Variation of Radon and Thoron Levels in Garhwal Homes

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ABSTRACT

Radon and thoron measurements were carried out in the houses of Garhwal Himalayas, India under a national radon survey programme by using LR-115 plastic track detector in twin chamber radon dosimeter. The radon dosimeter consists three different mode holders, namely bare mode, filter mode and membrane mode. The bare mode gives the values of radon/thorn concentration and their progeny while the filter and membrane modes give the values of radon/thoron gases and pure radon gas, respectively. The detectors are left exposed in indoor atmosphere for three months and this exposure cycle has been extended on a time integrated four quarterly cycle to cover all the four seasons of a calendar year. The measurements were made in two types of houses i.e. mud houses and cemented houses. Data from about 100 houses show that concentrations of indoor radon and thoron vary from 10.3 Bq/m^3 to 190.5 Bq/m^3 and 1 Bq/m^3 to 144.6 Bq/m^3, respectively. The levels of radon and thoron daughters vary from 0.1 mWL to 30.9 mWL and 0.1 mWL to 143.7 mWL, respectively. In general, the level of radon was observed highest in winter and lowest in summer. A detail analysis of radon and thoron distribution in different houses with seasonal variation is presented in this paper.

INTRODUCTION

Radon and its daughter products are identified as a cause of lung cancer among the miners (1). It has not been clear weather radon poses a similar risk of causing lung cancer in humans exposed at generally lower levels found in homes, but a number of indoor radon survey have been carried out in recent years around the world. The assessment of radiological risk related to inhalation of radon and radon progeny is based mainly on integrated measurements of radon (2). Additional information about the degree of equilibrium between the different redionuclides is necessary to access the true exposures. Generally, the thoron concentration in dwellings is considered negligible because of the short lifetime of the thoron (55.6 sec). The worldwide average estimated by UNSCEAR is 3 Bq/m^3(1). While calculating the risk, the contribution of thoron and its progeny can not be ignored. As such the radon measurements should be accompanied by the thoron measurement for assessment of the correct level of dose due to radionuclides present in the environment. During last several years, a number of studies dealing with radon and thoron measurements were carried out all over the world (3-9). Radon exposure are largely determined by the geology underlying the buildings, its construction and ventilation conditions (10-12). The concentrations of radon and its decay products show large temporal and local fluctuations in the indoor and outdoor atmosphere due to variation of temperature, pressure, building materials, ventilation condition, wind speed, etc. (13-15). The track-etch technique is recognized as the most reliable technique for integrated and long-term measurement of indoor radon/thoron concentrations (16-20). In present investigation, the measurements of radon, thoron and their daughter products are carried out by using LR-115 type II plastic track detector.

In recent years, it is observed that the exposure to radon is the most significant element of human irradiation by natural sources (1). It is therefore important to know the annual average indoor radon concentration in human environment. Keeping in view this fact, Department of Atomic Energy, Government of India has initiated a national radon survey. The survey was designed taking into account that its main goal is to obtain the annual average indoor radon concentration in different part of India and to find out the national radon average. In spring 1996, the collaborated research project of several institutions was started under the national radon survey project. A twin dosimeter was used for simultaneous measurements of radon and thoron inside the houses. The work presented in this paper is a part of the national radon survey. About 100 houses are surveyed in Garhwal Himalayas and the results of one year integrated measurements are presented in this paper.

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EXPERIMENTAL PROCEDURE

The measurements of radon, and thoron were carried out by using the LR-115 Type II, plastic track detector affixed inside the radon dosimeter along with a film attached outside for bare mode. The radon dosimeter consists three different mode holders, namely bare mode, filter mode and membrane mode. The bare mode gives the values of radon/thorn concentration and their progeny while the filter and membrane modes give the values of radon/thoron gases and pure radon gas, respectively. Three small pieces of LR-115 Type II plastic track detector of size 2.5 cm x 2.5 cm are fixed in twin chamber radon dosimeter for the measurement in different mode. The dosimeters are suspended inside the house at a height of about two meter from the floor. The films are exposed in the cities, towns and villages in Himalayan region, which covers six districts of Garhwal. After an exposure time of about three months, films are removed and etched in 2.5 N NaoH solution for two hours at 60 ^{o}C in a constant temperature bath. The films are then scanned for the measurement of track density by using a pre-calibrated spark counter. The recorded track densities are then converted in Bq/m^3 by using an appropriate calibration factor (21). This measurement was repeated on a time integrated four quarterly cycles to cover all the four seasons of a calendar year.

RESULTS AND DISCUSSION

The observed values of radon, thoron and their progeny concentrations are given in table 1. The concentrations of indoor radon and thoron are found to vary from 10.3 Bq/m^3 to 190.5 Bq/m^3 and 1 Bq/m^3 to 144.6 Bq/m^3, respectively. The levels of radon and thoron daughters vary from 0.1 mWL to 30.9 mWL and 0.1 mWL to 143.7 mWL, respectively.

Table 1. Average levels of radon, thoron and their daughter progeny inside the Garhwal homes.

