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MONITORING OF INDOOR RADON, THORON AND THEIR PROGENY IN SOME PARTS OF BUNDELKHAND

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The radon, thoron activities and inhalation doses have been measured in different dwellings of Bundelkhand region of Uttar Pradesh. Inhalation of indoor radon (^{222}Rn), thoron (^{220}Rn) and their progeny contribute a major fraction of total radiation dose to human beings from all possible sources of natural radioactivity. The indoor radon and thoron map of Bundelkhand region will provide a valuable database for any study related to radon and thoron anomalies. The indoor inhalation exposure effective doses have been compared with the dose constraint proposed by International Commission for Radiological Protection (ICRP).]

KEYWORDS: Radon, Thoron, Annual effective dose

INTRODUCTION

^{222}Rn (radon) and ^{220}Rn (thoron) are the two significant isotopes of radon which are produced from radium decay in lengthy sequences of decays that originates from natural radioactive series. Exposure to radon (^{222}Rn) and its progeny in indoor environment can result in sufficient inhalation risk to population. Studies have shown that natural sources account for almost 98% of average radiation dose received by human. Out of which about 52% is due to inhalation of radon, thoron and progeny present in the dwellings [1, 2]. Thoron being short lived relative to radon crosses over a much smaller distance from its source. Amount of thoron is enhanced only in region where Th/U ratio is very high.

There are three main mechanisms through which radon is supposed to enter into a building [3]; convection via utility access points, cracks and openings, diffusion from soil via the pore space of the building material and emanation from building materials. High indoor radon concentration is usually due to penetration from the surrounding soil. Radon levels in a home depend upon the level of radon in the soil, type of soil, porosity of soil, openings to buildings and ventilation. Outdoor radon concentrations are low but indoors this gas may accumulate in high concentrations emitted from the soil and from building materials when the room is not properly ventilated. Radon progenies are electrically charged and so can attach themselves to tiny dust particles, water vapours, 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 irradiate the tissue. Bronchial stem cells and secretion cells in airways are considered to be the main target cells for the induction of lung cancer resulting from radon exposure. The exposure of high concentrations of radon and its progenies for a long period lead to pathological effects like the respiratory functional changes and the occurrence of lung cancer [4]. Considering the adverse health effects of inhaled radon and its progeny, ICRP has made recommendations for the remedial action for this exposure in dwellings and work place [5].

Radiation data for the major part of Bundelkhand region have not been reported so far. Bundelkhand is an old landmass composed of horizontal rock beds resting on a stable foundation. The landscape is rugged, featuring undulating terrain with low rocky outcrops, narrow valleys, and plains. Surface rocks are predominantly granite of the Lower Pre-Cambrian/Arcane period. In the present work environmental monitoring of radon, thoron and their progeny in different dwellings of Bundelkhand region has been carried out using the radon-thoron twin dosimeter cups.

EXPERIMENTAL DETAILS

To measure the indoor ^{222}Rn, ^{220}Rn and progeny levels, the passive solid state nuclear track detector (SSNTD), LR-115, type II, pelliculable was employed in twin cup dosimeters developed at BARC Mumbai. This dosimeter is made of plastic cylindrical cups and is divided in to two equal compartments, each having the inner volume of 135 cc and a height of 4.5 cm[6]. The cup has three different modes- bare mode, filter mode and membrane mode. Three pieces of LR-115 solid state nuclear track detectors of the size (1 cm × 1 cm) were fixed in the dosimeters. These dosimeters were suspended in the dwellings at height of about 2.0m from the floor level for the period of three months. The bare mode detector registers tracks due to Radon, Thoron and their progeny. The tracks due to radon and thoron are registered by filter mode detectors, while the membrane mode detector registers alpha tracks only due to radon. At the end of three months, the exposed detectors were then etched in NaOH solution (2.5N) at 60^{o}C for two hours using a constant temperature bath. The tracks were counted using Spark counter. It is specially designed counter (manufactured by Pollteck Instruments Pvt. Ltd.) meant for counting the alpha tracks in pelliculable LR-115 detectors.

