An Experimental Study of Indoor Radon Measurement in Department of Physics, Yangon University of Education

Htwe Nwe Oo[1], Khin Than Win[2] and Khin Swe Oo[3]

Abstract

The present work was attempted to measure the estimation of the annual effective dose of indoor radon in Department of Physics, Yangon University of Education. Many techniques have been established for measuring the radiation in the environment. These techniques are based on the detection of emissions from the decay of radioactive material and its daughter products. Most of the methods are based on the detection of alpha particles, some on detection of beta emission while a few utilize gamma decays. In this research, time integrated long term radon measurement technique is used to measure radon concentration in the samples under investigation. For the measurement of radon concentration, we have used LR-115, Type II plastic track detector and irradiation time is 100 days, from 26th April 2017 to 3rd August 2017. The annual effective doses due to radon are ranging from 0.07 ± 0.0341 mSv/yr to 0.33 ± 0.0626 mSv/yr which are lower than 5 mSv/yr, the annual effective doses fixed for public (ICRP,2007).

(ICRP- International Commission on Radiological Protection Publications)

Key wards: Indoor Radon, solid state nuclear track detectors(SSNTD), radon concentration, annual effective doses

Introduction

It is well known that most natural materials such as sand, soil, cement and rock, etc., used as building materials for construction of houses and buildings, originate from different rocks and earth's crusts. Such materials are often rich in different naturally occurring radioactive elements. Concentrations of radionuclides present in building materials vary depending upon the local geological conditions. The building industry also uses large amounts of waste from other industries. These construction materials may cause radioactivity to be significantly higher than background levels. Long exposures to low levels of ionizing radiation can seriously increase health risks to humans (ICRP, 1990). The study of alpha activity in building materials is very important because alpha radiation is 1000 times more carcinogenic than gamma radiation. Knowledge of the natural radioactivity in building materials as a main continuous source of indoor radiation exposure is essential in the assessment of population exposures because 80% of their lifetime is spent in indoor air. Radon-222 formed from radium (^{226}Ra), is a noble gas with a half-life of 3.8 days, may be released from ground, rocks and also from building materials, and accumulate (Rawat, Jojo, Khan, Tyagi, & Rajendra Prasad, 1991), with its short lived progeny in the atmosphere inside of the dwellings.

Inhalation of ^{222}Rn and its short lived daughters has been linked to lung cancer in humans. When radium decays in soil grains, the resulting atoms of the radon isotope escape from the mineral grains to the atmosphere. The rate at which radon escapes or emanates from the soil is termed the radon emanation rate or the radon exhalation rate. Radon exhalation is a complex phenomenon depending upon a number of parameters such as radium content in soil, soil morphology, soil grain size, soil moisture, temperature, atmospheric pressure, and rainfall (Khan, Srivastava, & Azam, 2012). Such studies can be useful for the assessment of public radiation dose and performance of epidemiology as well as for keeping reference data records, to ascertain changes in the environmental

1. Assistant Lecturer, Dr., Department of Physics, Yangon University of Education
2. Lecturer, Department of Physics, Loikaw University
3. Professor and Head, Dr., Department of Physics, Yangon University of Education

radioactivity due to industrial, nuclear and other human activities (Singh, Singh, Singh, & Bajwa, 2009). With the above important points in mind, a study was undertaken for the assessment of natural distribution of radium content, alpha index and radon exhalation rates (both surface exhalation and mass exhalation rate) of the building samples collected from the rooms in Department of Physics, Yangon University of Education.

Experimental Techniques, Materials & Methods

Many techniques have been established for measuring the radiation in the environment. These techniques are based on the detection of emissions from the decay of radioactive material and its daughter products. Most of the methods are based on the detection of alpha particles, some on detection of beta emission while a few utilize gamma decays. Numerous methods and a variety of instruments are available for detection of such radiations.

Radon Measurement Techniques

Lots of techniques are available for measuring the concentration of radon in air, soil, water and in dwellings. These techniques are divided in two categories:

1. Instantaneous radon measurement technique
2. Time integrated long term radon measurement techniques

In the present study time integrated long term radon measurement technique is used to measure radon concentration in the samples under investigation. In this research we use the second technique.

Time Integrated Long Term Radon Measurement Techniques

Time-integrated schemes involve the accumulation of radon over longer period of time from a few days to a week or more. In these techniques, the radon is measured either directly by detecting the alpha emission or indirectly by detecting the radioactive decay products of radon.

