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Full Length Research Paper

Indoor ionizing radiation measurement in different departments of the Federal University of Technology Owerri

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The indoor background ionizing radiation of various offices of the various departments in Federal University of Technology, Owerri (FUTO) was estimated in this study. This was conducted using a well calibrated digital Geiger - Muller Counter (GCA - 04W). The highest value measured was 0.0873 ± 0.1432 μSv/h while the lowest value was 0.0006 ± 0.0001 μSv/h with an average value of 0.0052 ± 0.0013 μSv/h. The average value of the estimated absorbed dose rate for all the departments and annual effective dose equivalent (AEDE) was 4.549 ± 12.047 nGy/h and 22.313 ± 59.092 μSv/y, respectively. For the Excess Lifetime Cancer Risk (ELCR), the average value for the departments was found to be 0.061 ± 0.162. The results of this study show that the level of BIR in all the departments was lower than the world average. In general, it can be concluded that FUTO is relatively safe from the health hazards posed by BIR.

Key words: Background ionizing radiation, radiological risk, absorbed dose rate, annual effective dose equivalent, excess life cancer risk.

INTRODUCTION

The major sources of ionizing radiation in our environment are cosmogenic, anthropogenic and primordial sources (Omogunloye et al., 2021). Of all these sources, the primordial radiation sources are of the major concern, since the radiation from cosmogenic and anthropogenic sources are negligible. Primodial radiation levels are dependent on local geological conditions and geographical location of the area (Akortia et al., 2021). Ionizing radiation can be beneficial and harmful, depending on the levels of exposure. When the level of exposure to ionizing radiation exceeds certain limits within the environment, it becomes harmful and could cause certain health disorders such as acute leukemia, lung cancer, pancreas, hepatic, skin and kidney cancers, cataracts, and sterility (Vaiserman et al., 2018). To safeguard the health of the public from the adverse effects of exposure to background ionizing radiation (BIR), it has become necessary to survey the BIR levels within the environment. Recently, there were studies that have been directed towards investigating BIR levels in

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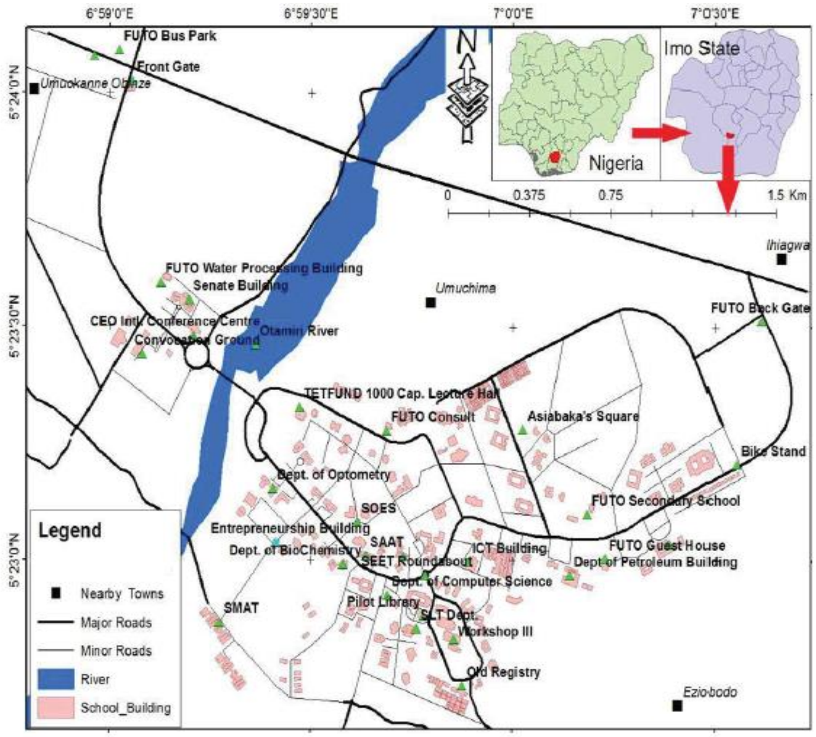

