COMPARISON OF RADON EXPLORATION IN DIFFERENT ENVIRONMENTAL SAMPLES BY USING LR-115 TYPE II DETECTOR

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Abstract

This work investigated the interaction of LR-115 type II Solid State Nuclear Track Detectors (SSNTDs) with various radiations (neutron, alpha, and gamma). After irradiation, the tracks formed were etched with alkaline solution 10 % NaOH at 60 °C for 90 min. The etched tracks in irradiated LR-115 type II were observed by using an optical microscope. In this study, radon exploration in different environmental samples such as coal, bottom ash, volcanic ash, mud volcano, Crown cement, and tobacco were carried out by using an LR-115 type II (an alpha sensitive plastic track detector). It indicates radon's existence as an alpha emitter in all different environmental samples. Among them, the radon concentration in the volcanic ash sample was found to be the highest value (105.5511 Bq/m^3) and exceed the national reference level (100 Bq/m^3) whereas in the coal sample, was found to be the second-highest value (100.6902 Bq/m^3).

Keywords: LR-115, radon, alpha track, environmental samples

Introduction

Radon is a colourless, odourless natural radioactive gas that is the most common source of radiation exposure in humans. Radon is the most common source of radiation exposure in our environment during a person's lifetime (Aziz *et al*., 2016).

The present study used SSNTDs in the track etches technique due to their simplicity, low cost, non-destructive, small size, and having the integrating capability for large scale studies for the measurement of radon concentration and radon exhalation rates studies in the environmental samples. It is of great interest in estimating the radiation risk to the public from radon and its daughters (Dorschel *et al.*, 2003).

LR-115 is a 12 μm thick red-dyed cellulose nitrate emulsion coated on a 100 μm thick inert polyester base. A high enough linear energy transfer has the highest sensitivity for alpha particles, fission fragments, and ionizing particles. Ionizing radiation passes through insulating solids, leaving narrow trails of intense damage on an atomic scale. These trails are known as 'Tracks'. They can be seen under an optical microscope after being treated with a suitable chemical etchant (Siems *et al.*, 2001).

Materials and Methods

This section mainly consists of three parts. The first part is related to the study on the effect of etching times with alpha irradiated LR-115. The second part is concerned with the interaction of LR-115 detectors by using neutron, gamma, and alpha radiations standard sources. The final part is concerned with the applications of LR-115 for radon level measurement from environmental samples; coal, bottom ash, volcanic ash, mud volcano, Crown cement, and tobacco.

Treatment of LR-115 Detector with Standard Sources

LR-115 detectors were cut into small pieces of 1 cm × 1 cm. These samples were irradiated with neutron from Am(Be) source, gamma from Co-60 source, and alpha from Am-241 source. The LR-115 was removed from the sources and etched chemically in 10% NaOH solution at 60 °C

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for 90 min in an oven. The etched tracks on the detectors were scanned, using an optical microscope (OLYMPUS BX-51). It was also concerned with examining the composition of SSNTDs before and after irradiation by using other auxiliary methods such as FT IR.

Detection of Radon via Alpha Particles in Different Environmental Samples

In this work, LR-115 detectors were used for measuring radon via alpha particles in the environmental samples. Each sample (100 g) was placed in the cylindrical "Can". The LR-115 detectors were fixed on the top inside of the "Can" for three months. The plastic "Can" is 7.5 cm in height and 8.0 cm in diameter. During this time the alpha particles from radon and its daughter would leave tracks on the detector. The LR-115 was removed from the plastic "Can" and etched chemically in the above procedure.

The track density of environmental samples was calculated by dividing the number of tracks by the microscope view area (19.635 10^{-4} cm^2) and exposure time (90 days). The radon activity was calculated using the track density and a calibration factor of 0.21 tracks/cm^2d (Eappen and Mayya, 2004). Radon activity was used to calculate the radon exhalation rate (Anil Sharma1 *et al*., 2014). The radon concentration in environmental samples was then computed using an exhalation rate (Abd-Elzaher, 2012).

