International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 15, Issue 11 [November 2026] PP: 114-120

Assessment of Background Radiation Levels in Gombe Metropolis, Gombe State, Nigeria.

Salahuddeen Bala Idris[1], Yusuf Ibrahim[1], Bello Saadu Abubakar
[1,]*Science Laboratory Technology Department, School of Science and Technology, Gombe State Polytechnic, Bajoga*
[2]*Department of Physics, Federal University Wukari,. PMB 1020*

ABSTRACT
Exposure to ionizing radiation is known to be responsible for certain health disorders such as cancer, cataracts and birth defects and humans are inevitably exposed to radiation which could be from either Natural or Man-made sources. For this reason, several international bodies have worked on standards in relation to radiation hazards and this has led to the establishment of maximum permissible dose limits (MPL) of 1Msv/yr for non-occupational exposure. This study assesses the background radiation level of Gombe metropolis of Gombe State in other to determine the effective dose of the area and compare the values obtained with maximum permissible dose limits (MPL). A total of twenty points were surveyed using a portable Geiger Muller LND 7223 radiation survey meter (GM Counter). At each measurement point, three readings in Count Per Minute (CPM) were taken with the Geiger Muller counter held at one meter above the ground and the average is taken as the mean Count Per Minute. The mean Counts per Minute obtained were converted to Exposure rates in mR/hr, Absorbed Dose rate in nGy/hr and Annual effective doses in mSv/yr. The exposure rate ranges from 7.2μR/hr to 12.5 μR/hr with a mean value of 9.3μR/hr. The absorbed dose obtained ranges from 62 nG/hr to 102 nGy/hr with mean of 78 nGy/hr which is slightly higher than the world average 55nGy/hr. The annual equivalent dose rate for indoor ranges from 0.316 to 0.512 with an average of 0.333 mSv/yr while the outdoor annual equivalent dose rate ranges between 0.079 to 0.128 mSv/yr with an average of 0.099 mSv/yr. These values are lower than the internationally approved annual dose limits of 1mSv/yr for members of the public by International Commission on Radiation Protection [ICRP]. Hence, it is concluded that there are no significant risks from harmful radiation exposure in Gombe metropolis.

Keywords: Background Radiation, Exposure, Geiger Muller, Absorbed dose, Effective dose

---

Date of Submission: 02-11-2026 Date of acceptance: 12-11-2026

I. Introduction

Radiation can be categorized as ionizing and non-ionizing. The basic difference between ionizing radiation and other common types of radiation in the environment such as heat is that it possesses sufficient energy to cause ionization. Ionizing radiation injury is dependent on a number of factors including: the nature (alpha (α), betta (β), and gamma (γ)) and energy of the radiation, the dose, time of exposure, homogeneity of dose and shielding. When the dose and dose rate is within the accepted level, the effect of radiation is small and most time no effect is noticed, although the effect of low-level radiation are not yet completely understood (ICRP, 1990). Human exposure to ionizing radiation from natural sources is an unending and unpreventable phenomenon on earth and exceeds that from all man-made sources (including: Medical, weapons testing and nuclear technologies) put together (Eke 2020). Radiation has always existed in the environment since the earth's origin and therefore, daily exposure to varied levels of background ionizing radiation is inevitable for humans (Ugbede& Echeweozo, 2017). Background radiation describes the ionizing radiation present in the environment at a particular location which is not due to the deliberate introduction of radiation sources. (Ugwuanyi, Nzotta, Ogolodom, Sibeudu, Ibekwe, & Ezeaku 2021). The sources of background radiations include cosmic radiations (primary and secondary), terrestrial radiations (from natural radium, uranium, and thorium and their decay products; radon gas which is the largest natural source of radiation exposure to human beings) internal radiations (radioactivity in the body) and artificial or man-made sources such as from medical exposure, weapon testing, nuclear technologies and use of office equipment (Norman2008). An increase in the use of technological equipment in offices can also increase the background radiation levels. Hence, Humans are inevitably exposed to background radiations both in work and public environments (Chiegwu,Onyeka, Ugwuanyi, Odunk, Ogolodom, Mbaba, Nwodo, & Ezechukwu, 2022).Given that radiation is an unavoidable component of the environment, background ionizing radiation (BIR) has gained a lot of attention from the general public

worldwide. (Sambo, Rafiu, Salawu, Yau, & Ekong 2022).The cumulative exposure to background ionizing radiation, over time, can pose health risks such as acute leukemia, lung cancer, kidney cancers, and cataracts, if not adequately monitored and controlled. Thus, the practice has been to monitor and assess the levels of exposure and keep one's exposure to ionizing radiation as low as reasonably achievable (Blessing &Muyiwa 2018). Consequently, several international bodies have worked on standards in relation to radiation hazards and this has led to the establishment of maximum permissible dose limits (MPL).

