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Assessment of Background Radiation Level and The Dose to Organs of Some Selected Office Buildings in FCT Abuja, Nigeria

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Abstract: In this study, the background exposure levels of some selected office buildings in FCT Abuja Nigeria were investigated. An in-situ background radiation level for twenty (20) office buildings in FCT Abuja was carried out using a calibrated portable Geiger Muller (GM) detector placed 1 m above the ground level. The geographical location of each sampling point was recorded using a Global Positioning System (GPS). The radiological hazards indices and radiation effective doses to different body organs were evaluated using the measured background radiation level. The obtained values of radiological hazard parameters were compared with recommended standards set by the International Commission on Radiological Protection (ICRP) and the United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) for hazard evaluation. The mean values of the outdoor background exposure levels (0.090 mRh^{-1}), absorbed dose rates (788.6 $nGyh^{-1}$), and excess lifetime cancer risk (3.53852×10^{-3}) are higher than the recommended safe limits of 0.0130 mRh^{-1}, 84.000 $nGyh^{-1}$, 0.29×10^{-3} respectively as recommended by UNSCEAR and ICRP. The mean annual effective dose equivalent (0.9672 $mSvy^{-1}$) is within the recommended permissible limits of 1.00 $mSvy^{-1}$ for general public exposure and the effective doses to different body organs are all below the recommended limits of 1.00 $mSvy^{-1}$. The background exposure levels in some selected office buildings in FCT Abuja are safe and may pose no significant hazard to the occupant.

Keywords: Background exposure level, Radiological hazard parameters, Inspector alert Nuclear radiation meter, and Abzat quarrying site.

1 Introduction

The ionizing radiation that permeates the surroundings is known as background radiation. It comes from both artificial and natural sources, such as cosmic radiation and environmental radioactivity from nuclear weapons testing fallout and accidents, as well as naturally occurring radioactive elements like radon and radium. For most people, background radiation that occurs naturally serves as their primary source of exposure [1-5].

Man-made radionuclides have found their way into the environment through processes like the imaging of the body with radionuclides in medicine and the production of electricity using radioactive uranium as fuel [6]. Humans are constantly exposed to radiation from both internal and external sources. The radionuclides that enter the body through food, water, and air are examples of internal sources, whereas space radiation and terrestrial radiation are examples of external sources. Radiation is present in all environments and poses a threat to human health, regardless of where it comes from [7-10].

The energy contained in extra solar radiation enables it to produce more radiation when it travels through the Earth's atmosphere, leading to the production of secondary particles or radionuclides in the atmosphere [7]. At high altitudes where the Earth's atmosphere is thinnest and close to the magnetic poles where the Earth's magnetic field is weakest, some secondary particles are most likely to reach the surface of the planet [11-15].

Cosmogenic radionuclides are those produced by radiation from space. Among them are sodium-22, carbon-14,

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beryllium -7, and tritium (hydrogen-3) [6]. Terrestrial radiation is the term used to describe radiation that comes from Earth. Primordial radionuclides, or radioactive substances that existed when the earth originated around 4.5 billion years ago, are found in igneous and sedimentary rocks throughout the world. These radionuclides spread from rocks into the soil, water, and even the atmosphere. In addition, these radionuclides have been dispersed by human activities like uranium mining. The group of radionuclides generated by the decay of uranium and thorium, as well as potassium-40 and rubidium-87, are known as primordial radionuclides [16-18]. In addition to being surrounded by naturally occurring radioactive materials found in rocks and soil, we are also constantly exposed to cosmic rays that enter Earth's atmosphere from space [19-20].

Cancer is known to be caused by exposure to high radiation levels [21-22]. However, because there are so many other variables that might skew the effects of radiation, it can be difficult to assess the health impacts of very low radiation doses, such as those from background radiation. [22]. The objective of this study is to determine the background radiation levels and the dose to organs doses of some selected office buildings in FCT Abuja, Nigeria.