Results and Discussion

Effect of Etching Parameters on LR-115 Detectors

Six LR-115 detectors were irradiated with Am-241 alpha radiation for 15 min. These detectors were etched in 10 % NaOH solution with different etching times (50, 60, 70, 80, 90, and 100 min) at 60 °C. The etching time (90 min) was chosen optimum condition for this research.

Observation of Tracks with Standard Sources

The detection of LR-115 with a neutron, gamma, and alpha radiations was studied. In this, the detector can not detect neutron and gamma radiations. LR-115 can detect especially for alpha. From the study on different alpha irradiation times (15, 30, 60, 90 min), the greater the irradiation times, the higher the track density on LR-115. But it will be damaged at irradiation time over 60 min. It was used for radon level measurement from the environmental samples.

Examination of Effect of Radiation on LR-115 by Using FT IR Method

From the FT IR spectra of the neutron, gamma, and alpha irradiated LR-115 detectors, it was found that the wavenumbers of functional groups in all irradiated detectors of different irradiation times do not differ before and after irradiation. The observations suggested that the potentiality of LR-115 can be used as dosimeters.

Observation of Radon via Alpha Particles from Environmental Samples

According to the experimental results, the LR-115 detector is more effective in alpha detection. Hence, it was used for observation of radon via alpha particles emitting environmental samples.

Each LR-115 detector was fixed at the top of inside each "Can" according to facing the detector and α-emitted via radon in coal, bottom ash, volcanic ash, mud volcano, Crown cement, and tobacco samples. After the exposure period of three months, they were etched in 10 % NaOH at 60 °C for 90 min.

The experimental results revealed that the whole tracks were found in all the LR-115 detectors placed in these environmental samples. The shape of the track observed agrees with the literature and it indicates that this is due to an interaction between detectors and alpha particles via radon present in it (Figures 1, 2, 3, 4, 5 and 6).

From Table 1, the track density was found to be between 1131.7658 and 1397.7308 track/ cm^2 in all detectors in the coal sample. The average value was found to be 1312.8484 track/cm^2. According to the observed track density, the radon activity was found to be between 5389.3611 and 6655.8610 Bq/m^3. The average was 6251.6589 Bq/m^3. The calculated radon exhalation rate values were between 0.4063 and 0.5018 Bq/m^2h and the mean value was 0.4713 Bq/m^2h. Therefore, the radon concentration in the coal sample was found to be 100.6902 Bq/m^3. Therefore, the annual effective dose equivalent rate of the Thitchauk coal mine lies within the intervention limit for mine workers. The mine workers in the Thitchauk coal mine are safe from health hazards from radon.

From Table 2, the track density was found to be between 38.1971 and 89.1266 track/cm^2 in all detectors in the bottom ash sample. The average value was found to be 66.2083 track/cm^2. According to the observed track density, the radon activity was found to be between 181.8909 and 424.4122 Bq/m^3. The average was 315.2776 Bq/m^3. The calculated radon exhalation rate values were between 0.0149 and 0.0348 Bq/m^2h and the mean value was 0.0258 Bq/m^2h. Therefore, the radon concentration in the bottom ash sample was found to be 5.5281Bq/m^3. As a byproduct of coal combustion, massive amounts of fly ash, and bottom ash are manufactured, which typically contain radioactive materials. Radon health effects adhere to the respiratory tract and lung areas in the factory environment, becoming a permanent source of radioactivity within the body and eventually causing lung cancer and bronchial tissue damage.

From Table 3, the track density was found to be between 1352.4602 and 1426.0250 track/ cm^2 in all detectors in the volcanic ash sample. The average value was found to be 1376.2270 track/ cm^2. According to the observed track density, the radon activity was found to be between 6440.2866 and 6790.5950 Bq/m^3. The average was 6553.4630 Bq/m^3. The calculated radon exhalation rate values were between 0.4855 and 0.5119 Bq/m^2h and the mean value was 0.4941Bq/m^2h. Therefore, the average radon concentration in the volcanic ash sample was found to be 105.5511 Bq/m^3. The people living around the volcano area should be noticed that health risk from radon and volcanic ash usually contains radon and other radioactive nuclides.

