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ASSESSMENT OF ANNUAL EFFECTIVE DOSE OF GAMMA RADIATION IN VISAKHAPATNAM, ANDHRA PRADESH STATE, INDIA

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ABSTRACT The living creatures on the earth are continuously exposed to radiation from extraterrestrial and terrestrial sources. These sources are caused to the ambient gamma dose rates which affect the dwellers. This study reveals the results of observations for a while about the dose in both indoor and outdoor atmospheres. The measurements were done in 17 locations in the Visakhapatnam district, Andhra Pradesh. The PM-1405 ambient radiation dosimeter was used to make these measurements, which is a portable detector based on the Geiger Muller counter. Annual effective dose (AED) was estimated using a standard method based on the measured average absorbed dose rates. The measured indoor absorbed dose rates in Visakhapatnam district 2021–June, ranged between 0.19±0.02 to 0.32±0.07 μSv.h-1, and the measured outdoor absorbed dose rates ranged from 0.15 ± 0.01 to 0.28±0.06 μSv.h-1 and the mean of indoor and outdoor measurements being 0.26±0.04 to 0.22±0.03 μSv.h-1 respectively. The indoor AED ranged between 0.93 to 1.57 mSv.y-1 and the outdoor AED ranged from 0.18 to 0.34 mSv.y-1 with average values of 1.3 mSv.y-1 and 0.27 mSv.y-1 respectively. In the year 2018 – June, the indoor and outdoor absorbed dose rates, measurements ranged from 0.18±0.01 to 0.34±0.06 μSv.h-1 and 0.16 ± 0.02 to 0.31±0.06 μSv.h-1 and the mean values being 0.26±0.03 to 0.21±0.03 μSv.h-1. The indoor and outdoor AED ranged from 0.88 to 1.67 mSv.y-1 and 0.2 to 0.38 mSv.y-1 with average values of 1.28 mSv.y-1 and 0.26 mSv.y-1 respectively for the year 2018, External exposure to terrestrial radiation for members of the public should not exceed an effective dose of roughly 0.48 mSv per year, as recommended by the UNSCEAR 2000 report. As a result, it may be assumed that the general population faces significant radiological hazards from terrestrial radiation caused by the natural radionuclides in the area.

KEYWORDS : Ambient gamma dose rate, Indoor and Outdoor absorbed dose rates, Portable survey meter, annual effective dose.

INTRODUCTION:

Since the formation of the earth (creation of the universe), natural radiation has been an integral part of our environment. Ionizing radiation is continuously emitted from a wide range of sources, including naturally radioactive substances [1]. Natural sources contribute 80% of our exposure, while man-made artificial sources contribute 20%. In natural radiation, one is high-energy cosmic ray particles from extraterrestrial sources which interact with the atmosphere and create radioactive nuclei. Radiation increases with the altitude from the mean sea level[3]. On a mountain top or aboard an aircraft, exposure is many times more intensive than at sea level. Aircrews spend much of their working life at altitudes where cosmic radiation is 20 times higher than normal background radiation[2]. Natural long-lived radioactive substances are present as impurities in fossil fuels. As wisely stated by Rutherford in 1905, "Every falling raindrop and snowflake carries some radioactive matter to the earth, while every leaf and blade of grass is covered with an invisible film of radioactive material". Several of the elements in the earth's crust are radioactive. Exposures vary depending on a variety of factors in different locations. There are areas with high levels of natural background radiation[4]. This widespread curiosity prompted radiation monitoring and surveys all across the world. This information helps analyse consequences for health and establish baseline data[5].

Radioactivity in the natural environment is mostly caused by indirect radioactive elements such as soil, building materials, and sand[6]. As Visakhapatnam is one of the fastest-growing cities in India and is going to host a nuclear facility, there is a need to monitor radiation dose in and around Visakhapatnam. Given radiation and environmental protection, a preliminary study on the estimation of radiation dose to the members of the public[7], has been carried out. This can help us to find out the population dose of the dwellers of Visakhapatnam district. According to UNSCEAR (2000), everyone in the world receives an effective dose of approximately 0.48mSv from terrestrial radiation on an annual basis. The amount of external exposure differs greatly among countries such as France, Germany, Italy, Japan, and the United States. According to an earlier study in this area, approximately 95 percent of the population lives in areas where the average yearly dosage outdoors ranges from 0.3 to 0.6 mSv[8].

