

ASSESSMENT OF INDOR RADON, THORON AND THEIR PROGENY LEVELS IN RESIDENTIAL HOUSES OF HARDOI, UTTAR PRADESH, (INDIA)

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Abstract

Radon, thoron and their progeny levels are significant natural sources of radiation exposure for general population in both living and working places. The concentration of radon varied from 15 Bq/m³ to 78 Bq/m³ with an average of 46 Bq/m³, while thoron concentration varied from 11 Bq/m³ to 26 Bq/m³ with an average of 18 Bq/m³. The concentration of radon progeny (EERC) varied from 10 Bq/m³ to 26 Bq/m³ with an average of 18 Bq/m³, while the concentration of thoron progeny (EETC) varied from 0.56 Bq/m³ to 1.91 Bq/m³ with an average of 1.11 Bq/m³. The value of equilibrium factor for radon varied from 0.19 to 0.76 with an average of 0.37 while for thoron it varied from 0.02 to 0.12 with an average of 0.06. Our experimental finding confirmed that the indoor radon, thoron and their progeny concentration were within internationally accepted norms.

Keywords: Pin hole dosimeter, DTPS, DRPS, Indoor radon & thoron concentration.

INTRODUCTION

Uranium is a naturally occurring radioactive element present in trace amount throughout the earth's crust. Radon is a progeny of uranium decay series formed from radioactive decay of radium in the environment, soil, ground water, oil and gas deposits. Radon is a ubiquitous naturally occurring radioactive gas present in our environment both indoor and outdoor. Ever since studies on uranium miners established the presence of a positive risk coefficient for the occurrence of the lung cancer in miners exposed to elevated levels of radon and its progeny, there has been a great upsurge of interest in programs concerned with the measurement of radon in the environment.

This interest was accentuated by the observations of elevated radon levels in the indoor environment in many countries at led to the realization of residential radon as being a possible public health issue in the western world. It was also hoped that in conjunction with epidemiological studies, large scale indoor radon surveys might lead to quantities understanding of the low dose effects of radon exposures. As a result of these, considerable amount of information is now available on the levels of radon gas and its progeny in the environment across the globe (UNSCEAR, 2000). Radiogenic lung cancer is oldest type of known radiation induced malignancy disease (ICRP, 1980). It was recorded in the 15th and 16th century among miners in Schneeberg region of Germany. The so called 'Schneeberger Krankheit' was diagnosed as lung cancer in 1879 (Harting and Hess, 1879). The correlation between radon daughters exposure and lung cancer was established in 1960s among uranium miners (Lundin et al., 1971).

It is now well established fact that radon when inhaled in large quantity causes lung disorders and is the second major cause of lung cancer after smoking. The exposure of population to high concentrations of radon and its daughters for a long period leads to pathological effects like the respiratory functional changes and the occurrence of lung cancer (BEIR, 1999). During recent years, radon monitoring has become a global phenomenon due to its health hazard effects on population (Radiation workers and general public). It has been estimated that out of naturally occurring 2.2mSv of dose, which an individual receives annually from low-level exposure, 1.27 mSv is due to radon isotopes and their short lived progeny (IAEA, 1988; Narayanan et al., 1991; ICRP, 2000). As the radon in the environment (Indoor and outdoor), soil, ground water, oil and gas deposits contributes the largest fraction of the natural radiation dose to population, tracking its contraction is thus of fundamental interest from radiation protection, health and hygiene point of view (whether in mining developments, coal fields, thermal power plants, housing, building construction material etc.)

MATERIAL AND METHODS

Measurement of indoor radon and thoron concentration:

The concentration of indoor radon & thoron was measured in residential houses by pin hole based ²²²Rn /²²⁰Rn discriminator dosimeter. The details and calibration of pin hole based ²²²Rn /²²⁰Rn discriminator dosimeter was described elsewhere (Sahoo et al. 2013). This dosimeter system has two compartment separated by a central pin holes disc made up of high density polyethylene material, acting as ²²⁰Rn discriminator. Four pin holes each with dimensions 2 mm length and 1 mm diameter are made in this circular disc. The schematic diagram of the dosimeter is shown in fig. 1. The dosimeter has a single entry through which gas enters first chamber namely "radon + thoron" chamber through a glass fiber filter paper (0.56 μm) and subsequently diffuses to second chamber namely "radon" chamber through pin holes cutting off 98% of the entry of ²²⁰Rn and 98% transmission of ²²²Rn in to this

chamber(Sahoo et, al. 2013). Each chamber is cylindrical having a length 4.1 cm and radius 3.1 cm. The LR 115 Type II films of size (2.5×2.5 cm²) were fixed at opposite end of the entry face in each chamber. The LR 115 type II film in first chamber measured track produced by α emitted from radon and thoron, while second chamber measured tracks due to radon only.