From Table 4, the track density was found to be between 16.9765 and 59.4177 track/cm^2 in all detectors in the mud volcano sample. The average value was found to be 32.2553 track/cm^2. According to the observed track density, the radon activity was found to be between 80.8404 and 282.9415 Bq/m^3. The average was 153.5968 Bq/m^3. The calculated radon exhalation rate values were between 0.0063 and 0.0221 Bq/m^2h and the mean value was 0.0120 Bq/m^2h. Therefore, the average radon concentration in the mud volcano sample was found to be 2.5573 Bq/m^3. Therefore, the average radon concentrations of mud volcanoes lie below the intervention limit for people.

From Table 5, the track density was found to be between 50.9295 and 89.1266 track/cm^2 in all detectors in Crown cement sample. The average value was found to be 68.7548 track/cm^2. According to the observed track density, the radon activity was found to be between 242.5213 and 424.4122 Bq/m^3. The average was 327.4037 Bq/m^3. The calculated radon exhalation rate values were between 0.0199 and 0.0348 Bq/m^2h and the mean value was 0.0269 Bq/m^2h. Therefore, the average radon concentration in Crown brands cement sample was found to be 5.7407 Bq/m^3. Although the measured radon concentration values in cement samples are below the recommended action level, cement usually contains radon. Therefore, the construction worker should be noticed the health risk from radon exposure.

From Table 6, the track density was found to be between 25.4647 and101.8589 track/cm^2 in all detectors in the tobacco sample. The average value was found to be 53.4759 track/cm^2. According to the observed track density, the radon activity was found to be between 121.2606 and 485.0425 Bq/m^3. The average was 254.6473 Bq/m^3. The calculated radon exhalation rate values were between 0.0100 and 0.0398 Bq/m^{2}h and the mean value was 0.0209 Bq/m^{2}h. Therefore, the average radon concentration in the tobacco sample was found to be 4.4650 Bq/m^3. The vast majority of radon-related lung cancer deaths occur in current and former smokers, and radon exposure raises the risk of lung cancer in everyone, whether they are current, former, or non-smokers. The majority of countries have an active anti-smoking public information campaign. Anti-smoking leaflets and information are available in health centers and hospitals. Lung health and cancer organizations are frequently involved in public awareness campaigns.

