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INVESTIGATION OF RADIOACTIVE ELEMENTS IN SEDIMENTS FROM THE AYEYARWADY RIVER BANK AT MAGWAY TOWNSHIP

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Abstract

The radioactive elements contain in sediment of Ayeyarwady River Bank at Magway Township were determined by Gamma Ray Spectroscopy of HPGe Detector. The aim of this study is to determine the natural (^{238}U, ^{232}Th, ^{40}K) radioactive levels in sediments collected from four different places in Ayeyarwady River Bank and also Ra_{eq}, D_R and H_{ex} will be calculated and compared with the recommended levels from UNSCEAR (2000) reports. The concentration of the natural radionuclide activity of ^{226}Ra, ^{232}Th, and ^{40}K are 0.0456 $Bqkg^{-1}$, 14.1361 Bqkg ^{1} and 1.1639 $Bqkg^{-1}$ were observed. These values are lower than the worldwide average value. The radiation hazard parameters of radium equivalent activity, absorbed dose rate and external hazard index for all samples are 20.3754 $Bqkg^{-1}$, 8.6079nGh^{-1} and 0.0549 $mSvy^{-1}$. These are not exceeded the maximum admissible limit. So, it can be assumed that the sediments are not hazard to the surrounding.

Keywords: Radium Equivalent Activity (Ra_{eq}), Absorbed Dose Rate (D_R), External Hazard Index (H_{ex}), HPGe Detector and radionuclide

Introduction

Naturally Occurring Radiation

Naturally occurring radiation or so-called "background radiation" can be found all around us. Natural radioactivity widely exists in the air, water, plants and the soil of earth's environment. Radiation come from soil have a significant portion of background radiation exposure of the population. Because it occurs in our natural environment, we encounter it every day through the food we eat, the water we drink, and the air we breathe. It is also in building materials and items we commonly use.

Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions and appear at different levels in the soils of each region in the world. Gamma radiation emitted from terrestrial materials is known as the major external source that affects the human body. The interaction of radiation with human body leads to various biological effects which may later show up many diseases. Information of radioactive level of an environment leads to control and preventing of diseases. Therefore, monitoring natural radioactivity in the environment is an important parameter for public health studies and assessing possible changes in the environment radioactivity. The aim of this study is to determine the natural (^{238}U, ^{232}Th, ^{40}K) radioactive levels in sediments collected from different four places in Ayeyarwady River Bank and also Ra_{eq}, D_R and H_{ex} will be calculated and compared with the recommended levels from UNSCEAR (2000) reports.

Radioactivity Measurements

Activity Calculations

The specific activity of ^{238}U, it is found from gamma-ray lines of ^{226}Ra at 186.04 keV, ^{214}Pb at 295.34 keV, ^{214}Pb at 351.69 keV and ^{214}Bi at 609.61 keV while the specific activity of ^{232}Th was evaluated from gamma-ray lines of ^{208}Tl at 75.43 keV, ^{212}Pb at 238.61 keV and ^{208}Tl at 583.71

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keV. The specific activity of ^{40}K was determined directly from its 1460.8 keV gamma-ray line. The calculation of the activity concentrations is given by equation;

$$A = \frac{N_A}{m\, \varepsilon\, P\gamma T} \tag{1}$$

where, N_A = net count rate for sample,

m = mass of the sample,

ε = efficiency of the interest gamma energy,

P_γ = emission probability of gamma ray intensity and

T = counting time

Radium Equivalent Activity (Ra_{eq})

Radium equivalent activity (Ra_{eq}) is used to assess the hazards associated with materials that contain ^{226}Ra, ^{232}Th and ^{40}K in Bq kg^{-1}, which is determined by assuming that 370 Bq kg^{-1} of ^{226}Ra or 259 Bq kg^{-1} of ^{232}Th or 4810 Bq kg^{-1} of ^{40}K produce the same γ dose rate. The Ra_{eq} of a sample in (Bq kg^{-1}) can be achieved using the following relation;

$$Ra_{eq} = A_{Ra} + 1.43 A_{Th} + 0.077 A_k \tag{2}$$

where, A_k, A_{Ra} and A_{Th} are the specific activities of ^{226}Ra, ^{232}Th and ^{40}K in Bqkg^{-1}.

