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Research Article

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Assessment of the Outdoor Ambient Radiation Levels at the Basic Schools in Dutsin-Ma Local Government Area, Katsina State

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Abstract Ionizing radiation when absorbed at higher doses poses health challenges to humans, leading to certain ailments like tumors, organ and tissue damage, sterility/infertility, genetic mutation, etc. This research was intended to measure and assess the outdoor ambient radiation levels in all the basic schools in Dutsin-Ma using Radiation Meter (Inspector Alert) for protection of the people. The study findings revealed that Mariamoh Ajiri Memorial School Dutsin-Ma and Gago Primary School were found to have the highest mean effective dose rate values of 0.359 mSv/yr and 0.461mSv/yr respectively while Government day senior secondary school "D" and Tashar-Mangwaro Primary School had shown the lowest annual effective dose rates of 0.256 and 0.175mSv/yr respectively. The overall average of the outdoor equivalent dose rates were computed and found to be 0.300±0.039 mSv/yr for the basic (secondary and primary) schools. These results compared favourably with recommended value set by ICRP (1990) as the worldwide average dose rate for the protection of human being as it lies within the safety limits. The radiation levels and the elevation of the secondary schools were correlated and a correlation coefficient of -0.369was obtained indicating a weak inverse proportion relationship between the variables.

Keywords Ambient Radiation, Outdoor, Basic Schools, Correlation Coefficient, Elevation

1. Introduction

In addition to the atmospheric air and its components, there exist other features that form our environment. Among these features are elementary particles known as radiation which on interaction with other particles or matter has potential to transfer energy. Radiation can be defined as any collection of elementary particles that have sufficient energy to interact with and transfer some of their energy to objects or materials that intercept their path [1]. It could be ionizing and non-ionizing [2]. Ionizing radiation is one that strips an electron from atom as they travel through matter [1]. Exposure to ionizing radiation for a long period of time may lead to tissue reaction, mutation and increasing the threat of malignancy [3]. Natural sources of radiation include; terrestrial and cosmic radiation while artificial source include consumer products such as building materials, X-ray machines, electronics etc. Terrestrial radiation is radiation from naturally occurring radionuclides in the soil, which include K-40, Th-232, U-238, Rb-87, U-235 and their descendants while cosmic radiation consists of fast moving particles that exist in space and originate from a variety of sources, including the sun and other celestial events in the universe. Air often contain radon (222Rn) gas a member of the series of radioactive disintegration of Uranium-238 [4] which is accumulated and increase the level of exposure to background radiation. After emission from the rocks or soil, radon goes to the air and significantly influence the outdoor background radiation. For the protection of human beings and other living organisms, the International Commission on Radiation Protection (ICRP) in 1990 [5] and UNSCEAR, 2000 [6] set a worldwide annual equivalent dose rate limits of exposure to ionizing radiation to be 2.4 and 1.0 mSv/yr for indoor and outdoor facilities respectively.

Measurement of the outdoor radiation levels in Abeakuta, Nigeria using Thermoluminescent Dosimetry and reported that the equivalent dose due to outdoor exposure in the city ranged from 0.19 to 1.64 mSv/yr and a mean of 0.45mSv/yr and the mean dose of extra-terrestrial radiation was estimated to be 0.18mSv/yr in the city [7]. In a work to assess the indoor and outdoor background radiation levels in Nasarawa State University, Keffi, Sadiq *et al.* [8] reported that the mean outdoor radiation levels at the University was in the range of 0.25 mSv/yr respectively, which were in good approximation with the internationally approved annual dose limits for members of the public(1.0 mSv/yr). Similarly, Termizi *et al*, [9], carried out an in situ assessment of the indoor and outdoor background radiaon in Akwanga and Keffi towns of Nasarawa state Nigeria using a new factory calibrated Inspector Alert Nuclear radiation meter (SN: 35440), by SE international. Their results revealed that the radiation levels are lower than the UNSCEAR limit with the mean effective dose equivalents less than the 2.4 mSv annual effective dose for areas of the normal background. These indicate that the natural background radiation levels in the two cities does not pose any significant health risk to the inhabitants and they concluded that the radiation levels are within the regulatory limits. Masok *et al.* [10] assessed the background ionizing radiation at the Science laboratories at Plateau State University, using a gamma-scout which was adjusted to detect the alpha, beta and gamma radiation. Their results showed that the mean equivalent dose rate per hour for the outdoor was 0.249. The mean annual equivalent dose rate of the laboratories were then computed for outdoor background radiation level and was found to be 0.44, and is below the world wide average dose of 1.0mSv/yr. The outdoor activities of individuals add up to approximately 5 to 6 hours a day [11]. Belay *et al [*12], investigated the radiation levels in buildings on the main campus of Haramaya University and at the towns of Harar and Dire Dawa, eastern Ethiopia using electronic personal Dosimeter (EPD). The results they obtained showed dependence of background radiation on height and supported the fact that background radiation depends on cosmic radiation which varies with altitude (the height from the ground level). It was assessed that the ambient background radiation levels of Federal University Dutsin-Ma Take-Off campus using Radiation Alert Inspector and their result showed that the mean outdoor annual equivalent dose of the background radiation in the school ranges from 0.23±0.03 to 0.46±0.10 mSv/yr with an overall average of 0.32±0.07 mSv/yr. They concluded that the ambient radiation levels in the take-off campus of the Federal University Dutsin-Ma are within the safety limit. Baraya, Sani, & Alhassan [13] assessed the Indoor and Outdoor background radiation of School of Technology, KanoState Polytechnic using Digital Radiation Meter. The research shows that the values of the mean indoor and outdoor annual equivalent dose rates are less than the world wide set limit.

