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Estimation of ambient gamma radiation levels in working places of industrial areas around Tumkur City

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ABSTRACT

This study presents the results of indoor and outdoor ambient gamma dose rates measured in and around industrial areas of Tumkur city. Different working places from four major industrial areas around Tumkur city in Karnataka state, India have been selected for the study. These measurements were carried out by using environmental radiation Dosimeter ER-709 which is a portable detector. By the measured average absorbed dose rates, annual effective dose (AED) has been calculated by a standard method. Results showed that the indoor absorbed dose rates in the air of Tumkur industrial areas ranged between 87 nGy h^{-1} to 191.40 nGy h^{-1} with an average of 136.45nGy h^{-1}. Outdoor absorbed dose ranges from 69.60 nGy h^{-1} to 113.83nGyh^{-1} with an average of 156.60 nGy h^{-1}. The indoor and outdoor AED ranged between 0.43 to 0.94 mSv/y with an average value of 0.67 mSv y^{-1} and 0.09 to 0.19 mSv y^{-1} with an average value of 0.14 mSv y^{-1} respectively. The total effective dose ranges from 0.51 to 1.13 with an average of 0.81 mSv y^{-1}. The calculated indoor and outdoor AEDs were found to be higher than the world average.

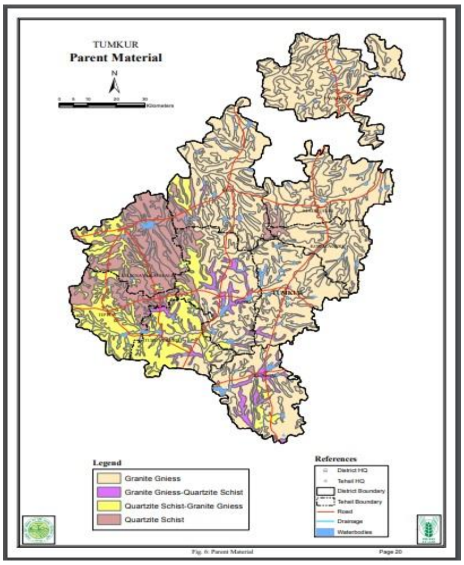
Key Words: Dosimeter; Radiation; Ambient Gamma

1. INTRODUCTION

It is impossible to escape from the continuous expose to the natural background radiation from living organisms. So Human beings are also continuously exposed to natural background. There are two main contributors to natural radiation exposure. First, the high energy cosmic ray particles incident on the earth's atmosphere. The other is the terrestrial radioactive materials which were originated during the formation of the earth. These materials are present everywhere in the earth's crust and also present in human body. The interactions of cosmic ray particles with the nuclei of atmospheric constituents can create a cascade of interactions and secondary reaction products as number of radioactive nuclei such as ^{3}H,^{7}Be and ^{14}C (1,2). The radiation dose from cosmic rays increases with latitude and altitude (3). So polar region of earth, mountain dwellers, aircrew and frequent air travellers receive higher doses of cosmic radiation(4). In addition to exposure from direct cosmic rays and cosmogenic radionuclide from extra-terrestrial sources, natural exposures arise mainly from the primordial radionuclides such as ^{238}U, ^{226}Ra, ^{232}Th, and ^{40}K. These radionuclides spread widely and present in almost all geological materials in the earth's environment**(5)**. As a result of rock weathering, radionuclides are carried to the soils, streams, and rivers by rain(6). Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the ecological and geographical conditions(7). The levels of radioactive nuclides in rock and soil vary with the geological locations(8). So it is important to measure the dose rates at different geological areas. Natural sources contribute about 80% exposure to the world's collective radiation exposure of the world's population**(9)**. In this context, environmental radioactivity measurements are necessary for determining the background radiation level due to natural radioactive sources of terrestrial and cosmic origins(10,11). Knowledge on terrestrial gamma radiation and radioactivity is vast important and interest in health physics. The presence of naturally occurring radionuclides in the environment may result in an external and internal dose received by a population exposed to them directly and via the ingestion/inhalation modes. The level of gamma dose inside the dwellings largely depends on the radioactivity content in building materials such as cement, marble, tile, granite, and soil, etc., used for construction (12). The present study is carried out to know the radiation levels from terrestrial radionuclides, to provide vital radiological baseline information, and to measure the dose rates at different geological aeas. The assessment of the radiological impact on workers and publics of the study area as a result of the radiation emitted by these radionuclides, is important since they contribute to the collective dose of the population. The aim of the present study is to measure the environmental terrestrial gamma radiation level in and around industrial areas of Tumkur city. And also to determine the annual effective radiation doses received by the workers and publics from indoor and outdoor ambient terrestrial gamma radiation present in the study area. For the above reason, an attempt has made first time in the study area, and it concentrate in and around different industrial areas around Tumkur city.

