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Measurement of Terrestrial Gamma Radiation Level and Annual Effective Dose in and Around Nuggihalli-Holenarasipura Schist Belts, Karnataka State, India

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Abstract
All individual living beings on the earth are exposed continuously to the radiations coming from terrestrial and extraterrestrial sources and also from their own bodies. The indoor and outdoor ambient gamma radiations are measured in and around Nuggihalli- Holenarasipura schist belts of Hassan district in Karnataka state. The measurements are carried out using the environment radiation dosimeter UR 705 which is a portable detector. Absorbed dose rate and annual effective dose rate are estimated by measuring the exposure rate. The total annual effective dose calculated from both indoor and outdoor varies from 0.68 to1.62 mSv.y-1 with an average value of 1.16 mSv.y-1. The calculated indoor and outdoor annual effective doses are found to be higher than the world average.

Keywords: Annual effective dose, Radiation dosimeter, Terrestrial gamma radiation, Nuggihalli-Holenarasipura schist belts

Introduction

All organisms on this earth are getting dose of high energetic radiation, which exists all around us. The maximum contribution to the average annual dose received by mankind is mainly from natural radiation [1-3]. Natural environmental radioactivity and associated gamma dose rate is depends on the type of soil, type of rock, local geology, building materials etc., People have been exposed to natural ionizing radiation of both terrestrial and extra-terrestrial origin in indoor and outdoor environment [4-6]. Knowledge on terrestrial gamma radiation and radioactivity will be play an important role in health physics [7, 8].The major contribution to the average annual dose received by mankind still comes from natural radiation. Significant portion of the background radiation arises from primordial radionuclides such as ^{40}K, ^{238}U, ^{232}Th [9-10]. Out of the total radiation exposure nearly 97.7% is from natural sources and only 2.3% is from manmade sources of radiation such as radioactive waste releases from nuclear reactor operations and accident, fallout from weapon tests, exposure due to radioactive waste dispose and other industries, medical & agricultural uses of radioisotopes[11]. It is never the less, ICRP has developed a detailed lung model to calculate the effective dose for exposure to air born radionuclides, still a simplification of actual respiratory anatomy and physiological behaviour is needed. More number of researchers has been actively participated in the measurement of ambient gamma radiation level and annual effective dose worldwide [12-18]. S. Javad Mortazavi M. has been reported that the high background radiation in Ramsar Iran, in this area background radiation is 55-200 times higher than the world average values because this area has dissolved radium in mineral water and deposits having elevated levels of thorium combine with higher concentrations of uranium [19]. Monica S. et.al., reported that the indoor and outdoor gamma dose rates in the coastal region of Porakad, Kerala using portable survey meter the average indoor gamma radiation value 468 nGy.h^{-1} and the average outdoor gamma radiation value 582 nGy.h^{-1} there observed values are higher as compare to the values of world and Indian average values [20]. Rosario R. et al., measured ambient dose equivalent rates are measured in different locations in Metro Manila range from 32.7 ± 2.2 to 59.3 ± 8.7 nSv.h^{-1} [21]. The detail comprehensive assessments of these doses are reported by UNSCEAR (2008, 2010, and 2011) and ICRP (10-11). Because of the wide variations in natural background exposure even within limited regions, more efforts are required to determine the detailed distribution of population within dose intervals for the various components of exposure. The aim of the present study is to measure indoor and outdoor ambient gamma radiation level in and around Nuggihalli-Holenarasipura schist belts, Karnataka State, India.

Study area

The present field study lying between the latitudes of 12° 37’ and 13° 23’ N and longitude 76° 00’, and 76° 53’ E. The Nuggihalli Schist Belt [NSB] extends for approximately 60 km strike length and maximum 2 km width having large and rich pockets of chromite. Titaniferous vanadiferous magnetite in disconnected patches comprises of major litho units of hornblende schist [22].

Holenarasipura schist belt [HSB] is trident in shape. The belt extends maximum length of 65 km from Doddagudda to Yedegondahalli with a wide range of 0.5 km to 3 km and belt covers an area of 250 Sq.km in which Yenneholerangana betta is a small hillock which is named after the God Rangaswamy. The southern terrain is high grade metamorphic terrain, northern part is metamorphosed [22]. The geological map of Nuggihalli-Holenarsipur schist belts along with the measured points are shown in Fig.1. This study area have varies types of rocks such as Granitoides, Ultramafic, Metabasic and Old peninisular gneiss. The purpose of the study is to measure the exposure rate in these varies types of rocks and also to measure the annual effective dose received by the peoples residing in this study area compared to the world average.

