MEASUREMENT OF TERRESTRIAL GAMMA RADIATION DOSE RATE USING THERMOLUMINESCENCE DOSIMETER IN THE BISHNUPUR DISTRICT OF MANIPUR.

H Nungshibabu Singh[1*], Th. Geeta Devi[2], B. Arunkumar Sharma[3] And S Nabadwip Singh[4]

Abstract:
Terrestrial gamma radiation is a significant component of natural background radiation, and accurate measurement is crucial for assessing radiation exposure in various environments. TLDs offer a reliable method for quantifying gamma radiation doses, providing a sensitive and versatile dosimetry tool. The application of thermoluminescence dosimeters has proven to be effective in capturing spatial and temporal variations of natural background radiation. The measurement of radiation dose rate in the Bishnupur District, Manipur contributes to the broader field of radiation monitoring, providing context to the local radiological environment from a global perspective. The average radiation absorbed dose rate of Bishnupur District is (0.800±0.087) mGy/yr with a maximum value of (1.021±0.054) mGy/yr and minimum of value of (0.640±0.015) mGy/yr.

Keywords: Terrestrial, Gamma radiation, Thermoluminescence dosimeter, Environmental dosimetry, Radiation dose.

[1*]Department of Physics, Manipur University, Canchipur, 795003, Manipur, India
[2]Department of Physics, Manipur International University, Ghari-795140, Manipur, India
[3]Department of Radiation Oncology, Regional Institute of Medical Sciences, Imphal-795004, Manipur, India
[4]Department of Physics, Oriental College (Autonomous), Takyel, Imphal-795001, Manipur, India

***Corresponding Author:** H Nungshibabu Singh
*Department of Physics, Manipur University, Canchipur, 795003, Manipur, India

DOI: 10.53555/ecb/2022.11.11.92

1. Introduction:

Terrestrial gamma radiation emanates from natural sources intricately woven into the Earth's environment, including radionuclides ^{40}K and the isotopes of the ^{238}U and ^{232}Th decay chain, present in soil and rocks, as well as interactions of cosmic rays with the Earth's atmosphere. This complex interplay results in the emission of gamma rays, contributing significantly to the natural background radiation that surrounds us. The comprehension and precise quantification of these radiation levels hold paramount importance for various critical domains. For environmental radiation monitoring, a nuanced understanding of terrestrial gamma radiation is indispensable. Monitoring enables the identification of radiation hotspots, variations across geographical regions, and potential environmental impacts. This information is pivotal for ensuring the well-being of ecosystems and minimizing the impact of radiation on flora and fauna (Singh et al, 2005, UNSC 1993, 2008).

Moreover, the assessment of health risks associated with terrestrial gamma radiation is a crucial facet of this scientific endeavor. Exposure to elevated radiation levels poses potential health risks to both humans and other organisms. Quantifying these risks allows for the establishment of guidelines and safety standards, fostering the protection of public health and the environment. The establishment of baseline data for specific regions is another key aspect of this research. By comprehensively understanding the natural levels of terrestrial gamma radiation in a given area, scientists can discern anomalous increases in radiation, whether natural or anthropogenic in origin. This baseline data forms the foundation for effective radiation management strategies, aiding in the identification of deviations that may warrant further investigation or intervention (Sharma BA et.al 2020, Suranjit S et.al 2020, Rajesh S and Kerur BR 2018, Singh SN etal 2017, Sharma AB and Singh NS 2018, Joyshangkar M et.al 2020).

Thermoluminescence dosimeters (TLDs) represent a sophisticated and widely utilized technology in the field of radiation dosimetry, relying on the fundamental principle of thermoluminescence. These dosimeters are specifically designed to quantify ionizing radiation doses, offering a robust and precise method for radiation measurement. The core of TLD technology lies in the use of sensitive crystalline materials within the dosimeter. These materials have the remarkable ability to accumulate energy when exposed to ionizing radiation, trapping electrons in elevated energy states within their crystalline structure. Subsequently, when subjected to controlled heating, these trapped electrons release the stored energy in the form of visible light—a phenomenon known as thermoluminescence.

