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INVESTIGATION OF RADON CONCENTRATION AND ANNUAL EFFECTIVE DOSE OF FIVE DIFFERENT TILE SAMPLES

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Abstract

Radon is a colourless and odourless inert gas and its isotopes can be found in the uranium and thorium decay sequences occurring in the nature. An alpha particle is emitted during its decay. Its progeny elements are formed as a result of series of decays which are also radioactive. A study of radon concentration has been carried out in the five different tile samples, using LR-II5 type II Solid State Nuclear Track Detectors (SSNTDs). According to the present measurement, it was found that, the value of radon ranges from 219.05 ± 11.90 Bqm^{-3} to 441.90 ± 32.86 Bqm^{-3} with an average value 337.86 ± 23.24Bqm^{-3}. The annual effective dose ranges from 3.76 ± 0.20 $mSvyr^{-1}$ to 7.6 ± 0.57 $mSvyr^{-1}$ with an average value of 5.81 ± 0.40 $mSvyr^{-1}$.

Keywords: Radon concentration, annual effective dose.

Introduction

Radon is a natural occurring radioactive gas and requires special instruments to detect its present. Radon is everywhere, but generally at very low concentration. Uranium is found in varying quantities in all rocks and soil, so consequently there are variations in the amount of radon depending where you are. Radon is slowly released from the ground, water and some building materials that contain very small amounts of uranium, such as concrete, bricks, tiles and gypros. Building materials (such as soil, brick, concrete, color cement and tile etc) are one of the major sources of indoor radon concentration in dwellings. The detection and radon concentration measurements are one of the most important procedures in environmental protection. In the present study, the radon concentration from the tile samples have been measured. Tiles samples have been collected from building shop in Yangon and are manufactured in Myanmar, Thailand, Malaysia and China. To estimate the radon concentration in these samples, solid state nuclear track detection technique (Can technique) was used. Figure (1) shows radioactive decay scheme of ^{22}Rn.In this radon concentration measurements, one type of solid state nuclear track detectors (SSNTDs), LR-115 type II was used. The principle of this technique was based on the production of track in the detector due to alpha particles emitted from radon and its progeny. After exposure, the tracks are made visible by etching and counted manually under the microscope. From the alpha track detection, we carried out alpha track densities, the radon concentrations and annual effective doses. The plastic track detector LR-115 Type II used in this work is a cellulose nitrate red dyed film, manufactured by Kodak Pathe France, LR-115 is a solid state nuclear track detector (SSNTD) based on cellulose nitrate and has been commonly used for measurement of concentration of radon gas and / or radon progeny. The sensitive surface for alpha particle, red dyed, is of 10μm thickness of cellulose nitrate (CN) layer on a colorless inert backing material and the base is 100μm polyester. The composition of LR-115 Type II ($C_6H_8O_9N_2$) is shown in fig

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(2). Its advantage is that after suitable etching, the tracks appear as colorless holes against a red background. Obviously, only one side of this film is sensitive, and this must be determined before used. Etched tracks show up as bright holes in a dark red background, and are very clearly visible under a low power microscope of magnification.