Solid State Nuclear Track Detectors (SSNTDs)

The use of solid state nuclear track detectors (SSNTDs) has become a well-known technique which has been widely applied in monitoring concentrations of radon gas by recording their emitted alpha particles. The development of methods for long-term integration measurements of radon progeny concentrations based on alpha spectrometry employing SSNTDs, are still being explored. There are several types of SSNTDs including inorganic crystals, glasses and plastics. Different type of 38 plastic track detectors viz. Bisplienol-A polycarbonate (Lexan, Makrofol), Allyl diglycol (CR-39) and cellulose nitrate (LR-115, CN-85) are available that record alpha energies of particular ranges. Visible tracks in different materials can only be produced if the specific energy loss (-dE/dx) is above the minimum threshold value for that material. For heavy particles, the etched track method was developed in nuclear physics experiments for cosmic rays and then it was applied for radon monitoring (Fleischer, 1965, Alter and Fleischer, 1981). These SSNTDs are insensitive to fast electrons, gamma rays and even protons. SSNTDs also have advantage to be mostly unaffected by humidity, low temperature, moderate heating and light. These nuclear tracks in solids can be revealed by a variety of techniques, one of the simple and most widely used techniques is preferential chemical etching and then tracks can be counted by optical microscope.

LR-115 Type II Detector

Commercially available, LR-115 type II films manufactured by DOSIRAD, France, are used in this study for detection and measurement of alpha radiation. LR-115 consists of an active layer or cellulose nitrate (chemical composition CeHgOgNa) of thickness 11.5 to 12.0 µm which is coated on 100 µm clear polyester base (PET). LR- 115 Type II SSNTD mainly detects the alpha particles having energy ranging from 1.7 to 4.8 MeV (Jonsson, 1981; Abu-Jarad et al., 1980). Accordingly, the plate out of radon daughters on the surface of LR-115 will not be registered because of their alpha energies (6.0 and 7.68 MeV from ^{218}Po and ^{214}Po, respectively) being more than its upper threshold value.

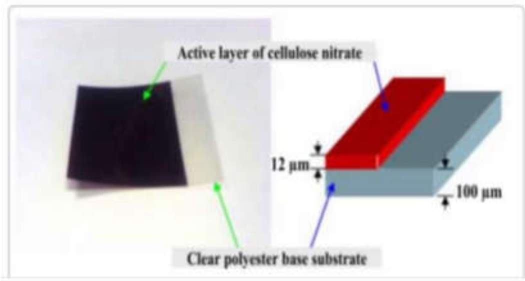

Figure 2. Structure of LR-115 Type II Detector

Track Etch Technique

In this technique, monitoring device used is LR-115 (SSNTD). The principle of detection involves the damage imparted in the detector material by alpha particles from radon and its decay products. Heavily ionizing particles passing through insulating medium, leave narrow trails of damage approximately (~30-100Å) on an atomic scale. By chemical etching these latent tracks can be enlarged to microscopically visible size. Then damage imparted in the detector is observed under optical microscope. Number of tracks per unit area in the detector is proportional to the average exposure rate and exposure time. Exposure time can range up to a year or more. Though several detector materials have been developed but LR-115 and CR-39 are the two most popular track detectors, which are being used for radon dosimetery.

There are some strong drawbacks in the use of solid-state nuclear track detectors viz.

• They only integrate the received flux of particles and therefore are not active detectors

• Track etch technique has poor sensitivity for integrated time periods of less than one month. In studies of indoor radon, monitoring time periods of about three months is adequate.

Optical Microscope

The counting of alpha tracks has been done in trinocular optical research microscope at a magnification of 400× shown in figure 3. It has motion along three mutually perpendicular directions. Paired eyepieces objectives 4×, l0×, 40×, l00× are available. This microscope can be used in any stage of colour contrast and in dark and bright fields.

Figure 3. Optical Microscope (400×)

Experimental Procedure

Technique

For the Measurement of radon concentration in the rooms, we have used the solid-state nuclear track detector method. The SSNTD LR-115 Type II plastic track detectors about (1cm × 1cm) were fixed at three sites with suitable height over a period of 100 days (from 26.4.2017 to 3.8.2017).

