Preliminary Study on Radon Concentration of Bricks and Block (Building Materials) Using Lr-115 Solid State Nuclear Track Detectors

Nyo Nyo[1], Sanda Myint[2], Swe Swe Yu[3] and Khin Swe Oo[4]

Abstract

Radon is a natural radioactive gas derived from geologic materials. Inhalation of the short-lived decay products of radon has been linked to an increase in the risk of developing lung cancers if present at elevated levels. Accurate knowledge of exhalation rate plays an important role in characterization of the radon source strength in some building materials. In this research, radon exhalation rate were be measured from bricks and blocks of building materials by using LR-115, to estimate the radiation exposure in the atmosphere. The radon concentrations from the bricks and blocks were found to vary from 206 to 305Bqm^{-3}. The levels of radon concentrations caused by the construction materials in the blocks and bricks were found within the internally recommended range 5mSvyr^{-1}.

Key word: Radon, Building Material, LR-115, Radon Concentration

Introduction

Radon is a noble radioactive gas produced by the decay of ^{226}Ra, a progeny of ^{238}U decay series. The main natural sources of indoor radon are soil, building materials (sand, rocks, cement and bricks), water sources, natural energy sources (gas and coal) which contain traces of ^{238}U. Building materials originate within the earth's crust and contain radionuclides from uranium and thorium series may give rise to the external radiation. Building materials like concrete, brick, cement, gravel and sand may contain natural radioactivity and also the source of indoor radiation exposure. People spend their time almost 80% indoor compare to outdoor. The combination of all building materials to construct dwelling, workplace, school, hospital and others may contribute the radon concentrations above 300Bqm^{-3}. Concentrations of radionuclides present in building materials vary depending upon the local geological conditions. The limit of action level recommended by international commission on radiological protection (ICRP)is 300Bqm^{-3} corresponds to an annual effective dose of 4mSv at work and 14mSv at home. Radon risk may give lung cancer to human by inhalation and ingestion. Since the general public is often unaware of the risks associated with indoor radon cause by building materials, this paper aims to investigate the radon concentrations emanates from the building materials in the counting chamber, to calculate the doses received to human and to assess the risk of lung cancer due to radon gas from building materials.

Solid State Nuclear Track Detector

Solid state nuclear track detectors (SSNTDs) provide the simplest, easiest and cheapest method for detecting various kinds of ionizing particles, i.e., alpha particles, protons, neutrons and fission fragments. Therefore, SSNTDs can be employed in many fields of science and technology, such as radon/thoron concentration estimates in environmental samples and assessments of doses from natural radiation and space radiation. When a heavy charged particle (alpha particle) bombards an SSNTD's surface, it will react with the detector's material (breaking the molecular bonds of the SSNTD's material creating a damaged zone along its path) until it has lost all of its energy on its passes through the SSNTD, creating a narrow latent track (30 - 100˚A). This latent track

1. Associate Professor, Dr., Department of Physics, Yangon University of Education
2. Assistant Lecturer, Dr., Department of Physics, Yangon University of Education
3. Assistant Lecturer, Dr., Department of Physics, Yangon University of Education
4. Professor /Head, Dr., Department of Physics, Yangon University of Education

can be directly observed under an electronic microscope. It can also be observed under an optical microscope after the application of a chemical etching process to enlarge the latent track's size.

A track is created in a SSNTD when an alpha particle hits the detector's surface. The formation of the track is characterized by the value of detector registration sensitivity ($V = V_t/V_b$), where (V_t) is the track etch rate, which is the removed layers of damaged surface of SSNTD (alpha-particle's hitting position) per unit time and (V_b) is the bulk etch rate. V_b is the rate of removing layers of the undamaged surface of SSNTD. V_b varies due to the SSNTD's chemical composition and manufacture process and to the chemical etching process. V_b can be calculated by using several methods, such as the decrease in the detector's thickness method, the loss of the detector's weight method or the fission-fragment diameter method.

