Estimation of Indoor Radon, Thoron and Dose Rates in Some Dwellings of Punjab

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Abstract

Radon (^{222}Rn) and its decay products are the major source of the inhalation dose received by humans due to natural radioactivity. The present work deals with assessment of indoor radon and thoron values in some of the dwellings of Punjab. This study also includes annual effective dose rates due to radon and thoron respectively. Equivalent dose rate to lungs is also summarized in this paper. The indoor radon concentration varies from 39.2 to 153.6 Bq/m^3 with average value of 77.7 Bq/m^3. The thoron concentration varies from 64.4 to 106.7 Bq/m^3 with average value of 83.6 Bq/m^3. The average values of annual effective dose due to radon and thoron are 2.24 mSv and 2.10 mSv respectively. Equivalent dose rate to lungs varies from 31.4 to 122.87 nSv with average value of 62.15 nSv. The mean value of the annual effective dose rates and equivalent dose rate to lungs from ^{222}Rn and ^{220}Rn in the study area is less than the world's average mean inhalation dose for ^{222}Rn and ^{220}Rn.

Keywords: *Pin-hole dosimeter, Indoor 222Rn and 222Rn, Annual effective dose, Lungs, Tracheo-bronchial, Pulmonary + pulmonary lymph*

1. Introduction

Uranium and thorium present in earth crust leads to radioactive decay of radium isotopes, which on decay produces radon and thoron radioactive gaseous. In 1901, Elster and Gietel revealed that radon is ubiquitous constituent of atmospheric air [1]. After uranium, thorium, radium and polonium, radon was discovered as 5th radioactive element on, which is highly radiotoxic and carcinogen by inhalation [2]. Radon is colorless, odorless, monatomic, tasteless, single radioactive gas which is chemically inert and non-flammable. Unlike other members of noble gas family, radon has no stable isotopes. Out of all known isotopes, these three isotopes are decay product of naturally occurring radioactive series: (i) Radon-222 (^{222}Rn): Radon having half life ($t_{1/2}$) of 3.8235 days is the most stable isotope of Radon. ^{222}Rn is decay product of radium (^{226}Ra) following ^{238}U decay series. Radon emits alpha radiation of energy 5.48 MeV. (ii) Radon-220: ^{220}Rn having half life ($t_{1/2}$) 55.6 sec also known as 'Thoron' is a natural decay product of Thorium-232 decay series. It emits alpha radiation of energy 6.28 MeV. (iii) Radon-219: ^{219}Rn having half life of 3.96 s is also known as actinion. It is member of ^{235}U series. Because of low abundance of ^{235}U, ^{219}Rn occur only at minute levels in nature [3].

However, these gases further decay and their decay products (^{218}Po and ^{214}Po) are harmful as well. Concern about the natural radioactivity present in the form of radon and its decay products have become fundamental as it contribute largest fraction of health risk factor among human population. On inhalation, these decay products deposited in different parts of lungs and can cause biological tissue damage because they emit short range energetic alpha particles. Because of these energetic alpha particles main part of human respiratory track i.e. Trachea-bronchial and pulmonary region could be at risk [4]. Scientist and national academy of scientist estimated the exposure to elevated level of radon gas may cause 15000-22000 lung cancer death a year, making radon the leading cause of lung cancer second only to cigarette smoking [5]. The worldwide annual effective dose received by the population from all natural and artificial sources is 2.8 mSv, about which 85 % of the dose (2.4

mSv) comes from only natural background radiations [6]. Thus in order to get data on indoor radon thoron and their corresponding annual effective doses in some dwellings of Punjab, this survey was conducted.