The ^{222}Rn measurement details using LR-115 detectors

Detector	- LR-115 Type II Cellulose Nitrate Red Dyed
Measurement Method	- the solid-state nuclear track detector method (hanged Technique)
Locations of Samples	- **sample No.1** at **Office I**
	- **sample No.2** at **Office II**
	- **sample No.3** at **Lab I**
	- sample No.4 at **Lab II**
	- sample No.5 at **Lab III**
Irradiation Time	- 100 days
Etchant	- 2.5 N NaOH at 70°C, without stirring
Etching Time	- 60 min
Microscope	- Optical (400x) Microscope

Etchant Preparation

N= Normality = Molarity

Water 1000 ml + NaOH 40g = 1N

1N $\longrightarrow$ Water 1000ml + NaOH 40g

2.5N $\longrightarrow$ Water100ml + NaOH 10g

2.5 N NaOH solution was prepared for etching the radon exposed LR-115 detectors. To obtain 2.5 N NaOH solution, 10 g of NaOH were put into 100 ml measuring cylinder. Then distilled water was poured on the NaOH in the measuring cylinder and stirred with a glass rod, until all NaOH were dissolved. The distilled water was added to get 100 ml solution. After that, the solution was poured into a 250 ml glass beaker.

All detectors and background are etched in 10% NaOH (2.5 N) solution for 60 minutes at temperature 70°C (shown in Fig 4). The temperature is kept constant with an accuracy of ±1°C, and then the detectors were removed from the solution and washed in distilled water. Each detector is observed under the microscope and open holes in LR-115-II are recorded. The background of the alpha track per day for SSNTD LR -115 Type II was 0.04 ± 0.028 track cm^{-2} day^{-1}.

Alpha Track Density

The alpha track density in solid state nuclear track detector is the number of net alpha track per unit area.

$$\text{Track Density} = \frac{\text{Number of Net Tracks}}{\text{Area of Counting}}$$

To reduce the statistical errors, alpha tracks were counted for fifty different views and the alpha densities were calculated. The results and calculations are shown in appendix.

Figure 4. Etching with NaOH solution at 70°C

Photomicrographs of tracks in sample detectors

Alpha-particle emissions from radon and its progeny are radon processes. Photomicrographs of track in samples are shown in photo 1 to photo 6.

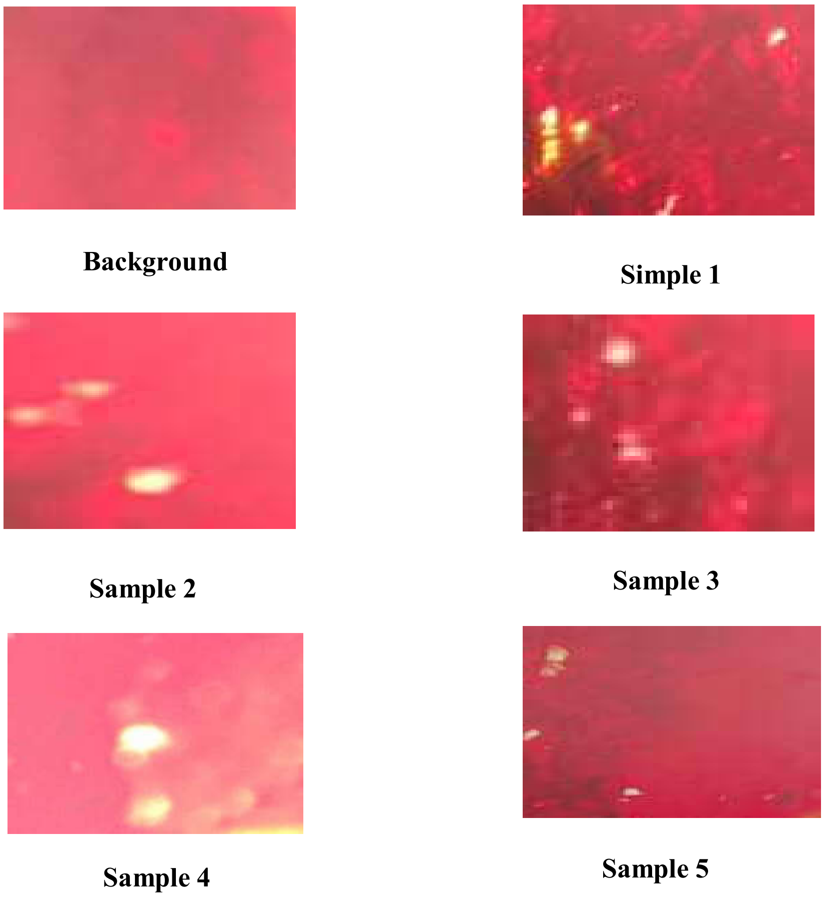

Figure 5. Photomicrographs of tracks in sample detectors

Table 1. The alpha track densities of five samples

Sr no.	Sample Name	Alpha Track Density (track cm^{-2} day^{-1})
1	Office I	0.71
2	Office II	0.97
3	Lab 1	0.26
4	Lab 2	0.46
5	Lab 3	0.2