The CR-39 detector (ally-diglycol carbonate, C_{12}-$H_{18}O_7$) is the most popular member of the SSNTD family, and it is available on a commercial scale. It can detect all alpha energies from zero to more than 7.7MeV without any degradation. The LR-115 detector, a sensitive cellulose nitrate (C_6-H_8O_8-N_2) detector, is also popular in radon/thoron measurements. It is composed of a layer of 12μm thick cellulose nitrate on a 100μm thick polyester supporter. The LR-115 detector can detect all alpha-particle energies in the range from 1.6MeV to 4.1MeV. The alpha track's color is dark gray with a white background in the case of the CR-39 detector while it is white with a red background in the case of the LR-115 detector.

In the present work, SSNTDs detectors, LR-115, was used to measure the alpha track densities, radon concentrations, and annual effective dose for building materials form building materials at Yangon. Thus, the work deals with the measurements of the characteristic parameters that could affect detector registration sensitivity, those parameters being the bulk etch rate and the dependence of the detector's sensitivity on the alpha-particle energy. This work also presents a simple method to study the dependence of those parameters on the alpha-particle energy.

Nuclear Track

A nuclear track in a soil is, in a sense, a line defect with a strain field around it and a locally enhanced chemical reactivity. A nuclear track is not dislocation. However it may be etched chemically like dislocation. Nuclear track is a complicated set of defects produced in any insulation solid amorphous as well as crystalline.

Alpha Track Density

The technique of SSNTD is based on the damage created in and insulating solid along the path of a heavy ionizing particles such as an alpha particles or a fission fragment. The damage along the path is called a track. The alpha track density in solid state nuclear track detector is the number of net alpha track per unit area.

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

Experimental Procedure

Six samples of building materials usually used for dwellings or building constructions were analyzed for radon concentration. In this research, the raw building material samples, three red-clay brick, one cement brick and two cement block were used, respectively.

For the measurement of radon concentration of the bricks and blocks, we have used LR-115 type II solid state nuclear track detectors (SSNTDs) method. The SSNTDs LR-115 plastic track detectors about (1cm x 1cm) were fixed at side over a period of 100days. These samples are shown in figure (1).

At the end of the exposure time, SSNTD (LR-115) samples were removed from the building materials. It was subjected to a chemical etching process. In etching process of the LR-115 detectors, 2.5N NaOH solutions at 70ºC for 60min(1hour) were used. The detectors were rinsed, dried and tracks produced by alpha particles were observed and counted for 50 fields of view under an optical-microscope (400x). the alpha track density was calculated in each detector.

Figure 1. The bricks and blocks of local building materials

Etchant Preparation

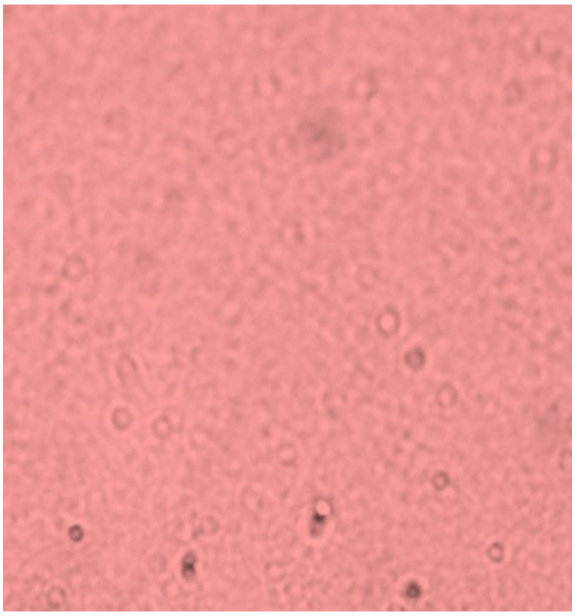
2.5N NaOH solution was prepared for etching the radon exposed LR-115 detectors. To obtain 2.5N NaOH solution, 10g of NaOH were put into measuring cylinder. Then100ml distilled water was poured on the NaOH in the measuring cylinder and stired with a glass rod, until all NaOH were dissolved. Then, etchant solution was get. After that, the solution was poured into a 250ml glass beaker. Six detectors were put into that solution.

