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Environmental Monitoring of indoor Radon, Thoron and their Progeny in Dwellings of Uttar Pradesh, India

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Abstract

The behavior of radioactive gases has received considerable attention over the past few decades due to the radiological risks to humans in indoor atmosphere. High radon levels were measured in dwellings of a number of countries including United States, Sweden and the United Kingdom. There is a concern that high levels of radon may contribute to an increased risk of lung cancer. These high indoor radon levels may exceed international guidelines and are associated with a number of factors including soil porosity, uranium content of the soil, building materials mode of construction, ventilation and metrological parameters. The variability of these factors accounts for the large range of the radon levels measured in dwellings. Recent epidemiological evidence suggests that inhalation of radon decay products in domestic environments could be a cause of lung cancer. The monitoring of radon, thoron and their progeny in different types of dwellings of Central Uttar Pradesh has been carried out using solid state nuclear track detector (SSNTD). The annual doses received due to radon and thoron by the inhabitants in the dwellings under study area has also been calculated. Based on the results it is found that the radon concentration in some selected parts of Central Uttar Pradesh varied from 21.17 Bq/m^3 to 43.04 Bq/m^3 with an average of (27.90 ± 1.03) Bq/m^3 while the thoron concentration in same dwellings varied from 12.37 Bq/m^3 to 22.79 Bq/m^3 with an average of (16.75 ± 0.55)Bq/m^3. The radon progeny levels in the dwellings under study area varied from 2.29 mWL to 4.65 mWL with an average of (3.02 ± 0.11) mWL while thoron progeny levels varied from 0.33 mWL to 0.62 mWL with an average of (0.45 ± 0.01)mWL. The annual dose received by the inhabitant in the dwellings under study area varied from 0.85 mSv to 1.6 mSv with an average of (1.12 ± 0.04) mSv.

Keywords: Indoor radon, thoron, environmental monitoring, annual dose.

Introduction

Radon is a radioactive gas that is present in trace amounts almost everywhere on the earth. It emanates from rocks, soils and gets distributed in the groundwater as well as in the lower atmosphere. Radioactive radon can migrate from soils and rocks and accumulate in surrounding enclosed areas such as homes and underground mines. It has been estimated that the radon, largely in homes, constitutes about 50% of the dose equivalent received by general population from all sources of radiation, both naturally occurring and manmade. There are a large number of radon sources in domestic buildings: ground underneath a dwelling, building materials, water supply, ambient air etc. The air pressure inside buildings is slightly lower than in the ground. The combustion appliances, like furnaces, hot water heaters and fireplaces as well as exhaust fans and vents, reduce the pressure indoors. Strong winds create a vacuum inside the buildings by the Bernoulli Effect. The modern houses tend to build up radon because the building envelope is almost airtight while the foundation is leaky to soil gas. The inflow of soil gas ranges from less than 1% to over 20% of the total fresh air infiltration into homes. Radon is also pulled inside by the difference in radon concentrations indoors and in the soil (diffusion). Radon tries to equalize the indoor concentration and its atoms easily penetrate through the pores in concrete[1,2].

The radon gas being heavier than air accumulates in the basement and on lower floors. Heating and air-conditioning, natural air movement, as well as diffusion of radon atoms through floors and walls, distribute radon throughout the house[3-8]. Radon decays overtime into radioactive particles that can be inhaled and trapped in the lungs as these daughter products remain in air born for a long time.When radon decays it forms its progeny ^{218}Po and ^{214}Po (solids progenies) which are electrically charged and can attach themselves to tiny dust particles, water, vapors, 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, there by irradiating the tissues. Bronchial stem cells and secretion cell in always are considered to be the main target cells for the induction of lung cancer resulting from radon exposure. This exposure of population to high concentration of radon and its progeny for long period lead to pathological effects like respiratory functional changes and the lunges of lung cancer[9].

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 workplaces. Keeping this in mind the environmental monitoring of radon, thoron and their progeny in some selected dwellings of Central Uttar Pradesh has carried out using twin cup radon/thoron dosimeter.