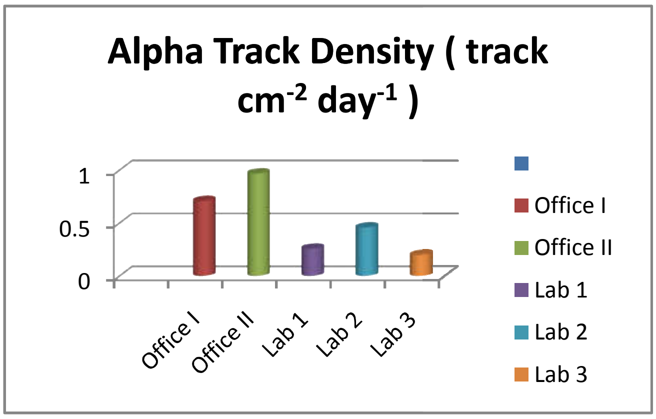

Figure 6. The alpha track densities of five

Table 2. Estimations of Radon concentration of five samples

Sr no.	Sample Name	Radon concentration (Bqm^{-3})
1	Office I	14
2	Office II	19
3	Lab 1	5
4	Lab 2	9
5	Lab 3	4

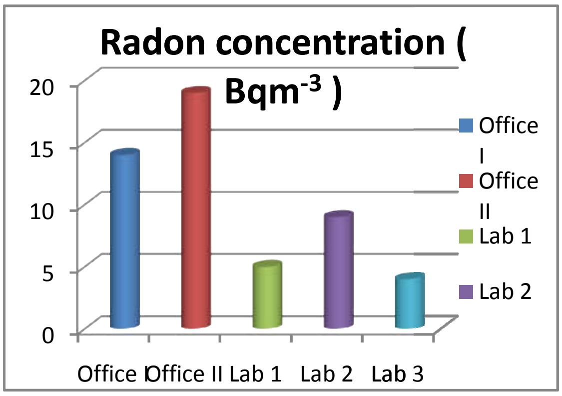

Figure 7. Estimations of Radon concentration of five samples

Table 3. The annual effective dose of the radon of five samples

Sr no.	Sample Name	Annual Effective Dose (m $Svyr^{-1}$)
1	Office I	0.24
2	Office II	0.33
3	Lab 1	0.09
4	Lab 2	0.16
5	Lab 3	0.07

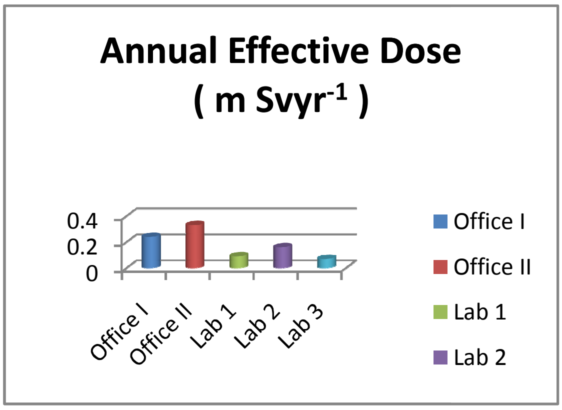

Figure8. The annual effective dose of the radon of five samples

Results and discussion

In the present work, radon emanated from five kinds of room in Physics Department has been measured. Estimation of radon concentrations in Physics Department rooms have determined from health hazards point of view. To analyze the radon concentration in Department rooms, solid state nuclear track detection technique was used.

For the measurements, sensitive LR-115 plastic track detectors were used. Based upon the available data obtained, the radon concentration, alpha track density and annual effective dose have been calculated. In the present investigations, the calculated values of radon concentration emanated from Department rooms vary from $4 \pm 1.9853 Bqm^{-3}$ to 19 ± 3.6405 Bqm^{-3} and alpha track density from 0.20 ± 0.0995 track $cm^{-2}day^{-1}$ to 0.97 ± 0.1826 track $cm^{-2}day^{-1}$ and annual effective dose from 0.07 ± 0.0341 $mSvyr^{-1}$ to 0.33 ± 0.0626 m $Svyr^{-1}$.