Etching of Detectors

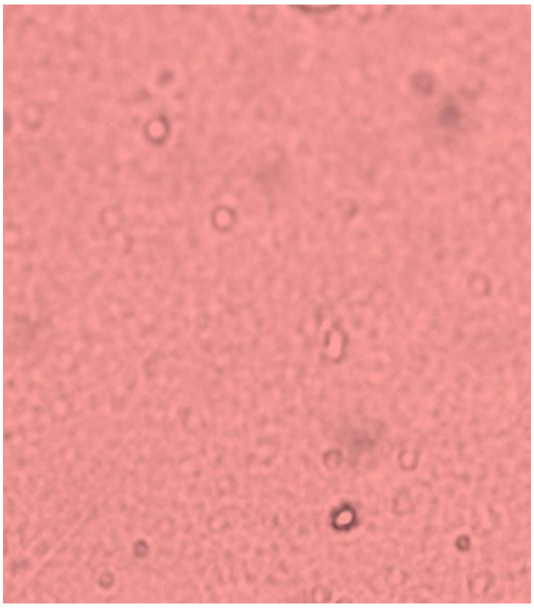
The beaker with detectors and 2.5N NaOH solution was heated on a stove with temperature controller. When the temperature reached at 70ºC, the radon exposed LR-115 detectors were put into the beaker for 60 minutes. During etching, the temperature was kept constant with and accuracy of ±1ºC. After etching, the solution in the beaker was poured into another beaker through small plastic sieve with handle, so that the detectors can be easily and firstly collected. Then, the detectors were washed under the running until the surface of the detectors became cleaned from etchant. Finally, the detectors were taken out and dried with filter paper.

Optical Microscope Used in the Present Work

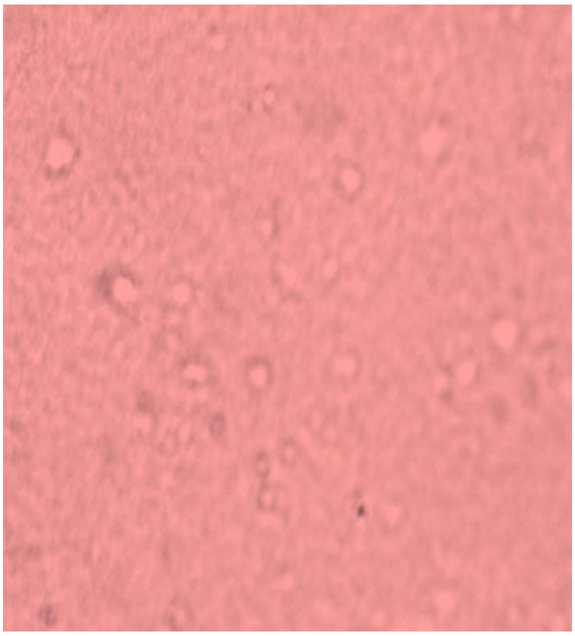
In this research, the counting and measuring diameter of the chemically etched tracks were carried out by using the optical microscope. The microscope consists of eyepiece 10x magnification and four lenses each with 10, 20, 40 and 100 times magnification. The generation of ion tracks of specified size and shape requires a microscopic control of the achieved results. Its great advantage of optical microscopy is using with ease requiring only little preparation. The tracks formed are viewed under different magnifications as the display monitor. The visible area containing tracks in SSNTDs will vary depending upon the magnification used. The numbers of track are usually counted at a suitable magnification. Photograph of alpha tracks in LR-115 sample detectors are shown in figure (3).



