Radon Concentration in Different Depths of Gold Mine during the Hot and the Cold Season

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Abstract

Solid state nuclear track detectors (SSNTD), known as the passive cup method is widely used for radon measurements. In this work, it is determined that the radon concentration in soil samples from five different depths of gold mine is carried out by using the passive cup method. This cup is a cylindrical plastic can with a radius of 5.5 cm and a height of 12.3 cm. The soil samples are collected from five different depths of gold mine located in Chay Taw Yar village, Shwe Kyin Township, Bago Division. The soil sample from each depth is enclosed in respective plastic can with a piece of CR-39 detector (1cm× 1cm). The alpha tracks in detector due to radon and its progeny is measured by using an optical microscope. A comparison is made up for radon concentration and annual effective dose from soil samples in five different depths of gold mine. Annual effective dose in soil samples are lower than the recommended level 50 $mSvyr^{-1}$. Thus, the mine workers and people who stayed near the gold mine do not need to be aware of radon and its progeny for their health hazards.

Keywords: passive, radon, annual effective dose**,** SSNTD

Introduction

Radon-222 is a naturally occurring, radioactive gas, with a half-life of 3.82 days. Radon comes from the natural radioactive breakdown of uranium-238, which has a half-life of 4.41 billion years. Since radon is in the gaseous state, it can diffuse through the soil to the atmosphere. Most of the naturally occurring Radon-222 in the environment comes from only within a few meters of depth in the earth's crust. Radon is present in trace amount almost everywhere on the earth, being distributed in the soil, the ore, and ground water and in the atmosphere. Radon in the ground, ground-water, or building materials enters working and living spaces and disintegrates into its decay products. Solid state nuclear track detectors known as passive are widely used for radon measurements. Radon concentrations are determined by measuring the emitted alpha particles which cause damage in the detector surface. Radon is present in trace amount almost every on the earth and is distributed in the soils, the ores, the ground water and in the atmosphere. The average radon concentrations in houses are generally lower than the average radon concentrations in underground mines. Workers in these regions are exposed to radon in several occupations. Underground uranium miners are exposed to the highest levels of radon and its decay products. Other underground workers and certain mineral processing workers may also be exposed to significant levels. They need to be protected from the contamination of radiation. Tracking the radon concentration is fundamental for radiation protection strategies and mitigation. Exhalation of radon from ordinary rock and soils can cause significant radon concentrations in tunnels, power stations, caves, pubic baths and spas. Radon is a national environment health problem. Almost all risk from radon comes from breathing air with radon and its decay products. High concentration of radon gives the largest radiation exposure to human being and causes the

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Materials and Methods

Measurement Condition

Detector	- CR-39 allyl diglycol carbonate
Measurement Technique	- Can Technique (Five different depths of soils samples)
Irradiation Time	- 100 days
Etchant	- 6 N NaOH at 70°C, without stirring
Etching Time	- 12 hrs
Microscope	- Nikon – Eclipse 50i with Digital Camera and pc

Data Collection and Processing

For data collection and processing, the following step by step procedures are as follows:

I. Sample collection
II. Sample preparation
III. Detector etching process
IV. Track counting

I. Sample collection

All the soil samples were collected at five different depths from 5 ft to 25 ft in a gold mine which has located at Chay Taw Yar village, Shwe Kyin Township, Bago Division. The soil samples were collected in the hot season and the cold season.

II. Sample preparation

Each soil sample was crushed, filtered through a sieve of 150 µm and oven dried at 60℃ for 6 hrs. 0.2 kg of each sample was put in a respective plastic can (11cm diameter x 12.3cm height). A piece of CR-39 detector used to measure the radon was fixed on the bottom of the lid of each can so that the sensitive side of the detector faced the sample. The can was tightly closed and sealed (Fig 1) and were kept in cool and dry place. The can without sample was also prepared for using the same procedure as the above to measure the background. The exposure time of the detectors was 100 days.