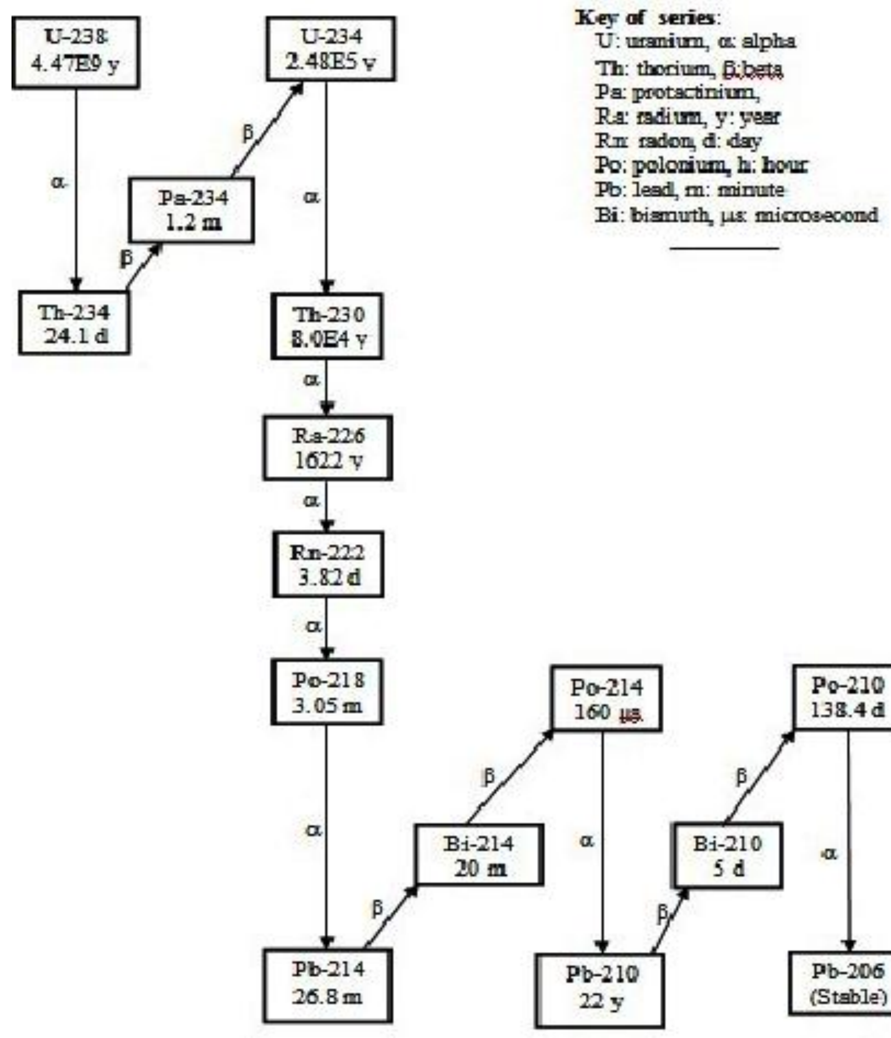

Figure 1 Radioactive decay scheme of uranium ^{238}U

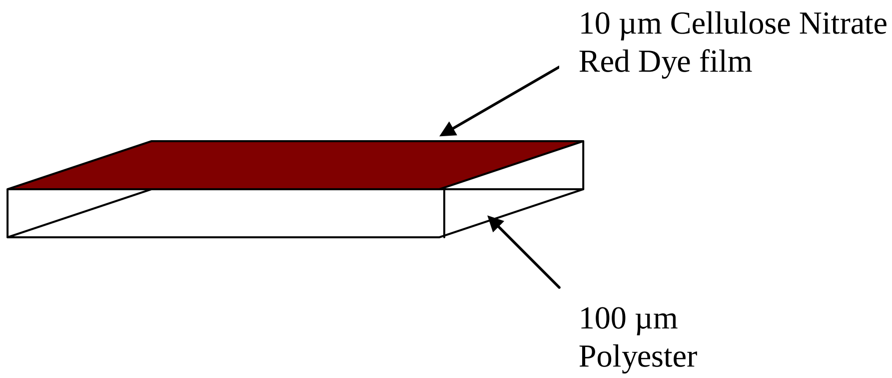

Figure 2 The Structure of the Solid State Nuclear Track Detector LR -115 Type II Cellulose Nitrate film

Sample Collection

To measure the radon concentration and annual effective doses, five kinds of tile were collected in the building materials shop in Yangon. Table (1) shows source of tile sample manufacture by Myanmar, Thailand, Malaysia and China. Figure (3) shows five kind of tile.