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 find out the level and amount of radiation people are being exposed to and to give proper recommendations. However, our basic schools have not been included in these fact findings. It is therefore necessary to know the level of radiation within the basic (Primary and Secondary) schools so as to be informed of the health risk if any exists. Dutsin-Ma Local Government Area is a basement and there exist variations in the designs of these schools, ranges from congestions of buildings, quality of building material and proximity of their location to some natural sources of ionizing radiation. The level of ionizing radiation have been reported in this work using radiation meter and the correlation between such radiation levels and the altitude of the area have also been analyzed for upper basic schools.

2. Materials and Method

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.

The digital radiation meter measures background radiation using a halogen-quenched Geiger-Muller counter detector tube (Inspector alert operation manual).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 [14].

Plate 1: (a) the Inspector Alert (b) the GPS

2.1. The Study Area and Sampled Schools

Plate 2: Map of Katsina State showing Dutsin-Ma Local Government

Dutsin-Ma Local Government Area of Katsina State lies between latitude $12^0 17.00$N' to $12^0 17.84$'N and longitude $007^0 26$'E. It is bounded by Kurfi and Charanchi L.G.A to the North, Kankia L.G.A to the East, Safana and Dan-Musa L.G.A to the West, and Matazu L.G.A to the South-East [15]. Dutsin-Ma L.G.A has a land size of about 552.323km^2, elevation of 605 m (1,985 ft) with a population of about 169,829 as at 2006 national population census with the people being predominantly farmers, cattle rearers and traders [16]. Table 1 and 2 show the key to the coding of the sampled secondary and the primary schools in this research.

2.2. Method of Data collection and Analysis

The list of the secondary and the primary schools in Dutsin-Ma local government were collected from the Zonal Education Quality Assurance and Local Government Education Authority offices, Dutsin-Ma and coded from SC1 to SC24 and PR1 to PR50 as shown in the tables 1 and 2.

The outdoor background radiation of the schools were measured 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 most of the schools, a minimum of thirty one (31) readings were taken outdoors in different locations within the school premises in order to capture the radiation well and cater for errors. The coordinates of the geographical location were taken with the use of the 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 **(**μSv/hr**)** and then finally converted to micro-Sievert per year (μSv/yr). The occupancy factor for outdoor is 0.2 as recommended by UNSCEAR (2000) [6]. The occupancy factor (OF) indicates the proportion of the total time during which an individual is exposed to a radiation field. The number of hours in the year were calculated based on 24 hours a day and multiplied by 365 days in a year to have eight thousand seven hundred and sixty hours per year (8760hr/yr). Conversion of the equivalent dose rate is as presented in the equations 1 and 2 below (UNSCEAR, 1988):

$$\mathrm{X}\ (\mu\mathrm{Sv/hr}) = \mathrm{Y}\ (\mathrm{mR/hr}) \times 10 \quad (1)$$

$$\mathrm{Outdoor\ (OAEDR)\ X\ (mSv/yr)} = \mathrm{Z}\ (\mu\mathrm{Sv/hr}) \times 8760\ (\mathrm{hr/yr}) \times 0.2 \times 0.001 \quad (2)$$

$$\sigma = \sqrt{\frac{\sum(x-\bar{x})^2}{N}} \quad (3)$$

Equation (1) converts radiation in milliRöentgen per hour to micro – Sievert per hour, equation (2) converts the outdoor equivalent dose from micro – Sievert per hour to milliSievert per year. X is the reading displayed directly from the radiation meter and Z is the converted outdoor meter's readings to micro-Sievert per hour while OAEDR is the Outdoor Annual Effective Dose Rates for the different places.