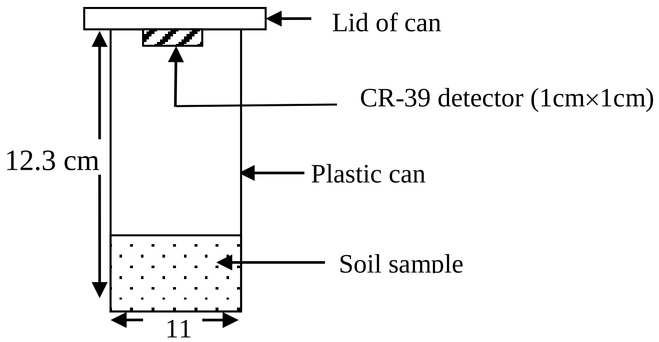

Figure 1. Experimental set up for the can technique

III. Detector etching process

After 100 days, all the detectors were removed from each plastic can and were etched in 6N NaOH solution. The solution was poured into a 100 mL glass beaker and heated on a stove with temperature controller. When the temperature reached at 70℃, all the alpha irradiated CR-39 detectors were put into the beaker simultaneously for 12 hrs in Figure 2. During etching, the temperature was kept at 70℃ with the accuracy of ±1℃. All the detectors were located at the same depth in the solution. After 12 hrs etching, the detectors were removed from the solution. Then, the detectors were washed under the running water until the surface of the detectors cleaned from etchant. The detectors were dried with filter paper.

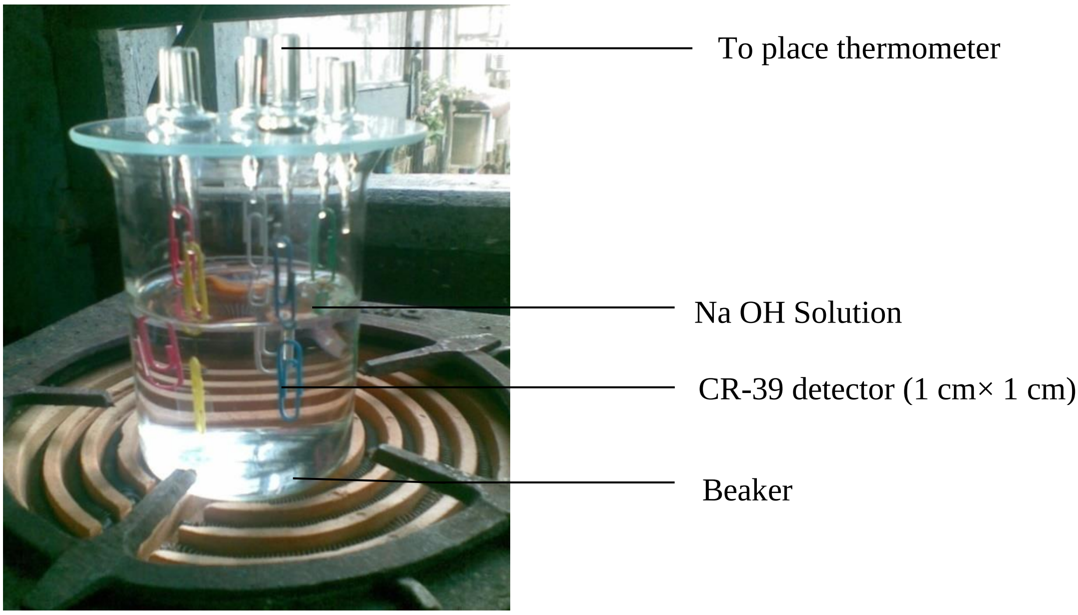

Figure 2. Experimental set up for etching process

IV. Track Counting

The number of tracks in CR-39 detector was viewed under the optical microscope with 40 X magnification (Figure 3). Only tracks that have been completely perforated from the sensitive layer have been counted. The number of tracks was recorded from 50 views by changing the vertical and horizontal position of the detector under the microscope. The average alpha track density was calculated by using the following equation.

$$\text{Average alpha track density} = \frac{\text{Average Net track/view}}{\text{microscope area} \times \text{Exposure time}} \quad (\text{track cm}^{-2}\ \text{day}^{-1})$$