Methodology

Concentration of radon, thoron and their daughter products were measured by using LR-115 Type II plastic track detector. The LR 115 type II detector consists of 12 µm red cellulose nitrate active layer and 100 µm clear polyester base substrate (as declared by manufacture). Three small pieces of detector films of size 2.5 cm x 2.5cm were fixed in a twin chamber radon/thoron dosimeter having three different modes. The bare mode gives the values of radon, thoron and their progeny concentrations while the filter and membrane modes records the values due to radon, thoron and pure radon gas, respectively. The dosimeters were suspended inside the house at a height of about two meters from the ground floor. After an exposure time of about three months, the detector films were removed, etched in 10% aqueous NaOH at 60 ^{0}C for 90 minutes without stirring. The temperature was kept constant with an accuracy of ± 1 ^{0}C. After etching, the detector were taken out of the etchant, washed and then dried. Finally the alpha tracks registered by the detector were then counted using spark counter. The recorded track density was then converted in the Bq/m3 by using an appropriate calibration factor[10]. Radon and thoron progeny levels in mWL have also been calculated using equilibrium factor 0.4 for radon and 0.1 for thoron[11]. Annual dose received by the inhabitants in the dwellings under study in mSv was estimated using the relation.

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

Where F_R is equilibrium factor for radon (F_R= 0.4 UNSCEAR and ICRP recommended); F_T is the equilibrium factor for thoron ($F_{T=}$ 0.1); C_R and C_T are radon and thoron concentrations, respectively.

Results and Discussion

Resulting values of indoor radon, thoron and their progeny concentrations along with annual dose received by the inhabitants in the dwellings under study are shown in table 1. The graphs between radon/thoron, their progeny concentrations are shown in figure-1and figure-2.

Based on the results it is found that the radon concentration in some selected parts of Central Uttar Pradesh varied from 21.17 Bq/m^3 to 43.04 Bq/m^3 with an average of (27.90 ± 1.03) Bq/m^3 while the thoron concentration in same dwellings varied from 12.37 Bq/m^3 to 22.79 Bq/m^3 with an average of (16.75 ± 0.55)Bq/m^3. The radon progeny levels in the dwellings under study area varied from 2.29 mWL to 4.65 mWL with an average of (3.02 ± 0.11) mWL while thoron progeny levels varied from 0.33 mWL to 0.62 mWL with an average of (0.45 ± 0.01)mWL. The annual dose received by the inhabitant in the dwellings under study area varied from 0.85 mSv to 1.6 mSv with an average of (1.12 ± 0.04) mSv. The concentration of radon, thoron and their progeny in mud houses were found higher compared to the other sites. The high values of radon and thoron in the mud house may be due to typical construction of the houses and the construction materials used. The emanation from the ground surface and from the building materials of mud houses results in the high value of radon and thoron inside room[12]. As the soil is an important source of indoor radon , the emanation of radon is also higher from the ground surface of the house[13].

Conclusion

It is concluded that the observed values of radon, thoron and progenies and annual dose received by the inhabitants in the houses of central Uttar Pradesh are well within the safe limit as prescribed by ICRP. Geological impacts on the values had minor effect as the entire selected area has almost same soil and rocks. On analyzing the results, it was observed that the radon, thorn and its daughter product concentration higher in mud houses. The possible cause could be the exhalation of radon gas from soil.

