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ASSESSMENT OF INDOOR RADIATION DOSE RECEIVED BY THE RESIDENTS OF NATURAL HIGH BACKGROUND RADIATION AREAS OF COASTAL VILLAGES OF KANYAKUMARI DISTRICT, TAMIL NADU, INDIA

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Abstract

Radiation exposure and effective dose received through two routes of exposure, viz. external and internal, via inhalation, by residents of coastal villages belonging to Natural High Background Radiation Areas (NHBRA) of Kanyakumari District and Tamil Nadu in India were studied. While the indoor gamma radiation levels were monitored using Thermo Luminescent Dosimeters (TLDs), the indoor radon and thoron gas concentrations were measured using twin chamber dosimeters employing Solid State Nuclear Track Detectors (SSNTDs, LR-115-II). The average total annual effective dose was estimated and found to be varied from 2.37 to 8.64 m Sv.

Keywords: Radon, Thoron, Effective dose

INTRODUCTION

Over the past few decades, there have been increasing interest in epidemiological studies pertaining to the health effects of chronic radiation exposure to population living in the natural high background radiation environment. A number of investigators have measured the indoor radiation level in dwellings from different parts of the world (Narayana *et al.*, 1998). These studies include large scale residential radon, thoron surveys carried out in several countries and many surveys of populations exposed to high background radiation areas (Sreenivasa Reddy *et al.*, 2003; Chougaonkar *et al.*, 2004). Natural high background radiation results from the naturally occurring radio nuclides, present in earth's crust and cosmogenic radiation from space. This background radiation is a major source of radiation exposure to the human. Inhalation is one of the pathways, by which radioactive nuclides are transferred into humans body. The long term monitoring of radioactivity in air provides useful information about the radiation in the environment and helps to evaluate their impact on man (Danalakshmi *et al.*, 2008). There are several areas in the world with certain pockets in Brazil, China, India, Australia, France and Iran, where the background radiation levels are alarmingly high. The major sources responsible for exposure are naturally occurring radio nuclides in the earth's crust such as ^{232}Th, ^{238}U, ^{226}Ra, ^{40}K, etc. which are associated with minerals such as monazite and zircon. Exposure to ionizing radiation from natural sources by man, whether indoor or outdoor, is a continuous and unavoidable feature of life on each (Obed *et al.*, 2005). In this study an attempt has been made to estimate the annual effective dose to humans inhabiting high background areas.

MATERIALS AND METHODS

For the present study, ten sampling stations were identified along the south – west coast from Muttom to Colachel via Manavalakurichi (Fig. 1). The radiation exposure and effective dose received by the residents of 10 villages belonging to natural high background radiation areas of coastal villages of Kanyakumari District of Tamil Nadu, India studied. Five houses in each village were selected for the study.

INTERNAL DOSE USING SSNTDs

The internal dose due to radon, thoron and progeny was estimated using SSNTD films (LR-115-II), exposed in three different modes. The installed SSNTDs was left undisturbed in their places for 90 days and replaced with new ones at the same place, and this process was continued for one year. At the end of the stipulated period of exposure, usually about three months, the dosimeters were retrieved and processed according to the standard procedure followed in the Environmental Assessment Division (EAD), BARC, India. The exposed SSNTD films were etched with 10% NaOH solution at 60^o C for 90 mm with mild stirring and the tracks developed are measured using a spark counter (Eappen *et al.*, 2001). The inhalation effective dose equivalent was estimated using the formula (Mayya *et al.*, 1998),

$$D = 10^{-3}[(0.17 + 9F_R)C_R + (0.11 + 32F_T)C_T] mSvy^{-1}$$

where C_R and C_T indicates the radon and thoron concentrations, respectively, and F_R and F_T are equilibrium factors for radon and thoron progeny corresponding to the extracted ventilation rates, respectively, (Barooah *et al.*, 2003). The details of the methodology involved, dosimetry technique, standardization and the measurement procedure are discussed elsewhere (Ramachandran *et al.*, 2003).