GEOLOGY OF THE STUDY AREA

The study area Tumkur is one of the districts of Karnataka state, India lying between latitudes N12^{0}45' and 14^{0}20', and longitudes E76^{0}20' and 77^{0}1'. The population of Tumkur city is 305,821. The average annual rainfall of the district is less than 750 mm. The dependence on groundwater for domestic and irrigation needs is high. The district mainly consists of rock types belonging to the Peninsular Gneissic complex (PGC), schistose rocks of Sargur group and Dharwar Supergroup, younger intrusives (Closepet granite and basic dykes) and thin patches of Quaternary gravels. The PGC occupies two-thirds of the area and is represented by migmatites, gneiss and other granitoids. The high grade schists of Sargur Group occur as continuous bands. Small enclaves within the PGC comprise of amphibolites, ultramafics and banded ferruginous cherts. The rocks of Dharwar Supergroup are exposed in two parallel belts, being the southern extensions of Chitradurga and Javanahalli schist belts. The younger intrusives include Closepet granite and basic dykes. Thin patches of Quaternary gravel horizons occur north of Pavagada. There are three prominent lineaments in the district trending ENE-WSW, NW-SE and N-S. Groundwater in the district occurs mainly in the weathered and fractured zones of gneisses, granites and schists(13). In the weathered formations groundwater occurs under water table condition, where it is under semi-confined to confined conditions in fractured formations at deeper levels. The deeper aquifer system is being tapped by bore wells having depths down to 200m.



MATERIALS AND METHODS

The natural background radiation dose rate is measured by using Environmental radiation dosimeter (ER-709 radiation survey meter) with halogen quenched gamma radiation detector type GM132 is used. The instrument was calibrated at the Radiation Standard and Calibration Lab, Nucleonix Systems (P) Ltd, using ^{137}Cs as a standard source. The instrument is calibrated to read exposure rate in two ranges with measuring sensitivity of 0.1 μRh^{-1} and 1μRh^{-1} and exposure with measuring sensitivity of 1 µR and accuracy ±10% with Cs-137. The energy response within ±20% ranges from 60 KeV to 1.33 MeV. The ER709 manufactured by NUCLEONIX SYSTEMS PVT LTD, Hyderabad, India, is exclusively designed to serve as low-level survey meter in indoor and outdoor atmosphere. It is an ideal choice for environmental radiation monitoring and also for geological prospecting of radioactive minerals. The terrestrial gamma dose rates were measured at the distance of approximately one meter above the ground at the inside and outside of the different types of buildings, soil, and in some quarries. For each location, eight measurements were done with 4 min interval, and these measurements were then averaged to single value and used these values to calculate effective dose. Data obtained for the external exposure rate in μRh^{-1} were converted into absorbed dose rate ($nGyh^{-1}$) using the conversion factor $\mu Rh^{-1} = 8.7\ nGyh^{-1}$, which stems from the definition of Roentgen. For calculating AED, we have used dose conversion factor of 0.7 $SvGy^{-1}$, and the occupancy factor (OF) for indoor and outdoor was 0.8 and 0.2, respectively. OF for indoor and outdoor situations was calculated based on interviews with peoples of the study area. People of the study area spent 5 to 6 hr in outdoor and 18 to 19 hr in indoor environment. This OF changes for women of the area who spent slightly more time in indoor environment as compared to men (OF =5/24 for outdoor, 19/25 for indoor environment). The AED for the external terrestrial radiation was calculated as described elsewhere using formula(14).