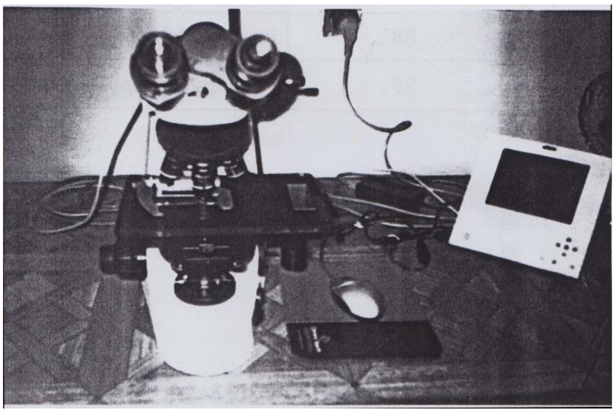

Figure 3. Microscope (Nikon-Eclipse 50i with digital camera and PC display)

Results and Discussion

The radon concentration and annual effective dose of soil samples collected at the depth of 5 ft to 25 ft are shown in Table (1) and Table (2). The photographs of the alpha tracks in CR-39 detector due to radon emitted from soil samples collected at the depth of 5 ft to 25 ft during the hot season and the cold season are shown in Figure 4-13. By using calibration factor $1Bqm^{-3}$ = 0.2 track cm^{-2} day^{-1}, radon concentration is evaluated from alpha track densities. The annual effective dose from radon in soil is calculated using conversion factor $1Bqm^{-3}$ = 0.0172 m Sv y^{-1}.During the hot season, the radon concentrations varied from 1393.95 ± 1179.95 Bqm^{-3} for G_1 (5 ft), 1567.45 ± 201.66 Bqm^{-3} for G_2 (10 ft), 1630.93 ± 209.71 Bqm^{-3} for G_3 (15 ft) and 1654.20 ± 212.71 Bqm^{-3} for G_4 (20 ft), 1750.00 ± 224.85 Bqm^{-3} for G_5 (25 ft). During the cold season, the radon concentrations varied from 914.45 ± 118.62 Bqm^{-3} for G_6 (5 ft), 939.75 ± 121.85 Bqm^{-3} for G_7 (10 ft), 961.45 ± 124.62 Bqm^{-3} for G_8 (15 ft) and 980.10 ± 126.98 Bqm^{-3} for G_9 (20 ft). 1060.25 ± 137.17 Bqm^{-3} for G_{10} (25 ft). The annual effective dose varied from 23.97 ± 3.09 $mSvy^{-1}$ for G_1 (5 ft), 26.96 ± 3.47 $mSvy^{-1}$for G_2 (10 ft), 28.05 ± 3.61 $mSvy^{-1}$ for G_3 (15 ft) and 28.45 ± 3.66 $mSvy^{-1}$ for G_4 (20 ft) and 30.10 ± 3.87 $mSvy^{-1}$ for G_4 (25 ft) during the hot season. The annual effective dose varied from 15.73 ± 2.04 $mSvy^{-1}$ for G_6 (5 ft), 16.16 ± 2.09 $mSvy^{-1}$for G_7 (10 ft), 16.54 ± 2.14 $mSvy^{-1}$ for G_8 (15 ft) and 16.864 ± 2.18 $mSvy^{-1}$ for G_9 (20 ft) and 18.24 ± 3.87 $mSvy^{-1}$ for G_{10} (25 ft) during the cold season. The radon concentration in soil samples at each depth during the hot season and the cold season are the same within the statistical error shown in Figure 14 and 15. A comparison of radon concentrations and annual effective dose in soil samples collected during the hot and the cold season are shown in Figure 16 and 17. It is found that radon emitted from soil samples collected at the hot season is higher than that in the cold season.

