

Measurement of Interior and Exterior Gamma Dose Rate in Air in Mandya City, Karnataka

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Abstract— Human exposure to radioactive disintegration by radionuclides present in the lithosphere is unavoidable. A built-up environment makes effective use of building materials which contains natural radioactive elements. The changes of radionuclides in the constructed environment are to be noticed. In this study, measurement of interior and exterior Gamma-ray dose rate has been carried out from 25 locations of Mandya city for the radiometric, geophysical and environmental surveys. The measurement has been done using a lightweight portable radiation dosimeter ER-709. The readings were recorded at about 1m from the ground surface. The finding indicates that, the absorbed gamma dose rate in interior and exterior air varied by $66.12 \times 10^{-9} \text{ Gyh}^{-1}$ to $131.89 \times 10^{-9} \text{ Gyh}^{-1}$ with average geometrical value of $95.11 \times 10^{-9} \text{ Gyh}^{-1}$ and $48.72 \times 10^{-9} \text{ Gyh}^{-1}$ to $77.60 \times 10^{-9} \text{ Gyh}^{-1}$ with average geometrical value of $58.45 \times 10^{-9} \text{ Gyh}^{-1}$. The yearly effective dose rate varies by $0.32 \times 10^{-3} \text{ Svy}^{-1}$ to $0.65 \times 10^{-3} \text{ Svy}^{-1}$ with average geometric value of $0.47 \times 10^{-3} \text{ Svy}^{-1}$ and $0.06 \times 10^{-3} \text{ Svy}^{-1}$ to $0.10 \times 10^{-3} \text{ Svy}^{-1}$ with average geometric value of $0.07 \times 10^{-3} \text{ Svy}^{-1}$. This is evidently upper than the worldwide average yearly effective dose.

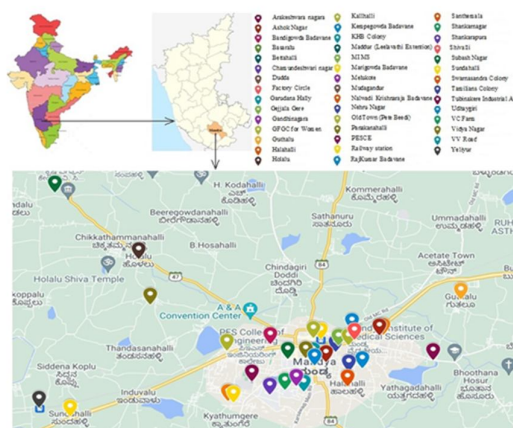
I. INTRODUCTION

The natural background radiations occurred from cosmic radiation, terrestrial radiation and internal radiation. Terrestrial gamma radiation mainly comes from potassium-40 and radionuclides of Uranium-238 and Thorium-232. Naturally occurring sources of gamma radiation from the earth are mainly the result of radioactive disintegration and secondary radiation. Gamma rays are ionizing radiations and consequently dangerous to life. Gamma radiation is released under the radioactive decay chain of Radon. Different techniques have been implemented to assess radon concentration. Radon is an invisible, colourless, odourless, tasteless, inert, radioactive gas formed by the decomposition of Uranium and Radium. Many researchers are paying attention worldwide to the naturally occurring radioactive, noble gas Radon (^{222}Rn). The Radon (^{222}Rn) originates innately from the soil and some materials used for construction of buildings. Further, it will enter the atmosphere by diffusion and advection [1]. Concentration of Radon fluctuates significantly with season and atmospheric conditions. As a radioactive element, Radon radiates alpha particles of energy 5.67 MeV which is ionizes ambient air [2]. Among all radionuclides, greater emphasis is placed on the progeny of Uranium-238 and Thorium-232 [2]. About 81% of the total radiation dose is from natural radioactivity and about 55% is from inhalation of radon and its offspring [4].

