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ASSESSMENT OF THE AMBIENT BACKGROUND RADIATION LEVELS AT THE TAKE-OFF CAMPUS OF FEDERAL UNIVERSITY DUTSIN-MA, KATSINA STATE-NIGERIA

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Abstract
This study investigates the ambient background radiation levels at the take–off campus of Federal University Dutsin–Ma (FUDMA), Katsina State in order to measure the indoor and outdoor radiation levels using a digital radiation meter (Radiation Alert Inspector). The radiation meter was held one meter above the ground and the ambient radiation levels in thirty-six (36) buildings, some road pavements and outdoor sports facilities were surveyed. The results obtained showed that, the Old Biology laboratory and Biochemistry laboratory were found to have the highest values of indoor annual equivalent dose rate of 2.27±0.29 mSv/yr and 2.27±0.33 mSv/yr respectively, while the lowest value for indoor annual equivalent dose rate was recorded as 0.85±0.22 mSv/yr at Lecture Halls 3 and 4. For the outdoor facilities, the main gate road pavement was found to have the highest mean effective dose of 0.24 mSv/yr while the Handball court had the lowest mean effective value of 0.16 mSv/yr. For the block of offices, the Senate Building recorded the highest indoor annual equivalent dose rate of 1.63±0.34 mSv/yr while Blocks B and Block D recorded the lowest values of 1.04±0.31 mSv/yr and 1.04±0.40 mSv/yr respectively. The overall average indoor and outdoor annual equivalent dose rates on the take-off site of FUDMA were computed and found to be 1.41±0.29 mSv/yr and 0.33±0.08 mSv/yr respectively. The correlation coefficient of 0.1846 was obtained indicating a weak relationship between the indoor and outdoor background radiation levels. A comparison of these results with the worldwide average limit of equivalent dose rate of 2.4 mSv/yr recommended by the International Commission on Radiation Protection, infers that the ambient indoor and outdoor radiation levels at the take-off site of FUDMA are within the safety limits. However, it is recommended that adequate ventilation be provided in the indoor facilities so as to prevent the accumulation of radon gas which is the primary source of harmful background radiation in the environment.

Keywords: *Ambient radiation, Radiation Alert Inspector, equivalent dose rate, correlation coefficient.*

Introduction

Radiation is any form of energy propagated as rays, waves, or stream of particles which could be ionizing and non-ionizing. Ionizing radiation produces ionization when it passes through matter and is more harmful than non-ionizing radiation (IAEA, 1986). Ionizing radiation is that type of radiation which is able to produce ions that is capable of disrupting life processes. Non ionizing radiations are not able to create ions, although they may adversely affect human health in other ways. We live in an environment where we are being exposed to certain amounts of ambient radiation every day, this ambient radiation may be from natural sources (e.g. radon gas, soil, granite rocks) or artificial sources (e.g. x-ray machines, building materials, radioactive wastes from reactors, etc.) in the environment and the level of radiation varies from one place to another (Farai and Vincent, 2006). Radon gas from the earth crust is the most abundant source of natural radiation in the environment. The radioactive disintegration of uranium-238 produces ^{222}Rn which in turn decays with a half-life of 3.82 days (Masok *et al.*, 2015). As it is inhaled, it penetrates into the lungs and the continuous deposition and penetration of such high energy particles through the lungs leads to tissue damage and mutation which leads to incidence of lung cancer (Chad-Umoren *et al.*, 2007; Maria *et al.*, 2010). Other natural radiation sources include radionuclides in the soil, cosmic radiation due to ionization of gases in the atmosphere and natural radioactivity due to radionuclides in the body (Osiga, 2014 and James *et al.*, 2015). The materials used in constructing buildings are also major sources of indoor radiation exposure to humans while in the soil, natural radioactivity is mainly due to ^{238}U, ^{40}K, ^{226}Ra which causes external and internal radiological hazard from consumption of crops grown on such (UNSCEAR, 1988). Generally, ionizing radiation when absorbed at higher doses poses health challenges to humans, leading to certain ailments like cancers, tumors, organ and tissue damage, sterility/infertility, genetic mutation, etc. (Jwanbot *et al.*, 2014).

