Estimation of external gamma radiation dose rate for personnel and students in the area of Kasetsart university, Thailand

C Pornnumpa¹, J Kanchanawarin²

¹Department of Applied Radiation and Isotopes, Faculty of Sciences, Kasetsart University
²Department of Physics, Faculty of Sciences, Kasetsart University

E-mail: fscicnp@ku.ac.th

Abstract. Kasetsart University, Bang khen is surrounded by several radiation agencies. In order to reduce concerns and confirm on radiation safety for university personnel and students, 130 points of the ambient gamma dose equivalent rate (H*(10)) were measured above the ground at 1 m and mapping around this area using a NaI(Tl) scintillator, Ø63×63 mm, including natural radioactive elements (K-40, Th-232, and U-238) from soil were collected in the 10 cm soil layer for 13 samples for investigating the natural background radiation. The gamma dose rates in air obtained were found between 0.04 µSv/h – 0.10 µSv/h with the average value was about 0.07 µSv/h. The location of minimum value was found at Chakrabandhu Pensiri Hall (13°50'57.5"N, 100°34'05.5"E), and the maximum value was found behind the Thailand Post Office, Kasetsart University branch. (13°50'50.6"N, 100°34'06.6"E). The activity concentration of U-238, Th-232 and K-40 from soil samples were determined using a gamma spectrometry analysis system with HPGe detector, which the average specific activity was also used to evaluate the absorbed dose rates (D) and the annual effective dose (E) for general population in the area.

1. Introduction
As the university is located near several radiation agencies, it may cause concerns about radiation safety for personnel and students. The main campus of Kasetsart University is located in the northern part of Bangkok (13°84'79.4"N, 100°56'91.3"E) and is surrounded by several radiation agencies such as Gamma Irradiation Service and Nuclear Technology Research Center (GISC), Thailand Institute of Nuclear Technology (TINT), Office of Atom for Peace (OAP), and Department of Applied radiation and Isotope, which all agencies use the radiation sources for education, research, and radiation services.

In general, main sources of background radiation are cosmic radiation and terrestrial gamma radiation. Those radiations are ionizing radiation and be able to interact with the middles. More than 90% of human radiation exposure arises from natural sources that is an important cause of health effects [1]. Most radiation exposure from terrestrial radionuclides comes from K-40, the decay series of Th-232, and the decay series of U-238 which are found in different amount of Earth’s surface depending on the geological and geographical features and as well as the materials used for buildings in such region[2]. In order to reduce concerns and confirm on radiation safety for those involved, gamma dose rate in air and the specific activity from soil samples were estimated and assessed the annual effective dose for university personnel and students.
2. Materials and Methods

2.1. Gamma mapping
A spectrometric Portable Radiation Scanner AT6101 (Atomtex, Republic of Belarus) was used for measuring the ambient gamma dose equivalent rate above the ground 1 m around the campus, calibrated by the TINT. 130 points were carried out every 50-200 m in each point around the area for outdoor gamma mapping. The average annual effective dose for personnel and students of the University was calculated by equation (1).

\[ E_{\text{out}} = X_{\text{out}} \times OF_{\text{out}} \times T \times CC \]  \hspace{1cm} (1)

\( E (\mu\text{Sv}/\text{y}) \) is annual effective dose when population exposed from background gamma radiation. \( X_{\text{out}} (\mu\text{Sv}/\text{hr}) \) means the outdoor gamma dose rate obtained from the detector. \( OF_{\text{out}} \) is outdoor occupancy factor (20% for outdoor). \( T \) is time (8760 Hours) and \( CC \) is conversion coefficient (0.7 for adults) reported by UNSCEAR to convert gamma dose rate in air to the effective dose [3].

2.2. Investigation of the natural background radiation from soil
The activity concentration of U-238, Th-232 and K-40 from 15 soil samples were determined using a gamma spectrometry analysis system with HPGe detector (Mirion Technologies (Canberra), Inc., the United states of America). All samples were dried at 105 °C until completely dry and were sieved with a 2mm mesh sieve and were packed in the container at 30 days for equilibrium between radon and its decay products[4]-[7]. The absorbed dose rates (D) and the annual effective dose (AEDE) for general population in the area were estimated by the energy peak of each nuclide in nature. The activity concentration of U-238 (C_U) was determined using gamma ray transition line of Bi-214 (1,765 keV). Ac-228 (911 keV) energy was used to determine the activity concentration of Th-232 (C_Tn). The energy peak at 1,460 was used to determine the activity concentration of K-40 (C_K). Background contributions were subtracted from the peak areas for the measured samples. The activity concentration (Bq/kg) was used to calculate the absorbed dose (D) by equation (2).

\[ D (\text{nGy}/\text{hr}) = 0.604C_{\text{Tn}} + 0.462C_{\text{U}} + 0.042C_{\text{K}} \]  \hspace{1cm} (2)

The annual effective dose (\( \mu\text{Sv}/\text{y} \)) is able to estimate followed equation (3)

\[ \text{AEDE} = D \times 8765 \times 0.2 \times 0.7 \times 10^{-3} \]  \hspace{1cm} (3)

3. Result

3.1. Gamma mapping
The gamma dose rates in air obtained were found between 0.04 \( \mu\text{Sv}/\text{h} \) – 0.10 \( \mu\text{Sv}/\text{h} \) with the average value was about 0.07 \( \mu\text{Sv}/\text{h} \) (Figure 1). The location of minimum value was found at Kasetsart University Main Auditorium ) 13°50'28.3"N, 100°34'31.1"E(, and the maximum value was found at Museum and Insect Park of 60 Years Kasetsart University ) 13°51'12.6"N, 100°34'01.9"E . In comparison, the average value obtained in this project was quite higher than the result from the Office of Atom for Peace (OAP) at 0.04\( \mu\text{Sv}/\text{h} \) (the average value of gamma dose rate in Bangkok). However, the annual effective dose to people and students of the University was estimated to be 0.05 mSv/y - 0.13 mSv/y that is safe to population compared to the level recommended by ICRP at 1 mSv/y.
3.2. *Investigation of the natural background radiation from soil*