In recent years, many researchers have assessed the level of background radiation and its awareness in some cities and institutions in the different geopolitical zones of Nigeria and their findings also revealed that radiation is a common companion in the human environment as it occurs either naturally or through man's activities (Abubakar, Sadiq, Musa, Hassan, & Malgwi 2017). Hence, it is essential to study and ascertain the level of background radiation within the environment of man to help man adopt appropriate means for radiation protection and control and so prevent the harmful effects of ionizing radiation be it from the background or man -made sources.

Several studies have been carried out in different parts of the world to measure and assess the natural radiation levels.Ramli, Aliyu, Agba, &Saleh (2014) assess the indoor and outdoor background radiation in Akwanga and Keffi towns of Nasarawa state using a halogen-quenched Geiger Muller (GM) detector (Inspector alert Nuclear radiation monitor SN: 3544). The results indicated that the mean indoor and outdoor annual effectve dose of Akwanga were 1.29± 0.13mSv/yr and 0.31±0.04 mSv/yr respectvely; and that of Keffi were 1.08± 0.15mSv/yr and 0.25±0.04 mSv/yr respectively. The radiation levels in both highly populated towns were found to be within the safe limit for areas of normal background set by UNSCEAR. Similarly,Olarinoye, Sharifat, Baba-Kutigi, Kolo&Aladeniyi (2010) carried out an in-situ measurement of the background radiation level at the vicinity of three campuses of two major tertiary institutions in Minna, Niger State College of Education Minna (NCM), Federal University of Technology Bosso Campus (FUTB) and at the Federal University of Technology Gidan- Kwano campus FUTG using a portable Geiger Mueller tube-based environmental radiation dosimeter. The average annual effective dose obtained was 0.189 mSv/yr which is less than the recommended limit of 1mSv/yr by International Commission on Radiation Protection [ICRP] for non-occupational population exposure. Background radiation measurements in Federal University of Technology, Owerri were also carried out by Eke & Emelue (2020) using a well calibrated Digital Geiger Muller counter models GCA – 04w. Results obtained for outdoor Dose rate ranges from 0.07 μSv/hr to 0.23 μSv/hr with a mean value of 0.144 μSv/hr. While the result for the indoor dose rate ranges from 0.08 μSv/hr to 0.21 μSv/hr with a mean of 0.14 μSv/hr.

Similarly, Ononugbo&Anekwe (2020) assess the radiation profile of three markets in Port Harcout using radiation exposure rate meter (Radalert-100). The mean absorbed doses estimated from the exposure rates for Mile 3, Mile 1 and Rumu-Okoro are 119.2, 113.68 and 114.8 nGy/hr respectively, while their mean equivalent doses are 1.15, 1.19 and 1.11 mSv/yr respectively. The annual effective dose calculated gave mean values of 0.14, 0.16 and 0.168 mSv/yr. However, these values are lower than the stipulated safe value of 1.0 mSv/yr.

Other studies include: Sadiq&Agbah (2011) studied the background radiation in the mines of Nasarawa state; results indicated that Alizaga Quarry has the maximum reading of 2.60 mSv/y. While the effective dose equivalent at the Maloney Hill Quarry in Keffi is 1.75 mSv/y.

This study aimed to assess the background ionizing radiation levels of Gombe metropolis through the following specific objectives: (i)measure and determine the background radiation exposure in the study area using Geiger Muller (GM) counter. (ii) Evaluate and determine the effective dose of the study area and (iii) Compare the values obtained with international safety limits.The results obtained from this work will form part of the baseline data for environmental radiation in the study area which was hitherto not available.

II. Materials and Method

The study area

Gombe town is located between latitudes 10° to $10^{0}20'$ N and longitudes $11^{0}01'$ E and 11°19′ E (figure 3.1) and has a population of about 250,000 people. It shares common boundary with Akko LGA in the South and West; Yamaltu-Deba to the East and Kwami to the North. It is the capital of Gombe State and occupies an area of about 45km^2 (Ministry of Land and Survey, Gombe, 2008). Gombe town is well linked by road to other regional centers like Biu / Maiduguri, Potiskum / Damaturu, Bauchi /Jos and Yola/Jalingo. The climate of Gombe is characterized by a dry season of six months, alternating with a six months rainy season.