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EXTERNAL DOSE USING TLDs

The external doses received by the residents were estimated using TLDs, replaced on a quarterly basis After the exposure of 90 days, the TLDs were analysed at EDA,BARC. During the replacement time the external gamma doses were also measured inside and outside the houses using a scintillation survey meter and the estimated doses were compared. The equilibrium factor for radon was taken as 0.4 and for thoron it was taken as 0.03 for indoor exposure (Ramachandran *et al.*, 2003). The occupancy factor was taken as 0.8. The total effective dose was estimated as the sum of the external and internal doses received from ^{232}Th and Rn/Tn progeny. In order to make a rough estimate for the annual indoor effective dose equivalent due to gamma radiation, one has to take into account the conversion coefficient from absorbed dose in air to effective dose and the indoor occupancy factor. In the UNSCEAR (2000) report, the Committee used 0.7 Sv Gy^{-1} for the conversion coefficient from absorbed dose in air to effective dose received by the inhabitants and 0.8 for the indoor occupancy factor.

RESULTS AND DISCUSSION

Ten different sampling stations with the names and coordinates are given in Table 1. At each site, the ambient gamma radiation level was measured with the Scintillometer at least in five different points and the mean values were considered. The Scintillometer was kept one meter above the ground level while measuring the dose rate. The indoor gamma dose, TLD and the percentage of monazite in the soil are given in Table 2 . The indoor gamma dose measured by TLD varied from 1.37 to 4.12 mSv y^{-1}. The maximum value was observed at Chinnavilai and the minimum at Colachel. The dose observed using Scintillometer also follows the same trend with a maximum of 3.45 mSv y^{-1} at Chinnavilai and the minimum of 1.08 mSv y^{-1} at Colachel. The percentage of monazite varied from 1.11 to 3.99. There is a good agreement between the dose estimated by both scintillation and TLDs as shown in Fig. 2. As the TLDs were exposed for 90 days the data collected are more reliable than that of scintillation survey meter. Hence doses collected from TLDs are used for the calculation of the effective dose. The variation seen in this high background area may be due to the variation in the monazite concentration and radon / thoron emanation from the soil to air. There is a significant positive correlation ($r = 0.89$, $n = 10$, $p < 0.05$) between the two doses as seen from Fig 3.

The indoor radon and thoron levels measured using SSNTDs and annual effective dose to inhalation of radon and thoron in this area as presented in Table 3. The Equilibrium Equivalent Concentration of radon varied from 13.01 to 52.51 Bq m^{-3} and that of thoron varied from 0.75 to 4.93 Bq m^{-3}. Comparable values have been reported in Denmark (Ulbak *et al*., 1988) where the thoron level varied from 0.75 to 4.93 Bq m^{-3}. The higher contribution from radon (Fig.4). is attributed to the longer half life of radon. The indoor radon/thoron in all the villages fall within the world average level of 40 Bq m^{-3} and 10 Bq m^{-3} respectively (UNSCEAR, 2000). As expected there is a positive significant correlation between radon and thoron concentrations ($r =0.93$, $n = 10$, $p < 0.05$) as observed Fig.5. The variation in the indoor gamma dose is due to the contribution from the building construction material, ventilation and air exchange rates of the buildings and locations. The innocent people especially the fishermen folk living in the coastal belt are using the highly active monazite sand for construction of houses which increases their indoor gamma dose. The external and internal doses can be considerably reduced by removing the monazite content present in the soil by mineral separation. The internal dose due to the gases can be further reduced by providing proper ventilation to the houses. Over-exposure to radiation could cause possible cytogenetic changes.

The external dose varies from 1.37 to 412 mSv y^{-1} whereas the internal dose from 1.00 to 4.52 mSv y^{-1} and the total dose ranging from 2.37 to 8.64 mSv y^{-1}.The International Commission on Radiological Protection (ICRP, 1994) has recommended that remedial action against radon is always justified above a continued annual effective dose of 10 mSv y^{-1}. From the results given in Table 4, However the annual effective dose in all the villages under the study area are found to be below the limit of 10 mSv y^{-1} .