Absorbed Dose Rate (D_R)

Absorbed dose rate (D_R), due to γ-rays emitted from radionuclides maintained in those samples can be calculated from the following equation;

$$D_R\ (\text{nGy h}^{-1}) = 0.462\ A_{Ra} + 0.604\ A_{Th} + 0.042\ A_K \tag{3}$$

where, A_{Ra}, A_{Th} and A_k are the specific activities of ^{226}Ra, ^{232}Th and ^{40}K in Bqkg^{-1}.

External Hazard Index (H_{ex})

The external hazard index is an evaluation of the hazard of the natural gamma radiation. The objective of this index is to limit the radiation dose to the admissible dose equivalent limit around 1mSvy^{-1}. In order to evaluate this index, one can use the following relation;

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_k}{4810} \leq 1 \tag{4}$$

Materials and Methods

Sample Collection and Preparation

Four soil samples (S1, S2, S3 and S4) were collected from different places of Ayeyarwady River Bank at Magway Township, Magway region. Sample 1 (S1) was collected from near the Mya Thalon Pagoda, Sample 2 (S2) was collected from near the Magway Bridge, Sample 3 (S3) was collected from around the view point of We Love Magway and Sample 4 (S4) was collected from in front of the Nan Htike Thu Hotel. The location map of collected samples and geographic coordinates of the samples are shown in Figure 1 and Table 1. Each sample was air dried in about two weeks and removing unwanted materials by sieved with 0.5

cm meshes and ground to get homogeneous powder. Then the samples were weighed 500 g by using digital balance. And then they were analyzed by HPGe detector.

Table 1. Geographic Coordinates (latitudes and longitudes) of the Sampling Locations

No.	Sampe	Latitude	Longitude
1	S1	20° 9' 56.92" N	94° 54' 59.76" E
2	S2	20° 8' 58.59" N	94° 54' 57.62" E
3	S3	20° 8' 32.43" N	94° 55' 02.64" E
4	S4	20° 7' 59.30" N	94° 55' 28.07" E

Figure 1 Location Map for Collected Samples

Experimental Procedure

In this experiment, HPGe detector was used to detect the gamma radiation after passing through the absorbing material and this passed information (electron pulses) were amplified by preamplifier and the fast spectroscopy amplifier and collected by using MCA based on personal computer. The HPGe detector used in operating voltage is -1500V. This value is fixed for all measurements and measuring time in 7200 seconds. The experimental set-up used in this investigation is shown in Figure (2) and the detector efficiency is presented in Figure (3).

Figure 2 The Experimental Set-up

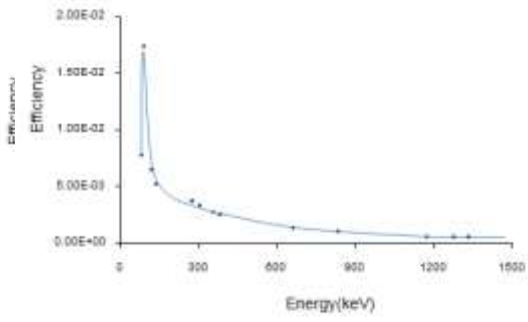

Figure 3 The Detector Efficiency

Results and Discussions

In the present work, the natural radionuclides contained in sediments samples were determined by gamma spectroscopy system. The naturally occurring gamma radionuclides: ^{212}Pb (238.22 keV), ^{228}Ac (338.12 keV), ^{214}Pb (351.76 keV), ^{208}Tl (510.68keV), ^{228}Ac (583.31 keV), ^{214}Bi (609.03 keV), ^{228}Ac (911.55 keV), ^{228}Ac (969.01keV) and ^{40}K (1460.2 keV) were identified in sediment samples.

The comparative values of background and sediment samples are shown in Figure (4) and (5). The net counts values of different sediment samples are shown in Table 2. It was found that the net area counts of ^{212}Pb (238.63 keV) is highest and ^{228}Ac (968.97 keV) is lowest. Similarly, activities with different energies are presented in Table 3 and their comparisons are described in Figure (6). The activities of ^{208}Tl **(**510.68 keV) and ^{228}Ac (583.41 keV) are the highest values in these elements.

Moreover, the activities of A_{Ra}, A_{Th} and A_K in sediment samples with worldwide average are shown in Table 4 and Figure (7). The average value of A_{Ra} is 0.0456 Bqkg^{-1}, A_{Th} is 14.1361 Bqkg^{-1} and A_K is 1.1639 Bqkg^{-1}. These values are lower than the worldwide average value.