The International Commission on Radiation Protection (ICRP) in 1990 set a worldwide annual equivalent dose rate limit of exposure to ionizing radiation to $1\, mSv/yr$ for the protection of human beings and wildlife (ICRP, 1990) while the average effective dose rate limit of 2.4 mSv/yr was set by the United Nation Scientific Committee on the Effects of Atomic Radiations (UNSCEAR) for most indoor facilities such as research laboratories, conference halls, lecture venues, offices, etc. (UNSCEAR, 2000). It has also been revealed by researchers that, the number of hours residents spent indoors is more than the number of hours/activities they do outdoor. According to Ononugbo *et* *al.* (2015), the outdoor activities of individuals add up to approximately 5 to 6 hours a day while the rest of the time 18 to 19 hours of the day is spent indoor either sleeping, studying, resting and the rest. Thus, the indoor radiation in an environment differs from the outdoors. Masashi *et al.*, (2014) asserted that, resident's exposure to radiations is evaluated by using reduction coefficient for radiation levels in houses and buildings. The reduction coefficient is the ratio of indoor and outdoor ambient dose equivalent rates for evaluating indoor exposure doses and this is provided by International Atomic Energy Agency (IAEA, 1986). It is therefore necessary to know the level of radiation within our living environment because of its health implications to life. The fact that, exposure to high doses of ionizing radiation has implication on human life has been given much research attention in so many places, so as to ascertain the amount of radiation people are being exposed to and to give recommendations.

Tyovenda *et al.* (2011) assessed the indoor and outdoor ambient radiation level from different locations at the University of Mkar and the results they obtained showed a safety level in most locations of the indoor and outdoor facilities except along the granite paved road way outside the school gate which exceeds the limits of 1 *mSv/yr* set by the International Commission on Radiology Protection. Sadiq and Agba (2012) reported that the mean outdoor and indoor radiation levels at the Nassarawa State University Keffi was in the range of 0.25 and 1.08 mSv/yr respectively, which were in good approximation with the internationally approved annual dose limits for members of the public (1 mSv/yr). Masok *et al.* (2015) assessed the background ionizing radiation sources at the Biochemistry, Chemistry, Microbiology and Physics laboratories at Plateau State University, Bokkos to determine the radiation levels both within the laboratories and their environs using a gamma-scout which was adjusted to detect the alpha, beta and gamma radiation in $\mu Sv/hr$. Their results showed that the mean equivalent dose rate per hour for indoor background radiation for the laboratories was found to be 0.256 $\mu Sv/hr$ while the outdoor was 0.249 $\mu Sv/hr$. The mean annual equivalent dose rate of the laboratories were then computed for indoor and outdoor background radiation level to be 1.54 mSv/yr and 0.44 mSv/yr respectively, and are in a good proportion below the world wide average dose of 2.4 mSv/yr. Jwanbot *et al.* (2012) measured the background ionizing radiation profile within the Chemistry research laboratory and Physics Laboratory III of the University of Jos and their immediate neighborhood using gamma scout (model GS2 with serial number A20). The results of the radiation levels recorded showed that the Chemistry research laboratory indoor and outdoor radiation levels were 2.111 mSv/yr and 2.081 mSv/yr respectively, while the Physics laboratory III indoor and outdoor ambient radiation levels were 2.733 mSv/yr and 2.435 mSv/yr respectively. The high values obtained which were below the world wide average effective dose rate limit of 2.4 mSv/yr are due to the fact that these science laboratories also harbour a number of active radiation sources.

In more recent times, Ushie *et al.* (2016) investigated the exposure level to background radiation emitted from laboratories in Cross-River University of Technology (CRUTECH) Calabar, Nigeria. The result obtained indicates that the workers and students operating in the Physics, Biology, Chemistry and Microbiology laboratories were operating within the recommended safety limit of 1.0 mSv/yr while those in the Biochemistry laboratory, Civil, Mechanical and Electrical engineering workshops were operating at 11.6, 10.23, 9.53, and 8.83 msv/yr respectively, which is way above the threshold value. Similarly, Abubakar *et al.* (2017) in a research carried out at Asaba Federal Medical Center (FMC) assessed the indoor radiation profile of the center's radiology department and found out that the Mean Indoor Post Exposure (MIPE) was $0.88 \pm 0.28\, mSv/yr$ which inferred that radiation level was kept within the permissible radiation limit as stipulated by the ICRP and UNSCEAR of 1 mSv/yr, thus affirming that the radiological Department of FMC Asaba was safe from excess exposure to ionizing radiation.