AED ($mSvy^{-1}$) = D×T×OF×CC …………………(1)

Where D is absorbed dose rate; T is time in hour for 1 year (8760 h); OF is 0.8 and 0.2 for indoor and outdoor exposure, and CC is the conversion coefficient; in the UNSCEAR 1993 report, the Committee used 0.7 $SvGy^{-1}$ for the conversion coefficient from absorbed dose in air to effective dose received by adults.

RESULTS AND DISCUSSION

The measurement of indoor and outdoor average ambient gamma absorbed dose and annual effective dose rate in the working places near the industrial areas is important because they discharge effluents to environment and they are contributing for the enhance levels of radionuclides in soil, water and building materials. The effective doses to infants and children can differ compared to adults in the schools and working places (15). Indoor and outdoor absorbed dose and annual effective dose rate in the working places of the study area are given in table-1

Table-1 Indoor and outdoor absorbed dose and Annual effective dose rate in the working places of the study area

Industrial area	Working Place	Absorbed dose ($nGy\ h^{-1}$)		Effective dose ($mSv\ y^{-1}$)		
		Indoor (D_{in})	Outdoor (D_{out})	Indoor (E_{in})	Outdoor (E_{out})	Total (E_{total})
Vasanthanarasapura	School	117.45	78.3	0.58	0.10	0.67
	Hotel	104.4	87	0.51	0.11	0.62
Antharasanahalli	Public library	121.8	104.4	0.60	0.13	0.73
	School	143.55	113.1	0.70	0.14	0.84
	College	130.5	108.75	0.64	0.13	0.77
	Hotel	139.2	100.05	0.68	0.12	0.81
Hirehalli	School	160.95	139.2	0.79	0.17	0.96
	Anganawadi	137.46	100.05	0.67	0.12	0.80
	Bank	147.9	143.55	0.73	0.18	0.90
	College	174	147.9	0.85	0.18	1.03
	Health Center	165.3	143.55	0.81	0.18	0.99
	Garments	139.2	126.15	0.68	0.15	0.84
	Training institute	191.4	156.6	0.94	0.19	1.13
Tumkur university (City)	Science college	87	104.4	0.43	0.13	0.55
	Bank	147.9	108.75	0.73	0.13	0.86
	Library	113.1	100.05	0.55	0.12	0.68
	Polytechnic	147.9	117.45	0.73	0.14	0.87
	Hotel	87	69.6	0.43	0.09	0.51
Minimum		**87.00**	**69.60**	**0.43**	**0.09**	**0.51**
Maximum		**191.40**	**156.60**	**0.94**	**0.19**	**1.13**

Average	**136.45**	**113.83**	**0.67**	**0.14**	**0.81**

The data from table-1 shows that the indoor absorbed dose varies from 87 to 191.4 $nGyh^{-1}$ with a mean of 136.45 nGy h^{-1} corresponding equivalent effective dose varies from 0.43 to 0.94 with a mean of 0.67 mSv y^{-1} . The outdoor absorbed dose rate varies from 69.60 to 156.6 nGy h^{-1} with a mean of 113.83 nGy h^{-1} corresponding equivalent effective dose varies from 0.09 to 0.19 with a mean of 0.14 mSv y^{-1}. The data from table-1 shows indoor gamma dose rate in working places of the study area are higher than the outdoor. The outdoor gamma dose rate is mainly depends on radionuclides present in soil and parent rock(16). This is because these locations are comprised by migmatite and gneiss rocks. These rocks contain lower activity of radionuclides as shown in table-2.

