Proceeding of 3rd International Science Postgraduate Conference 2015 (ISPC2015)

NATURAL ENVIRONMENTAL RADIOACTIVITY IN THE SOIL OF TERENGGANU STATE, MALAYSIA

[1]*NURADDEEN NASIRU GARBA, [2]AHMAD TERMIZI RAMLI, [3]MUNEER AZIZ SALEH, [4]HAMMAN TUKUR GABDO, [5]MOHD SYAZWAN BIN MOHD SANUSI, [6]ABUBAKAR SADIQ ALIYU

[1,2,4,5,6] Department of Physics, Faculty of Science, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

[3]Department of Nuclear Engineering, Faculty of Petroleum and Renewable Energy Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

[1]nurangetso@yahoo.com, [2]Termizi@dfiz2.fs.utm.my [3]mouneersaleh@yahoo.com, [4]tukurgabdo@yahoo.com, [5]msyazwanutm@gmail.com, [6]sadiqulkafawi4real@yahoo.co.uk

*Corresponding author

Abstract. The activity concentrations of naturally occurring radionuclides in environmental medium such as soil play an important role in setting national and international average doses to public for radiation protection purposes. This work measures the activity concentrations of the naturally occurring radionuclides (^{226} Ra, ^{232}Th and ^{40}K) in soil samples of Terengganu state, Malaysia using hyper pure germanium (HPGe) spectrometry. The mean (range) activity concentrations of ^{226}Ra, ^{232}Th, and 40K in the soil samples 79 ± 3 (20 ± 1 - 151 ± 5) Bq kg^{-1} with the mean value of Bq kg^{-1} for ^{226}Ra; 84 ± 3 (8 ± 1 - 182 ± 6) Bq kg^{-1} for ^{232}Th, and 545 ± 55 (47 ± 5 - 1056 ± 107) Bq kg-1 for 40K. Upon comparing these values with the world averages for ^{226}Ra, ^{232}Th and ^{40}K, which are 33, 36 and 474 Bq kg^{-1}, respectively. It is therefore, evidently seen that the mean activity concentrations of ^{226}Ra and ^{232}Th in the soil of Terengganu are slightly more than twice their corresponding global averages. The mean activity concentration of ^{40}K in the soil of Terengganu is ~ 15% higher than the world average.

Keywords: Environmental radioactivity; activity concentrations; 232Th; 226Ra; 40K; Terengganu

1.0 INTRODUCTION

Natural environmental radioactivity arises mainly from primordial radionuclides such as ^{40}K and also from ^{238}U and ^{232}Th decay series, which occur at trace levels in all ground formation [1]. Several studies performed worldwide have measured the activity concentration of natural radionuclides in soil [2-10]. In Malaysia, studies have been conducted to measure the terrestrial natural radioactivity as well as the human health consequences [11-22].

This study is one of the few pioneer which consider the State of Terengganu for the measurement of terrestrial gamma radiation dose rates and the top soil activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K.

2.0 EXPERIMENTAL

2.1 METHODS

2.1.1 Study Area

The study area is located in the North-eastern part of Peninsula Malaysia, covering latitude 4 º00 ´00 to 5 º15' ´00 N and longitude 102 º15' ´00 to 103 º 45´00. It is bordered in the Northwest by Kelantan state, the southwest by Pahang, and the east by the South China Sea. Several outlying islands, including Pulau Perhentian, Pulau Kapas and Pulau Redang, are also a part of the state. The state consists of seven districts **(Figure 2.**1) and has a total area of 13,035 km^2 and a population of 1,015,776 as of 2010 [23]. The study area is underlain by eight geological formations described by Director of Geological Survey, 1985 shown in **(Figure 2.2)**.