MATERIALS AND METHODOLOGY

The PM-1405 radiation survey meters feature a large energy calibrated GM tube for measurement of the ambient equivalent dose rate of X-ray and gamma radiation in the range of 0.1 Sv.h-1 to 100 mSv.h-1 (10 R.h-1). The instrument was calibrated using 137 Cs as a standard source at Polimaster Ltd's radiation Standard and Calibration Lab. The PM-1405 was manufactured by POLIMASTER Ltd, Minsk, Republic of Belarus. This survey meter is designed for searching, detecting, and localizing gamma and beta radiation sources. The instrument is calibrated to read exposure with a measuring sensitivity of 0.01 μSv to 10 μSv with a measurement accuracy of ±20%. The Survey instrument also can measure beta radiation flux density from contaminated surfaces (as well as the ambient dose equivalent rate of gamma and X-ray radiation)[9]. Whenever the user's threshold levels are reached, the instrument emits loud alarms and records the resultant counts in Search Mode. It's an excellent choice for measuring radiation levels in the environment. The equipment can estimate the intensity of surfaces beta contaminated of various environmental items by opening the unique screen filter and selecting beta radiation flux density measurement mode. Small and lightweight, having a big LCD with backlight, audio alert, and nonvolatile memory. Its sole purpose is to detect low-level terrestrial gamma dose rates in both indoor and outdoor settings.

The terrestrial gamma dose rates are measured for different types of buildings in different areas at an approximate distance of one meter above the ground[6]. Eight measurements were obtained at each location with a 4-minute time interval. The average value of those eight measurements is used in the calculation of effective dose measurements. Sampling locations were selected randomly within the district. The AED for the external terrestrial radiation was calculated using the formula.

$$AED\,(mSv.y^{-1}) = D \times T \times OF \times CC \qquad \ldots\ldots\ldots (1)$$

Where AED is the annual effective dose D is the absorbed dose rate; T is time in hours - for 1 year (8760h); OF (Occupancy Factor) is 0.8 for Indoor and 0.2 for outdoor exposure, and CC is Conversion Coefficient - As per UNSCEAR 1993 report, 0.7 $Sv.Gy^{-1}$ is considered as CC to convert absorbed dose in the air to effective dose received by adults in members of the public[3].

Geology Of Study Area

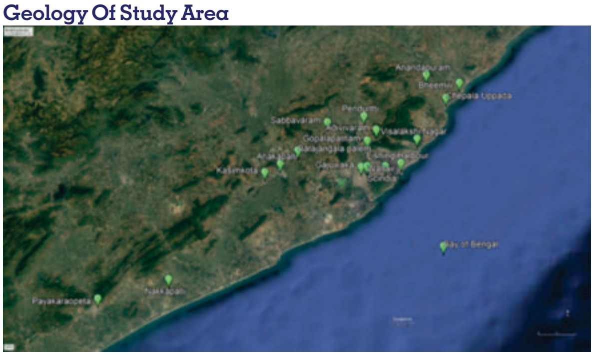

Fig 1: Sampling locations in and around the Visakhapatnam

Fig 1 shows the map of Visakhapatnam, which is a coastal district of Andhra Pradesh. Spread over an area of 13,140 sq km and is situated between 17°30' to 18°30' North latitude and 82°0' to 83°30' east longitudes. The terrain of the district is dominantly hilly, thickly wooded, and rugged. A small narrow coastal plain lies in the southern part. The highest elevation in the district is 1645m and the lower elevation is 29m above Mean Sea Level (MSL). The district is drained by Sarada, Tandava, and Gosthani rivers and their tributaries[10]. The rivers flow south, southeast, and empty into the Bay of Bengal. Eastern ghat mobile belt exposes all the characteristics of Lithounits similar to the others belonging to Eastern Ghats Supergroups such as the Khondalite, Charnockite, and Migmatite. The major minerals found in the district are gemstone, bauxite, graphite, apatite, vermiculite, magnetite, marble/crystalline, and phlogopite mica[4].

