



Estimation of seasonal variation in Radon, thoron and their progeny levels in some dwellings

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Abstract: Radon and its progeny are the major contributors in the radiation dose received by general population of the world. Keeping this in mind the environmental radon, thoron and their progeny measurements have been carried out in some dwellings. The radon thoron twin dosimeter cups designed by environmental assessment division of Bhabha Atomic Research Centre (BARC) Mumbai, India have been used for this study. Three pieces of LR-115 type II solid-state nuclear track detectors are fixed in the dosimeters. The dosimeters were suspended in the dwellings for three months during a season. The specially designed twin cup dosimeter used in present study consists of two chambers of cylindrical geometry separated by a wall in the middle with each having a length of 4.5 cm and radius of 3.1 cm. This dosimeter employs three SSNTDs out of which two detectors were placed in each chamber and a third one was placed on the outer surface of the dosimeter. One chamber is fitted with glass fiber filter so that radon and thoron both can diffuse into the chamber while in other chamber, a semi permeable membrane made of latex or cellulose nitrate, having a thickness of 25 μm is used. The membrane mode measures the radon concentration alone as it can diffuse through the membrane but suppresses the thoron. The twin cup dosimeter also has a provision for bare mode enabling it to register tracks due to radon, thoron and their progeny in total. To observe the effect of environmental conditions the measurements have been carried out during different seasons of the year. The radon-thoron progeny levels and annual dose received by the inhabitants in the dwellings under study have also been calculated. The levels are found to be higher during winter season as compare to other seasons of the year.

Keywords: Radon, Annual effective dose, LR-115 type II, Radioactivity.

I. Introduction

About 90% of radiation exposure to human arises from natural sources such as cosmic radiation, terrestrial radiation and exposure to radon, thoron and their progeny etc. Various studies have been made on exposure to many of the forms of natural radiation [1]. These studies have shown that more than 50% of annual exposure to humans is from radon and its daughter products. Also it is a well-known that the radiations from the naturally occurring radioactive material originating from the earth's crust are the major contributors to the total background exposures to the human populations which includes external gamma radiations exposures and inhalation exposures, the latter being due to radon, thoron and their progeny [2]. The major inhalation does is contributed by the radon progeny nuclides. All building materials shows various amounts of radioactivity as most of these are derived from rocks and soil which contains uranium-238 and thorium-232 series and the radioactive isotope of potassium-40. All these can be sources of both internal and external radiation exposure. Internal exposure takes place through the inhalation of radon gas and external exposure occurs through the emission of penetrating gamma radiations [3].

The problem of radon is an important global problem of radiation hygiene particularly in homes. Radon is a radioactive gas of natural origin, is produced by the disintegration of uranium. In general, there are three main mechanisms of radon entry into a building⁴; convection via utility access points, cracks and openings, diffusion from soil via the pore space of the building material and emanation from building materials. Indoor high radon concentration is usually due to penetration of radon from the surrounding soil. Radon levels in a home can fluctuate from day to day, depending upon the level of radon in the soil, type of soil, airflow through the soil, openings to building and ventilation. Outdoor radon concentrations are low but in case of indoors, this gas may accumulate in high concentrations emitted from the soil and from building materials when the room is not properly ventilated. Radon emanation from the soil depends upon its radium content but also upon mineralogy, porosity, grain size, moisture content and permeability of host rock and soil [4-5].

Radon gas decays overtime into radioactive particles that can be inhaled and trapped in the lungs as these daughter products remain air borne for a long time. When radon decays it forms its progeny ^{218}Po and ^{214}Po , which are electrically charged and can attach themselves to tiny dust particles, water vapours, oxygen, trace gases in indoor air and other solid surfaces. These daughter products remain air-borne for a long time and can easily be inhaled into the lung and can adhere to the epithelial lining of the lung, thereby irradiating the tissue.