Table 1. Radon Concentration and annual effective dose of soil samples collected during the hot season

Sample	The depth of the mine (ft)	Radon concentration (Bqm^{-3})	Annual effective dose ($mSvy^{-1}$)
G_1	5	1393.95 ± 179.95	23.97 ± 3.09
G_2	10	1567.45 ± 201.66	26.96 ± 3.47
G_3	15	1630.70 ± 209.71	28.05 ± 3.61
G_4	20	1654.20 ± 212.71	28.45 ± 3.66
G_5	25	1750.00 ± 224.85	30.10 ± 3.87

Table 2. Radon Concentration and annual effective dose of soil samples collected during the cold season

Sample	The depth of the mine (ft)	Radon concentration (Bqm^{-3})	Annual effective dose ($mSvy^{-1}$)
G_6	5	914.45 ± 118.62	15.73 ± 2.04
G_7	10	939.75 ± 121.85	16.16 ± 2.09
G_8	15	961.45 ± 124.62	16.54 ± 2.14
G_9	20	980.10 ± 126.98	16.86 ± 2.18
G_{10}	25	1060.25 ± 137.17	18.24 ± 3.87

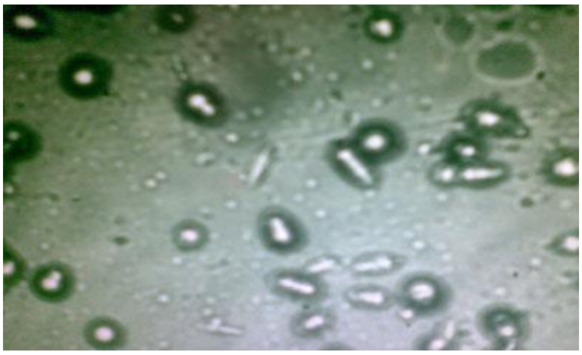

Figure 4. Alpha track due to radon in soil from the depth 5 ft during the hot season

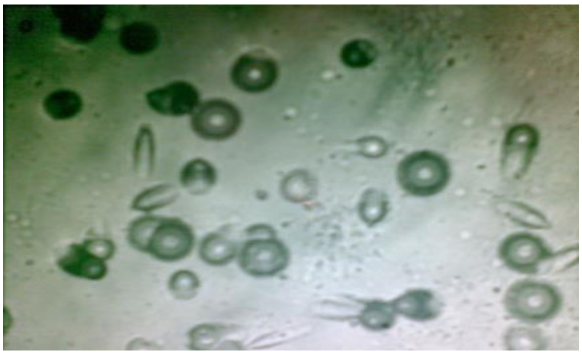

Figure 5. Alpha track due to radon in soil from the depth 10 ft during the hot season

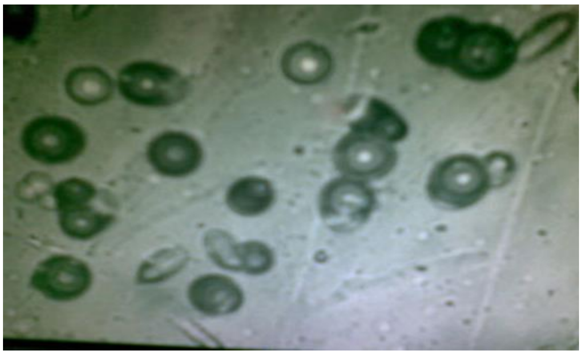

Figure 6. Alpha track due to radon in soil from the depth 15 ft during the hot season

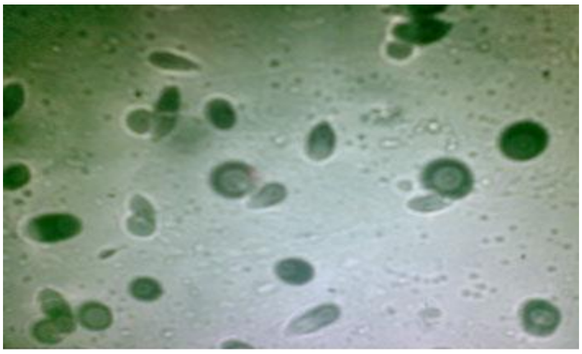

Figure 7. Alpha track due to radon in soil from the depth 20 ft during the hot season

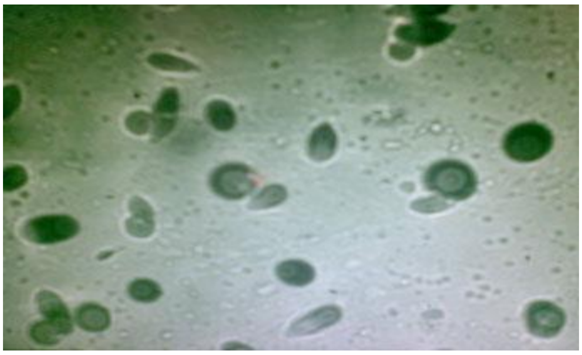

Figure 8. Alpha track due to radon in soil from the depth 25 ft during the hot season

