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Measurements of the equilibrium factor of radon in Aizawl, Mizoram, India

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ABSTRACT

Radon (^{222}Rn), being a radioactive gas has its parent nucleus originated from ^{238}U. From ^{238}U there is a series of 14 decays to form a stable nucleus of ^{206}Pb. The equilibrium factor in its simple term may be defined as ratio of the amount of progeny nucleus to that of a parent nucleus. Measurement of Equilibrium Factor (F-factor) for radon has been carried out in 24 dwellings in Aizawl City, which were specifically selected according to the site location and materials used for construction of the dwellings. In measuring F-factor for radon we have made use of absorber-mounted nuclear track detectors (LR-115) which selectively register the tracks due to alpha emissions from ^{214}Po which is the ^{222}Rn progeny species. This detector is termed as DRPS (direct radon progeny sensor). DRPS is used for estimating the Equilibrium Equivalent Radon Concentration (EERC). The concentration of ^{222}Rn is measured by using Solid State Nuclear Track Detector (LR-115) mounted in a BARC type twin cup dosimeter. The F-factor for radon is then calculated using the measured EERC and measured concentrations of radon. Our measurement shows the F-factor for radon in Aizawl city is 0.3, which is close to the worldwide value (0.4) for indoor conditions.

Key words: DRPS; EERC; equilibrium factor; radon; progeny, SSNTD.

INTRODUCTION

Radon is constantly decaying and giving rise to radon progenies. These are short-lived and decay until reaching a long-lived isotope of lead. The F-factor is used to describe the ratio between radon and its progeny. An F-factor of 1 means equal amounts of radon and its progeny. It is well-known that in radon problem, the progeny species and not the radon are primarily responsible for lung doses. Among the progenies, short lived nuclei viz. ^{214}Po is focused due to its high contribution in deposition and emission of alpha particles inside the lung.

In the past years, the equilibrium factors (F

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-factor) for radon was a globally assumed value and even the calculation of radon progenies were inferred using this value. Based on the available data, UNSCEAR specified a value of F = 0.4 for indoor environment.[1] These are understood as representative mean values in a global sense and might vary across countries and geographical locations. In the absence of better locally available estimates, these values have been employed for estimating progeny concentrations and lung doses in several programmes across the world.

With the advent of passive detection techniques using solid state nuclear track detectors (SSNTDs), direct progeny sensor (DPS) has been developed. Direct radon progeny sensor (DRPS) is a passive, deposition-based technique for estimating the time-integrated equilibrium equivalent radon concentration (EERC) in indoor environment. The values of equilibrium factor (F) of radon are bounded between 0 and 1. Its value in the indoor air depends mainly on the pseudo-ventilation rates, which is the sum of the air exchange rate and the wall removal rate in the dwelling. These quantities are expected to vary from house to house as well as from time to time in a given house. In a statistical sense, these may be treated as distributed quantities. In turn, this would result in the distribution in the equilibrium factors.

FORMULAE, MATERIALS AND METHODS

In measuring the equilibrium factor, one has to know the concentrations of the parent nuclei and progenies. The concentrations of progeny was determined through EERC by using DRPS. DRPS detector system is based on selectively registering alpha tracks originating from the deposited progeny activity on LR-115 type solid-state nuclear track detectors. The selection of alpha particle energies was achieved by mounting absorbers of suitable thicknesses on the LR-115 detectors. The radon progeny sensor has an absorber thickness of 37 μm to detect mainly the alpha particles emitted from ^{214}Po (7.69 MeV) formed from the eventual decay of ^{218}Po, ^{214}Pb and ^{214}Bi atoms deposited on it. This thickness mainly ensures that lower energy alpha emissions (from the gases and other airborne alpha emitters) do not pass through the absorber.[2] Since the system is intended for use in the deposition mode, it is necessary to avoid uncontrolled static charges from affecting the deposition rates and hence aluminized side of the mylar was chosen to act as the deposition surface.[3]

The indoor measurement of parent radon concentrations was carried out also using LR-115 detector film. These films were exposed for a minimum of 90 days using Twin cup dosimeter, which was hanged overhead on the ceiling at the height of minimum 1.5 m from the floor and at least 10 cm away from any surface. Twin cup dosimeter was of BARC Type and was a cylindrical plastic chamber divided into two equal compartments.[4] Films were inserted at these compartments by which tracks were recorded. In one compartment, pin hole cap was used to block the entry of nuclei other than radon. Filter paper was used to cover the entry point of the compartment blocking the entry of the progeny.[5] Dosimeters and DRPS were together exposed adjacent to each other for the same duration.

The exposed films were then etched using 2.5N NaOH solution at 60°C for 90 mins for clear visibility of tracks for counting. The tracks recorded in this SSNTD films were then counted using a spark counter. The track densities were used to calculate the radon and progenies concentrations and hence these were related to find the equilibrium factor of radon.

Important Formulae used in calculation of F-factor for radon were:

(1) *For calculating radon concentration from the track density of pinhole compartment of the dosimeter.*

$$C_R(Bq/m^3) = \frac{T_P}{Calibration\ \ factor \times Exposure\ period\ (days)}$$

where C_R is the radon concentration and T_P is the tract density of films in pin hole compartment. Calibration factor used = 0.023 for radon in pinhole.

(2) *Equivalent Equilibrium Radon Concentration is calculated as*

$$EERC\ (Bq/m^3) = \frac{T_{DRPS}}{Calibration\ \ factor \times Exposure\ period\ (days)}$$

where T_{DRPS} is the track density obtained by counting tracks in the etched film of the DRPS. Calibration factor used[6] = 0.09

(3) *Equilibrium Factor for Radon is calculated as*

$$F_R = \frac{EERC\ (Bq/m^3)}{C_R\ (Bq/m^3)}$$

where C_R is the concentration of radon calculated using track density from Pin hole compartment and *EERC* is the Equivalent Equilibrium Radon Concentration.