The standard deviation of the data is calculated using equation 3 to take into account the degree of dispersion of the data sets for more accuracy.

The Linear correlation coefficient γ, which measures the strength and the direction of a linear relationship between two variables, was calculated using The Pearson product moment correlation coefficient given by equation 4 [17] to ascertain the relationship between the ambient radiation levels and elevation; that is to ascertain whether the cosmic radiation (a natural source of radiation) which varies with altitude is responsible for the ambient radiation detected outdoors.

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

A positive γ value implies direct proportionality (increasing trend) while a negative γ value indicates an inverse proportionality. Aγ value above 0.5 implies a strong relationship while aγ 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) [17].

3. Results and Discussion

The Average results and bar charts obtained from the measurement of the outdoor ambient radiation levels at the twenty four (24) secondary schools and fifty (50) government primary schools in Dutsin-Ma local government area are displayed in Table 1, Figure 1 and Table 2, Figure 3 respectively.

The Pearson's correlation coefficient γ, between the outdoor annual equivalent dose rates for different secondary schools and their corresponding elevations was computed in order to determine the nature of the relationship between them. The correlation coefficient of -0.369 was obtained which indicates an inverse proportion relationship between the variables. The relationship between the two variables is displayed in the scatter diagram (figure 2) below.

Table 1: Summary of the Outdoor Ambient Radiation Levels in mR/hr, μSv/hr and mSv/yr for the secondary schools

Name of School	Geographical Location	Elevation (m)	School Code	OAEDR (mSv/yr)
Jamu International College Dutsin-Ma	N12˚27.744'E007˚29.717'	529	SC1	0.321±0.063
MariamohAjiri Memorial International School	N12˚27.646' E007˚28.94'	491	SC2	0.359±0.068
Damy Preparatory School Dutsin-Ma	N12˚28.1' E007˚29.405'	543	SC3	0.326±0.039
Community College of Arabic And Islamic studies	N12˚27.637' E007˚29.73'	510	SC4	0.315±0.060
Shema Community College of Arabic And Islamic studies	N12˚27.926' E007˚31.421'	510	SC5	0.275±0.060
Community Day Secondary School Dutsin-Ma	N12˚27.879' E007˚31.002'	535	SC6	0.277±0.049
Government Girls Arabic Senior Secondary School	N12˚27.647' E007˚30.357'	529	SC7	0.319±0.058
Government Girls Arabic Junior Secondary School	N12˚27.647' E007˚30.357'	529	SC8	0.298±0.072
Government Girls Senior Secondary School	N12˚27.602' E007˚30.375'	529	SC9	0.305±0.058
Government Girls Junior Secondary School	N12˚27.602' E007˚30.375'	529	SC10	0.289±0.053
Government Girls Junior Secondary School Shema	N12˚30.73' E007˚32.25'	568	SC11	0.329±0.072
Government Senior Secondary School Karofi	N12˚28.985' E007˚35.047'	579	SC12	0.270±0.046
Government Junior Secondary School Karofi	N12˚29.02' E007˚35.054'	572	SC13	0.296±0.054
Government Senior Secondary School Kuki	N12˚24.818' E007˚35.745'	575	SC14	0.308±0.051
Government Senior Secondary School Bagagadi	N12˚28.356' E007˚37.568'	510	SC15	0.307±0.067
Government Pilot Senior Secondary School	N12˚26.301' E007˚28.643'	527	SC16	0.321±0.068
Government Pilot Junior Secondary School	N12˚26.301' E007˚28.643'	527	SC17	0.310±0.056
Government Science Secondary School Dutsin-Ma	N12˚26.138' E007˚28.395'	520	SC18	0.319±0.063
Isa Kaita College demonstration School	N12˚26.01' E007˚29.159'	532	SC19	0.307±0.070
Zunnurain	N12˚25.96' E007˚28.59'	522	SC20	0.329±0.040
Government Senior Secondary School Dabawa	N12˚31.531' E007˚28.976'	534	SC21	0.305±0.049
Government Senior Secondary School Darawa	N12˚28.942' E007˚29.279'	543	SC22	0.256±0.046
Government Junior Secondary School Darawa	N12˚28.942' E007˚29.279'	543	SC23	0.261±0.039
Government Day Secondary School Makera	N12˚19.082' E007˚27.588'	516	SC24	0.322±0.075
Mean		0.305±0.057		

