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INDOOR AND OUTDOOR BACKGROUND EXPOSURE LEVEL ASSESSMENT OF SOME LOCATIONS IN NATIONAL YOUTH SERVICE CORPS ORIENTATION CAMP, KEFFI, NASARAWA STATE, NIGERIA

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ABSTRACT

Background: Human activities have increased the relative concentration of the radionuclides, referred to as the technologically enhanced naturally occurring radioactive materials (TENORMS) in our society.
Aim: To assess the indoor and outdoor background exposure level of some selected locations in National Youth Service Corp Orientation camp, Keffi, Nasarawa state, Nigeria.
Methodology: A total of ten halls were selected and the exposure rate for four sampling points (two indoor and two outdoor) for each of the hall were measured using a handheld Inspector Alert Nuclear Radiation Monitor. The Radiation Monitor was held at an elevation of 1.0m above ground level and a geographical positioning system (GPS) was used to record the location. The absorbed dose rate, annual effective dose rate, excess lifetime cancer risk and organ doses were calculated.
Results: The result obtained are in the range of 0.16 – 0.36 mR/h, 0.016 - 0.026 μSv/h, 0.11-0.25 mSv/y, and 0.39- 0.88 for ER, ADR, AEDR, and ELCR respectively. The calculated mean organ dose is 0.122, 0.110, 0.131, 0.156, 0.118, 0.087, and 0.129 for lungs, ovaries, bone marrow, testes, kidney, liver, and whole body respectively.
Conclusion: The obtained values of AEDR and organ doses are lower than the recommended dose limit by ICRP and UNSCEAR. This indicates that the inhabitant of the orientation camp is safe of radiation hazards.
Recommendation: It is recommended that this same study be done at other NYSC camp sites in the country.
. **Keywords**: Background exposure level, Inspector alert nuclear radiation meter, AEDE and Organ dose

Introduction

Background exposure from naturally occurring radioactive materials (NORMS) is present in all environments and do varies from place to place. Human activities have increased the relative concentration of the radionuclides, referred to as the technologically enhanced naturally occurring radioactive materials (TENORMS) [1]. Determining population's exposure to radiation from building materials is important, because almost 80% of human life is spent indoors [2]. Several studies have been carried out in countries such as Vietnam [3] and Turkey [4]. In Vietnam, the estimated outdoor and indoor annual effective doses to the population were found to be higher than the corresponding values in the rest of the world. In Nigeria, National youth service is a compulsory assignment for fresh Nigerian graduates. Graduates from across the country converge in a camp for exercise. Transfer of all sought of materials into the camp by the graduates and the routine maintenance of the camp is inevitable. These activities among others could raise the background exposure level of the camps. In this study, the indoor and outdoor background exposure level of some selected locations in National Youth Service Corp Orientation camp, Keffi, Nasarawa state, Nigeria was assessed to ascertain the safety of the inhabitants.

Methods:

Study Area

Keffi is a town in Nasarawa State, Nigeria. Keffi is 50 kilometers away from the federal capital territory, Abuja. National youth service corps (NYSC) orientation camp Keffi, Nasarawa state is a camp where corps members are trained and given the guidelines and principles to effectively serve the nation for a period of 12 months. Graduates from all over the country are camped together for a period of 21 days on average for the orientation program and training. The camp is located at the out sketch of Keffi town. It is an uphill area characterized by rocks around the camp.

Sampling and measurement

The indoor and outdoor background exposure level of National Youth Service Corp Orientation camp was determined using a factory calibrated Inspector Alert Nuclear radiation meter with the serial number 35440, made in USA by ion spectra (International Med. Com. Inc) using alkaline battery 0f 9.0volts manufactured in the year 2014. The meter was recalibrated at the Nigerian Institute of Radiation Protection Research, University of Ibadan, Nigeria in the year 2021 to authenticate its efficacy and efficiency. The meter's sensitivity 3500 CPM/ (mR.h^{-1}) referenced to Cs-137 and its maximum alpha and beta efficiencies are 18% and 33% respectively. It has a halogen-quenched Geiger-Muller detector tube of effective diameter of 45 mm and a mica window density of 1.5-2.0 mg.cm-2 (Inspector alert operation manual).

