ASSESSMENT OF NATURAL RADIOACTIVITY AND RADIATION HAZARDS IN SEDIMENTS FROM MEIKTILA LAKE

KhinThi Tar Win[1], Win Zaw[2]

Abstract

In this present study, the natural radioactivity levels of sediments from Meiktila Lake, Meiktila Township, Mandalay Region have been investigated by using HPGe detector and analysed with the Gamma Vision-32 The radium equivalent activity, the absorbed dose rate and external hazard in each sample was calculated to assess the radiation hazard for people. All sample have shown radium equivalent activity ranged from 157.30Bq kg^{-1} to 181.80Bq kg^{-1}. The observed values of radium equivalent activity for all samples were less than the permissible limits of 370 Bq kg^{-1}. The values of calculated absorbed dose rates in the samples under investigated are ranged from 97.10 $nGyhr^{-1}$ to 112.26 $nGhr^{-1}$. The value of absorbed dose rate for all samples were higher than the average global terrestrial radiation of 55 $nGhr^{-1}$. But the calculated values of external hazard index values for all samples were less than the permissible value 1.0 $mSvy^{-1}$.

Keywords: natural radioactivity, gamma spectroscopy, activity concentration, radiation hazard, absorbed dose rate

Introduction

Sediments: Sediments is loose, hard material lying on top of solid rock. Sediment comes in many forms and sizes, and can originate from a variety of sources. Sediment is produced by the weathering and erosion of rocks exposed at Earth's surface. Chemical sediment forms as minerals crystallize and settle from water that contains lots of dissolved particles. Biochemical sediment accumulates as plants and animals die and their hard parts, such as skeletons and shells, are deposited on the ocean floor. There are various kinds of sediments on the earth. They are rock, gravel and sand, consolidated clay, silt/soft clay, mixture (rock/sand/silt/soft clay).

Sample Location

Meiktila Lake is situated in the central portion of Meiktila town, a district in Mandalay division, Myanmar. It measures seven-miles in length and half a mile in breadth, and covers an area of three and half square miles. It is a long lake stretching from north to south. The lake is crossed by two bridges which are one for road and the other for railway line in the central area of the lake. Meiktila Lake is an artificial lake created by man. The lake has an elongated shape.

It is bounded on the north by Inpetlet village, on the east by Contonment area, Zayashebyin, Myomalay, Yanmyoaung and Wunzin Words, on the south by Naw-zan-taung village and on the west by Aungsan, Paukchaung and Nandawgon Words, Ga-lon-kon and Shin-myo villages. In Meiktila Township the most prominent streams are found on the west of Meiktila Lake. On the east of the lake, streams are mostly artificial drainage channels. On the west of the Meiktila Lake, Mondaing Chaung and Kanni Chaung are the most prominent streams. Though Thinbon Chaung and Chaunggauk Chaung serve as boundary lines, they do not pass through the township. This water is used in various forms including drinking and agricultural crops. The Lake is naturally filled with rain fall water.

[1] Dr, Lecturer, Department of Physics, Meiktila University
[2] Dr, Lecturer, Department of Physics, University of Mandalay

Calculation of Activity

The activity of the sediment samples were calculated by the following equation.

$$A = \frac{N_A}{m\varepsilon P_\gamma T} \quad (1)$$

where, N_A = net area for sample

m = mass of sample in kilogram

P_γ = emission probability of interested gamma ray

T = counting time (in second)

ε = efficiency of the interest gamma energy

Calculation of Radium Equivalent Activity

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 260 Bq kg^{-1} of ^{232}Th or 4810 Bq kg^{-1} of ^{40}K produce the same gamma dose rate. The Ra_{eq} of a sample (Bq kg^{-1}) is based on the estimation that 1 Bq kg^{-1} of ^{226}Ra, 0.7 Bq kg^{-1} of ^{232}Th and 13 Bq kg^{-1} of ^{40}K produces the same gamma radiation dose rates. The index is given as the following relation.

$$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.0077A_k \quad (2)$$

Where $A_{Ra,}A_{Th}$and A_K are the specific activities of ^{226}Ra,^{232}Th and^{40}K in Bqkg^{-1}. The ^{226}Ra concentration was determined from 77 keV, 295 keV, and 351keV gamma-peak of ^{214}Pb and 609 keV, 1120 keV and 1155 keV gamma-peak of ^{214}Bi. ^{232}Th was achieved by 911 keV gamma-peak of ^{228}Ac, 238 keV gamma-peak ^{212}Pb and 583 keV gamma-peak of ^{208}Tl. The ^{40}K was directly determined using the 1460 keV gamma-peak from ^{40}K itself.

