Monitoring of Radon Concentration for Different Building Types in Hinthada

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Abstract

Radon is the naturally occurring radioactive gas found in our environment which originates from the natural decay of uranium and radium found in rocks and soils all over the world. Radon monitoring is essential in determining the actual level of exposure in buildings. In this work, a comparative study of the indoor radon gas concentration level of different building types was done in order to assess the radon concentration level as compared to the world set limit. The indoor radon gas level measurement was done using CR-39(Solid State Nuclear Track Detector SSNTD) detector and passive (long-term measurement) technique. After exposure the tracks are made visible by chemical etching and counted manually under the biological microscope (N-101A Model). The radon activity was calculated from the alpha track density by using calibration factor $1Bqm^{-3}=0.344track\ cm^{-2}day^{-1}$. The radon concentrations were calculated in terms of Bqm^{-3}.The annual effective dose was calculated in terms of $mSvy^{-1}$.These annual effective dose values were lower than the limited level $5mSvy^{-1}$ recommended by ICRP (The International Commission on Radiological Protection).Moreover, through this study, this paper aim to create interest and raise public awareness of the radon hazard in the community.

Keywords; Radon, Radon concentration, Health risk, Reference level

INTRODUCTION

Radon is a naturally occurring radioactive gas. Radon is a colourless, odorless, and tasteless gas that can seep through soil, rock, and water and gets into the air you breathe. When uranium decays, it produces radium, which in turn decays to produce radon. Radon is an inert gas; therefore, it is a noble gas family. Radon does not react with air, water, and others, but its decay daughters are electrically charged so that they are reactive and they are the cause of radiological health effects on humans. Radon is a gaseous radioactive element having the symbol Rn, the atomic number 86, an atom, an atomic weight of 222, a melting point of -76ºC, and a boiling point of - 62ºC. ^{222}Rn has a half-life of 3.82 days. All radon isotopes emit α-particles. The short-lived progeny that decay emits heavily ionizing radiation called α-particles. ^{222}Rn releases α-particle with 5.49 MeV of energy when it decays to polonium-218. α -particles lose their energy very rapidly and only travel very short distances in dense media. Radon typically moves up through the ground to the air above and into your home through cracks in the floor or at floor-wall junctions, gaps around pipes or cables, small pores in hollow-block walls, or sumps or drains. Radon levels are usually higher in basements, cellars, and living spaces in contact with the ground. However considerable radon concentration can also be found above the ground floor.

Radon monitoring is essential in determining the actual level of exposure in buildings. Different building materials such as cement, rock, concrete, marble, paints, and gypsum always

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contain uranium and radium. The types of construction materials of the building and the soil composition around the building determine the amount of indoor radon concentration. The design, construction, and ventilation of the building are the major factors that determine the amount of indoor radon (^{222}Rn) concentration.

Any building may have a radon problem that has increased in many countries. The background level of radon in the outside air generally quite low, but in indoor locations radon levels in the air may be higher. Inside an enclosed space, like a home, it cannot disperse and can reach high levels. Radon levels are often higher in the fall and winter because windows and doors are closed up more often, reducing ventilation in your home. The concentration of radon in buildings depends on the local geology, for example, the uranium content and permeability of the underlying rocks and soils. Therefore, the detection and radon concentration measurements are one of the most important procedures. International Commission on Radiological Protection (ICRP) has recommended the limit to be $5mSvy^{-1}$ received from radon its progeny above which it can be a health hazard. Moreover, through this study, we aim to create interest and raise public awareness of the radon hazard in the community.

Health Risk

Radon likes carbon monoxide. Radon occurs in the environment mainly in the gaseous phase. People are mainly exposed to radon through breathing air. Radon is the largest and most variable contributor to public radiation exposure. If we breathe in high levels of radon over long periods, this exposure can lead to damage to the sensitive cells of our lungs which increases the risk of lung cancer. It has been considered that radon is the second leading cause of lung cancer after smoking is responsible for developing lung cancer. Therefore, the risk of developing lung cancer depends on:

1. How much radon is in your home and the location where you spend most of your time (e.g., the main living and sleeping areas)?
2. The amount of time you spend in your home.
3. Whether you are a smoker or have ever smoked/not?
4. Soil characteristics.
5. Construction type.
6. Occupant lifestyle.
7. Weather

If you smoke and live in a home with high radon levels, you increase your risk of developing lung cancer.