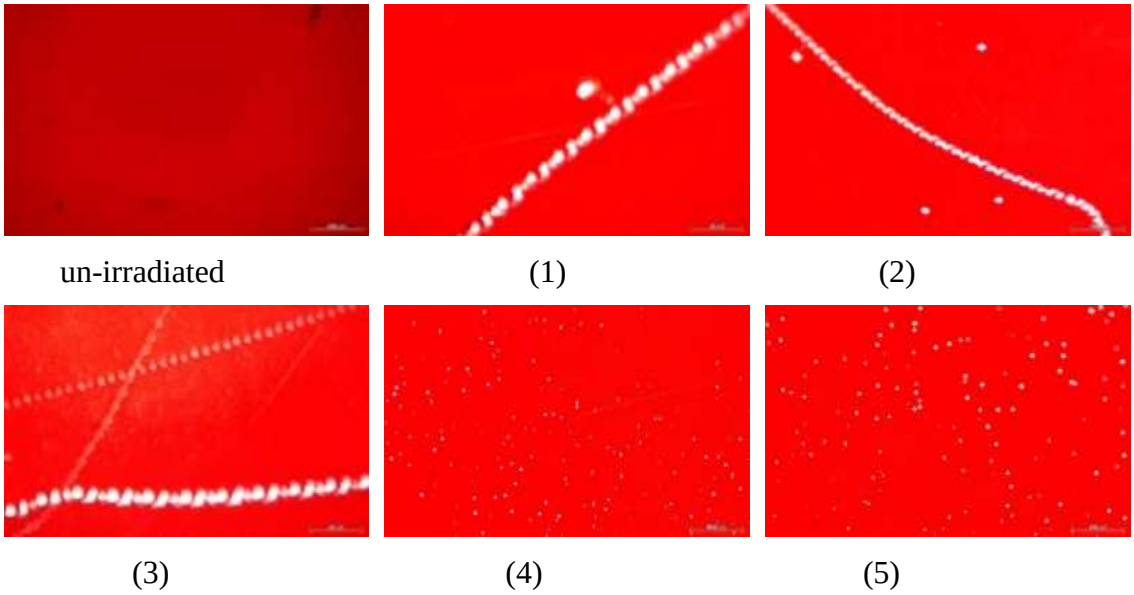

Figure 1 Photomicrographs (1 to 5) for the revelation of the alpha particle tracks in LR-115 detectors for coal sample from Thitchauk coal mine

Table 1 Measurement of Track Density, Radon Activity, Radon Exhalation Rate, and Radon Concentration from Coal Sample

LR-115	Track density (tracks/cm^{2}d)	Radon activity (Bq/m^3)	Radon exhalation rate (Bq/m^{2}h)	Radon concentration (Bq/m^3)	Annual effective dose (mSv/y)
1	1131.7658	5389.3611	0.4063	86.8019	2.4371
2	1329.8249	6332.4993	0.4774	101.9922	2.8636
3	1346.8013	6413.3397	0.4835	103.2942	2.9001
4	1358.1190	6467.2334	0.4876	104.1622	2.9245
5	1397.7308	6655.8610	0.5018	107.2003	3.0098
Mean Value ± SD	1312.8484 ±93.2592	6251.6589 ±444.0912	0.4713 ±0.0335	100.6902 ±7.1526	2.8270 ±0.2008

* International reference level of radon concentration = 100 Bq/m^3

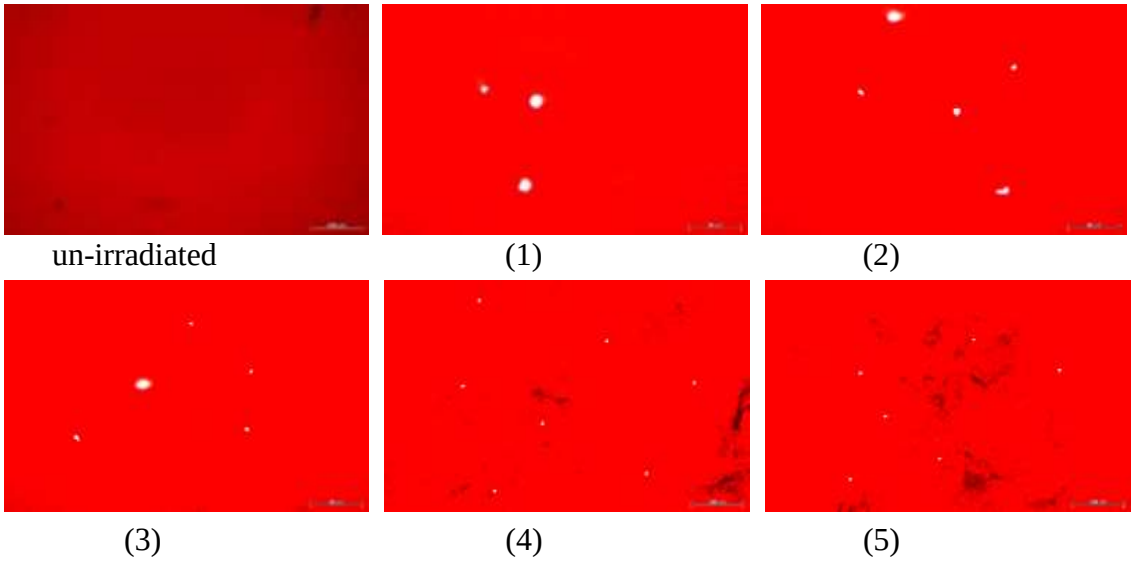

Figure 2 Photomicrographs (1 to 5) for the revelation of the alpha particle tracks in LR-115 detectors for bottom ash sample from Hom Pan Tile Factory, Sagaing

