Original Research Article

Determination of Fluoride concentration in Drinking Water Resource at Lao P.D.R.

ABSTRACT

Introduction: Consuming water from different sources might lead to different fluoride intake levels for human health. High or low-concentration contamination can cause risk factors for human health, such as dental cavities, dental fluorosis, and skeletal tissues. Accordingly, there is a limited amount evidence of fluoride contamination in drinking water among Lao people,

Aims: To estimate the level of fluoride concentration in drinking water sources and describe fluoride water drinking knowledge and behavior of Lao people.

Place and Duration of Study: The study was taken place in two areas of Laos: the northern and the southern, between May to December, 2023

Methodology:A cross-section was performed. The questionnaires were used in face-to-face interviews to gather information about participants, such as demographics, fluoride knowledge, and drinking water behavior. Testing for fluoride content was conducted using an ExStik FL700 fluoride meter from Extech Instrument. The data analysis was used SPSS for descriptive analysis.

Results:A total of 496 simples (36% male, and 63.10% Female; range ages 16-85 years). The study by contributing fluoride to 118 samples of drinking water that were collected for a criterion was that the mean level of fluoride concentration was 0.124 ppm, which is in the range of 0.01-0.7 ppm, SD=0.126. In addition, almost all the drinking water resources of the sample participants were from bottled water (82.3%). The behavior of water drinking was high in more than 2 liters per day and not boiling water before drinking (73%). The fluoride knowledge's participants were more in don't know of fluoride (91.30%).

Conclusion: Fluoride is a naturally occurring mineral on the surface of the planet that can contaminate food, air, and other resources, especially water. Annually, a fluoride contamination assessment is required for optimal health.

Keywords: Fluoride concertation, drinking water, Oral health risk factor, fluoride knowledge, dinking behavior.

1. INTRODUCTION

Fluorine is a mineral found in several naturally occurring minerals on the earth's surface and crust, including fluorite, cryolite, and fluorapatite[1]. Fluoride has been

added in increasing concentrations to natural fluids, particularly groundwater and natural rivers in some regions such as India and Central Africa. Contains a maximum of approximately 10 mg of fluoride per liter [2][3]. Epidemiological studies have shown that high fluoride concentrations can increase the risk of developing enamel fluorosis, dental fluorosis, skeletal fluorosis and soft tissue problem see as hypothyroidism[4, 5][6] . Moreover, in 2003, the WHO recommended that the standard amount of artificial fluoride in community water supplies is 0.5-1.0 mg/L [7]. Although fluoride may be a necessary component for humans, there is evidence that fluoride is a critical substance in relation to the prevalence of dental caries. Fluoride is typically used to prevent dental caries systemically and topically. Fluoride is believed by many studies to be incorporated into the surface of teeth, making them more resistant to decay and demineralizing early dental erosion cause by acid from bacteria. When fluoride is supplied systemically during all stages of tooth formation and topically, there were a significant decrease in dental caries. Both are exposed while drinking water containing fluoride[8].

Lao PDR is a developing nation with many residents living in rural areas. The majority of Laotians work in agriculture. Thus, there is still a paucity of private drinking water systems in residential areas, particularly in the country's northern and southern regions. Only 48% of primary schools and 25% of health institutions have access to safe drinking water in rural areas, according to the previous reporter's report from 2020[9].As the Lao national community on nutrition revealed, 90.15% of the country's population can access water supplies[10]. According to the reviewer, a higher fluoride concentration in drinking water is one of the risk factors for health issues, but it can typically be used to promote good health by preventing dental cavities. Therefore, the study was conducted for determine fluoride contamination in Laos' drinking water resources.

2. MATERIAL AND METHODS

A descriptive cross-sectional study was conducted in the study. It was conducted at 4 villages; 2 villages in Lungprabang province (Northern part) and 2 villages in Champasck province (Southern part) of Lao PDR. In each province were 1 village representative in rural and 1 village representative in city. The simple size was calculates using the following formula[11].

$$n = \frac{p \times q \times z_{\propto}^{2} \times N}{\Delta^{2} \times N + p \times q \times {z_{\propto}}^{2}}$$

Where;

n = the required simple size.

p and q = a part and its inverse value in each class of the general totally (p=0.5; q=0.5)

z_{α}=Standard error division =95%=1.96.