Study Area

Hinthada lies in the Ayeyarwady division. It is situated on the bank of the Ayeyarwady river. Hinthada is located above 26ft from the sea water level in Hinthada Township, Ayeyarwady Region, Myanmar. The division is situated between 17º 15' – 17 º50' North latitudes and 95º 10' – 95º 35' East longitudes. It is a commercial town. The population of the town is about 449950 persons that include various nationalities and foreigners such as Indians and Chinese. The area of Hinthada Township is 378.695 square miles. Hinthada Township comprises many quarters. It was selected for the Payargyi Quarter. The location of the study area has been shown in the figure.1. Payargyi Quarter lies in the middle of town and it has a population of about 2591persons. Many houses in Payargyi Quarter are very densely populated and the houses are close to each other. There is the pagoda, many monasteries, markets, a railway station, private hospitals, a middle school, a high school and kindergartens nearer the Payargyi Quarter. Besides, there is a road running from north to south and east to west through the township. The radon level depends on the type of building and building materials. Therefore, the different building types are chosen in the same quarter.

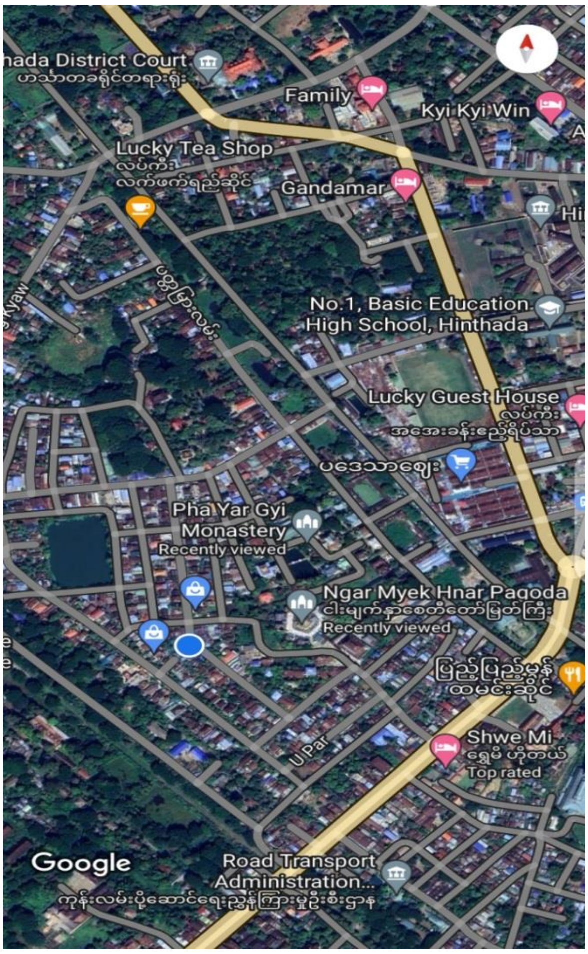

Figure 1. Location of the study area

Experimental Details

Monitoring Material

To monitor radon, both active and passive techniques have been developed. The indoor radon gas level measurement was done using CR-39 (Solid State Nuclear Track Detector SSNTD) detector and passive (Long – term measurement) technique. The most popular member of the SSNTDs family, CR-39 was selected because CR-39 is a highly sensitive charge particle detector. Large sheets of CR-39 having 250 um thickness, supplied by Page Mouldings, Ltd., UK) were cut into small pieces of sizes 1cmx1cm. Seven samples of CR-39 detectors were hung up inside the seven different buildings. And then, another seven samples of CR-39 detectors were fixed inside these buildings such that two pieces of CR-39 were placed inside each building. All CR-39 detectors were hung-up and fixed 2m above the ground level to avoid direct alpha emission from building materials. All these detectors were also made at the same time and same technique. The detectors were exposed for 100days. During the exposure time, the tracks of alpha particles were registered in the detectors.

Track Etching System

At the end of the exposure time, the CR-39 detector was removed from each building. The alpha tracks were not clearly visible and, therefore, could not be counted at first. So, CR-39 detectors were etched for 5 hours in a 6N NaOH solution at 70ºC in a bath at a constant temperature. After etching CR-39 detectors were cleaned in running water for 20minutes and dried flat between tissues wipes to remove the etchant and etch products from the surface of the detector.

Track Counting System

The tracks produced by alpha particles were observed. The etched tracks on the detectors were counted using biological microscope model N-101A with a digital camera attached and a display system (PC). According to the observations of the different views of the screen of the PC, alpha tracks were counted to reduce the statistical errors. To obtain realistic statistics of the tracks, 50 field views were selected randomly on the detector surface.