Table 2 Measurement of Track Density, Radon Activity, Radon Exhalation Rate and Radon Concentration from Bottom Ash Sample

LR-115	Track density (tracks/cm^{2}d)	Radon activity (Bq/m^3)	Radon exhalation rate (Bq/m^{2}h)	Radon concentration (Bq/m^3)
1	38.1971	181.8909	0.0149	3.1893
2	63.6618	303.1516	0.0249	5.3155
3	63.6618	303.1516	0.0249	5.3155
4	76.3942	363.7819	0.0299	6.3786
5	89.1266	424.4122	0.0348	7.4417
Mean Value ± SD	66.2083 ±16.8914	315.2776 ±80.4352	0.0258 ±0.0066	5.5281 ±1.4104

* International reference level of radon concentration = 100 Bq/m^3

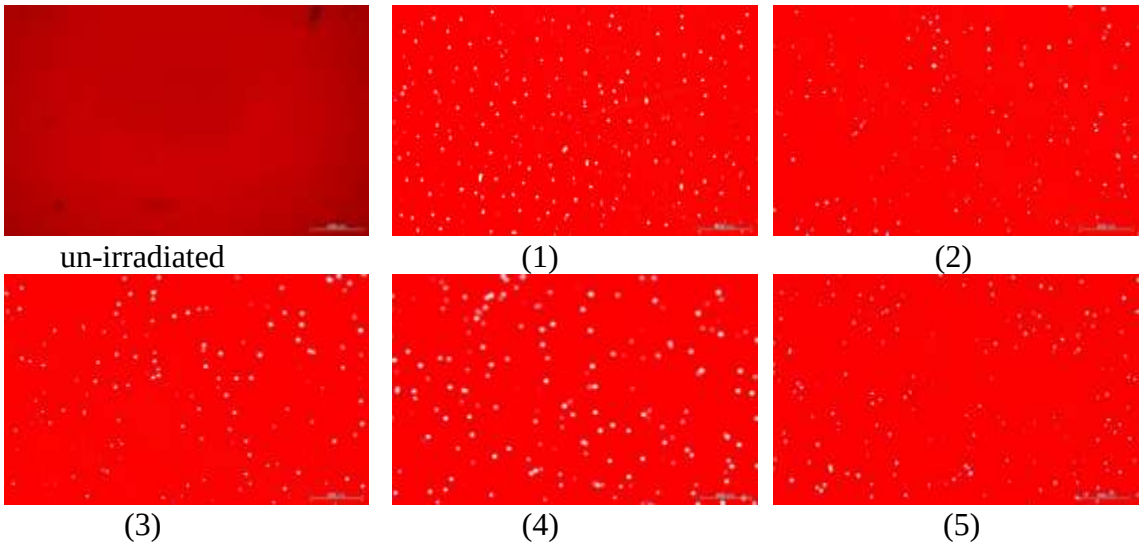

Figure 3 Photomicrographs (1 to 5) for the revelation of the alpha particle tracks in LR-115 detectors for volcanic ash sample from Kyaukphyu township

Table 3 Measurement of Track Density, Radon Activity, Radon Exhalation Rate and Radon Concentration from Volcanic Ash

LR-115	Track density (tracks/cm^{2}d)	Radon activity (Bq/m^3)	Radon exhalation rate (Bq/m^{2}h)	Radon concentration (Bq/m^3)
1	1352.4602	6440.2866	0.4855	103.7282
2	1358.1190	6467.2334	0.4876	104.1622
3	1369.4367	6521.1270	0.4916	105.0303
4	1375.0955	6548.0738	0.4937	105.4643
5	1426.0250	6790.5950	0.5119	109.3703
Mean Value ± SD	1376.2270 ±26.1534	6553.4630 ±124.5397	0.4941 ±0.0094	105.5511 ±2.0058