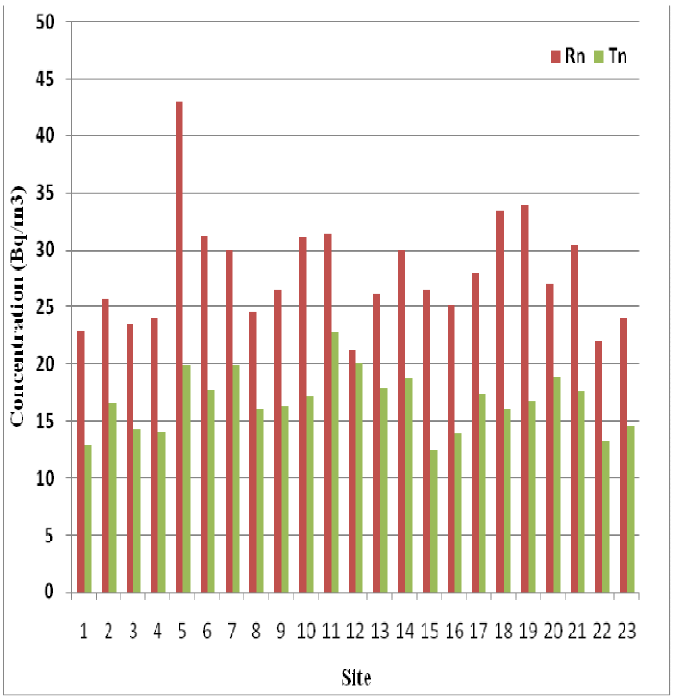

Figure-1
Radon/ Thoron Concentration (Bq/m^3)

Table-1
Radon, thoron & their progeny levels in some selected dwellings of central Uttar Pradesh.

Site	Radon Concentration (Bq/m^3)	Thoron Concentration (Bq/m^3)	Radon Progeny (mWL)	Thoron progeny (mWL)	Annual Dose Received (mSv)
1	22.85	12.93	2.47	0.35	0.90
2	25.67	16.57	2.77	0.45	1.06
3	23.44	14.25	2.53	0.39	0.95
4	24.08	14.08	2.60	0.38	0.96
5	43.04	19.92	4.65	0.54	1.60
6	31.29	17.71	3.38	0.48	1.24
7	30.00	19.92	3.24	0.54	1.25
8	24.61	16.04	2.66	0.43	1.02
9	26.50	16.33	2.86	0.44	1.08
10	31.13	17.13	3.36	0.46	1.22
11	31.46	22.79	3.40	0.62	1.36
12	21.17	20.08	2.29	0.54	1.02
13	26.13	17.83	2.82	0.48	1.10
14	30.07	18.79	3.25	0.51	1.23
15	26.50	12.37	2.86	0.33	0.99
16	25.08	13.92	2.71	0.38	0.98
17	28.00	17.38	3.03	0.47	1.14
18	33.50	16.13	3.62	0.44	1.26
19	33.88	16.75	3.66	0.45	1.28
20	27.00	18.88	2.92	0.51	1.15
21	30.42	17.63	3.29	0.48	1.21
22	22.00	13.25	2.38	0.36	0.89
23	24.00	14.50	2.59	0.39	0.97
Min.	21.17	12.37	2.29	0.33	0.85
Max.	43.04	22.79	4.65	0.62	1.60
AM ± SE	27.90 ± 1.03	16.75 ±.55	3.02 ±.11	0.45 ± .01	1.12 ± .04

* SE (standard error) = σ/√N, where σ is standard deviation and N is the no. of observations

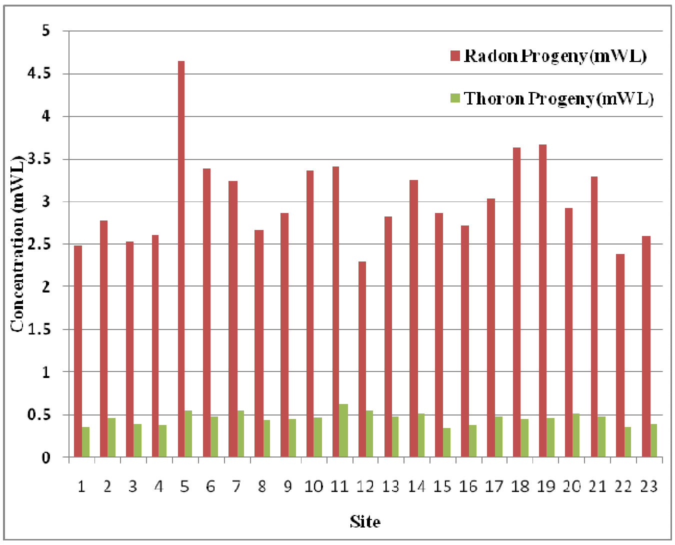

Figure-1
Radon progeny/Thoron Progeny Concentration

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