Table-2: Mean activity concentration of ^{226}Ra, ^{232}Th, ^{40}K, ratio of ^{232}Th to ^{226} Ra, gamma absorbed dose and annual effective dose in the rock samples

Type of rock	**Activity of radionuclides (Bq kg^{-1})**			**Total Gamma Absorbed dose (nGy h^{-1})**	**Annual effective dose (mSv y^{-1}) E $_{total}$**
	^{226}Ra	**^{232}Th**	**^{40}K**		
Pink Phoriphytic Granite	150±3	200±2.5	1800±15	265.16	1.63
Dolerite Granite	25±1.2	29±1.5	500±5	49.92	0.31
Grey Granite	50±0.8	125±0.4	1320±18	153.64	0.94
Granite Genesis	85±2	158±2.5	201±8	143.08	0.88
Horn blende	42±0.7	86±2.1	112±4	76.02	0.47
Migmatite Gneiss	20±1.5	35±2.2	450±4	49.15	0.30
Minimum	**20±1.5**	**25±0.4**	**450±4**	**49.15**	**0.30**
Maximum	**150±3**	**200±2.5**	**1800±15**	**265.16**	**1.63**
Average	**65.6±1.3**	**81.8±1.5**	**854.2±12**	**122.83**	**0.75**

The soil of this location derived from these parent rocks hence it is observed lower gamma dose rate in these locations. The indoor gamma dose rate is higher compared to the outdoor because higher activity of radionuclides present in the building materials in addition to the soil, building materials contribute significantly to the indoor gamma dose rate. The building materials used for this working places are concrete bricks for walls and for floorings red oxide concrete and vitrified tiles are used. These building material contains higher activity of radionuclides compared to the soil as given in **table-3.**

Table-3. Mean activity concentration of ^{226}Ra, ^{232}Th, ^{40}K , ratio of ^{232}Th to ^{226} Ra, gamma absorbed dose and annual effective dose of the building materials of the study area

Location	**Activity of radionuclides (Bq kg^{-1})**			**Gamma Absorbed dose (nGy h^{-1}) (D_{in}+D_{out})**
	^{226}Ra	**^{232}Th**	**^{40}K**	
Pink phoriphytic Granite	130±3.1	200±3.3	1600±8.5	467.6
Kadapa stone	30±1.1	41±1.1	536±5.2	115.58
Ceramic tile	64±2.4	83±2.5	385±3.8	180.98
Vitrified tile	50±2.2	58±2.3	197±3.2	125.56
Black granite	24±0.8	25±0.9	500±4.1	89.58
Grey granite	66±2.8	70±2.6	1450±7.1	253.72
Rajasthan marble (white)	15±0.6	26±0.8	45±1.3	46
Soil brick	25±0.8	40±1.2	100±2.3	75
Sand	10±0.5	15±0.6	40±1.3	28.9
Cement brick	29±0.9	45±0.7	150±2.9	88.18
Cement Ultch	23±0.8	32±0.8	160±2.6	69.16
Gravel (Stone)	42±0.5	68±2.5	642±4.7	164.8
Minimum	**10±0.5**	**15±0.6**	**40±1.3**	**28.90**
Maximum	**130±3.1**	**200±3.7**	**1600±8.5**	**467.60**
Average	**42.19±2.3**	**58.58±2.3**	**487.91±5.2**	**142.09**

The lower indoor and outdoor gamma dose rate were observed in the garments of Hirehalli industrial area and Tumkur city. Slightly lower gamma dose rate were observed in Hirehalli compared to other working places. Because the nature of the work in this places are cloth cutting and stitching. These materials contains very low activity of radionuclides. The area of the garments industries are very large and fans used inside the industry. Good ventilation is maintained inside the industry. The building material used for the construction are cement blocks having lower activity of radionuclides compared to granite. Similarly lower values of gamma are observed in garments of Tumkur city. In these garments the lower indoor gamma dose rate are observed compared to garments of Hirehalli industrial area this is because the radionuclides present in the soil of the area are lower. Gamma dose rates in working places of the study are is given in figure 1.