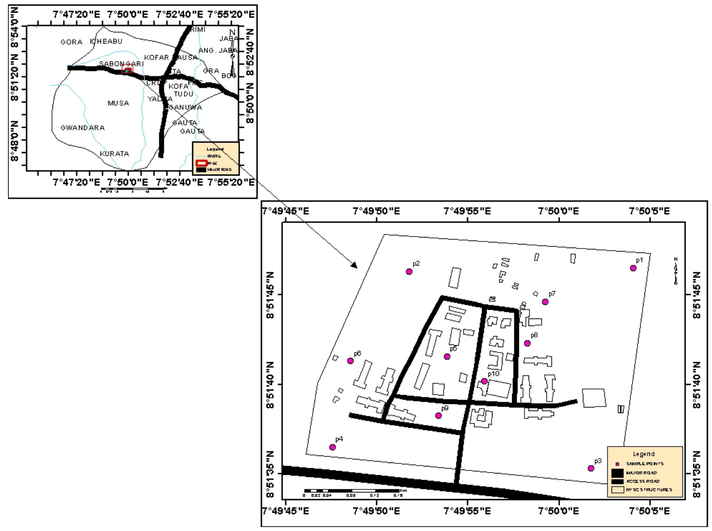

Fig. 1: Map of study area.

A total of ten sampling locations (Kit Store Block, Lecture Hall, Male Hostel Block A, Male Hostel Block B, Male Hostel Block C, Male Hostel Block D, Female Hostel Block E, Female Hostel Block F, Female Hostel Block G, and Female Hostel Block H) in the National Youth Service Corp orientation camp was assessed. Background exposure rate of four sampling points (two indoor and two outdoor) at each of the sampling locations were measured using an inspector alert nuclear radiation meter. Three measurements each was carried out and a mean value of each data was obtained to account for the errors in the data. Readings were taken between the hours of 1200 and 1600 because the radiation meter has a maximum response to radiation within these hours as recommended by the National Council on Radiation Protection and measurements [5]. An in-situ approach of measurement with the standard practice of raising the detector tube 1.0 m above ground level with its window facing the point under investigation was adopted to enable sample points maintain their original environmental characteristics [6, 7]. The locations of each of the sample points were determined using a geographical positioning system

(GPS). The exposure rate obtained were quantitatively used to assess the radiation health impact to the public in the study area and radiation effective doses to different organs of the body by performing several radiological health hazard indices calculations using well established mathematical relations.

$$Count\ rate\ per\ minute\ (CMP) = 10^{-3}\ Roentgen\ x\ F$$

Where F is the quality factor, which is equal to 1 for external environments.

Radiological Hazard Indices

Absorbed Dose Rate (ADR) in Air

The absorbed dose is used to assess the potential for any biochemical changes in specific tissues. It quantifies the radiation energy that might be absorbed by a potentially exposed individual. The measured outdoor background exposure levels were converted to radiation absorbed dose rate in air using Equation 3 according to Agbalagba *et al*. [7] and Rafique *et al*. [8].

$$1\ \mu Rh^{-1} = 8.7\ \eta Gy/h = 8.7x10^{-3}\ (1/8760y)\ nGy\mathrm{y}^{-1} \qquad 2$$

This implies that:

$$1mRh^{-1} = 8.7\ \eta Gy\mathrm{h}^{-1}\ x\ 103 = 8700\ nGyh^{-1} \qquad 3$$

Annual effective dose equivalent (AEDE)

The AEDE is used in radiation assessment and protection to quantify the whole body absorbed dose per year. It is used to assess the potential for long-term effects that might occur in the future. The annual effective dose equivalent (AEDE) per year received by workers and the population is obtained from equation 4 [9, 10].

$$AED(mSv.\ y^{-1})\ outdoor = D\ (nGy.\ h^{-1})\ x\ 8760h\ x\ CF\ x\ OFx10^{-3} \qquad 4$$

where D is the absorbed dose rate in nGy/h, 8760 h is the total hours in a year, CF is the dose conversion factor from absorbed dose in air to the effective dose in Sv/Gy (CF = 0.7 Sv/Gy), OF is the occupancy factor, the expected period the members of the population would spend within the study area. OF = 0.2 for outdoor as it is expected that human beings would spend 20 % of their time outdoors as recommended by ICRP [9].

Excess lifetime cancer risk (ELCR)

The ELCR was evaluated using the AEDE values as shown in Equation 5 according to Agbalagba *et al*. [7] and Rafique *et al*. [8].

$$ELCR = AEDE\ (mSv/y)\ x\ DL\ x\ RF \qquad 5$$

Where DL is average duration of life (70 years), and RF is the fatal cancer risk factor per Sievert (Sv^{-1}). For low-dose background radiation, which is considered to produce stochastic effects, ICRP 103 uses a fatal cancer risk factor value of 0.05 for public exposure [9].

