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Archives of Applied Science Research, 2011, 3 (1):77-82

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ISSN 0975-508X
CODEN (USA) AASRC9

Assessment of indoor radon, thoron and their decay products in the surrounding areas of Firozabad, Uttar Pradesh, India

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ABSTRACT

Study of indoor radon/thoron has been carried out in some dwellings of Firozabad, Uttar Pradesh, India using LR-115 type II plastic track detectors. Radon is an invisible radioactive gas that occurs naturally in the environs. It comes from the natural breakdown of uranium in soils and rocks. Lung cancer risk depends upon the concentration of radon and their decay products in air above recommendation level. In the present study the value of concentration of radon ranges from 31.5 to 141.4 Bqm^{-3} whereas the value of thoron concentration ranges from 9.3 to 75.2 Bqm^{-3}. The value of radon progeny ranges from 3.4 to 15.3 Bqm^{-3} while the value of thoron progeny ranges from 3.3 to 27.3 Bqm^{-3}. The inhalation dose varies from 0.15 to 0.71 mSv.y^{-1}.The annual exposure (Rn + Tn) in terms of WLM ranges from 0.24 to 1.46 while annual exposure (Rn + Tn) in terms of mjhm^{-3} ranges from 0.85 to 5.17 with an average of 2.9. The life time fatality risk of the residents of the study area ranges from 0.72 × 10^{-4} to 4.38 × 10^{-4} with an average value of 2.5 × 10^{-4}. The annual effective dose ranges from 0.93 - 5.66 mSvy^{-1} with an average value of 3.2.

[Keywords: Indoor radon, Thoron, Solid state nuclear track detector, Effective dose]

INTRODUCTION

Radon, thoron and its (α-emitting) decay products is naturally occurring in the environment in the form of ionizing radiation. It can affect radiation hazard although sources are concentrated in covered areas like caves, mines and poorly ventilated houses. These factors can give rise to radiation exposure in the environment if their concentration is very high either due to natural causes (high background radiation area (Kerala), rock phosphate deposit, uranium deposit, industrial radiation, uranium and coal thermal power plant etc) [1]. These are unstable radioactive nuclei coming from the U^{238} and Th^{232} radioactive decay series. Indoor radon, thoron and its decay products is assumed to be health hazardous for human. As these are inert gases therefore it can easily disperse into the environment as soon as it is released. About 90% of average radiation dose received by human from natural sources and about 50% is due to inhalation of radon, thoron and their progeny present in the dwellings [2]. In dwellings radon and thoron level enter through the cracks, sump, and joints. In poorly ventilated spaces the radon concentration may reach levels of great concern [3]. Radon, thoron and its decay products (^{218}Po and ^{214}Po) attach to aerosols and gets traped in the tracia bronchial system during inhalation thereby irradiating the bronchial tissues. It constitutes a significant radiation hazard to human lungs and occurrence of lungs cancer [4, 5].

Assumed exceptionally high uranium and thorium ratio can cause of increased radon and thoron [6]. The radon and thoron concentration is highly inhomogeneous and is strongly dependent on the distance from the source [7, 8].

It is dependent on the ventilation rate because its decay constant (64 h^{-1}) is much higher than normal ventilation rate ($1h^{-1}$) and the behavior of the radon progeny is similar to thoron progeny according to its half life [9]. Radon and thoron in environment comes from two sources terrestrial and extraterrestrial radiation [10]. Such type of radiation exposure effects internal and external part of human body [2]. Internal exposure occurs through the inhalation of radon gas and external exposure occurs through the emission of penetrating gamma radiation [11]. It is supposed that the health effect of inhabitants is negligible due to the inhalation of thoron and its progeny but recent studies in many countries have shown that this may not be completely correct [12]. People spend about 80% of their time in homes or offices. Therefore precaution is needed; several scientist and research workers are engaged in the measurement of radon thoron and its progeny by using LR-115 type II plastic track detectors in the environment [1, 14-19]. Firozabad city suffers from pollution because about four hundreds glass industries are registered in Firozabad and these industries produces different kind of glass material. Therefore the motivation of our study is the possible health risk assessment, due to the radon, thoron and its short lived decay products in inhalation.

