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The design of a radon chamber for the calibration of radon monitors at the Centre for Applied Radiation Science and Technology, Mafikeng, South Africa.

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Abstract

The aim of the study was to design a radon chamber for the calibration of radon monitors at the Centre for Applied Radiation Science and Technology. There are radon monitors in South Africa, however, there are no known calibration facilities in the country. Therefore, there is a need to design radon chambers. The radon chamber was designed with a Perspex material of thickness 6mm and of volume of 0.5 m^3. Tudor-shaft soil samples whose ^{226}Ra activities were known were used as radon sources. Experimentally; radon concentration, humidity, temperature and pressure were measured with the AlphaGUARDs. The computed radon ingrowth activities were used as a standard for calibrating the experimentally obtained radon activities from radon monitors (AlphaGUARDs). The calibration factors for the experiment were the differences between the radon monitors and the computed radon ingrowth activities at equilibrium determined as 223.97 Bq and 339.83 Bq.

Background

- Radon is the most contributing source of ionizing radiation in the atmosphere to human beings. It is a colorless, odorless gas that causes lung cancer due to greater levels of absorbed radiation dose.
- Organizations such as the International Commission on Radiological Protection recommends that the radon concentration level in dwellings should not exceed 300 Bq/m^3 (Fuente et al., 2018).
- There are many radon detectors made for determining radon concentration levels. However, not all radon detectors are well calibrated, some radon detectors need to be frequently monitored and calibrated in radon chambers to produce accurate and reliable radon concentration measurement (Azimi-Garakani, 1992).
- The most common method of calibrating the radon detectors is exposing them to a steady flow of radon concentration from a standard radon source in an airtight radon chamber, under controlled environmental parameters (Lopez-coto, 2007).

One of the facilities to calibrate radon detectors is in a designed radon chamber is the Centre of Applied Radiation Science and Technology. The aim of this study is to design a radon chamber for the calibration of radon monitors at the Centre for Applied Radiation Science and Technology

Methods

Uranium-238 (Origin of the Radon source)

- Undergoes several disintegrations to transform into radon which also undergoes several transformations to reach a stable lead-206 (Pb-206). It is seen in the figure that radon is obtained from radon which is in soils and rocks.
- A radon source from the radium rich soil was prepared. The activity radium was determined by the high purity germanium detector. From the radium activity concentration, radium activity was determined and estimated for 28 days by the Bateman equation given by:

$$A_d = \frac{\lambda_d}{\lambda_d - \lambda_P} * (A_P) * (e^{-\lambda_P t} - e^{-\lambda_d t})$$

Design

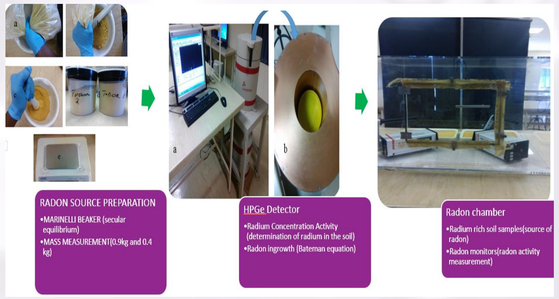

Fig (a): Sample preparation and radon chamber

- A radon chamber was designed with a Perspex glass of 6mm thickness and a volume of 0.5 m^3
- Radium rich samples were de-gased and inserted in the chamber to build up radon in the chamber for a period of days. The radon in the chamber is measured by radon monitors.

Calibration

- The radon ingrowth was calculated over a period of 28 days. The processed data for radon ingrowth was considered to be reference radon activity for this study.
- The experimental measurements for radon activity measured with AlphaGUARDs AG2261 and AG2260 over a period of 28 days were tabulated in a spreadsheet.
- The relationship between the reference radon activity and experimental radon measurements of radon was observed.
- To calibrate monitors the average difference between the reference radon activity and the respective AlphaGUARD measurement was calculated using equation given as:

$$C = Y - \Delta D$$

where C is the Calibrated monitor value, Y is the initial reading of the monitor and ΔD is the difference between reference radon activity and respective AlphaGUARD measurement, calculated as AlphaGUARD reading - reference radon activity.

Results

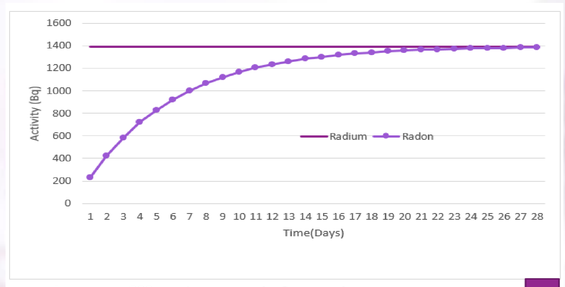

Figure 1: ^{222}Rn ingrowth from the 1394.67Bq radium source

Reference radon standard to be used as a calibration standard for the radon monitors.

Figure 1 is the model of the expected behavioural pattern of the radon activity in the chamber designed.

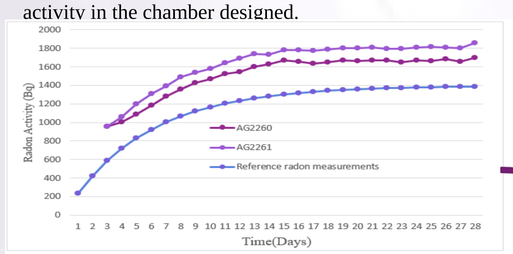

Figure 2 : ^{222}Rn reference values and radon monitor 1(AG2260) and 2(AG2261) radon activity measurement.

Non-calibrated monitors vs reference radon standard

It is seen that the radon monitors measurement values are in similar pattern with the reference radon standard values, but the radon monitors and the reference radon standard are not in alignment and therefore needs to be adjusted with adjustment values (C=Y-ΔD) for calibration.

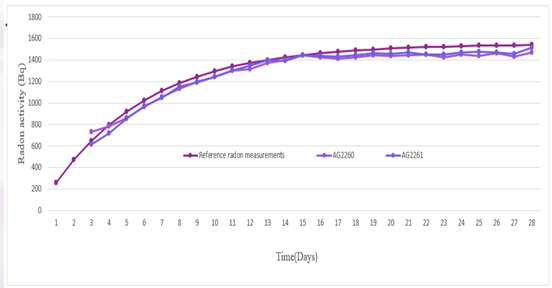

Figure 3: The reference ^{222}Rn activities comparison to experimental ^{222}Rn activities over 28 days.

The application of the calibration factors or adjustment values resulted in the alignment of radon monitors to the reference radon standard.

Figure 3 shows that the radon monitors are in alignment or proximity to the reference radon standard according to the calibration values used.

Conclusion

- A radon chamber was successfully designed to calibrate radon monitors.
- Uranium rich soil samples provided reference radon values to calibrate radon monitors
- The calibration factors for the study were determined as 223.97Bq(AG2260) and 339.83Bq (AG2261)
- The calibrated radon monitors can be used for environmental analysis of radon.
- In future improvement of the radon chamber will be the addition of tools to simulate varying environmental parameters(temperature, air pressure, relative humidity), and the behavioural comparison of radon monitors in accurate measurements under varying environmental conditions.

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