Materials and Method

Equipment used

The main equipment used in this research include the Digital Radiation Meter (Radiation Inspector Alert) and Geographical Positioning System (GPS). A personal computer and Excel software were also used for statistical analysis. Plates 1(a.) and 1(b.) shows the radiation inspector alert and the GPS used in the work.

(a.) (b.)

Plate 1: (a.) Digital Radiation meter (Inspector Alert); (b.) Geographical Positioning System (GPS)

The digital radiation meter measures background radiation using a Geiger-Muller (G-M) counter which is inbuilt. The G-M counter operates based on the ionization of gases caused by radiation. It consists of a cylindrical metal tube filled with a gas and an opening called a 'window' made of a material (e.g. paper) that can be easily penetrated by alpha, beta, or gamma rays. At the center of the cylindrical tube is a wire which is connected to one terminal of a source of direct current, and the metal cylinder is attached to the other terminal. The ions and electrons produced by the ionizing radiation permit conduction of an electrical current. This current flows between the wire and metal cylinder whenever ions are produced by incoming radiation. The current pulse created when radiation enters the cylindrical tube is amplified and each current pulse is counted and displayed on a digital screen as a measure of the amount of background radiation measured (wps.prenhall.com, 2015).

The Study Area and Sampled Points

Dutsin-Ma is a Local Government Area in Katsina State, North-Western Nigeria. Dutsin-Ma LGA lies on latitude 12°26'N and longitude 07°29'E. It is bounded by Kurfi and Charanchi LGAs to the north, Kankia LGA to the East, Safana and Dan-Musa LGAs to the West, and Matazu LGA to the Southeast (Abaje *et al.*, 2014). The Federal University Dutsin-Ma was established on 7th February, 2011 along with eight other Federal Universities to tackle the challenges of inadequate enrolment space for eligible University applicants in some educationally less privileged states who don't have Federal Universities. With the support of the State Government, the permanent as well as the take-off site were identified; with the take-off site located at Kilometer Sixty Katsina-Kankara road in Dutsin-Ma Local Government Area of Katsina State (FUDMA, 2015). Table 1 shows the key to the coding of the sampled points in this research while Plate 2 shows a satellite view of the sampled points in FUDMA.

Table 1: Area Code Key to the Sampled Areas in FUDMA in this Research and their Geographical Coordinates

Area Code	Location	Geographical Location
AC1	New Physics Laboratory	N12°28'24.5", E007°29'10.2"
AC2	Old Physics Laboratory	N12°28'23.8", E007°29'13.3"
AC3	New Chemistry Laboratory	N12°28'24.7", E007°29'10.9"
AC4	Old Chemistry Laboratory	N12°28'22.9", E007°29'14.6"
AC5	New Biology Laboratory	N12°28'24.7", E007°29'10.5"
AC6	Old Biology Laboratory	N12°28'23.9", E007°29'14.3"
AC7	Biochemistry Laboratory	N12°28'22.9", E007°29'13.1"
AC8	Administrative Block 1	N12°28'21.5", E007°29'15.7"
AC9	Administrative Block 2	N12°28'23.3", E007°29'15.3"
AC10	Administrative Block 3	N12°28'24.1", E007°29'15.6"
AC11	Security Unit	N12°28'19.8", E007°29'14.4"
AC12	Block A	N12°28'22.1", E007°29'15.7"
AC13	Block B	N12°28'21.0", E007°29'13.7"
AC14	Block C	N12°28'21.3", E007°29'12.8"
AC15	Block D	N12°28'20.6", E007°29'09.4"
AC16	Block E	N12°28'20.9", E007°29'11.9"
AC17	Lecture 5 & 6	N12°28'21.6", E007°29'13.4"
AC18	Lecture 3 & 4	N12°28'21.8", E007°29'13.6"
AC19	Old ICT Laboratory	N12°28'21.8", E007°29'14.5"
AC20	GIS Laboratory & EDC	N12°28'21.8", E007°29'12.8"
AC21	Lecture Room 1 & 2	N12°28'22.9", E007°29'15.2"
AC22	Large lecture hall 1 & Lecture Hall 7	N12°28'23.3", E007°29'11.9"
AC23	Large Lecture Hall 2	N12°28'23.9", E007°29'12.3"
AC24	Senate Building	N12°28'20.9", E007°29'09.6"
AC25	School Library	N12°28'18.3", E007°29'09.1"
AC26	TetFund Block of offices 2013 A	N12°28'21.0", E007°29'08.5"
AC27	TetFund Block of offices 2013 B	N12°28'21.0", E007°29'10.9"
AC28	School Clinic	N12°28'14.8", E007°29'11.2"
AC29	Works Department	N12°28'15.8", E007°29'12.4"
AC30	New ICT Complex	N12°28'20.6", E007°29'06.9"