Δ= Difference in effect of two intervention which is required (estimates effect size) Δ=5%

N = General totally amount (N_1=128; N_2=181, N_3=210, N_4=120 (Local administration authority according from annual reported, 2023)**;** N_1**=**Rural village**,** N_2 =City village of Lung prabang province; $N_{3=}$ Rural village, $N_{4=}$ City village of Champasack province.

$$n1 = \frac{50 \times 50 \times 1.96^2 \times 128}{5^2 \times 128 + 50 \times 50 \times 1.96^2} = 96\,; \quad n2 = \frac{50 \times 50 \times 1.96^2 \times 181}{5^2 \times 181 + 50 \times 50 \times 1.96^2} = 123$$

$$n3 = \frac{50 \times 50 \times 1.96^2 \times 210}{5^2 \times 210 + 50 \times 50 \times 1.96^2} = 135; \quad n4 = \frac{50 \times 50 \times 1.96^2 \times 120}{5^2 \times 120 + 50 \times 50 \times 1.96^2} = 97$$

Provided inevitable loss amongst the participants in the course of study for various reasons the calculated sample size was increased by 10%:

$$n1 = 96 + (10\% \times n1) = 106; \quad n2 = 123 + (10\% \times n2) = 135$$
$$n3 = 135 + (10\% \times n3) = 148; \quad n4 = 97 + (10\% \times n4) = 107$$

A tally simple size =106+148+135+107= 496

Inclusion criteria: all available sources of drinking water such as river, wells, spring, boreholes, bottled water in household sample during the study. Exclusion criteria: The same source of drinking water in each household sample participant was not collected and unclean drinking water source, which has been contaminated with chemicals from factories or another site.

Question interview: An open-ended questionnaire was administered by face-to-face interview from 4 dentists from faculty of dentistry, including the pilot questionnaires were used to ensure their reliability with 30 household sample participant living in Vientiane capital of the same geographic of group data collection.

Drinking water resource sample collection: a 500 ml sample of each participant's drinking water source was collected in a disabled plastic bottle and labeled with a unique identifier, date, time and area was collected a sample.

Fluoride concentration analysis: 2 dentists from the faculty of dentistry evaluated the fluoride concentration. The first dentist to develop a sample water solution and the last to perform a fluoride concertation calculation. The situation of detected of fluoride concentration was a room temperature or at least 25°C[12]. The ExStik FL700 fluoride meter from Extech Instrument has conducted on study site for fluoride test of water. Total ionic strength adjustment buffer (TISAB) table were used as reagent. For values exceeding the meter's operating arrange of 0.00-9.99, deionized water used for dilution. Base on the instrument's user guide, the fluoride meter was calibrated between 1and 10 ppm fluoride standard and other tablet in 20ml to 10 ppm fluoride

standard, respectively. [13][14]. Fluoride concentration evaluation processed flowed by: First, the instrument of fluoride concentration was calibrated before tests. The positive control contained 20 ml of a 1 ppm fluoride standard solution, while the negative control had 20 ml of distilled water with one tablet reagent of the Total Ionic Strength adjustment buffer (TISAB) added.Second, add one tablet of the Total Ionic Strength Adjustment Buffer (TISAB) reagent to 20 ml of sample water drinking from the collection in the simple cup. Wait for the table to dissolve, mix well, and then completely rinse the instrument's end with distilled water before wiping it dry with a clean tissue. The instrument has immersed into the simple preparation. Last, after 35 second an instrument was display the value of the fluoride concertation in a numeric arrange from the 0 to 9.99 ppm[14]. Statistical were performed with SPSS (Statistical Package for Social Sciences) version 27. Data on the following by characteristic, drinking water fluoride knowledge, behavior and fluoride concentration levels are presented using the descriptive statistic frequency percentage, mean, standard deviation.

