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Assessment of ^{226}Ra levels and the lifetime cancer fatality risk from drinking water in Muang District, Maha Sarakham province

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Abstract - ^{226}Ra is radioactive and decayed from uranium, which is found naturally in soil and rock, and can get into water consumption supplies. Exposure to the radium in high doses, which is much higher than the levels seen in drinking water can be inducing cancer. In this study, A total of 69 drinking water samples were collected from Muang District, Maha Sarakham Province, and were measured ^{226}Ra in water samples via Mn-fiber using gamma spectrometry (HPGe detector). The results showed that ^{226}Ra concentrations ranged from 0 to 0.097 Bq/l and an average value of 0.025±0.003 Bq/l. All measured ^{226}Ra concentrations are well below the allowed maximum level recommended by the WHO is 1 Bq/l. Lifetime cancer risk, as a result of ingestion of ^{226}Ra by people from the study areas shows that an average of 3.81 out of 1,000,000 may go through some of the fatality cancer development, and 0.53 out of 1,000,000 may go through some of the hereditary effects.

Keywords: ^{226}Ra, The lifetime cancer fatality risk, HPGe

1. Introduction

Radionuclides of natural origin exist in varying amounts in water (El-Zayat *et al.*, 2022; Atyotha *et al.*, 2022) which is strongly related to the common naturally occurring radionuclides in the two primordial radioactive series (^{238}U and ^{232}Th series), Many radionuclides in the radioactive decay series of ^{238}U are highly radiotoxic, where the most radiotoxic among them is ^{226}Ra, which is known as a carcinogen (Hashim *et al.*, 2014). ^{226}Ra is radioactive that can accumulate in the environment, such as rocks, soil, water, plants, and food (Ezzulddin & Mansour., 2020; Kappke *et al.*, 2016). However if radioactive is accumulated in the human body at a high level, it will affect your health. When people drink water containing ^{226}Ra dissolved in a high volume, can cause cancer in various organs such as the lungs, liver, kidneys, and endocrine organs (Atyotha *et al.*, 2022; Kappke *et al.*, 2016). The researchers were aware of the problems in this regard, so we have measured the amount of ^{226}Ra in drinking water that people use on a regular basis. We choose to study drinking water samples from villages in the research areas in order to measure the safety and the risks that affect the health of people in the study area.

2. Materials and methods

2.1 Preparation

The 69 drinking water samples were packaged in 10 liter gallons (Before packing, the water must be opened for 5-10 minutes). ^{226}Ra was captured from the water sample with Mn-fiber, which was a filter made from acrylic fiber coated with Potassium permanganate ($KMnO_4$) (Atyotha., 2016). After that, it is placed in a sealed container and allowed to enter the equilibrium radiation for about 30 days.

2.2 The ^{226}Ra activity concentration

After a month, ^{226}Ra in drinking water samples were measured by the gamma spectrometry (HPGe detector) for 20 hr/ sample. Calculation of ^{226}Ra in tap water samples was taken by the net peak area from gamma radiation of ^{226}Ra at 186.2 keV using the following equation 1. (Atyotha., 2016)

$$A = \frac{cps}{E \times I \times V} \tag{1}$$

Where, A = The ^{226}Ra activity concentration (Bq/l), cps = count rate of gamma radiation at 186.2 keV per measurement time (sec), E = The efficiency of HPGe detector, I = Proportion of gamma radiation at 186.2 keV of ^{226}Ra = 4%, V = volume of tap water sample (l)

2.3 The dose rate intake

The dose rate intake of ^{226}Ra from drinking water was measured for different age groups as following equation 2. (El-Zayat *et al.*, 2022; El-Gamal *et al.*, 2019)

$$D = A \times C_R \times C_F \tag{2}$$

Where, D = The dose rate intake (Sv/y), A = The ^{226}Ra activity concentration (Bq/l), C_R = the annual intake of drinking water (l/y) which is 150, 350, and 500 l for infants (0-2 y), children (3-17 y), and adults (18+y) respectively, C_F = is the ingested dose conversion factor for related V, which is 9.6, 8, and 2.8 (x 10^{-7} Sv/Bq) for infants, children, and adults, respectively.