RESULTS

Figure 1 shows the average concentrations of radon for two seasons in each dwelling within Aizawl City in which dosimeters and DRPS were deployed together side by side. 24 dwellings were selected at different localities. The radon concentrations vary from 4.03-40.44 Bq/m^3 with geometric mean of 11.35 Bq/m^3.

Figure 2 is the average EERC values which were obtained from the DRPS collected in two seasons. The EERC values vary from 22.37-80.77 Bq/m^3 with a geometric mean of 41.39 Bq/m^3.

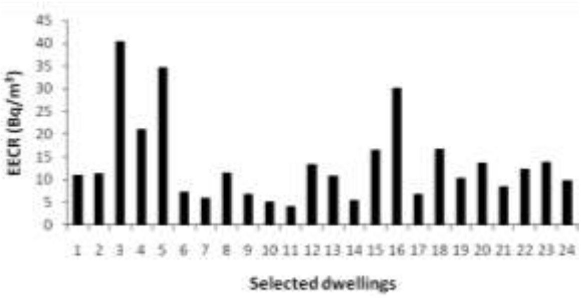

Figure 2. Average EERC in Aizawl City for rainy season 2008 and summer season 2009.

Figure 3 shows the equilibrium factors which were obtained by calculating the values obtained from radon concentration and EERC values in each dwelling. The equilibrium factors for each of the dwellings were found to be ranging from 0.10-0.86 and the average value of equilibrium factor is 0.32.

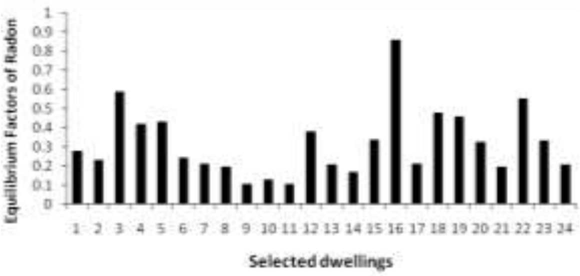

Figure 3. Equilibrium factors of radon (FR) in Aizawl City.

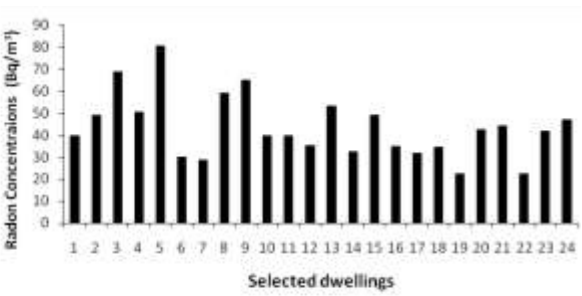

Figure 1. Average concentrations of radon in Aizawl City for rainy season 2008 and summer season 2009.

DISCUSSION AND CONCLUSION

From Figures1 & 2, it was observed that

the EERC value is always lower than that of the parent nuclei concentration. Hence the F-factor for radon will never be 1 or more than 1.

As any other part of the state of Mizoram, the climate of Aizawl is moderate throughout the year. The temperature varies between 20° C-30°C during summer and 11°C-21°C during winter. As a result, the ventilation rate is always high and does not vary much during winter and summer. This can be attributed to the range of F-factor found within Aizawl City.

The variation of radon concentration in building type materials is reported elsewhere.[7] It is worth noting that a complete re-inforced concrete building has the highest concentration of radon in a year. However, due to mild climatic condition throughout a year, seasonal variation of radon concentration do not vary much and the concentration of radon inside the dwellings is found to be much below the action level of WHO prescription throughout a year. As a result the progeny concentration is also found to be very low.

It is interesting to conclude that the globally assumed value of F-factor and our experimentally obtained value are also in good agreement.

REFERENCES

1. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (1993). Nations. Sources and Effects of Ionizing Radiation. Report to the General Assembly, with scientific annexes. United Nation Sales Publication E.94.IX.2. United Nations, New York.
2. Mishra R, Mayya YS & Kushwaha HS (2009). Measurement of 220Rn/222Rn progeny deposition velocities on surfaces and their comparison with theoretical models. *Aerosol Sci,* 40, 1-15.
3. Mishra R (2008). Deposition velocity monitors: Technique for direct progeny measurement. *Proceedings of Radon – 2008, 25-28, DAE – BRNS Theme Meeting*, March 11-13, 2008.
4. Mayya YS, Eappen KP & Nambi KSV (1998). Methodology for mixed field inhalation dosimetry in monazite areas using a twin cup dosimeter with three track detectors. *Radiat Prot Dosim,* 77, 177-184.
5. Eappen KP (2005). *Development of a Passive Dosimeter for the Estimation of Inhalation Dose due to Radon and Thoron.* PhD Thesis, University of Mumbai.
6. Mishra R & Mayya YS (2008). Study of a deposition-based direct thoron progeny sensor (DTPS) technique for estimating equilibrium equivalent thoron concentration (EETC) in indoor environment. *Rad Meas,* 43, 1408-1416.
7. Rohmingliana PC, Vanchhawng L, Thapa RK, Sahoo BK, Singh OP, Zoliana B & Mayya YS (2009). Measurement of indoor radon and thoron concentrations in correlation to geographical location and construction types of buildings in Mizoram (with special reference to Aizawl, Champhai and Kolasib districts). *Proceedings of the Conference of Physics Academy of North East (PANE)*, Tripura University, 3-4 April 2009.