The average absorbed dose rates of the indoor and outdoor environment in the selected locations of Visakhapatnam district are summarized in table-1 and table-2. Using the conversion factor of 0.7 Sv.Gy-1 and the indoor occupancy factor of 0.8 Sv.Gy-1, the annual effective dose corresponding to the population in the study region was calculated [3].

RESULTS AND DISCUSSIONS

In the year 2018, from Table 1, the indoor gamma radiation levels were found to be in the range from 0.18 ± 0.01 to 0.34±0.06 $\mu Sv.h^{-1}$ with a mean value of 0.26±0.03 $\mu Sv.h^{-1}$. The estimated effective dose varied from 0.88 to 1.67 $mSv.y^{-1}$ with a mean of 1.28 $mSv.y^{-1}$. The effective dose was found to be minimum at Gajuwaka and maximum at Pendurthi. The outdoor gamma radiation levels were in the range from 0.16±0.02 $\mu Sv.h^{-1}$ to 0.31±0.06 $\mu Sv.h^{-1}$ with mean value of 0.21±0.03 $\mu Sv.h^{-1}$. The effective gamma dose rate found to be in the range 0.2 $mSv.y^{-1}$ to 0.38 $mSv.y^{-1}$, with a mean of 0.26 $mSv.y^{-1}$. The minimum value is found at Nakkapalli and the maximum value found at Chepalauppada.

In the year 2021, from Table 2, the values were higher compared to previous studies. The indoor gamma radiation levels varied from 0.19 ± 0.02 to 0.32 ± 0.07 $\mu Sv\ h^{-1}$ and corresponding mean value is 0.26 ± 0.04 $\mu Sv.h^{-1}$. The dose was found to be minimum at Nakkapalli and maximum at Pendurti and Chepaluppada. The effective dose. The outdoor gamma radiation levels varied from 0.15 ± 0.01 to 0.28 ± 0.06 $\mu Sv.h^{-1}$ and corresponding mean value is 0.22 ± 0.05 $\mu Sv.h^{-1}$. The indoor annual effective gamma dose rate ranged between 0.93 and 1.57 $mSv.y^{-1}$, and the outdoor annual effective dose ranged from 0.18 to 0.34 $mSv.y^{-1}$ with average values of 1.3 $mSv.y^{-1}$ and 0.27 $mSv.y^{-1}$. The minimum value was found at Nakkapalli and the maximum at Pendurti and Bheemili. Comparisons between the two years as shown in Fig(1) and Fig(2).

Table 1: Absorbed Dose And Effective Dose Of Indoor And Outdoor Environment – June 2018.

