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Studies on thoron and its progenies levels around Bangalore rural district

C.Ningappa[1], J.Sannappa[2]*, M.S.Chandrashekara[3], L.Paramesh[3]

[1]Vidya Vikas Institute of Engineering and Technology, Mysore-570 010, (INDIA)

[2]Department of Physics, Yuvaraja's College, Mysore-570 005, (INDIA)

[3]Department of studies in Physics, University of Mysore, Manasagangotri, Mysore -570 006, (INDIA)

E-mail: sannappaj@yahoo.co.in

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ABSTRACT

The thoron survey was performed in granite quarries around Bangalore rural district in the scope of a lung cancer epidemiological study. Long duration measurements of outdoor thoron and its progenies concentrations were made around granite quarries of Bangalore rural district by using solid state nuclear track detector based double chamber dosimeters (LR-115, Type-II Plastic track detector) during summer and winter period (2006-07). The thoron concentration in granite quarries varies from 30 to 160 Bq.m^{-3} with a median of 84.5 Bq.m^{-3} and its progenies varies from 0.1 to 4.0mWL with a median of 1.2mWL respectively. Higher concentrations of thoron and its progenies were observed where the granite rocks are exposure to the surface and are containing higher concentration of thorium. The concentration of thoron and its progenies and equivalent effective dose are tabulated with light limit of ICRP limits.

KEYWORDS

Thoron;
Outdoor;
SSNTDs;
Spark counter;
Granite quarries.

INTRODUCTION

In the most human radiation exposure studies, the contribution of thoron is usually neglected. But for a long time, it is well known that residuals of high background areas like Brazil, China and India where the predominant geological materials, decomposed granites, which has relatively high content of ^{232}Th, receives high doses so, it is incorrect to neglect thoron studies. The study area shows higher concentration of thoron and its daughter products and activity of ^{232}Th[1]. Exposure of persons to high concentrations of radon, thoron and their short lived progenies for a long periods leads to pathological effects like the respiratory functional changes and occurrence of lung cancer[2-7]. Many authors have investigated radon, thoron and their progenies owing to the effect of natural radiation exposure on health, particularly in relationship with various type of cancer[8-17]. In 1988, the International Agency for Research on Cancer (IARC) identified radon is a lung concerning gas[18]. The granite rocks relatively higher contents of radionuclide[19].

Surveys in Europe and Asia revealed that the dose contribution due to inhalation of thoron and its short-lived progenies could equal or even exceed that of radon and its progenies. The low-level concentration of

radiation emitted from these materials contributes heavily to the exposure dose to the public living around the quarries and workers[20]. In view of the fact that the study on environmental radiation levels from the granite quarries important. The results would serve as base line data for the populated area near the granite quarries aiming at assuming the risk caused to the public by exposure of the terrestrial radiation. Therefore data obtain from such study may be used locally to establish if and where controls are needed. The aim of the present study is to measurement of concentrations of thoron and its progenies and radiation dose due to these gases to the population and workers in granite quarries.

Study area

The area of the present study is the Bangalore rural district in Karnataka, India. It is located in the southern part of Karnataka State. Bangalore is the capital of Karnataka state. The district occupies an area of 5854 sq. kms lying between Latitudes 12° 15' and 13° 31' and Longitudes 77° 04' and 77° 59' covering parts of the toposheets 57 G and H.

The geology of this part of southern India[21-22] forms predominantly a granitic terrain with numerous varieties of granite and granitic gneiss, charnockite, alkaline rocks etc. The rocks around Bangalore rural District are called closepet granites. These rocks are younger than peninsular granites. These rocks are also consists of pegmatite. The common rocks are pink, gray, porphyritic, gneiss, feldspar and dolerite. Within this vast granitic complex, deposits of quartzite, sandstone, and marble are found in significant quantities. The rocks are of peninsular gneiss and are widely distributed throughout this area. The emplacement of alkaline dykes has domed up the area. The mining activity in this area covering a strange of more than 80 hillocks spread between Kanakapura, Ramanagara and Bidadi over 500 square kilometer (shown in figure 1). About 40 granite quarries are seen around this area out of which 28 quarries are selected. Nearly 4000 laborers are involved in stone crushing and loading activities. The soil in this area is red sandy loam with traces of yellow and black soil. The soil being porous, permits free internal and downward movement of water. Mixed red and black colored soil is formed the underlying parent rock, which is mostly granite.