2 Experimental Section

2.1 Materials and Methods

Using a factory-calibrated Inspector Alert Nuclear radiation meter (SN:35440, manufactured by SE International, Inc. USA), the background exposure levels were measured. The meter's maximal alpha and beta efficiencies are 18% and 33%, respectively, and its sensitivity is 3500 CPM/(mR.h^{-1}) referred to as Cs-137. It contains an efficient 45 mm diameter halogen-quenched Geiger-Muller detector tube with a mica window density of 1.50 –2.00 mg. cm^{-2} (Inspector alert operation manual). Twenty (20) office buildings were randomly selected in FCT Abuja, Nigeria. Using an Inspector Alert Nuclear meter, background radiation level measurements were made in the quarry locations. The National Council on Radiation Protection and Measurements (National Council on Radiation Protection, 1993) advised that the radiation meter has a maximum response to radiation during these hours, so those are the times when the measurements were taken. To preserve the original environmental features of the sample sites, an in-situ measurement technique was used, following the typical procedure of elevating the detector tube 1.0 m above ground level with its window facing the place under research [23-24]. A geographical positioning system was used to pinpoint each of the squaring spots' positions (GPS). Through the use of well-established mathematical relations, several radiological health hazard index calculations were performed to quantitatively assess the radiation health risk to the general public at the quarrying site and the radiation-effective doses to various body organs based on the obtained exposure rate.

$$Count\ rate\ per\ minute\ (CMP) = 10^{-3}\ Roentgen\ x\ F \quad (1)$$

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

The absorbed dose is employed to evaluate the possibility of any biochemical alterations in particular organs. It measures the amount of radiation energy that a person who may be exposed to it could absorb. The measured outdoor background exposure levels were converted to radiation absorbed dose rate in the air using Equation 3 according to Agbalagba *et al*. [24] and Rafique *et al*. [25].

$$1\ \mu Rh^{-1} = 8.7\ \eta Gyh^{-1} = \frac{8.7x10^{-3}}{(1/8760y)}\ nGyy^{-1} \quad (2)$$

This implies that:

$$1mRh^{-1} = 8.7\ \eta Gyh^{-1}\ x\ 10^{3} = 8700\ nGyh^{-1} \quad (3)$$

The AEDE is used in radiation assessment and protection to quantify the whole.

Body absorbed dose per year. It is used to assess

Table 1: Background exposure levels and related radiological health hazards indices of the study area.

Sampling point code	Longitude	Latitude	E (mR.h^{-1})	ADR (nGy.h^{-1})	AEDE (mSv.y^{-1})	ELCR (x10^{-3})
OB1	9^{o}00’44’’ N	7^{o}28’42’’ E	0.170	1479.0	1.81384	6.3484
OB2	9^{o}03’00’’ N	7^{o}28’19’’ E	0.067	582.9	0.71486	2.5020
OB3	9^{o}03’03’’ N	7^{o}28’58’’ E	0.057	495.9	0.60817	2.1286
OB4	9^{o}03’27’’ N	7^{o}30’00’’ E	0.083	722.1	0.88558	3.0995
OB5	9^{o}04’50’’ N	7^{o}30’01’’ E	0.011	95.7	0.11736	0.4107
OB6	9^{o}03’01’’ N	7^{o}30’10’’ E	0.099	861.3	1.05629	3.6970
OB7	9^{o}05’03’’ N	7^{o}29’20’’ E	0.079	687.3	0.84290	2.9501

OB8	9°05’50’’ N	7°30’00’’ E	0.091	791.7	0.97094	3.3982
OB9	9°06’38’’ N	7°28’21’’ E	0.180	1566.0	1.92054	6.7218
OB10	9°05’43’’ N	7°29’24’’ E	0.020	174.0	0.21339	0.7468
OB11	9°05’34’’ N	7°30’42’’ E	0.110	957.0	1.17366	4.1078
OB12	9°07’59’’ N	7°29’28’’ E	0.091	791.7	0.97094	3.3982
OB13	9°07’17’’ N	7°29’48’’ E	0.097	843.9	1.03495	3.6223
OB14	9°06’33’’ N	7°27’26’’ E	0.013	113.1	0.13870	0.4854
OB15	9°06’14’’ N	7°28’43’’ E	0.100	870.0	1.06696	3.7343
OB16	9°05’43’’ N	7°27’44’’ E	0.067	582.9	0.71486	2.5020
OB17	9°04’47’’ N	7°26’37’’ E	0.089	774.3	0.94960	3.3236
OB18	9°04’23’’ N	7°27’43’’ E	0.180	1566.0	1.92054	6.7218
OB19	9°03’42’’ N	7°27’32’’ E	0.089	774.3	0.94960	3.3236
OB20	9°03’08’’ N	7°28’26’’ E	0.120	1044.0	1.28036	4.4812
Mean			0.090	788.6	0.96720	3.3852
Min			0.011	95.7	0.11736	0.4107
Max.			0.180	1566.0	1.92054	6.7218

