Analysis of Radionuclides in Water and Sediments from Two Hot Springs near Panglong

Lae Lae Win, Aye Aye Mu, Aye Myat Mon

Abstract

The water samples of two hot springs, Kye-Thi and Hko-Lam near Panglong were examined in Public Health Laboratory. The water chemical analysis reports are chemically potable. The radionuclides contained in sediment samples from these hot springs in Southern Shan State were determined. The gamma activities were measured to investigate the radionuclides in the sediment samples with NaI (Tl) gamma ray spectrometer by using Gamma-Vision 32 Software. By analyzing the spectra, the following radioisotopes were investigated. They are ^{228}Ac, ^{212}Pb, ^{208}Tl, ^{226}Ra, ^{214}Pb and ^{214}Bi. Those radionuclides were the products of U and Th natural radioactive series. It is expected that U and Th are concentrated in sediments of the hot springs. Concentration of these nuclides in sediment samples were calculated by using measured data and literature values. All radionuclide concentrations in the hot spring sediment samples were found to be very low percentage.

Introduction

Hot springs have been found in Kachin State, Shan State, Kaya State, Kyaukpyu area in the southern part of Yakhine State, central Myanmar area, Shwebo-Monywa area and especially in Mon State and Tanintharyi Region. Hot springs are usually associated with the later stages of volcanic activity, and just as volcanic phenomena are manifested particularly along fissures or faults in the rocks of the earth's crust, so hot springs often tend to be associated with similar faults.

It is possible for underground water to take up large amounts of mineral matter and bring them to the surface again in springs. As rain falls on the surrounding peaks, it percolates into the rather porous sedimentary rocks. As it descends through the rock, it picks up a variety of materials, everything from radium to sulphur.

Prrofessor , Department of Physics, Panglong University
Lecturer, Department of Physics, Panglong University
Assistant Lecturer, Department of Physics, Panglong University

The ground water seeping through joints and cracks in the bedrock penetrates to depths of several thousand feet where it comes in contact with heated rocks. Hydrostatic pressure from behind forces it to ascend by circuitous courses through seams and cracks in unaltered rock which slowly widen under the disintegration influences of igneous vapors. Finally, the thermal waters, following these rocks, issue at the surface as hot springs and pools. Underground reservoirs are thus excavated and become sources of hot spring and, under favorable conditions, of geysers. The warm water allows an abundance of algae and bacteria to live. The warm water also allows an abundance of life to survive.

The smell of hot springs is reminds of rotten eggs and clears sinuses better than nasal mist. The smell is a result of H_2S (Hydrogen Sulphide), a gas similar to natural gas. It results from anaerobic bacteria converting some of the dissolved sulphur in the water to H_2S. This can be seen in springs like Radium where the water reaches the surface through aerated caves, which allow the H_2S to oxidize before it reaches the surface; the end of the result outcome has indicated any smell at all.

There is no essential difference between hot springs or geysers. A geyser requires three critical elements in order to form: a water supply, a heat source, and the proper kind of underground water circulation system. If only two of these out of three components are present, hot spring will found. Although there are many places in the world where hot springs can be found, geysers are extremely rare, largely due to the three specific requirements for their formation.

In this research, the water samples of the two hot springs were determined by Water Chemical Analysis in Public Health Laboratory, Mandalay. The sediment samples of these two hot springs were identified with NaI (Tl) scintillation detector by Gamma Spectrometric Analysis in Experimental Nuclear Physics Laboratory, Mandalay University.

Materials and Methods

Sample Location (Sampling Site), Collection and Preparation

Hot springs have been found Kye-Thi (Lat 21º 56´ (N), Long 97º 50´ (E)) and Hko-Lam (Lat 21º 6´ 15″(N), Long 98º 6´ 15″ (E)) in Southern Shan States. The water samples from the two hot springs were each collected with two liter bottles. The bottom sediments were collected with a one-inch in diameter pipe from the depth. The hot springs water temperatures were collected at about 60°C and 40°C. Kye-Thi hot spring is situated from 3128 feet above the sea level. Hko-Lam hot springs is situated from 2821 feet above sea level. The samples preparation like drying, grinding, homogenization and packing in proper geometrical dimensions for gamma spectrometric analysis was carried out for sediment samples. The sediment samples were dried at room temperature, avoiding the loss of any volatile radionuclides. The dried sediments were pulverized and sieved to pass through a 1-2 mm mesh. The meshed sediments were transferred to plastic containers of 300g capacity for gamma activity analysis.

Public Health laboratory Determination for Water Samples

The two water samples were tested in Public Health Laboratory in Mandalay. The water chemical analysis reports include test, result, highest desirable level and maximum permissible level. The test gives appearance, colour (platinum, cobalat scale) and pH value. The total solids, total hardness (as $CaCo_3$), total alkalinity (as $CaCo_3$), calcium, magnesium, chloride and sulphate are represented in P.P.m(mg/l).

Experimental Procedure in Gamma Transmission Measurement for Sediment Samples

The two sediment samples were investigated with Gamma Emission Measurement. In gamma ray spectrometry system, the following equipments are included. They are NaI (Tl) scintillation detector associated with ORTEC (Model 296) photomultiplier tube, high voltage power supply, preamplifier (Model 142 PC), fast spectroscopy amplifier (Model 671), a pulse stored multi-channel analyzer (MCA) together with Gamma Vision 32 software installed in PC. The high voltage power supply was used for supplying the potentials for the detector. The operating voltage for NaI (Tl) scintillation detector is 1000V. The 3" x 3" NaI (Tl) Scintillation detector was used to detect the gamma radiation intensity before and after passing though the absorbing material and this information (electronic pulses) was amplified and stored in MCA based on personal computer. . The whole system including detector and all other modules were from ORTEC.

