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Estimation of Terrestrial Gamma Radiation Dose and Annual Effective Dose Around Industrial Areas of 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. 15 locations 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 and outdoor absorbed dose rates in air of Tumkur industrial areas ranged between 137 to 310nGy/h with an average of 226.1nGy/h and 88 to 275 nGy/h with an average of 188.3 nGy/h respectively. The indoor and outdoor AED ranged between 0.672 to 1.521 mSv/y with an average value of 1.09 mSv/y and 0.108 to 0.337 mSv/y with an average value of 0.231 mSv/yrespectively. The total effective dose ranges from 0.780 to 1.858 with an average of 1.340 mSv/y. The calculated indoor and outdoor AEDs were found to be higher than the world average.

KEYWORDS: Annual effective dose, radiation dosimeter, Tumkur, terrestrial gamma radiation

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INTRODUCTION

Human beings are continuously exposed to natural background radiation which is inescapable feature on earth. There are two main contributors to natural radiation exposure. First one is high-energy cosmic ray particles incident on the earth's atmosphere. The other main contributors are the terrestrial radioactive materials which originate from the formation of the earth and are present everywhere in the earth's crust. They are also present in the 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, mountain dwellers, aircrew and frequent air travelers receive higher doses of cosmic radiation[4]. In addition to exposure from direct cosmic rays and cosmogenic radionuclide from extraterrestrial 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[15].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 areas. 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[12]. 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

Tumkur is one of the districts of Karnataka state, India lying between latitudes N 12^{o}45' and 14^{o}20', and longitudes E 76^{o}20' and 77^{o} 1' with a population of 25,84,711. 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.[13] 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.[14]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. Geological map of the study area is as shown in Fig. 1