The potential for long-term effects that might occur in the future. The AEDE per year received by workers and the population is obtained from equation 4 [7, 26].

$$AEDE(mSv.y^{-1})_{outdoor} =$$

$$D(nGy.h^{-1})x\,8760h\;x\;CF\;x\;OFx10^{-3} \quad (4)$$

where D is the absorbed dose rate in $nGyh^{-1}$, 8760h is the total hours in a year, CF is the dose conversion factor from the absorbed dose in the 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 UNSCEAR [26].

The organ dose (D_{organ}) 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 Idris *et al.* [4] and Ugbede & Benson [11].

$$D_{organ}(mSvy^{-1}) = AEDE\;x\;F\;x\;10^{-3} \quad (5)$$

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 (1996) [22]. are 0.68, 0.64, 0.58, 0.69, 0.82, 0.62, and 0.46 respectively.

The excess lifetime cancer risk (ELCR) was evaluated using the AEDE values as shown in Equation 6 according to Idris *et al.* [4] and Rafique *et al.* [25].

$$ELCR = AEDE\;(mSvy^{-1})\;x\;DL\;x\;RF \quad (6)$$

where DL is the 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 [22].

3 Results and Discussion

Table 1 presents the background outdoor exposure level measurements along with the corresponding radiological health risk indicators. ADR, yearly AEDE, ELCR, and D_{organ} are the radiological health risk indices that were used to evaluate the research area's health. The background exposure rate is measured and has a mean value of 0.090 mRh-1, ranging from 0.011 to 0.180 mRh^{-1}. The mean readings were higher than the UNSCEAR-recommended allowable level of 0.013 mRh^{-1} [26]. This could be attributed to the materials used in building, furniture, and electrical appliances used in the buildings. The mean exposure level reported here is higher than the 0.015±0.001mRh^{-1} and 0.018±0.004 mRh^{-1} value observed by Ugbede & Benson [23] in Emene Industrial Layout of Enugu State, Nigeria, and Osimobi *et al.* [27] in solid mineral mining sites of Enugu State, Nigeria.

The computed absorbed dose rate value has a mean value of 788.6 $nGyh^{-1}$ and a range of 95.7 $nGyh^{-1}$ to 1566.0 $nGyh^{-1}$. The mean absorbed dose rate exceeds both the advised safe limit of 84.0 $nGyh^{-1}$ for outdoor exposure and the world-weighted average of 59.00 $nGyh^{-1}$ [7, 26, 28]. The mean dose rate obtained from this investigation is greater than the dose rates of 126.15 ±5.10 $nGyh^{-1}$ published by Ugbede & Benson [23] and 132.16±24.36 nGyh-1 reported by Agbalagba et al. [24].

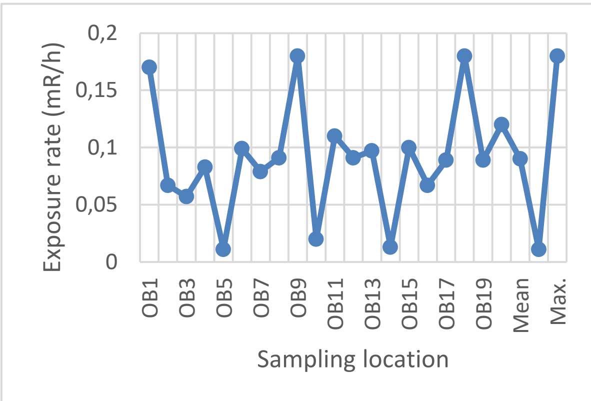

Fig. 1: Comparison of measured exposure rate in the study locations.