MATERIALS AND METHODS

Experimental Details

Study of indoor radon, thoron and its progeny have been carried out in some dwellings from March 2009 to June 2009 of Firozabad district, Uttar Pradesh, India using LR-115 type II plastic track detectors in the "Bare" mode [3,17-19,27]. The detectors are sensitive to α–particles and are widely used for radon and its short-lived decay products measurement. The size of detectors was taken 1.5 × 1.5 cm for recording the tracks of α-particles emitted by radon and its short-lived decay products present in the ambient air, typically Po^{218} and Po^{214} which generally attach themselves to the aerosols. The detectors were fixed on cards and mounted on the walls for 91 days inside the room at a height of about 7 feet from the ground. The α-particles originating from radon and its short-lived decay products has been registered as tracks in the detectors, if α-particles from radon and its short lived daughter products have their energies in the range of about 1.7-4.1 MeV [20, 21]. Once the exposure period is over, the detectors were etched in 2.5 N NaoH solution at 60°C for 90 min in a constant temperature water bath in our laboratory. The counting of alpha tracks has been done using a binocular optical research microscope with a magnification of 100×. The details of standard calibration methods are described [22] and the concentration of radon and thoron gases were calculated in terms of (Bqm^{-3}) using the following expression [22].

$$C_R = t_{rm} / TK_{rm} \quad ---(1)$$

$$C_T = t_{total} - K_{rf} C_{Rn} T / TK_{tf} \quad ---(2)$$

Where t_{total} is the total tracks recorded in the SSNTD film

T is exposure time in days

t_{rm} is the track register on detector

$$K_{rf} = 0.023 \pm 0.004 tracks.cm^{-2} d^{-1} / Bq.m^{-3}$$
$$K_{tf} = 0.019 \pm 0.002 tracks.cm^{-2} d^{-1} / Bq.m^{-3}$$
$$K_{rm} = 0.021 \pm 0.003 tracks.cm^{-2} d^{-1} / Bq.m^{-3}$$

The inhalation dose was calculated (in $mSvy^{-1}$) using the relation

$$D_{in}\left(mSvy^{-1}\right) = C\left(0.11 + 40 \times 0.03\right) \times 24 \times 0.8 \times 365 \times 10^{-6} \ldots (3)$$

Where C is radon or thoron concentration [2], the radon and thoron progeny working levels (PAEC) were calculated using the following relation [23].

$$C_{Rn}\left(Bqm^{-3}\right) = \frac{3700 \times WL_R}{F_R} ---(4)$$
$$C_T\left(Bqm^{-3}\right) = \frac{275 \times WL_T}{F_T} ---(5)$$

where $F_R = 0.4$ and $F_T = 0.1$ are the equilibrium factor of radon and thoron [24]. The calculations have been made using the conversion factors given elsewhere [25, 26]. The annual exposure have been calculated through radon progeny by using (WLM = 36 × WL) while an exposure of an individual to radon progeny of 1WLM is equivalent to 3.54 $mJhm^{-3}$. The life time fatality risk and the annual effective dose received by the bronchial and pulmonary regions of human lungs have been calculated by using the conversion factor of 3×10^{-4} WLM^{-1} and 3.88 $mSvWLM^{-1}$.

RESULTS AND DISCUSSION

The table 1 - shows the values of radon concentration, thoron concentration, radon progeny, thoron progeny, and inhalation dose while Table 2 - shows the values of annual exposure, life time fatality risk and effective dose in urban dwellings of Firozabad district of Uttar Pradesh (India). The values of radon concentration vary from 31.5 to 141.4 Bqm^{-3} with an average of 89.5 and a standard deviation 31.8 whereas the values of thoron concentration vary from 9.3 to 75.2 Bqm^{-3} with an average of 36.7 and a standard deviation 20.9. The values of radon progeny ranges from 3.4 to 15.3 Bqm^{-3} with an average value of 9.6 Bqm^{-3} and a standard deviation of 3.4 while the values of thoron progeny ranges from 3.3 to 27.3 Bqm^{-3} with an average of 13.3 Bqm^{-3} and a standard deviation 7.6. All values are found to be lower than the recommended action level 200 Bqm^{-3} ICRP[25]. The values of inhalation dose vary from 0.15 to 0.71 $mSv.y^{-1}$ with an average of 1.08 and standard deviation is 0.45. The annual exposure (Rn + Tn) in terms of WLM ranges from 0.24 to 1.46 with an average value of 0.83 and standard deviation 0.37, while annual exposure (Rn+ Tn) in terms of $mjhm^{-3}$ ranges from 0.85 to 5.17 with an average of 2.9 and a standard deviation 1.3. The life time fatality risk of the residents of the study area ranges from 0.72×10^{-4} to 4.38×10^{-4} with an average value of 2.5×10^{-4} and a standard deviation 1.1×10^{-4}. The annual effective dose ranges from 0.93 to 5.66 with an average value of 3.2 and a standard deviation 1.4. The detectors were fitted inside rooms and few detectors were inside glass factory. All values obtained under the limit [25], depending on the type of house construction, ventilation conditions and location. It is observed that in all the places the annual inhalation dose and annual effective dose is below the action level 3-10 $mSvy^{-1}$ has been recommended by ICRP [25].