CONCLUSION

The total effective dosage (indoor + outdoor) received by the villagers under the study area falls below the prescribed limit of 10 mSvy^{-1} (ICRP). But Kadiapattinum and Chinnavilai area have recorded the maximum in the study area. The higher values are attributed to the radioactive hotspots in the area wherein the local populace have their residences built.

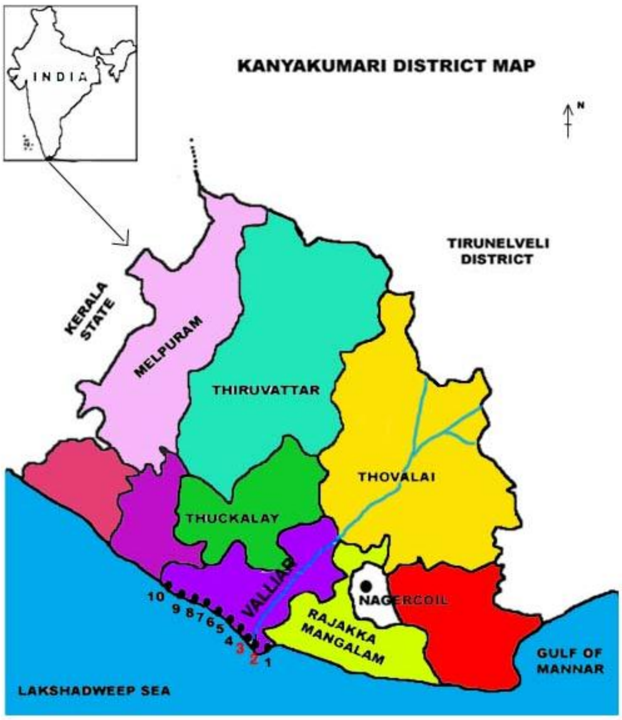

Fig 1. The Sampling Stations

1. Muttom
2. Kadiapattinam
3. Chinnavilai
4. Periavilai
5. Manavalakurichi
6. Parapattu
7. Kootumangalam
8. Pudur
9. Mondaikadu
10. Colachel

Table 1: Geographical locations of the sampling stations

S.No	Sampling Stations	Latitude N	Longitude E
1	Muttom	08 º 07.439 ´	077 º 19.000 ´
2	Kadiapattinum	08 º 07.921 ´	077 º 18.361´
3	Chinnavilai	08 º 08.608 ´	077 º 18.137 ´
4	Periavilai	08 º 08.728 ´	077 º 17.997 ´
5	Manavalakurichi	08 º 09.112 ´	077 º 17.654 ´
6	Parapattu	08 º 09.332 ´	077 º 17.471 ´
7	Kootumangalam	08 º 09.445 ´	077 º 17.308 ´
8	Pudur	08 º 09.562 ´	077 º 16.923 ´
9	Mondaikadu	08 º 09.784 ´	077 º 16.656 ´
10	Colachel	08 º 10.338´	077 º 15.316 ´

Table 2: Comparision of estimated dose by Scintillation survey meter and TLD exposure

Sampling stations	Dose estimated Using Scintillometer (mSv y^{-1})	Dose estimated Using TLD (mSv y^{-1})	% of monazite.
Muttom	1.37	2.01	1.16
Kadiapattinum	2.95	3.04	3.00
Chinnavilai	3.45	4.12	3.99
Periavilai	2.65	2.89	1.21
Manavalakurichi	2.43	2.13	1.25
Parapattu	2.12	3.12	2.31
Kootumangalam	2.05	1.92	1.15
Pudur	1.37	1.47	2.73
Mondaikadu	2.11	2.37	1.08
Colachel	1.08	1.37	1.11

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Table 3: Radon Thoron concentration and the annual effective dose (mSvy^{-1})