S. No	Location	Latitude	Longitude	Indoor		Outdoor		Total Effective Dose ($mSv.y^{-1}$)
				Absorbed Dose ($\mu Sv.h^{-1}$)	Effective Dose ($mSv.y^{-1}$)	Absorbed Dose ($\mu Sv.h^{-1}$)	Effective Dose ($mSv.y^{-1}$)	
1	Waltair	17°41'12.54"N	83°13'6.53"E	0.29 ± 0.03	1.42	0.25 ± 0.03	0.31	1.73
2	Visalakshi Nagar	17°45'13.31"N	83°20'31.52"E	0.28 ± 0.02	1.37	0.2 ± 0.03	0.25	1.62
3	Fishing harbor	17°41'44.97"N	83°18'9.07"E	0.26 ± 0.05	1.28	0.21 ± 0.03	0.26	1.54
4	Gopala Patnam	17°44'52.71"N	83°13'4.49"E	0.19 ± 0.03	0.93	0.17 ± 0.02	0.21	1.14
5	Scindia	17°41'14.90"N	83°15'50.93"E	0.26 ± 0.03	1.28	0.19 ± 0.03	0.23	1.51
6	Gajuwaka	17°41'6.45"N	83°12'12.77"E	0.18 ± 0.01	0.88	0.17 ± 0.02	0.21	1.09
7	Anakapalli	17°41'22.72"N	83° 0'8.51"E	0.25 ± 0.03	1.23	0.21 ± 0.04	0.26	1.49
8	Kasim Kota	17°40'10.24"N	82°57'53.62"E	0.27 ± 0.02	1.32	0.19 ± 0.03	0.23	1.55
9	Nakkapalli	17°24'43.51"N	82°43'45.55"E	0.19 ± 0.02	0.93	0.16 ± 0.03	0.20	1.13
10	Adavivaram	17°46'24.74"N	83°14'24.58"E	0.24 ± 0.03	1.18	0.19 ± 0.03	0.23	1.41
11	Payakarao Peta	17°21'44.77"N	82°33'11.12"E	0.26 ± 0.03	1.28	0.22 ± 0.02	0.27	1.55
12	Bata Jangala Palem	17°46'44.57"N	83° 6'25.29"E	0.31 ± 0.03	1.52	0.24 ± 0.05	0.29	1.81
13	Sabbavaram	17°48'5.83"N	83°11'13.16"E	0.29 ± 0.05	1.42	0.23 ± 0.03	0.28	1.70
14	Pendurti	17°48'19.92"N	83°12'32.16"E	0.34 ± 0.03	1.67	0.28 ± 0.03	0.34	2.01
15	Chepala uppada	17°50'41.34"N	83°24'10.71"E	0.29 ± 0.03	1.42	0.31 ± 0.06	0.38	1.80
16	Bheemili	17°53'15.06"N	83°26'44.45"E	0.28 ± 0.06	1.37	0.22 ± 0.05	0.27	1.64
17	Anandapuram	17°54'28.04"N	83°22'9.56"E	0.31 ± 0.04	1.52	0.26 ± 0.04	0.32	1.84
	Minimum			0.18 ± 0.01	0.88	0.16 ± 0.02	0.2	0.90

	Maximum			0.34 ± 0.06	1.67	0.31 ± 0.06	0.38	2.05
	Geo Mean			0.26 ± 0.03	1.28	0.21 ± 0.03	0.26	1.54
	SD			0.04 ± 0.01	0.22	0.04 ± 0.01	0.05	0.27

Table 2: Absorbed Dose And Effective Dose Of Indoor And Outdoor Environment – June 2021.

S. No	Location	Latitude	Longitude	Indoor		Outdoor		Total Effective Dose (mSv.y^{-1})
				Absorbed Dose (μSv.h^{-1})	Effective Dose (mSv.y^{-1})	Absorbed Dose (μSv.h^{-1})	Effective Dose (mSv.y^{-1})	
1	Waltair	17°41'12.54"N	83°13'6.53"E	0.31 ± 0.04	1.52	0.26 ± 0.02	0.32	1.84
2	Visalakshi Nagar	17°45'13.31"N	83°20'31.52"E	0.26 ± 0.04	1.28	0.21 ± 0.01	0.26	1.54
3	Fishing harbor	17°41'44.97"N	83°18'9.07"E	0.24 ± 0.03	1.18	0.21 ± 0.04	0.26	1.44
4	Gopala Patnam	17°44'52.71"N	83°13'4.49"E	0.22 ± 0.02	1.08	0.19 ± 0.03	0.23	1.31
5	Scindia	17°41'14.90"N	83°15'50.93"E	0.25 ± 0.05	1.23	0.21 ± 0.03	0.26	1.49
6	Gajuwaka	17°41'6.45"N	83°12'12.77"E	0.24 ± 0.03	1.18	0.18 ± 0.01	0.22	1.4
7	Anakapalli	17°41'22.72"N	83° 0'8.51"E	0.27 ± 0.06	1.32	0.21 ± 0.02	0.26	1.58
8	Kasim Kota	17°40'10.24"N	82°57'53.62"E	0.25 ± 0.04	1.23	0.19 ± 0.02	0.23	1.46
9	Nakkapalli	17°24'43.51"N	82°43'45.55"E	0.19 ± 0.03	0.93	0.15 ± 0.02	0.18	1.11
10	Adavivaram	17°46'24.74"N	83°14'24.58"E	0.21 ± 0.03	1.03	0.21 ± 0.03	0.26	1.29
11	Payakarao Peta	17°21'44.77"N	82°33'11.12"E	0.31 ± 0.03	1.52	0.26 ± 0.03	0.32	1.84
12	Bata Jangala Palem	17°46'44.57"N	83° 6'25.29"E	0.29 ± 0.06	1.42	0.24 ± 0.03	0.29	1.71
13	Sabbavaram	17°48'5.83"N	83°11'13.16"E	0.27 ± 0.04	1.32	0.23 ± 0.04	0.28	1.6
14	Pendurti	17°48'19.92"N	83°12'32.16"E	0.32 ± 0.04	1.57	0.28 ± 0.03	0.34	1.91
15	Chepala uppada	17°50'41.34"N	83°24'10.71"E	0.32 ± 0.06	1.57	0.27 ± 0.03	0.33	1.9
16	Bheemili	17°53'15.06"N	83°26'44.45"E	0.31 ± 0.07	1.52	0.28 ± 0.06	0.34	1.86
17	Anandapuram	17°54'28.04"N	83°22'9.56"E	0.29 ± 0.04	1.42	0.24 ± 0.03	0.29	1.71
	Minimum			0.19 ± 0.02	0.93	0.15 ± 0.01	0.18	1.11
	Maximum			0.32 ± 0.07	1.57	0.28 ± 0.06	0.34	1.91
	Geo Mean			0.26 ± 0.04	1.3	0.22 ± 0.03	0.27	1.57
	SD			0.04 ± 0.01	0.2	0.04 ± 0.01	0.05	0.25