Table 1- Radon concentration, thoron concentration, radon progeny, thoron progeny and inhalation dose in some dwellings

Sr No	Location	C_{Rn} (Bqm^{-3})	C_T (Bqm^{-3})	Radon Progeny (mWL)	Thoron Progeny (mWL)	Inhalation Dose D_{in} (Rn+Tn) ($mSv.y^{-1}$)
1	room	81.8	25.6	8.8	9.3	0.98
2	workshop	111.8	68.8	12.0	25.0	1.66
3	room	31.5	9.3	3.4	3.3	0.37
4	workshop	122.3	36.8	13.0	13.4	1.46
5	room	42.9	13.9	4.6	5.0	0.52
6	room	85.1	52.6	9.2	19.1	1.26
7	room	98.4	30.1	10.6	10.9	1.18
8	workshop	123.3	75.2	13.3	27.3	1.82
9	room	89.1	26.9	9.6	9.8	1.06
10	room	48.7	14.5	5.2	5.3	0.58
11	workshop	141.4	41.1	15.3	14.9	1.68
12	workshop	113.7	68.3	12.3	24.8	0.67
13	room	63.1	20.3	6.8	7.4	0.76
14	room	100.3	30.7	10.8	11.2	1.20
Avearage value		89.5	36.7	9.6	13.3	1.08
Standard Deviation		31.8	20.9	3.4	7.6	0.45

Table 2- Annual exposure (Rn + Th), Life time fatality risk factor and annual effective Dose

Sr No	Annual Exposure Rn (WLM)	Annual Exposure Th (WLM)	Annual Exposure Rn + Th (WLM)	Annual Exposure Rn + Th $mjhm^{-3}$	Life time Fatality Risk Factor $\times 10^{-4}$	Annual Effective Dose ($mSv.y^{-1}$)
1	0.32	0.33	0.65	2.30	1.95	2.52
2	0.43	0.90	1.33	4.71	3.99	5.16
3	0.12	0.12	0.24	0.85	0.72	0.93
4	0.47	0.48	0.95	3.36	2.85	3.69
5	0.17	0.18	0.35	1.24	1.05	1.36
6	0.33	0.69	1.02	3.61	3.06	3.96
7	0.38	0.39	0.77	2.73	2.31	2.99
8	0.48	0.98	1.46	5.17	4.38	5.66
9	0.35	0.35	0.70	2.48	2.10	2.71
10	0.19	0.19	0.38	1.35	1.14	1.47
11	0.55	0.54	1.09	3.86	3.27	4.23
12	0.44	0.89	1.33	4.71	3.99	5.16
13	0.25	0.27	0.52	1.84	1.56	2.02
14	0.39	0.40	0.79	2.80	2.37	3.06
A Value	0.35	0.48	0.83	2.9	2.5	3.2
S. D.	0.12	0.27	0.37	1.3	1.1	1.4

CONCLUSIONS

The values of radon concentration, thoron concentration, inhalation dose and annual effective dose do not show major concern. Our results have been found lower when compared to the other authors [3, 19]. From the present work it has been concluded that the radon levels in running factory having maximum and minimum in room. The values are found to be lower than the action levels (3-10 $mSv.y^{-1}$) recommended by ICRP [25].

Acknowledgement
The Authors are grateful to Prof. Alim Husain Naqvi, Chairman D/O Applied Physics, Aligarh Muslim University, Aligarh and Dr. Ameer Azam D/O Applied Physics, Aligarh Muslim University, Aligarh for providing all necessary facility for carried out this work. The author is thankful for the co-operation from the house owners.

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