Figure 2.1: Districts map of the study area

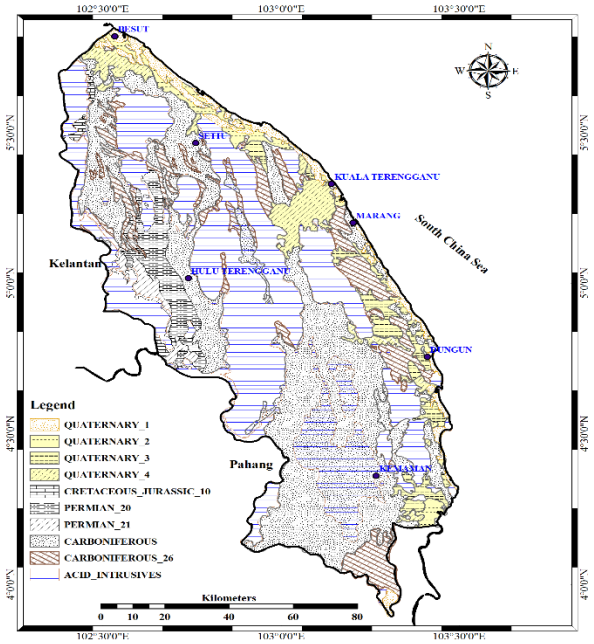

Figure 2.2 Geological formations map of Terengganu

2.2 Data Collection

2.2.1 Sample collection and preparation

2 kg soil samples were collected from the state of Terengganu, which widely covered each of the eight districts. Twenty four soil samples were taken from the depth of 10 - 15 cm within a marked cleared area of about 50 cm in diameter and mixed thoroughly, in order to obtain a representative sample of that area. They are taken away from roads, trees, buildings and any other source of obstruction. The sampling locations were recorded with a global positioning system (GPS). The collected samples were packed in a well labeled polythene bags and transported to the laboratory.

In the laboratory, the samples were oven dried at 110 ^{0}C for 24 hours, cleared of stones and pebbles, crushed and ground to a fine powder and passed through a 400 µm and 250 µm mesh sieved to be homogenized. The homogenized samples were then weighted and packed into a standard 500 mL Marinelli beakers and stored for about thirty days to attain secular equilibrium between radium and its progeny, this procedure have been adopted in past studies [24-26].

2.2.2 Sample analysis

A coaxial high purity germanium (HPGe) detector (GC2018-7500 SL) manufactured by Canberra with a relative efficiency of 20 % relative to a 7.62 cm × 7.62 cm NaI (Tl) detector and a resolution of 1.8 keV for the 1332 keV gamma ray emission of ^{60}Co, Genie 2000 (VI.3) software from Canberra was used to analyze the spectra.

The energy calibration was done using a point source of ^{241}Am (59.54keV), ^{137}Cs (661.62 keV) and ^{60}Co (1173 and1332 keV), whereas efficiency was calibrated using a 500 mL multi-nuclide standard solution. A Marinelli beaker full with de-ionized water was counted to strip the background from the samples. The value of Minimum Detectable Activity (MDA) was 13 Bq kg^{-1} for ^{40}K, 1 Bq kg^{-1} for ^{226}Ra and 2 Bq kg^{-1} for ^{232}Th for a counting time of 21,600 s [27, 28].

The activity of ^{226}Ra was determined based on gamma ray emissions of ^{214}Pb (352 keV) and ^{214}Bi (609), ^{232}Th was determined based on the emissions of ^{208}Tl (583.1 keV) and ^{228}Ac (911.2 keV) and that of ^{40}K was determined directly from it emission energy of 1461.8 keV. The concentrations of ^{226}Ra and ^{232}Th were calculated from the weighted mean activity values determined for various emissions. IAEA Soil 6, IAEA S-14 and IAEA S-16 were used for quality control and assurance.

3.0 RESULTS AND DISCUSSION

Activity concentrations of naturally occurring radionuclides were measured for 24 soil samples collected using (HPGe) detector. The measured activity concentration of ^{226}Ra varied from 20 ± 1 to 151 ± 5 Bq kg^{-1} with a mean value of 79 ± 3 Bq kg^{-1}, ^{232}Th activity concentrations ranged from 8 ± 1 to 182 ± 6 Bq kg^{-1}with a mean value of 84 ± 3 Bq kg^{-1} and the activity concentrations of ^{40}K ranged from 47 ± 5 to 1056 ± 107 Bq kg^{-1} with a mean value of 545 ± 55 Bq kg^{-1}as shown in Table 1.