When it comes to the biological effects, it is very essential to be acquainting with the concentration of radon level in livelihood environment [5]. Radon itself is not liable for the health risk, being chemically inert; it does

not accumulate much in the body. In contrast, the major concern is for short-lived radon decay products. These substances are chemically reactive and can thus be deposited into the tissues of the respiratory tract when inhaled. Subsequent particle decay can damage cells near the deposition site; this may causative for lung cancer [6].

II. GEOGRAPHIC AREA OF MANDYA DISTRICT



III. EXPERIMENTAL METHOD

rate (nGyh^{-1}) [10]. Similarly, to convert the absorbed dose to effective dose in air, the conversion coefficient of 0.7 SvGy^{-1} and occupation factor of 0.8 for interior air and 0.2 for exterior air were used [11].

The yearly effective gamma dose rates in interior and exterior air were calculated using the equation (1) and (2):

$$\text{Interior} = D_{\text{in}} \times 8.760 \times 10^3 \text{ hy}^{-1} \times 0.8 \times 0.7 \text{ SvGy}^{-1} \times 10^{-6} \quad (1)$$

$$\text{Exterior} = D_{\text{out}} \times 8.760 \times 10^3 \text{ hy}^{-1} \times 0.2 \times 0.7 \text{ SvGy}^{-1} \times 10^{-6} \quad (2)$$

Here D_{in} and D_{out} are the interior (mSvy^{-1}) and exterior (mSvy^{-1}) absorbed gamma dose rates in air (nGyh^{-1}) respectively.

IV. DISCUSSION ON RESULT

Interior and exterior gamma-ray dose rates have been measured in Mandya city using a portable, lightweight radiation dosimeter ER-709. The measurements were carried out from 25 different locations of Mandya city about 1m height from ground level for radiometric geophysical and environmental surveys. The variation of absorbed gamma dose rate, yearly effective gamma dose rate and the ratio of yearly effective gamma dose rate in interior and exterior air from different locations of Mandya town is shown in Table 1. The graphical variation of interior and exterior absorbed gamma dose rate in air from different locations of Mandya town is shown in Fig 2. The yearly effective gamma dose rate from different locations of Mandya town is shown in fig 3.

The absorbed gamma dose rate in interior and exterior air varied from $66.12 \times 10^{-9} \text{ Gyh}^{-1}$ to $131.89 \times 10^{-9} \text{ Gyh}^{-1}$ with a geometrical average of $95.11 \times 10^{-9} \text{ Gyh}^{-1}$ and $48.72 \times 10^{-9} \text{ Gyh}^{-1}$ to $77.60 \times 10^{-9} \text{ Gyh}^{-1}$ with a geometrical mean value of $58.45 \times 10^{-9} \text{ Gyh}^{-1}$. Respectively the higher values of interior and exterior rate of absorbed gamma dose in air were found $131.89 \times 10^{-9} \text{ Gyh}^{-1}$ and $64.03 \times 10^{-9} \text{ Gyh}^{-1}$ in Thubinakere Industrial area; $118.67 \times 10^{-9} \text{ Gyh}^{-1}$ and $58.46 \times 10^{-9} \text{ Gyh}^{-1}$ in Swarnasandra; $116.23 \times 10^{-9} \text{ Gyh}^{-1}$ and $57.07 \times 10^{-9} \text{ Gyh}^{-1}$ in Guthalu; $112.75 \times 10^{-9} \text{ Gyh}^{-1}$ and $57.42 \times 10^{-9} \text{ Gyh}^{-1}$ in Ashoka Nagara; $109.27 \times 10^{-9} \text{ Gyh}^{-1}$ and $56.38 \times 10^{-9} \text{ Gyh}^{-1}$ in Vidya Nagara; $108.92 \times 10^{-9} \text{ Gyh}^{-1}$ and $57.42 \times 10^{-9} \text{ Gyh}^{-1}$ in Rajakumar Badavane; $108.58 \times 10^{-9} \text{ Gyh}^{-1}$ and $53.27 \times 10^{-9} \text{ Gyh}^{-1}$ in Nehru Nagara; $107.53 \times 10^{-9} \text{ Gyh}^{-1}$ and $77.60 \times 10^{-9} \text{ Gyh}^{-1}$ in Kempegowda Badavane; $107.53 \times 10^{-9} \text{ Gyh}^{-1}$ and $67.51 \times 10^{-9} \text{ Gyh}^{-1}$ in Subhash Nagara; $101.62 \times 10^{-9} \text{ Gyh}^{-1}$ and $70.30 \times 10^{-9} \text{ Gyh}^{-1}$ in Factory Circle; $100.92 \times 10^{-9} \text{ Gyh}^{-1}$ and $56.38 \times 10^{-9} \text{ Gyh}^{-1}$ in Lalithanayak Badavane; $99.18 \times 10^{-9} \text{ Gyh}^{-1}$ and $65.42 \times 10^{-9} \text{ Gyh}^{-1}$ in Nalvadi Krishnaraja Badavane; $95.00 \times 10^{-9} \text{ Gyh}^{-1}$ and $64.03 \times 10^{-9} \text{ Gyh}^{-1}$ in Halahalli. In addition to this, absorbed gamma dose rate in air were found to be slightly higher in interior condition. This can be due to increased activity concentration of the radionuclides found in younger granites, granodiorite, and pegmatite, occasional patches of schist, phyllite, shale, limestone/marbles, quartz and unclassified crystalline rocks.