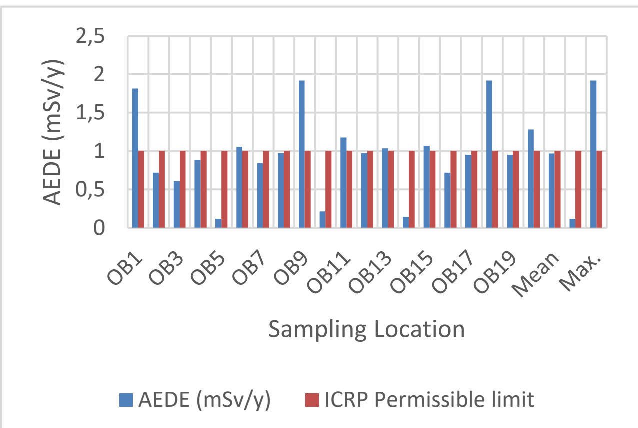

Fig. 2: Comparison between the annual effective dose equivalent (AEDE) rate in the study area and permissible safe limit.

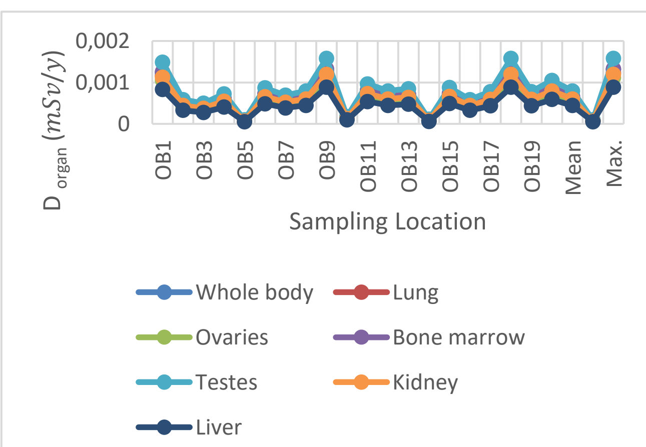

Fig. 3: Comparison of the doses to different body organs.

The computed AEDE values have a mean value of 0.9672 $mSvy^{-1}$ and vary from 0.11736 to 1.92054 $mSvy^{-1}$. The levels fall within the UNSCEAR and ICRP suggested tolerable limits of 1.00 $mSvy^{-1}$ for the general public, although being higher than the global average value of 0.07 $mSvy^{-1}$ [14]. The office buildings in FCT Abuja remain within the UNSCEAR and ICRP permissible limits, according to the results. The public's exposure to radiation, however, does not happen right away. In the Emene Industrial Layout of Enugu State, Nigeria, and the Ononugbo and Mgbemere [29]. fertilizer-producing area of Onne River State, the AEDE values obtained from the current study are greater than those reported by Ugbede & Benson [23].

The computed values of ELCR range from 0.4107 x 10^{-3} to 6.7218×10^{-3}, with a mean value of 3.3852 x 10^{-3}. This mean value exceeds the 0.29×10^{-3} global average. The public who live or work near the quarrying site has a very high lifetime cancer risk, and cancer development in this population is highly likely. The ELCR values found in this study are less than those found in the Uburu Salt Lake settings in Ebonyi State, Nigeria, as reported by Agbalagba et al. [24] and Avwiri et al. [2].

4 Conclusions

This study was conducted in FCT Abuja, to investigate the radiological effects of the background exposure level of some selected office buildings. The radiation levels examined in this work are found within the global average value given by UNSCEAR and ICRP, as well as the permissible dose limits. The study indicates that the office buildings may not pose any health hazard. This finding may be related to the materials used for building, furniture, and electrical appliances. The study's findings offer the baseline data needed to evaluate any potential environmental radioactive contamination in the area shortly.

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