Table 1.0 Activity concentrations of natural radionuclides in the districts within the study area

District	K (Bq kg^{-1})		Ra (Bq kg^{-1})		Th (Bq kg^{-1})	
	Mean	Range	Mean	Range	Mean	range
Besut	424 ± 45	83 - 1056	83 ± 4	20 - 115	82 ± 4	8 - 160
Dungun	589 ± 58	266 - 929	74 ± 2	39 - 114	106 ± 4	51 - 182
Hulu Terengganu	431 ± 44	262 - 828	91 ± 3	60 - 148	93 ± 4	49 - 166
Kemaman	588 ± 58	47 - 986	81 ± 3	29 - 151	84 ± 3	34 - 131
Kuala Terengganu	504 ± 50	459 - 549	33 ± 1	22 - 43	51 ± 2	45 - 57
Marang	475 ± 48	475 - 475	55 ± 2	55 - 55	79 ± 3	79 - 79
Setiu	762 ± 75	655 - 832	89 ± 3	51 - 121	79 ± 3	47 - 132
Terangganu State	545 ± 55	47 - 1056	79 ± 3	20 - 151	84 ± 3	8 - 182

The measured activity concentration of of ^{226}Ra and ^{232}Th in the soil of Terengganu were slightly more than twice their corresponding global averages. The mean activity concentration of ^{40}K in the soil of Terengganu was ~ 15% higher than the world average. It can be observed from **(Figure 3.1)** that the highest ^{226}Ra activity concentrations were found in the Hulu Terengganu with mean activity concentrations of 91 ± 3 Bq kg^{-1}.

Dungun has the highest activity concentrations of ^{232}Th with a mean value of 106 ± 4 Bq kg^{-1} whereas the highest concentration of ^{40}K was found in Setiu district with a mean value of 762 ± 75 Bq kg^{-1}. The areas which are covered by acid intrusive geological formations and overlain by Haplic Acrisol- Haplic Acrisol - Gleyic Luvisol soil type has the highest mean activity concentration of ^{226}Ra, while the area covered by mostly acid intrusive geological formation and overlain by Dystric Fluvisols - Dystric Gleysol soil type has the highest activity concentration of ^{232}Th.

The lower concentrations was observed in areas which are covered by carboniferous geological formation and overlain by Haplic Acrisol- Haplic Acrisol - Gleyic Luvisol soil type for both ^{226}Ra and ^{232}Th respectively. ^{40}K activity concentration was found to be higher in carboniferous geological formation and overlain by Haplic Acrisol- Haplic Acrisol - Gleyic Luvisol soil types.

.