Table 1: Area Code Key to the Sampled Areas in FUDMA in this Research and their Geographical Coordinates (Continued)

Area Code	Location	Geographical Location
AC31	New Classrooms Block	N12°28'23.6", E007°29'06.3"
AC32	Indoor Sporting Building	N12°28'21.8", E007°29'04.6"
AC33	Recreational Building	N12°28'23.5", E007°29'04.1"
AC34	Block of Offices near language Lab	N12°28'23.9", E007°29'11.2"
AC35	HOD's Block	N12°28'22.8", E007°29'11.7"
AC36	Auditorium	N12°28'19.6", E007°29'12.4"
AC37	Football Pitch	N12°28'19.1" E007°29'02.8"
AC38	Handball Court	N12°28'20.7", E007°29'00.9"
AC39	Basketball Court	N12°28'21.9" E007°29'02.7"
AC40	Lawn Tennis Court	N12°28'22.9", E007°29'02.8"
AC41	Volleyball Court	N12°28'21.9", E007°29'01.3"
AC42	Badminton Court	N12°28'21.9", E007°29'01.7"
AC43	Main gate road pavement	N12°28'20.2", E007°29'15.8"
AC44	Exit road pavement	N12°28'16.4", E007°29'14.0"
AC45	Science Laboratory complex road pavement	N12°28'23.6", E007°29'08.0"
AC46	New ICT Complex road pavement	N12°28'21.8", E007°29'07.5"
AC47	School Clinic road pavement	N12°28'18.0", E007°29'11.5"
AC48	Road pavement to Sport Field	N12°28'19.5", E007°29'05.6"

Plate 2: Satellite View of Federal University Dutsin-Ma take-off Campus Showing the Sampled Points (Google maps, 2017; modified)

Method and Analysis

The indoor and outdoor background radiation of Federal University Dutsin-Ma take-off Campus was measured in forty-eight (48) different locations using a digital radiation meter (Inspector alert). The radiation meter was held one meter above the ground to capture the average exposure level (height) of the human body and oriented vertically upward during the measurement of readings so as to expose the window of the device to incoming radiation. For each location, ten readings were taken, five indoors and five outdoors. Outdoor measurements for locations like football fields, road pavements and paths were also taken. The coordinates of the geographical locations were taken with use of a GPS. The effective dose readings were taken in milliRöentgen per hour (mR/hr) directly from the display screen of the radiation meter. The results were then converted to micro-Sievert per hour ($\mu Sv/h$) and then finally converted to micro-Sievert per tear ($\mu Sv/yr$). The occupancy factors for indoor and outdoor are 0.8 and 0.2 respectively as recommended by UNSCEAR (2000). The occupancy factor (OF) indicates the proportion of the total time during which an individual is exposed to a radiation field. We calculate the number of hours in the year based on 24 hours a day and multiplied by 365 days in a year to have ($8760 hr/yr$). Conversion of the equivalent dose rate is as presented in the equations below (UNSCEAR, 1988):

(1) $X(\mu Sv/hr) = Y(mR/hr) \times 10$

(2) $Indoor\ (IAEDR): X(mSv/yr) = Y(\mu Sv/hr) \times 8760\ (hr/yr) \times 0.8 \times 0.001$

(3) $Outdoor\ (OAEDR): X(mSv/yr) = Z(\mu Sv/hr) \times 8760\ (hr/yr) \times 0.2 \times 0.001$