Calculation of Absorbed Dose Rate

The measured activity of ^{226}Ra, ^{232}Th and ^{40}K were converted into doses by applying the factors 0.461, 0.623 and 0.041 for radium, thorium and potassium respectively. These factors were used to calculate the total absorbed gamma dose rate in air at 1m above the ground level using this equation

$$D\ (nGyh^{-1}) = 0.461\ A_{Ra} + 0.623\ A_{Th} + 0.041\ A_K \quad (3)$$

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

Calculation of External Hazard Index

The external hazard index is obtained from Ra_{eq} expression through the supposition that its maximum value allowed (equal to unity) corresponds to the upper limit of Ra_{eq}(370 Bqkg^{-1}). This index value must be less than unity in order to keep the radiation hazard insignificant; i.e., the radiation exposure due to the radioactivity from construction materials is limited to 1.0 mSvy^{-1}. Then, the external hazard index can be defined as

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

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

Sample Collection and Preparation for Gamma Ray Detection Method

The sediment samples were collected three different points from Meiktila Lake, Meiktila Township, Mandalay Region. The map of collection of the samples was as shown in Figure (1). The sample preparation like drying, grinding homogenization and packing in proper geometrical dimensions for gamma spectrometric analysis was carried out for sediments samples. These samples were dried at room temperature, avoiding the loss of radionuclide. The dried samples, 500 gram, were transferred to plastic containers for gamma activity analysis.

Experimental Set-Up for Gamma Emission Measurement

The experiments were carried out using gamma ray spectroscopy system with high purity germanium detector (HPGe). In gamma ray spectroscopy system, the following equipments are included. They are the HPGe detector ORTEC (model GMX 10P4-70-RB-SMN), cooler (model CFG-X-COOL-III-230), preamplifier (model A257N), fast spectroscopy amplifier ORTEC (Model-671), digital signal processor (DSPEC-LF) which also include high voltage power supply, a pulse stored Multi-Channel Analyzer (MCA) together with Gamma Vision-32 software installed in PC and data readout devices as shown in Figure (2). The operating voltage for HPGe detector is negative 1500 V dc. The detector was surrounded with a lead shielding (thickness is 7 cm) to reduce a possible background radiation that comes from the environment . From the collected gamma spectrum, the radionuclides present in the sample are identified and their activity concentrations are determined from the gross and net area of the full energy gamma peak. For present measurement, the samples measured for 10800 seconds. The background spectrum was measured under the same conditions. At the end of the counting period, the spectrum that was recorded may be displayed on the screen. The spectra stored in MCA were analyzed by the application of Gamma Vision-32 software.