Table 1 Tile Sample are manufactured by Myanmar, Thailand, Malaysia and China

Sample Code	Source of Tile Sample Manufactured
T1	Benhur (Thailand)
T2	ATC (Sagging)
T3	Roma (Malaysia)
T4	Five Star (China)
T5	Tharyarwadi (Myanmar)

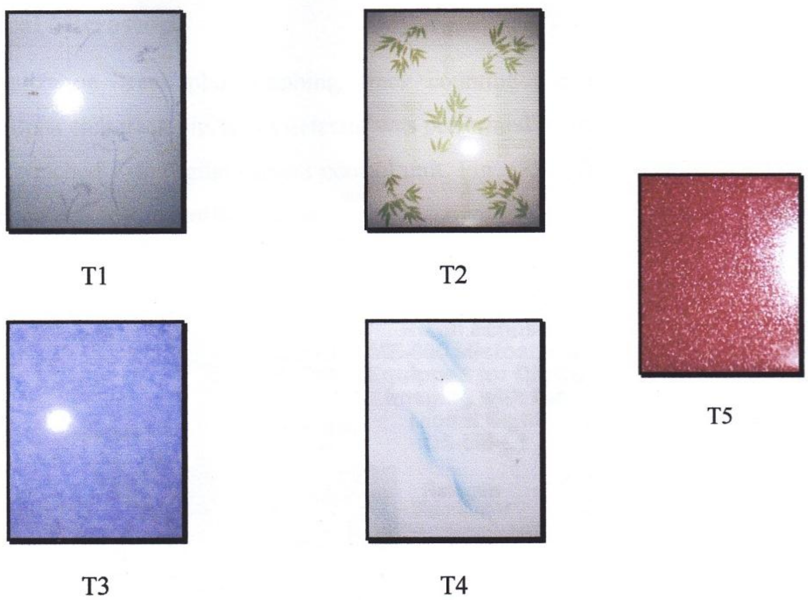

Figure 3 Five kinds of tile

Experimental Details

In this work, a known amount 100g of five different tiles samples were placed in a plastic cans. Figure (4) shows the balance that was used to measure the NaOH pellets. LR-115 Type II CN detector about (1cm$\times$ $1cm$) were fixed on the bottom of the lid of each can with tape such that, sensitive side of detector faced the specimen. The can was tightly closed from the top and sealed. The geometrical parameters of plastic can were diameter 6.8 cm, height 9.9 cm, volume $360cm^3$ as illustrated in Figure (5). In order to eliminate any background counts due to assembly set up, LR-115 Type II was fixed on the bottom of the lid of can without tile samples. At the end of the exposure time, the detectors were removed from the lid of plastic can and subjected to a chemical etching process. The LR-115 detectors were etched in 2.5 N NaOH solution at 60 ˚C for 80 mins. During etching, the temperature was kept constant with an n accuracy for 1˚C and without stirring. The etching process detector is show in figure (6).