Figure 1. Geographical map of FUTO.
Source: Eke and Emelue (2020).

various areas. Eke and Emelue (2020) evaluated the BIR levels in Federal University of Technology, Owerri (FUTO). Agbalagba (2017) investigated the outdoor gamma radiation exposure dose rate for eastern Nigeria. Etuk et al. (2017) similarly investigated the BIR levels in Ikot-Ekpene, Akwa-Ibom State, Nigeria. Agbalagba (2020) also assessed the BIR levels, excess life cancer risk (ELCR) and gamma dose rates in Effurun and Warri, Delta State, Nigeria. Other studies related to BIR levels can be found in the literature (Agbalagba and Anekwe, 2021; Ekong et al., 2019).

In the present study, the BIR levels of fifty departments/centres within FUTO, Imo State, Nigeria will be measured using a Geiger Muller Counter. The health hazard indices such as absorbed dose rate, AEDE and ELCR were also estimated. The resulting indices will then be compared to the world average so as to make an inference on the radiological risk due to the BIR exposure.

MATERIALS AND METHODS

Study area

FUTO is located in Owerri west local government area of Imo State, Nigeria. It is located within the coordinates N5°23.5615' and E 6°59.1758'. The institution is bounded by communities such as Eziobodo, Ihiagwa, Obinze, and Umuchima. It covers a land area of approximately 4580 ha and has a population of approximately forty five thousand, which includes the staff and students (Eke and Emelue, 2020). Owerri is bordered by the Otamiri River to the east and the Nworie River to the south. Its environment has a good number of markets, industries, banks, restaurants, and hotels. It also has some important educational institutions in its environs which include Imo State Polytechnic, Umuagwo; Federal Polytechnic, Nekede; Imo State University, Owerri; Alvan Ikoku Federal College of Education; and so many secondary schools. A geographical map of FUTO is as shown in Figure 1.

Background radiation measurements

The background ionizing radiation level in this work was measured using a well calibrated digital Geiger – Muller Counter GCA – 04W. This instrument measures the Natural Background Radiation rates in count per minutes (CPM) and count per seconds (CPS). The digital detector can detect alpha, beta and gamma radiations. The main element in this detector is the probe or tube with a gas-filled chamber. The wall of the GM tube is a thin metal cylinder (cathode) surrounding a center electrode (anode). It has a thin mica window in the front; it allows the passage of detection of alpha particles. The tube is filled with Neon, Argon and Halogen gas.

The indoor background radiation of five offices in each of the fifty departments sampled in FUTO was measured. The instrument was always checked to ensure the battery of about 9 V was always active for accurate reading. The counter was set to mSv and readings were taken after 1 min. The Geiger–Muller counter was held at about 1 m above the ground level at an open space. Measurements were taken at three different parts of each office. Two successive readings were taken at each point and the mean value was calculated and recorded. Each count was converted to micro-Sievert per hour (μSv/h). The measured data for the background ionizing radiation (BIR) was used to calculate the absorbed dose rate (D), the annual effective dose equivalent (AEDE) and the excess life cancer risk (ELCR).

RESULTS AND DISCUSSION

BIR measurements

Table 1 shows the BIR measurements for this study and the estimated radiological hazard indices. The BIR measurements within the offices were all below the world average of 0.013 mRh^{-1}. The average value reported for the study was 0.0052 ± 0.0139 μSv/h. The highest BIR exposure was observed in the Department of Food Science and Technology and this could be from the building materials within the offices or the surrounding environment. This suggests that, the level of radionuclides in the Food Science Department was relatively higher than in other departments studied.

Absorbed dose rate

The absorbed dose rate (D), was calculated using the conversion factor

$$1\mu Rh^{-1} = 8.7nGyh^{-1} = \frac{8.7\times10^{-3}}{(1/8760y)}\mu Gyy^{-1} = 76.212\mu Gyy^{-1} \quad (1)$$

The following conversion factor was also used:

$$\left.\begin{aligned} &1\mu R/h = 0.01\mu Sv/h \\ &\Rightarrow 1\mu Sv/h = 870nGy/h \end{aligned}\right\} \quad (2)$$

Generally, the absorbed dose rate due to BIR was found to be low suggesting low level radiation hazard in the studied environment. In the Department of Food science and Technology, the absorbed dose rate was found to be higher than the world average and should be a source of concern, this can be observed in Figure 2. In general, the mean value obtained in this study is lower than the world population weighted average gamma dose rate value of 59 $nGyh^{-1}$ (UNSCEAR, 2000). The absorbed dose rate is also lower than what was obtained by Agbalagba (2017) in the Warri environment.