Effective dose to different body organs (D_{organ})

Dorgan estimates the amount of radiation dose intake to various body organs and tissues. The D_{organ} of the body due to inhalation was calculated using Equation 5 as given by Ugbede & Benson [6].

$$D_{organ}\ (mSv/\mathrm{y}) = AEDE\ x\ F\ x\ 10^{-3} \qquad 6$$

Where F is the conversion factor of organ dose from air dose. The F value for whole body lungs, ovaries, bone marrow, testes, kidney, and liver as given by ICRP [9] are 0.68, 0.64, 0.58, 0.69, 0.82, 0.62, and 0.46 respectively.

Results:

Table 1 presents the raw result of the indoor and outdoor background exposure level measurements and their corresponding sampling points and geopoints. The mean background exposure level and the radiological health hazards parameters associated with them are presented in Table 2. Table 3 presents the associated organ doses (D_{organ}).

Table 1: Raw results of background exposure level and their corresponding geopoints.

S/n	Geopoint		Sample Point	Sample Code	Exposure rate (mR/h)
	North	East			
1	8.862922	7.834466	Kit Store Block (KSB)	KSB1	0.16
				KSB2	0.77
				KSB3	0.27
				KSB4	0.24
2	8.862869	7.831048	Lecture Hall (LH)	LH1	0.17
				LH2	0.69
				LH3	0.12
				LH4	0.13
3	8.859802	7.833828	Male Hostel Block A (MHBA)	MHBA1	0.32
				MHBA2	0.11
				MHBA3	0.24
				MHBA4	0.10
4	8.860137	7.829871	Male Hostel Block B (MHBB)	MHBB1	0.07
				MHBB2	0.09
				MHBB3	0.10
				MHBB4	0.36
5	8.861546	7.831622	Male Hostel Block C (MHBC)	MHBC1	0.10
				MHBC2	0.97
				MHBC3	0.48
				MHBC4	0.49
6	8.861473	7.830152	Male Hostel Block D (MHBD)	MHBD1	0.11
				MHBD2	0.80
				MHBD3	0.06
				MHBD4	0.07
7	8.862397	7.833128	Female Hostel Block E (MHBE)	FHBE1	0.61
				FHBE2	0.04
				FHBE3	0.09
				FHBE4	0.05
8	8.861753	7.832853	Female Hostel Block F (FHBF)	FHBF1	0.64
				FHBF2	0.09
				FHBF3	0.09
				FHBF4	0.06
9	8.860623	7.831494	Female Hostel Block G (FHBG)	FHBG1	0.27
				FHBG2	0.33
				FHBG3	0.04
				FHBG4	0.46
10	8.861156	7.832198	Female Hostel Block H (FHBH)	FHBH1	0.03
				FHBH2	0.43
				FHBH3	0.54
				FHBH3	0.15

Table 2: Calculated radiological hazard parameters.

S/n	Sampling Code	ER (mR/h)	ADR (µSv/h)	AEDR (mSv/y)	ELCR×10^{-3}
1	KSB	0.36	0.036	0.25	0.88
2	LH	0.28	0.028	0.20	0.70
3	MHBA	0.19	0.019	0.13	0.46
4	MHBB	0.16	0.016	0.11	0.39
5	MHBC	0.51	0.051	0.36	1.26
6	MHBD	0.26	0.026	0.18	0.63
7	FHBE	0.20	0.020	0.14	0.49
8	FHBF	0.22	0.022	0.15	0.53
9	FHBG	0.28	0.028	0.20	0.70
10	FHBH	0.29	0.029	0.20	0.70
	Mean	**0.27**	**0.027**	**0.19**	**0.67**

Table 3. Calculated organ doses of human body.

S/n	Sampling Code	D_{organ} (mSv/y) Lungs	Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole Body
1	KSB	0.160	0.145	0.173	0.205	0.155	0.115	0.170
2	LH	0.128	0.116	0.138	0.164	0.124	0.092	0.136
3	MHBA	0.083	0.075	0.090	0.107	0.081	0.060	0.088
4	MHBB	0.070	0.064	0.076	0.092	0.068	0.051	0.075
5	MHBC	0.230	0.209	0.248	0.295	0.223	0.166	0.245
6	MHBD	0.115	0.104	0.124	0.148	0.112	0.083	0.122
7	FHBE	0.090	0.081	0.100	0.115	0.087	0.064	0.095
8	FHBF	0.196	0.087	0.104	0.123	0.093	0.069	0.102
9	FHBG	0.128	0.116	0.138	0.164	0.124	0.092	0.136
10	FHBH	0.128	0.116	0.138	0.164	0.124	0.092	0.136
	Mean	**0.122**	**0.110**	**0.131**	**0.156**	**0.118**	**0.087**	**0.129**