* International reference level of radon concentration = 100 Bq/m^3

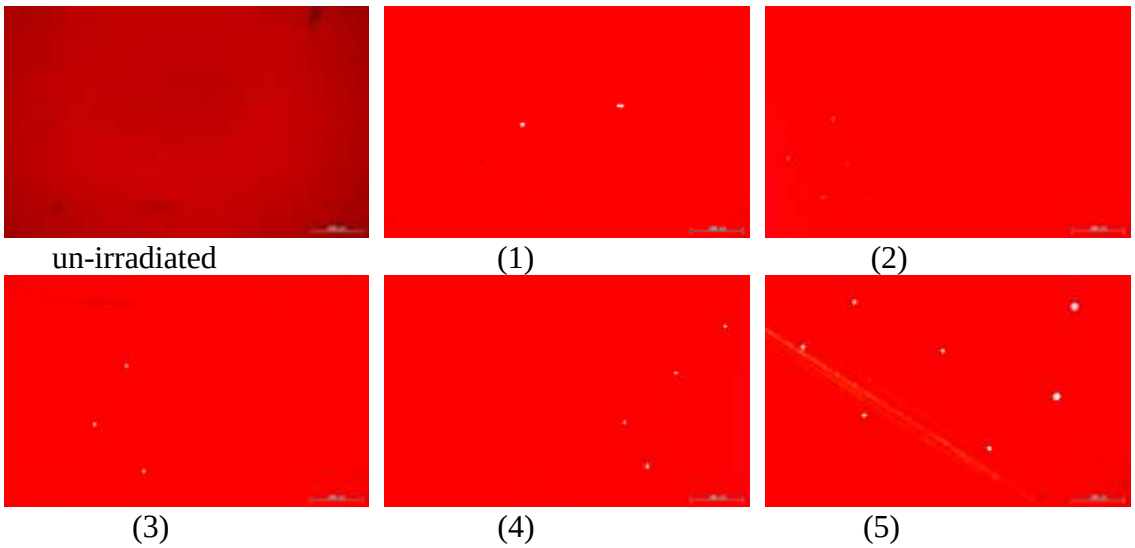

Figure 4 Photomicrographs (1 to 5) for the revelation of the alpha particle tracks in LR-115 detectors for mud volcano sample from Nagarpwattaung, Minbu township

Table 4 Measurement of Track Density, Radon Activity, Radon Exhalation Rate, and Radon Concentration from Mud Volcano

LR-115	Track density (tracks/cm^{2}d)	Radon activity (Bq/m^3)	Radon exhalation rate (Bq/m^{2}h)	Radon concentration (Bq/m^3)
1	16.9765	80.8404	0.0063	1.3459
2	25.4647	121.2606	0.0095	2.0189
3	25.4647	121.2606	0.0095	2.0189
4	33.9530	161.6808	0.0126	2.6919
5	59.4177	282.9415	0.0221	4.7108
Mean Value ± SD	32.2553 ±14.6037	153.5968 ±69.5416	0.0120 ±0.0054	2.5573 ±1.1578