In the present study, yearly effective gamma dose rates of interior and exterior air obtained from different locations are likened with the readings reported for other environments of the world, and it is shown in Table 2. The interior and exterior yearly effective dose rate varies from $0.32 \times 10^{-3} \text{ Svyr}^{-1}$ to $0.65 \times 10^{-3} \text{ Svyr}^{-1}$ with a average geometric value of $0.47 \times 10^{-3} \text{ Svyr}^{-1}$ and $0.06 \times 10^{-3} \text{ Svyr}^{-1}$ to $0.10 \times 10^{-3} \text{ Svyr}^{-1}$ with a average geometric value of $0.07 \times 10^{-3} \text{ Svyr}^{-1}$ which is slightly higher compared to the worldwide average of the yearly effective dose rate [11]. The observed variability attributed to the geographical characteristics of the study area

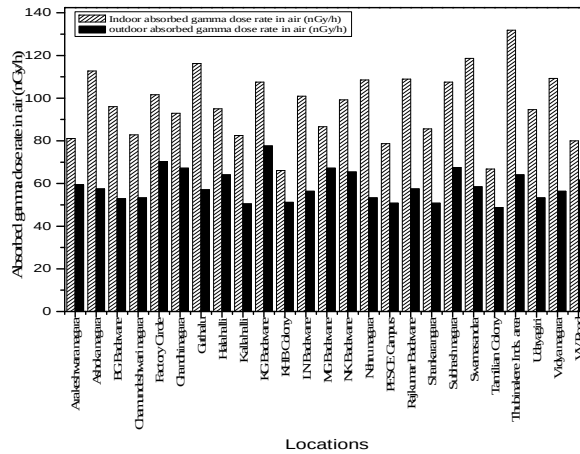


Figure 2: Variation of interior and exterior absorbed effective gamma dose rate in air from different areas of Mandya city