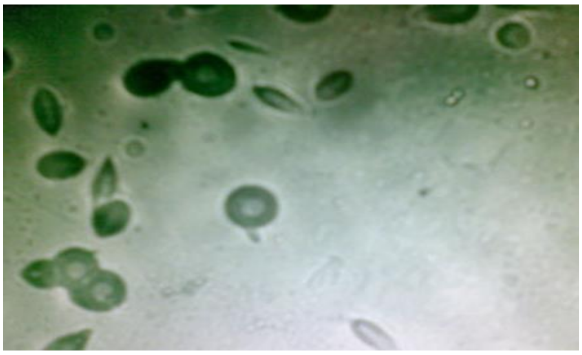

Figure 9. Alpha track due to radon in soil from the depth 5 ft during the cold season

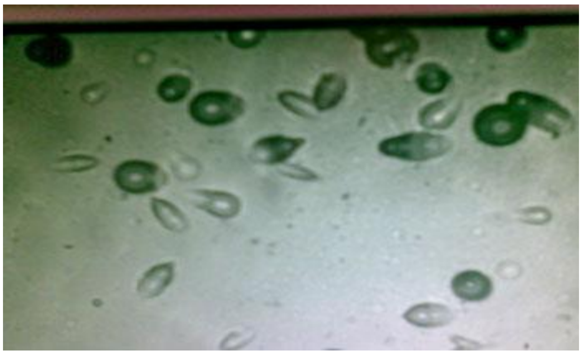

Figure 10. Alpha track due to radon in soil from the depth 10 ft during the cold season

Figure 11. Alpha track due to radon in soil from the depth 15 ft during the cold season

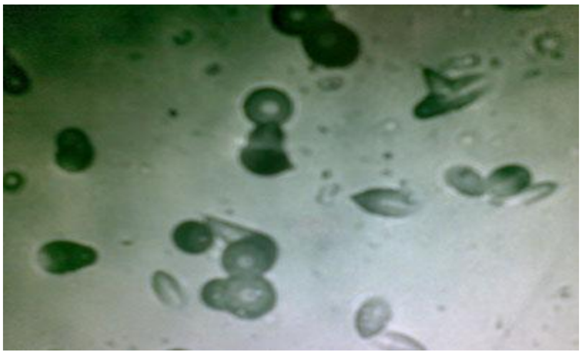

Figure 12. Alpha track due to radon in soil from the depth 20 ft during the cold season

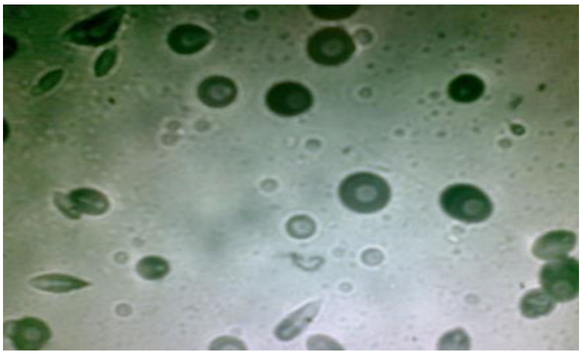

Figure 13. Alpha track due to radon in soil from the depth 25 ft during the cold season