2. Methodology

The measurement of indoor radon level in dwellings will be done with Solid State Nuclear Track Detectors (SSNTDs), which is one of the most widely technique used for indoor radon survey. LR-115, type II plastic strippable thin cellulose nitrate films [7] are used as solid state nuclear track detectors because of their high durability and stability. These detectors are used in pin hole dosimeter (Figure 1) for the detection of alpha particles emitted by radon and its decay products. Alpha particles originated from radon and decay products forms tracks in the detector. After the exposure of three months, the detectors will be retrieved and subjected to chemical etching in 2.5N NaOH solution at a temperature of 60 °C so that tracks formed will be enlarged. The tracks then will be counted using spark counter or optical microscope.

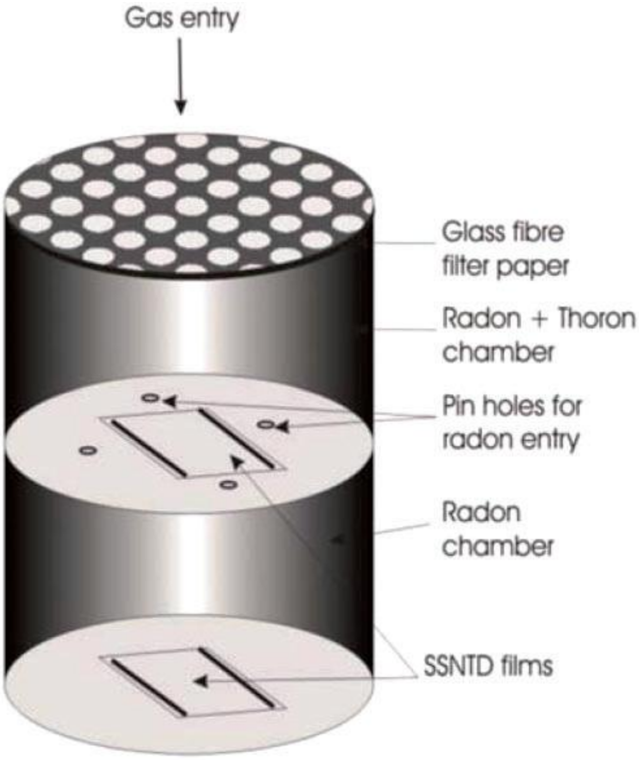

Figure 1. Pin Hole Dosimeter

2.1. Measurement of ^{222}Rn and ^{220}Rn and corresponding dose rates

The concentration of ^{222}Rn and ^{220}Rn in the indoor environment can be calculated using the relations [8]:

$$C_R = T_1/d.K_R \quad (1)$$

$$C_T = (T_2 - T_1)/d.K \quad (2)$$

where C_R and C_T are radon and thoron concentration, T_1 is the track density observed in 'radon' compartment. K_R is the calibration factor of radon in 'radon' compartment (0.0170±0.002 Tr.cm^{-2} /Bq.d.m^{-3}); d is the number of days of exposure; T_2 is the track density observed in the 'radon+thoron' compartment and K_T (0.010±0.001Tr. Cm^{-2}/Bq.d.m^{-3}) are the calibration factors of radon and thoron in 'radon + thoron' compartment.

The annual effective dose due to radon and thoron can also be calculated using the following relations [9]:

- Annual effective dose due to radon

$C_R(Bq/m^3)*0.46*7000\ h*9nSv\ (Bq.h.m^{-3})^{-1}$ (3)

- Annual effective dose due to thoron

$C_T(Bq/m^3)*0.09*7000\ h*40nSv\ (Bq.h.m^{-3})^{-1}$ (4)

According to united nation scientific committee on effects of atomic radiation (UNSCEAR), Annual equivalent dose to lungs can be calculated by taking into account the radon concentration of air present inside the lungs by using eq.(5), [10]

Equivalent Dose, $H = 8*10^{-10}*C_R$ (5)