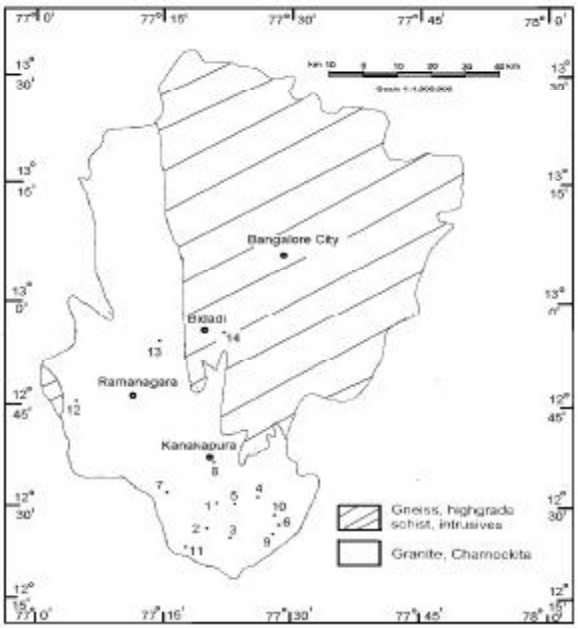

Figure 1: Study area (Bangalore district)

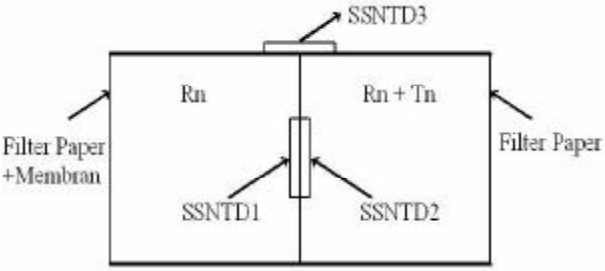

Figure 2: Twin-cup dosimeter

Methodology

Thoron and its progenies concentrations in some dwellings around the granite quarries were measured using Solid State Nuclear Track Detectors (SSNTD) based double chamber dosimeters. SSNTDs films are thin sheets of dielectric materials such as Cellulose Nitrate (CN) and polycarbonates. They are sensitive to alpha but not to beta and gamma radiation. They are unaffected by moderate humidity, heat and light. Normally LR-115 TYPE-II (Kodak Pathe, France) plastic track detector (C N film) is preferred for measurement of these gases and their progenies.

The double chamber dosimeter cups used for monitoring thoron and its progenies are shown in figure 2. Each chamber has a length of 4.5cm and a radius of 3.1cm. The SSNTDs used are 12μm thick. The SSNTD1 placed in compartment 1 measures only radon, which diffuses into it from the ambient air through

TABLE 1: Average ^{220}Rn and its progeny concentrations and equivalent effective dose