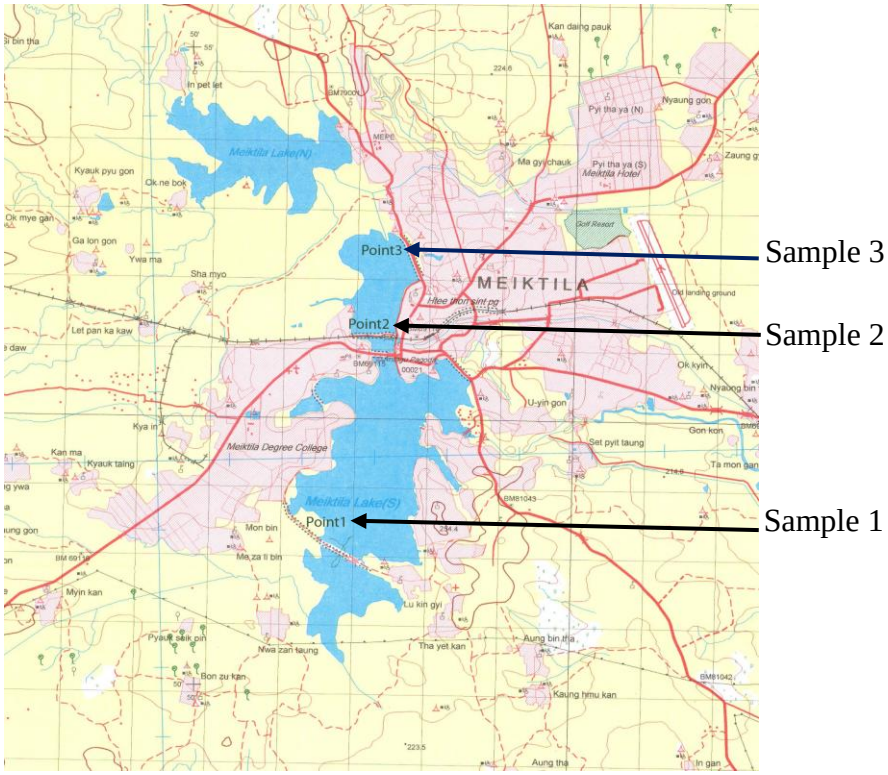

Figure 1 Map of the sampling area

Energy calibration

The standard radioactive sources of known energies were used to calibrate the spectrometer. Seven standard sources emitting 14 different gamma energies ranging from 81 keV to 1332 keV: ^{133}Ba (81 keV, 276.34 keV, 302.85 keV, 356.02 keV, 383.85 keV), ^{57}Co (122.06 keV and 136.46 keV), ^{137}Cs (661.66 keV) ,^{54}Mn (834.85 keV), ^{22}Na (511 keV and 1274.53 keV), ^{65}Zn (1115.55 keV) and ^{60}Co (1173.24 keV and 1332.50 keV) were used for 1800 seconds placing at 5 cm above the detector cap. The data are as shown in Table (1) and the energy calibration curve is as shown in Figure (3).

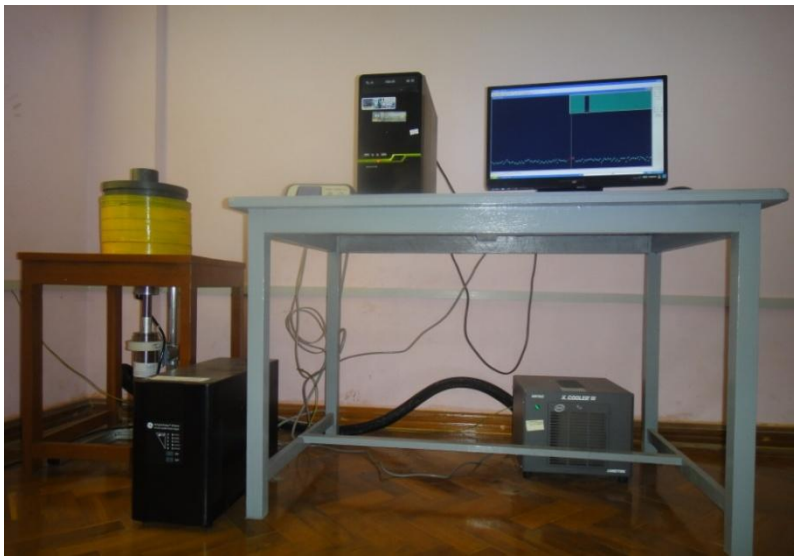

Figure 2 Photograph of the HPGe gamma detection system

Table 1 Energy calibration data for HPGe detector

Sr.no	Standard Sources	Channel	Energy (keV)
1	Ba-133	428	81.00
2	Co-57	645	122.06
3	Co-57	721	136.46
4	Ba-133	1460	276.34
5	Ba-133	1600	302.85
6	Ba-133	1881	356.02
7	Ba-133	2029	383.85
8	Na-22	2702	511.00
9	Cs-137	3499	661.66
10	Mn-54	4414	834.85
11	Zn-65	5899	1115.55
12	Co-60	6204	1173.24
13	Na-22	6740	1274.53
14	Co-60	7046	1332.50