56 No of residential houses were selected in 18 villages for the measurement of indoor radon and thoron concentration in different types of dwellings in study area. The dosimeters were deployed in the residential houses at the height of about 2 m. After an exposure period of 90 days, the detector were retrieved from dosimeters and chemically etched with 10% of NaOH solution at 600C for 90 minutes without stirring (Ramola et al. 1996, Ramachandran, 1998). Tracks recorded in SSNTD films were counted using spark counter.

$$CR = T1 / (d \cdot kR) \text{ ————— (1)}$$

$$CT = (T2 - d \cdot CR \cdot kR') / (d \cdot kT) \text{ ————— (2)}$$

Where, T1 is the track density observed in radon chamber. kR is the calibration factor of radon in radon chamber. For radon, kR (0.019 ± 0.003 tr. cm⁻² per Bq.d.m⁻³), d is the number of days of exposure time. T2 is the track density observed in “radon + thoron” chamber, kR' (0.019 ± 0.003 tr. cm⁻² per Bq.d.m⁻³) and kT (0.016 ± 0.005 tr. cm⁻² per Bq.d.m⁻³) are the calibration factors of radon and thoron in “radon + thoron” chamber.

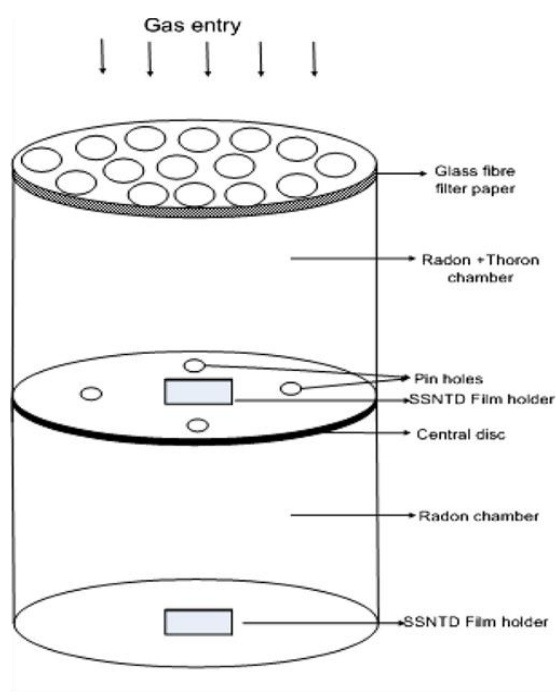


Figure 1: schematic diagram of pin hole dosimeter

MEASUREMENT OF RADON AND THORON PROGENY CONCENTRATION:

The concentration of radon and thoron progeny was measured by using deposition based direct radon and direct thoron progeny sensors (DRPS and DTPS). These are made of passive nuclear track detectors (LR 115) mounted with the absorbers of appropriate thickness. For thoron progeny, the absorber is 50 μ m aluminized Mylar and which selectively detects only 8.78 Mev α - particles emitted from ²¹²Po; while for radon progeny, the absorber is a combination of aluminized Mylar and Cellulose nitrate of effective thickness 37 μ m to detect mainly 7.67 Mev α - particles emitted from ²¹⁴Po.

56 DTPS & DRPS are suspended with pin hole based radon/thoron discriminator in sleeted houses in study area. The tracks recorded in the exposed LR 115 film is related to Equilibrium Equivalent Concentration (EEC) using sensitivity factor. The number of tracks per unit time (T) can be correlated to the Equilibrium Equivalent Progeny Concentration in air using the sensitivity factor (S) (Mishra and Mayya 2008).

$$EEC \text{ (Bq/m}^3\text{)} = T \text{ (Tracks. cm}^{-2} \cdot \text{d}^{-1}\text{)} / S \text{ [Tracks. cm}^{-2} \cdot \text{d}^{-1} / \text{EEC(Bq/m}^3\text{)]} \text{ ————— (3)}$$

where $S = 0.94$ Tracks. Cm-2.d-1/EETC (Equilibrium Equivalent Thoron Concentration) (Bq/m^3) for thoron progeny and $S = 0.09$ Tracks. Cm-2.d-1/EERC (Equilibrium Equivalent Radon Concentration) (Bq/m^3) for radon progeny.