* International reference level of radon concentration = 100 Bq/m^3

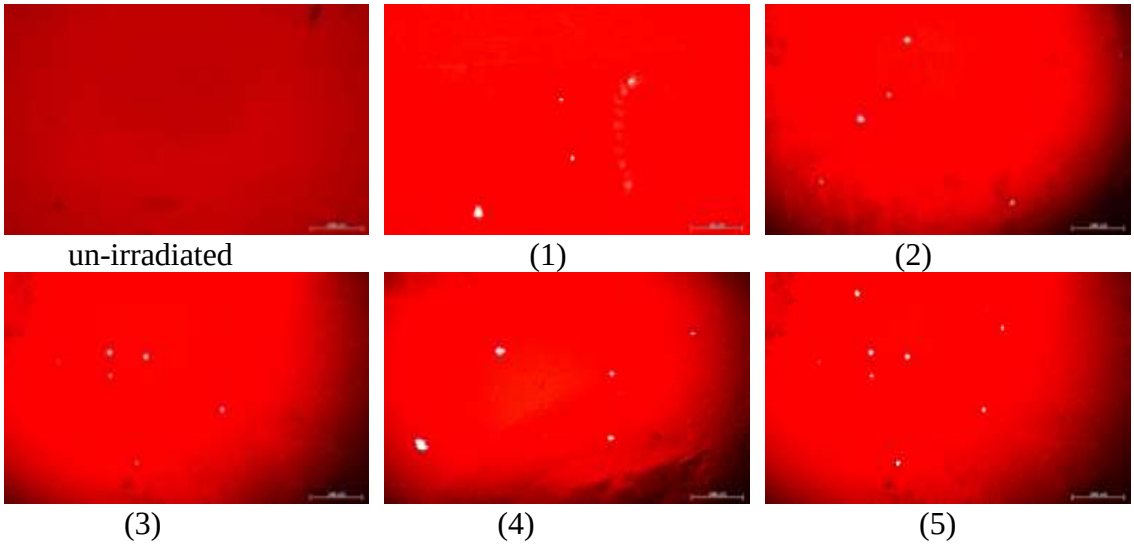

Figure 5 Photomicrographs (1 to 5) for the revelation of the alpha particle tracks in LR-115 detectors for crown brands cement

Table 5 Measurement of Track Density, Radon Activity, Radon Exhalation Rate, and Radon Concentration from Crown Cement

LR-115	Track density (tracks/cm^{2}d)	Radon activity (Bq/m^3)	Radon exhalation rate (Bq/m^{2}h)	Radon concentration (Bq/m^3)
1	50.9295	242.5213	0.0199	4.2524
2	63.6618	303.1516	0.0249	5.3155
3	63.6618	303.1516	0.0249	5.3155
4	76.3942	363.7819	0.0299	6.3786
5	89.1266	424.4122	0.0348	7.4417
Mean Value ± SD	68.7548 ±12.9845	327.4037 ±61.8310	0.0269 ±0.0051	5.7407 ±1.0842

* International reference level of radon concentration = 100 Bq/m^3

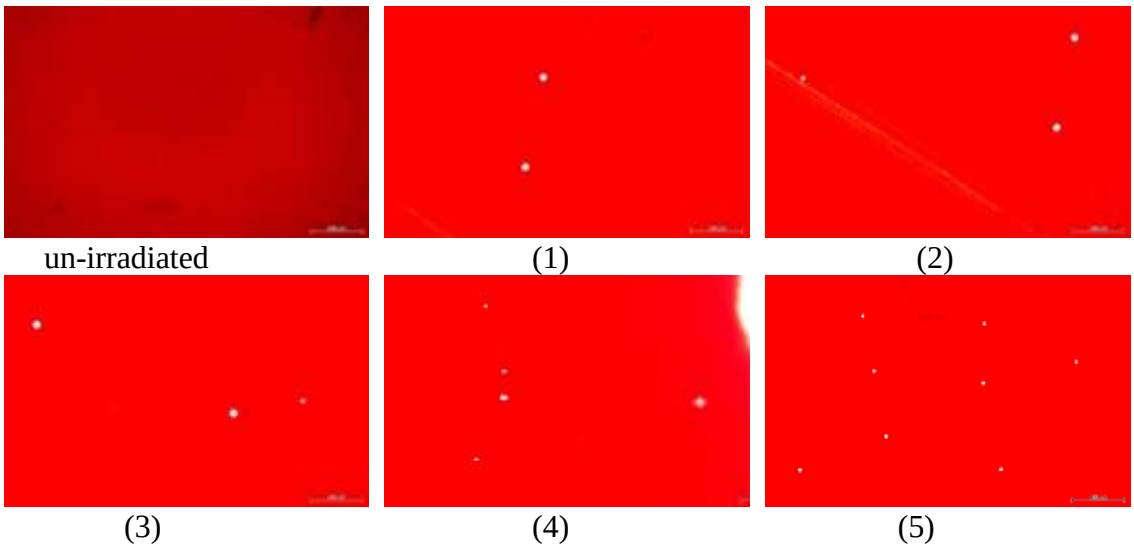

Figure 6 Photomicrographs (1 to 5) for the revelation of the alpha particle tracks in LR-115 detectors for tobacco sample