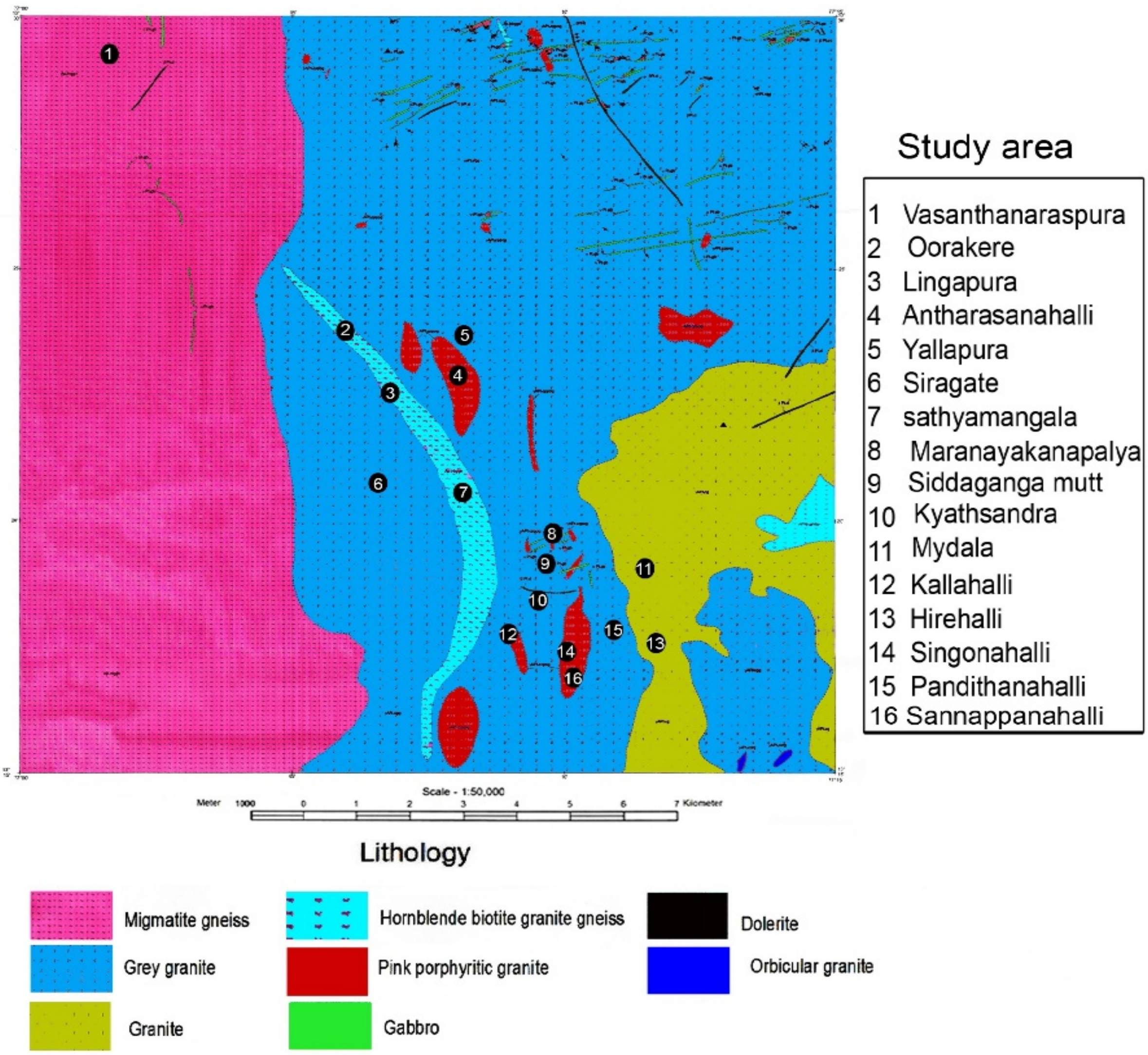

Figure.1 Geological map of the Tumkur Industrial areas

MATERIALS AND METHODS

Environmental radiation dosimeter (ER-709 radiation survey meter) with halogen quenched gamma radiation detector type GM132 is used to measure natural background radiation dose rate. 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 1 μRh^{-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 (nGy/h) using the conversion factor μRh^{-1} = 8.7 nGy/h, which stems from the definition of Roentgen. For calculating AED, we have used dose conversion factor of 0.7 Sv/Gy, 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 h in outdoor and 18 to 19 h 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[16].

$$AED(mSv/y)=D\times T\times OF\times CC \qquad (1)$$

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 Sv/Gy for the conversion coefficient from absorbed dose in air to effective dose received by adults, respectively.

RESULTS AND DISCUSSION

The average absorbed dose rates from indoor and outdoor terrestrial gamma radiation at 15 selected location of study area are summarized in Table 1.Each location is divided into 4 parts and at each parts8 to 10 readings were recorded and average was taken.The indoor gamma absorbed dose rates in air of Tumkur industrial areas ranged between 137 to 310 nGy/h with an average of 226.1 nGy/h and 88 to 275 nGy/h with an average of 188.3 nGy/h. This is higher than the world average of 84 nGy/h[17]. Similarly outdoor gamma absorbed dose rates values were found in the range of 88 to 275 nGy/h with an average of 188.3 nGy/h. This value is higher than the world average of 59 nGy/h, respectively. The variation of indoor and outdoor gamma absorbed dose rates at different locations was shown in fig.2.

The outdoor AED ranged between 0.672 to 1.521 mSv/y with an average value of 1.09 mSv/y and 0.108 to 0.337 mSv/y with an average value of 0.231 mSv/y, respectively. The total effective dose ranges from 0.780 to 1.858 with an average of 1.340 mSv/y.the variation of indoor, outdoor and total annual effective dose rates at different locations of industrial area is shown in fig.3. From the figure it is evident that outdoor annual effective dose is lesser than indoor annual effective dose. In all the locations of the study area indoor absorbed dose rates were higher than the outdoor atmosphere. Higher levels of absorbed dose rate in indoor atmosphere are mainly depends on the wastage discharged to environment by the industries, type of rock used and building materials for the construction.

The lower values of gamma absorbed dose rates were found at Vasanthanarasapura, oorkere, Lingapura, Ajjagondanahalli, Satyamangala. Hornblende biotite granite gneiss and migmatite gneiss are covered in these areas. Since gamma absorbed dose depends on the activity of primordial radionuclides present in rocks and soil, the activity of these were found to be less in these rocks, therefore the gamma absorbed doses were also lower[21,22].Higher values of gamma absorbed dose rates were found at Singonahalli, Kallahalli, Sannappanahalli, and Yallapura. This is due to these locations are attributed by Pink Phoriphytic granite, which contain higher activity of primordial nuclides which results in higher values of gamma absorbed dose rates were. Kyathsandra, Pandithanahalli, Sira gate, Antharasanahalli these locations are comprised by grey granite. The grey granites contains slightly less activity of radium (^{226}Ra) compared to pink granite. The activity of primordial radio nuclides in rocks also depends upon the mineral composition also. Hence these areas show slightly lower gamma absorbed dose rates. Places near the granite cutting and polishing industries, stone crushers and near manufacturing of cement blocks the outdoor terrestrial gamma absorbed rates are higher. In these industries the small dust granitic powder released during the activities released to environment leading to higher concentration of terrestrial gamma radiation. Higher values are observed due to poor ventilation also. The use of gneissic granites, soil, and other decorative stones for the construction of walls and floor and due to poor ventilation conditions inside the buildings enhances the radon concentration and also radon daughter concentration; this contributes to the elevated gamma absorbed dose. The sizes of fines are very small; thereby, it increases the radioactivity[18]. The outdoor variations of gamma dose rates from place to place may be attributed due to change in geology, weathering conditions and the type of industrial waste discharged by the industries. However, some measurements in areas with intrusive rocks of the granitic type also have doses rates below 200 nGy/h. This could be due to weathering mechanisms such as rainfall and flooding, which may have transferred the uranium and thorium from granitic soil[19]. The lower terrestrial gamma absorbed radiation dose rate was observed at vasanthanarasapura industrial area because the industries present here do not discharge radionuclide materials into the atmosphere. Most of the industries are agro based and food processing units are working.