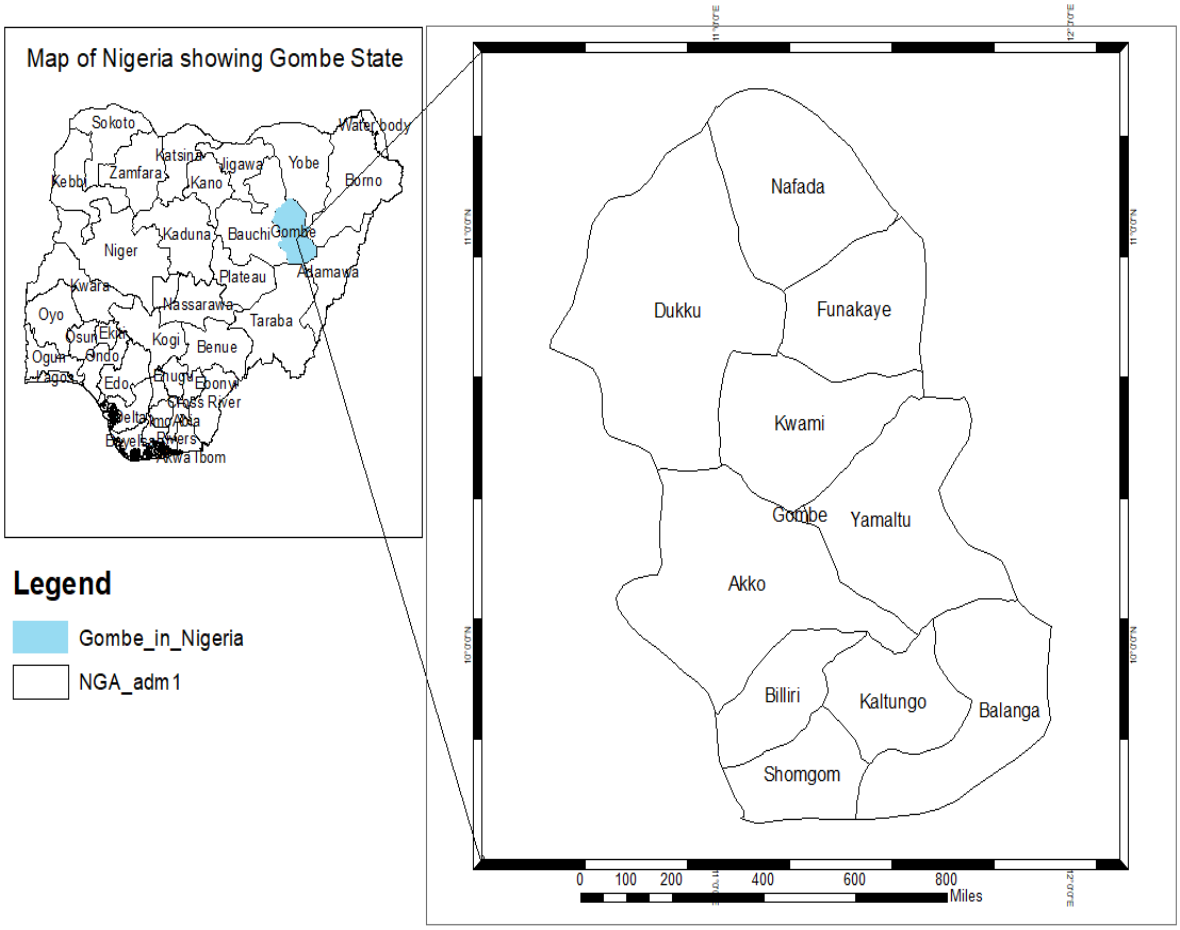


Figure1. Map of showing Gombe town

Sample description and locations

Table1: Sample location and description

S/N	Measurement sites	Longitude	Latitude	Site description
1	G1	$11^0$08.64’	10°18.72	FCE junction
2	G2	$11^0$09.11’	10°17.82’	Federal Low cost
3	G3	11°10.20’	10°18.40’	G.S.U
4	G4	$11^0$10.66’	10°17.25’	Main market
5	G5	$11^0$08.16’	10°17.20’	Bauchi park
6	G6	11°10.28’	10°16.84’	Bolari
7	G7	$11^0$07.57’	10°17.77’	Shongo estate
8	G8	$11^0$10.40’	10°15.90’	Bypass junction
9	G9	$11^0$10.10’	10°16.20’	Pantami
10	G10	$11^0$10.53’	10°17.62’	Herwagana
11	G11	$11^0$11.58’	10°17.58’	Old Market
12	G12	11°10.51’	10°18.76’	Arawaqtrs
13	G13	11°12.36’	10°16.91’	Nasarawo
14	G14	11°09.62’	10°17.21’	Jekadafari
15	G15	11°11.58’	10°17.57’	Kasuwankatako
16	G16	11°09.24’	10°17.32	Checheniya
17	G17	11°10.13’	10°17.80’	Tudunwada
18	G18	11°11.20’	10°18.40’	Malam Inna
19	G19	11°11.32’	10°16.23’	Madaki
20	G20	11°12.35’	10°15.9’	Yelenguruza

