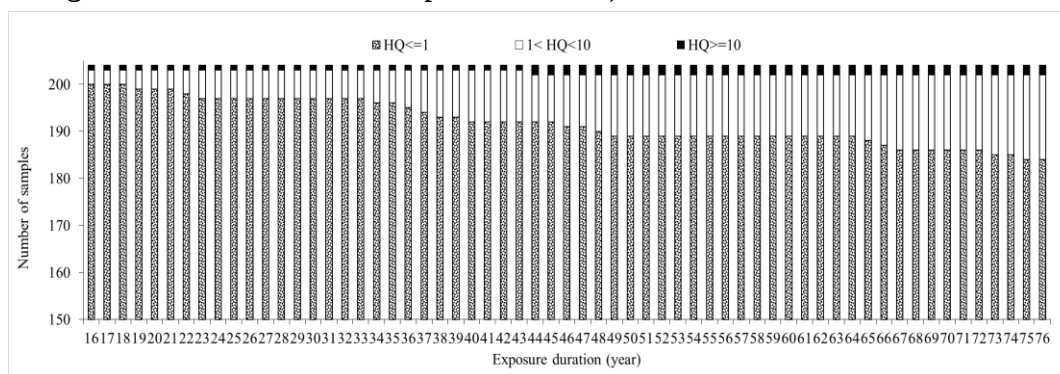


**Figure 3.** Depth distribution of high concentration As (>10 µg/L) in ground water at Daknong.

Among 19 high As concentration samples in this study, only two samples were collected from dug-wells. The remaining samples were collected from tube-wells. According to the results, the depth of tube-wells with over 10 µg/L As water samples ranging between 40 and 100 meters (fig. 3). These results were similar to the data in Pakistan [10] and in Lamdong, Vietnam [11].

### 3.2. Local human health risk concerns

In this study, all the ground water, surface water, and treated water were considered domestic water because of local people's behavior. Almost all local people use ground water or surface water directly for their domestic demand without treatment. Even if they use water from small local rural water supply centers, they still face up the risk of As exposure because almost of those centers are using basic treatment technology or without treatment. So far, Daknong has 242 rural water supply centers that could serve 126,770 people. However, until 2018, only 56 rural water supply centers were still working (Daknong Department of Agriculture and Rural Development, 8/2018).



**Figure 4.** HQ results for each exposure duration from 16 to 76 years.

The results showed three HQ values presented greater than 1 from 16-years (adult) exposure with As in drinking water suggested that the water from those wells should not be used for drinking. Most of As impact on human health relates to As contaminated in drinking water [1]. As mentioned above, in Vietnam, a large number of people in rural areas use ground water directly for drinking and other domestic demand. Unfortunately, much previous research in Vietnam showed that

As contaminate in ground water at high level at Red River plain [5] or Mekong delta [12]. In Middle Highlands of Vietnam, As contaminants were only found in some areas at Lamdong, including Cattien [13] and Dateh [14] districts.

#### 4. CONCLUSIONS

The high As concentrations that exceeded the Vietnamese drinking water and domestic water were found in 19 samples at Krongno, Cujut, Dakglong, Dakmil, and Gianghia. Among them, one treated water from a water supply center at Dakmil presented high As concentration indicates the high risk for local people's health. Three HQ values presented greater than 1 suggested that the water from those wells should not be used for drinking.

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### TÓM TẮT

#### Ô NHIỄM ASEN TRONG NƯỚC SINH HOẠT TẠI TỈNH ĐẮK NÔNG, VIỆT NAM: HIỆN TRẠNG VÀ MỐI NGUY ĐẾN SỨC KHỎE CON NGƯỜI

Asen (As), một trong những kim loại có thể gây ung thư cho con người, tồn tại trong nước dưới đất và gây ra nhiều mối nguy hại đến sức khỏe con người trên toàn thế giới. Trong những năm qua, ở Việt Nam đã phát hiện nhiều giếng nước có nhiễm As ở nồng độ cao. Năm 2017, Trung tâm Y tế dự phòng tỉnh Đắk Nông đã công bố trong báo cáo của mình về kết quả khảo sát phát hiện mức As cao trong cả nước giếng và nước cấp sinh hoạt ở tỉnh này. Nghiên cứu này thực hiện khảo sát 651 mẫu nước trên các khu vực khắp tỉnh Đắk Nông bao gồm 83 mẫu nước cấp, 114 mẫu nước mặt và 455 mẫu nước dưới đất, kết hợp với 100 mẫu lặp cho các loại mẫu. Toàn bộ mẫu được xác định pH trước khi bảo quản bằng a-xít  $\text{HNO}_3$  2% rồi mang về phòng thí nghiệm phân tích As trên thiết bị quang phổ cao tần plasma ghép khối phổ. Kết quả cho thấy có 19 mẫu có nồng độ As cao hơn mức giới hạn  $10 \mu\text{g/L}$ . Hơn thế nữa, ngoài nguồn nước cấp được phát hiện As vượt ngưỡng bởi Trung tâm Y tế dự phòng, một nguồn nước cấp khác với As cao cũng đã được tìm thấy từ nghiên cứu này. Trong số các mẫu nước giếng có Asen cao, kết quả tính toán hệ số nguy hại cho kết quả ba giá trị cao hơn 1, cho thấy các giếng nước này cần phải có các biện pháp xử lý trước khi sử dụng làm nước uống.

**Từ khóa:** Asen; Thạch tín; Nước giếng; Nước sinh hoạt; Đắk Nông.

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