Table-1 Gamma dose rate and annual effective dose in the study area

Industrial area	Geology of Area	Absorbed dose (nGyh^{-1})		Annual effective dose (mSv y^{-1})		
		Indoor	Outdoor	Indoor	Outdoor	Total
Vasantanarsapur	Migmatite Gneiss	137	88	0.672	0.108	0.780
Ajjagondanahalli	Migmatite Gneiss	149	114	0.731	0.140	0.871
Antharasanahalli	Grey granite	244	250	1.197	0.307	1.504
Lingapura	Hornblend	170	119	0.834	0.146	0.980
Oorkere	Hornblend	189	143	0.927	0.175	1.103
Yallapura	Pink Phoriphytic granite	260	210	1.275	0.258	1.533
Sira gate	Grey granite	246	203	1.207	0.249	1.456
Satymangala	Hornblend Biotite Gneiss	195	142	0.956	0.174	1.131
Hirehalli	Granite	216	194	1.059	0.238	1.298
Marnayakanapalya	Dolerite	166	150	0.814	0.184	0.998
Singonahalli	Pink Phoriphytic granite	290	266	1.423	0.326	1.749
Pandithanahalli	Grey granite	256	196	1.256	0.240	1.496
Kyathasandra	Grey granite	269	206	1.319	0.253	1.572
Kallahalli	Pink Phoriphytic granite	310	275	1.521	0.337	1.858
Sannappanahalli	Pink Phoriphytic granite	295	269	1.447	0.330	1.777
Minimum		**137**	**88**	**0.672**	**0.108**	**0.780**
Maximum		**310**	**275**	**1.521**	**0.337**	**1.858**
Average		**226.1**	**188.3**	**1.109**	**0.231**	**1.340**