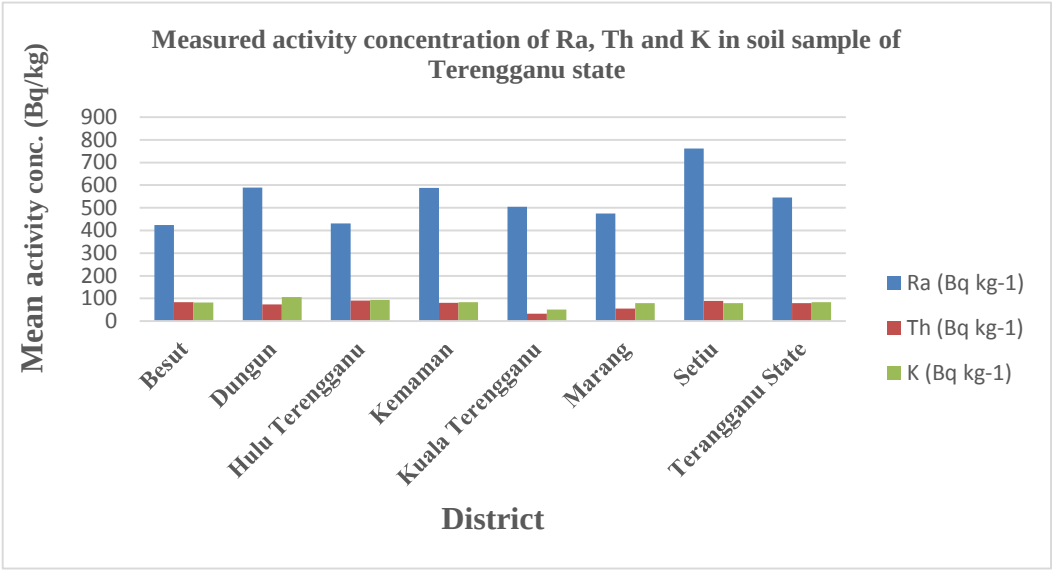

Figure 3.1: A plot of district's Ra, Th and K mean activity conc. in Terengganu

4.0 CONCLUSION

The mean activity concentration of ^{226}Ra, ^{232}Th and ^{40}K was found to be 79 Bq kg^{-1}, 84 Bq kg^{-1} and 545 Bq kg^{-1} respectively. The mean activity concentration of ^{226}Ra and ^{232}Th are about two times higher than the world average whereas the mean activity concentration of ^{40}K is slightly higher than the world average value of 420 Bq kg^{-1}.

Acknowledgement
This project is funded by the Atomic Energy Licensing Board (AELB), Ministry of Science, Technology and Innovation, Malaysia under project title: PEMETAAN ISODOS SINARAN GAMA DATARAN, SEMENANJUNG Malaysia, which involved Lee, M.H., Heryanshah, A., Wagiran, H., and Said, M.N. The consultancy was managed by GITM Sdn Bhd. The authors would like to thank the Ministry of Higher Education Malaysia (MOHE) and Universiti Teknologi Malaysia (UTM) for support and funding under UTM Research University Grant; QJ130000.2526.03H67.

REFERENCES

[1]. Tzortzis, M., Svoukis, E. and Tsertos, H. A comprehensive study of natural gamma radioactivity levels and associated dose rates from surface soils in Cyprus. *Radiation protection dosimetry*. 2004. 109(3): 217-224.
[2]. McAulay, I. and Morgan, D. Natural radioactivity in soil in the Republic of Ireland. *Radiation Protection Dosimetry*. 1988. 24(1-4): 47-49.
[3]. Quindos, L., Fernandez, P., Soto, J., Rodenas, C. and Gomez, J. Natural radioactivity in Spanish soils. *Health Physics*. 1994. 66(2): 194-200.
[4]. Ahmad, N. and Khatibeh, A. Indoor Radon Levels and Natural Radioactivity in Jordanian Soils. *Radiation Protection Dosimetry*. 1997. 71(3): 231-233.
[5]. Karahan, G. and Bayulken, A. Assessment of gamma dose rates around Istanbul (Turkey). *Journal of environmental radioactivity*. 2000. 47(2): 213-221.

[6]. Al-Jundi, J. Population doses from terrestrial gamma exposure in areas near to old phosphate mine, Russaifa, Jordan. *Radiation Measurements*. 2002. 35(1): 23-28.

[7]. Matiullah, Ahad, A., ur Rehman, S., ur Rehman, S. and Faheem, M. Measurement of radioactivity in the soil of Bahawalpur division, Pakistan. *Radiation Protection Dosimetry*. 2004. 112(3): 443-447.

[8]. Tahir, S., Jamil, K., Zaidi, J., Arif, M., Ahmed, N. and Ahmad, S. A. Measurements of activity concentrations of naturally occurring radionuclides in soil samples from Punjab province of Pakistan and assessment of radiological hazards. *Radiation Protection Dosimetry*. 2005. 113(4): 421-427.

[9]. Fatima, I., Zaidi, J., Arif, M., Daud, M., Ahmad, S. and Tahir, S. Measurement of natural radioactivity and dose rate assessment of terrestrial gamma radiation in the soil of southern Punjab, Pakistan. *Radiation Protection Dosimetry*. 2008. 128(2): 206-212.

[10]. Saleh, I. H., Hafez, A. F., Elanany, N. H., Motaweh, H. A. and Naim, M. A. Radiological study on soils, foodstuff and fertilizers in the Alexandria region, Egypt. *Turk. J. Eng. Environ. Sci*. 2007. 31: 9-17.

[11]. Saleh, M. A., Ramli, A. T., Alajerami, Y. and Aliyu, A. S. Assessment of environmental ^{226} Ra, ^{232}Th and ^{40} K concentrations in the region of elevated radiation background in Segamat District, Johor, Malaysia. *J. Environ. Radioac.* 2013. 124: 130-140.

[12]. Ramli, A. T., Sahrone, S. and Wagiran, H. Terrestrial gamma radiation dose study to determine the baseline for environmental radiological health practices in Melaka state, Malaysia. *Journal of Radiological Protection*. 2005. 25(4): 435.