Table 4: Summary of the Outdoor Ambient Radiation Levels in mSv/yr for the primary schools

Name of Primary School	**Geographical Location**	**School Code**	**OAEDR (mSv/yr)**
Yarima Primary School	N12^{0}26.778'E007^{0}29.716'	PR1	0.274±0.008
Yandaka Primary School	N12^{0}27.005'E007^{0}29.711'	PR2	0.345±0.033
Sheik MuhdAbubakar Gumi	N12^{0}27.386'E007^{0}29.305'	PR3	0.403±0.038
Zubairu Pilot Primary School	N12^{0}27.526'E007^{0}29.379'	PR4	0.274±0.017
Na-Alhaji Primary School	N12^{0}27.521'E007^{0}30.438'	PR5	0.315±0.025
Maitsani Primary School	N12^{0}28.755'E007^{0}26.779'	PR6	0.321±0.022
Gammo Primary School	N12^{0}28.264'E007^{0}28.099'	PR7	0.245±0.025
Darawa Primary School	N12^{0}28.658'E007^{0}29.453'	PR8	0.385±0.014
Dabawa Primary School	N12^{0}31.805'E007^{0}29.015'	PR9	0.397±0.022
Gamzoka Primary School	N12^{0}31.555'E007^{0}28.272'	PR10	0.181±0.017
Fasadda Primary School	N12^{0}31.787'E007^{0}30.305'	PR11	0.339±0.041
Shema Primary School	N12^{0}31.676'E007^{0}32.003'	PR12	0.310±0.008
Yarwashe Primary School	N12^{0}32.728'E007^{0}32.043'	PR13	0.304±0.017
Muri Primary School	N12^{0}29.668'E007^{0}32.466'	PR14	0.391±0.022
Gizawa Primary School	N12^{0}28.361'E007^{0}31.495'	PR15	0.368±0.038
Kofa Primary School	N12^{0}27.834'E007^{0}30.932'	PR16	0.397±0.030
kwimi Primary School	N12^{0}28.743'E007^{0}30.350'	PR17	0.298±0.025
Gago Primary School	N12^{0}25.066'E007^{0}29.480'	PR18	0.461±0.060
Tabobi Primary School	N12^{0}24.005'E007^{0}30.325'	PR19	0.391±0.079
Dagelawal Primary School	N12^{0}24.667'E007^{0}31.507'	PR20	0.257±0.022
Daguda Primary School	N12^{0}23.429'E007^{0}31.480'	PR21	0.263±0.025
Shantalawa Primary School	N12^{0}25.847'E007^{0}31.517'	PR22	0.292±0.008
Wakaji Primary School	N12^{0}26.087'E007^{0}30.722'	PR23	0.257±0.030
Sada Primary School	N12^{0}27.096'E007^{0}30.346'	PR24	0.292±0.008
faguwa Primary School	N12^{0}29.185'E007^{0}33.327'	PR25	0.239±0.022
Karofi Model Primary School	N12^{0}29.439'E007^{0}35.167'	PR26	0.263±0.025
Ribi Primary School	N12^{0}29.085'E007^{0}35.682'	PR27	0.234±0.008
Mukaddas Primary School	N12^{0}29.558'E007^{0}36.742'	PR28	0.257±0.017
Bagagadi Primary School	N12^{0}28.053'E007^{0}37.568'	PR29	0.274±0.030
Yalwa Primary School	N12^{0}28.900'E007^{0}37.935'	PR30	0.251±0.030
Kuki Primary School	N12^{0}24.546'E007^{0}36.091'	PR31	0.245±0.014
Kwatangiri Primary School	N12^{0}25.547'E007^{0}36.370'	PR32	0.269±0.030
Kundu Primary School	N12^{0}25.332'E007^{0}35.289'	PR33	0.333±0.025
Dantakiri	N12^{0}22.327'E007^{0}35.420'	PR34	0.234±0.008
Fan'amale Primary School	N12^{0}21.803'E007^{0}36.155'	PR35	0.222±0.008
Gandi Primary School	N12^{0}22.411'E007^{0}33.917'	PR36	0.210±0.014
Makwanta Primary School	N12^{0}23.368'E007^{0}32.586'	PR37	0.286±0.058
Kagara Primary School	N12^{0}25.473'E007^{0}27.601'	PR38	0.257±0.030
sabongarinsafana Primary School	N12^{0}25.033'E007^{0}25.781'	PR39	0.257±0.033
Badole Primary School	N12^{0}23.723'E007^{0}26.858'	PR40	0.216±0.044
Garhi Primary School	N12^{0}22.564'E007^{0}27.703'	PR41	0.304±0.033
makera Primary School	N12^{0}20.813'E007^{0}29.826'	PR42	0.210±0.038
Makera Nomadic Primary School	N12^{0}20.163'E007^{0}29.401'	PR43	0.333±0.066
UnguwarZakara Primary School	N12^{0}29.411'E007^{0}29.110'	PR44	0.269±0.030
SabonGariZobe Dam Primary School	N12^{0}19.378'E007^{0}28.083'	PR45	0.315±0.025
Buturkai Primary School	N12^{0}20.838'E007^{0}25.894'	PR46	0.263±0.038
Tashar-Mangwaro Primary School	N12^{0}19.764'E007^{0}25.394'	PR47	0.175±0.038
DogonRuwa Primary School	N12^{0}19.460'E007^{0}23.608'	PR48	0.245±0.038
Kurechin Fulani Primary School	N12^{0}19.149'E007^{0}22.649'	PR49	0.274±0.030
Sanawa Primary School	N12^{0}17.369'E007^{0}25.609'	PR50	0.199±0.008
Mean		**0.288±0.023**	