Variable	Winter		Summer		Rainy		Autumn	
	Min	Max	Min	Max	Min	Max	Min	Max
Radon Concentratio (Bq/m^3)	18.2	190.5	11.9	128.6	17.9	189.3	10.3	130.7
Thoron Concentration Bq/m^3)	1.0	144.6	1.0	88.5	1.0	55.4	1.0	107.8
Radon and Progeny Concentration (WLM)	0.1	30.9	0.7	10.7	0.7	13.9	0.7	23.9
Thoron and Progeny Concentration (WLM)	0.1	143.7	0.1	74.0	0.1	66.2	0.1	64.8
Equilibrium Factor between Radon and Progeny (F_{Rn})	0.02	0.9	0.08	0.9	0.09	0.9	0.09	0.9
Equilibrium Factor between Thoron and Progeny (F_{Tn})	0.01	0.9	0.01	0.9	0.01	0.9	0.01	0.9
Ventillation Rate (l/h)	0.01	11.7	0.01	14.4	0.01	12.5	0.01	12.5
Dose Rate (µSv/h)	0.01	1.5	0.03	0.9	0.03	0.8	0.03	0.9

In addition to concentrations of radon, thoron and their progeny, an attempt was also made to calculate the values of equilibrium factors, ventilation rate and resulting dose rates due to their exposure. The equilibrium factor between radon and progeny was observed to vary between 0.02 and 0.9 while the value for thoron and progeny was found to vary from 0.01 to 0.9 (Table 1). The ventilation rate was found to vary from 0.01 *l*/h to 14.4 *l*/h. A highest ventilation rate was observed in summer and lowest in the winter. The resulting dose due to radon, thoron and progeny was observed between 0.01 to 1.5 µSv/h.

The observed values of radon concentration are found comparable with the variation observed in the countrywide radon concentration of 11 to 124.3 Bq/m^3 with a GM 33.2 Bq/m^3 (22). Houses surveyed in present study are located in the hilly region of Garhwal Himalayas, which consists the rock type phylites, quartzite and gneisses with slightly higher uranium content. Most of the houses in cities and towns of study area are constructed with cement and bricks whereas in surrounding villages the houses are mud houses. These houses are constructed with local stone and rocks with a thin past of mud. In general the radon concentration was found higher in mud houses than that in cemented houses, which also justify our previous findings (20). The ground floor of such houses is directly constructed on the soil top with a coating of mud. The ground floor allows more radon to diffuse inside the house because of higher porosity of material used. The emanation of radon is also higher from rocks and local stones. In addition, the mud houses have small doors and a small window (some without window), which remains closed for most of time to conserve the energy in this hilly region. Due to poor ventilation condition, the radon is accumulated inside the house and thus results in higher radon concentration.

A comparison of indoor radon concentration for different seasons is shown in Table 2. The radon concentration was found highest in winter and lowest in summer. The winter/summer ratio was observed maximum while the winter/autumn ratio was found minimum. The high values in winter are mainly because of ventilation factor.

Table 2. Relative indoor radon concentration for different seasons.

Place	Number of Houses	Winter/Summer	Winter/Rainy	Winter/Autumn
Tehri	12	1.59	1.36	1.06
Padiyargaon	11	1.11	1.08	1.23
New Tehri	10	0.93	0.93	0.88
Nail	11	1.35	1.24	1.22
Malideval	3	1.79	1.48	1.31
Koti Colony	5	1.67	1.04	1.23
Manjur	4	1.21	0.94	1.11
Dhikholgaon	3	1.26	0.93	0.85
Thanegaon	2	1.31	1.00	1.22
Serain	2	1.00	1.01	0.77
Rajgaon	5	1.16	0.99	N.A.
Uppu	5	1.08	N.A.	0.76
Dang	4	1.12	0.79	0.95
Chamma	3	1.03	0.94	0.80
Chham	2	1.10	1.12	1.14
Average	82	1.25	1.06	1.04

The indoor radon is found influenced mainly by the ventilation condition of the house. The ventilation rate is found maximum in summer and minimum in winter (Table 1). Being the hilly region, it remains cold in winter and people use to keep the windows and doors of houses closed. However, some unusual results (high radon concentration in summer than winter) were also recorded in the houses of New Tehri, a newly constructed town (Table 2). The winter/summer ratio in this town was recorded below 1 i.e. 0.93. This is again due to ventilation conditions inside the houses. In summer, the occupants of houses have temporarily moved to other places for a short duration. This unusual variation was observed mainly in schools, which remained closed for a long time during the summer vacation. As such high radon concentrations were observed in summer. The concentrations of radon and its progeny also follow the same trend as it was recorded maximum in summer and minimum in winter. However, the trend for thoron is observed slightly different (Table 1). The thoron concentration was found maximum in winter but minimum in rainy season. A similar trend was observed for thoron progeny. This behavious perhaps may be due to low emanation of thoron during rainy season. It may be possible that due to low half-life, thoron can not escape easily from the capillaries of soil, which are mostly occupied by water during the rainy season. The resulting dose due to radon, thoron and their progeny is found maximum in winter and minimum in rainy season.

CONCLUSIONS

Finally it may be concluded that the observed values of radon, thoron and daughter products and the resulting dose in the houses of Garhwal Himalayass are well within the safe limit as prescribed by ICRP (23). However, the values are quite higher than that reported at other places in India. The high radon level in mud houses suggests that the building materials and mode of the construction of houses influence the indoor radon levels. In view of the quality and number of mud houses in the area, a large population in that area is expected to expose to a high value of radon, thoron and progeny with a potential risk of lung cancer. A detail comparison of the results will be available after the completion of the countrywide radon survey project.

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