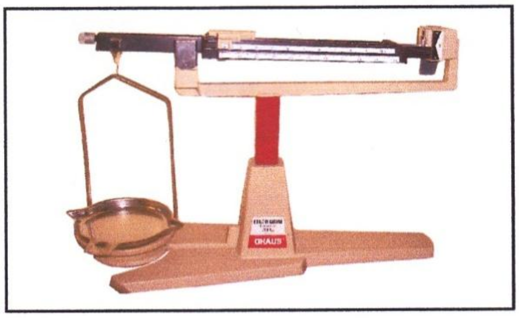

Figure 4 The balance that was used to measure the NaOH pellets

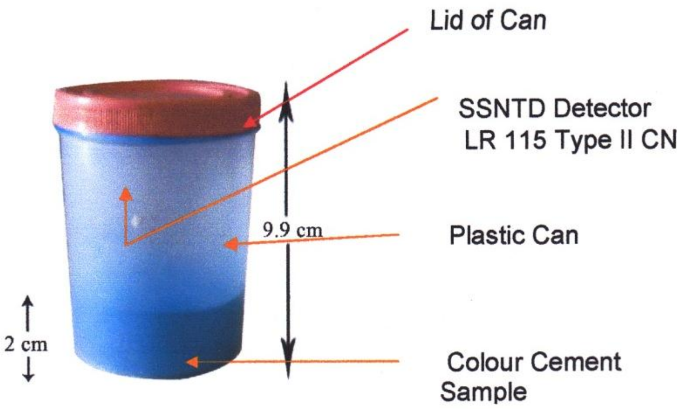

Figure (5) The photograph of the can technique

Track Counting

After etching, the solution in the beaker is poured into another beaker through small plastic sieve with handle. Thus, the detectors can be easily and fastly collected. Then the detectors were washed with water until the surface of the detectors became cleaned. Finally, the detectors were taken out and dried on the filter paper and the tracks produced by particles were observed and counted using Nikon Eclipse ME-600 Microscope Equipped for Digital imaging with the Digital Sight DS-5M-L1, Department in Yangon University. The mostly used method of track counting employs an optical microscope is as shown in figure (7). According to the observation views of the screen of microscope, alpha tracks were counted to reduce the statistical errors. The photographs of alpha tracks in LR-115 detectors are shown in figure (8) to figure (12).

In this work, alpha tracks were counted for different fifty views and the track densities were calculated by using equations:

$$\text{Track Density (track cm}^{-2}\text{) day}^{-1}\text{)} = \frac{\text{Number of Net Tracks}}{\text{Area of counted view} \times \text{Exposure time}} \qquad (1)$$

$$\text{Radon (Bqm}^{-3}\text{)} = \frac{\text{Track Density}}{\text{Calibration Factor}} \qquad (2)$$

$$\text{Annual Effective Dose} = \text{Radon Concentration} \times 0.0172 \text{ mSvyr}^{-1} \qquad (3)$$

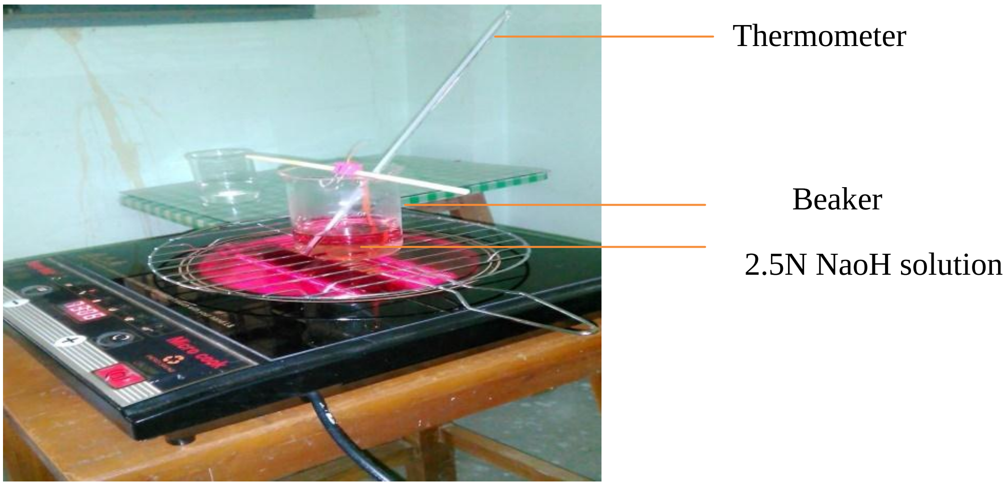

Figure 6 Etching Process of Detectors

Figure 7 Optical Microscope and Camera Control Unit

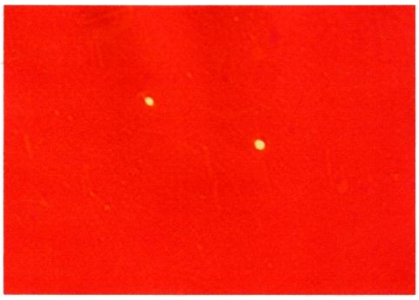

Figure 8 Photomicrograph of alpha tracks in LR-115 Type II CN for Tile T1 (Benhur)