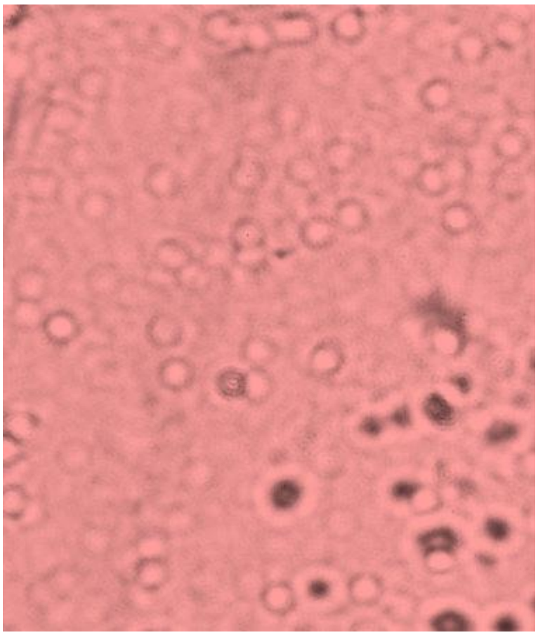
(a) Background



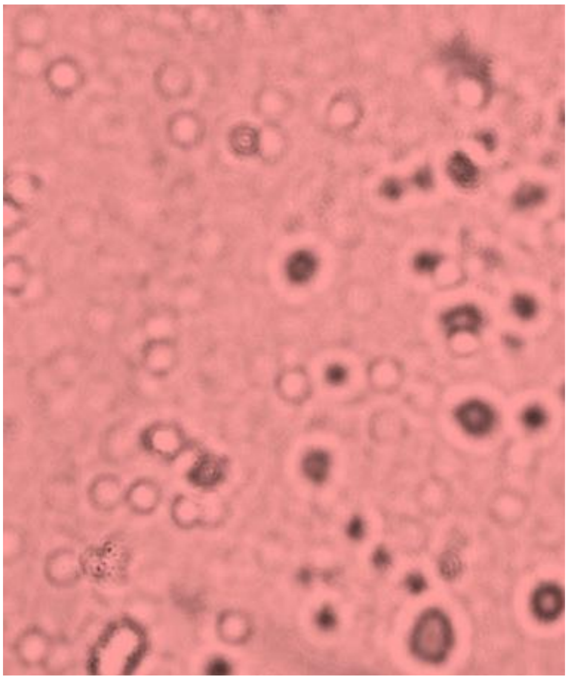
(b) eight holes cement brick [Sample (1)]



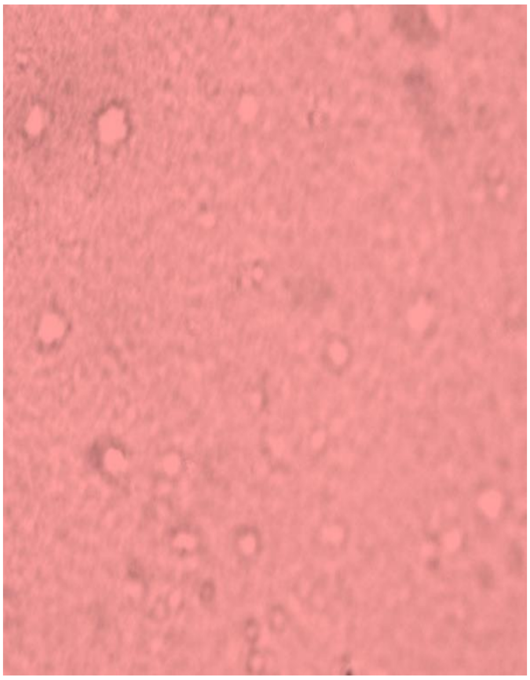
(c) eight holes red-clay brick [Sample (2)]



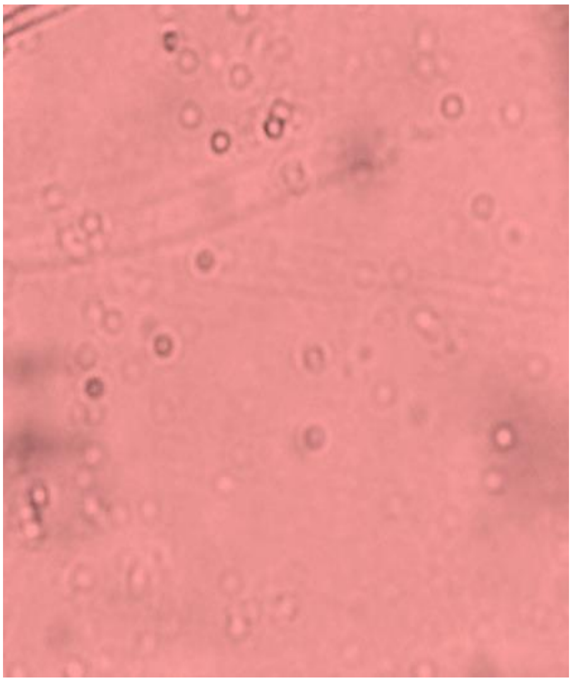
(d) ten holes red-clay brick [Sample (3)]