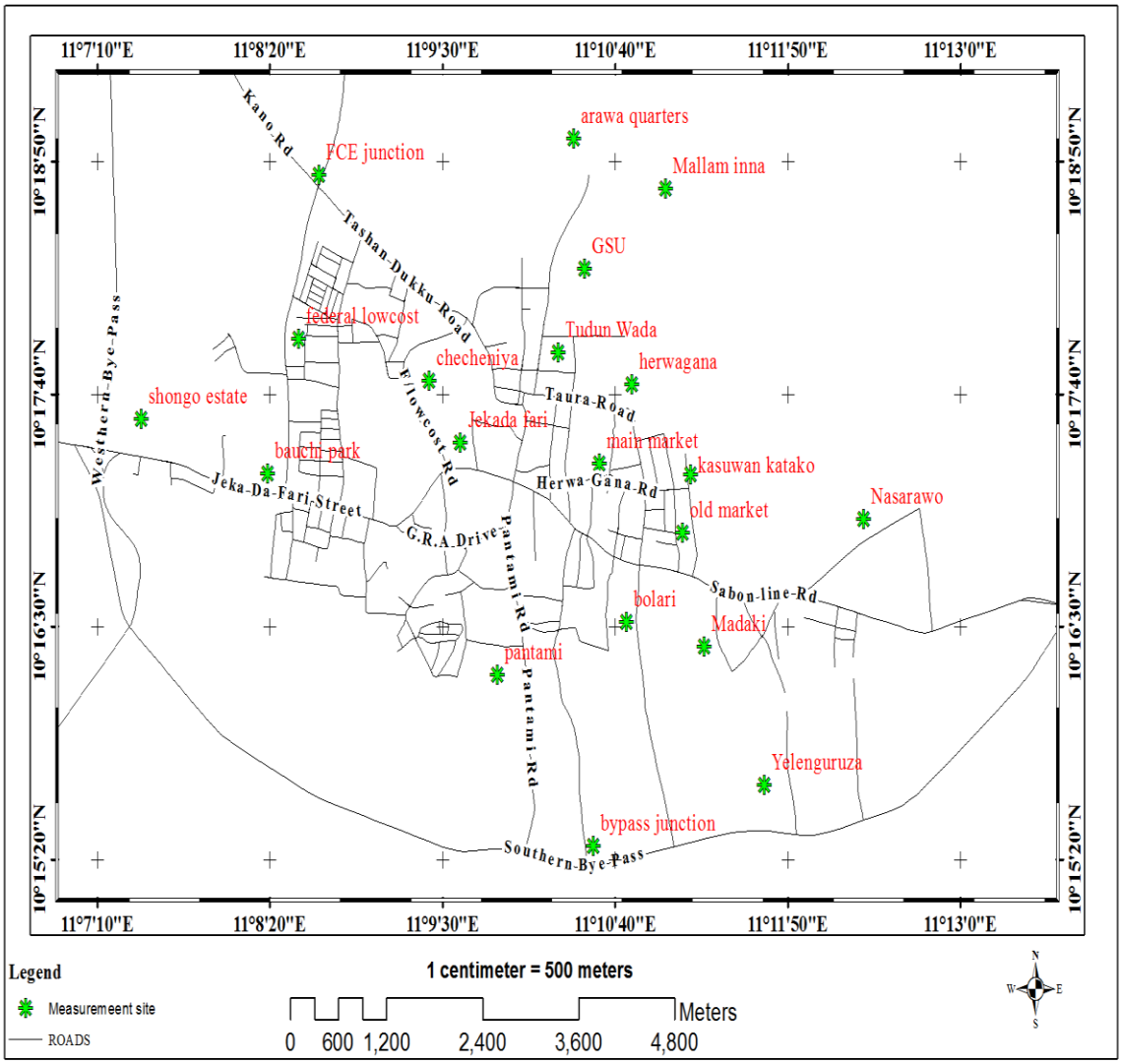


Figure 2. A map showing the sample locations

2.1 Method

A hand-held portable Geiger Muller tube, manufactured by LND, INC. which has the ability to detect and count alpha, beta and gamma particles, was used to measure the environmental radioactivity in count per second. The device senses ionizing radiation by means of the GM tube with a thin mica window. The sensor is LND 7223 halogen quenched with mica window 2.5-3.0 mg/cm^2 thick. The tube is fully enclosed inside the instrument. The instrument was factory calibrated with ^{60}Co with gamma sensitivity of 2700CPM/mR/hr.

