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Estimation of Cancer Risk from External Gamma Dose Rates for Human Habitats around KGF Gold Mines

*1Shiva Prasad NG

*1Department of Physics, Govt. First Grade College, Srirangapatna, Karnataka, India.

Abstract

The external gamma dose rates in air were measured at a height of 1 m from gound level at residential locations surrounding gold mine area of KGF town using a scintillometer [Type SM 141D, Electronics Corporation of India Limited (ECIL)]. The absorbed dose rate observed varies from 110.34 – 189.65 nGy h^{-1} with a mean value of 135.94 nGy h^{-1} for indoor and it varies from 72.53 – 132.37 nGy h^{-1} with a mean value of 94.41 nGy h^{-1} for outdoor environment. The risk of cancer due to indoor and outdoor gamma radiation exposure were estimated. The cancer risk for the population of the study area for indoor environment varies in the range of 22.05×10^{-4} – 37.90×10^{-4} with a mean value of 28.19×10^{-4}. The mean life time cancer risk for each person working in study area is found nearly ten times higher than the global average of 2.99×10^{-4}. It is in the range of 3.62×10^{-4} – 6.61×10^{-4} with a mean value of 4.72×10^{-4} for outdoor environment. This mean value is higher than the global average of 2.99×10^{-4}. The results obtained in the present study are compared with the values reported for other parts of the world and discussed. The results show that these people are at higher radiation risk compared to others.

Keywords: Absorbed dose, the annual effective dose, cancer risk

Introduction

Background radiation is natural and ubiquitously present in the environment and varies significantly from place to place on the globe. People living in granite areas or in mineralised sands receive more terrestrial radiation than in other areas, whereas people living or working at high altitude receive more radiation from cosmic rays [1].

The research region is located near Kolar Gold Fields (KGF), which is home to Bharath Gold Mines Limited (BGML), the second-deepest underground mine in the world (at 3209 m). The research region is composed of the following geological formations: quartzite, champion gneiss, metabasalt, dolerite dyke, grey granite, and hornblende gneiss. A sizable amount of the research region is covered in hornblende gneiss and closepet granite. The present study aims to estimate the life time cancer risk to the population of the study area due to indoor and outdoor gamma radiation exposure. The gamma exposure rates were taken from the literature values available elsewhere reported by others.

Materials and Methods

At various locations throughout the study area, ambient gamma radiation levels were measured indoors and outdoors using a scintillometer [Type SM 141D, Electronics Corporation of India Limited (ECIL)]. A portable radiation survey metre that is lightweight is called a scintillometer. A photomultiplier is optically connected to a thallium triggered sodium iodide crystal that serves as the detector. All measurements were taken at a height of 1 m. Five to six readings were taken at each location, and the arithmetic mean of those readings was calculated. The measured exposure rate (in μR h^{-1}) was converted into absorbed dose rate (in nGy h^{-1}) using the conversion factor of 1 μR h^{-1} = 8.77 nGy h^{-1} which stems from the definition of the Roentgen[2]. The dose rate recorded by this instrument includes both terrestrial and cosmic ray components.

For the present study, author selected eight locations surrounding the gold mines of KGF city. They are Robertson pet (L-1), Anderson pet (L-2), Marikuppam (L-3), Sambram hospital (L-4), Krishnapuram (L-5), BEML Nagar (L-6), Oorgaum (L-7), Champion (L-8).

There is a linear relation between the lifetime relative risk of all cancers and background gamma radiations. Studies have been conducted to examine the risks of cancer in areas of high natural background radiation [3-4]. The life time cancer risk to the population of the study area due to indoor and outdoor gamma radiation exposure from natural radionuclides was calculated using the relative risk equation and the fatal cancer risk factor [5].

$$R = E \times AL \times RF$$

Where, E is the annual effective dose equivalent, AL is average lifetime (70 y), RF is the risk factor (0.0582 Sv^{-1}), fatal cancer risk per Sievert (BEIR VII) [6].

Results and Discussion

The absorbed dose rate observed varies from 110.34 – 189.65 nGy h^{-1} with a mean value of 135.94 nGy h^{-1} for indoor environment and for outdoor environment it varies from 72.53 – 132.37 nGy h^{-1} with a mean value of 94.41 nGy h^{-1}. This mean value is high when compared to the Indian national average values of 80.7 nGy h^{-1} and 88.5 nGy h^{-1} reported by

*Corresponding Author: Shiva Prasad NG

Mishra and Sadasivan[7] and Nambi *et al* [2]., respectively. The higher values of absorbed dose rates observed in the study region are mainly attributed to the local geology of the region which largely comprises of numerous varieties of granites. It is well known that granites are enriched with radioactive elements.

From the measured external gamma dose rates, the life time cancer risk is estimated for indoor environment and results are presented in Table 1.

Table 1: The life time cancer risk due to indoor gamma exposure.

Sl. No.	Location	Life time cancer risk (10^{-4}) Indoor
1	L – 1	37.90
2	L – 2	27.95
3	L – 3	26.45
4	L – 4	22.05
5	L – 5	25.52
6	L – 6	25.09
7	L – 7	23.32
8	L – 8	37.24
Range		22.05 – 37.90 (28.19)

The values given in the parenthesis are the mean values.