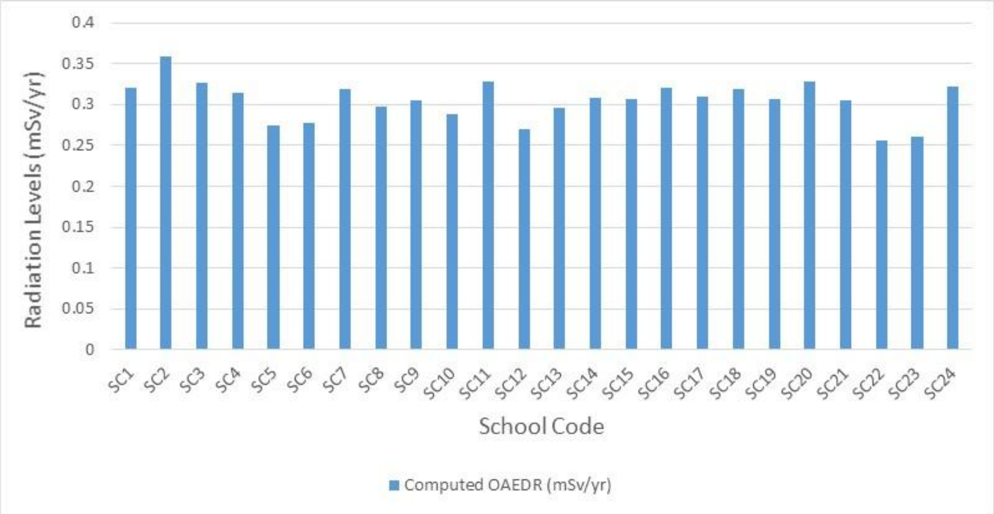

Figure 1: The computed outdoor annual equivalent dose rates for the secondary schools

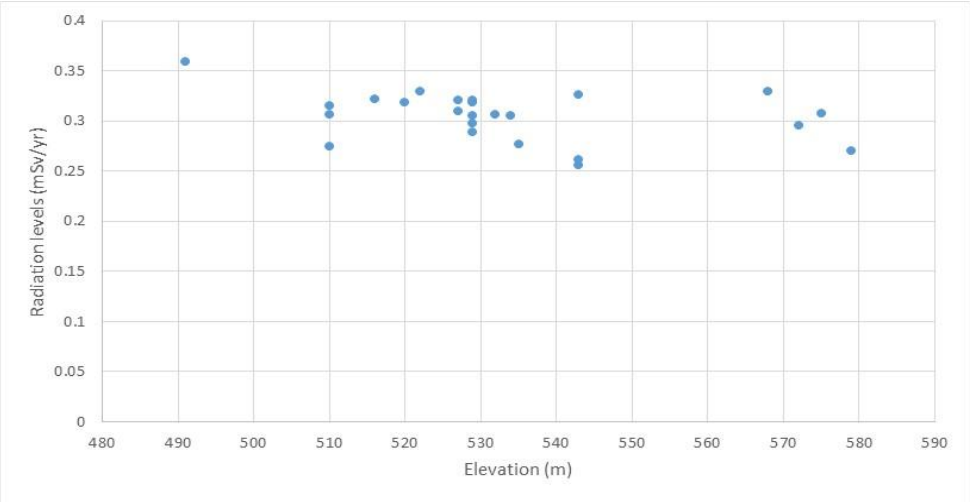

Figure 2: Scatter Diagram of the computed OAEDR and the elevation for the secondary schools