A total of twenty (20) representative points including were adopted for this study (table 1) . At each measurement site, three readings were taken with the Geiger Muller counter held at one meter above the ground for 60 seconds and the average counts of these three readings is taken as the mean activity for that measurement site. The standard error was also calculated.

The activity in count per minute obtained from the instrument was converted to exposure rate in mR/hr, using equation 1 from the instrument specification and absorbed dose rate in nGy/hr using the relation, equation 2, for the external exposure rate as given by Avwiri, 2013

2700 CPM = 1 mR/hr (1)

1μR/hr = 8.7 nGy/hr (2)

In order to estimate the annual effective doses, the conversion coefficient from absorbed dose in air to effective dose and the indoor and outdoor occupancy factor was taken into account. In the (UNSCEAR, 2000) report, the Committee used 0.7 *Sv Gy*$^{-1}$for the conversion coefficient from absorbed dose in air to effective dose received by adults, and 0.8 for the indoor occupancy factor, 0.2 for the outdoor occupancy implying that 20 % of time is

spent outdoors, on average, around world. The annual effective dose rate indoors and outdoors, in units of *mSv per year*, were calculated by equation 3 and 4 respectively.

EDR indoor (mSv y^{-1}) = DR (nGy/h) ×24h×365.25d ×0.8)×0.7Sv/Gy×10^{-6} (3)

EDR outdoor (mSv y^{-1}) = DR (nGy/h) ×24 h ×365.25 d ×0.2×0.7 Sv/Gy×10^{-6} (4)

Where EDR = Effective dose rate

DR = Dose Rate

III. RESULTS AND DISCUSSION

Assessment of background radiation level of Gombe metropolis have been carried out using a Geiger Muller counter and the results are presented in table and figures. Table 2 presents the exposure rates, the absorbed dose rates and the annual effective indoor and outdoor dose equivalents for the study area.

Table 2. Mean Count per second, Exposure rates, absorbed dose and indoor and outdoor effective dose of the measurement sites

S/N	Measurement Site	Mean Count per minute (CPM)	Exposure Rate (μR/hr)	Absorbed Dose (Gy/h)	Whole body equivalent dose (mSv/yr)	
					Indoor	Outdoor
1	G1	31.10±5.94	11.50±2.20	99.40±19.14	0.459±0.094	0.122 ± 0.024
2	G2	26.35± 2.44	9.76±0.91	84.91 ± 7.86	0.417± 0.039	0.104 ± 0.010
3	G3	22.20 ±1.34	8.22±0.50	71.53± 4.33	0.351± 0.021	0.088 ± 0.005
4	G4	30.21±3.03	11.19±1.12	97.34±9.76	0.476± 0.048	0.119 ± 0.012
5	G5	21.00±2.60	7.78±0.96	69.67± 8.38	0.332± 0.041	0.085 ± 0.010
6	G6	24.68±2.65	9.14±0.98	79.52 ±8.54	0.390± 0.042	0.098 ± 0.011
7	G7	20.30±2.35	7.52±0.87	65.41±7.57	0.321±0.037	0.080 ± 0.009
8	G8	20.00±1.41	7.41±0.52	64.44±4.54	0.316±0.022	0.079 ± 0.006
9	G9	22.64±1.14	8.39±0.42	72.95±3.67	0.358±0.018	0.089 ± 0.005
10	G10	22.40±1.34	8.30±0.50	72.18±4.32	0.354±0.021	0.089 ± 0.006
11	G11	28.00±1.32	10.37±0.49	90.22±4.25	0.443±0.021	0.111 ± 0.005
12	G12	22.40 ±1.32	8.30±0.49	72.18 ± 4.25	0.354 ± 0.021	0.089 ± 0.006
13	G13	26.80±1.84	9.93±0.68	86.36±5.92	0.424±0.029	0.106 ± 0.007
14	G14	20.20±2.73	7.50±1.01	65.25± 8.80	0.322±0.043	0.080 ± 0.011
15	G15	26.00±3.40	9.70±1.26	83.78±10.96	0.411±0.054	0.103 ± 0.013
16	G16	25.00±1.23	9.26±0.46	80.56±3.96	0.395±0.019	0.099 ± 0.005
17	G17	26.40±1.66	9.79±0.62	85.07±5.35	0.417±0.026	0.104 ± 0.007
18	G18	24.60±1.10	9.11±0.41	79.27±3.54	0.389±0.017	0.097 ± 0.004
19	G19	22.60±1.14	8.37±0.42	72.82±3.67	0.357±0.018	0.089 ± 0.005
20	G20	21.40±1.14	7.93±0.42	68.96± 3.67	0.338± 0.018	0.085 ± 0.005
MEAN		24.24 ± 1.64	8.90±0.61	77.56±5.28	0.381±0.026	0.096± 0.007

