Indian J. Phys. **83** (**8**) 1201-1207 (2009)

Studies on radon/thoron and their decay products in granite quarries around Bangalore city, India

C Ningappa[1], J Sannappa[1]*, M S Chandrashekara[2] and L Paramesh[2]
[1]Department of Physics, Yuvaraja's College, Mysore-570 005, Karnataka, India
[2]Department of Studies in Physics, University of Mysore, Manasagangotri, Mysore-570 006, Karnataka, India

E-mail : sannappaj@yahoo.co.in

Abstract : The radon survey was performed in granite quarries around Bangalore rural district and Bangalore city as part of a lung cancer epidemiological study. Long duration measurements of indoor and outdoor radon, thoron and their progenies concentrations were made around granite quarries of Bangalore rural district by using Solid State Nuclear Track Detector (SSNTD, LR-115, Type-II Plastic track detector) during summer and winter period (2006-07). The increase of radioactivity in granite quarries and inhalation dose to workers and populations near the quarries have been summarized. The higher concentrations of radon and thoron in granite quarries suggest radiation health effects on workers and public around the quarries is higher than permissible levels. The results are presented and analyzed with reference to ICRP limits.

Keywords : Radon, thoron, SSNTD, Spark counter, granite quarries.

PACS Nos. : 29.40.Wk, 07.88.+y, 89.60.-k, 29.25.Rm, 91.30.pd

1. Introduction

All organisms including human beings are continuously exposed to radiation from natural sources. Among all the natural sources of radiation dose to man, inhalation of ^{222}Rn and its progenies contributes about 50% of global effective dose [1–4]. The exposure to α-radiation emitted from ^{222}Rn and its daughter products gave health hazard not only to uranium mines, but also to people living in normal houses, working places like thermal power plant, coal fields, granite areas and other related industries [5]. Nature has gifted several geological materials to mankind for building construction purposes. Granite is the one of the most important rock is used in building materials. The granite rocks relatively higher contents of ^{226}Ra, ^{232}Th and ^{40}K [6]. Many surveys have been performed to estimate the indoor and outdoor ^{222}Rn concentrations. Median of arithmatic mean values reported from different parts of the globe is found to be

*Corresponding Author

46 Bq.m^{-3} and the median of maximum values is found to be 480 Bq.m^{-3} [1,7–8].

In view of the fact studies on environmental radiation levels in granite quarries are important. The results would serve as base line data for the populated area near the granite quarries and help in assessing the risk caused to the public by both indoor and outdoor exposure to the terrestrial radiation.

2. Study area

The present area is granite quarries around Bangalore rural district (Kanakapura, Ramanagara and Bidadi) as shown in Figure 1. Bangalore is the capital city of Karnataka state, India. It lies in the South-East quadrant of state at 12°8′ latitude and 77°37′ longitude. The geology of this part forms predominantly a granite terrain with numerous varieties of granites rocks [9]. About 32 granite quarries are seen around this area out of which 28 quarries are selected. Nearly 4000 laborers are found in stone crushing and loading activities. The mining activity in this area covers 80 hillocks spread between Kanakapura, Ramanagara and Bidadi over 1000 square kilometers.

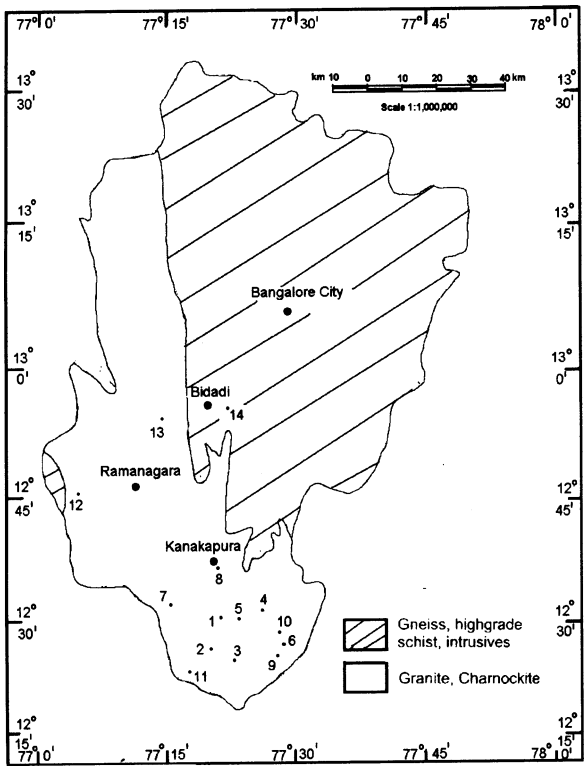

Figure 1. The study area in the Bangalore (rural and urban) district.