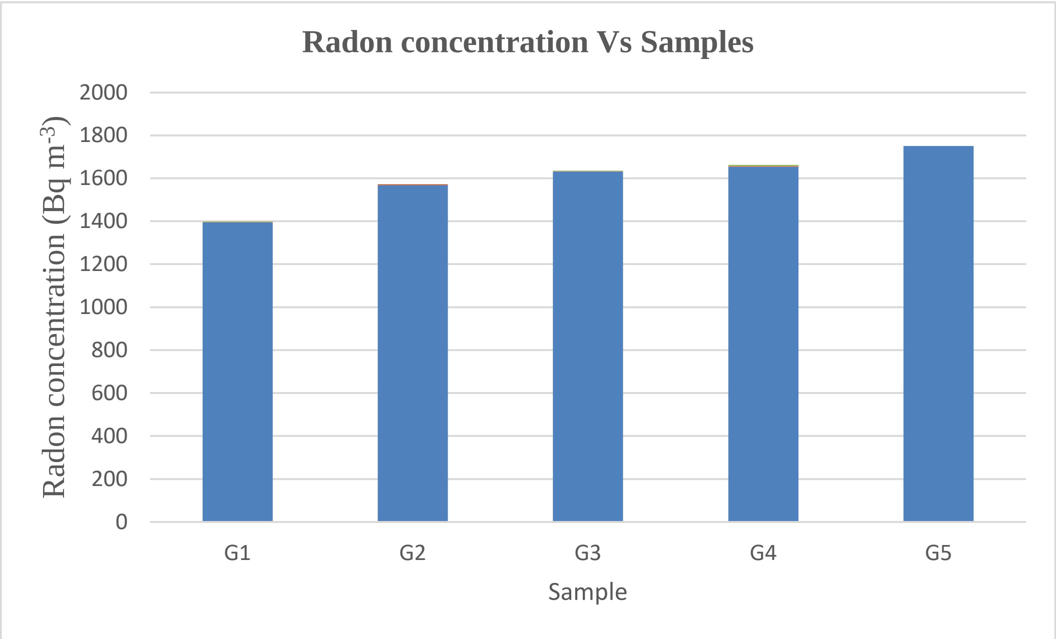

Figure 14. Radon concentration of soil samples collected the depth of 5 ft to 25 ft during the hot season

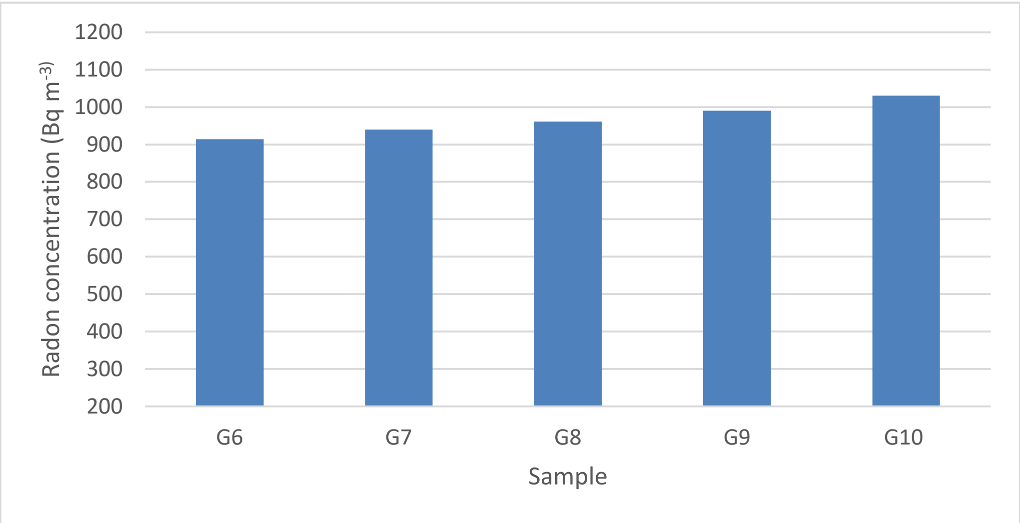

Figure 15. Radon concentration of soil samples collected the depth of 5 ft to 25 ft during the cold season