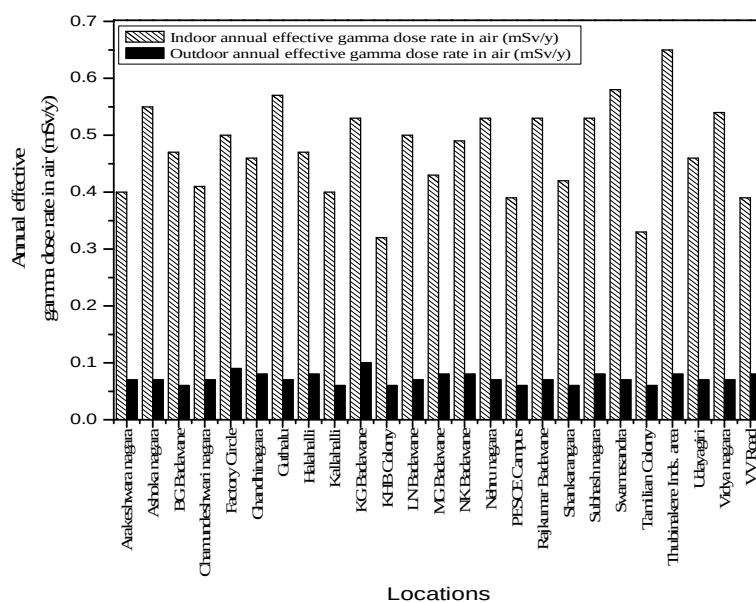


Figure 3: Variation of yearly interior and exterior effective gamma dose rate to air from different locations of Mandya city

TABLE I: ABSORBED GAMMA DOSE RATE IN AIR AND YEARLY EFFECTIVE GAMMA DOSE RATE IN AIR FROM DIFFERENT AREAS OF

MANDYA CITY

Sl No.	Locations	Absorbed Gamma Dose rate in Air ($10^{-9}\text{Gy}\cdot\text{h}^{-1}$)		Yearly Effective Gamma Dose rate in Air ($10^{-3}\text{Sv}\cdot\text{y}^{-1}$)			Ratio: Interior to Exterior
		Interior	Exterior	Interior	Exterior	Total	
1	Arakeshwara Nagara	81.08	59.51	0.40	0.07	0.47	1.36
2	Ashoka Nagara	112.75	57.42	0.55	0.07	0.62	1.96
3	BG Badavane	96.05	52.90	0.47	0.06	0.54	1.82
4	Chamundeswari Nagara	82.82	53.24	0.41	0.07	0.47	1.56
5	Factory Circle	101.62	70.30	0.50	0.09	0.58	1.45
6	Gandhi Nagara	92.92	67.16	0.46	0.08	0.54	1.38
7	Guthalu	116.23	57.07	0.57	0.07	0.64	2.04
8	Halahalli	95.00	64.03	0.47	0.08	0.54	1.48
9	Kallahalli	82.48	50.46	0.40	0.06	0.47	1.63
10	KG Badavane	107.53	77.60	0.53	0.10	0.62	1.39
11	KHB Colony	66.12	51.16	0.32	0.06	0.39	1.29
12	LN Badavane	100.92	56.38	0.50	0.07	0.56	1.79
13	MG Badavane	86.65	67.16	0.43	0.08	0.51	1.29
14	NK Badavane	99.18	65.42	0.49	0.08	0.57	1.52
15	Nehru Nagara	108.58	53.24	0.53	0.07	0.60	2.04
16	PESCE Campus	78.65	50.81	0.39	0.06	0.45	1.55

17	Rajakumar Badavane	108.92	57.42	0.53	0.07	0.60	1.90
18	Shankara Nagara	85.61	50.81	0.42	0.06	0.48	1.68
19	Subhash Nagara	107.53	67.51	0.53	0.08	0.61	1.59
20	Swarnasandra	118.67	58.46	0.58	0.07	0.65	2.03
21	Tamilian Colony	66.82	48.72	0.33	0.06	0.39	1.37
22	Thubinakere Inds. area	131.89	64.03	0.65	0.08	0.73	2.06
23	Udayagiri	94.66	53.24	0.46	0.07	0.53	1.78
24	Vidya Nagara	109.27	56.38	0.54	0.07	0.61	1.94
25	VV Road	80.04	61.60	0.39	0.08	0.47	1.30
Geometric Mean		95.11	58.45	0.47	0.07	0.54	1.63
Minimum		66.12	48.72	0.32	0.06	0.39	1.29
Maximum		131.89	77.6	0.65	0.1	0.73	2.06
Geometric SD		16.34	7.39	0.08	0.01	0.08	0.27

TABLE II: INTERIOR AND EXTERIOR YEARLY EFFECTIVE GAMMA DOSE RATE IN AIR FROM DIFFERENT PARTS OF THE WORLD.