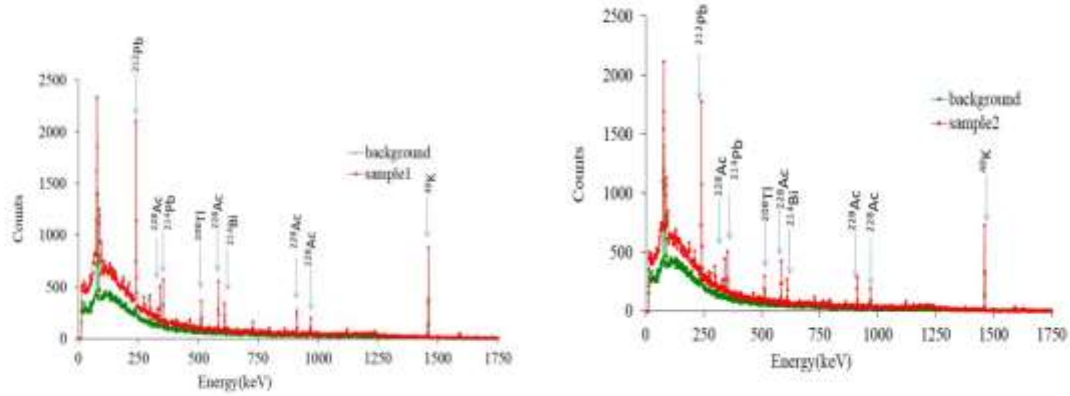

Figure 4 Comparison of background and sediment samples (S1) and (S2)

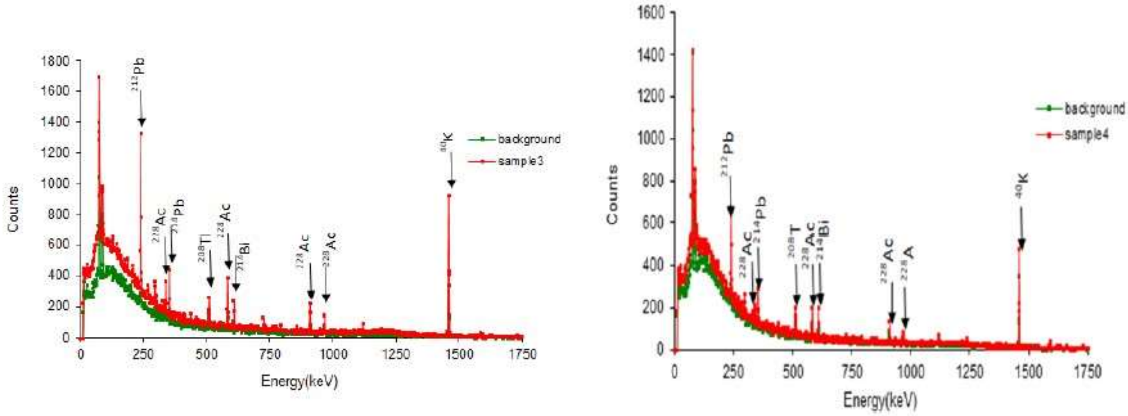

Figure 5 Comparison of background andsediment samples (S3) and (S4)

Table 2 . Comparison of Net Area (counts) for Sediment Samples

No.	Series	Element	Energy (keV)	Net area (counts) for sediment samples			
				sample 1	sample 2	sample 3	sample 4
1	^{232}Th	^{212}Pb	238.63	3878±448	3310±447	3268±454	3193±447
2	^{232}Th	^{228}Ac	338.32	793±272	687±259	741±268	640±276
3	^{238}U	^{214}Pb	351.93	933±280	807±272	766±270	832±272
4	^{232}Th	^{208}Tl	510.68	439±221	365±134	406±198	414±196
5	^{232}Th	^{228}Ac	583.41	897±275	702±289	717±250	677±287
6	^{238}U	^{214}Bi	609.31	548±267	417±201	516±221	426±204
7	^{232}Th	^{228}Ac	911.20	113±90	80±20	76±20	55±07
8	^{232}Th	^{228}Ac	968.97	22±10	19±02	17±09	179±20
9	^{40}K	^{40}K	1460.83	1000±287	852±282	1253±292	1169±292