Annual effective dose equivalent (AEDE)

AEDE was computed from the absorbed dose rates. Dose conversion factor of 0.7 $Sv\ Gy^{-1}$ and an occupancy factor for indoor exposure of 0.8 were used in the computation. The annual effective dose was calculated from:

$$AEDE = D_{nGyh^{-1}} \times 0.8 \times 8760h \times 0.7_{SvGy^{-1}} \quad (3)$$

$$AEDE = D_{nGyh^{-1}} \times 4.905\mu Sv \quad (4)$$

The mean AEDE indicates low radiological risk from the BIR, since it is just about 5.4% of the world average. Nevertheless, it was observed that the highest value from Food Science and Technology Department is about 91% of the world average, which is a source of long-term concern as shown in Figure 3.

Excess life cancer risk (ELCR)

ELCR was computed using the following equation:

$$ELCR = AEDE_{mSvy^{-1}} \times LE \times RF$$

where *LE* is the life expectancy which was taken as 55 years for Nigeria as given by World Bank records (2020). RF is the fatal risk factor which is taken as 0.05 Sv^{-1} (Charles, 2008). The ELCR in three departments (Crop science, Financial Management Technology and Centre for Energy and Power Systems Research and Food Science Technology) was found to be higher than the world average value (Figure 4). Because the area under investigation is an official area and not a residential area, the likelihood of the occupants developing cancer from BIR is very low.

Conclusion

BIR was measured in various departments within Federal University of Technology, Owerri (FUTO). From the BIR measurements, the hazard indices-absorbed dose rate, AEDE and ELCR were calculated and the results in general showed a low level of BIR. Only the department of Food Science and Technology seems to pose significant radiological risk from BIR. In general, it can be concluded that FUTO is relatively safe from the radiological hazards due to BIR. It is recommended that the levels of ionizing radiation should be monitored in other parts of the university. Further studies should be carried out to determine the sources of the high levels of BIR within some parts of the school.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

Table 1. BIR measurements and the estimated hazard indices from the study.

Department	Measurement (μSv/h)	Absorbed dose rate (nG/h)	AEDE (μSv/year)	ELCR×10^{-3}
Physics	0.0009	0.740	3.630	0.010
Geology	0.0010	0.870	4.267	0.012
Biology	0.0009	0.818	4.012	0.011
Agricultural Economics	0.0010	0.844	4.140	0.011
Science Laboratory Tech.	0.0008	0.713	3.497	0.010
Chemistry	0.0010	0.844	4.140	0.011
Mathematics	0.0006	0.548	2.688	0.007
Dental	0.0009	0.783	3.841	0.011
Optometry	0.0008	0.696	3.414	0.009
Public Health	0.0010	0.853	4.184	0.012
Architecture	0.0010	0.879	4.311	0.012
Civil Engineering	0.0043	3.767	18.477	0.051
Mechanical Engineering	0.0021	1.801	8.834	0.024
Mechatronics	0.0017	1.496	7.338	0.020
Electrical and Electronics Engineering	0.0010	0.879	4.311	0.012
Food Science and Tech.	0.0873	75.934	372.456	1.024
Polymer and Textile Engineering	0.0161	13.964	68.493	0.188
Quantity surveying	0.0017	1.479	7.254	0.020
Agricultural Engineering	0.0009	0.783	3.841	0.011
Petroleum Engineering	0.0008	0.705	3.458	0.010
Microbiology	0.0011	0.914	4.483	0.012
Animal science	0.0009	0.809	3.968	0.011
Chemical Engineering	0.0009	0.783	3.841	0.011
Computer Science	0.0013	1.131	5.548	0.015
Biotechnology	0.0100	8.735	42.845	0.118
Statistics	0.0046	3.993	19.586	0.054
Crop science	0.0257	22.350	109.627	0.301
Financial Management Technology	0.0300	26.057	127.810	0.351
Biomedical Technology	0.0009	0.800	3.924	0.011
Agricultural Extension	0.0010	0.844	4.140	0.011
Environmental Technology	0.0018	1.583	7.765	0.021
Forestry and Wildlife	0.0022	1.897	9.305	0.026
Soil science	0.0019	1.627	7.980	0.022
Surveying and Geo-informatics	0.0012	1.061	5.204	0.014
Urban and Regional Planning	0.0008	0.713	3.497	0.010
Building Tech.	0.0010	0.896	4.395	0.012
Prostetics and Orthopaedic Technology	0.0008	0.713	3.497	0.010
Fishery and Aquaculture Technology	0.0011	0.974	4.778	0.013
Anatomy	0.0020	1.775	8.706	0.024
Physiology	0.0013	1.096	5.376	0.015
Management Technology	0.0012	1.061	5.204	0.014
Entrepreneurship	0.0017	1.496	7.338	0.020
Information Technology	0.0010	0.827	4.056	0.011
Project Management	0.0008	0.731	3.586	0.010
Transport Management	0.0012	1.079	5.292	0.015
Maritime Management Technology	0.0014	1.175	5.763	0.016
Agricultural Engineering	0.0011	0.931	4.567	0.013
Biochemistry	0.0015	1.288	6.318	0.017