Bronchial stem cells and secretion cells in airways are considered to be the main target cells for the induction of lung cancer resulting from radon exposure. The exposure of population to high concentrations of radon and its daughters for a long period lead to pathological effects like the respiratory functional changes and the occurrence of lung cancer [6]. Based upon current knowledge about health effects of inhaled radon and its progeny, ICRP has made recommendations for the control of this exposure in dwellings and work place [7]. Keeping this in mind the environmental monitoring of radon, thoron and their progeny in some dwellings of eastern Haryana has been carried out using radon-thoron dosimeter cups. The climate of Haryana is of pronounced character, very hot in summer and very cold in winter. The locations under study are the parts of the districts of Panipat and Sonapat.

II. EXPERIMENTAL TECHNIQUES

For the measurement of concentration of radon, radon and thoron both, and total sum of radon, thoron and their progeny in the dwellings, the radon-thoron mixed field dosimeter popularly known as, 'Twin Chamber Radon-Thoron Dosimeter', developed by Bhabha Atomic Research Centre (BARC) has been employed. The specially designed twin cup dosimeter used in present study consists of two chambers of cylindrical geometry separated by a wall in the middle with each having a length of 4.5 cm and radius of 3.1 cm. This dosimeter employs three SSNTDs out of which two detectors were placed in each chamber and a third one was placed on the outer surface of the dosimeter. One chamber is fitted with glass fiber filter so that radon and thoron both can diffuse into the chamber while in other chamber, a semi permeable membrane made of latex or cellulose nitrate, having a thickness of 25 μm is used. The membrane mode measures the radon concentration alone as it can diffuse through the membrane but suppresses the thoron. The twin cup dosimeter also has a provision for bare mode enabling it to register tracks due to radon, thoron and their progeny in total. Therefore, using this dosimeter we can measure the individual concentration of radon, thoron, and their progeny at the same time (Fig.-1).

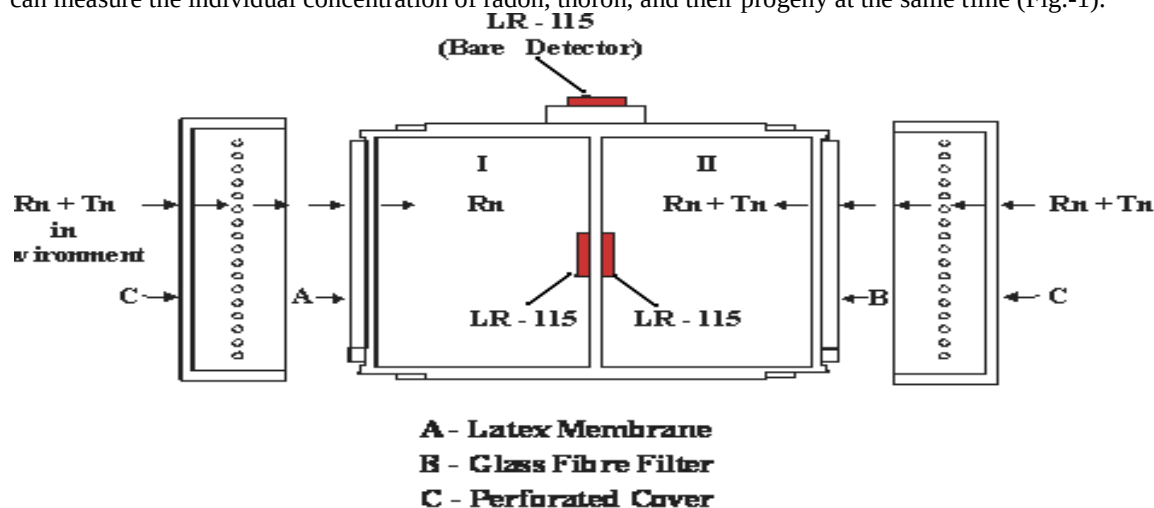


Fig.-1 Twin Chamber Radon-thoron dosimeter cups used in the present study

The dosimeters were suspended at a height a height of about 1.5 m in order to evaluate the annual average indoor radon levels. At the end of the exposure time, the detectors were removed and subjected to a chemical etching process in 2.5N NaOH solution at 60°C for 90 minutes. The detectors were washed and dried and the tracks produced by the alpha particles were observed and counted under an optical Olympus microscope at 600X. A large number of graticular fields of the detectors were scanned to reduce statistical errors.