Table 4. The Alpha track density, Radon Concentration and Annual Effective Dose of Five room samples.

Sr No.	Sample Name	Alpha Track Density (track cm^{-2} day^{-1})	Radon concentration (Bqm^{-3})	Annual Effective Dose (m $Svyr^{-1}$)
1	Office I	0.71 ± 0.1485	14 ± 2.9620	0.24 ± 0.0509
2	Office II	0.97 ± 0.1826	19 ± 3.6405	0.33 ± 0.0626
3	Lab 1	0.26 ± 0.1083	5 ± 2.1592	0.09 ± 0.0371
4	Lab 2	0.46 ± 0.1259	9 ± 2.5102	0.16 ± 0.0431
5	Lab 3	0.20 ± 0.0995	4 ± 1.9853	0.07 ± 0.0341

SE (Standard Error) = $\sqrt{\frac{\delta^2}{N}}$, where δ is the standard deviation and N is the number of observation.

The part of the study involved measurements in a single dwelling in Physics Department, Yangon University of Education for 100 days from April 26 to August 3, 2017. The calculated values of the alpha track densities, radon concentrations, and annual effective doses for five room samples are presented in Table 4. For estimation of annual effective does for five kinds of room samples by using the value of annual effective dose was recommend by International Commission of Radiological Protection Publication (ICRC, 2007) where : Bq/m^3 = 0.0172 m Svy^{-1}, the average annual effective doses due to radon are ranging from 0.07 ± 0.0341 $mSvyr^{-1}$ to 0.33 ± 0.0626 m $Svyr^{-1}$.

According to international recommendations, the average exposure dose due to radon in Department rooms from 0.07 ± 0.0341 $mSvyr^{-1}$ to 0.33 ± 0.0626 $mSvyr^{-1}$ which are lower than 5 $mSvyr^{-1}$, the annual effective dose also lies under in ICRP recommendation.

Conclusion

Although, the sample (2) rooms of office II has the highest radon concentration and annual effective dose compared with the other room samples. The annual effective dose in that room sample (2) is lower than ICRP limited level. The value of annual effective dose recommended by International Commission on Radiological Protection Publication (ICRP) is 5 m Sv/yr. So that tested radon level is low in room samples. It is seen from the data, the low level of radon in five kinds of Department room samples typically do not cause health hazards to users as well as the community.

Acknowledgments

We respectfully thank to Dr Pyone Pyone Aung (Pro rector) and Dr Kay Thwe Hlaing (Pro rector) Yangon University of Education. Besides, we are greatly thank to my supervisor Professor Dr. Khin Swe Oo (Head of Department of Physics) Yangon University of Education for her helpfully guidance and our colleagues.

References

Abu-Jarad, F., Fremlin, J. H., & Bull, R. (1980). A study of radon emitted from building materials using plastic alpha-track detectors. Physics in Medicine and Biology, 25, 683e694. PMID: 7454758.

Amin, R. M., & Eissa, M. F. (2008). Radon level and radon effective dose rate determination using SSNTDs in Sannur cave, eastern desert of Egypt. Environmental Monitoring and Assessment, 143, 59e65.

Elzain, A. (5 June 2014). Radon exhalation rates from some building materials used in Sudan. published online Indoor and Built Environment, 1e9.

Abu-jarad F, 1988, Application of nuclear track detectors for radon related measurements, Nucl Tracks Radiat Meas, 15(1-4), 525-530.

Abu-Jarad F, Fremlin J H, Bull R, 1980, A study of radon emitted from building materials using plastic-track detectors. Phys. Med.Biol.25, 4 683-694.

Singh S, Singh B and Kumar A, 2001, Measurement of Indoor radon levels in dwellings and estimation of uranium in environmental samples from Una district, Himachal Pradesh, using passive detector technique, Rad. Prot.Env. 24 (1&2),445.

Jonsson G, 1981, The angular sensitivity of Kodak LR film to alpha particles. Nucl. Instr. Meth. 190,407.

Khan, M. S., Srivastava, D. S., & Azam, A. (2012). Study of radium content and radon exhalation rates in soil samples of northern India. Environmental Earth Sciences, 67(5), 1363e1371.

Rawat, A., Jojo, P. J., Khan, A. J., Tyagi, R. K., & Rajendra Prasad. (1991). Nuclear Tracks and Radiation Measurements, 19(14), 391.