This paper is focused on the application of $CaSO_4$:Dy as TLDs to measure terrestrial gamma radiation dose rates. By strategically deploying TLDs in various locations within the study area, to capture the intricate variations in gamma radiation levels. The TLDs, acting as sensitive detectors, will accumulate radiation energy over the monitoring period. The advantage of TLDs in measuring terrestrial gamma radiation lies in their high sensitivity, ability to discern low levels of radiation, and their capacity to provide cumulative dose information. This exploration extends the scope of TLD applications, offering insights into the intricate dynamics of natural background radiation and facilitating a comprehensive understanding of the radiation environment in the studied region.

2. Material and Methods

The thermoluminescence (TL) method of the measurement of terrestrial gamma radiation dose rate followed the BARC protocol on "Environmental Radiation Surveillance Using TLDS: Protocol and Quality Assurance". The steps involved in the measurement dose are as follows:

TLD cards were placed on a cleaned tray and then cleaned with acetone before annealing and stored properly in clean and dust-free condition in a box. Then the TLD cards were dried at room temperature for 12-16 hrs. The TLD cards were annealed into a furnace at which the temperature was raised from ambient to 300°C and maintained for 4 hours. After this annealing period, the furnace was allowed to cool down naturally and the tray containing the TLD card was removed after the temperature of the furnace was about room temperature. The TL readout of at least 5 annealed TLDs was carried out by TL Research Reader and their count was about 25-30 count in the absence of such low readings, the entire TLD was subjected to the annealing process again.

Fig 1: Placement of TLD in the selected area

The annealed cards were wrapped in black polythene and put inside a specially designed TLD cage of copper of thickness of about 1mm. Finally, the cage containing the TLD was sealed in a black polythene/PVC packet. Now the TLD is ready for deployment in the selected areas as shown in Figure 1.

The meticulous deployment strategy of Thermoluminescence Dosimeters (TLDs) played a pivotal role in ensuring accurate and comprehensive data collection regarding terrestrial gamma radiation dose rates. The TLDs were strategically placed at an elevation of at least 1 meter from the ground and maintained a distance of 1 meter from any surrounding walls. The careful selection of deployment height and positioning aimed to minimize potential interference from ground-level radiation sources and wall interactions, ensuring a representative measurement of the ambient radiation environment.

Precise documentation of the date and time of TLD deployment was undertaken, providing a temporal reference for subsequent analyses. Once deployed, the TLDs remained undisturbed for a minimum of 3 months, allowing for a robust assessment of long-term radiation exposure levels. This extended deployment period ensured the accumulation of sufficient radiation energy for a comprehensive evaluation of terrestrial gamma radiation. A Global Positioning System (GPS) was employed to record the latitude, longitude, and altitude of each deployment site. This geospatial information is vital for correlating radiation levels with specific geographical locations, facilitating a nuanced understanding of regional variations in terrestrial gamma radiation.

After the 3-month deployment period, the TLDs were retrieved from the selected sites. The collected data underwent meticulous analysis to determine terrestrial gamma radiation dose rates. This analysis took into account spatial variations, acknowledged potential influences from local geological features, and considered seasonal fluctuations in radiation levels.

3. Experiment

The additional set of 10 Thermoluminescence Dosimeter (TLD) cards, kept in isolation within a lead pot to prevent inadvertent exposure, underwent calibration at RIMS, Imphal. The calibration was performed at various doses, specifically 0.5, 1, 1.5, and 2 mGy, serving as reference points for establishing the TLDs' response to different levels of ionizing radiation dose.

The process involved irradiating the TLD cards and subsequently recording their Thermoluminescent (TL) glow curves. The calibration curve, essential for translating TL glow curve characteristics into quantifiable radiation doses, was then constructed. Figure 2 presents this calibration curve, illustrating the relationship between the recorded TL signals and the known irradiation doses. The slope of the regression line derived from the calibration curve is a key parameter, and it serves as the calibration factor. The calibration factor, determined through this process, is fundamental for accurately converting the TL signals from subsequent measurements into corresponding radiation doses. This meticulously conducted calibration procedure establishes a reliable relationship between the TLDs' response and the actual radiation doses, ensuring the accuracy and validity of the dosimetric measurements undertaken in the study.

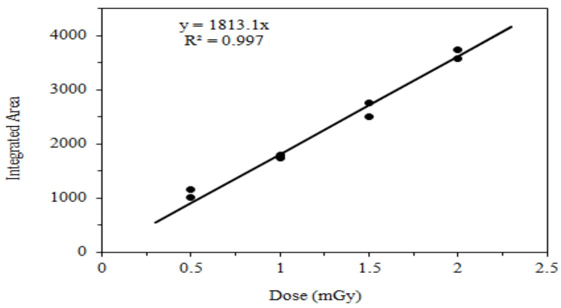

Figure 2: The calibration curve.