Sampling stations	^{222}Rn(Bq m^{-3})	^{220}Rn(Bq m^{-3})	Annual effective dose (mSv y^{-1})
Muttom	14.12	0.92	1.12
Kadiapattinum	40.81	4.93	3.87
Chinnavilai	52.51	4.62	4.52
Periavilai	28.43	2.01	2.31
Manavalakurichi	27.95	1.71	2.20
Parapattu	25.51	1.18	1.89
Kootumangalam	18.31	0.85	1.36
Pudur	15.74	1.25	1.30
Mondaikadu	20.32	1.35	1.62
Colachel	13.0	0.75	1.00

Table 4: Total (external + internal) dose received by the residents of the study area

Sampling stations	External (mSvy^{-1})	Internal (mSvy^{-1})	Total (mSvy^{-1})
Muttom	2.01	1.12	3.13
Kadiapattinum	3.04	3.87	6.87
Chinnavilai	4.12	4.52	8.64
Periavilai	2.89	2.31	5.20
Manavalakurichi	2.13	2.20	4.33
Parapattu	3.12	1.89	5.01
Kootumangalam	1.92	1.36	3.28
Pudur	1.47	1.30	2.77
Mondaikadu	2.37	1.62	3.99
Colachel	1.37	1.00	2.37

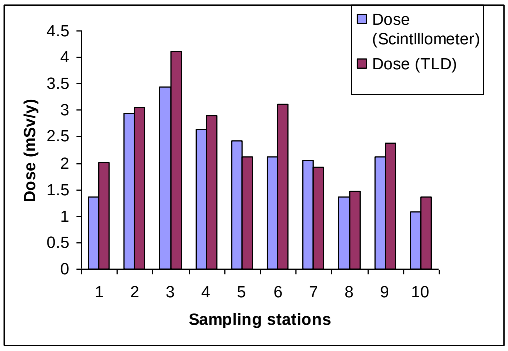

Figure 2: Comparison of dose due to Scintillometer and TLD

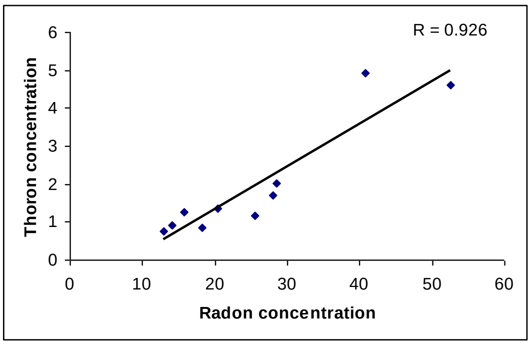

Figure 3: Correlation between Radon and Thoron

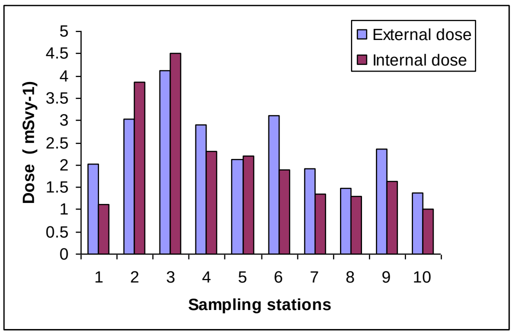

Figure 4: Comparison of external and internal dose

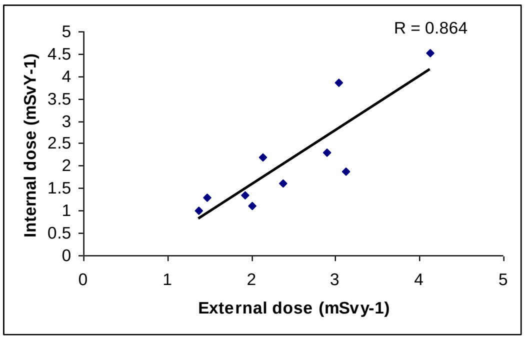

Figure 5: Correlation between external and internal dose

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