Comparison Between The Study Area In 2021 And 2018, Indoor-survey Meter Readings At Visakhapatnam District. (in Msv.y^{-1})

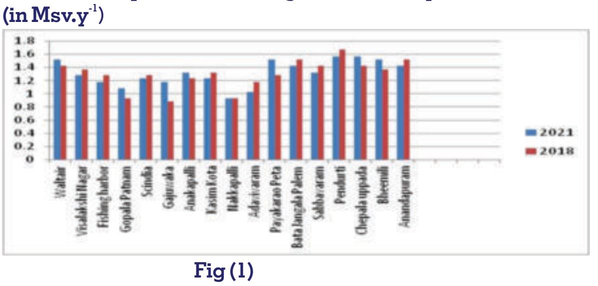

Fig (1)

Comparison Between The Study Area In 2021 And 2018, Outdoor Survey Meter Readings At Visakhapatnam District, 2021 and 2018 (in mSv.y^{-1}).

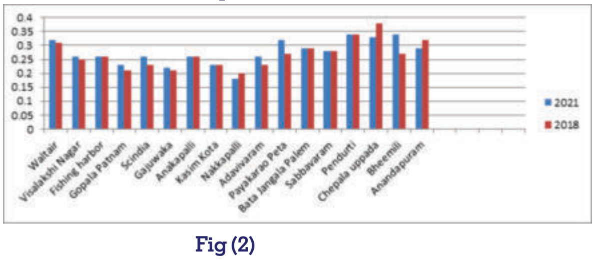

Fig (2)

CONCLUSIONS:

The purpose of this study is to determine the rates of indoor and outdoor terrestrial gamma radiation dosage in the Visakhapatnam district The average indoor terrestrial gamma dose rate in the research area was determined to be 1.28 mSv.y-1 in 2018, whereas the average outdoor terrestrial gamma dose rate was 0.26 mSv.y-1. The average indoor terrestrial gamma radiation rate is 1.3 mSv.y-1 in 2021, while the average outdoor terrestrial gamma dose rate is 0.27 mSv.y-1, both of which are higher than the global average.The resultant indoor absorbed dose values are high compared to Indian average (55 nGy.h^{-1} or 0.0385 mSv h^{-1}) and global average (56 nGy.h^{-1})[11] as per UNSCEAR, 2000[3], [8]. Outdoor absorbed dose values are also high when compared to the global average of 67 nGy.h^{-1} (as per UNSCEAR, 2000). The annual effective doses were measured for both indoor and outdoor environments using equation-1 per UNSCEAR, 2000. The study area mainly major part contains rocks(red gravel) and is near to coast[12][13]. These values are not exceeded the health hazard indexes values, but it's not above the hazard indices values so it are not harmful to the dwellers of Visakhapatnam.

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