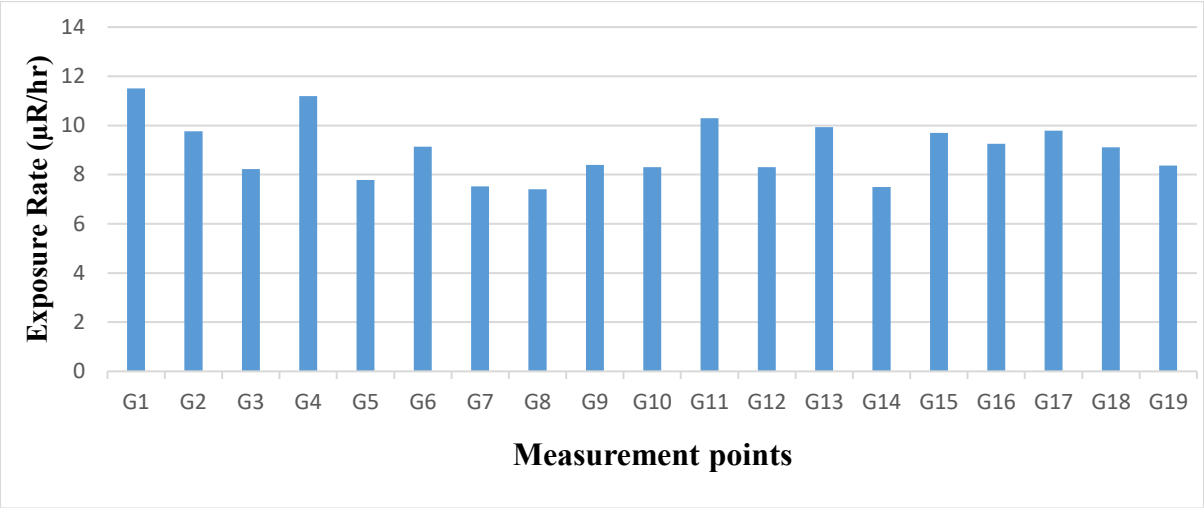


Figure 3: Exposure rates against the measurement sites

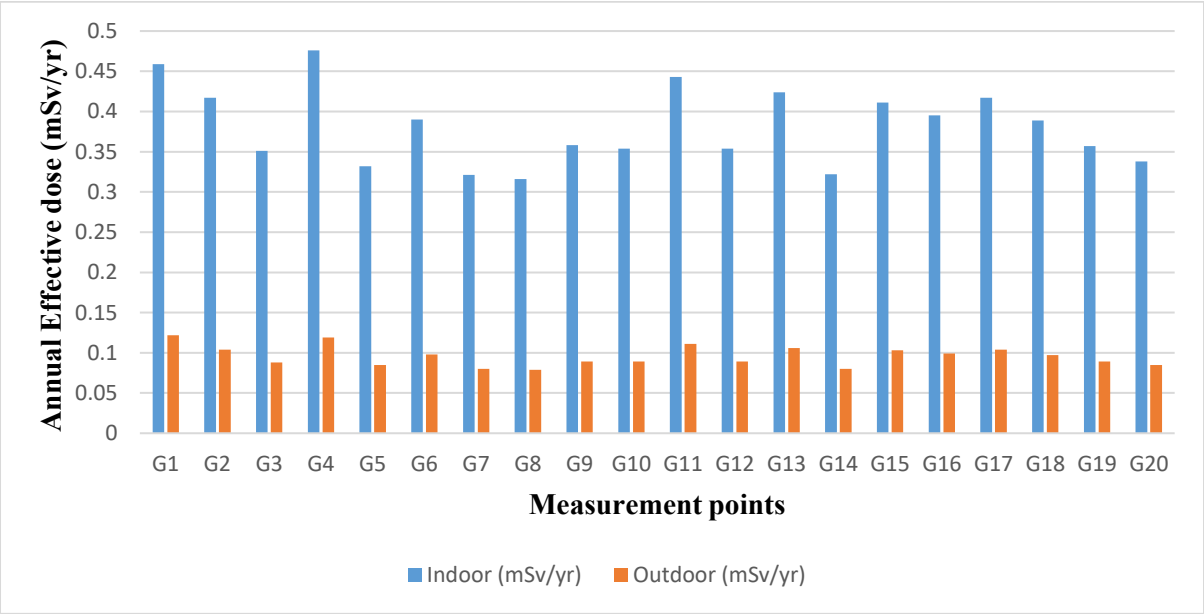


Figure 4:Annual effective indoor and outdoor dose of the measurement site

The exposure rate measured ranged from 7.50 ±1.01 to 11.50±2.02 µR/hr with mean value of 8.90 µR/hr. The absorbed dose rate ranged from 65.25± 8.797nGy/h to 99.40±5.14nGy/h with an average of 77.107±5.284nGy/h. It can be seen from Figure 1 that point P1, the gate, has the highest activity of 99.40±19.14nGy/h. This may be as a result of radionuclides present in the soil of that area.

The annual effective indoor dose as presented in table 1 ranged from 0.322±0.043 to 0.459±0.094 mSv/yr. The lowest measurement of 0.322 mSv/yr was recorded from the class room A1, while the highest value of 0.459 mSv/yr is from the From Gate as shown in figure 2. The annual effective outdoor dose ranged between 0.080 ± 0.012mSv/yr to 0.122 ± 0.024mSv/yr.

The mean values for the indoor and outdoor effective doses are 0.381with standard deviation of 0.026 mSv/yr and 0.096± 0.007mSv/yr respectively.

In comparison with the values obtained from measurements, these values are higher than the values of 0.144 and 0.14 mSv/yr obtained by Eke et al for federal University of Technology Owerri. It is also higher than the mean value of 0.189 mSv/yr obtained by Olarinoye et al for the two tertiary institutions in Minna, Niger state. Similarly, the values obtained in this assessment are much lower than the values 1.29 mSv/yr and 0.31 mSv/yr obtained by Termizi et al for Akwanga and Keffi towns of Nasarawa states, and the values of 1.15, 1.19 and 1.11 mSv/yr as obtained by Ononugbo and Anekere for Mile 3, Mile 1 and Rumo Okoro markets in Porthacout state respectively.

However, the values obtained in this study for both outdoor and indoor radiation Dose rates are lower than the world standard recommended value 1 mSv/yr for non-occupational populace.