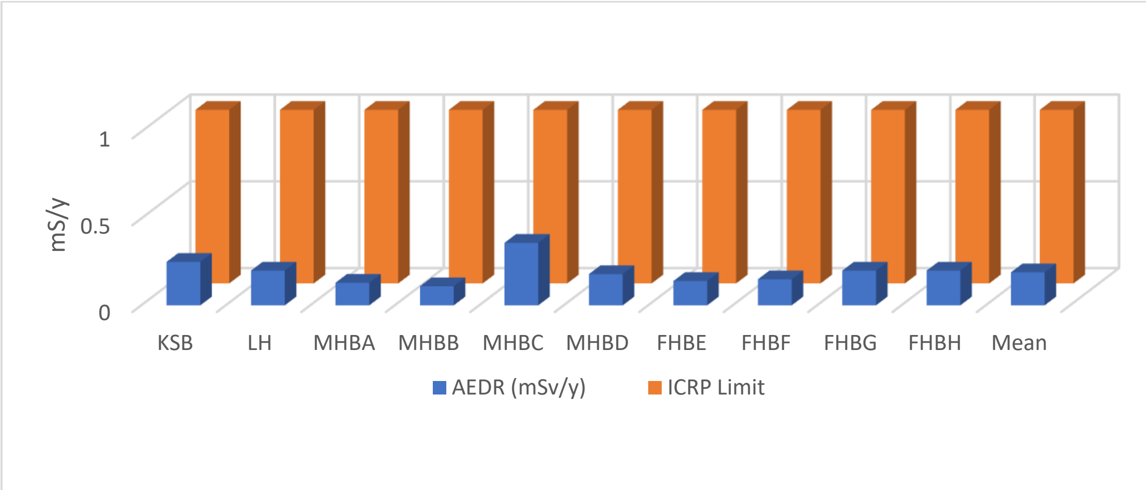

Fig. 2: Comparison of the calculated AEDR with ICRP limit

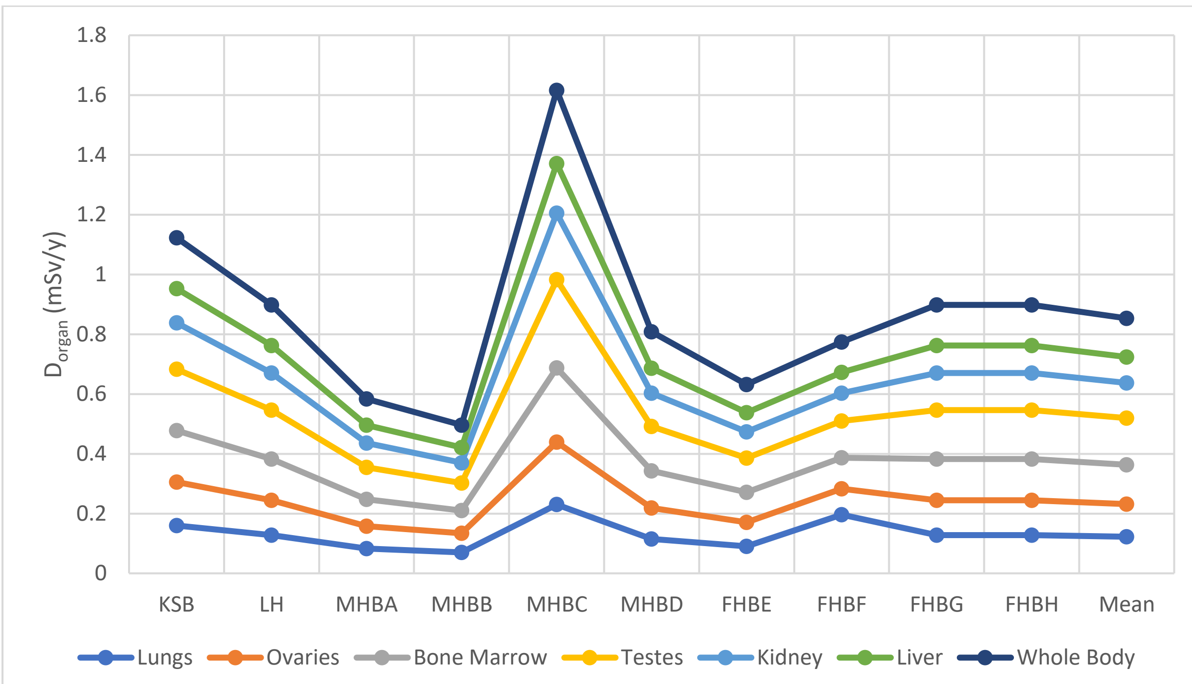

Fig. 3: Comparison of the calculated organ doses.