Equation (1) converts radiation in milliRöentgen per hour to micro – Sievert per hour, equation (2) converts the indoor equivalent dose from micro – Sievert per hour to milliSievert per year while equation (3) converts the outdoor equivalent dose from micro – Sievert per hour to milliSievert per year. X is the reading displayed directly from the radiation meter, Y and Z are the converted indoor and outdoor meter's readings to micro-Sievert per hour while IAEDR and OAEDR are the Indoor and Outdoor Annual Effective Dose Rates for different places respectively. The Linear correlation coefficient, which measures the strength and the direction of a linear relationship between two variables, was calculated to ascertain the relation between indoor and outdoor ambient radiation; that is to ascertain whether the indoor sources are responsible for the ambient radiation detected outdoors and vice versa. The Pearson product moment correlation coefficient) r, is given by (Mathbits, 2015):

(4) $$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2}\sqrt{n(\sum y^2) - (\sum y)^2}}$$

A positive r value implies direct proportionality (increasing trend) while a negative r value indicates an inverse proportionality (decreasing trend). An r value above 0.5 implies a strong relationship while an r value below 0.5 implies a weak relationship between the variables. Zero or near zero correlation coefficient indicates no relationship between the variables (no trend).

Results and Discussion

The summary of the results obtained from the measurement of the ambient radiation levels in the different lecture venues and laboratories at the take-off site of FUDMA are displayed in Tables 2 and Figure 1.

Table 2: Summary of Indoor and Outdoor Ambient Radiation Levels in $\mu Sv/hr$ and mSv/yr for Lecture Venues

Area Code	Mean Y(μSv/hr)	Mean Z(μSv/hr)	IAEDR (mSv/yr)	OAEDR (mSv/yr)
AC1	0.242±0.04	0.260±0.06	1.70±0.31	0.46±0.10
AC2	0.282±0.03	0.17±0.02	1.98±0.19	0.30±0.03
AC3	0.190±0.04	0.168±0.04	1.33±0.30	0.29±0.07
AC4	0.188±0.03	0.160±0.03	1.32±0.22	0.28±0.06
AC5	0.188±0.03	0.172±0.06	1.32±0.24	0.30±0.11
AC6	0.324±0.04	0.244±0.05	2.27±0.29	0.43±0.08
AC7	0.324±0.05	0.170±0.05	2.27±0.33	0.30±0.10
AC17	0.140±0.02	0.190±0.03	0.98±0.15	0.33±0.05
AC18	0.122±0.03	0.160±0.04	0.85±0.22	0.28±0.07
AC19	0.178±0.03	0.234±0.03	1.25±0.22	0.41±0.05
AC20	0.188±0.06	0.164±0.04	1.32±0.44	0.29±0.08
AC21	0.204±0.07	0.208±0.04	1.43±0.47	0.36±0.07
AC22	0.140±0.06	0.166±0.04	0.98±0.39	0.29±0.08
AC23	0.200±0.06	0.166±0.04	1.40±0.44	0.29±0.07
AC25	0.156±0.03	0.192±0.03	1.09±0.24	0.34±0.05
AC31	0.206±0.03	0.190±0.06	1.44±0.18	0.33±0.10
AC32	0.218±0.05	0.160±0.03	1.53±0.36	0.28±0.04
AC33	0.226±0.05	0.134±0.02	1.58±0.33	0.23±0.03
AC36	0.182±0.06	0.182±0.06	1.28±0.44	0.33±0.18
Mean	0.205±0.04	0.184±0.04	1.44±0.30	0.32±0.07

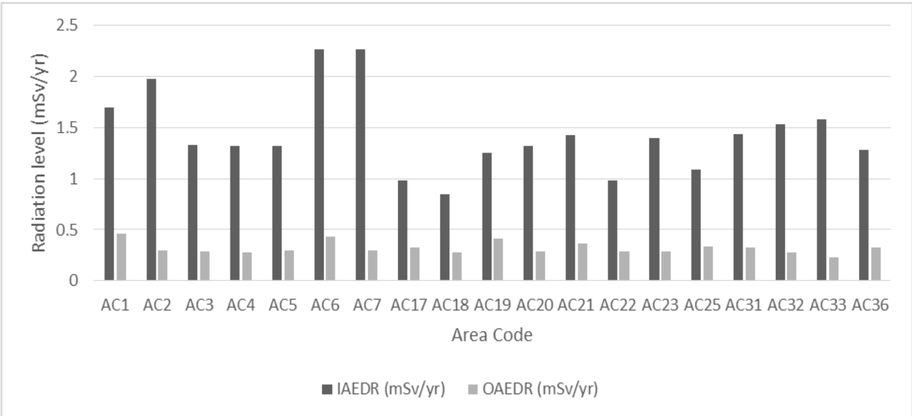

Figure 1: Comparison chart of indoor and outdoor ambient radiation levels in the different lecture venues