3. RESULTS AND DISCUSSION

A total 496 of patriciates in the study, a number of gender group of participants in the study was more by Female (63.1%), while age groups more in 25 to 49 years' old with (70.2%). More education level at primary school (24.6%). Over 70% had shown not boiling water before drinking, 72.60% had drinking water more than 2 liters per day, and 86.70% had to pay for water they didn't know fluoride (91.30%), including never tested fluoride concertation level in the past. As a table 1

Table 1 Demographic characteristic, drinking water consuming behavior, fluoride's knowledge

Gender	**Number**	**Percentage**
Male	183	36.90
Female	313	63.10
Age		
>25	23	4.60
25-49	348	70.20
50-74	117	23.60
<75	8	1.60
Education		
No education	95	19.20
Primary school	137	27.60
Middle school	122	24.60
Secondary school	108	21.80
Higher	34	6.90
Preparing water consuming		

Not boiling	366	73.80
Boiling	104	21.00
Other	26	5.20
Drinking water liter per day		
2 liter>	136	27.40
< 2 liter	360	72.60
Cost for drinking water		
No pay	66	13.30
Pay	430	86.70
Payment per year for drinking water		
1-396.000 kip	107	24.90
397.000-900.000 kip	112	26.00
900.100-1.326.000 kip	104	24.20
<1.326.000 kip	107	24.90
Fluoride knowledge		
Don't know	453	91.30
Know	43	8.70
Drinking water fluoride concentration levels evaluation in past		
Never	496	100
Ever	0	0.00

Table 2 shows details the distribution of resources for drinking water participants in the rural and city villages of Lung Prabang and Champasack province, with a higher percentage coming from bottled water: 17.9%, 26.8%, 17.7%, 19.8%, and 1.2%.

Table 2.Distribution of the resource for drinking water.

Type of water resources	**Lung prabang provinces**		**Champasack provinces**		**Total**
	Rural N(%)	**City N(%)**	**Rural N(%)**	**City N(%)**	
Tap water	-	2(0.4.00%)	-	9(1.80%)	11(2.20%)
River	2(0.40%)	-	5 (1.00%)	-	7(1.40%)
Spring	7(1.40%)	-	-	-	7(1.40%)
well water	2(0.40%)	-	-	-	2(0.40%)
Borehole water	6(1.20%)	-	55(11.10%)	-	61(12.30%)
Bottled water	89(17.90%)	133(26.80%)	88(17.70%)	98(19.80%)	408(82.30%)
Total	**106 (21.40%)**	**135(27.20%)**	**148(29.80%)**	**.07(21.60%)**	**496(100%)**

- No distribution of drinking water resource types

As a result, 496 householders participated in the study by contributing fluoride to 118 samples of drinking water that were collected for a criterion of mean 0.124, which is in the range of 0.01-0.7 ppm. Table 3. Note that drinking water resource from river

and spring was lowest level concentration of fluoride with a mean 0.082ppm and 0.015ppm, while the highest concentrations were drinking water resources from borehole water with mean 0.22 ppm. as detailed in table 3.

Table 3.Fluoride concentration levels

Type of drink king water resource	n. sample householder	n. sample drinking water	F-conc** Rang	F-conc** Mean (ppm*)	SD
Tap water	11	3	0.02-0.3	0.101	0.103
River	7	7	0.03-0.1	0.082	0.298
Spring	7	7	0.01-0.02	0.015	0.005
well water	2	2	0.03-0.04	0.035	0.007
Borehole water	61	61	0.02-0.7	0.22	0.169
Bottled water	408	43	0.01-0.5	0.11	0.114
Total	**496**	**118**	**0.01-0.7**	**0.124**	**0.126**