This experimental setting was fixed for throughout the whole research measurement in the Experimental Nuclear Laboratory in Mandalay University. In this research, the standard four gamma sources ^{22}Na (activity = 1μCi, half-life = 2.6 years, energy = 511.00 keV and 1274.54 keV), ^{60}Co (activity = 1μCi, half-life = 5.27 years, energy = 1173.23 keV and 1332.49 keV), ^{137}Cs (activity = 1μCi, half-life = 30.2 years, energy = 661.65 keV) and ^{133}Ba (activity = 1μCi, half-life = 10.8 years, energy =81.00 keV ,303keV and 356keV)were used for energy calibration. The calibration time was 300 seconds. These sources have May 2013 manufactured date.

The lead (Pb) shielding was used to shield cosmic rays and other radiations in environment. In this work, conversion gain was set at 2048.Coarse gain was fixed at 20 and fine gain was 0.87. Shaping time was 1 μ second. Real time was set at 15000 seconds and live time was set at 7200 seconds.

By putting the polythene container on the NaI (Tl) scintillation detector, the background was measured for two hours. The sediment samples were placed in the container and were measured for about two hours. Using the displayed energy information, an unknown radioisotope can be identified and determined by the gross area and net area of full energy peak. The photograph of the experimental arrangement for detecting system is shown in Figure (1).The top view for sediment sample in the lead shield is illustrated in Figure (2). The photograph of sediment sample in the container is also shown in Figure (3). Intensity of gamma-rays spectrum lines were calculated by using the equation (1).The equation of the activity of the sample is

$$\mathbf{A_{sample} = \frac{C_{sample}}{\varepsilon W P_{\gamma}}} \qquad (1)$$

A_{sample} = Activity of the samples (Bq/kg)