Zone	Villages	Quarries	Conc. (Bq.m^{-3})	Progenies conc. (mWL)	Eq.eff.dose (mSv.y^{-1})
			^{220}Rn	^{220}Rn	Total
		A.Kanakapura Taluck			
I	1. Maralebekuppe	Q_1	136	2.00	0.25
		Q_2	160	1.17	0.30
	2. Alanahally	Q_3	87	1.20	0.16
		Q_4	100	2.22	0.19
	3. Hosahally	Q_5	130	0.65	0.24
	4. Terinadoddi	Q_6	130	1.40	0.24
II	5. Kodihally	Q_7	142	2.10	0.27
		Q_8	115	2.56	0.22
		Q_9	110	1.23	0.21
	6. Nayakaradoddi	Q_{10}	60	1.16	0.11
		Q_{11}	150	1.12	0.28
	7. Ramanahally	Q_{12}	70	0.75	0.13
		Q_{13}	112	1.20	0.21
III	8. Maharajakatte	Q_{14}	60	0.15	0.11
		Q_{15}	66	0.45	0.12
		Q_{16}	38	0.4	0.07
	9. Puttadasanadoddi	Q_{17}	42	0.13	0.08
		Q_{18}	39	0.18	0.07
IV	10.Moolegondi	Q_{19}	42	0.10	0.08
		Q_{20}	30	4.0	0.06
	11. Kabballi	Q_{21}	42	0.20	0.08
		Q_{22}	35	0.60	0.07
		B.Ramanagara Taluck			
II	12. L B Palya	Q_{23}	89	3.20	0.17
		Q_{24}	82	2.80	0.15
	13. K G Hosahally	Q_{25}	128	1.42	0.24
		Q_{26}	79	1.30	0.15
		C.Bidadi Hobli			
	14. KallugopaHally	Q_{27}	76	2.10	0.14
		Q_{28}	118	1.30	0.22
	Average		88	1.32	0.17

a semi-permeable membrane(e.g. latex, cellulose nitrate etc.). These membranes have permeability constants in the range of 10^{-8}-10^{-7} cm^2.s^{-1} and allow more than 95% of the radon gas to diffuse and suppress thoron gas to less than 1% [23]. On the other hand, the glass fiber filter paper in compartment 2 allows both radon and thoron gas to diffuse in and hence the tracks on SSNTD2 are related to the concentration of both gases. The SSNTD3 exposed in the bare mode(placed on the outer surface of the dosimeter) registers alpha tracks attributable to the air borne concentrations of both the gases and their progenies[24]. To measure thoron and its progenies concentrations the detector was mounted inside an inverted 1-liter plastic cylinder on protection against direct sunlight and a nylon stocking covered the entire assembly to protect the dust filter from insects. At the end of the stipulated period of exposure, usually about 100 days, the dosimeters are retrieved and all the three SSNTDs are etched with 10% of NaOH solutions for 1hr at a bath temperature of about 60°C.The track density of alphas in the film was determined using a spark counter. The thoron levels and its progenies working level concentrations are calculated by the following relations.

$$C_R\,(Bq.m^{-3}) = T_m / d.S_m \quad (2)$$

$$C_T\,(Bq.m^{-3}) = T_f - d\,.C_R\,S_{rf}/d.S_{tf} \quad (1)$$

Where, d=Period of exposure, (days); T_f = Track density of the film in filter compartment; S_{rf} =Sensitivity of radon in filter compartment; S_{tf} =Sensitivity of thoron in filter compartment; C_R = Radon concentration; C_T = Thoron concentration

$$R_T\,(mWL) = C_T F_T / 0.275 \quad (2)$$

Where, R_T = Thoron progenies concentration; F_T = 0.91 f_{TB} +

$0.09f_{TC}$

Where f_{TB} and f_{TC} are activity fractions with respect to parent gas, F_T be the equilibrium factor for thoron progenies, corresponding to the extracted ventilation rate[24]. From the equilibrium factors working level concentrations are calculated. The inhalation dose due to thoron was calculated by using conversion coefficient 32mSvy^{-1} and equilibrium factor 0.1 for thoron. The dose coefficient for thoron dissolved in blood are calculated using conversion coefficient 0.11nSv. Finally an estimation of the inhalation dose in mSv.y^{-1} may be provided using the formula[2].

$$D(mSv.y^{-1}) = (0.11 + 32F_T)\, C_T \times 1750 \times 10^{-6} \quad (3)$$

RESULTS AND DISCUSSIONS

Measurement of thoron and its progenies concentrations were performed in 28 granite quarries during the winter and summer period (2006-07) by using Solid State Nuclear Detector (SSNTD). To understand the role of geology of rocks, the study area is divided into four zones on the bases of types and colours of bedrock.