IV. Conclusion

The assessment of natural background ionizing radiation in Gombe state polytechnic Bajoga was carried out using a Digital Geiger Muller counter. The result of the study showed that the Background radiation levels are within the permissible levels. Hence, it can be concluded that the habitants of the study area are not at any risk due to radiation exposure. However, efforts should be made to maintain or reduce the current level of exposure.

REFERENCES

[1]. Abubakar, A., Sadiq, A.A., Musa, M.G., Hassan, J., & Malgwi, D.F. (2017). Assessment of indoor ionizing radiation profile in radiology department FMC Asaba, Delta State, Nigeria. *International Organization of Scientific Research (IOSR) Journal of Dental and Medical Sciences, 16*(1), 98-101.

[2]. Avwiri GO, Egieye JF, Ononugbo CP. (2013). Radiometric survey of Aluu landfill in Rivers state, Nigeria. *Advan. Phys. Theory Appl, 22*, 24-30.

[3]. Blessing OB, Muyiwa AA. (2018). Assessment of Background Radiation Levels in Selected Diagnostic Radiology Department across Ondo, Nigeria. *Journal of Pure & Applied Physics, 8*(1), 16-19.

[4]. Chiegwu, H.U., Onyeka, J.O., Ugwuanyi, D.C., Odunk, D.D., Ogolodom, M.P., Mbaba, A.N., Nwodo, V.K., & Ezechukwu, U.N. (2022). Assessment of background ionizing radiation exposure levels in industrial buildings in Nnewi, Anambra State, Nigeria. *International Journal of Research in Medical Sciences, 10*(2), 305-315.

[5]. Eke BC, Emelue HU. (2020). Measurement of Background Ionizing Radiation in the Federal University of Technology Owerri, Nigeria Using Calibrated Digital Geiger Counter. *International Journal of Physical Research and Applications, 3*, 070-074.

[6]. Farai I.P, Jibri NN. (2000). Baseline studies of terrestrial outdoor gamma dose rate levels in Nigeria. *Radiation. Protection. Dosimetry, 88*(3), 247-254.