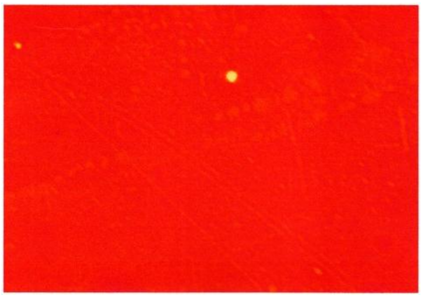

Figure 9 Photomicrograph of alpha tracks in LR-115 Type II CN for Tile T2 (ATC)

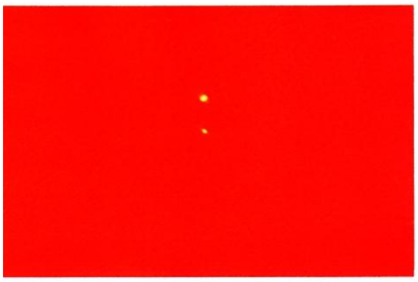

Figure 10 Photomicrograph of alpha tracks in LR-115 Type II CN for Tile T3 (Roma)

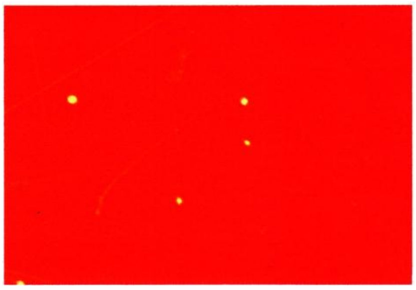

Figure 11 Photomicrograph of alpha tracks in LR-115 Type II CN for Tile T4 (Five Star)

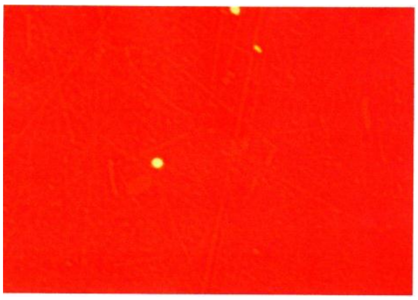

Figure 12 Photomicrograph of alpha tracks in LR-115 Type II CN for Tile T5 (Tharyarwadi)

Results and Discussion

From the experimental work, the estimate of radon concentrations and the annual effective doses were carried out. Average number of alpha tracks and track densities of each sample were calculated by using equation (1). By using calibration factor 0.05016 track cm^{-2} day^{-1} = 1 Bqm^{-3}, radon concentrations can be calculated from equation (2). And then the annual effective doses were calculated by using equation(3).The average number of tracks and track densities were mentioned in Table (2). The radon concentrations and annual effective doses were mentioned in Table (3) and Table (4).The graphs of alpha track densities, radon concentrations and annual effective doses from three different places are shown in Fig (13) to Fig (15).The comparison graph of ICRP Level and Samples in annual effective doses are shown in Fig (16).

Table 2 The Alpha Track Densities (track cm^{-2} day^{-1}) for three different floors

Sr. No.	Name of Samples	Average number of Alpha Tracks	Alpha Track Densities (track cm^{-2} day^{-1})
1	T1	9.48 ± 0.67	9.28 ± 2.10
2	T2	8.60 ± 0.54	8.42 ± 0.56
3	T3	7.34 ± 0.49	7.15 ± 0.52
4	T4	6.20 ± 0.39	6.03 ± 0.42
5	T5	4.76 ± 0.23	4.60 ± 0.25

Table 3 The radon concentrations (Bq m^{-3}) for three different floors

Sr. No.	Name of Samples	Radon concentrations (Bq m^{-3})
1	T1	441.90 ± 32.86
2	T2	400.90 ± 26.67
3	T3	340.48 ± 24.76
4	T4	287.14 ± 20.00
5	T5	219.05 ± 11.90