RESULTS AND DISCUSSION

Table No. 2 shows the summarized results of radon, thoron, EERC, EETC concentration and equilibrium factor for radon and thoron. It is clear from table No2. that the concentration of radon varied from 15 Bq/m^3 to 78 Bq/m^3 with an average of 46 Bq/m^3 . while value of thoron concentration varied from 11 Bq/m^3 to 26 Bq/m^3 with an average of 18 Bq/m^3 .

The concentration of radon progeny (EERC) varied from 10 Bq/m^3 to 26 Bq/m^3 with an average of 18 Bq/m^3 while the Concentration of thoron progeny (EETC) varied from 0.56 Bq/m^3 to 1.91 Bq/m^3 with an average of 1.11 Bq/m^3 . The value of equilibrium factor for radon varied from 0.19 to 0.76 with an average of 0.37 while the equilibrium factor for thoron varied from 0.02 to 0.12 with an average of 0.06.

Based on the result it observed that the concentrations of radon and thoron were found to vary with ventilation condition, building materials, mode of construction of a house. Higher concentrations of indoor radon and thoron are observed in poorly ventilated buildings, mud houses (mud wall, mud floor and mud roof). The possible cause could be the exhalation of radon gas from soil. All India average levels of radon lie between 40 Bq/m^3 to 143 Bq/m^3 . All the other values presented in table - 1 like radon, thoron concentration, EERC, EETC and equilibrium factor are found under the safe limit as recommended by various agencies (UNSCERA, 2000, ICRP, 1993).

Table 1: Radon, thoron and their progeny concentration in Hardoi

VILLAGE	Rn (Bq/m^3)	Tn	EERC	EETC	F FOR Rn	F FOR Tn
PALI	20	11	13.37	0.65	0.66	0.06
RUPAPUR	15	24	11.52	0.6	0.76	0.02
NADKHERA	52	20	16.07	0.96	0.31	0.05
JOTPURVA	78	13	14.86	1.39	0.19	0.11
HARPALPUR	35	17	18.87	0.99	0.54	0.06
KAKRA	48	16	20.80	1.91	0.43	0.12
SAWYAZPUR	42	14	13.37	1.18	0.32	0.09
ANJHI SHAHABAD	45	19	14.23	1.34	0.31	0.07
GAHRI CHAND KHAN	45	25	19.73	1.4	0.44	0.06
NAGLA LOTHU	58	26	17.41	0.94	0.3	0.05
DANIYA PUR	35	25	17.48	1.77	0.5	0.07
BEHTA GOKUL	70	20	13.77	0.96	0.2	0.05
HARDOI CITY	40	16	16.49	0.56	0.41	0.03
BILGRAM	42	22	16.87	0.95	0.4	0.04
SHAHABAD	53	13	14.28	1.06	0.27	0.08
ROSANPURVA	45	18	10.43	1.14	0.23	0.06
LAKHNAUR	45	13	11.8	1.17	0.26	0.09
JALPAPUR	59	18	12.7	0.98	0.21	0.05
AVE.	46	18	15.22	1.11	0.37	0.06
MAX.	78	26	20.8	1.91	0.76	0.12
MIN.	15	11	10.43	0.56	0.19	0.02
SD.	15	5	2.93	0.37	0.16	0.03
GM.	43	18	14.96	1.05	0.35	0.06
S.E	3.53	1.18	0.69	0.09	0.04	0.01

Table 2: (Summurasied results of Radon, thoron, EERC, EETC & Equilibrium factor in residential houses of Hardoi, Uttar Pradesh)

	Rn (Bq/m^3)	Tn (Bq/m^3)	EERC (Bq/m^3)	EETC (Bq/m^3)	F(Rn)	F(Tn)
Average	46	18	15.22	1.11	0.37	0.06
Minimum	15	11	10.43	0.56	0.19	0.02
Maximum	78	26	20.8	1.91	0.76	0.12
Standard Deviation	15	5	2.93	0.37	0.16	0.03
Geometric Mean	43	18	14.96	1.05	0.35	0.06