The risk of cancer due to indoor gamma radiation exposure was calculated using the relative risk relation provided by UNSCEAR[3]. The cancer risk for the population of the study area varies in the range of $22.05\text{x}10^{-4}$ – $37.90\ \text{x}10^{-4}$ with a mean value of $28.19\text{x}10^{-4}$. This is nearly ten times higher than the global average of $2.99\text{x}10^{-4}$. The graph drawn from the results obtained are shown in the figure 1.

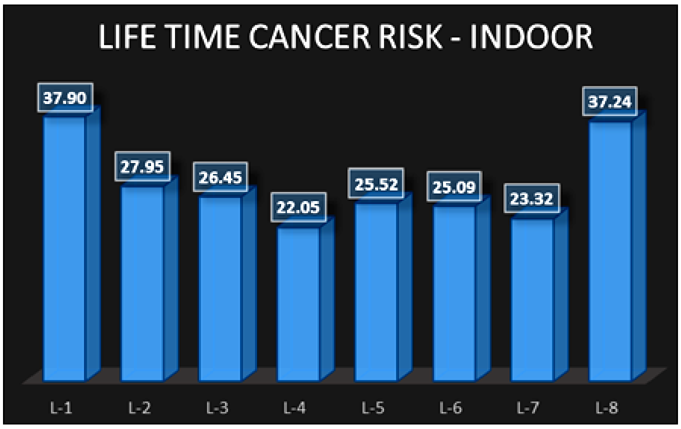

Fig 1: Graph showing the life time cancer risk for indoor environment

The life time cancer risk is estimated for outdoor environment and results are presented in Table 2.

Table 2: The life time cancer risk due to outdoor gamma exposure.

Sl. No.	Location	Life time cancer risk (10^{-4}) Outdoor
1	L – 1	6.61
2	L – 2	4.66
3	L – 3	4.81
4	L – 4	3.62
5	L – 5	4.11
6	L – 6	4.49
7	L – 7	4.32
8	L – 8	5.11
Range		3.62-6.61 (4.72)

The cancer risk for the population of the study area due to outdoor gamma exposure varies in the range of $3.62\text{x}10^{-4}$ – $6.61\ \text{x}10^{-4}$ with a mean value of $4.72\text{x}10^{-4}$. This mean value is higher than the global average of $2.99\text{x}10^{-4}$. The graph obtained from the results obtained are shown in figure 2.

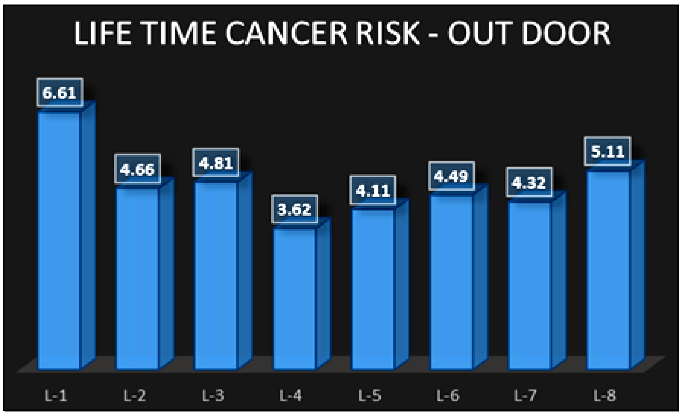

Fig 2: Graph showing life time cancer risk for outdoor environment

The data obtained in the present study is compared with the values reported for other parts of India, globe and world average values and are shown in Table 3.

Table 3: Comparative table.

Sl No	Location	Life time cancer risk (10^{-4})	Reference
1	KGF	4.73	Present study
2	Shimoga, India	7.21	[8]
3	Odisha, India	9.37	[9]
4	Hassan, India	10.59	[10]
5	Bangalore, India	10.47	[11]
6	Kenya	17.93	[12]
7	Malaysia	3.75	[5]
8	Japan	2.16	[13]
9	Greese	2.28	[13]
10	China	2.53	[13]
11	Russia	2.65	[13]
12	World	2.40	[5]

The literature values of life time cancer risk reported for other regions is shown in figure 3. From the figure it can be seen that the highest value is reported for Kenya which is almost eight folds higher than the world average value.

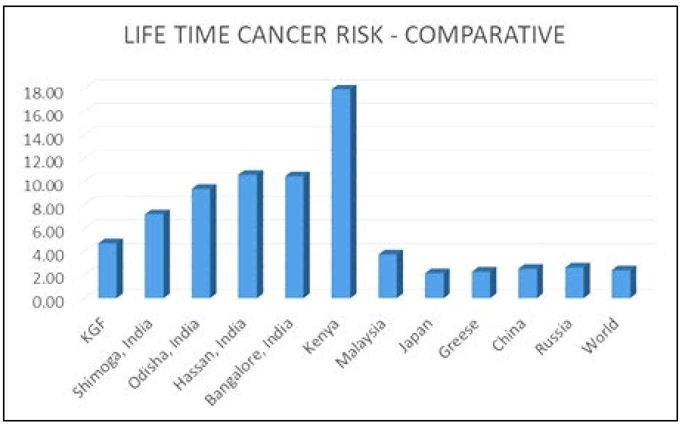

Fig 3: Graph showing life time cancer risk for other environments

Conclusions

The mean life time cancer risk found in the present study are found to be high compared to the world average values. The results show that the granite quarry workers are at higher radiation risk.

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