The thermoluminescence Dosimeters (TLDs) strategically deployed at pre-selected sites within the Bishnupur District were collected after a comprehensive exposure period of 3 months to capture a representative record of the accumulated radiation exposure in the designated locations. To delve into the intricate details of the absorbed radiation, the glow curves of the TLDs were meticulously measured using the TL Research Reader. The glow curves, exemplified in Figure 3, visually depict the intensity of thermoluminescent emission as a function of temperature, providing a unique signature indicative of the cumulative radiation exposure.

Subsequently, the corresponding integrated area calculated from the TL glow curves of the different TLD cards collected at various deployment sites was analyzed using the DRC curves as depicted in Figure 2 from which the radiation dose rate of the particular site was determined. The DRC serves as a crucial tool for translating the TLD glow curve characteristics into quantifiable radiation dose rates, allowing for the precise determination of the absorbed radiation levels at the designated locations.

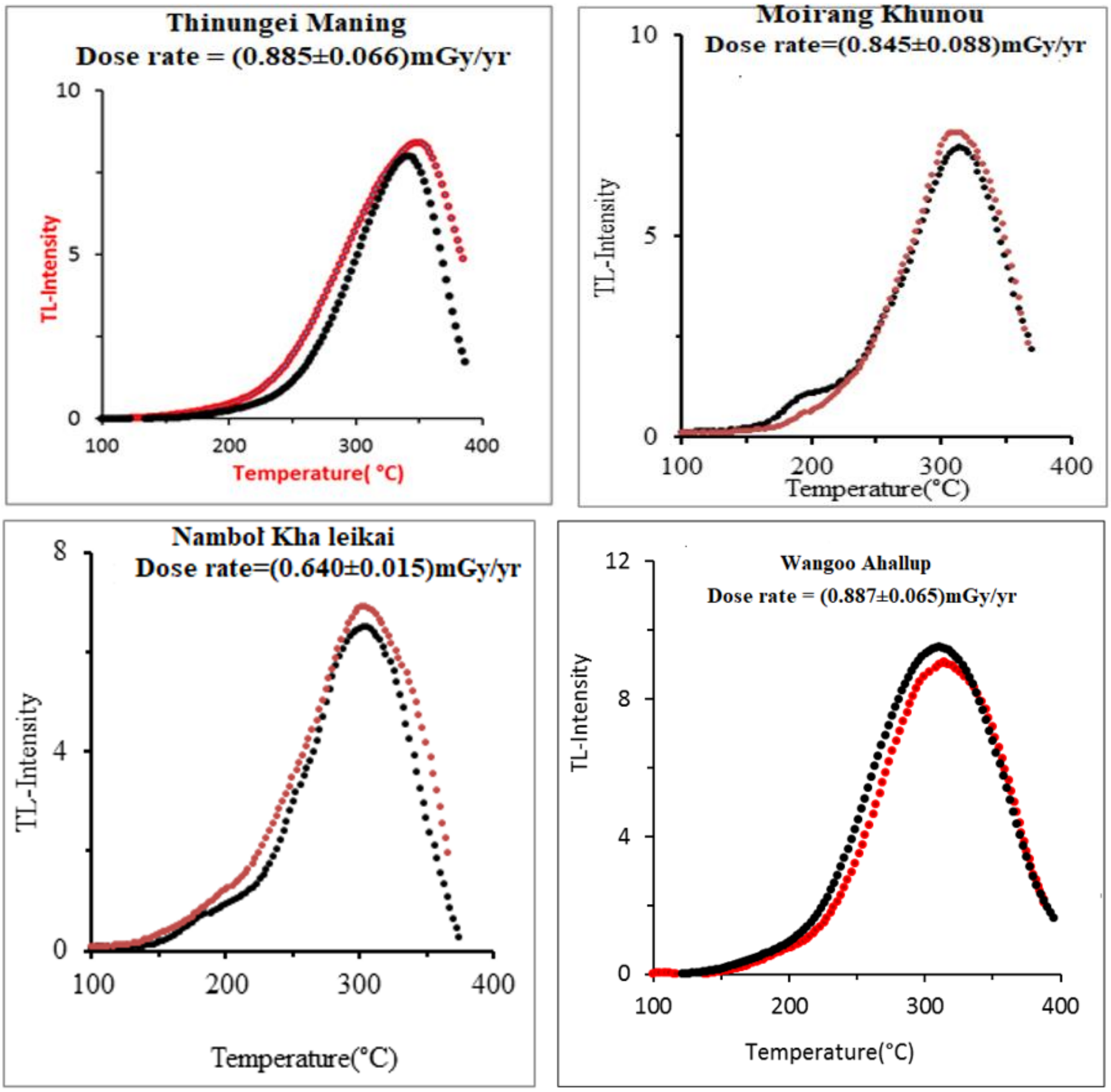

Figure 3: TL glow curves of the phosphors placed at selected sites of Bishnupur District for a period of 3-months. (Red and Black glow curves are the glow curves for two TLDs placed at the same site for same time.)

This integrated methodology, encompassing TLD deployment, glow curve measurements, and dose rate calculations, forms a crucial component of our comprehensive investigation into terrestrial gamma radiation dynamics in the Bishnupur District. By employing advanced dosimetry techniques and meticulous analysis, we ensure the reliability and accuracy of our findings. This approach contributes significantly to enhancing our understanding of the radiation environment in the studied region, facilitating informed insights into terrestrial gamma radiation dynamics.

4. Results and Discussion:

The radiation dose rates measured using the Thermoluminescence Dosimeter (TLD) method at various sites across the Bishnupur district in Manipur are detailed in Table 1. Notably, these values closely align with the radiation dose rates reported in the study conducted by Sharma, B.A. and Singh, N.S in 2018, utilizing the Micro Survey meter. This consistency in results between the TLD method and the Micro Survey meter underscores the reliability and accuracy of our measurements, providing a robust assessment of the terrestrial gamma radiation levels in the region.

Table 1: Radiation Dose Rate measured at different sites of Bishnupur district of Manipur.

