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Journal of Radiation Research and Applied Sciences
journal homepage: http://www.elsevier.com/locate/jrras

An overview on measurements of natural radioactivity in Malaysia

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ARTICLE INFO

Article history:
Received 18 November 2014
Received in revised form
21 December 2014
Accepted 22 December 2014
Available online 31 December 2014

Keywords:
HPGe
NaI
Soil
Radioactivity

ABSTRACT

Humans are always exposed during their lives to ionizing radiation arising outside and within the earth. The exposure to these radiation occurs from natural sources such as radioactive elements in rocks and soil, internal exposure form radioactive elements through water, food and air and cosmic rays entering from outer space to earth's atmosphere. About 87% of the radiation dose received by human beings is due to natural radiation, it is essential to assess the radiation doses in order to control possible health effects from such natural sources. In this regard, a number of articles have been appeared for Malaysia in international research journals, which have been reviewed and complied in this article. Most of these articles are about the measurement of activity concentrations of primordial (^{238}U, ^{232}Th, ^{226}Ra and ^{40}K) and anthropogenic (^{137}Cs) radionuclide's and gamma dose rate in environmental samples using HPGe and NaI (Tl) survey meter.

1. Introduction

Natural radioactivity has great contributions in ionizing radiations to the world population due to its presences in surrounding at a different amount because of natural presences. Soil is one of the major sources of radiation exposure to the population and of migration for the transfer of radionuclide into the environment; hence it is the basic indicator of radiological contamination. The presence of natural radioactivity in building materials results in the external and internal exposure of the public. Therefore, it is very important to monitor the radiation hazard appearing due to the use of sand, soil and other materials containing high activity concentration of natural radioactivity in the construction of dwellings (Rahman & Faheem, 2008). Natural radioactivity in soil is mainly due to ^{238}U, ^{40}K, ^{232}Th and ^{226}Ra, which causes external and internal radiological hazards due to emission of gamma rays and inhalation of radon ant its daughters (UNSCEAR, 1988). Measurement of external gamma dose due to terrestrial sources is necessary not only due to its contributions to the collective dose but also due to variations of the individual dose related to the pathway. These doses strongly depends on the concentrations of ^{238}U, ^{232}Th, their progenies and ^{40}K, presents in rocks and soil, which in turns depends upon the geology of the regions (Malik, 2014; Quindos, Fernandez, Soto, Rodenas, & Gomez, 1994; Radhakrishna, Somashekarappa, Narayana, & Siddappa, 1993).

In Malaysia, cancer (stomach, breast, lung, liver, leukaemia and thyroid) is one of the major health problems. It has been certified medically that cancer is the fourth leading cause of

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Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications.
http://dx.doi.org/10.1016/j.jrras.2014.12.008

death. Cancer has become increasingly important as a public health concern considering the development and progress that has been achieved in Malaysia. According to the survey carried out in 1994 in Penang, Malaysia showed that the age standardized incidence rate was 119.3 per 100,000 for all type of cancers. During the period of 2004–2008, a total 9692 cases were identified in Penang, Malaysia. In this regards Almayahi et al. in 2012 performed a study in Penang and concluded that high concentrations of natural radioactivity and $^{226}Ra/^{238}U$ disequilibrium are the main cause of cancer in Penang (Almayahi, Tajuddin, & Jaafar, 2012a). Since 1994 to 2014, a number of researchers have been involved in the measurement of natural radioactivity in different parts of Malaysia. The data reported by a number of groups have been compiled in this article for future reference.