C_{sample} = Net count rate for sample

W = Weight of the sample under the NaI(Tl) crystal in kg

P_{γ} = Gamma emission probability for energy E

ε = Full energy peak efficiency

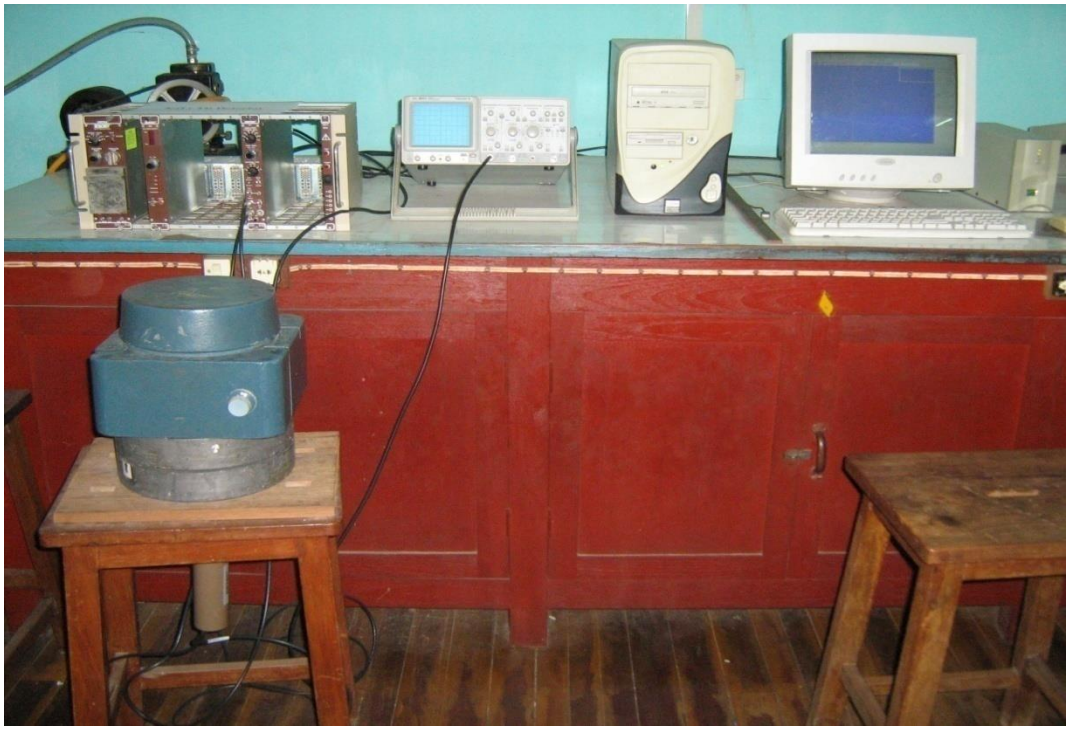

Figure (1) Photograph of Experimental Arrangement for Detecting System

Figure (2) Photograph of top view for sediment sample in the lead shield

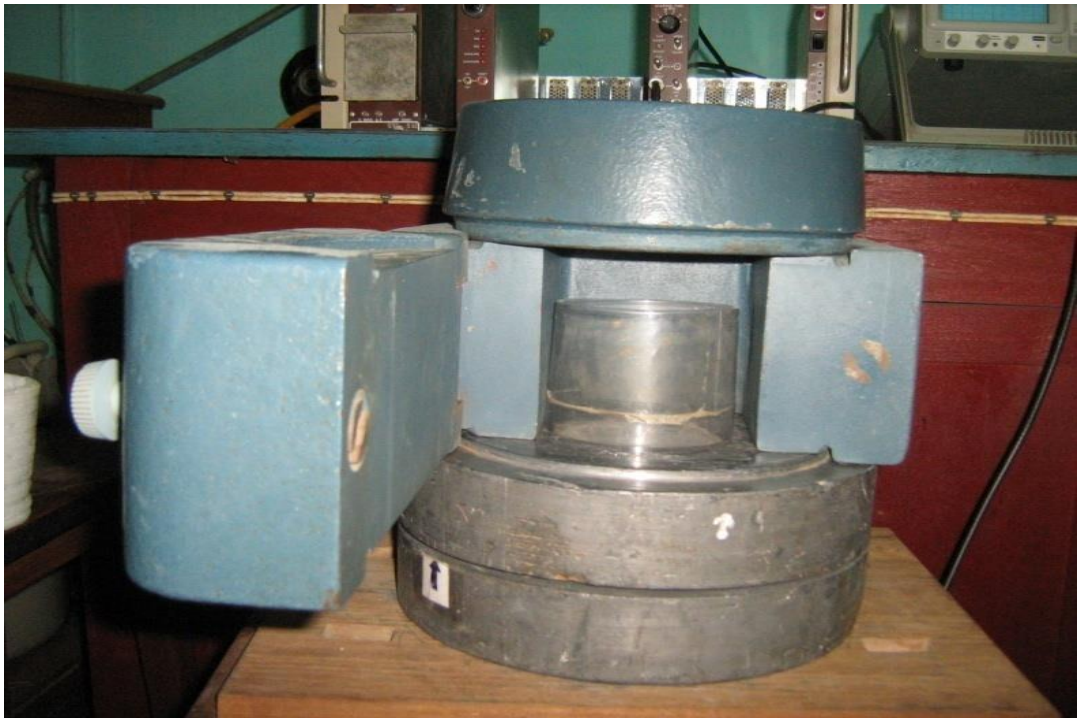

Figure (3) Photograph of sediment sample in the lead shield

Results and Discussions

The water chemical analysis report for Kye-Thi hot spring is listed in Table (1). The water chemical analysis report for Hko-Lam hot spring is listed in Table (2).The comparison for the results of the two analysis are illustrated in Figure (4) .The results are lower than the maximum permissible level. Therefore they are safe for use.

Results of sediment samples are identified by analysis of Gamma Vision Software. The radionuclides present in the sediment samples of two hot springs are shown in Table (3). Results of sediment samples observed are ^{208}Tl and ^{228}Ac daughter nuclei in ^{232}Th decay series, which are shown in Figure (5). The sediment samples observed are ^{214}Pb, ^{214}Bi, ^{234}Th and ^{226}Ra daughter nuclei in the ^{238}U decay series as shown in Figure (6). Although the half-life of the elements is short, according to the continuous spectrum of the samples, it can be assumed that there must be parent nuclei existing in them. The Table (4) is the radionuclides concentrations (Bq/kg) obtained from IAEA-385 reference material (Irish Sea Sediment). The activity concentration of different radionuclides in two sediment samples are calculated in Table (5).From Table (4) and Table (5), it can be seen that the activity concentration in the present research is less than that of IAEA-385. The comparison of gamma spectra with background and sediment samples of Kye-Thi hot spring is shown in Figure (7). Also the comparison of gamma spectra with background and sediment samples of Hko-Lam hot spring is shown in Figure (8). The comparison of three gamma spectra with background and two sediment samples from two hot springs is illustrated in Figure (9).According to Figure (9), the activity concentration in Kye-Thi sediment samples was much higher than the activity concentration in Hko-Lam sediment samples. Also the comparison of radionuclides in the two sediment samples from the two hot springs is represented in Figure (10).

Table (1) Water Chemical Analysis Report for Kye-Thi Water Sample

Test	Result	Highest desirable level	Maximum Permissible level
Appearance	Clear		
Colour (Platinum,Cobalat Scale)	7	5 Units	50 Units
Turbidity (Slilcada Scale Unit)	-	5 NTU	25 NTU
pH value	6.4	7.0 to 8.5	6.5 to 9.2
Total Solids P.P.m(mg/l)	1320	500 mg/l	1500 mg/l
Total Hardness(as $CaCo_3$) P.P.m(mg/l)	240	100 mg/l	500 mg/l
Total Alkalinity (as $CaCo_3$) P.P.m(mg/l)	910	600 mg/l	950 mg/l
Calcium as Ca P.P.m(mg/l)	98	75 mg/l	200 mg/l
Magnesium as Mg P.P.m(mg/l)	7	30 mg/l	150 mg/l
Chloride as Cl P.P.m(mg/l)	30	200 mg/l	600 mg/l
Sulphate as So_4 P.P.m(mg/l)	279	200 mg/l	400 mg/l
Total Iron as Fe P.P.m(mg/l)	Nil	-	-