Table 3 Activities of Various Radionuclides in Sediment Samples

No	Series	Element	Energy (keV)	Activity Bq/kg (S1)	Activity Bq/kg (S2)	Activity Bq/kg (S3)	Activity Bq/kg (S4)
1	^{232}Th	^{212}Pb	238.63	0.4878	0.4164	0.4111	0.4016
2	^{232}Th	^{228}Ac	338.32	0.4072	0.3528	0.3805	0.3286
3	^{238}U	^{214}Pb	351.93	0.0162	0.0140	0.0133	0.0145
4	^{232}Th	^{208}Tl	510.68	37.4983	31.1774	34.6795	35.3629
5	^{232}Th	^{228}Ac	583.41	59.0722	46.2304	47.2183	44.5841
6	^{238}U	^{214}Bi	609.31	0.0881	0.0670	0.0829	0.0685
7	^{232}Th	^{228}Ac	911.20	0.0406	0.0287	0.0273	0.0197
8	^{232}Th	^{228}Ac	968.97	0.0131	0.0113	0.0101	0.1067
9	^{40}K	^{40}K	1460.83	1.0893	0.9281	1.3649	1.2734

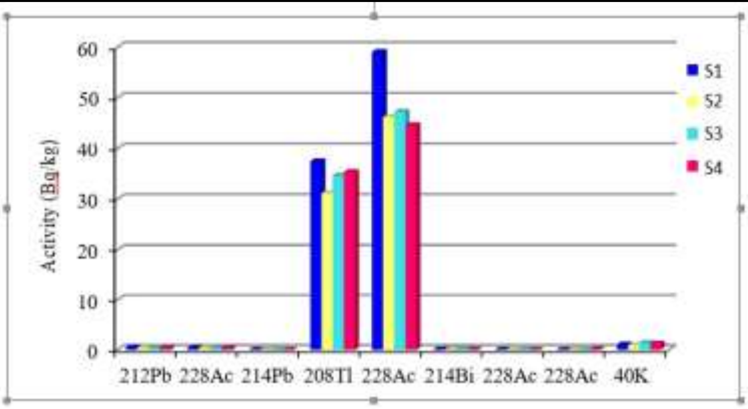

Figure 6 Comparison of Activity for Various Radionuclides in Sediment Samples

Table 4 Activities of A_{Ra}, A_{Th} and A_K in Sediment Samples with Worldwide Average

No.	Sample	A_{Ra} ($Bqkg^{-1}$)	A_{Th} ($Bqkg^{-1}$)	A_K ($Bqkg^{-1}$)
1	S1	0.0521	16.2532	1.0893
2	S2	0.0405	13.0362	0.9281
3	S3	0.0481	13.7878	1.3649
4	S4	0.0415	13.4673	1.2734
5	Range	0.0405-0.0521	13.0362-16.2532	1.0893-1.3649
6	Average	0.0456	14.1361	1.1639
7	Worldwide Average UNSCEAR (2000)	35	30	400

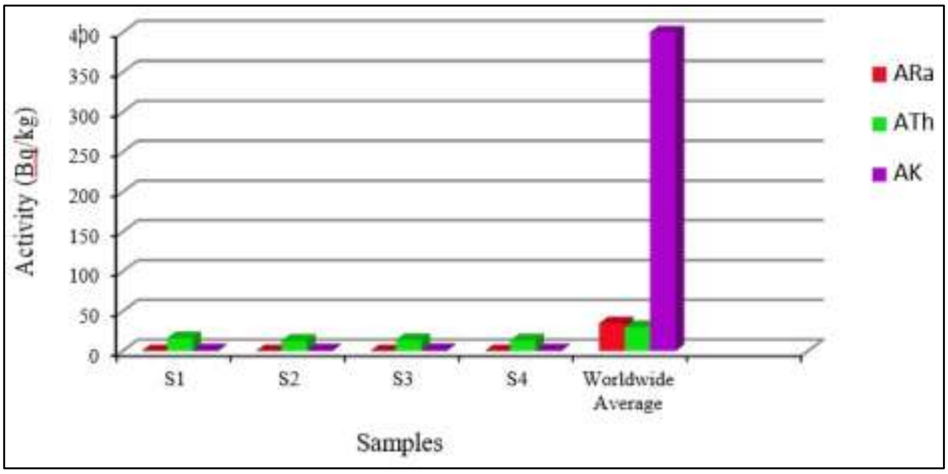

Figure 7 Values of A_{Ra}, A_{Th} and A_K in Sediment Samples Compare with Worldwide Average

The results of the radium equivalent activity, absorbed dose and external hazard index for all samples are presented in Table (5) and Figure (8). This shows that the Ra_{eq} values of sediment samples varied from 18.7537 to 23.4755 $Bqkg^{-1}$ with an average of 20.3754 $Bqkg^{-1}$. It can be seen that the value of all samples does not exceed the maximum admissible value (worldwide average) of 370 $Bqkg^{-1}$.