Table 1. Cont'd

Materials and Metallurgical Engineering	0.0018	1.557	7.637	0.021
Centre for Energy and Power Systems Research	0.0335	29.162	143.040	0.393
Mean	0.0052 ± 0.0013	4.549 ± 12.047	22.313±59.092	0.061±0.162
World average	0.274	59.000	410.000	0.290

Source: Author's 2022

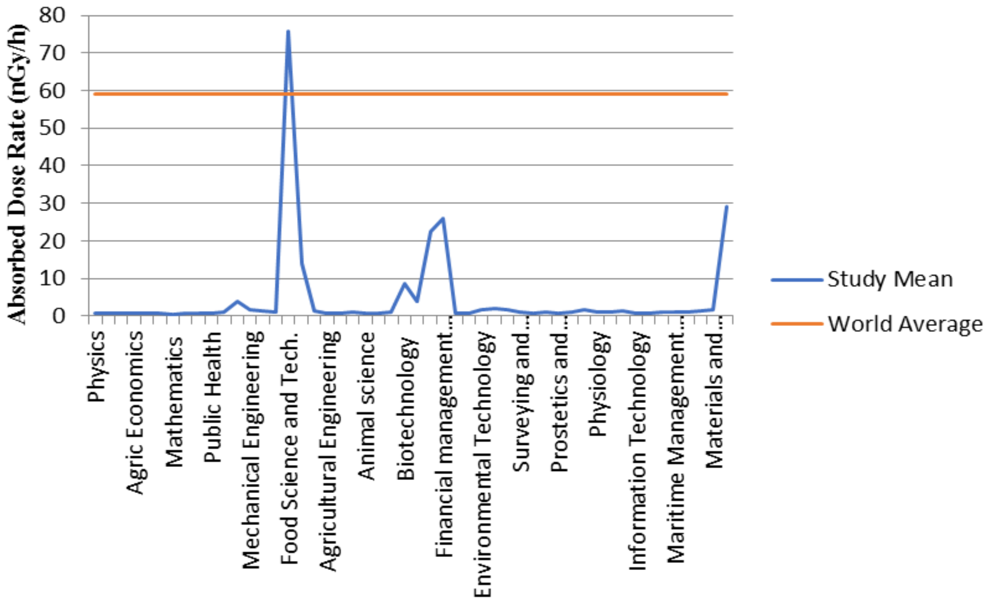

Figure 2. Absorbed dose rates for the various departments compared with the world average.
Source: Author's 2022