Locations	Yearly Effective Gamma Dose rate in air (mSvy ⁻¹)		References
	Interior	Exterior	
Kollam district, Kerala, India	7.56	4.83	[12]
Chikkamagalur district, Karnataka,	0.95	0.21	[13]
Shimoga District, Karnataka, India	0.87	0.24	[14]
Vietnam	0.37	0.09	[15]
Bushehr city, Iran	0.38	0.29	[16]
Abuja	0.75	0.19	[17]
Nigeria	1.54	0.44	[18]
World Average	0.41	0.07	[11]
Mandya city	0.47	0.07	Present study

V. CONCLUSION

The interior and exterior gamma background radiation was recorded in 25 different areas of Mandya city using a portable lightweight environmental radiation dosimeter ER-709. The absorbed gamma dose rate of interior and exterior air was compared with the yearly effective dose rate. It is observed that, yearly effective dose rate in the study area found evidently upper than the global average. Hence, comprehensive study of the rate of background radiation dose is necessary to the population of Mandya city.

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REFERENCES

- [1] United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) Annexure A. Sources and effects of ionizing radiation. United Nations, New York, (1988).
- [2] Charan Kumar, K. and Nagaraja Kamsali. One year of ^{222}Rn concentration at a typical rural site in South India, *Radiation Protection and Environment*. 44, 73-78 (2021).
- [3] Wilkening, M. Radon in the Environment. 1st ed. Netherlands: Elsevier; 1(1990).
- [4] Studies on gamma dose rates in indoor and outdoor environment of Hassan city, Karnataka. Shashikumar, T. S., Ningappa, C., Shivalinge Gowda, and Chandrasekhar. *Radiation Protection Dosimetry*, Vol. 188 (4), 516–521(2020).
- [5] Nagaiah, N. and Shivaprasad, N. G., Ambient gamma exposure level in air and the associated radiation dose to the population of Bengaluru, South India. *Vijnanabharathi* 1(1), 60–68 (2016).
- [6] William, W. Nazaroff. Radon Transport from Soil to Air, Department of Civil Engineering, University of California, Berkeley. *Reviews of Geophysics*, 30 (2), 137-160 (1992).
- [7] Taskin, H., Karavus, M., Ay, P., Topuzoglu, A., Hidioglu, S. and Karahan, G. Radionuclide concentrations in soil and lifetime cancer risk due to gamma radioactivity in Kirklareli, Turkey. *J Environ Radioact*. 100, 49–53 (2009).
- [8] Ground Water Information Booklet of Mandya district, Karnataka. Government of India, Ministry of Water Resources, Central Ground Water Board, South Western Region, Bangalore, (2008).
- [9] Stanton, M. R., Wanty, R. B., Lawrence, E. P. and Briggs, P. H. Dissolved Radon and Uranium, and Ground-Water Geochemistry in an Area near Hylas, Virginia, U.S. Geological Survey Bulletin 2070. (Washington: United States Government Printing Office) (1996).
- [10] Nambi, K. S., Bapat, V. N., David, M., Sundram, V. K., Sunta, C. M., and Soman, S. D. Country wide environmental radiation monitoring using thermoluminescence. *Radiation Protection Dosimeter*. 24, 27–31 (1987).
- [11] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Sources, Effects, and Risks of Ionizing Radiation. New York: United Nations: United Nations Scientific Committee on the Effects of Atomic Radiation. (2000).
- [12] Monica, S., Visnu Prasad, A. K., Soniya, S. R., and Jojo, P. J. Estimation of indoor and outdoor effective doses and lifetime cancer risk from gamma dose rates along the coastal regions of Kollam district, Kerala *Radiation Protection and Environment*. 39(1), 38-43 (2016).
