Radon Levels in Dwellings of Some Indian Cities

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Radiological importance of radon among other naturally occurring radionuclides is due to the fact that it is a noble gas in the uranium decay series with a fairly long half-life of 3.7 days. Being an inert gas it can easily disperse into the atmosphere as soon as it is released. The solid alpha active decay products of radon (^{218}Po, ^{214}Po) become airborne and attach themselves to the dust particles, aerosols and water droplets in the atmosphere. When inhaled, these solid decay products along with air may get deposited in the trachea-bronchial and pulmonary region of lungs resulting in the continuous irradiation of the cells, which may cause lung cancer. Measurement of time integrated concentration of indoor radon and its progeny are important as these are responsible for a major part of natural radiation dose to human beings and may be responsible for lung cancer. LR-115 Type II solid state nuclear track detectors have been used to estimate the radon concentration in dwellings in various cities from different states of India. Annual effective dose has been calculated from the radon concentration to carry out the assessment of the variability of expected radon exposure of the population due to radon and its progeny. The radon levels in the dwellings vary from 64.8 to 222.1 Bq m^{-3} whereas annual effective dose vary from 2.5 to 7.5 m Sv. Radon concentration in Panmana (Kerala), the so called high back ground area is about two times more than the normal back ground area.

Key Words: Radon, Solid state nuclear track detectors, HBRA, Radon activity, Alpha tracks, Effective dose.

INTRODUCTION

The risk of lung cancer for workers in uranium mines is known for a long time and is related to radon exposure[1]. Radon is generated from radium present in soil, building materials and even water. Radon is a noble gas in the uranium decay series with a fairly long half-life of 3.8 days. Being an inert gas it can easily disperse into the atmosphere as soon as it is released. The solid alpha active decay products of radon (^{218}Po,^{214}Po) become airborne and attach themselves to the dust particles, aerosols and water droplets in the atmosphere. When inhaled, these solid decay products along with air may get deposited in the

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trachea-bronchial (T-B) and pulmonary (P) region of lungs resulting in the continuous irradiation by α-particles on the cells which may cause lung cancer[2-4]. Radon in dwellings is generated from radium present or existing or accumulated in soil, construction materials and water. Radon and its daughter products may pose a significant health hazard, especially when concentrated in some enclosures such as underground mines, caves, cellars or poorly ventilated and badly designed houses. Thus radon concentration in dwellings is important due to the health risk and to determine the design of control strategies. Indoor radon concentration depends in a complex way on the characteristic of the soil, the type of building structure, ventilation condition and occupant's behavior.

In homes the predominant source of radon in indoor air is the soil beneath structures, but building materials and water used in the homes and in a few cases natural gas may also contribute[5]. The concentrations of radium in soil and in rocks vary several orders of magnitude. This variation in source strength results in the variation in radon concentrations among dwellings. Keeping the radiation hazards of radon for general population in mind, it is quite important to make a systematic study of the indoor radon concentration in Indian dwellings. For this purpose, radon measurements have been carried out in a number of dwellings in the cities of different states of India *i.e.* Mathura, and Agra in U.P; Dehradun in U.A., Banswara in Rajasthan; Palampur and Baijnath in H.P., Bhatinda in Punjab, and Panmana, Eravipuram and Thankassery in Kerala. Panmana is in the vicinity of the High Back Ground Area (HBRA), whereas Eravipuram and Thankassery are about five to six Km away from HBRA

EXPERIMENTAL

Nuclear track-*etc*h detectors (LR-115 type II Solid Sate Nuclear Detectors (SSNTDs) were employed for measuring the Potential Alpha Energy Concentration (PAEC) of radon progeny in Working Level (WL) units. The pieces of the detector films of size 2 × 2 cm, fixed on a thick flat card were exposed in bare plastic track detection technique [6,7] by hanging the cards on the wall in the room for a period of 90 to 100 days such that the detector viewed a hemisphere of radius at least 6.9 cm, the range of ^{214}Po α-particles in the air. No surface was closer than this range as the decay products would act as an indeterminate α-particles sources. Detectors were mounted vertical and the locations were so selected that the dust collection on the detectors be minimum. After exposure, the detectors were collected and brought back to the laboratory for analyses. The films were *etc*hed in 2.5 N NaOH solution at 60^{0}C for 90 min in a constant temperature water bath. The counting of alpha tracks was done using a binocular optical research microscope with a magnification of 400X. The track density registered in the bare detector will, therefore, be a function of radon and its progeny concentration in air. The radon concentration in Bq.m^{-3} was estimated from working level by using the following equation[8,9].

$$R_nC\ (Bqm^{-3}) = \frac{WL \times 3700}{F}$$

The equilibrium factor for radon has been taken as 0.4 as suggested by UNSEAR, 2000[10].