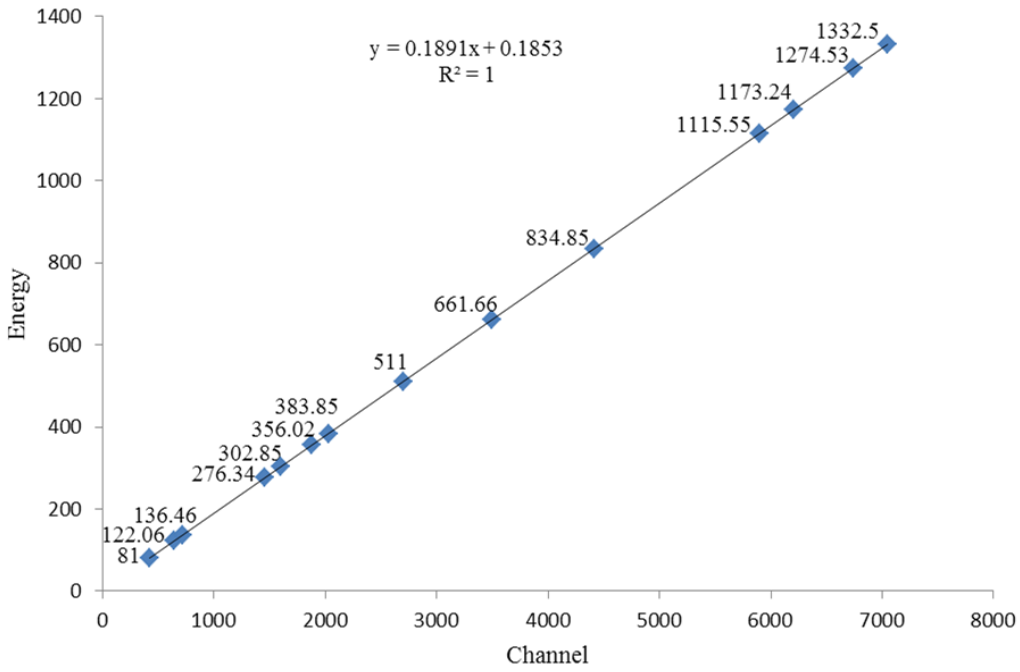

Figure 3 Energy calibration curve for HPGe detector

Results

The presence of radionuclide in sediment samples were investigated with HPGe detector and analyzed using Gamma Vision-32 Software. The radionuclide present in sediments samples are ^{207}Bi (74.97 keV), ^{214}Pb(77.17keV) , ^{208}Tl(84.68keV),^{207}Bi (84.80 keV), ^{212}Pb(238.63 keV), ^{214}Pb (295.22 keV), ^{228}Ac (338.40 keV), ^{214}Pb (351.99keV), ^{208}Tl (510.72keV), ^{208}Tl (583.14 keV),^{214}Bi (609.32 keV),^{228}Ac (911.07 keV),^{228}Ac(968.9 keV),^{228}Ac and^{40}K (1460.75 keV).

The collected background and sample spectra were shown in Figure (4) to Figure (7). The average activity of ^{226}Ra, ^{232}Th and ^{40}K in Bq kg^{-1} for sediment samples are as shown in Table (2). The average values of radiation hazard parameters for sediment samples are as shown in Table (3).