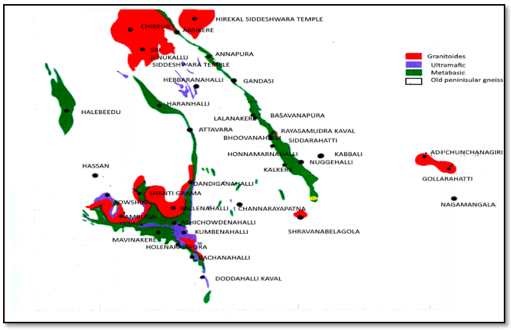

Figure 1 Geological Map of Nuggihalli-Holenarsipur Schist Belts, Hassan Dist, Karnataka State, India [22]

Methodology

The external gamma dose rates in air are measured in different locations of the study area using portable GM tube based Environmental radiation dosimeter (MICRO-R-SURVEY METER NUCLEONIX UR-705) Hyderabad, India, is exclusively designed to serve as low level survey meter in indoor atmosphere. The detailed methodology is given elsewhere [23]. Once operated, the dosimeter gives a radiation dose rate value after few minutes. The measurements are made at a height of one meter from the ground. The arithmetic mean value of readings is taken at each place. The exposure rate ($\mu R.h^{-1}$) is converted into absorbed dose rate ($nGy.h^{-1}$) using a conversion factor of $1 \mu R.h^{-1} = 8.7\ nGy.h^{-1}$ and annual effective dose in $mSv.y^{-1}$ is calculated by using the below equation [24-25].

$$AED\ (mSv.y^{-1}) = D \times T \times OF \times CC \times 10^{-6} \quad (1)$$

Where, D is absorbed dose rate, T is time in hour for one year (8760 hours), OF is occupation factor of 0.8 for indoor and 0.2 for outdoor, and CC is conversion coefficient 0.7 Gy-1.

Results and Discussion

The results of indoor and outdoor absorbed dose rates are summarized in Table 1. The indoor absorbed dose rates varied from 87 to 217.5 $nGy.h^{-1}$ with average value of 154.18 $nGy.h^{-1}$. High absorbed dose rates are evident in Shravanabelagola, Adichunchanagiri, Sri Jenukallu Siddeshwara Temple, Hirekal siddeshwara temple, Ballenahalli and Dandiganahalli. The variations in the indoor absorbed dose rates is due to the type of flooring, ventilation and local geology in which the soil and rocks contained higher amount of radionuclides such as ^{238}U, 232Th, and ^{40}K [20, 22]. In contrast lower absorbed dose rates have been observed at Doddahalli Kaval, Kowshika and Kumbenahalli. The lower absorbed dose rate is because of good ventilation and prevailing local geology in which the soil and rocks contained lower amount of radionuclides such as ^{238}U, ^{232}Th, and ^{40}K [20, 22, 29-30]. The indoor annual effective dose for the public's of study area varied from 0.43 to 1.07 $mSv.y^{-1}$ with average value of 0.75 $mSv.y^{-1}$.

The outdoor absorbed dose rate varied from 52.2 to 130.5 $nGy.h^{-1}$ with average value of 82.65 $nGy.h^{-1}$. The variation in absorbed doses is due to local geology [22]. High absorbed dose rates have been observed in Shravanabelagola, Adichunchanagiri, Sri Jenukallu Siddeshwara Temple, Hirekal siddeshwara temple, and Dandiganahalli. The local geology of this area is covered by granitoids having higher amount of radioactive elements such as ^{238}U, ^{232}Th, and ^{40}K [22]. The lower absorbed dose rates are found in Mavinakere, Doddahalli Kaval, Kowshika and Kumbenahalli, and in the contrast the local geology of surroundings comprising soil and rocks have lower concentration of radionuclides [22]. The annual effective dose inhaled by the public of this study area varied from

0.26 to 0.60 $mSv.y^{-1}$ with average value of 0.41 $mSv.y^{-1}$. The total annual effective dose varies from 0.68 to 1.62 $mSv.y^{-1}$ with average value of 1.16 $mSv.y^{-1}$. The indoor absorbed dose rates are higher as compared to outdoor absorbed dose rates except in some locations. Higher levels of indoor absorbed dose rates are mainly due to the use of rocks and building materials for building construction as they contain higher amount of natural radionuclides such as ^{238}U, ^{232}Th, and ^{40}K [22,26-27]. The use of gneissic granites, soil, and other decorative stones for the construction of walls and floor combined with poor ventilation inside the buildings increase the absorbed dose rates. The variations in the absorbed dose rates from one location to another in outdoor may be due to variations in local geology, rainfall and soil moisture [22, 28-30]. The radionuclides present in the parent rocks may be the main contributors for slightly higher radiation level observed in these geological areas. The average outdoor absorbed dose rates in Nuggihalli-Holenarsipur schist belts and in the different countries are presented in Table 2. The average outdoor absorbed dose rate in the present study is 82.65 $nGy.h^{-1}$ which is greater than the world average value of 59 $nGy.h^{-1}$.