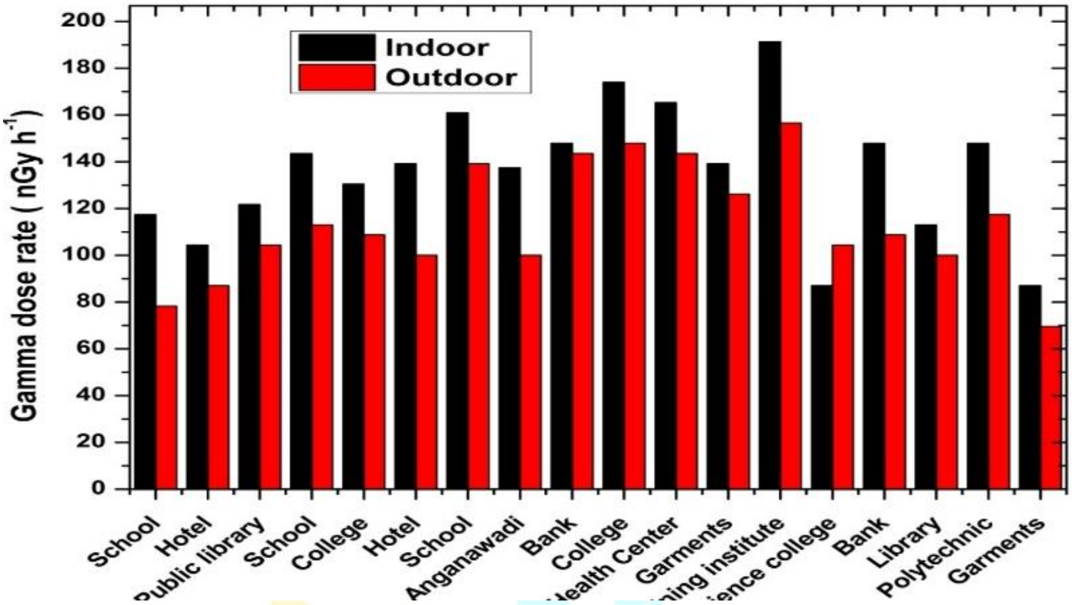


Figure-1 Gamma dose rate in working places of the study area

The indoor and outdoor gamma dose rate in the working places of Hirehalli industrial area are higher than Vasanthanarasapura and Antharasanahalli. This industrial area is comprised of grey granite, pink granite and pink phoriphytic granites which containing higher activity of radionuclides. The activity of radionuclides in soil of these area are also have higher values compared to other locations. Another reason for this increase in the indoor gamma dose rate is industrial activities (17). During the stone crushing and cutting a large quantity of fine powder is produced and spread more than 2km around the crushers. The powder is spread in the atmosphere and gradually deposited on the buildings, crops and plants in the environment. This powder contains higher activity of radionuclides. Because it is produced from the granite stones which contains higher activity of radionuclides(18,19). May be due to this enhanced indoor gamma dose rate were observed in the working places of Hirehalli industrial areas. The estimated radionuclides have higher activity of values of radionuclides. The annual dose of the working places near the industrial areas varies from 0.51 to 1.13 mSv y^{-1} with a mean of 0.81 mSv y^{-1}. The average indoor, outdoor and total effective gamma dose rate of the working places are higher than the global average values(20). The total absorbed and equivalent effective gamma dose rate of the study area are higher than the global average values. The measured average gamma absorbed and equivalent effective dose rate in soil are compared with the reported in different parts of Karnataka, India and other parts of the globe were given. These dose rate of the study area are lower than the Indian and global average values.

CONCLUSION

The ambient gamma dose in industries and working places (absorbed and equivalent effective dose rate) not only depends on activity of radionuclides present in the soil, rocks and building materials but also depends on industrial activities and human activities, type of building and ventilation conditions. Higher gamma dose rate were recorded at the stone crushers compared to other industries. The industrial activity of stone crushers impact on enhance gamma dose rate at the industries, near dwellings and working places. The ambient gamma dose rate due to the workers, public and children of the study areas were higher than the global average.