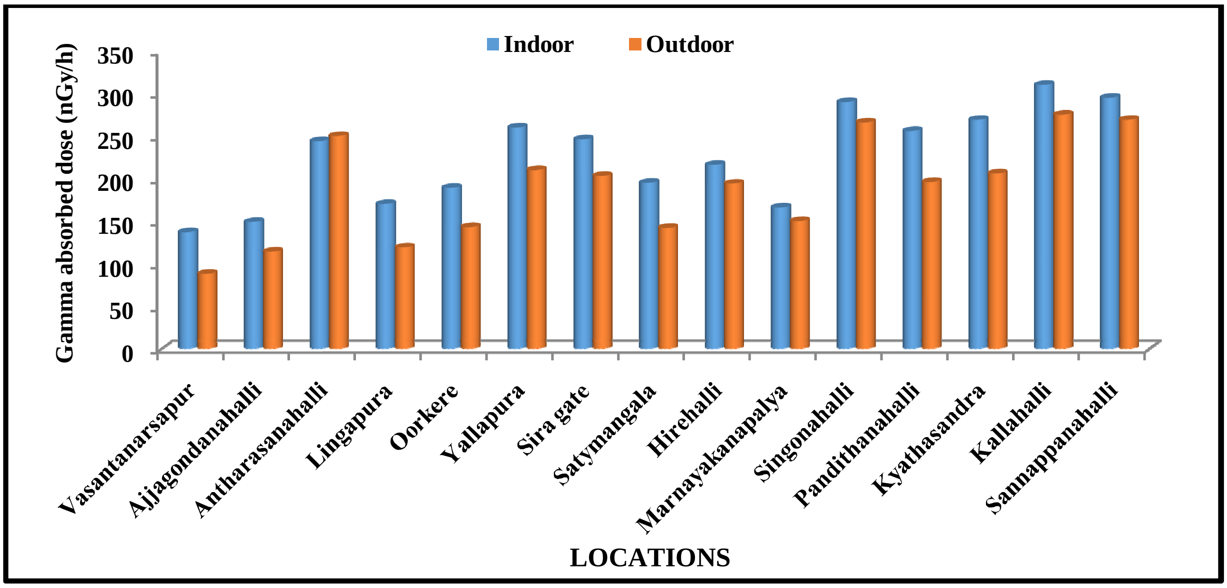

Fig:2-Variation of Indoor and Outdoor gamma absorbed dose at different locations

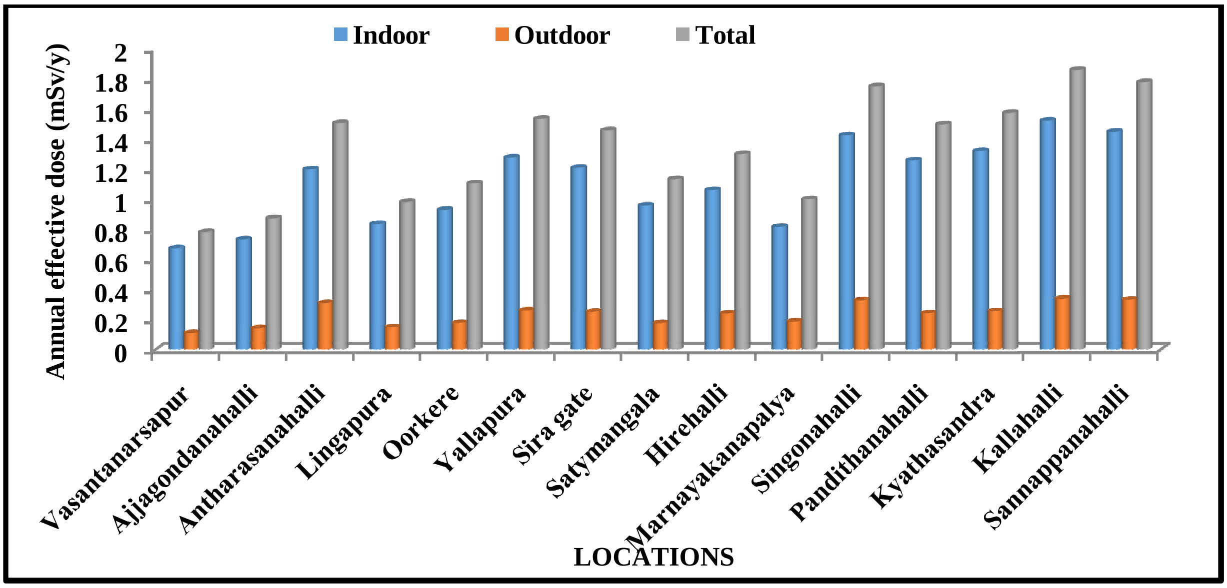

Fig:3 Variation of indoor, outdoor and total annual effective dose at different locations

The average gamma absorbed dose values were measured by using survey meter are compared with values reported in different parts of Karnataka, India and other parts of the world were given in the table 2.

Table-2. Average absorbed gamma dose and effective dose in different environs

Region	Absorbed dose (nGy h^{-1})		Effective dose (mSv y^{-1})		Reference
	Indoor	Outdoor	Indoor	Outdoor	
Bangalore	384.1	412.0	0.88	0.51	[18]
Mysore	75.7	40.3	0.36	0.06	[15]
Bangalore rural	351.9	371.6	-	-	[18]
Gogi region	104	97	-	-	[23]
Shimoga	192.42	177	0.87	0.23	[16]
Hassan district	288	260.4	1.41	0.31	[21]
Koppa and NR Pura Chikmagalur District	193.14	174	0.95	0.21	[24]
Indian average	59	56	-	0.08	[25]
China	99	62	0.55	0.09	[25]
Bulgaria	75	70	0.45	0.10	[25]
Finland	80	63	0.49	0.08	[25]
Germany	53	70	0.41	0.10	[25]
Japan	50	49	0.32	0.07	[25]
Norway	95	73	0.48	0.10	[25]
Spain	68	43	0.40	0.06	[25]
Sweden	110	56	0.65	0.08	[25]
U.K.	60	34	0.35	0.05	[25]
Global average	84	59	0.45	0.08	[25]

CONCLUSION

The study has established the baseline data on gamma absorbed dose and annual effective dose to workers and dwellers in the industrial areas of Tumkur city. The results are comparable with those reported for other regions in India and world. From the observations the indoor average gamma absorbed dose rate is higher than the outdoor. The average annual effective dose due to gamma to the workers and dwellers of the study area are found to be1.340 $mSvy^{-1}$ which is slightly higher than the dose limit of 1 $mSvy^{-1}$ recommended by ICRP[20].

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