Table 2 presents the results of indoor and outdoor annual equivalent dose rate from lecture venues. The mean annual equivalent dose rate from indoor ranges from 0.85±0.22 mSv/yr to 2.27±0.33 mSv/yr with an average of 1.41±0.29 mSv/yr as presented in table 1. In figure 1, the chart presented showed that, AC6 (Old Biology laboratory) and AC7 (Biochemistry laboratory) have the highest value of annual equivalent dose rate 2.27±0.29 mSv/yr and 2.27±0.33 mSv/yr respectively all for indoor. The possible reasons for the high values in Biochemistry laboratory could be either as a result of high concentration of Radon gas in air within the laboratory or higher activity levels in the radio – nuclides in the building materials (e.g. soil, blocks and tiles) used in the construction of the laboratory (UNSCEAR, 1998). Also, the present of UV-Spectrophotometer in this laboratory can emit ionizing radiation at high energy. This could also be a reason for high values. The high value recorded in the old Biology laboratory might be due to foundation rocks beneath the laboratory which could contain some active radio – nuclides and some radio – nuclides in the building materials. The annual equivalent dose rate value of 1.98±0.19 mSv/yr recorded in Old Physics laboratory could be due to the same reasons as that of old Biology laboratory because of they are close to each other. AC18 (Lecture Hall 3 & 4) which has the lowest value of 0.85±0.22 mSv/yr equivalent dose rate might be due to low activity from the foundation rocks used in building and proper ventilation of the place as it can be seen that most of its windows are broken thereby leaving no accumulation of radon gas inside the building. The outdoor annual equivalent dose rate presented from Table 1, ranges from 0.23±0.03 mSv/yr to 0.46±0.10 mSv/yr with an overall average of 0.32±0.07 mSv/yr. As can be seen from Figure 2, AC1 (New Physics laboratory) has the highest value of equivalent dose rate of 0.46±0.10 mSv/yr while AC33 (recreational building) has the lowest value of 0.23±0.03 mSv/yr. The average outdoor equivalent dose rate value is low compared to 2.4 mSv/yr limit set by the ICRP (1990) for the worldwide average dose rate for human being.

The Pearson's correlation coefficient *r* between the indoor and outdoor annual equivalent dose rate for different lecture venues was computed in other to determine the nature of the relationship between the indoor and outdoor ambient radiation level. The correlation coefficient of +0.261 was obtained which indicates a weak relationship in the variation between the indoor and outdoor background radiation levels. The physical implication of this is that the radiation sources outside these lecture venues are largely not responsible for the indoor radiation levels and vice-versa. The summary of the results obtained from the measurement of the ambient radiation levels in the different offices and office facilities at the take-off site of FUDMA are displayed in Tables 3 and Figure 2.

Table 3: Summary of Indoor and Outdoor Ambient Radiation in $\mu Sv/hr$ and mSv/yr of Offices

Area Code	Mean Y($\mu Sv/hr$)	Mean Z($\mu Sv/hr$)	IAEDR (mSv/yr)	OAEDR (mSv/yr)
AC8	0.180±0.03	0.202±0.06	1.26±0.22	0.35±0.10
AC9	0.180±0.02	0.214±0.04	1.26±0.17	0.37±0.08
AC10	0.212±0.04	0.202±0.04	1.49±25	0.35±0.06
AC11	0.192±0.04	0.204±0.04	1.35±27	0.36±0.07
AC12	0.196±0.06	0.236±0.05	1.37±0.43	0.41±0.08
AC13	0.148±0.04	0.182±0.05	1.04±0.31	0.32±0.09
AC14	0.186±0.03	0.208±0.06	1.30±21	0.36±0.11
AC15	0.148±0.06	0.186±0.06	1.04±0.40	0.33±0.10
AC16	0.192±0.06	0.194±0.01	1.35±0.42	0.34±0.02
AC24	0.232±0.05	0.226±0.02	1.63±0.34	0.40±0.03
AC26	0.208±0.02	0.204±0.05	1.46±0.16	0.36±0.08
AC27	0.230±0.06	0.208±0.01	1.61±0.39	0.36±0.16
AC28	0.230±0.04	0.162±0.05	1.61±0.22	0.28±0.10
AC29	0.192±0.04	0.156±0.04	1.35±0.24	0.27±0.06
AC30	0.182±0.04	0.162±0.05	1.28±0.32	0.28±0.10
AC34	0.230±0.05	0.178±0.05	1.61±0.20	0.31±0.08
AC35	0.180±0.02	0.218±0.04	1.26±0.14	0.38±0.07
Mean	0.195±0.04	0.197±0.05	1.37±0.27	0.34±0.08