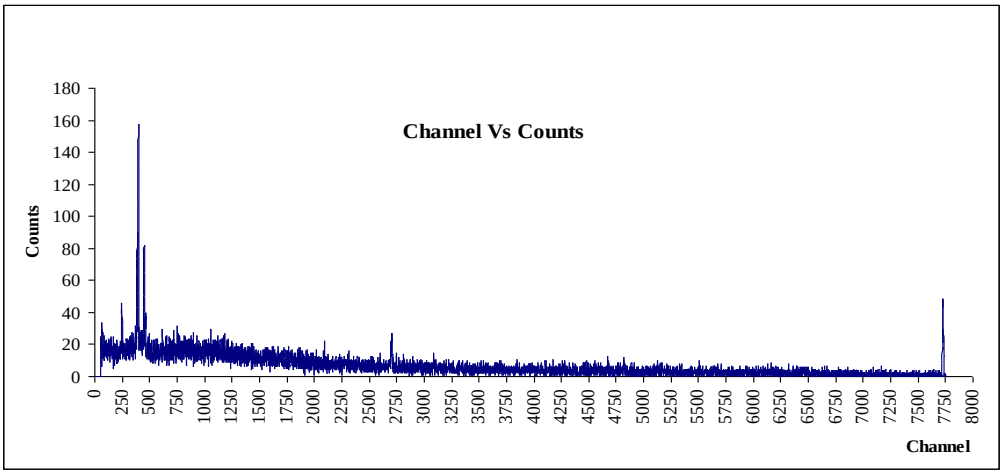

Figure 4 Background Spectrum of HPGe Detector for Counting Time 3 hrs

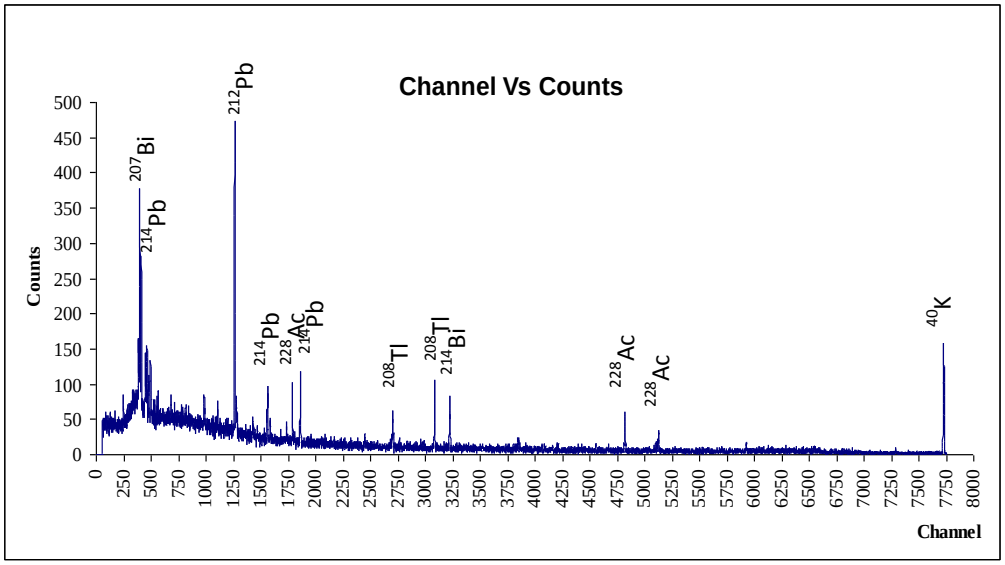

Figure 5 Energy Spectrum of the Sediments Sample S1 for Counting Time 3 hrs

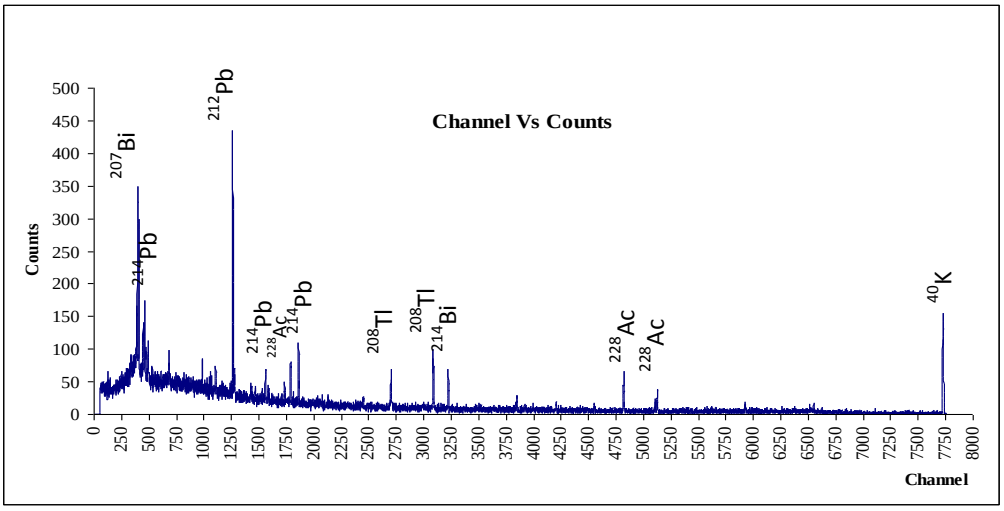

Figure 6 Energy Spectrum of the Sediments Sample S2 for Counting Time 3 hrs

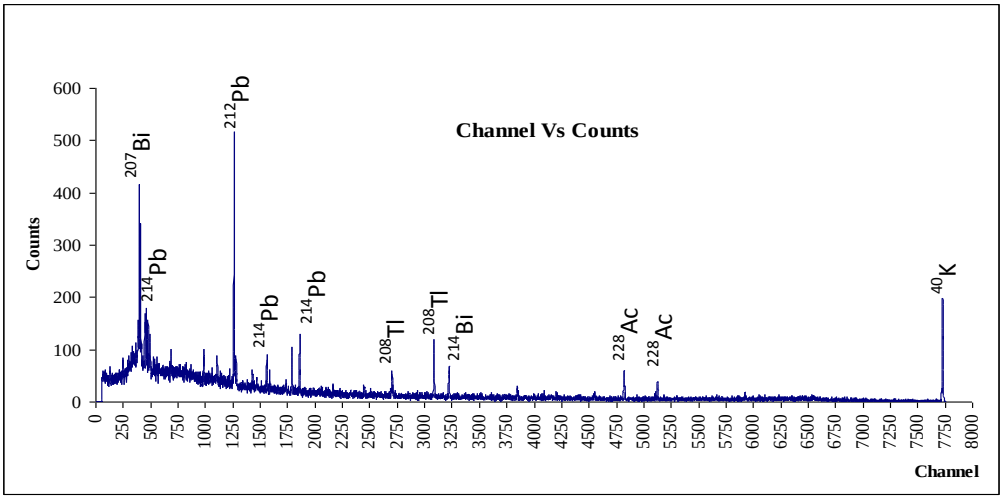

Figure 7 Energy Spectrum of the Sediments Sample S3 for Counting Time 3 hrs

Table 2 The average activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K (Bqkg^{-1})

Sr No	Sample	Ra-226	Th-232	K-40
1	S1	65.98	59.93	729.49
2	S2	59.67	70.27	745.07
3	S3	63.04	78.43	857.56

Table 3 The average values of radiation hazard parameters for the samples

Sr No	Sample	Ra_{eq} (Bq kg^{-1})	Dose Rate (nGyhr^{-1})	Hex
1	S1	157.30	97.10	0.56
2	S2	165.89	101.08	0.59
3	S3	181.80	112.26	0.65

Discussion

According to Table (3), the radium equivalent activity (Ra_{eq}) values for all samples under investigation are ranged from 207.85Bq kg^{-1} to 241.23Bq kg^{-1}. The observed values are less than 370 Bq kg^{-1}, which is the adopted valued for safely used. The average values of calculated absorbed dose rates in the samples under investigation are ranged from 97.10 $nGyhr^{-1}$ to112.26$nGyhr^{-1}$, it is twice of the world average value 55 $nGyhr^{-1}$. The calculated values for external hazard index obtained in this study are ranged from0.56to 0.65. Since these values are lower than unity, thus it can be concluded that the radiation hazard is insignificant for the people living near this area.

Conclusion

In this research work, we have been done activity of sediment sample using different type of efficiency calibration method. ^{214}Pb is the daughter nucleus of ^{238}U and ^{212}Pb, ^{208}Tl and ^{228}Ac are the daughter nuclei ^{232}Th decay series. Therefore, it can be found that the radionuclides in sediment samples are the daughter nuclei