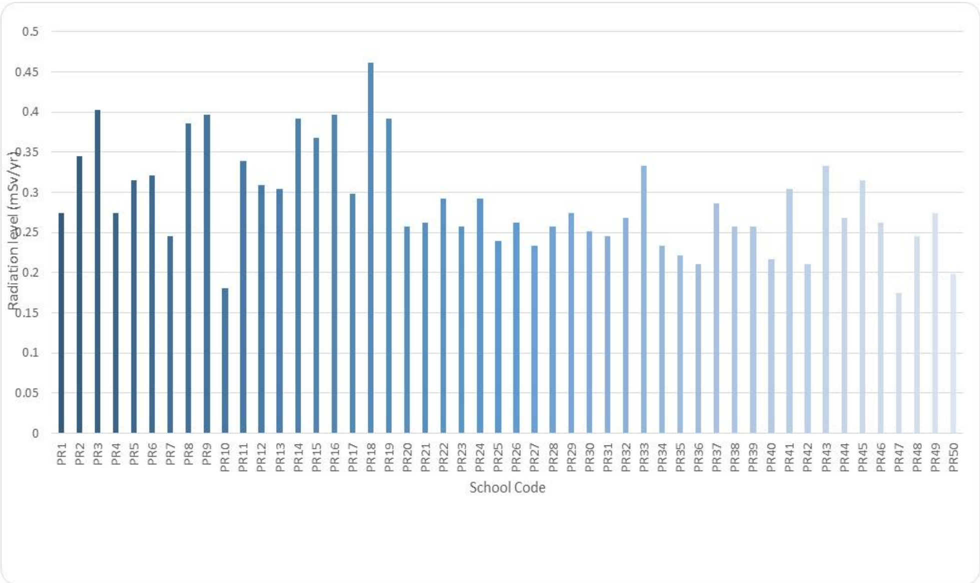

Figure 3: The computed outdoor annual equivalent dose rates for the secondary school

Table 1 presents the results of the outdoor annual equivalent dose rate from secondary schools. The mean annual equivalent dose rate ranges from 0.256±0.046mSv/yr to 0.359±0.068mSv/yr with an overall average of 0.305±0.057mSv/yr, while Table 2 presents the results of the outdoor annual equivalent dose rate from primary schools. The mean annual equivalent dose rate ranges from 0.175±0.038mSv/yr to 0.461±0.060mSv/yr with an overall average of 0.288±0.023mSv/yr.

It could be deduced from figure 1 that SC2 has the highest value of 3.59 mSv/yr. This is as a result higher activity levels of radio – nuclides in the building materials (e.g. soil, blocks and cement) used in the construction of the ground floor and other structures of the school as it can be seen that the classrooms, laboratories, administrative and other blocks such as library are built in one place and the school is under construction. SC22 has the lowest value of 0.256mSv/yr which might be due to low activity from the Soil, School farms and proper ventilation within the school premises as observed during taking data that the buildings in the school are well spaced. Figure 3 revealed PR18 has the highest ambient radiation of 0.461±0.060mSv/yr while the overall lowest of 0.175±0.038mSv/yr was obtained PR47.

As shown in Fig. 2 above, the relationship between the computed OAEDR and the elevation of the secondary schools is inverse proportion in nature. But the relationship is not perfect since higher altitude does not always result in higher value of the OAEDR as could be observed in the figure. The physical implication of this is that the altitude does not significantly affect the radiation levels in the schools.

4. Conclusion

In this work the results of the outdoor annual equivalent dose rates from all the secondary and government primary schools in Dutsin-Ma were measured. The overall mean Outdoor Annual Effective Dose Rate (OAEDR) of 0.300±0.039 mSv/yr was recorded. It is admirable to note that all the ambient radiation recorded for all the outdoor facilities fall way below the recommended limit of 1.0mSv/yr set by the International Commission on Radiation Protection (ICRP) in 1990.

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