(e) no hole red-clay brick [Sample (4)]



(f) rectangular shape design cement block[Sample (5)]



(g) rhombus shape design cement block [Sample (6)]

Figure 2. Photomicrograph of alpha tracks in LR-115 to radon from sample (1) to (6)

Results, Discussion and Conclusion

Results and Discussion

In this study LR-115 plastic track detectors was used to measure the alpha track densities, radon concentrations, and annual effective dose in building samples collected from Yangon. The calculated values of the alpha track densities, radon concentrations, and annual effective dose for building materials at Yangon are presented in table (1). The values of alpha track densities of radon from six kinds of building materials samples vary from 10.31 to 15.31trackcm^{-2}day^{-1}. The values of radon concentrations are found to vary from 206 to 305Bqm^{-3} and a standard deviation of 54.392. Five samples values of radon concentrations in all samples under test were found to be lower than the permissible value of 300Bqm^{-3} recommended by International Commission on Radiological Protection (ICRP). One (no hole red-clay brick) of the radon concentrations among six kinds of building materials samples was found to be a little larger than the permissible value of 300Bqm^{-3}. The values of radon concentrations in all samples were found to vary from 3.54 to 5.25mSvy^{-1}. The highest annual effective dose of sample-4 (no hole red-clay brick) was found to be quite lower than the value of 14mSvy^{-1} recommended by International Commission on Radiological Protection (ICRP).

Table 1. Alpha track density, radon concentration and annual effective dose of bricks and blocks (building materials)

Sr No.	Sample Name	Alpha Track Density ($trackcm^{-2}day^{-1}$)	Radon Concentration (Bqm^{-3})	Annual Effective Dose ($mSvyr^{-1}$)
1.	Sample (1)	10.31 ± 2.925	206 ± 58.31722	3.54 ± 1.003
2.	Sample (2)	13.62 ± 2.776	272 ± 55.33700	4.67 ± 0.952
3.	Sample (3)	14.81 ± 3.064	295 ± 61.08400	5.08 ± 1.051
4.	Sample (4)	15.31 ± 2.895	305 ± 57.70900	5.25 ± 0.993
5.	Sample (5)	14.55 ± 2.090	290 ± 41.66700	4.99 ± 0.717
6.	Sample (6)	13.64 ± 2.620	272 ± 52.23600	4.68 ± 0.898

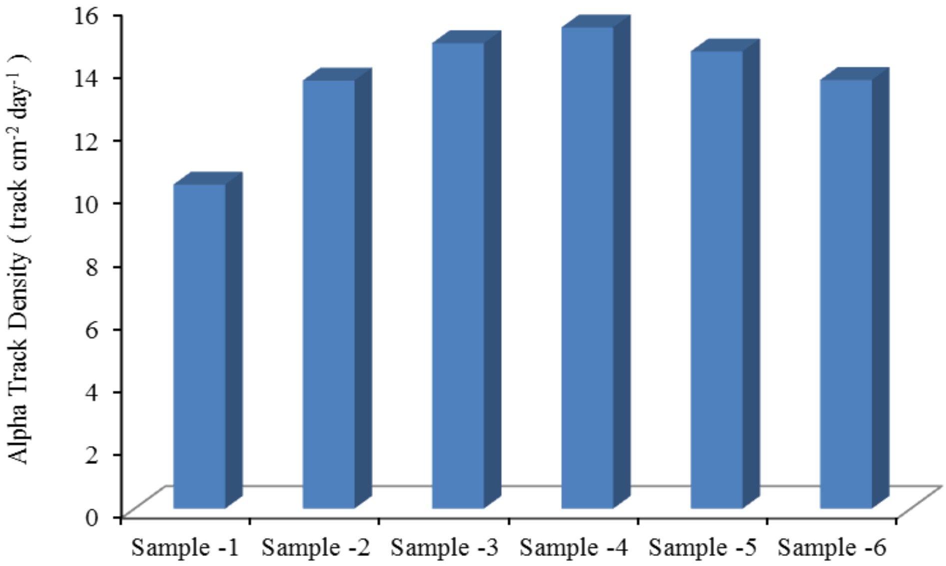


Figure 3. The comparison graph of alpha track density of the building material samples.