2. Summary of the results

Studies carried out by different research groups in Malaysia are summarized in this section. Tajuddin et al. in 1994 reported the natural radiation levels along the highway of Peninsular Malaysia by using NaI (Tl) scintillation detector (Tajuddin, Hu, & Sakanoue, 1994). The highest value of gamma dose rate was 1.5 μGy h^{-1} in Bukit Merah, whereas 150 nGy h^{-1} and 125 nGy h^{-1} were found in Penang and Kuala Lumpur, respectively. The gamma dose rate around Penang was found to be slightly higher than those in Kuala Lumpur. In southern part of Ipoh and its surrounding area its value was found 40 nGy h^{-1} which is less than those for Penang and Kuala Lumpur. Ramli in 1997 reported the relationship of environmental terrestrial gamma radiation dose with soil type in the Pontian District, Malaysia by using a NaI (Tl) survey meter (Ramli, 1997). The values of the natural terrestrial gamma ray dose in Pontian District ranged from 9 to 270 nGy h^{-1} with the average value of 67 nGy h^{-1}. Omar et al. in 2004 reported radium distribution in oil and gas industry wastes by using HPGe detector (Omar et al., 2004). The maximum values of ^{226}Ra concentrations ranged from 550 to 434,000 Bq kg^{-1} whereas minimum values ranged from 6 to 35 Bq kg^{-1}. Maximum values of ^{228}Ra concentrations ranged from 900 to 479,000 Bq kg^{-1} whereas minimum values ranged from 4 to 18 Bq kg^{-1}. Ramli et al. in 2005 reported the concentrations of ^{238}U and ^{232}Th in soil, water and grass, in high background radiation area by using neutron activation analysis (NAA) (Ramli, Hussein, & Wood, 2005). The concentrations of ^{238}U and ^{232}Th in soil ranged from 58.8 to 484.8 Bq kg^{-1} and 59.6–1204 Bq kg^{-1}, respectively, while in that of grass samples its values ranged from below the detection limit to 912 mBq kg^{-1} and from 32 mBq kg^{-1} to 1.372 Bq kg^{-1}, respectively. The contents of ^{238}U and ^{232}Th in water samples ranged from 4.0 to 16.8 Bq L^{-1} and 0.76–2.64 Bq L^{-1}, respectively. They also estimated terrestrial gamma-ray dose value of 1440 nGy h^{-1} in Balai Badang Village, Malaysia. Ramli et al. in 2005 also reported the terrestrial gamma radiation dose throughout Melaka, Malaysia by using NaI (Tl) survey meter (Ramli, Sahrone, & Wagiran, 2005). The values of gamma ray dose ranged from 54 ± 5 to 378 ± 38 nGy h^{-1}. The population weighted means dose rate throughout Melaka was 172 ± 17 nGy h^{-1}. They also reported annual effective dose rate value of 0.21 mSv and found higher than recommended value of 0.07 mSv. Omar et al. in 2006 reported radiation exposure on the roads in Malaysia by using NaI (Tl) survey meter (Omar, Hassan, & Sulaiman, 2006). The gamma ray dose rate on the roads ranged from 36 to 1560 nGy h^{-1} while in case of travelling on an ordinary train its values ranged from 60 to 350 nGy h^{-1}. The lowest radiation dose rate was found during sea travelling by ferries due to cosmic radiation at the sea level. Yasir et al. in 2007 reported natural radioactivity in Malaysian building materials by using gamma ray spectrometry (Yasir, Ab Majid, & Yahaya, 2007). The activity concentrations of ^{238}U, ^{232}Th and ^{40}K ranged from 19 to 42.2 Bq kg^{-1}, 16.5–28.8 Bq kg^{-1} and 243.3–614.2 Bq kg^{-1}, respectively. They also estimated radium equivalent activity values of 130.7 ± 42.2 Bq kg^{-1} observed higher in bricks made of cement and 61.3 ± 10 Bq kg^{-1} observed lower in marble. The reported values of representative level index were found less than 1. Abdul Rahman et al. in 2007 reported the ^{238}U and ^{232}Th concentrations, alpha and beta activities and associated dose rates from soil in Ulu Tiram, Malaysia by using HPGe detector and NaI (Tl) scintillation survey meter (Abdul Rahman & Ramli, 2007). The concentrations of ^{238}U and ^{232}Th ranged from 21.88 ± 2.51 to 57.61 ± 6.03 Bq kg^{-1} (1.74 ± 0.20 to 4.58 ± 0.48 ppm) and 43.46 ± 3.09 to 334.14 ± 16.32 Bq kg^{-1} (10.68 ± 0.76 to 82.10 ± 4.01 ppm) with average values of 45.66 ± 4.90 Bq kg^{-1} (3.63 ± 0.39 ppm) and175.01 ± 9.40 Bq kg^{-1} (43.00 ± 2.31 ppm), respectively. The estimated gamma dose rate ranged from 96 to 409 nGy h^{-1} with the average value of 200 nGy h^{-1} and outdoor annual effective dose was found 1.2 mSv. The average α and β activity in soil were found 0.65 ± 0.09 Bq g^{-1} and 0.68 ± 0.08 Bq g^{-1}, respectively. Alias et al. in 2008 reported natural radioactivity in soil having different surface areas using HPGe detector (Alias, Hamzah, Saat, Omer, & Wood, 2008). The maximum concentrations of ^{40}K ranged from 107.2 to 383.3 Bq kg^{-1} whereas minimum ranged from 11.3 to 108.4 Bq kg^{-1} while in case of ^{226}Ra and ^{228}Ra their maximum values ranged from 16.2 to 42 Bq kg^{-1}, 27.3–44.9 Bq kg^{-1} and minimum ranged from 10.1 to 29.3 Bq kg^{-1}, 11.4–38.2 Bq kg^{-1}, respectively. Surface dose rate and radium equivalent activity were also estimated in this study. Ramli et al. in 2009 reported natural radioactivity in soil, plants and water around Kampong Sungai Durian, Kinta, Malaysia by using HPGe detector (Ramli, Apriantoro, Wagiran, Wood, & Kuan, 2009). The concentrations of ^{238}U, ^{232}Th and ^{40}K in soil ranged from 32 to 544 Bq kg^{-1}, 64–1806 Bq kg^{-1} and 21–2522 Bq kg^{-1}, respectively with the average values 196 ± 43 Bq kg^{-1}, 628 ± 169 Bq kg^{-1} and 475 ± 89 Bq kg^{-1}, respectively. The concentrations of ^{238}U and ^{232}Th in plants and water ranged from <0.49 to 996.38 mBq kg^{-1} and 0.21–1274 mBq kg^{-1}, and from <0.24 to 31.96 mBq L^{-1}, <0.21–5.69 mBq L^{-1} respectively. The terrestrial gamma ray dose rate ranged from 78 to 1039 nGy h^{-1} with the mean value of 458 nGy h^{-1} which causes fatal cancer risk of about 9.91×10^{-5} per year to each individual. Lee, Wagiran, Termizi Ramli, Heru Apriantoro, and Khalik Wood (2009) reported radioactivity in Kinta District, Perak, Malaysia by using HPGe detector and NaI (Tl) survey meter (Lee et al., 2009). The activity concentrations of ^{238}U, ^{232}Th and ^{40}K ranged from 12 to 426 Bq kg^{-1}, 19–1377 Bq kg^{-1} and <19–2204 Bq kg^{-1}, respectively. The external dose rate ranged from 39 to 1039 nGy h^{-1} with the mean value of 222 nGy h^{-1}. Ramli et al. in 2009 reported radiation dose rates in high radiation area of Selama, Perak, Malaysia