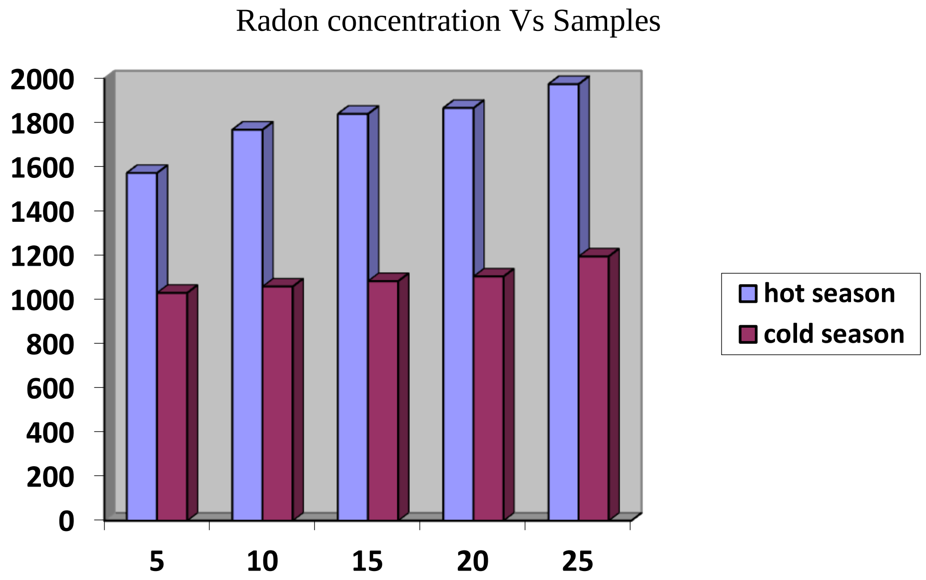

Figure 16. Comparison of radon concentration in soil with depth and season

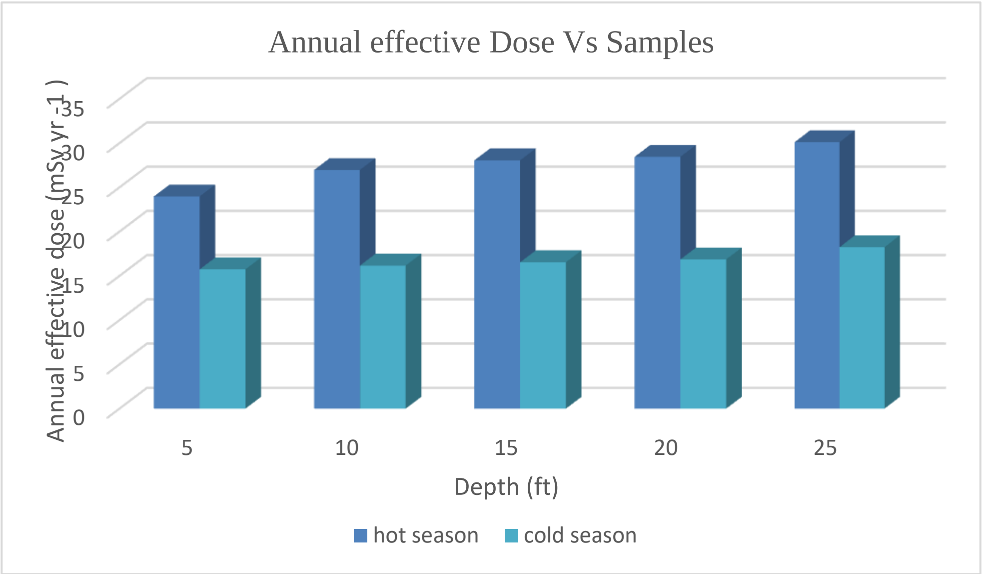

Figure 17. Comparison of annual effective dose in soil with depth and season

Conclusion

The radon concentrations in soil at the depth of 5 ft to 25 ft are the same within the statistical error. It is estimated that the same contents of uranium distributed in soil between the depth (5 ft to 25 ft) in gold mine. Radon concentrations in soil samples collected during the hot season is higher than that in the cold season. It is estimated that radon emission from the soil depends on the season. The dried soils roduce the large amount of radon which migrated to air and being recorded in CR -39 detector. Annual effective dose in soil samples collected during the hot and the cold season from the depth of 5 ft to 25 ft is lower than the recommended level 50 mSvyr^{-1}. The exposure to the population of high radon concentration and its daughters for a long period leads to pathological effects like the respiratory functional changes and the occurrence of lung cancer. The radon and its products generated from the soil in gold mine do not create radiation hazards to the environment. Thus, the mine workers and people who stayed near the gold mine do not need to be aware of radon and its products for their health hazards.

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