[13]. Lee, S. K., Wagiran, H., Termizi Ramli, A., Heru Apriantoro, N. and Khalik Wood, A. Radiological monitoring: terrestrial natural radionuclides in Kinta District, Perak, Malaysia. *Journal of environmental radioactivity*. 2009. 100(5): 368-374.

[14]. Gabdo, H., Ramli, A., Sanusi, M., Saleh, M. and Garba, N. Terrestrial gamma dose rate in Pahang state Malaysia. *Journal of radioanalytical and nuclear chemistry*. 2014: 1-6.

[15]. Ramli, A. T., Rahman, A. T. A. and Lee, M. Statistical prediction of terrestrial gamma radiation dose rate based on geological features and soil types in Kota Tinggi district, Malaysia. *Applied Radiation and Isotopes*. 2003. 59(5): 393-405.

[16]. Ramli, A. T. Environmental terrestrial gamma radiation dose and its relationship with soil type and underlying geological formations in Pontian district, Malaysia. *Applied Radiation and Isotopes*. 1997. 48(3): 407-412.

[17]. Saleh, M. A., Ramli, A. T., Alajerami, Y., Aliyu, A. S. and Bt Basri, N. A. Radiological study of Mersing District, Johor, Malaysia. *Radiat. Phys. & Chem.* 2013.

[18]. Ramli, A. T., Hussein, A. W. and Wood, A. K. Environmental ^{238}U and ^{232}Th concentration measurements in an area of high level natural background radiation at Palong, Johor, Malaysia. *Journal of environmental radioactivity*. 2005. 80(3): 287-304.

[19]. Ramli, A. T., Hussein, A. W. and Lee, M. Geological influence on terrestrial gamma radiation dose rate in the Malaysian State of Johore. *Applied Radiation and Isotopes*. 2001. 54(2): 327-333.

[20]. Ramli, A. T., Apriantoro, N. H., Wagiran, H., Wood, A. K. and Kuan, L. S. Health risk implications of high background radiation dose rate in Kampung Sungai Durian, Kinta District, Perak, Malaysia. *Global Journal of Health Science*. 2009. 1(2): P140.

[21]. Garba, N. N., Ramli, A. T., Saleh, M. A., Sanusi, M. S. and Gabdo, H. T. Assessment of terrestrial gamma radiation dose rate (TGRD) of Kelantan State, Malaysia: Relationship between the geological formation and soil type to radiation dose rate. *Journal of Radioanalytical and Nuclear Chemistry*. 2014. 302(1): 201-209.

[22]. Garba, N. N., Ramli, A. T., Saleh, M. A., Sanusi, M. S. and Gabdo, H. T. Terrestrial gamma radiation dose rates and radiological mapping of Terengganu state, Malaysia. *Journal of Radioanalytical and Nuclear Chemistry*. 2014. 10.1007/s10967-014-3818-2: 8.

[23]. Statistics, D. o. Population and Housing Census of Malaysia 2010. 2010: 55.

[24]. Saleh, M. A., Ramli, A. T., Alajerami, Y. and Aliyu, A. S. Assessment of Natural Radiation Levels and Associated Dose Rates from Surface Soils in Pontian District, Johor, Malaysia. *Journal of Ovonic Research*. 2013. 9(1): 17-26.

[25]. Ibrahiem, N., El Ghani, A. A., Shawky, S., Ashraf, E. and Farouk, M. Measurement of radioactivity levels in soil in the Nile Delta and Middle Egypt. *Health Physics*. 1993. 64(6): 620-627.

[26]. Mollah, A., Rahman, M., Koddus, M., Husain, S. and Malek, M. Measurement of high natural background radiation levels by TLD at Cox's Bazar coastal areas in Bangladesh. *Radiation protection dosimetry*. 1987. 18(1): 39-41.

[27]. IAEA *Measurement of Radionuclides in Food and the Environment - A Guidebook* Technical Reports, Vienna: International Atomic Energy Agency 1989.

[28]. IAEA *Guidelines for radioelement mapping using gamma ray spectrometry data* IAEA-TECDOC-CD-1363: International Atomic Energy Agency, Vienna. 2003.