REFERENCES

1. Engel, J., Gaisser, T. K., Lipari, P., & Stanev, T. (1992). Nucleus-nucleus collisions and interpretation of cosmic-ray cascades. *Physical Review D, 46*(11), 5013.
2. Fletcher RS, Gaisser TK, Lipari P, Stanev T. sibyll: An event generator for simulation of high energy cosmic ray cascades. Physical Review D. Nov 1, 1994;50(9):5710.
3. Prescott JR, Hutton JT. Cosmic ray contributions to dose rates for luminescence and ESR dating: large depths and long-term time variations. Radiation measurements. Apr 1, 1994;23 (2-3):497-500.
4. Gabdo HT, Ramli A T, Sanusi MS, Saleh MA, Garba NN. Terrestrial gamma dose rate in Pahang state Malaysia. Journal of radioanalytical and nuclear chemistry. Mar 1, 2014; 299(3):1793-8.
5. Manahan S. Environmental chemistry. CRC press; 2017 Feb 24. 6. Choubey VM, Bartarya SK, Ramola RC. Radon in Himalayan springs: a geohydrological control. Environmental Geology. Apr 1, 2000;39(6):523-30.
7. Hendry JH, Simon SL, Wojcik A, Sohrabi M, Burkart W, Cardis E, Laurier D, Tirmarche M, Hayata I. Human exposure to high natural background radiation: what can it teach us about radiation risks? Journal of Radiological Protection. May 19, 2009;29(2A): A29.
8. Mahur AK, Kumar R, Sonkawade RG, Sengupta D, Prasad R. Measurement of natural radioactivity and radon exhalation rate from rock samples of Jaduguda uranium mines and its radiological implications. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms. Apr 1, 2008;266(8):1591-7.
9. World Health Organization. Guidelines for drinking-water quality. World Health Organization; 2004 Aug 31.
10. Tzortzis M, Tsertos H, Christofides S, Christodoulides G. Gamma radiation measurements and dose rates in commercially-used natural tiling rocks (granites). Journal of environmental radioactivity. Jan 1, 2003;70(3):223-35.
11. Bozkurt A, Yorulmaz N, Kam E, Karahan G, Osmanlioglu AE. Assessment of environmental radioactivity for Sanliurfa region of southeastern Turkey. Radiation Measurements. Sep 1, 2007;42(8):1387-91.

12. Sannappa J, Chandrashekara MS, Sathish LA, Paramesh L, Venkataramaiah P. Study of background radiation dose in Mysore city, Karnataka State, India. Radiation measurements. Feb 1, 2003;37(1):55-65.
13. Md NK, Vinayachandran N, Jose B, Vashistha R. Radon in groundwater in Tumkur district of Karnataka with special reference to sampling sensitivity. Journal of the Geological Society of India. Jun 1, 2014;83(6):665-8.
14. Sannappa J, Chandrashekara M S, Sathish LA, Paramesh L, Venkataramaiah P. Study of background radiation dose in Mysore city, Karnataka State, India. Radiation measurements. Feb 1, 2003;37(1):55-65.
15. Saito, Kimiaki, et al. "Construction of a computed tomographic phantom for a Japanese male adult and dose calculation system." *Radiation and environmental biophysics* 40.1 (2001): 69-76.
16. Goddard, C. C. "Measurement of outdoor terrestrial gamma radiation in the Sultanate of Oman." *Health physics* 82.6 (2002): 869-874.
17. Hamlat, M. S., S. Djeffal, and H. Kadi. "Assessment of radiation exposures from naturally occurring radioactive materials in the oil and gas industry." *Applied Radiation and Isotopes* 55.1 (2001): 141-146.
18. Sannappa, J., et al. "Study of background radiation dose in Mysore city, Karnataka State, India." *Radiation measurements* 37.1 (2003): 55-65.
19. Ningappa C, Sannappa J, Karunakara N. Study on radionuclides in granite quarries of Bangalore rural district, Karnataka, India. Radiation protection dosimetry. Aug 4, 2008;131(4): 495-502. India." *Radiation Protection and Environment* 38.4 (2015): 154.
20. United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR). Sources and effects of ionizing radiation. United Nation, New York (2000).