Conclusion

The present study has measured the indoor and outdoor absorbed dose rates in and around Nuggihalli-Holenarsipur schist belts. High absorbed dose rates are absorbed at the locations where granitoides are present, having higher amount of natural radionuclides such as ^{238}U, ^{232}Th, and ^{40}K, lower absorbed dose rates are present at the locations where Altramafic and metabasic type of rocks are present. The average absorbed dose rate in this study area is higher than the limit of global average. The indoor, outdoor and total annual effective doses in the study area are higher than the global average limit.

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Table 1 Absorbed Dose Rate, Annual Effective Dose Estimated from various Locations of Nuggihalli-Holenarsipur Schist Belts

Locations	Exposure rate (μR.h-1)		Absorbed dose rate (nGy.h-1)		Annual effective Dose (mSv.y-1)		Total Annual effective Dose (mSv.y-1)
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	
Nagamangala	14±02	06±02	121.8	52.2	0.60	0.26	0.85
Gollarahatti	20±03	12±03	174	104.4	0.85	0.51	1.37
Shravanabelagola	21±05	14±03	182.7	121.8	0.90	0.60	1.49
Adichunchanagiri	21±04	15±04	182.7	130.5	0.90	0.64	1.54
Channarayapatna	18±03	11±02	156.6	95.7	0.77	0.47	1.24
kalkere	18±02	12±02	156.6	104.4	0.77	0.51	1.28
Nuggehalli	15±03	08±02	130.5	69.6	0.64	0.34	0.98
Kebbali	14±02	06±03	121.8	52.2	0.60	0.26	0.85
Honnamarnahalli	14±02	06±01	121.8	52.2	0.60	0.26	0.85
Siddarahatti	15±03	08±02	130.5	69.6	0.64	0.34	0.98
Bhoovanahalli	16±02	07±01	139.2	60.9	0.68	0.30	0.98
Rayasamudra kaval	16±03	08±02	139.2	69.6	0.68	0.34	1.02
Lalanakeri	18±03	09±02	156.6	78.3	0.77	0.38	1.15
Basavanapura	18±03	08±03	156.6	69.6	0.77	0.34	1.11
Gandasi	19±03	08±03	165.3	69.6	0.81	0.34	1.15
Hebbaranahalli	18±03	08±03	156.6	69.6	0.77	0.34	1.11
Annapura	20±03	13±04	174	113.1	0.85	0.55	1.41
Sri Jenukallu Siddeshwara Temple	22±04	13±02	191.4	113.1	0.94	0.55	1.49
Arsikere	20±03	12±03	174	104.4	0.85	0.51	1.37
Chikkur	21±04	13±02	182.7	113.1	0.90	0.55	1.45
Hirekal siddeshwara temple	24±04	14±02	208.8	121.8	1.02	0.60	1.62
Doddahalli Kaval	10±02	06±01	87	52.2	0.43	0.26	0.68
Bachanahalli	16±03	07±02	139.2	60.9	0.68	0.30	0.98
Holenarasipura	15±02	08±02	130.5	69.6	0.64	0.34	0.98
Kumbenahalli	12±03	06±02	104.4	52.2	0.51	0.26	0.77
Mavinakere	16±02	06±01	139.2	52.2	0.68	0.26	0.94
Athichowdenahalli	19±05	07±03	165.3	60.9	0.81	0.30	1.11
Ambuga	21±05	12±03	182.7	104.4	0.90	0.51	1.41
Ballenahalli	25±06	12±02	217.5	104.4	1.07	0.51	1.58
Kowshika	12±06	06±02	104.4	52.2	0.51	0.26	0.77
Shantigrama	18±04	10±03	156.6	87	0.77	0.43	1.20

Dandiganahalli	21±05	14±02	182.7	121.8	0.90	0.60	1.49
Hassan	18±04	12±03	156.6	104.4	0.77	0.51	1.28
Attavara	16±06	07±06	139.2	60.9	0.68	0.30	0.98
Haranhalli	17±03	08±03	147.9	69.6	0.73	0.34	1.07
Halebeedu	20±04	10±04	174	87	0.85	0.43	1.28
Maximum value	25±06	14±02	217.5	130.5	1.07	0.60	1.62
Minimum Value	10±02	06±01	87	52.2	0.43	0.26	0.68
Average value	17.72±03	9.52±02	154.18	82.65	0.75	0.41	1.16

Table 2: Mean Outdoor Absorbed Dose Rates in the Study Area Compared with the Values Reported from Other Countries and World Average

Countries	Outdoor absorbed dose rate	References
Japan	53	[27]
USA	47	[27]
Egypt	22	[27]
Greece	56	[27]
China	62	[27]
Portugal	84	[27]
Russia	65	[27]
Spain	76	[27]
Malaysia	92	[28]
Odisha, India	230	[29]
Shimoga, India	177	[30]
Nuggihalli-Holenarasipura schist belts	82.65	Present study
World (outdoor)	59	[28]
World (indoor)	84	[28]