Table (2) Water Chemical Analysis Report for Hko-Lam Water Sample

Test	Result	Highest desirable level	Maximum Permissible level
Appearance	Clear		
Colour (Platinum,Cobalat Scale)	5	5 Units	50 Units
Turbidity (Slilcada Scale Unit)	-	5 NTU	25 NTU
pH value	6.9	7.0 to 8.5	6.5 to 9.2
Total Solids P.P.m(mg/l)	1020	500 mg/l	1500 mg/l
Total Hardness(as $CaCo_3$) P.P.m(mg/l)	870	100 mg/l	500 mg/l
Total Alkalinity (as $CaCo_3$) P.P.m(mg/l)	650	600 mg/l	950 mg/l
Calcium as Ca P.P.m(mg/l)	69	75 mg/l	200 mg/l
Magnesium as Mg P.P.m(mg/l)	19	30 mg/l	150 mg/l
Chloride as Cl P.P.m(mg/l)	50	200 mg/l	600 mg/l
Sulphate as So_4 P.P.m(mg/l)	176	200 mg/l	400 mg/l
Total Iron as Fe P.P.m(mg/l)	Nil	-	-

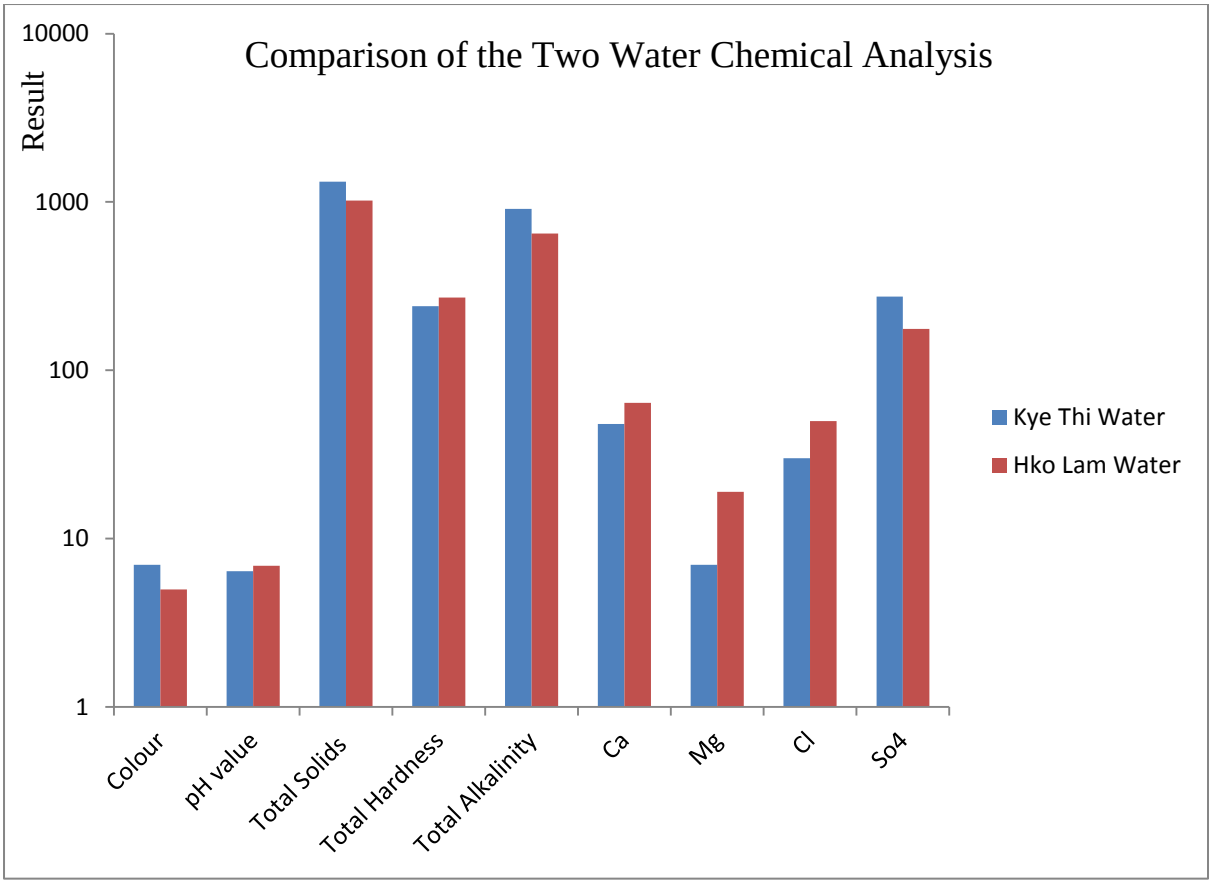

Figure (4) The comparison of the two water chemical analysis reports

Table (3) Radionuclides Present in Sediment Samples of Two Hot Springs investigated by γ-ray Spectroscopy using NaI(Tl) Detector

Radionuclide	Energy (keV)	Gamma Emission Probability (%)	Half-Life
^{234}Th	69.92	2.419	24.10 d
^{226}Ra	186.16	3.59	1600 y
^{212}Pb	238.89	43.30	10.64 h
^{212}Pb	300.08	3.28	10.64 h
^{214}Pb	352.28	37.6	26.80 m
^{208}Tl	582.99	84.5	3.05 m
^{228}Ac	911.51	25.8	6.15 h
^{214}Bi	1051.96	0.315	19.90 m
^{40}K	1464.93	11	1.28 E9 y
^{214}Bi	1662.86	2.92	19.90 m

Table (4) Radionuclide Concentrations (Bq/kg) Obtained from IAEA-385 Reference Material (Irish Sea Sediment)

Isotope	95%Confidence Interval (Bq/kg)
^{212}Pb	33.0-39.0
^{214}Pb	20.0-22.4
^{226}Ra	21.8-24.0
^{234}Th	22.4-34.1
^{208}Tl	9.3-13.5
^{228}Ac	29.8-32.6
^{214}Bi	17.8-21.0
^{40}K	603-625
^{238}U	28.0-30.5