Table 6 Measurement of Track Density, Radon Activity, Radon Exhalation Rate and Radon Concentration from Tobacco Sample

LR-115	Track density (tracks/cm^{2}d)	Radon activity (Bq/m^3)	Radon exhalation rate (Bq/m^{2}h)	Radon concentration (Bq/m^3)
1	25.4647	121.2606	0.0100	2.1262
2	38.1971	181.8909	0.0149	3.1893
3	38.1971	181.8909	0.0149	3.1893
4	63.6618	303.1516	0.0249	5.3155
5	101.8589	485.0425	0.0398	8.5049
Mean Value ± SD	53.4759 ±27.1889	254.6473 ±129.4709	0.0209 ±0.0106	4.4650 ±2.2702

* International reference level of radon concentration = 100 Bq/m^3

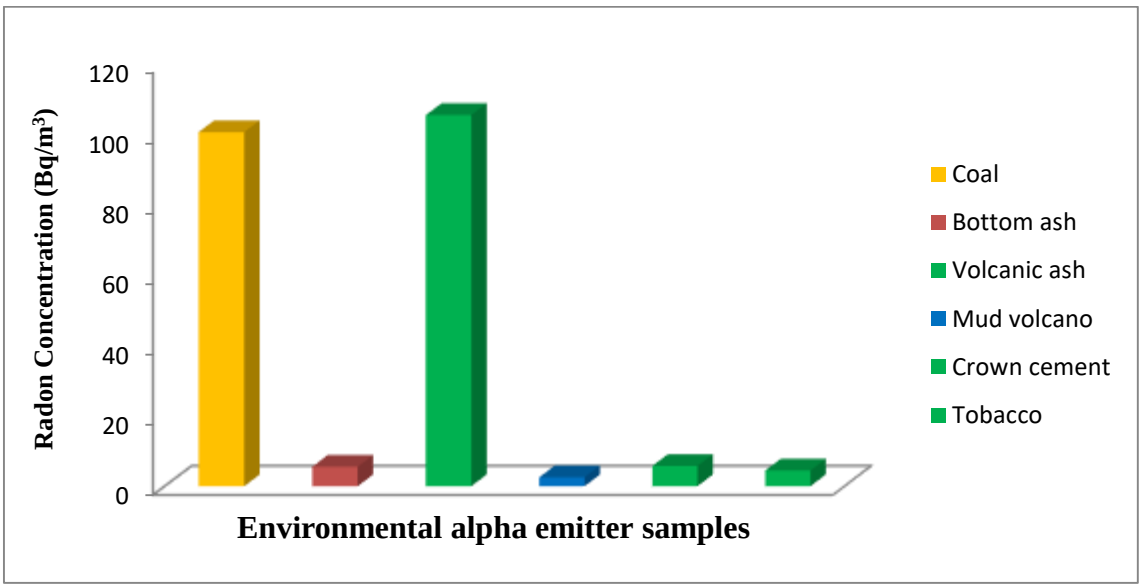

Figure 7 Average radon concentration of different environmental samples

From this figure, radon was found to be present in all these samples. Whether its concentration is low or high, it should be aware of the risk for people.

Conclusion

In this research work, most of the radon is trapped in coal and volcanic ash samples. Therefore, mine workers and people living around the volcano area should be concerned about their health due to radon exposure. The average radon concentrations of mud volcanoes lie below the intervention limit for people. The people living around Minbu are safe from health hazard from radon. Although the measured radon concentration values in the cement sample are below the recommended action level, cement usually contains radon. Therefore, the construction worker should be noticed the health risk from radon exposure. In addition, this risk seems to apply even at low radon concentrations, which is below the reference levels applied in several countries. Furthermore, active smokers have a significantly higher risk of lung cancer than nonsmokers.

Overall, radon has been discovered in environmental samples, and whether the concentration is low or high, it should be considered a risk to human health.

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