2.4 The lifetime cancer risk

The radiation health effects of drinking water taking were estimated in people can cancer risks by the methodology of ICRP (El-Zayat *et al.*, 2022; Abbasi & Mirekhtiary, 2019; Duong *et al.*, 2021). In this presentation, the health risks to individuals as a result of exposure to low-dose radiation from V were estimated as following equations 3 and 4. (Mahmoud & El-Zohry, 2020; Ononugbo & Nwaka., 2017)

$$L_C = D_{av} \times C_C \times L \quad (3)$$

$$L_H = D_{av} \times C_H \times L \quad (4)$$

Where Dav = The average dose rate intake of infants, children, and adults (Sv/y), LC is the lifetime cancer fatality risk and LH is the lifetime cancer hereditary risk and CC and CH are caner effect coefficients of 5.5×10^{-2} and 0.2×10^{-2} (Sv-1) for fatality and hereditary risk respectively reported by ICRP and L is the lifetime of continuous exposure of the population to low-level radiation from ^{226}Ra, which assumed to be 70 years

3. Results and discussion

The results will show statistical data for ^{226}Ra concentration, salinity, conductivity, temperature, pH and The dose rate intake and the lifetime cancer fatality risk (LC and LH) in the research areas of 14 sub-districts, 69 samples were randomly collected as shown in Table 1 and Table 2., respectively.

Table 1. The average ^{226}Ra concentration and parameter of drinking water

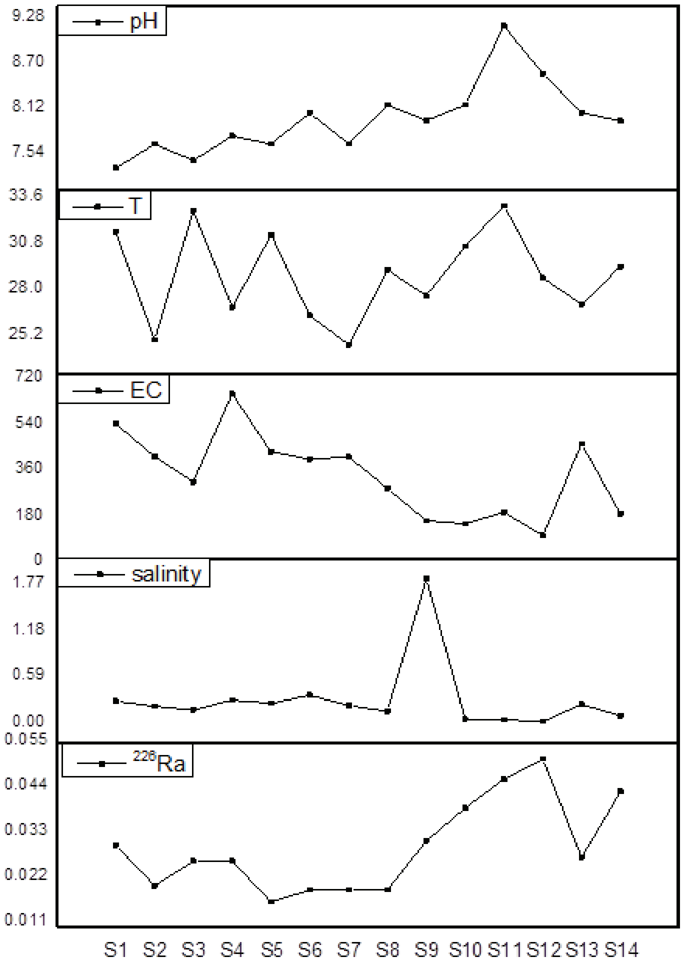
Site	No. samples	^{226}Ra concentration	salinity	EC	T	pH
		Bq/l	ppt	µS/cm	^{0}C	
Talat	16	0.030	0.27	528	31.2	7.3
Khwa	6	0.020	0.2	398	24.6	7.6
Kaeng Loeng Chan	5	0.026	0.16	300	32.5	7.4
Waeng Na	3	0.026	0.28	645	26.6	7.7
Tha Song Khon	1	0.016	0.24	417	31.0	7.6
Tha Tum	8	0.019	0.34	388	26.1	8.0
Ladpattana	10	0.019	0.21	397	24.3	7.6
Khok Ko	3	0.019	0.14	275	28.9	8.1
Huai Ang	2	0.031	1.82	148	27.3	7.9
Nong Pling	4	0.039	0.04	136	30.3	8.1
Nong No	1	0.046	0.03	181	32.8	9.1
Don Wan	1	0.051	0.01	91	28.4	8.5
Koeng	7	0.027	0.23	448	26.8	8.0
Bua Kho	2	0.043	0.08	176	29.1	7.9

Table 1, shows the results of ^{226}Ra from the drinking water samples varied from 0 to 0.097 Bq/l with an average of 0.026±0.0035 Bq/l, while the parameters of the quality of drinking water are as follows: 1) salinity varied from 0.01 to 3.62 ppt with an average of 0.27±0.12 Bq/l; 2) conductivity (EC) varied from 59 to 1,130 µS/cm with an average of 368.35±35.59 µS/cm; 3) temperature varied from 22.5 to 34.2 ^{o}C with an average of 27.53±0.44 ^{o}C, and 4) pH varied from 6.7 to 9.1 with an average of 7.8±0.08. the ^{226}Ra concentration levels of the drinking water samples collected from different sites in study areas were found to be lower than the action level of 1 Bq/l, recommended by WHO (Ononugbo & Nwaka., 2017; Yamada *et al.*, 2022; WHO, 2017). Therefore, ^{226}Ra concentrations level in the drinking water of these areas is safe for people to intake. The results from Table 1 were used to create a map for the relationship between ^{226}Ra concentration and parameters in the drinking water of research areas as shown in Figure 1.