Revision of the reference sheet dated January (1996)

Table (5) Activity Concentration of Different Radionuclide in two Sediments Samples

Sediment Sample Sites	Activity Concentration (Bq kg^{-1})									
	^{134}Th	^{226}Ra	^{212}Pb	^{212}Pb	^{214}Pb	^{208}Tl	^{228}Ac	^{214}Bi	^{40}K	^{214}Bi
Kye-Thi	21.19	23.69	11.95	36.95	14.41	2.25	2.58	-	40.40	-
Hko-Lam	16.95	22.74	5.57	37.87	19.95	1.09	2.30	-	10.10	-

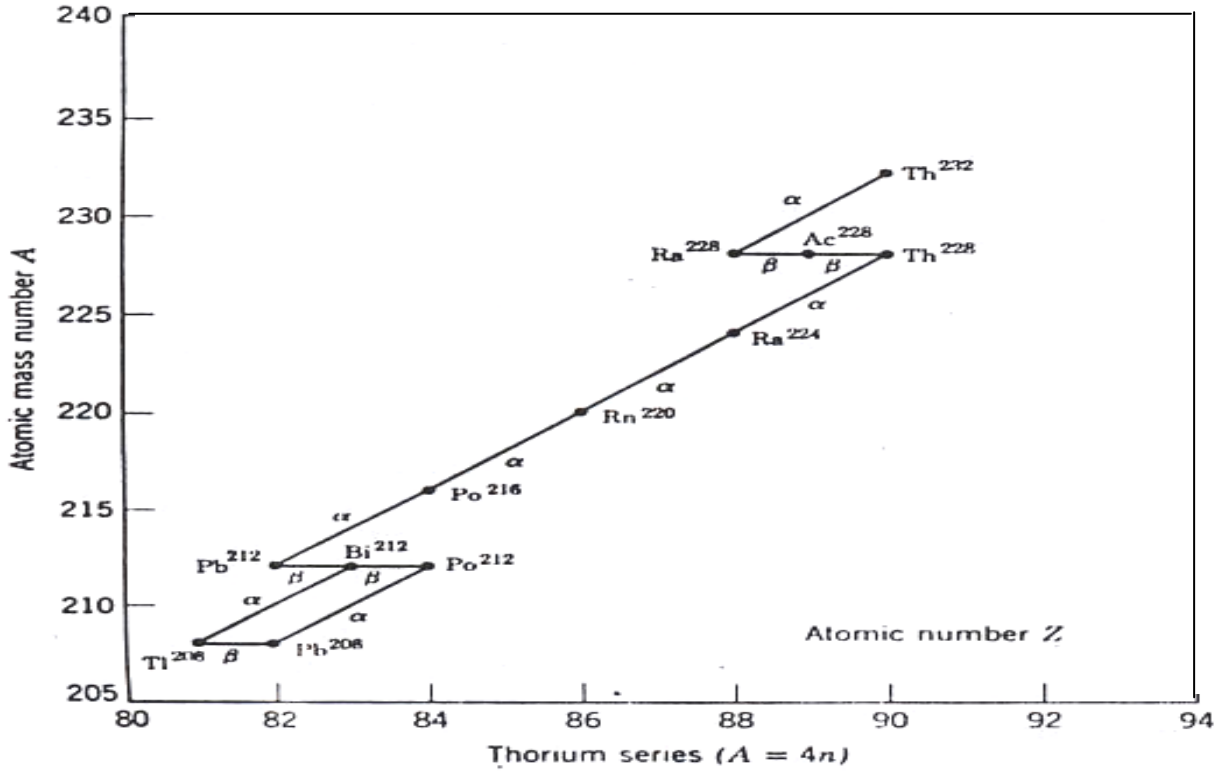

Figure (5) Thorium series

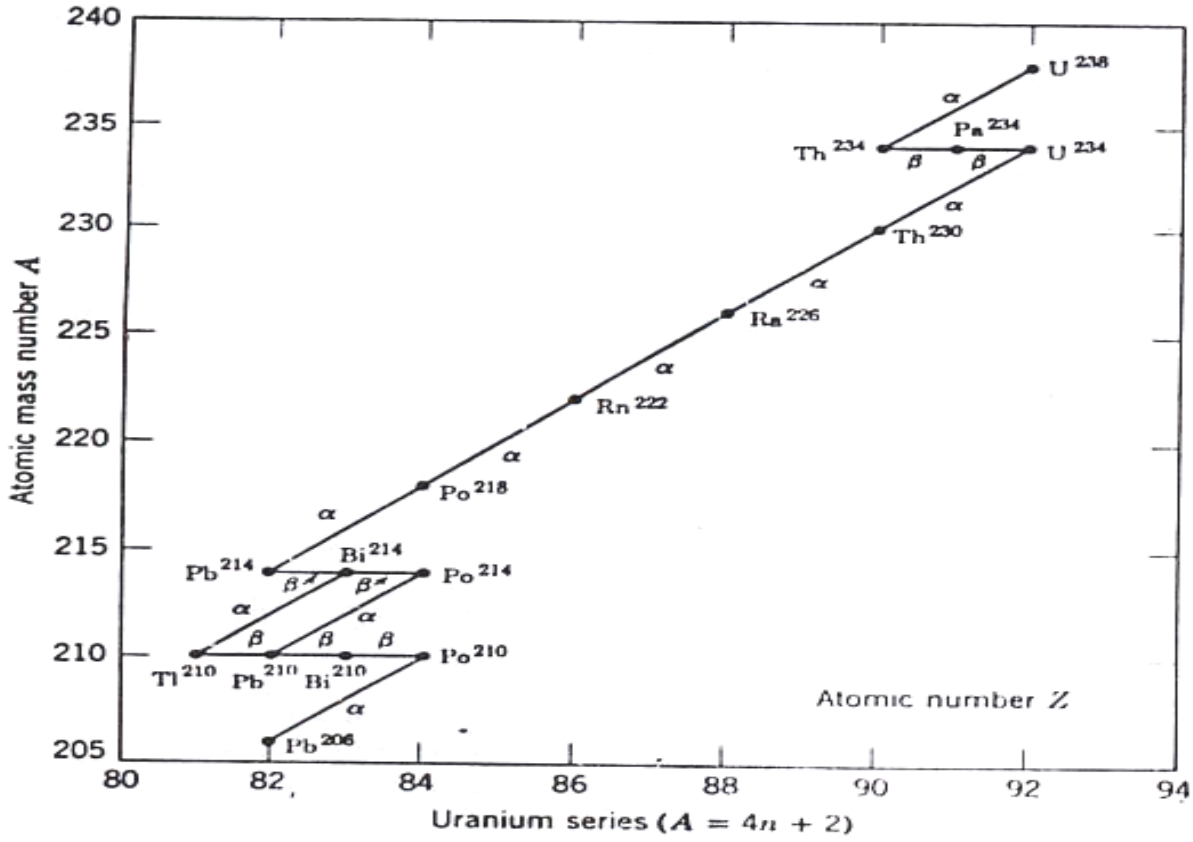

Figure (6) Uranium series

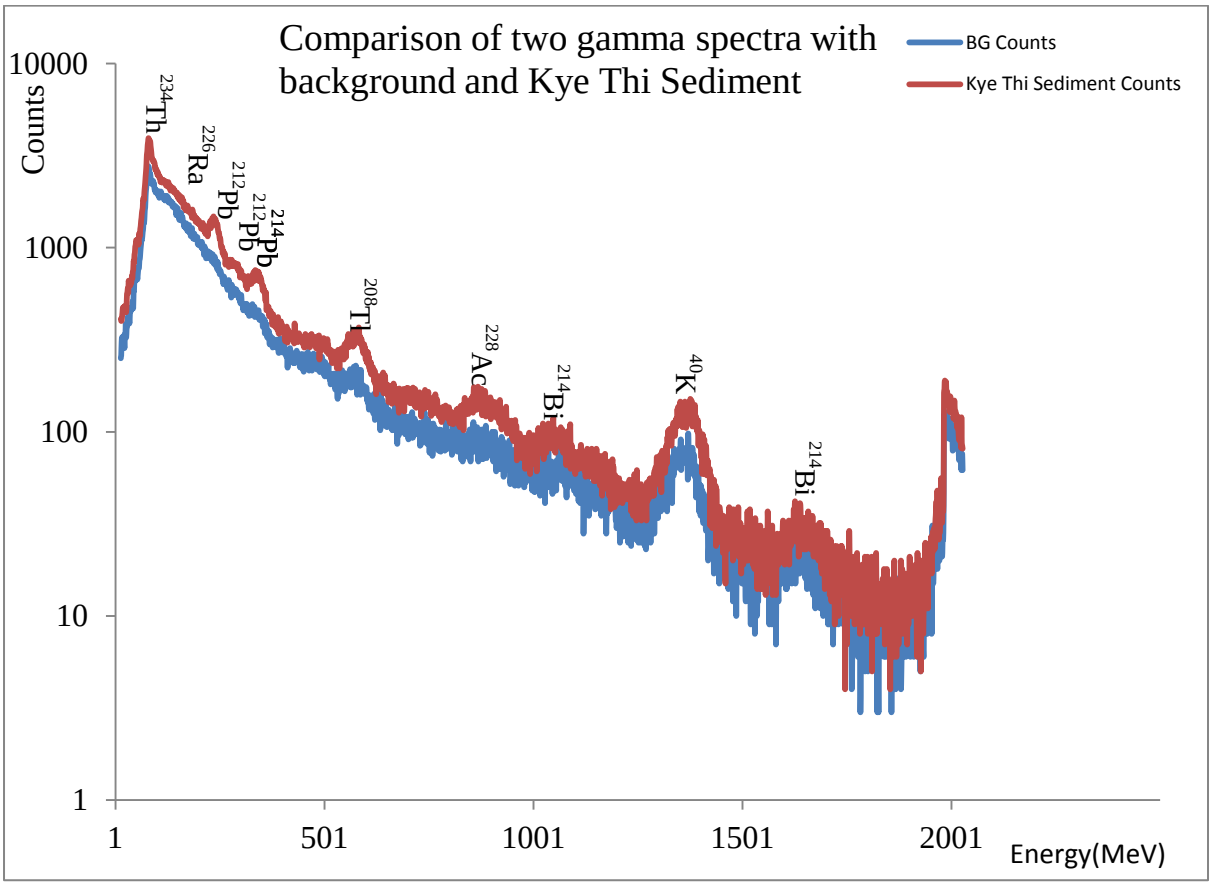

Figure (7) Comparison of gamma spectra with background and sediment samples of Kye-Thi hot spring