Sl No.	Sites where phosphors are placed	Latitude Longitude	Dose rate (mGy/year)	Sl No.	Sites where phosphors are placed	Latitude Longitude	Dose rate (mGy/year)
1	Utlow Mayai Leikai	24°43□24.4□ 93°51□26.1□	0.877±0.057	36	Ningthoungong Maning	24°34□9.1□ 93°45□19.4□	0.945±0.055
2	Nambol Mamang Leikai	24°42□44.7□ 93°50□23.1□	0.816±0.042	37	Thinungei Mamang	24°33□9.5□ 93°45□53.1□	0.755±0.074
3	Nambol Awang Leikai	24°43□12.9□ 93°50□6.5□	0.720±0.045	38	Thinungei Maning	24°31□39.6□ 93°45□16.6□	0.885±0.066
4	Nambol Kha Leikai	24°42□59.8□ 93°49□43.7□	0.640±0.015	39	Sunishiphai Maning Leikai	24°30□50.7□ 93°45□29.1□	0.935±0.088
5	Nambol bazar	24°43□15.9□ 93°50□□□□□	0.935±0.065	40	Naranshina Bazar	24°30□25.0□ 93°45□37.5□	0.866±0.076
6	Maibam Lokpa Ching	24°43□15.9□ 93°48□53.8□	0.732±0.054	41	Sandangkhong	24°25□49.9□ 93°49□30.5□	0.845±0.067
7	Ishok Maning	24°41□35.5□ 93°49□26.4□	0.656±0.013	42	Ithai Khunou	24°25□26.1□ 93°49□13.2□	0.966±0.087
8	Naorem Ching	24°41□21.2□ 93°48□24.5□	0.810±0.101	43	Moirang Lai haraopham	24°29□50.2□ 93°47□2.37□	0.854±0.089
9	Oinam Kha Leikai	24°41□43.1□ 93°47□2.6□	0.732±0.065	44	Muti Purpose Hr. School, Moirang	24°30□2.7□ 93°47□21.7□	0.801±0.056
10	Oinam Bazar	24°41□47.1□ 93°47□11.5□	0.722±0.072	45	Moirang Mamang	24°29□20.7□ 93°47□52.2□	0.688±0.045
11	Irengbam Mamang	24°41□43.5□ 93°47□36.9□	0.665±0.065	46	Moirang Khunou	24°26□57.2□ 93°47□27.8□	0.845±0.088
12	Irengbam Mayai	24°41□55.2□ 93°46□58.1□	0.645±0.083	47	Thanga Samurou Leikai	24°31□21.8□ 93°48□51.6□	0.725±0.084
13	Leimaram Awang	24°43□4.1□ 93°47□13.7□	0.765±0.077	48	Thanga Lawai	24°27□49.6□ 93°47□8.9□	0.925±0.045
14	Irengbam Awang	24°42□3.2□ 93°47□□□□□ □	0.676±0.035	49	Wangu Shaban	24°23□6.8□ 93°49□57.2□	0.845±0.054
15	Irengbam Maning	24°41□0.9□ 93°47□42.1□	0.856±0.066	50	Wangu Bazar	24°21□6.0□ 93°50□42.3□	0.845±0.095
16	Leimaram Mamang	24°42□43.0□ 93°47□35.7□	0.725±0.054	51	Chairen Leingangbi	24°19□53.6□ 93°51□4.1□	0.888±0.085
17	Leimaram Kha	24°42□46.5□ 93°46□53.5□	0.886±0.089	52	Yaingangpokpi	□□□□□□□ □□□□□□□ □□□□□□□ □□	0.887±0.056