Table 2. The dose rate intake and the lifetime cancer fatality risk (L_C and L_H)

Site	Dose intake (µSv/y)			lifetime cancer risk x10^{-6}	
	Infants	Children	Adults	L_C	L_H
Talat	6.35	0.0010	R	5.49	0.87
Khwa	2.82	0.0001	R	3.62	0.51
Kaeng Loeng Chan	3.72	0.0010	R	4.77	0.67
Waeng Na	3.77	0.0011	R	4.84	0.69
Tha Song Khon	2.32	0.0007	R	2.98	0.42
Tha Tum	2.80	0.0008	R	3.59	0.50
Ladpattana	2.71	0.0008	R	3.48	0.48
Khok Ko	2.71	0.0008	R	3.49	0.49
Huai Ang	4.47	0.0013	1.49	5.74	0.80
Nong Pling	5.68	0.0016	1.89	7.29	1.02
Nong No	6.62	0.0019	2.21	8.50	1.19
Don Wan	7.34	0.0021	2.45	9.42	1.32
Koeng	3.94	0.0011	R	5.06	0.72
Bua Kho	6.13	0.0017	R	7.86	1.10

***Remark**: R<1 nSv/y



***Remark:**
Name of Subdistrict;
S1=Talat
S2= Khwa
S3=Kaeng Loeng Chan
S4=Waeng Na
S5=Tha Song Khon
S6=Tha Tum
S7=Ladpattana
S8=Khok Ko
S9=Huai Ang
S10=Nong Pling
S11=Nong No
S12=Don Wan
S13=Koeng
S14=Bua Kho

Figure 1. the relationship between ^{226}Ra concentration and parameters in the drinking water of research areas

From table 2, shows the results of dose rate intake from the drinking water samples for different age groups as follows: the dose rate intake for infants varied from 0 to 13.96 µSv/y with an average value of 2.96±0.46 µSv/y, and the dose rate intake for children and adults, which most of them have very a few values varies from 0-1 nSv/y. The dose rate intake in (µSv/y) for the water consumption of the mentioned locations for infants, children, and adults is lower than that recommended by WHO is 100 µSv/y. According to the results in Table. 2, the lifetime fatality of cancer varied from 0 to 17.92×10^{-6} with an average value of 3.81×10^{-6}, while the lifetime hereditary effects varied from 0 to 2.51×10^{-6} with an average value of 0.53×10^{-6}. The findings show that an average of 3.81 out of 1,000,000 may go through some of the fatality cancer development and 0.53 out of 1,000,000 may go through some of the hereditary effects.

The results from Table 2 were used to create a map for the relationship between ^{226}Ra concentration and lifetime cancer fatality risk (L_C) and lifetime cancer hereditary risk (L_H), which as a result of ingestion of ^{226}Ra in drinking water by people from the study areas as shown in Figure 2.