3. Results and Discussion

The values of indoor radon and thoron concentration and their corresponding annual effective doses are summarized in Table 1 along with ventilation conditions of dwellings. The indoor radon concentration varies from 39.2 to 153.6 Bq/m^3 with average value of 77.7 Bq/m^3. The thoron concentration varies from 64.4 to 106.7 Bq/m^3 with average value of 83.6 Bq/m^3. The average values of annual effective dose due to radon and thoron are 2.24 mSv and 2.10 mSv respectively. Figure 2 shows distribution of annual effective dose rates due to radon and thoron in different dwellings under study area

Table 1. Indoor Radon, Thoron Concentration and Annual Effective Dose Rates Due to Radon and Thoron

S. No.	Location	Ventilation Rate	Radon concentration (Bq/m^3)	Thoron concentration (Bq/m^3)	AED Due to Radon (mSv)	AED Due to Thoron (mSv)	H (nSv)
1.	Location 1	Poor	153.6	83.3	4.45	2.10	122.9
2.	Location 2	Average	76.5	78.9	2.21	1.98	61.2
3.	Location 3	Average	95.8	67.2	2.77	1.69	76.6
4.	Location 4	Average	110.5	106.7	3.20	2.68	88.4
5.	Location 5	Good	39.2	73.3	1.13	1.84	31.4
6.	Location 6	Average	52.9	64.4	1.53	1.62	42.4
7.	Location 7	Average	60.8	95.6	1.76	2.40	48.6
8.	Location 8	Average	64.1	97.8	1.85	2.46	51.2
9.	Location 9	Good	59.5	70	1.72	1.76	47.6
10.	Location 10	Average	64.1	98.9	1.85	2.49	51.2

4. Conclusion

- In some dwellings the measured values of thoron concentration are higher than the radon concentration but do not exceed the recommended action level [11].

- The higher values of thoron may be due to the higher amount of Thorium (232Th) present as compared to the Radium (226Ra).
- The mean value of the annual effective dose rates from ^{222}Rn and ^{220}Rn in the study area is less than the world's average annual dose rates for ^{222}Rn and ^{220}Rn [12]. Therefore, the health hazards related to radiation are expected to be negligible in the studied area.

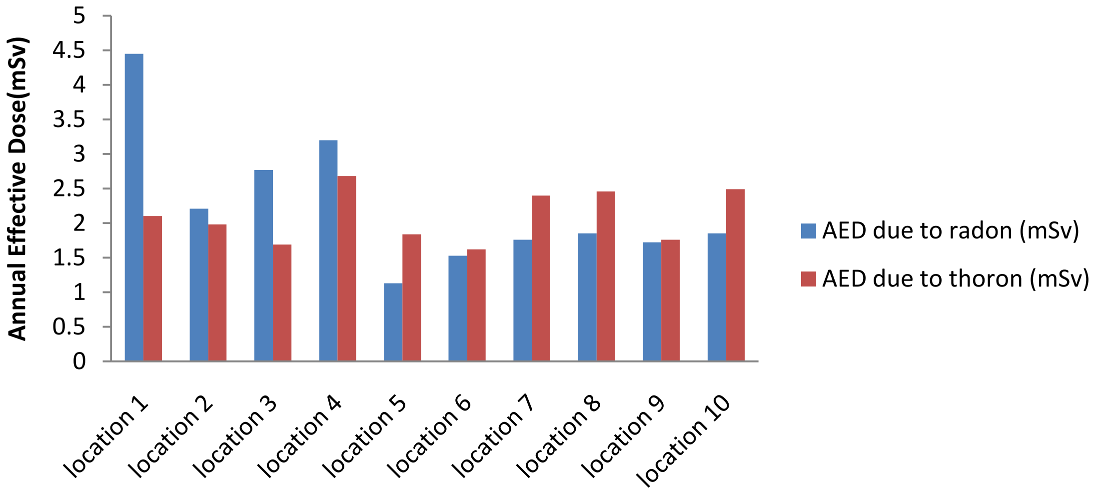

Figure 2. Distribution of Annual Effective Dose Rates Due to Radon and Thoron in Different Dwellings of Study Area

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