Radioisotopes of uranium, thorium, and potassium were detected by a gamma spectrometer for background radiation measurement in 15 soil samples from Kasetsart University. Sampling areas and the specific activity values are shown in table 1. Ac-228 (thorium-232) had the average value at 20.69 Bq/kg (4.18 – 45.7). Bi-214 (uranium-238) was found 153.07 Bq/kg (33.40 – 306.11). While K-40 (potassium) was found 722.51 Bq/kg (158.89 – 876.85). The D values and the AEDE values obtained are shown in table 2. From the highest value could estimate the annual effective dose to be 0.24 mSv/y. The average of absorbed dose rate was evaluated to be 113.56 (nGy/h) and the annual effective dose from the average value was calculated for outdoor terrestrial gamma radiation at 0.14 mSv/y. The AEDE value was compared to the safety standard by ICRP limit, which the exposure of population is less than 1 mSv/y.

**Figure 1.** (a) locations of 150 points for gamma dose rate and (b) contour map of gamma dose rate.
Table 1. Sampling locations and specific activity of soil samples.

| Location                  | Specific Activity: S.A. (Bq Kg\(^{-1}\)) |
|---------------------------|------------------------------------------|
|                           | Th-232  | U-238  | K-40  |
| Building Information 50 years | 45.71   | 36.12  | 866.99|
| Faculty of Agriculture    | 36.12   | 33.41  | 786.44|
| Faculty of Science        | 38.10   | 33.40  | 778.33|
| Department of Soil Science| 24.75   | 306.11 | 862.21|
| Phaholyothin Gate          | 11.34   | 124.41 | 658.42|
| Ngamwongwan Gate1          | 17.47   | 204.61 | 656.83|
| Ngamwongwan Gate3          | 17.47   | 166.44 | 731.19|
| Register Building          | 21.25   | 246.38 | 702.80|
| Canteen                   | 14.44   | 153.83 | 876.85|
| Sport Office               | 16.40   | 188.08 | 715.85|
| Nuclear Research Center 1  | 21.80   | 304.52 | 861.38|
| Nuclear Research Center 2  | 20.37   | 220.18 | 739.27|
| Nuclear Research Center 3  | 9.40    | 88.55  | 660.30|
| Nuclear Research Center 4  | 11.52   | 147.61 | 781.84|
| Nuclear Research Center 5  | 4.18    | 42.40  | 158.89|
| Average ± SD              | 20.69 ±11.06 | 153.07 ± 90.63 | 722.51 ± 168.32 |

Table 2. Shows the absorbed dose rate (D) and the annual effective dose equivalent (AEDE) of each sample.

| Location                  | D (nGy hr\(^{-1}\)) | AEDE (mSv y\(^{-1}\)) |
|---------------------------|---------------------|------------------------|
| Building Information 50 years | 80.71   | 0.10                   |
| Faculty of Agriculture    | 70.28   | 0.09                   |
| Faculty of Science        | 71.13   | 0.09                   |
| Department of Soil Science| 192.58  | 0.24                   |
| Phaholyothin Gate          | 91.98   | 0.11                   |
| Ngamwongwan Gate1          | 132.67  | 0.16                   |
| Ngamwongwan Gate3          | 118.16  | 0.14                   |
| Register Building          | 156.18  | 0.19                   |
| Canteen                   | 116.62  | 0.14                   |
| Sport Office               | 126.87  | 0.16                   |
| Nuclear Research Center 1  | 190.03  | 0.23                   |
| Nuclear Research Center 2  | 145.07  | 0.18                   |
| Nuclear Research Center 3  | 74.32   | 0.09                   |
| Nuclear Research Center 4  | 107.99  | 0.13                   |
| Nuclear Research Center 5  | 28.78   | 0.04                   |
| Average ± SD              | 113.56 ±44.31 | 0.14 ± 0.05 |
4. Conclusion
However, the annual effective doses to people and students of the University from this study are able to confirm on radiation safety to population compared to the level recommended by ICRP at 1 mSv/y. From all data of this research, the gamma dose rates in the air around the Kasetsart University are safe and the values of background radiation in the soil do not affect the human body.

5. References
[1] UNSCEAR 2000 Report to General Assesmbly. Annex B: Exposure from natural radiation sources and report to general assembly with scientific annexes. Vol 1. New York, pp. 1220
[2] Oladele B B, Arogunjo A M and Aladeniyi K 2018 Int. J. Radiat. Res. 16 363-370
[3] UNSCEAR 2000 REPORT Vol. I sources and effects of ionizing radiation, annex a: dose assessment methodologies. New York: United Nations Scientific Committee on the effects of atomic radiation
[4] Mollah S, Rahman N M, Kodlus M A and Husain S R 1987 J. of Radiat. Prot. Dosim. 1839-41
[5] Ibrahim N M, Ghani A E A H, Shawky E M, Ashraf E M and Farouk M A 1993 J. of Health physics 64 620-27
[6] Ramli A T 2009 Applied Physics Research 1 45-52
[7] Najam L A and Younis S A 2015 Int. J. of Nov. Res. in Phy. Chem. & Math. 2 1-9