Discussion:

Outdoor Background Exposure Rate Levels

The outdoor background exposure rate measured ranges from 0.16 mR/h at MHBB to 0.51 mR/h at MHBC with an average value of 0.27 mR/h. The mean outdoor background exposure rate for the environment studied exceeded the permissible recommended limit of 0.013 mR/h [11-13]. The high exposure rate level in some area is attributed to the geological formation, geophysical characterization and synthetic activity that contributes to the overall radiation level. Chemicals, petroleum products, and construction materials like granite, cement, asphalt etc. The high outdoor background levels indicate that the environment is radiologically unhealthy and contaminated for the public. The mean exposure level reported here is higher than 0.015 ± 0.001mR/h and 0.018±0.004 mR/h value observed by Ugbede & Benson [6] in Emene Industrial layout of Enugu State, Nigeria and Osimobi *et al.* [10] in solid mineral mining sites of Enugu State, Nigeria.

Absorbed Dose Rate (ADR) in air.

The range of calculated absorbed dose rate value is between 95.7 nGy/h and 783.0 nGy/h with observed mean value of 184.875 nGy/h. The mean absorbed dose rate appears to be higher than the recorded world weighted average of 59.00 $nGyh^{-1}$ (Agbalagba, Avwiri & Ononugbo, 2016; Monica *et al.*, 2016) [7, 14] and recommended safe limit of 84.0 nGy/h [4, 12, 14] for outdoor exposure. These dose rates result indicates contamination of the environment by radiation. Although the health effect to the residents of the locality may not be immediate, there is the potential for long-term health hazards in the future due to the doses accumulated. The mean dose rate from this investigation is higher than 126.15 ±5.10 nGy/h dose rates earlier reported by Ugbede & Benson [6] in Emene Industrial Layout of Enugu State, Nigeria but was below the 132.16±24.36 nGy/h for Ughelli metropolis in Delta State Nigeria by Agbalagba et al. [7].

Annual effective dose equivalent (AEDE)

The calculated values of AEDE varies from 0.011 mSv/y at MHBB to 0.36 mSv/y at MHBC with an average value of 0.19 mSv/y. This is higher than the world average value of 0.07 $mSvy^{-1}$ [4, 7, 10] but within UNSCEAR and ICRP recommended permissible limits of 1.00 mSvy-1 for the public [4, 6, 10]. This indicates that the studied location is radiologically contaminated but still within the ICRP and UNSCEAR permissible limit. However, there is no immediate radiological health effect on members of the public. The AEDE from the present study are like those reported by Idris *et al.* [5].

Excess lifetime cancer risk ELCR

The mean excess lifetime cancer risk is 0.67×10^{-3} and 2.289×10^{-3} for indoor and outdoor measurements respectively. This mean value is higher than the world average value of 0.29×10^{-3}. This lifetime cancer risk is quite high and the possibilities of cancer development by residents who wish to spend all their lifetime in the area is imminent. The ELCR values reported in this study are higher than those reported by Idris et al. [5], Ugbede et al. [6] and Agbalagba et al. [7].

Effective dose to different body organs (Dorgan)

The mean organ doses estimated for the lungs, ovaries, bone marrow, testes, kidney, liver, and whole body due to exposure and inhalation of radiation in Keffi NYSC camp are 0.122, 0.110, 0.131, 0.156, 0.118, 0.087 and 0.129 mSv/y respectively. These results are found to be below the tolerable limits of 1.0 mSv [4, 6, 13] which indicate that the radiation levels do not constitute any immediate health effect on residents of the study location. From the results, it is concluded that the testes and bone marrow have the highest and lowest sensitivity to radiation respectively. Ugbede & Benson reached similar conclusion [6] and Agbalagba, Avwiri & Ononugbo [7].

Conclusion

This study was carried out to assess the radiological impact of indoor and outdoor background exposure level of some halls in the NYSC orientation camp, Keffi, Nasarawa State, Nigeria. The radiation levels investigated in this study are well within the recommended dose limits and are within the world average value reported by ICRP and UNSCEAR. Generally, the study shows that the NYSC orientation camp in Keffi is relatively safe radiologically with little contamination which could be attributed to the geological formation and partly due to human activity in the area. However, the contamination will not pose any immediate radiological health effect on residents of the area but there is tendency for long -term health hazards in the future such as cancer due to doses accumulated. The result from this study provides the baseline information for the assessment of any environmental radioactive contamination of the area in foreseeable near future. It is recommended that this same study be done at other NYSC camp sites in the country.

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