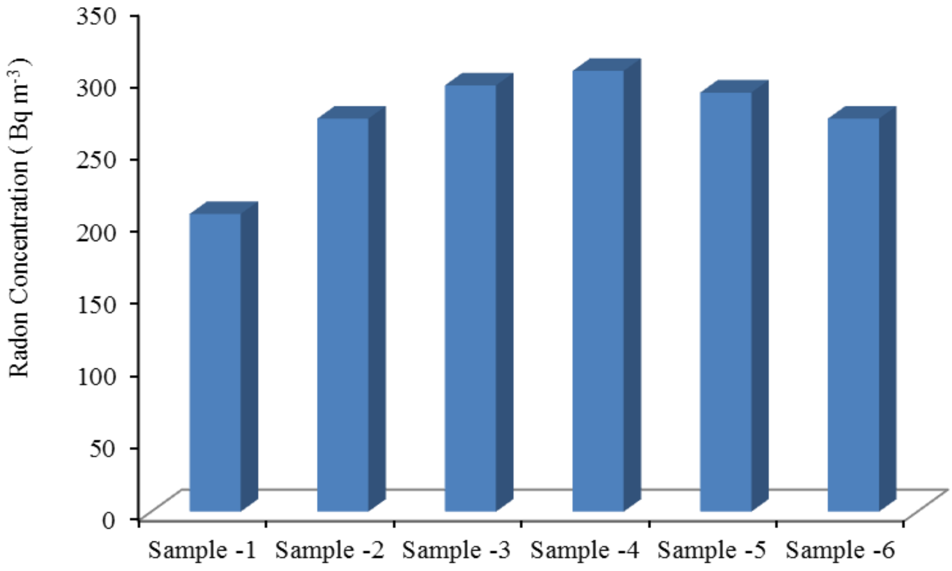


Figure 4. The comparison graph of radon concentration of the building material samples

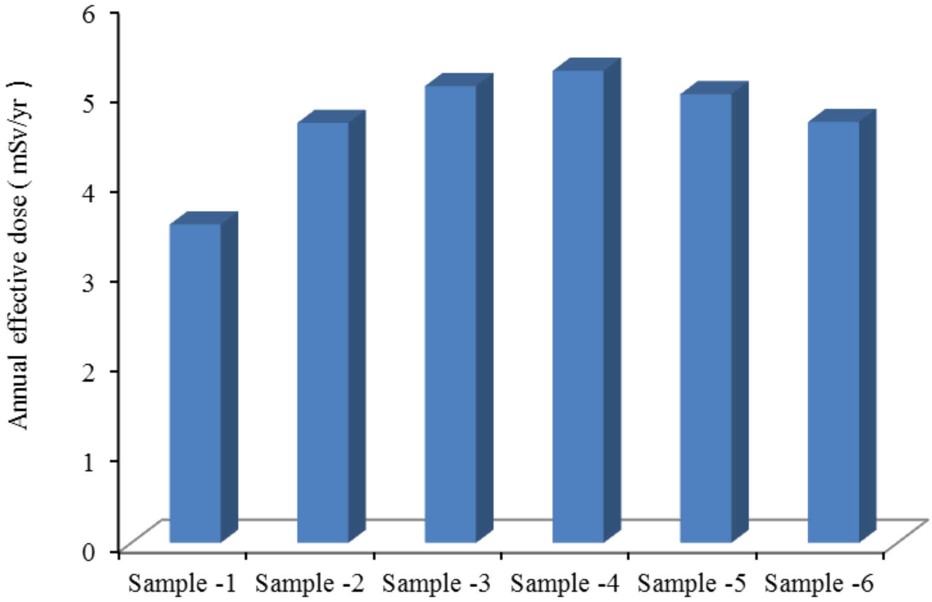


Figure 5. The comparison graph of annual effective dose of the building material samples

Conclusion

It is seen from the data's, there is no sign of danger and do not occur health hazards to the users and the people that community. The sample-4 (no hole red-clay brick) has the highest annual effective dose with other brick samples used by the LR-115 detectors. Although the annual effective dose of all samples are lower than ICRP (2018) limited level 14mSvyr^{-1}. So it can be concluded that the tested radon level and the annual effective doses are saved from the health hazard of radium point of view.

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