- [13] Srinivasa, E., Rangaswamy, D. R., Suresh, S., Umesh Reddy, K., and Sannappa, J. Measurement of ambient gamma radiation levels and radon concentration in drinking water of Koppa and Narasimharajapura taluks of Chikmagalur district, Karnataka, India. *Radiation Protection and Environment*, 41(1), 20-25 (2018).
- [14] Rangaswamy, D. R., Srinivasa, E., Srilatha, M. C., and Sannappa, J. Measurement of terrestrial gamma radiation dose and evaluation of annual effective dose in Shimoga District of Karnataka State, India. *Radiation Protection and Environment*. 38(4), 154-159 (2015).
- [15] Kazumasa Inoue, Masahiro Fukushima, Tan Van Le, Hiroshi Tsuruoka, Shogo Kasahara and Veerasamy Nimelan. Distribution of gamma radiation dose rate related with natural radionuclides in all of Vietnam and radiological risk assessment of the built-up environment. *Scientific Reports*. 10, Article number: 12428 (2020).
- [16] Ali Mahmoud Pashazadeh, Mahdi Aghajani, Iraj Nabipour, and Majid Assadi. Annual effective dose from environmental gamma radiation in Bushehr city. *J Environ Health Science*. 12, 4 (2014).
- [17] James, I. U., Moses, I. F., Vandi, J. N., and Ikoh, U. E. Measurement of Indoor and Outdoor Background Ionising Radiation Levels of Kwali General Hospital, Abuja. *J. Appl. Sci. Environ. Manage*. 19 (1) 89 – 93 (2015).
- [18] Felix Masok. Assessment of indoor and outdoor background radiation levels in plateau state University Bokkos Jos, Nigeria, (2015).
- [19] T S Shashikumar, S Revanna, M N Ramachandra, G V Ashok, C Ningappa, Shivalinge Gowda. "MEASUREMENT OF RADON SOIL GAS IN AND AROUND BHARATHINAGARA, MANDYA DISTRICT", *Radiation Protection Dosimetry*, 2019
- [20] K N Narasimhamurthy, G V Ashok, T S Shashi Kumar, N Nagaiah, M B Karthik Kumar. "A Study on the radiation dose due to dissolved ^{222}Rn in water samples of Mandya city, Karnataka, India" *Radiation Protection Dosimetry*, 2021
- [21] Mukesh Prasad, V. Ranga, G. Anil Kumar, R. C. Ramola. "Radiological impact assessment of soil and groundwater of Himalayan regions in Uttarakhand, India", *Journal of Radioanalytical and Nuclear Chemistry*, 2019
- [22] S. Monica, A.K. Visnu Prasad, S.R. Soniya, P. J.Jojo. "Comparison of Gamma Dose Levels in Assessed by Various Methods", *Materials Today: Proceedings*, 2019
- [23] Muhammad Rafique. "Ambient indoor/outdoor gamma radiation dose rates in the city and at high altitudes of Muzaffarabad (Azad Kashmir)", *Environmental Earth Sciences*, 2013
- [24] Sumit Sharma, Kamini Mehta, Saurabh Narang, Ajay Kumar. "Dose estimation from the exposure to radon, thoron and their progeny concentrations in the environs of Kangra area, Himachal Himalayas, India", *Groundwater for Sustainable Development*, 2020
- [25] Muzahir Ali BALOCH, Aziz Ahmed QURESHI, Abdul WAHEED, Muhammad ALI et al. "A Study on Natural Radioactivity in Khewra Salt Mines, Pakistan", *Journal of Radiation Research*, 2012
- [26] Baskaran, I. "Effect of accelerators and stabilizers on the formation and characteristics of electroless Ni-P deposits", *Materials Chemistry & Physics*, 20060910

- [27] Sumit Sharma, Kamini Mehta, Saurabh Narang, Ajay Kumar. "Dose estimation from the exposure to radon, thoron and their progeny concentrations in the environs of Kangra area, Himachal Himalayas, India", Groundwater for Sustainable Development, 2020.