Calculations

The track count for fourteen CR-39 samples was calculated using the following equation.

$$\text{Track Density} = \frac{\text{Net number of track}}{\text{Microscopic view area} \times \text{exposure}} \quad (\text{trackcm}^{-2}\text{day}^{-1})$$

Then Radon activity was calculated from the alpha track density by using calibration factor $1\text{Bqm}^{-3} = 0.344\ \text{trackcm}^{-2}\text{day}^{-1}$. The radon concentrations were calculated in terms of Bqm^{-3}.The annual effective dose was calculated in terms of mSvy^{-1}.The calibration Factor was obtained through the relation between track density, radon concentration and exposure time.

RESULTS AND DISCUSSION

Radon concentration from seven building types of Payargyi Quarter, each in Hinthada and samples were measured and calculated. The mean of track density, and annual effective dose values were shown in Table-1.

Table-1. The mean of track density, radon concentration and annual effective dose in seven buildings

No	Sample	Building Types	Track Density ($\text{trackcm}^{-2}\text{day}^{-1}$)		Radon Concentration (Bqm^{-3})		Annual Effective Dose(mSvy^{-1})	
			Fixed	Hung-up	Fixed	Hung-up	Fixed	Hung-up
1	B_1	Religious Building	28.51	24.44	82.88	71.05	1.61	1.21
2	B_2	Tiled Building	36.25	35.03	105.38	101.83	1.79	1.73
3	B_3	Building made of bricks only	26.48	24.44	76.98	71.05	1.31	1.21
4	B_4	Building made of bricks with cement plaster	32.59	28.92	94.74	84.07	1.61	1.43
5	B_5	Building made of bricks with cement plaster and new washed	33.81	30.55	98.29	88.81	1.67	1.51
6	B_6	Building made of Bricks with cement plaster and old washed	37.48	37.07	105.38	101.83	1.79	1.73
7	B_7	Building built with many mirrors	46.44	39.92	135.00	116.05	2.29	1.97

The results indicate that radon concentration levels in B_6 and B_7 are higher than the radon concentration level measured in other buildings. The lowest value was found in B_3. The resulting range is between ($1.21 mSvy^{-1}$-$2.29 mSvy^{-1}$). Maximum radon concentration is detected in B_7. This is because B_7 was closed and had poor ventilation with glass-enclosed walls. This might be due to the reduction of airflow rates with increases in radon concentration. Radon concentration was found to be the lowest in B_3 since B_3 is opened and well-ventilated. The differences between concentration levels obtained for different buildings are probably due to the geological characteristics of the soil.

CONCLUSION

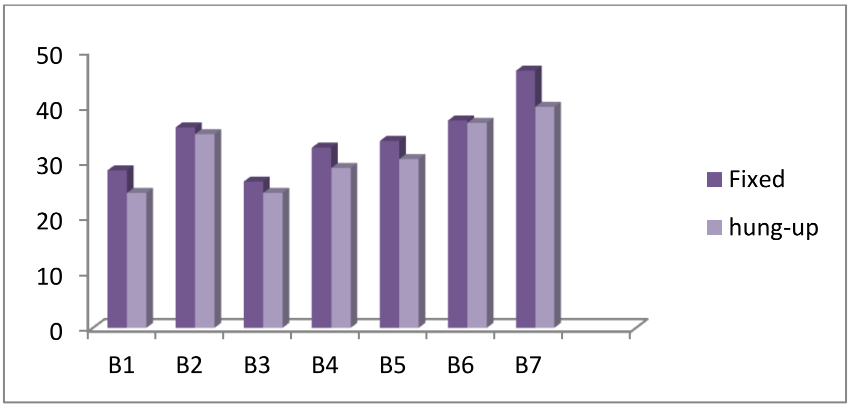

Figure 2. Track density comparison graph of CR-39 detectors are fixed and hung-up in seven Buildings

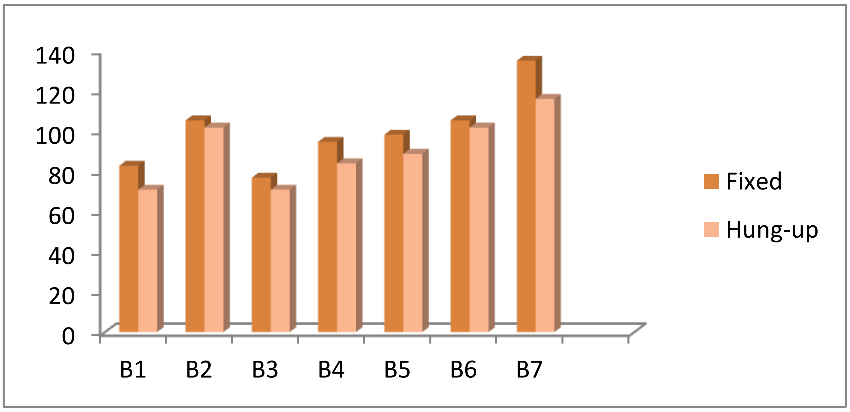

Figure 3. The Radon concentration comparison graph of CR-39 detectors is fixed and hung-up in seven buildings