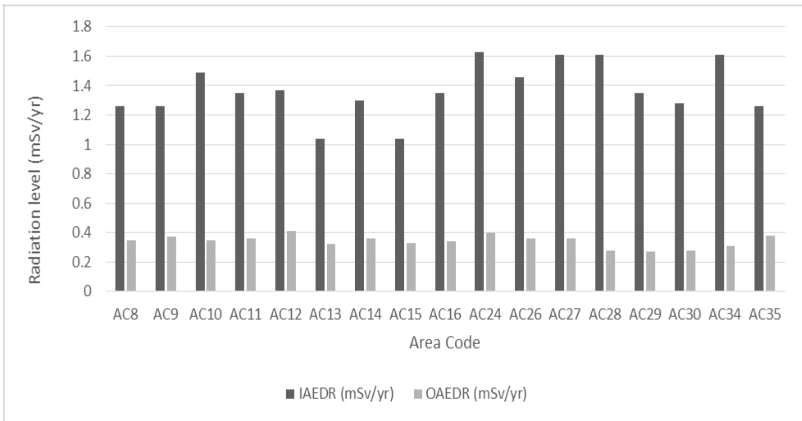

Figure 2: Comparison chart representation of indoor and outdoor ambient radiation levels in the different blocks of offices

From Table 3, the indoor and outdoor annual equivalent dose rate from offices was presented. The range of the indoor annual equivalent dose rate as presented is from 1.04±0.31 mSv/yr to 1.63±0.34 mSv/yr with an overall average of 1.37±0.27 mSv/yr. AC24 (Senate Building) recorded the highest indoor annual equivalent dose rate of 1.63±0.34 mSv/yr as presented in Figure 2, while AC13 (Block B) and AC15 (Block D) recorded the lowest values of 1.04±0.31 mSv/yr and 1.04±0.40 mSv/yr respectively. The high value recorded from Senate building could be due to activity from concentration of radon gas inside the building, higher activity of radio – nuclides present in the building materials used in construction and foundation granite rocks on which the building is standing on top. Similar reasons could also be attributed to relatively high values 1.46±0.16 mSv/yr and 1.61±0.39 mSv/yr gotten from tetfund Block of offices 2013 A and B respectively as they are closely together. The school clinic has a value of 1.61±0.22 mSv/yr possibly due to reasons not far from those in the senate building and possibly medical activities of the clinic. Blocks B and C recorded low values possibly because of proper ventilation leading to less accumulation of radon gas inside the buildings.

The outdoor annual equivalent dose rate presented from Table 2 ranges from 0.27±0.06 mSv/yr to 0.41±0.08 mSv/yr with an overall average of 0.34±0.08 mSv/yr. The combined chart of figure 2 showed that the highest value of annual equivalent dose rate 0.41±0.08 mSv/yr was recorded in AC12 (Block A) and lowest value of 0.27±0.06 mSv/yr was recorded in AC29 (Works Department). All the values obtained from all these places monitored were low compare to 2.4 mSv/yr limit set by the ICRP (1990) for human being protection against ionizing radiation. The combined chart presented in Figure 2 revealed that radiation is more concentrated inside than outside the building. The Pearson's correlation coefficient *r* used to determine the nature of the relationship between the indoor and outdoor ambient radiation also indicated almost no relationship in the variation between the indoor and outdoor background radiation levels with the correlation coefficient value of 0.0675. The physical implication being that the radiation sources outside the buildings are not responsible for the indoor radiation levels and vice-versa.