18	Yumnam Khunou Awang	24°41□0.9□ 93°47□35.7□	0.789±0.045	53	Yaingangpokpi Mkaha	□□□□□□□ □□□□□□□ □□□□□□□ □□	0.877±0.085
19	Yumnam Khunou Kha	24°40□56.7□ 93°47□30.6□	0.725±0.035	54	Khoijuman Khullen	□□□□□□□ □□□□□□□ □□□□□□□ □□	0.825±0.042
20	Keinou Kha leikai	24°40□40.5□ 93°47□7.5□	0.725±0.035	55	Thenjang	□□□□□□□ □□□□□□□ □□□□□□□ □□	0.885±0.065
21	Keinou Mamang Leikai	24°40□10.9□ 93°46□31.3□	0.812±0.075	56	Loktak Project Road	□□□□□□□ □□□□□□□ □□□□□□□ □□	0.745±0.045
22	Ngaikhong Khunou	24°39□18.5□ 93°46□□□.9□	0.745±0.074	57	Kha Khunou Thangnarel lambi	□□□□□□□ □□□□□□□ □□□□□□□ □□	0.894±0.042
23	Ngaikhong khullen South West	24°38□□□.5□ 93°47□□8.2□	0.723±0.045	58	Khoirentak	□□□□□□□ □□□□□□□ □□□□□□□ □□	0.785±0.085
24	Ngaikhong Khullen Thabakhong	24°37□□8.5□ 93°45□□□.3□	0.712±0.041	59	Tronglaobi	□□□□□□□ □□□□□□□	0.854±0.098

						□□□□□□□□□	
25	Bishnupur Mamang	24°37□18.7□ 93°46□□□.3□	0.745±0.045	60	Torbung	□□□□□□□□□□□□□□□□□□□□□□	0.854±0.085
26	Bishnupur Loukoi Pat	24°37□18.7□ 93°45□□□□□□	0.722±0.042	61	Wangoo Keirap	□□□□□□□□□□□□□□□□□□□□□□□	0.885±0.076
27	Bishnupur Makha	24°37□40.1□ 93°45□29.7□	0.887±0.056	62	Kasom Tampak	□□□□□□□□□□□□□□□□□□□□□□	0.868±0.085
28	Toubul Mamang	24°37□□□.5□ 93°48□□□.7□	0.745±0.075	63	Komlakhong	□□□□□□□□□□□□□□□□□□□□□□□	0.735±0.082
29	Khoijuman Kabui Leikai	24°36□□□.6□ 93°47□□□.6□	0.745±0.056	64	Thongam	□□□□□□□□□□□□□□□□□□□□□□□	0.655±0.045
30	Kwasiphai Mamang Leikai	24°36□□□.3□ 93°46□□□□□□	0.654±0.054	65	Keirenphabi	□□□□□□□□□□□□□□□□□□□□□□□	0.845±0.056
31	Nachou Mamang	24°35□□□.3□ 93°46□□□.9□	0.755±0.054	66	Kha Thingungei	□□□□□□□□□□□□□□□□□□□□□□□	0.755±0.088
32	Nachou Awang Leikai	24°34□8.3□ 93°46□21.1□	0.825±0.047	67	Wangoo Ahallup	□□□□□□□□□□□□□□□□□□□□□□□□	0.887±0.065
33	Potsangbam Mamang Leikai	24°35□□□□□□ 93°46□□□□□□	0.745±0.045	68	Sagang Makha	□□□□□□□□□□□□□□□□□□□□□□□	0.875±0.065
34	Potsangbam Awang Leikai	24°35□□□□□□ 93°45□□□□□□	0.766±0.052	69	Saiton	□□□□□□□□□□□□□□□□□□□□□□□	0.855±0.042
35	Ningthoukhong Kha Leikai	24°33□□□□□□ 93°45□2.6□	0.745±0.055	70	Ukhatampak	□□□□□□□□□□□□□□□□□□□□□□	1.021±0.054