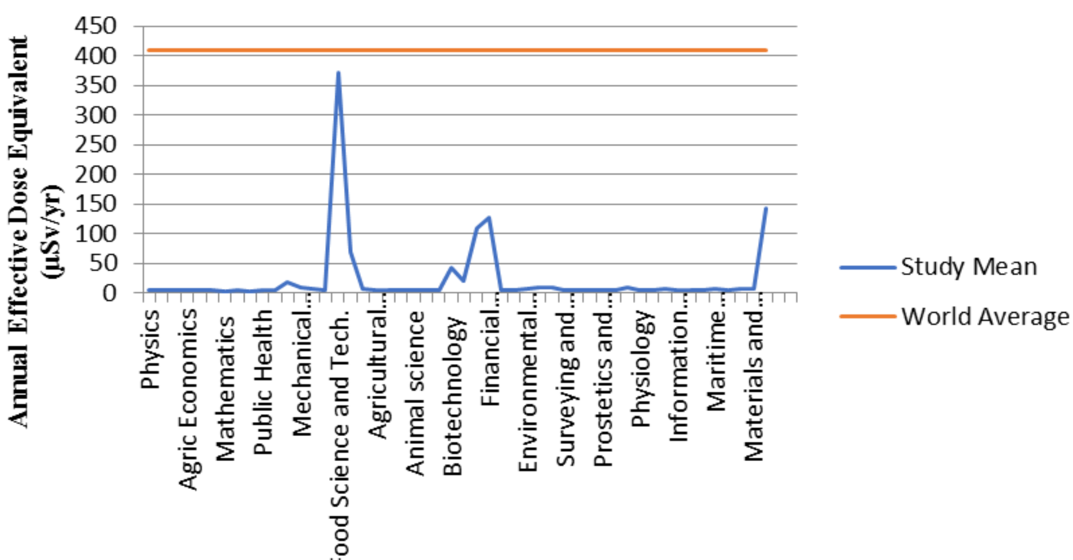

Figure 3. Annual effective dose equivalent for the various departments compared with the world average.
Source: Author's 2022

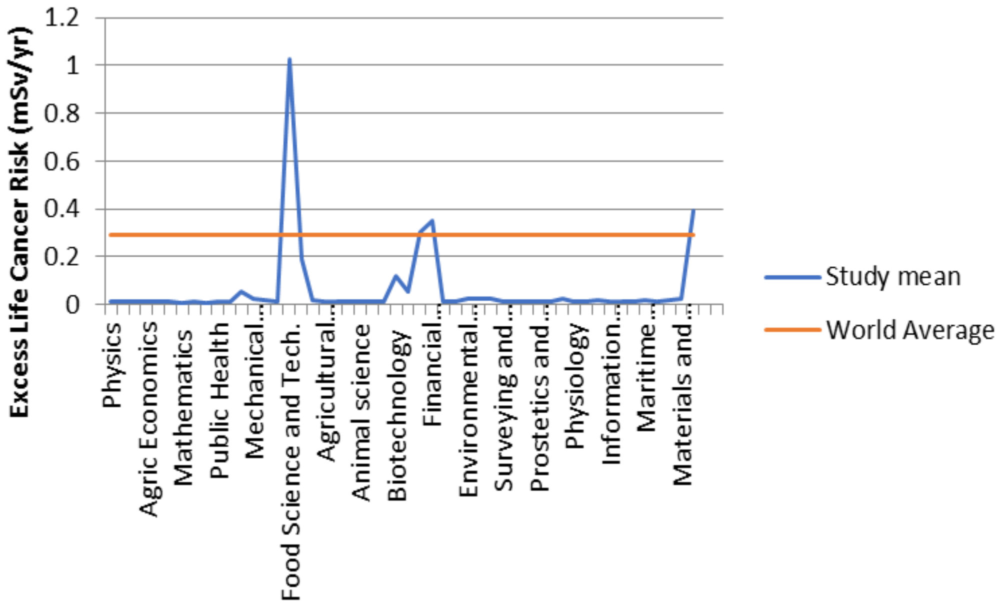

Figure 4. Excess life cancer risk for the various departments compared with the world average.
Source: Author's 2022

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