Table 4: Summary of Ambient Radiation in $\mu Sv/hr$ and mSv/yr of Road Pavement and Outdoor Sport Facilities.

Area Code	Location	Mean Z(μSv/hr)	OAEDR (mSv/yr)
AC37	Football Pitch	0.203±0.04	0.29±0.07
AC38	Handball Court	0.158±0.04	0.28±0.07
AC39	Basketball Court	0.208±0.04	0.36±0.07
AC40	Lawn Tennis Court	0.166±0.04	0.29±0.06
AC41	Volleyball Court	0.178±0.04	0.31±0.07
AC42	Badminton Court	0.218±0.03	0.38±0.06
AC43	Main gate road pavement	0.238±0.05	0.42±0.09
AC44	Exit road pavement	0.202±0.06	0.35±0.10
AC45	Science Laboratory complex road pavement	0.212±0.04	0.37±0.07
AC46	New ICT Complex road pavement	0.172±0.06	0.30±0.10
AC47	School Clinic road pavement	0.196±0.04	0.34±0.07
AC48	Road pavement to Sport Field	0.210±0.03	0.37±0.06
	Mean	0.136±0.03	0.24±0.05

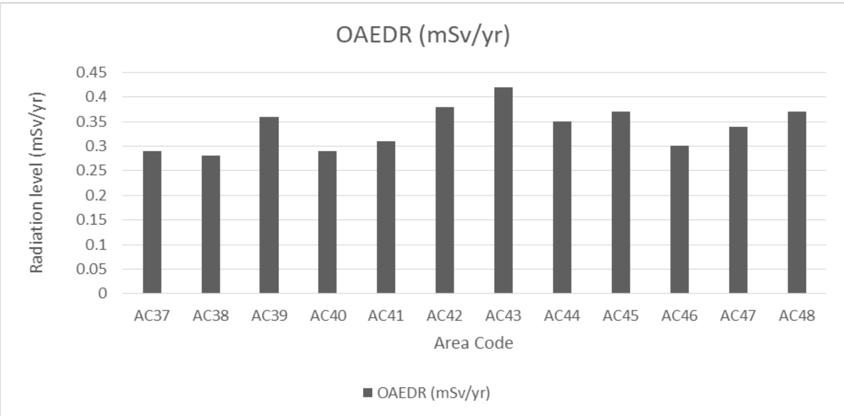

Figure 3: Outdoor ambient radiation levels at different outdoor facilities

From Table 3 and Figure 3, the outdoor annual equivalent dose rate ranges from 0.28±0.07 mSv/yr to 0.42±0.09 mSv/yr with an overall average of 0.24±0.05 mSv/yr. The highest value was recorded along AC43 (Main gate road pavement) with a value of 0.42±0.09 mSv/yr while the lowest was recorded in AC38 (Handball Court) with a value of 0.24±0.05 mSv/yr. All the values obtained in all these places monitored were very low compare to the 2.4 mSv/yr limit set by the ICRP (1990) for human being protection against ionizing radiation.

Conclusion

In this work the results of the indoor and outdoor annual equivalent dose rates from lecture venues, block of offices and also the outdoor annual equivalent dose rates from open structures of Federal University Dutsin-Ma take off Campus were measured. The overall mean Indoor Annual Effective Dose Rate (IAEDR) of 1.41±0.31 mSv/yr (0.212±0.04 mSv/hr) was recorded (i.e. for indoor facilities such as lecture halls, laboratories, office) while the overall mean Outdoor Annual Effective Dose Rate (IAEDR) of 0.33±0.08 mSv/yr (0.227±0.03 mSv/hr) was also recorded (i.e. for outside buildings, road pavements and outdoor sports facilities). It is worthy to note that all the ambient radiation recorded for all the outdoor facilities fall way below the recommended limit of 1.0 mSv/yr set by the International Commission on Radiation Protection (ICRP) in 1990 while the background radiation for the indoor facilities falls below the worldwide value of 2.4 mSv/yr average equivalent dose limit set for ionizing radiation by the United Nation Scientific Committee on the Effects of Atomic Radiations (UNSCEAR) in 2000. Thus, the ambient radiation levels in the take-off campus of Federal University Dutsin-Ma are within the safety limit and hence, there are no health risks from harmful radiation exposure in the location.

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