For the absorbed dose values which is ranged from 7.9315 to 9.8868 nGh^{-1} with a mean value of 8.6079 nGh^{-1}. The estimated mean value of D_R in the samples is lower than the worldwide average absorbed dose rate value of 60 nGh^{-1}.

Moreover, the calculated value of external radiation hazard index (H_{ex}) of sediment samples varied from 0.0506 to 0.0631 $mSvy^{-1}$ and with an average of 0.0549 $mSvy^{-1}$ which is also lower than the recommended value $\leq$ 1. So, it can be assumed that this area is not hazard to the surrounding.

Table 5. Values of the Radium Equivalent Activity, Absorbed Dose and External Hazard Index in Sediment Samples with Worldwide Average

No.	Sample	Ra_{eq} (Bq kg^{-1})	D_R (nGyh^{-1})	H_{ex} (mSvy^{-1})
1	S 1	23.4755	9.8868	0.0631
2	S 2	18.7591	7.9315	0.0506
3	S 3	19.8698	8.4073	0.0536
4	S 4	19.3978	8.2063	0.0524
5	Range	18.7537 - 23.4755	7.9315 - 9.8868	0.0506 - 0.0631
6	Average	20.3754	8.6079	0.0549
7	Worldwide Average UNSCEAR (2000)	370	60	≤ 1

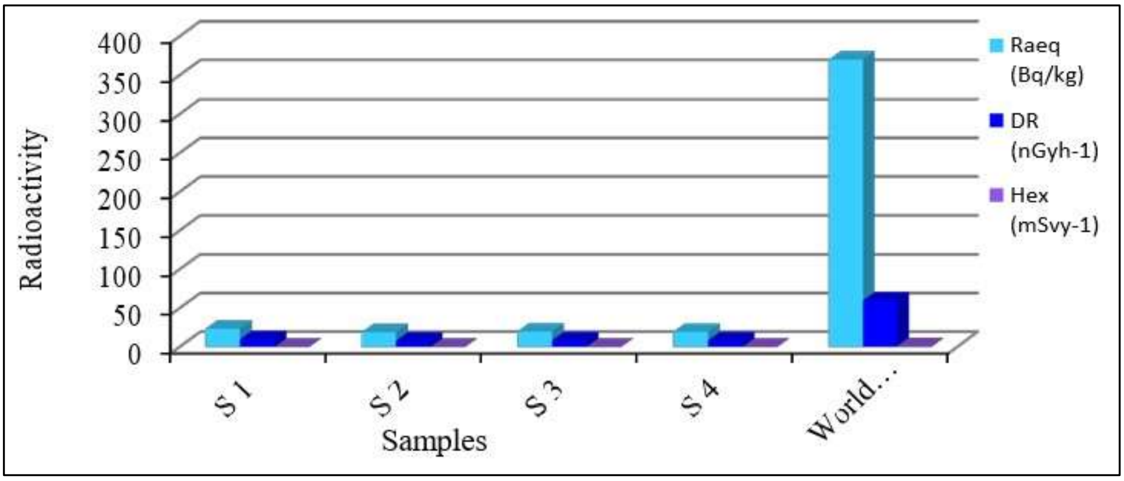

Figure 8 Values of Ra_{eq}, D_R and H_{ex} in Sediment Samples Compare with Worldwide Average

Conclusion

The activity of radionuclides of ^{226}Ra, ^{232}Th, and ^{40}K were measured by a gamma-ray spectrometry system in sediment samples collected from the Ayeyarwady River Bank. The activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in all sediments were found to be normal. The radiological assessment of Ra_{eq}, D_R and H_{ex} are good agreement in the worldwide average value. So, the river bank at Magway Township may not pose radiology risk to harmful effects of ionization from the natural radionuclide in the sediment.

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