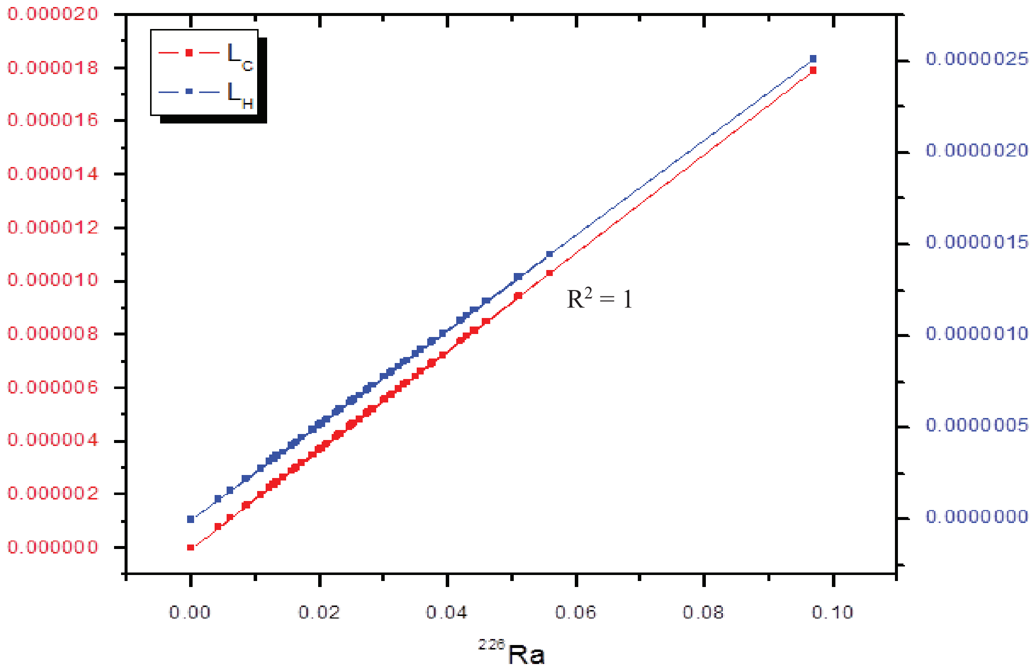


Figure 2. the relationship between ^{226}Ra concentration and L_C, L_H

Figure 2 the relationship of the graph is $R^2 = 1$, illustrating that, when a person ingests high levels of radium-containing drinking water, it directly affects the risk of death from cancer or may directly affect genetic changes.

The results from Table 1 (^{226}Ra concentration and GPS coordinates of sampling) were used to create a contour map for the distribution of ^{226}Ra concentration in 14 Sub-districts of Maha Sarakham Province as shown in Figure 3.

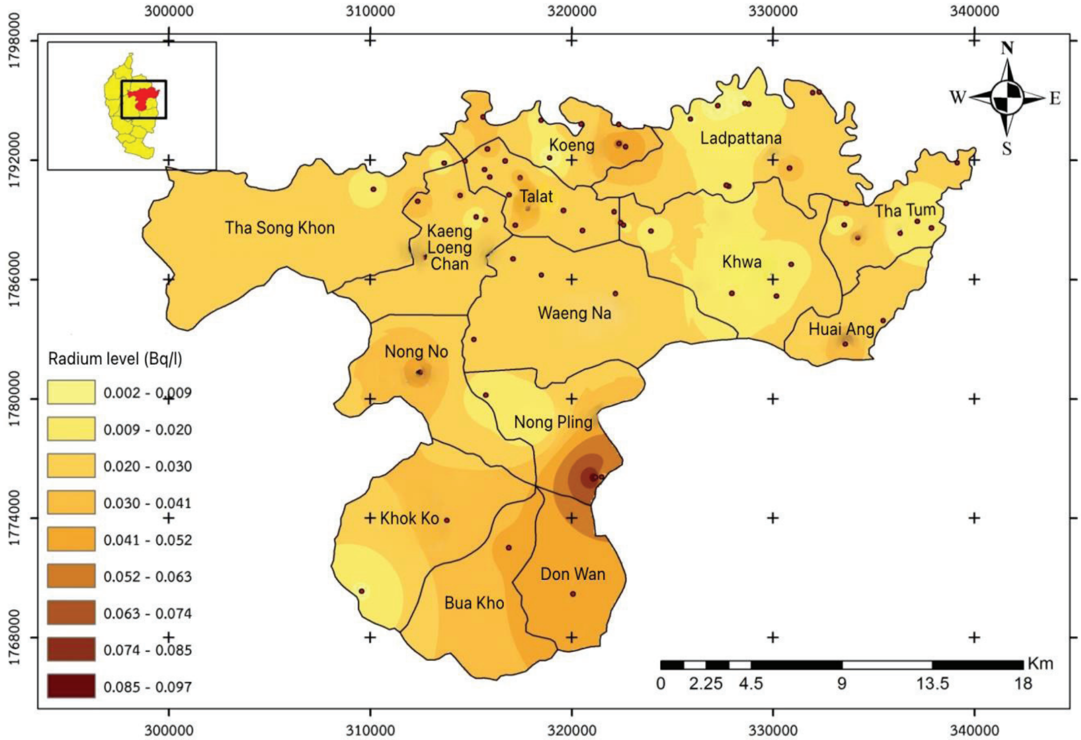


Figure 3. Contour map of ^{226}Ra concentration in research area.

4. Conclusion

In this research, ^{226}Ra concentration level has been calculated in 69 drinking water samples collected from different locations in Muang District, Maha Sarakham Province using Techniques for capturing radium in water by Mn-fiber together with measurements of gamma radiation at 186.2 keV by HPGe detector. Furthermore, the dose rate intake as a result of the ingestion of ^{226}Ra through drinking water consumption and the estimated lifetime cancer fatality risk and lifetime cancer hereditary risk were analyzed and discussed. All results analyzed are lower than those recommended by the WHO. Therefore, the relative cancer risk from ^{226}Ra exposure is low and is safe for people when the hazardous health effects of radiation are concerned in this study area.

5. References

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