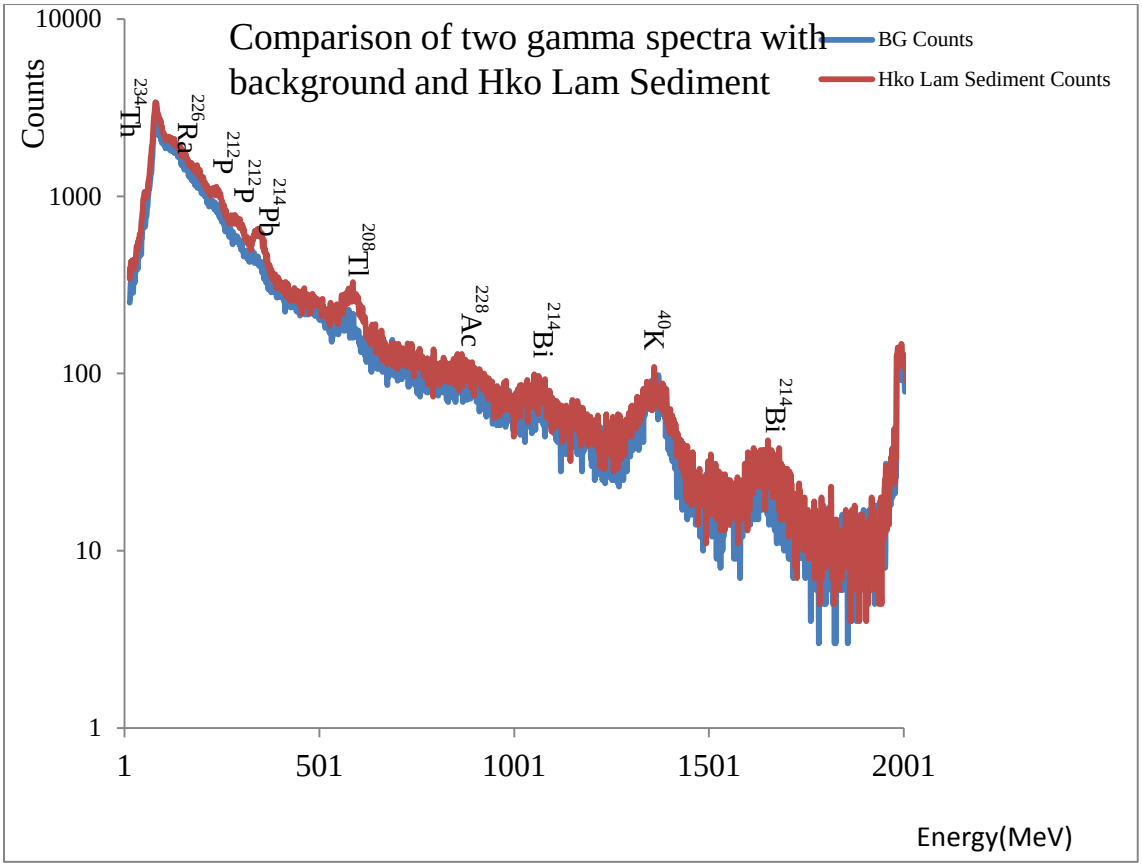

Figure (8)Comparison of gamma spectra with background and sediment samples of Hko-Lam hot spring

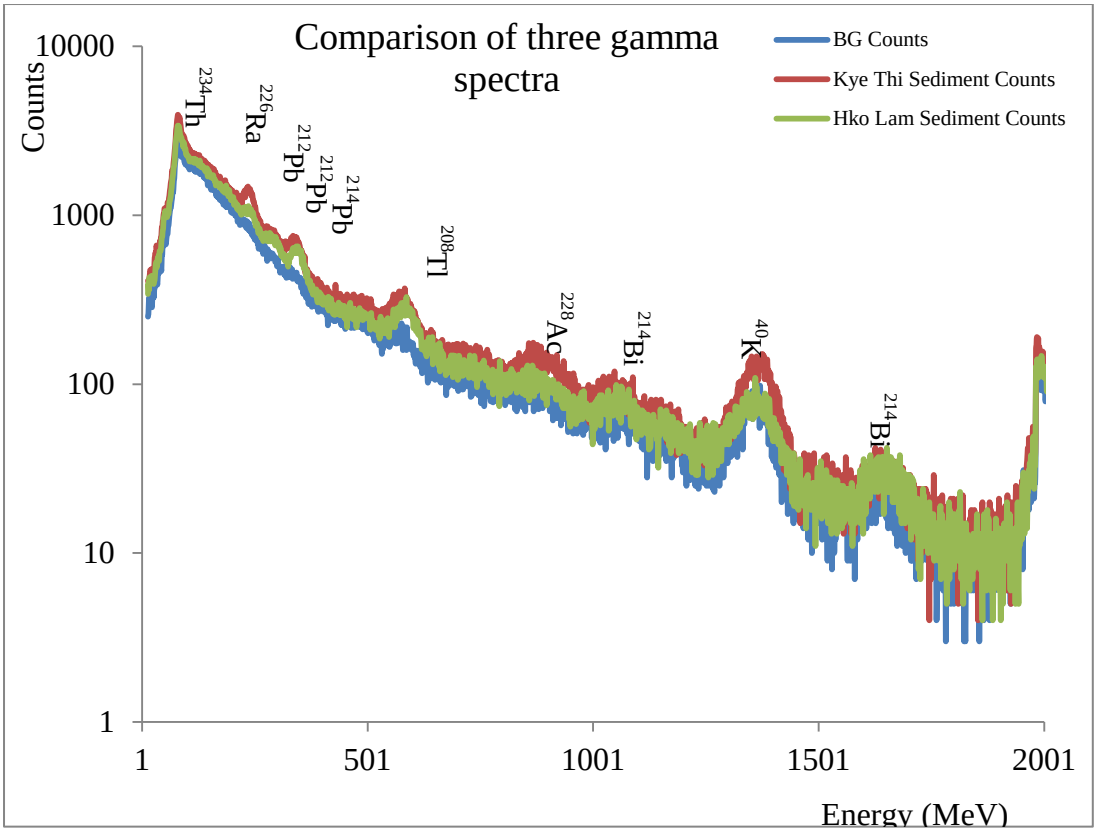

Figure (9) Comparison of three gamma spectra with background and two sediment samples of two hot springs