3. Methodology

Indoor and outdoor concentrations of ^{222}Rn, ^{220}Rn and their progeny were measured

around the granite quarries by using solid state nuclear track detectors. The inhalation dose due to radon and thoron, was calculated by using conversion coefficient 9 nSv $(Bq.h.m^{-3})^{-1}$ and 32 nSv $(Bq.h.m^{-3})^{-1}$. The dose coefficient for radon and thoron dissolved in blood are calculated using conversion coefficient 0.17 nSv $(Bq.h.m^{-3})^{-1}$ for radon and 0.11 nSv $(Bq.h.m^{-3})^{-1}$ for thoron. Finally an estimation of the inhalation dose in $mSv.y^{-1}$ may be provided using the formulae [2].

$$D\ (\text{Indoor})\ (mSv.y^{-1}) = \{(0.17 + 9F_R)C_R + (0.11 + 32F_T)C_T\} \times 7000 \times 10^{-6} \quad (1)$$

$$D\ (\text{Outdoor})\ (mSv.y^{-1}) = \{(0.17 + 9F_R)C_R + (0.11 + 32F_T)C_T\} \times 1760 \times 10^{-6} \quad (2)$$

Where C_R and C_T are the ^{222}Rn and ^{220}Rn concentration, F_R and F_T are the equilibrium factor for ^{222}Rn and ^{220}Rn concentration respectively. Occupational factor of 1760 hours for outdoors and 7000 hours for indoors is used.

4. Results and discussion

Measurement of ^{222}Rn, ^{220}Rn and their progenies concentrations were performed in 28 granite quarries and different dwellings (50) of 14 villages around the quarries during the winter (November-February) and summer (March-May) period (2006-07). To understand the role of geology of rocks in the study area is divided into four zones on the bases of types and colours. In the first zone the rocks are pink in colour. In second zone the rocks are gray in colour. In the third zone pink granites are overlapped by altered granites. In the fourth zone pink granites are overlapped by dolerite (black type rock).

All the quarries are surrounded by hillocks. Accordingly zone wise variation of concentration of ^{222}Rn, ^{220}Rn and their progenies levels are summarized in Table 1. The present studies establish that concentrations of ^{222}Rn, ^{220}Rn and their progenies depend on types of rocks, geological formation rocks of that area, stone cracks and breaks of the bedrock due to mining activity. The maximum concentration of ^{222}Rn, ^{220}Rn and their progenies were observed in quarries Q_1, Q_2, Q_3 and Q_4 of first zone of Maralebekuppe and Alanahally villages. All these quarries are rich in pink granite. These are younger than altered granites and higher concentration is observed because these rocks may be containing higher activity of ^{226}Ra and ^{232}Th and ^{40}K [10–12]. The activity of ^{226}Ra and ^{232}Th in soil and rock is found to be varying from 32.41 $Bq.kg^{-1}$ to 163.65 $Bq.kg^{-1}$ and 36.91 to 548.6 $Bq.kg^{-1}$, respectively. The pink granite shows higher activity compared to altered and gray granite [2]. The mean values of activity of radium and thorium were found to be 91.94 $Bq.kg^{-1}$ and 302.69 $Bq.kg^{-1}$, respectively. The activity of all these radionuclides is above the global average.

The II-zone is rich in gray colour granite and we observe slightly less concentration of the gases compared to I-zone. The low concentration of ^{222}Rn, ^{220}Rn and their

Table 1. Average outdoor ^{222}Rn, ^{220}Rn concentration levels and inhalation dose.