*1 part per million (ppm) =1 mg/L
**

Fluoride concentration

The study's findings, the average fluoride concentration in drinking water resources was found to be low 0.124 mg/L when compared to WHO recommendations [14]. In order, the average of fluoride was highest in groundwater drinking resources as a borehole water, while a lowest in drinking water resources from surface as river and spring water resources. the result study was similar GT. Tayanin (1999) noted that the lowest value for fluoride concentration in drinking water in Laos from stream water was 0.013 ppm and the average fluoride concentration in drinking water in Luagpraban was 0.512 ppm[15]. Including the 2003 study by Hoque et al. published in Bangladesh, the average concentration of fluoride was found to range from 0.02 to 2.32 mg/L; the lowest concentration was found in surface water, with a mean of 0.14±0.10 mg/L, while the highest concentration was found in groundwater, with a mean of 0.33±0.21 mg/L. [16]. Whereas a study in Cambodia (2022) shown that in the Southern coastal area was exospore to fluoride concentration >50mg/L [17]. E. Shaji et al. (2024) recommend investigating the high fluoride in groundwater by exploiting rich rocks that include minerals such as biotite and amphiboles, especially in metamorphic basement rocks[18]. Furthermore, the findings indicated that the distribution concentration of fluoride is contingent upon the various sources identified in each region.

Conversely, the study we found the groups that drank more than 2 liters of water per day. Sawka, MN(2005) note that the net body water balance, which is astonishingly well-regulated day-to-day (loss = gain) [19]. Including, the body of an

individual requires water due to a variety of components that affect the intake of water for instance dietary habits, physical activity and climate [20], this finding suggests that the low amount of fluoride in their drinking water did not effected of fluoride concertation in the human body. Therefore, consuming more liters of drinking water each day does not always mean that the water was contamination with fluoride at high fluoride concentration levels.

The main drinking water resource for participants was bottled water that was unboiled before drinking is different study by GT. Tayanin (1999) showed that the main drinking water resource for the Lao people in Vientiane was the Mekhonge river, and water was boiled before drinking [15]. According to the result, in the current situation, a majority of consumers changed their behavior compared to the past, and following C ferrite-AMBIO (2010), bottled water consumption is a global trend, driven by factors such as taste, safety, and health concerns. Consumers prefer bottled water over tap water due to its perceived purity and safety. Urbanization, increased care usage, and changing working habits have led to a higher demand for bottled water. The use of plastic in bottles makes them lighter and easier to carry. The expansion of shopping centers and the decline of agriculture and industry have also contributed to the rise in bottled water consumption. Overall, bottled water is a popular choice for consumers worldwide [21][22]. However, the human body and environment were the impact sites of the plastic applied, with micro plastics causing severe harm to human cells[23]. resulting in major health consequences such as lung illness, cancer[24], and climate change[25].

In addition, the study also had some limitations due to the prevalence of dental caries. Therefore, if the applicant should have completed the following examination, it was conducted according to the criteria of the oral health survey was approved by WHO. especially in the oral exam.

4. CONCLUSION

The identification of low fluoride levels, regional variations and potential sources of contamination highlights the need for urgent action to address these issues. It is imperative that stakeholders work together to implement effective management strategies and policies to ensure a safe and sustainable drinking water supply for all, especially in the prevention of oral health in Laos.

ETHICAL APPROVAL

Ethical Approval was approved from the Ethic Committee of University of Health Sciences Lao PDR no. 502/IREC, date27/4/2023.

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DEFINITION, ACRONYMS, ABBREVIATIONS

1. The concentration of fluoride in drinking water refers to the mineral ionic form of naturally occurring water, and it could differ based on the source and treatment methods. Normally, measurement in part per million (ppm)or milligram per liter (mg/l).
2. Drinking water resources refer to sources of water that provide clean, safe water for people to consume. The resource can include rivers, taps, springs, wells, boreholes, and bottled water. Normally, measurement in litter per day.
3. Fluoride knowledge's refers to information, understanding, or experiment related to fluoride in person.
4. Drinking water behavior refer to person drinking water patterns, habits, and choices in variable for their consumption of water.