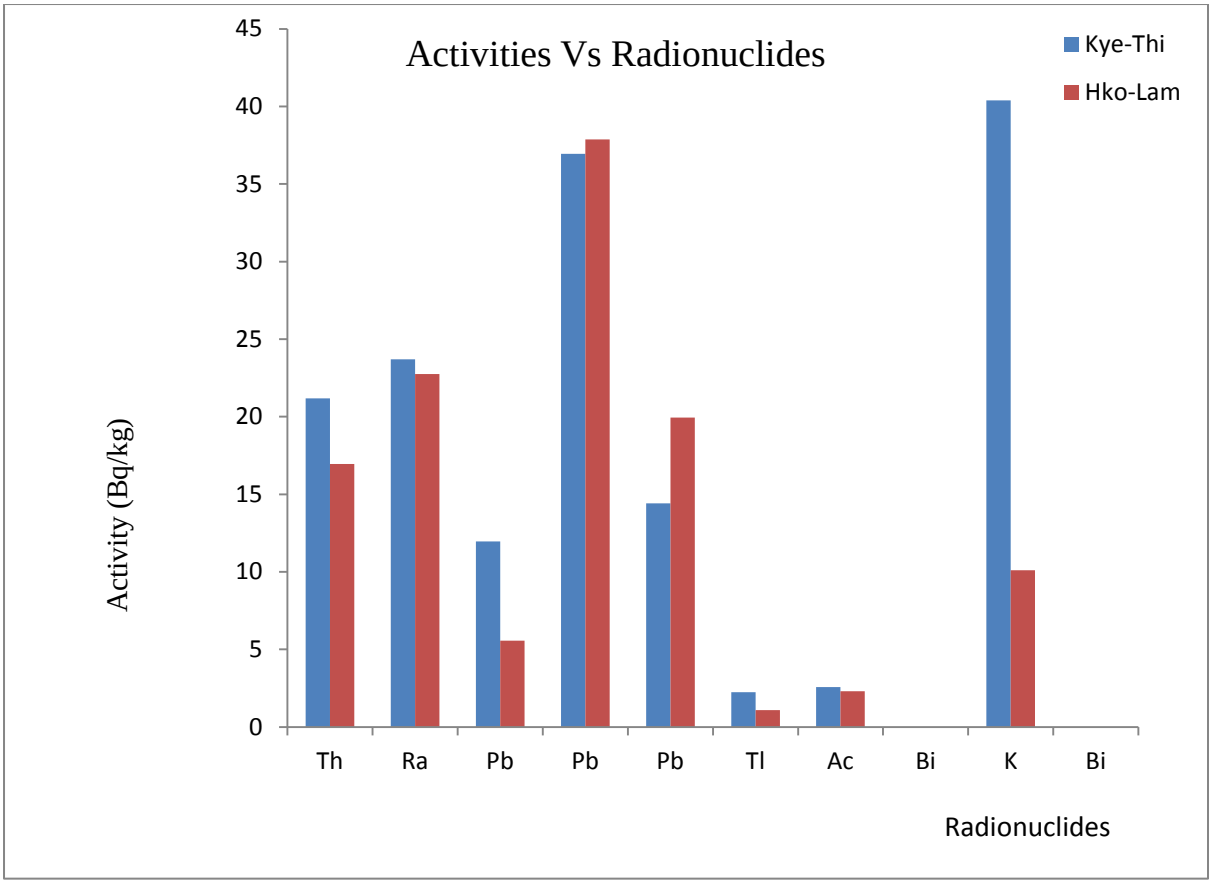

Figure (10) Comparison of radionuclides in two sediments samples from two hot springs

Conclusion

In Water Chemical Analysis, the water in the two hot springs is chemically potable in the remark. In Gamma Spectrometric Analysis, ^{238}U may be determined via ^{234}Th, which has gamma emissions at 63.3, 92.4, and 92.8 keV at secular equilibrium being assumed. Measurement of ^{235}U is that which emits gamma photons at 185.7 keV. ^{228}Th is determined by measuring the gamma peaks emitted from its daughters, 238keV ^{212}Pb and 241keV ^{226}Ra or 583.1keV ^{208}Tl. ^{226}Ra is determined by measuring its own gamma emissions at 186.5keV if it is separated from ^{235}U (IAEA, 1990). Alternatively, in the growth of its photo-emitting daughters, ^{214}Bi and ^{214}Pb may be measured, either directly or by using chemical separation.

The results show that no components hazardous to health and no toxic chemical substances were found. Activities of all radioactive nuclei were very low level. It is assumed that these radionuclides originated from the hot spring, not from the surrounding area. The radionuclides found in the measured samples were the products of ^{238}U and ^{232}Th natural radioactive series. Therefore, it is expected that ^{238}U and ^{232}Th are concentrated in sediment of hot springs. Content of natural radionuclide in hot spring water are influenced by sediment.

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