It is noteworthy that the radiation dose rates observed in our study surpass the world average annual dose rate, as reported in the paper by Alaamer A.S. in 2012. This higher radiation dose rate signifies that the Bishnupur district experiences elevated levels of terrestrial gamma radiation compared to the global average. Understanding such regional variations is crucial for establishing baseline data, informing radiation safety guidelines, and comprehensively assessing the environmental radiation landscape. These findings contribute a valuable radiation dose mapping of this Bishnupur district and will be usefull in radiological environment studies from a global perspective.

5. Conclusion:

The utilization of thermoluminescence dosimeters for measuring terrestrial gamma radiation dose rates proves effective, providing valuable insights into the spatial and temporal variations of natural background radiation. This study of TLD may enhance the understanding of environmental radiation exposure, supporting informed decision-making in radiological protection and risk assessment at minimal cost. The maximum radiation dose rate of the Bishnupur district is found to be (1.021±0.054) mGy/a, the minimum is found to be (0.640±0.015) mGy/a, and the average dose rate is (0.800±0.087) mGy/a.

Reference

1. Alaamer A.S., 2012. Measurement of natural radioactive in sand samples collected from Ad-

Dahna desert in Soudi Arabia. World J Nucl Sci Technol, 2,187.

2. Joyshangkar M, Suranjit S, Singh SN, Sharma BA, Singh RT, 2020. Measurement of terrestrial gamma radiation dose rate and radioactivity levels in the southern hilly regions of Manipur, India, Radiat Prot Environ, 43: 13-20.
3. Rajesh, S. and Kerur, B.R., 2018. Assessment of natural radioactivity levels dur to 238U, 232Th and 40K in the soil samples of Raichur district, Karnataka, India, Radiat Prot Environ, 41: 51-4.
4. Sharma, A.B. and Singh A.S., 2018. Assessment of natral background gamma radiation levels in and around Loktak Lake of Manipur, India, Radiat Prot Environ, 41: 94-8.
5. Sharma, B.A., Singh, S.N., Singh, N.S and Singh, H.N., 2020. Measurement of natural radioactivity of building materials used in the southern valley region of Manipur, India. Radiat Prot Environ, 43: 82-7.
6. Sharma, A. B., and Singh, N.S., 2018. Assessment of natural background gamma radiation levels in and around Loktak Lake of Manipur, India. Radiat Prot Environ, 41: 94-8.
7. Singh, S.N., Sharma, B.A. and Devi, T.P., 2017. Study of natural radioactivity (238Ra, 232Th and 40K) in soil samples for the assessment of averages effective dose and radiation hazard parameters. Radiat Prot Environ, 40: 154-8.
8. Singh, S., Rani A. and Mahajan, R.K., 2005. 226Ra, 232Th and 40K analysis in soil samples from some areas of Punjab and Himachal Pradesh, India using gamma ray spectrometry, Radiat Meas 39:431-9.
9. Suranjit, S., Singh, O.S., Singh, S.N. Sharma, B.A., 2020. Assessment of radioactivity of different types of houses in Imphal city, Manipur, India, Radiat Prot Environ, 43: 26-30.
10. United Nations Scientific Committee on the Effects of Atomic Radiation. 1993. Sources and Effects of Ionizing Radiation. New York: United Nations.
11. United Nations Scientific Committee on the Effects of Atomic Radiation 2008. Sources and Effects of Ionizing Radiation. New York: United Nations