Table 4 The Annual Effective Doses (m Sv yr^{-1}) for three different floors

Sr. No.	Name of Samples	Annual Effective Doses (m Sv yr^{-1})
1	T1	7.60 ± 0.57
2	T2	6.89 ± 0.46
3	T3	5.86 ± 0.43
4	T4	4.94 ± 0.34
5	T5	3.76 ± 0.20

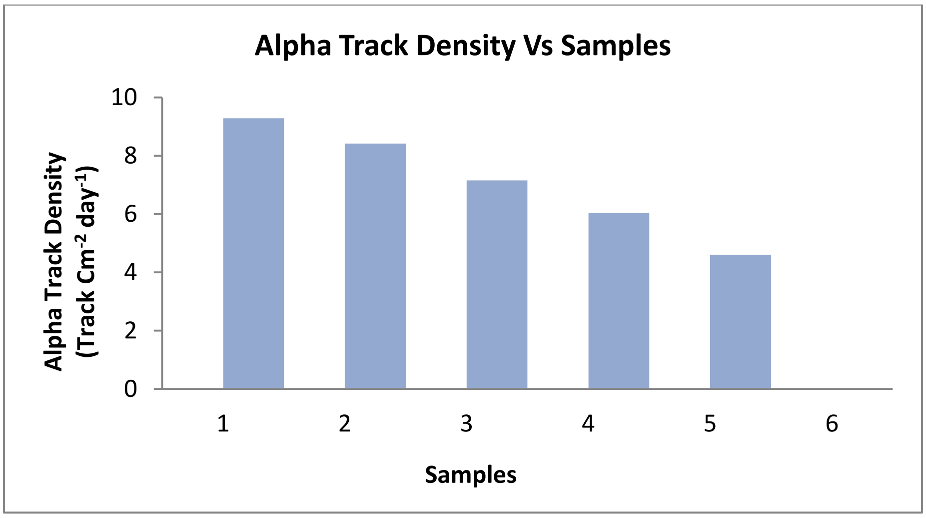

Figure 13 Comparison graph of alpha track densities for five different tiles

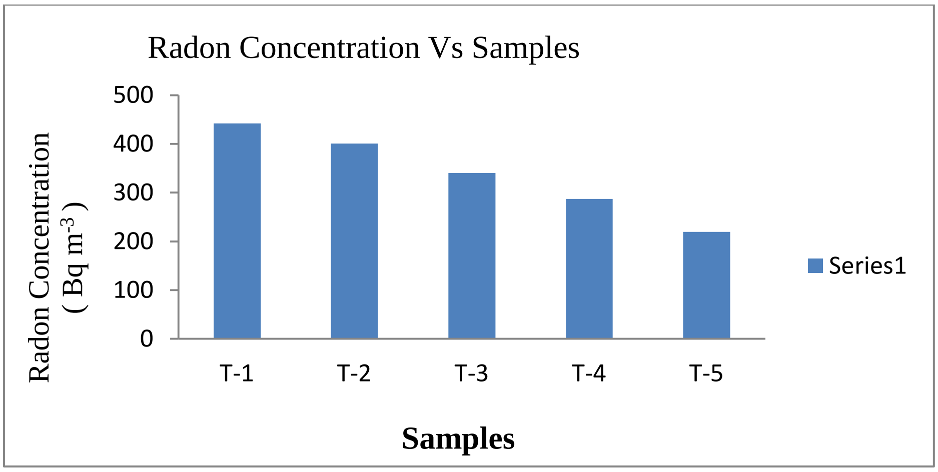

Figure 14 Comparison graph of radon concentrations for five different tiles

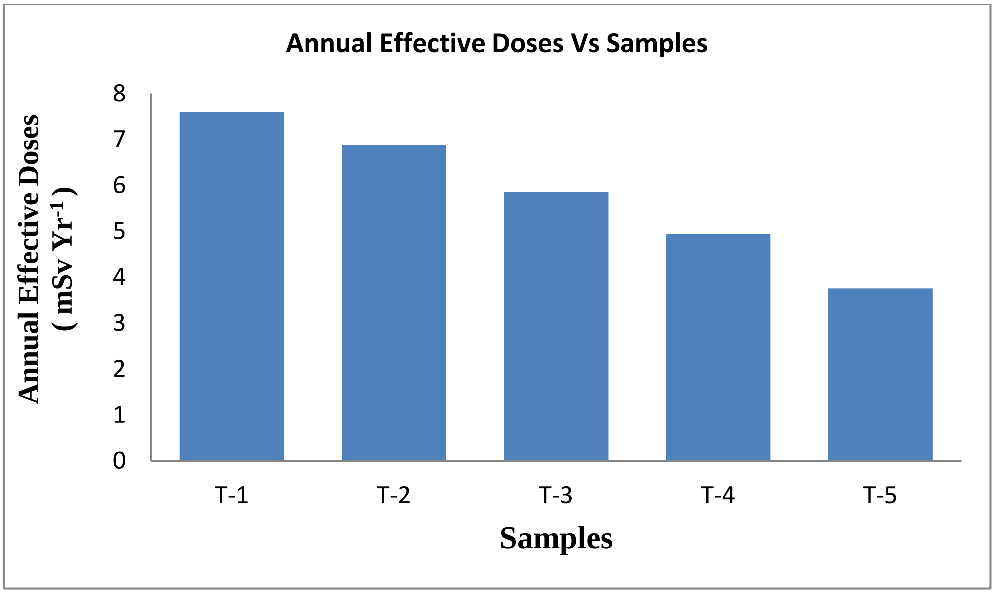

Figure 15 Comparison graph of annual effective doses for five different tiles

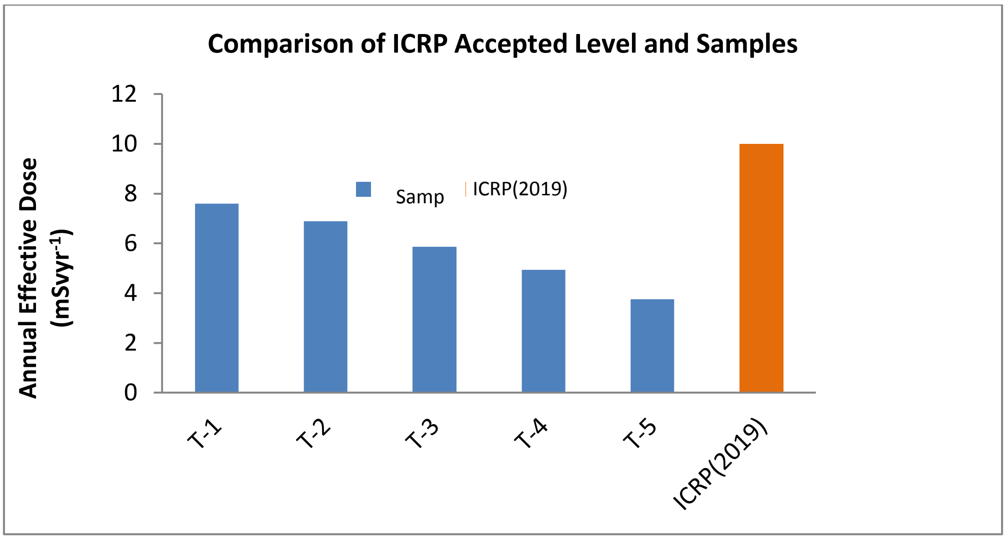

Figure 16 Comparison of ICRP Accepted Level and Samples

Conclusion

Radon is the biggest contributor to natural radiation in the environment and causes long term health concern. Therefore, the measurement of radon concentration is needed for environmental purpose. The results of indoor radon concentration measured with LR-115 type II were presented in this work. The results have been found lower than that of ICRP limited level. In general, the studied tiles samples are safe to use as construction material, and there is a good covenant between all measurements of radon concentration and annual effective dose.

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