Zone	Village	Quarries	Conc. (Bq.m^{-3})		Progeny Conc. (mWL)		Inhalation dose (mSv.y^{-1})
			^{222}Rn	^{220}Rn	^{222}Rn	^{220}Rn	Total
	A. Kanakapura Taluck	Q_1	250	136	5.2	2.0	2.7
I	1. Maralebekuppe	Q_2	280	160	4.4	1.2	3.1
	2. Alanahally	Q_3	175	87	1.6	1.2	1.9
		Q_4	190	100	3.0	2.2	2.1
	3. Hosahally	Q_5	164	130	1.1	0.6	1.9
	4. Terinadoddi	Q_6	149	130	1.3	1.4	1.7
		Q_7	170	142	1.8	2.1	1.9
	5. Kodihally	Q_8	140	115	1.1	2.6	1.6
II		Q_9	132	110	1.5	1.2	1.5
	6. Nayakaradoddi	Q_{10}	100	60	2.4	1.2	1.1
		Q_{11}	185	150	2.8	1.1	2.1
	7. Ramanahally	Q_{12}	110	70	1.4	0.8	1.2
		Q_{13}	138	112	1.4	1.2	1.6
		Q_{14}	90	60	0.3	0.2	1.0
III	8. Maharajakatte	Q_{15}	50	66	0.3	0.4	0.6
		Q_{16}	74	38	1.2	0.4	0.8
	9. Puttadasanadoddi	Q_{17}	60	42	0.2	0.1	0.7
		Q_{18}	65	39	0.3	0.3	0.7
IV	10. Moolegondi	Q_{19}	55	42	0.2	0.1	0.6
		Q_{20}	45	30	2.3	4.0	0.5
	11. Kabballi	Q_{21}	50	42	0.2	0.2	0.6
		Q_{22}	55	35	0.2	0.6	0.6
	B. Ramanagara Taluck	Q_{23}	168	89	2.4	3.2	1.8
	12. L B Palya	Q_{24}	155	82	2.2	2.8	1.7
V	13. K G Hosahally	Q_{25}	140	128	1.9	1.4	1.6
		Q_{26}	165	79	1.8	1.3	1.8
	C. Bidadi Hobli	Q_{27}	150	76	3.2	2.1	1.6
	14. Kallugopahally	Q_{28}	135	118	1.7	1.3	1.5

progenies were observed in quarries of III and IV-zone. This is because mining activity was stopped in these quarries. In III-zone pink granites are overlapped by altered granites (about 3–7 meters) and in IV-zone pink granites are overlapped by dolerites (about 3–6 meters).

4.1. Indoor concentration :

The results of indoor ^{222}Rn, ^{220}Rn and their progeny concentrations were measured in different types of dwellings of 14 villages around quarries, belongs to Bangalore rural district are summarized in Table 2.

Table 2. Average indoor ^{222}Rn, ^{220}Rn and their progeny concentrations and inhalation dose around granite quarries.

Sl. No	Villages	Type of house (Roof and Floor)	Conc. (Bq.m^{-3})		Progeny Conc. (mWL)		Inalation dose (mSv.y^{-1})
			^{222}Rn	^{220}Rn	^{222}Rn	^{220}Rn	
		A. Kanakapura Taluck					
1	M Bekuppe	Small tiled, F-Cement	205	105	13.5	9.8	6.2
		Mud house, F-Bare	300	170	10.7	12.2	9.2
		Mangalore tiled, F-Cement	180	130	15.6	17.5	5.9
		Hut, F-Bare	155	80	11.1	3.1	4.7
2	Alanahally	Small tiled, F-Bare	240	120	19.6	22	7.2
		Mud house, F-Bare	260	150	16.7	25	8.0
		Hut, F-Bare	170	90	9.8	10.2	5.2
		Concrete, F-Cement	190	90	6.8	4.2	5.7
3	Hosahally	Mangalore tiled, F-Cement	150	100	17	22	4.7
4	Terinadoddi	Mangalore tiled, F-Cement	113	96	3.9	14	3.7
5	Kodihally	Small tiled, F-Bare	180	135	8.6	15	5.8
6	N Doddi	Mangalore tiled, F-Cement	149	139	6.8	8	5.0
		Mangalore tiled, F-Cement	160	90	12.5	9.5	4.9
7	Ramanahally	Small tiled, F-Bare	175	76	8.2	6.8	5.2
		Concrete, F-Cement	120	76	0.8	0.4	3.7
8	M Katte	Mangalore tiled, F-Cement	96	65	7.8	5.9	3.0
9	P D Doddi	Hut, F-Bare	70	58	0.3	0.2	2.3
10	Moolegondi	Hut, F-Bare	65	45	0.2	0.2	2.0
11	Kabballi	Hut, F-Bare	55	42	0.2	0.0	1.8
		B. Ramanagara Taluck					
12	L B Palya,	Concrete, F-Cement	110	82	0.9	0.5	3.5
13	K G Hosahally	Concrete, F-Cement	85	70	0.4	0.7	2.8
		Small tiled, F-Cement	125	92	3.3	13.5	4.0
		C. Bidadi Hobli					
14	K G Hally	Concrete, F-Cement	115	65	0.4	0.3	3.5

Higher concentrations of ^{222}Rn, ^{220}Rn and their progenies were observed in Alanahally, Maralebekuppe villages. They are situated where the granite (pink) rocks very well exposed to the surface compared to other zones. The bedrock or soil beneath a dwelling have high content of radium, due to mining activity the bedrocks gets destroyed and fissured. Hence these gases can diffuse into the dwellings through the structure of bedrock along the different layers and the cracks resulting in high concentration of ^{222}Rn and ^{220}Rn [13–15]. The lower concentration of ^{222}Rn, ^{220}Rn and their progenies were observed in III- and IV-zone. This may be due the mining activity is completely stopped and the pink granite rocks are overlapped by dolerites and

altered granites at a depth of 3–7 meters. Dolerite and altered granites may be containing lower activity of radionuclides.