The measured track density (Track/cm²/day) was converted into radon and thoron concentration using calibration factors [2]. Radon and thoron progeny levels in mWL has also been calculated using indoor equilibrium factor as 0.4 for radon and 0.1 for thoron from UNSCEAR [3]. Annual dose received by the inhabitants in the dwellings under study in mSv was estimated using the relation [4-5]:

$$D = [(0.17 + 9 F_R) C_R + (0.11 + 32 F_T) C_T] \times 7000 \times 10^{-6}$$

Where, F_R = equilibrium factor for radon; C_R = radon concentration; F_T = equilibrium factor for thoron and C_T = thoron concentration.

III. RESULTS AND DISCUSSION

In Rainy season in Panipat, the concentration of radon has been found to vary from 46 to 61 Bqm⁻³ with an average of 52 $\pm$ 2 Bqm⁻³. Annual effective dose received during Rainy season varied from 1.5 to 1.8 mSv with an average of 1.7 $\pm$ 0.1 mSv. In Winter season in Panipat, the concentration of radon has been found to vary from 53 to 76 Bqm⁻³ with an average of 64 $\pm$ 3 Bqm⁻³. Annual effective dose received during winter season varied from 1.7 to 2.4 mSv with an average of 2.1 $\pm$ 0.3 mSv. In Summer season in Panipat, the concentration of radon and

thoron has been found to vary from 38 to 91 Bqm⁻³ with an average of 52 ± 4 Bqm⁻³. Annual effective dose received during summer season varied from 1.3 to 2.7 mSv with an average of 1.7 ± 0.1 mSv. In Rainy season in Sonipat, the concentration of radon has been found to vary from 30 to 46 Bqm⁻³ with an average of 37 ± 2 Bqm⁻³. Annual effective dose received during Rainy season varied from 1.2 to 1.5 mSv with an average of 1.4 ± 0.2 mSv. In winter season in Sonipat, the concentration of radon has been found to vary from 38 to 61 Bqm⁻³ with an average of 51 ± 3 Bqm⁻³. Annual effective dose received during winter season varied from 1.3 to 1.9 mSv with an average of 1.7 ± 0.1 mSv. In summer season in Sonipat, the concentration of radon has been found to vary from 23 to 53 Bqm⁻³ with an average of 41 ± 3 Bqm⁻³. Annual effective dose received during summer season varied from 1.3 to 1.9 mSv with an average of 1.7 ± 0.1 mSv. There is a variation in the concentration of radon, thoron, and their progeny from one location to another in the Study area during the same season which may be due to the composition of the soil beneath the dwellings and the type of construction material used. The levels are found to be higher during winter season as compare to other seasons of the year which may be due to poor ventilation conditions in winter.

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Location (Samples)	Radon conc. (Bqm ⁻³)	Thoron conc. (Bqm ⁻³)	Radon progeny levels (mWL)	Thoron progeny levels(mWL)	Annual Effective dose(mSv)
Panipat (9) (Rainy season)	52±2	12±1	5.6±0.2	0.3±0.1	1.7±0.1
Panipat (9) (Winter season)	64±3	15±1	6.9±0.3	0.4±0.1	2.1±0.3
Panipat (12) (Summer season)	52±4	10±1	5.0±0.3	0.3±0.1	1.7±0.1
Location (Samples)	Radon conc. (Bqm ⁻³)	Thoron conc. (Bqm ⁻³)	Radon progeny levels (mWL)	Thoron progeny levels(mWL)	Annual Effective dose(mSv)
Sonepat (9) (Rainy season)	37±2	16±1	3.8±0.2	0.5±0.1	1.4±0.2
Sonepat (9) (Winter season)	51±3	13±1	5.6±0.3	0.4±0.1	1.7±0.1
Sonepat (12) (Summer season)	41±3	15±3	4.5±0.3	0.4±0.1	1.6±0.1

AM (arithmetic mean); * SE (statistical error)