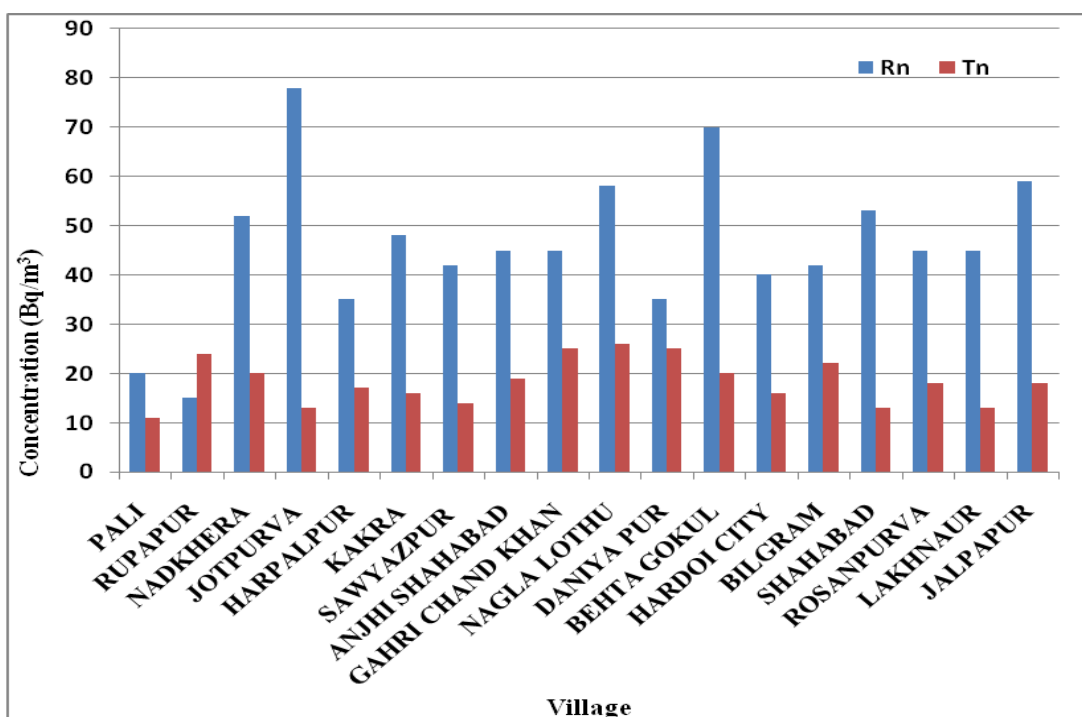


Figure 1: Rn/Tn graph for various locations

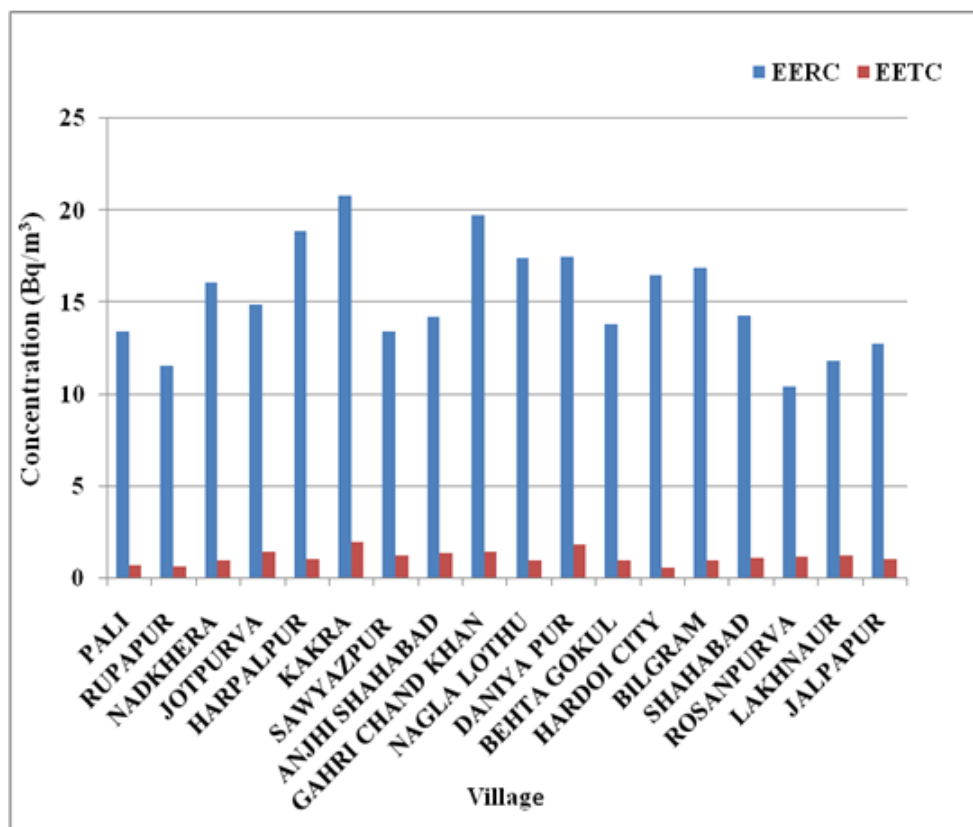


Figure 2: EERC/EETC graph for various locations

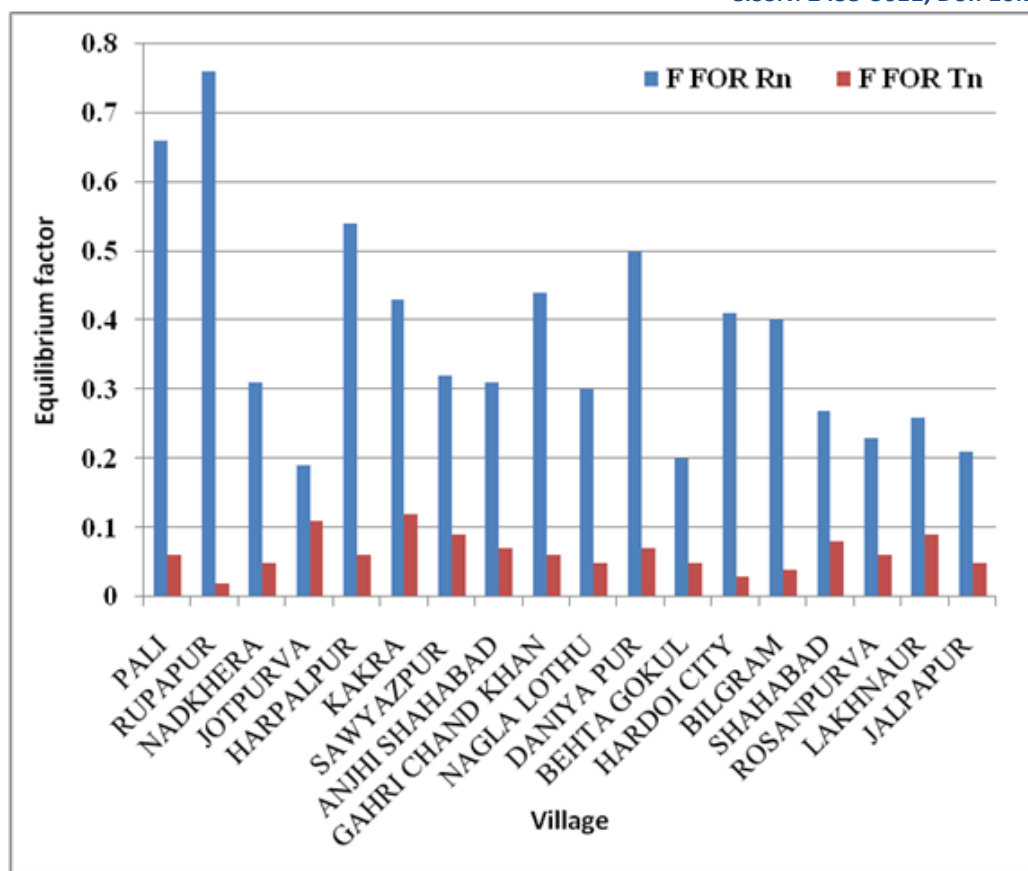


Figure 3: F (Rn)/ F(Tn) graph for various locations

CONCLUSIONS

It is observed that the concentration of radon and thoron in mud houses are high compared to the cemented houses. The higher concentration of radon and thoron in some houses is possibly because of the poor ventilation condition in houses. The emanation from the ground surface and from the building materials of mud houses results in the high value of radon and thoron inside the room (Anil Kumar et.al. 2015). The activity concentration of radon, thoron and their progeny are largely influenced by the factors such as topography, type of house construction, building materials, temperature, pressure, humidity, ventilation, wind speed and even the life style of the people living the house (Martz et al., 1991, Subba Ramu et al., 1988).

In present study it is found that the indoor radon, thoron and their progeny concentration is below internationally accepted norms and there is no urgent need for any special intervention on this account. However, since the neighbor regions of HarDOI city is undergoing major new construction activity, it would be useful for the city administration to educate property developers and builders in the region on the measures they could take to minimize indoor radon and thoron gas build up.

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