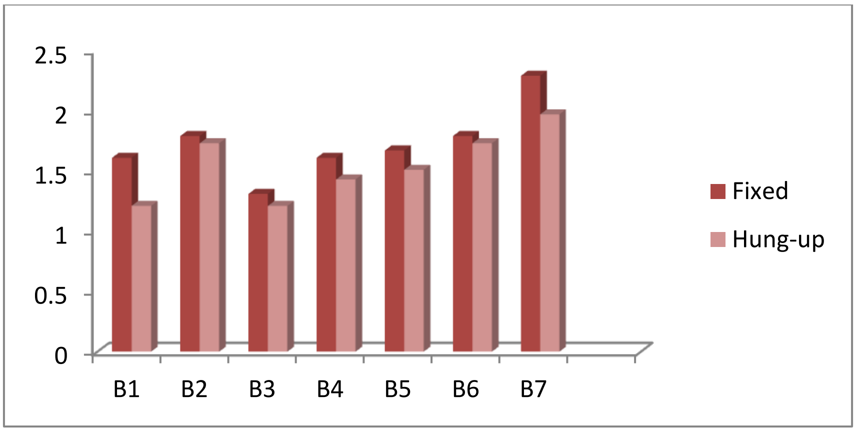

Figure 4. Annual effective dose comparison graph of CR-39 detectors are fixed and hung-up in seven buildings

In conclusion, the average radon concentration and annual effective dose of hung up CR-39 detectors are less than fixed detectors. The variation of concentration at a different location in the same room was also investigated. This was accomplished by placing two detectors at two different positions (hung up and fixed). The results showed that the radon concentration level was obtained from detectors placed away from the windows. Good ventilation is the simplest way which is one of the most important things for reducing radon concentration in buildings. The average indoor radon concentrations in the monitored buildings were lower than 5mSvy^{-1} (See Table-1). These values are below the radon reference levels as recommended by ICRP. Accordingly, medical efforts should be focused mainly on reducing the radon concentration levels as well as effective consideration to improve the ventilation and adopt the mitigation technique to reduce the concentration of radon from the buildings. The measured radon concentration levels as well as radon exhalation rates were found to be less than the reference levels. So, the monk and the people who lived in the seven different types of buildings are safe from a health point of view.

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References

D. Cares, “Guide for Radon Measurements in Public Buildings”.

E. Concerted-action, I. Air, Q. I. Ts, and I. On, “EUROPEAN CONCERTED-ACTION on in Indoor Air prepared by”.

E. Atlas and N. Radiation, “Radon”.

EPA(1993) "Protocols For Radon And Radon Decay Product Measurements In homes". EPA 402-R-92-003 May, 1993.

ICRP(1997) "Radiation Protection in Uranium and Other Mines". ICRP Publication 24, Ann. ICRP 1(1)

ICRP(2014) "Radiological Protection against Radon Exposure" ICRP Publication 126, Ann. ICRP 43(3).

M. Gupta, A. K. Mahur, R. G. Sonkawade, and K. D. Verma, "Monitoring of indoor radon and its progeny in dwellings of Delhi using SSNTDs," vol. 2, no. 5, pp. 421–426, 2011.

Report of the independent Advisory Group on Ionising Radiation Health Protection Agency 2009.

Report of the independent Adyisory Group on Ionising Radiation (2019) "Radon and Public Health" Health Protection Agency 2009. RCE-11

"Radon and Health," no. February, 2011.

S. Pervin, S. Yeasmin, M. U. Khandaker, and A. Begum, "Radon Concentrations in Indoor and Outdoor Environments of Atomic Energy Centre Dhaka , Bangladesh , and Concomitant Health Hazards," vol. 1, no. June, pp. 1–10, 2022, doi: 10.3389/fnuen.2022.901818.

S. Uranium, "Chapter 8.3," vol. 222, no. 1, pp. 1–14, 2001.

W. A. Alhamdi and K. M. S. Abdullah, "Estimation of indoor radon concentration and dose evaluation of radon and its progeny in selected dwellings in Duhok city , Kurdistan Region , Iraq," vol. 20, no. 2, 2022, doi: 10.52547/ijrr.20.2.30