1. The rocks are pink colour in the first zone. They are extended to several kilometers and these rocks are observed in quarries of Alanahally and Maralebekuppe.
2. The rocks are gray colour in second zone. These rocks are observed in quarries of Hosahally, Terinadoddi, Kodihally, Nayakaradoddi, Ramanahally (Kanakapura Taluck), L B Palya, K G Hosahally (Ramanagara Taluck) and Kallugopahally (Bidadi Hobli).
3. Pink granites are overlapped by altered granites in the third zone. These rocks are observed in quarries of Maharajakatte and Puttadasanadoddi.
4. Pink granites are overlapped by Dolerite (Black type rock) in the fourth zone. They are extended to several kilometers. These rocks are observed in quarries of Moolegondi and Kabballi.

All the quarries are surrounded by hillocks. Accordingly zone wise variation of thoron and its progenies concentration levels are summarized in TABLE 1. From the Table, the concentration of thoron varies from 30 to 160 Bq.m^{-3} with a median of 84.5 Bq.m^{-3} and its progenies vary from 0.1 to 4.0mWL with a median of 1.2mWL. There is no correlation was observed between thoron and its progenies. The wide variation may be due to the human activity and atmospheric condition. The progenies concentrations show negative correlation with parent gases. The present study establishes that the correlation between thoron and its progenies, geological formation of that area, stone cracks and breaks of the bedrock due to mining activity.

The maximum concentration of thoron and its progenies were observed in first zone quarries Q_1, Q_2 of Alanahally and Q_3, Q_4 of Maralebekuppe villages. All these quarries are attributed by pink granite. These are younger than altered granites and these rocks may be containing higher activity of radionuclide. Emanation of thoron depends on the activity of ^{232}Th present in rocks, porosity, grain size and permeability[24-26]. Due to the mining activity, the structure of the bedrock in the vicinity of the quarries gets destroyed and fissured. Due to these transformations in bedrock, thoron is easy to migration over the ground and the subsequent penetration into atmosphere and houses near the quarries. The rocks are broken into finer grains due to the mining activity. As a result the grain size decreases and the activity of ^{232}Th increases resulting higher concentration of this gas. This is an addition exposure to the public and the workers.

Gray granites were observed in second zone. Quarries Q_5 of Hosahally, Q_6 of Terinadoddi, Q_7, Q_8, Q_9 of Kodihally, Q_{10}, Q_{11} of Nayakaradoddi Ramanahally, Q_{23}, Q_{24} of L B Palya, Q_{25}, Q_{26} of K G Hosahally and Q_{27}, Q_{28} of Kallugopahally villages belong to second zone shows slightly less concentration of thoron compared to first zone. The gray granite may be consists of low concentration of ^{232}Th. Pink granites are overlapped by altered granites in the third zone. These rocks are observed in quarries of Maharajakatte and Puttadasana doddi. Quarries of Q_{14}, Q_{15}, Q_{16} of Maharajakatte and Q_{17}, Q_{18} of Puttadasanadoddi villages pink granites are overlapped by altered granites. These rocks may be contains less concentration of ^{232}Th. These granite quarries show slightly low concentration of thoron progenies compared to second zone quarries.

The low concentration of thoron and its progenies were observed in fourth zone quarries of Q_{19}, Q_{20} Moolegondi and Q_{21}, Q_{22} Kabballi villages. This may be due the mining activity is completely stopped and the pink granite rocks are overlapped by dolerite at a

depth of 3-7 meters. Dolerite (Black color) rocks may be containing low concentration of ^{232}Th.

CONCLUSION

The maximum concentrations of thoron and its progenies have been observed in first zone, attributed by pink granites and places where the mining activity was takes place. The concentration of thoron is mainly depends on the activity of radionuclides present in soil, rocks and mining activity. In the third and fourth zone, low concentrations of thoron and its progenies were observed. This is because mining activity was stopped and these zones attributed by altered granites and dolerite. The activity of radionuclides in altered granites and dolerite is lesser compared to pink and grey granites. The result shows that the impacts of radiation hazard due to mining activity (crushing and loading) on the laborers and public near the quarries are considerable. The concentrations of thoron and its progenies levels are higher than global average.

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