of Uranium and Thorium series. These radionuclides (^{208}Tl and ^{228}Ac) are caused by β decays and these activities are less than other radionuclides . These are determined by the HPGe detector, which is high resolution detector. In all sediments samples, the concentration of ^{40}K and ^{214}Pb are greater than the others radionuclides. And then, the concentration of ^{40}K and ^{214}Pb in north lake are greater than south lake. We concluded that it is because of the amount of water in South lake is greater than north lake. So radionuclides are more deposit in North Lake.

Acknowledgements

We wish to express our deepest gratitude to Dr.Ba Han, Rector, Meiktila University, Dr Kay Thi Thin, Pro-Rector, Meiktila University for their permission to summit this paper. Dr. Hla Hla Than, Professor and Head of Physics Department Meiktila University and Dr Hla Win, professor., Department of Physics, Meiktila University, for their permission and moral support throughout the paper. We are also grateful to all teaching staff of Physics Department, Meiktila University.

References

Csuros M., "Environmental Sampling and Analysis for echnicians", Lewis Publishers, Boca Raton, U.S.A (1994).

Grieco P. and Trattner R., "Sampling for Environmental Data Generation", SciTech Publishers, Matawan, NJ, U.S.A (1990).

T.M.S. El-zakla et al.,"Studying of Naturally Occuring Radionuclides for Some Environomental Samples and its Hazardous Effects", Physica Department, Faculty of Sciemce, Fayoum University (2014).

Broerman E., Upp, D. L., Twomey, T. R., and Little, W., "Performance of a New Type of Electrical Cooler for HPGe Detector Systems", ORTEC, PerkinElmer Instruments, U.S.A(2000).

ORTEC Software and Manual, "Gamma Vision -32 Gamma-Ray Spectrum Analysis and MCA Emulator for Microsoft Window 95,98,2000 and NT ", U.S.A, (1995).

Knoll. G. F., "Radiation Detection and Measurement", John Wiley & Sons, Third Edition, New York, (2000).