[7]. Ibrahim, B.M., Alhassan, A.J., Ali, S.A., & Sunday, A.J. (2023). Recent review of natural and artificial background radiation dosimetry studies in Saudi Arabia. *Radiation and Environmental Biophysics, 62*(193). https://doi.org/10.1007/s00411-023-01029-0

[8]. Mgbeokwere, C., Ononugbo, C.P., & Gbarato, O.L. (2023). Radiological Assessment of Background Ionizing Radiation Exposure Rates from Solid Mineral Mining Sites in Ikwo Local Government Area of Ebonyi State, Nigeria. *Asian Journal of Advanced Research and Reports, 17*(11), 214-225.

[9]. Norman EB. (2008). Review of common occupational hazards and safely concerns for nuclear medicine technologist. *Journal of Nuclear Med Tech, 36*(1), 11-17.

[10]. Obed R.I, Farai I.P, Jibiri N.N. (2005). Population Dose Distribution due to Soil Radioactivity Concentration Levels in 18 cities across Nigeria. *J Radiol Prot, 25*, 305–312. [PubMed: https://pubmed.ncbi.nlm.nih.gov/16286693/]

[11]. Olarinoye IO, Sharifat I, Baba-Kutigi AN, Kolo MT, Aladeniyi K. (2010). Measurement of Background Gamma Radiation Levels at Two Tertiary Institutions in Minna, Nigeria. *Journal of Applied Science and Environmental Management, 14*(1), 59-62.

[12]. Ononugbo C, Anekwe U. (2020). Background Gamma Radiation in Nigerian Market Environment. *American Journal of Environmental Sciences, 16*(3), 48-54. DOI: 10.3844/ajessp.2020.48.54.

[13]. Onumejor CA, Akinpelu A, Arijaje TE, Usikalu MR, Oladapo OF, Emetere ME, Omeje M, Achuka JA. (2019). Monitoring of Background Radiation in Selected Schools in Ota, Ogun State Nigeria by Direct Measurement of Terrestrial Radiation Dose Rate. In *International Conference on Energy and Sustainable Environment*, *IOP Conf. Series: Earth and Environmental Science, 331*(1), 012038. IOP Publishing. doi: 10.1088/1755-1315/331/1/012038.

[14]. Oviri, M.O., Fredrick, O.U., & Ochuko, A. (2023). Environmental Risk Assessment of Background Radiation, Natural Radioactivity and Toxic Elements in Rocks and Soils of Nkalagu Quarry, Southeastern Nigeria. *Journal of Hazardous Materials Advances, 10*(2023)

[15]. Ramli T, Aliyu AS, Agba EH, Saleh MA. (2014). Effective Dose from Natural Background Radiation in Keffi and Akwanga Towns, Central Nigeria. *International Journal of Radiation Research, 12*(1), January 2014.

[16]. Sadiq A.A, Agba EH. (2011). Background radiation in Akwanga, Nigeria. *Working and Living Environmental Protection, 8*, 7-11.

[17]. Sambo, I., Rafiu, A.A., Salawu, M., Yau, U.I., & Ekong, G. (2022). Measurement of Background Ionizing Radiation in Kogi State, Nigeria. *International Journal of Current Science Research and Review, 05*(11), November 2022. DOI: 10.47191/ijcsrr/V5-i11-29

[18]. Taskin H, Karavus M, Ay P, Topuzoglu A, Hindiroglu S. (2009). Radionuclide Concentrations in soil and lifetime cancer risk due to the gamma radioactivity in Kirklareli, Turkey. *J. Environ. Rad., 100*, 49-53. [PubMed: https://pubmed.ncbi.nlm.nih.gov/19038480/]

[19]. Ugbede, F.O., & Echeweozo, E.O. (2017). Estimation of annual effective dose and excess lifetime cancer risk from background ionizing radiation levels within and around quarry site in Okpoto-Ezillo, Ebonyi State, Nigeria. *Journal of Environment and Earth Science, 7*(12), 74-79.

[20]. Ugwuanyi, D.C., Nzotta, O.N., Ogolodom, M.P., Sibeudu, T.F., Ibekwe, A.M., & Ezeaku, N.O. (2021). Background radiation levels in selected dumpsites in Nnewi community setting Southeast Nigeria. *International Journal of Radiation Research, 19*(3), July 2021.

[21]. United Nations Scientific Committee on the Effect of Atomic Radiation. (2008). Sources and Effects of Ionizing Radiation UNSCEAR Report 2008.