TOTAL ANNUAL INDOOR INHALATION EFFECTIVE DOSE EQUIVALENTT

The concentrations of radon (C_R) and thoron (C_T) in Bq. m^{-3} were determined from the track densities (T_1) in cellophane membrane compartment and (T_2) in filter compartments using the equations [6, 7] :

$$C_R = \frac{T_1}{d / k_m} \qquad \dots (1)$$

$$C_T = \frac{T_2 - C_R\, d.k_{rf}}{d\,.K_{tf}} \qquad \dots (2)$$

where k_m and k_{rf} are calibration factors for radon gas in the membrane and filter paper compartments, k_{tf} is calibration factor for thoron in filter paper compartment and d is duration of exposure in days. Calibration factors have been calculated as (k_m = 0.019 tr. cm^{-2} d^{-1} per Bq m^{-3}) for SSNTD-1 (compartment *M*) and (k_{rf} = 0.019 tr. cm^{-2} d^{-1}per Bq m^{-3}) for SSNTD-2 (compartment F) k_{tf} = 0.016 tr. cm^{-2} d^{-1} per Bq m^{-3}) and used in the present study [8]. The annual indoor inhalation effective dose equivalent (in mSv) due to radon, thoron and their progenies received by the inhabitants in the dwellings under study was estimated using the following equation (UNSCEAR, 2000) [9]:

$$D\ (mSv^{-1}) = [(0.17 + 9F_{Rn})\ CRn + (0.11 + 32F_{Th})\ C_{Th}] \times 8760 \times 0.8 \times 10^{-6}$$

where, F_{Rn} =equilibrium factor between radon and its progeny; C_{Rn} = radon concentration; F_{Th}= equilibrium factor between thoron and its progeny and C_{Th} = thoron concentration. Here 0.8 is the indoor occupancy factor. Radon and thoron progeny levels in mWL have also been calculated using indoor equilibrium factor 0.4 for radon and 0.1 for thoron from UNSCEAR [9].

Table 1. Radon and Thoron concentration and inhalation dose in some localities of Bundelkhand region

Location	Radon Con. C_R (Bqm^{-3})	Thoron Con. C_T (Bqm^{-3})	Inhalation Dode D ($mSvy^{-1}$)
Maudaha	30.4 ± 2	24.3 ± 2	1.5
Karwi	65.4 ± 7	26.1 ± 4	2.5
Kabrai	62.9 ± 8	24.4 ± 4	2.4
Mahoba	122.8 ± 19	13.8 ± 5	3.9
Manikpur	66.5 ± 9	32.3 ± 3	2.7
Atarra	32.6 ± 3	18.1 ± 3	1.4
Banda	34.1 ± 2	12.8 ± 3	1.3
Hamirpur	62.1 ± 9	22.9 ± 5	2.3

Table 2. Comparison of indoor radon levels with some data of different regions

Range	Region	Reference
37-134	Rajasthan	Kumar *et al*., 1994 [10]
145-165	Himachal Pradesh	Virk, 1999 [11]
58-240	Punjab	Singh *et al*., 2005 [12]
44-373	Kerala	Kumar *et al*., 2007 [13]
30-287	Tamilnadu	Kumar & Prasad, 2007 [14]
13.5-143	All India	Ramchandran, ,1998 [15]
30.4-122.8	Bundelkhand (U.P)	Present Study

RESULTS AND DISCUSSION

Table 1 gives the radon and thoron concentration in the dwellings of some parts of Bundelkhand region. The radon concentration varies from 30.4± 2 to 122.8 ± 19 Bqm^{-3}. The thoron concentration in the same dwellings varies from 12.8 ± 3 to 32.3 ± 3 Bqm^{-3}. It is to be noted that the indoor variation of radon and thoron concentrations are mainly caused by the variation in the ventilation conditions which can be controlled by the occupants. The indoor radon levels in many of the dwellings are observed to be higher than the world wide indoor radon level of 40 Bqm^{-3} (UNSCEAR, 2000). The indoor thoron levels were higher than the worldwide value of 10 Bqm^{-3} (UNSCEAR, 2000).

The International Commission on Radiological Protection (ICRP, 1994) recommends the remedial action against radon above annual effective dose rate of 10 mSv, an action level within 3-10 $mSvy^{-1}$ has been proposed. From the results of the annual indoor effective dose in table-1, it is evident that for average occupancy of 7000 h per year, the effective dose in all the dwellings is found to be below the remedial action limit of 10 mSv.

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