To obtain the Potential Alpha Energy Concentration (PAEC) of radon progeny in mWL, LR-115 type II detector films should be calibrated with a known radon concentration under the conditions almost similar to those, which prevail in Indian dwellings. For this purpose, the detectors were calibrated[11,12] in a radon exposure chamber at the facility available in Environmental Assessment Division of Bhabha Atomic Research Centre, Mumbai. The mean calibration factor for LR-115 type II detector was found to be 442 tracks cm^{-2} d^{-1} per WL.

RESULTS AND DISCUSSION

Table 1 presents the radon levels and Potential alpha activity in the dwellings of different cities of various states of India. The radon levels in the dwellings vary from 64.8 to 222.1 Bq m^{-3} and Potential alpha activities vary from 7.9 to 24.0 mWl. The radon activity depends on many factors i.e soil beneath the house, flooring, building materials, ventilation conditions, type of construction *etc.*

Panmana in Kerala is the city situated in the vicinity of High Background Area and the radon levels in the dwellings are found to be about two times more than the normal back ground areas of the state (Eravipuram, the town far from HBRA)[8]. The radon activity depends on many factors *i.e.* soil beneath the house, flooring, building materials, ventilation conditions, type of construction *etc.*

Palampur and Baijnath cities are situated in the hilly region of the state of Himachal Pradesh, a state known for U-mineralization. Radon levels in the dwellings surveyed in these cities are in the action level limit[13]. Other cities of the present studies are situated in the normal background areas. Radon levels are found higher in Mathura as compared to Agra. Both being normal background area, this may be due to Mathura being at closest distance from big oil refinery. Table-2 presents the annual effective dose in the dwellings of different cities of various states of India. The effective dose equivalents using the conversion factor of 9 mSv/WLM proposed by (ICRP 1986)[14] varies from 2.5 to 7.5 m Sv.

The International Commission on Radiation Protection (ICRP-65, 1993)[15] has recommended that remedial action against radon is justified

TABLE-1
RADON LEVELS AND POTENTIAL ALPHA ACTIVITY IN SOME INDIAN CITIES

Cities	No. of dwel.	Potential alpha activity (mWL)		Radon concentration			
		Range	Aver.	Range ($Bq.m^{-3}$)	Aver. value ($Bq\ m^{-3}$)	S.D. ($Bq.m^{-3}$)	Rel. Std.%
Eravipuram (Kerala)	21	2.9-17.3	14.2	26.8 - 227.5	131.7	56.6	42.9
Panmana (Kerala)	19	4.6-42.5	24.0	42.5 - 393.1	222.1	103.0	46.4
Thankassery (Kerala)	24	5.3-45.4	17.5	44.3 – 373.3	144.7	61.5	42.5
Dehradun (U.A.)	34	2.6-19.8	7.9	21.0-162.5	64.8	35.3	54.5
Mathura (U.P.)	39	2.6-22.6	12.6	20.0-185.4	103.8	45.6	43.8
Agra (U.P.)	36	2.4-18.4	9.7	19.8-151.5	80.3	36.1	44.9
Banswara (Rajasthan)	44	1.8-34.4	11.8	15.0-282.7	95.9	76.3	79.5
Palampur (H.P.)	10	6.9-25.8	15.1	56.7-212.0	123.8	52.1	42.4
Baijnath (H.P.)	15	5.1-32.3	17.8	41.9-265.5	146.8	72.9	49.7
Bhatinda (Punjab)	33	6.3-27.3	14.9	51.8-224.5	125.6	45.3	36.1

TABLE-2
ANNUAL EFFECTIVE DOSE IN SOME INDIAN CITIES

Cities	Range	Average Value	S.D.	Rel. Std.%
Eravipuram (Kerala)	0.9-7.7	4.5	1.9	42.2
Panmana (Kerala)	1.5-13.3	7.5	3.5	46.7
Thankassery (Kerala)	1.7- 14.2	5.5	2.3	41.8
Dehradoon (U.A.)	0.8-6.2	2.5	1.4	54.8
Mathura (U.P.)	0.8-7.1	3.9	1.7	43.9
Agra (U.P.)	0.8-5.8	3.1	1.4	45.2
Banswara (Rajasthan)	0.6-10.8	3.6	2.9	73.2
Palampur (H.P.)	2.1-8.1	4.7	2.0	42.4
Baijnath (H.P.)	1.6-10.0	5.6	2.8	49.8
Bhatinda (Punjab)	2.0-8.6	4.8	1.7	36.1

above a continued effective dose of 10 mSv, while an action level within the range of 3-10 mSv per year has been proposed. The action level for radon concentration should be in the range between 200 and 600 Bq m^{-3}.

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