The variation of ^{222}Rn, ^{220}Rn and their progenies in different types of dwellings in I-zone of Maralebekuppe villages is shown in Figure 2. Mud houses have higher concentrations compared to concrete houses and huts. It is known that the major contribution to indoor ^{222}Rn, ^{220}Rn and their progeny concentrations is due to local soil where the dwellings exist [16]. The huts have thatched roofs and small heights (2 meters) and involve good ventilation hence these show less concentration of ^{222}Rn, ^{220}Rn and their progenies concrete houses have good ventilation and hence show slightly less concentration.

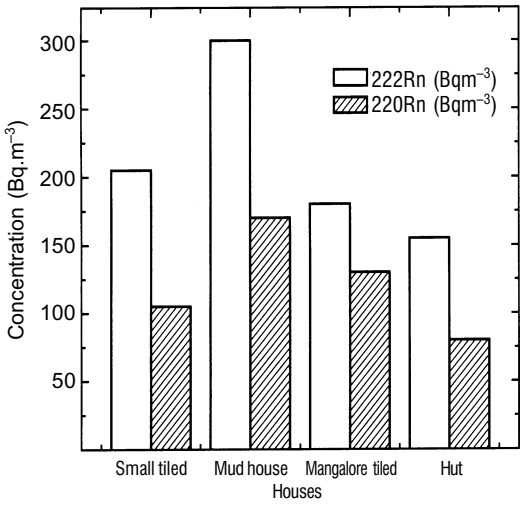

Figure 2. Variation of radon and thoron concentration in different types of dwellings at Maralebekuppe village.

5. Conclusion

The maximum progeny concentrations of ^{222}Rn and ^{220}Rn have been observed in the quarries where the mining activity takes place. In some places outdoor concentration of ^{222}Rn, ^{220}Rn and their progenies are higher than indoor concentrations. The concentration mainly depends on the activity of radionuclides present in soil and rocks. The results show that the impact of radiation hazard due to mining activity (crushing and loading) on the laborers and public near the quarries is considerable. As per the ICRP recommendation, it becomes necessary to take remedial steps for the reduction of ^{222}Rn and ^{220}Rn daughters in dwelling places, if the level is found to be more than 200 Bq.m^{-3}. The public inhalation dose due to ^{222}Rn and ^{220}Rn is higher than the global average.

References

[1] UNSCEAR, *United Nations Scientific Committee on the Effects of Atomic Radiation,* Report to the General Assembly with Scientific Annexes-**Vol.1** : Sources and Effects of Ionizing Radiation (2000)

[2] J Sannappa, M S Chandrashekara, L A Sathish, L Paramesh and P Venkataramaiah *Radiat. Meas.* **37** 55 (2003)

[3] J Porstendorfer *J. Aerosol. Sci.* **25** 219 (1994)

[4] P Ayotte, B Levesque, D Gaurien, McGregar, R G Martel, S Gingers, W B Walker and E G Letourneau *Health Phys.* **75** 297 (1998)

[5] J H Lubin and Boice *Natl. Cancer Inst.* **89** 49 (1997)

[6] N R Varley and A G Flowers *Radiat. Prot. Dosim.* **77** 171 (1998)

[7] UNSCEAR, United Nations Scientific Committee on the Effects of Atomic Radiation, Report to the General Assembely with Scientific Annexes : Sources, Effects and risks of Ionizing Radiation (1998)

[8] M Doi, S Kobayashi, F Fujimoto, K Hidenori and Yonehara *Radiat. Prot. Dosim.* **45** 425 (1992)

[9] M S Krishnan *Geology of India and Burma* (6^{th} edn.) (New Delhi : Batra Art Printers) (1982)

[10] S Manjunatha *ISRP* (1997)

[11] L C S Gunderson *U.S. Geological Survey Bulletin* **32** (1971)

[12] R Buchli and W Burkart *Health Phys.* **56** 423 (1989)

[13] J M S Sannappa, Chandrashekara and L Paramesh *Indoor Built. Environ.* **15** 283 (2006)

[14] A Durrani and R Ilic *Radon Measurements by Etched Track Detectors* (World Scientific Pvt Ltd.) (1997)

[15] K Kristiansson and L Malnquist *Geophysics* **47** 1444 (1982)

[16] K P Eappen, T V Ramachandran, A N Shaik and Y S Mayya *Radiat. Prot. Environ.* **24** 410 (2001)