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In-Situ Measurement of Soil and Rock Background Ionization Radiation at Edwin Clark University and Its Environs, South-South, Nigeria

Rufus Chigozie Nwankwo[1], Gregory Onomakere Avwiri[2]

[1]Department of Physical Sciences, Faculty of Science, Edwin Clark University, Kiagbodo, Nigeria

[2]Department of Physics, Faculty of Science, University of Port Harcourt, Port Harcourt, Nigeria

Email address

nwankwo_c_rufus@yahoo.com (R. C. Nwankwo), gregory.avwiri@uniport.edu.ng (G. O. Avwiri)

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Abstract

In this study, the levels of ionizing radiation in the soil/rock were measured in-situ at the Edwin Clark University (ECU), Kiagbodo, Delta State, South-south Nigeria and its environs. Radiation is useful in many respects but it also associated with several health risks to man. People all over the world are daily exposed to radiations of different types – both ionizing and non-ionizing radiations- which are ingested or absorbed into the human body in varying concentrations or intensities through different sources. Ingested or absorbed radiations have been reported as the cause of major health problems such as cancer, damage to the genes, bones, blood cells and different body tissues, which ultimately can result in death. These radiations are emitted from various sources, but environmental radiation is particularly connected with terrestrial and cosmic sources. In Nigeria, not much attention has been paid to irradiation within buildings (known as indoor background radiation), although studies have revealed the presence of hazardous ionizing radiations within buildings. It has been established that continuous exposure to nuclear radiation even at low dose rates within a building can cause genetic damage in human beings. In addition, exposure above permissible levels to radiation within the environment or outside buildings (known as outdoor background radiation) has similar genetic effect that can result in cancer. In this study, Indoor and outdoor soil and rock ionizing radiation levels in the Edwin Clark University environment have been measured. A Radiation monitor (Radalert 100) and ETREX Germin GPS were used for the measurement. A total of 40 points (20 outdoor and 20 indoor) were surveyed across the university for soil and geologic contribution to background environmental radiation. Our results depict the outdoor rate of radiation exposure to vary between 0.106 μSv/h and 0.199 μSv/h, while for the indoor measurement, the least exposure rate is 0.106 μSv/h while a peak exposure rate 0.199 μSv/h was obtained. The results also reveal the average exposure rates within and outside the buildings for all points studied to lie between 0.14675 μSv/h and 0.130197 μSv/h respectively. These radiation levels, however, do not exceed the safety exposure threshold of 1.0×10^{-3}Sv per annum in line with the recommendations of world's radiation regulatory agencies for populations not engaged in occupations that lead to radiation exposure. The levels of ionizing radiation measured in the study area were found to be due to the prevailing geology (the constituent rocks and soil) as the major natural source of radiation in the area, as no radiation generators exist within and around the university.

Keywords

Soil, Rock, Ionization, Radiation, Dose, Rate, Radalert

1. Introduction

Radiation is useful in many respects but it also associated with several health risks to man. People all over the world are daily exposed to radiations of different types – both ionizing and non-ionizing radiations- which are ingested or absorbed into the human body in varying concentrations or intensities through different sources. Ingested or absorbed radiations have been reported as the cause of major health problems such as cancer, damage to the genes, bones, blood cells and different body tissues, which ultimately can result in death [1, 2, 3]. Radiations from the sun, soil, rock, drinkable surface water and groundwater as well as from decay of radionuclides in the human body have been identified as means of exposure of humans to their damaging effects [4]. In Nigeria, background ionizing radiation within buildings is underestimated or not given the necessary attention whereas several studies have shown that the internal environments within buildings are characterized or affected by damaging ionizing radiation [3]. Buildings are known to irradiate the associated indoor environments as most of the materials used for their construction such as rocks, which contain mineral elements, are spontaneously radioactive. There is, therefore, need to determine the level of background ionizing radiation within buildings [5]. Studies show that if one is exposed for a long time to nuclear radiations from a building, such long periods of exposure could lead to damage of the cells and genes in the body even when such radiations are characterized by low emission rates [6]. A major concern with ionizing radiations is that they are emitted naturally from rocks and soil leading to the continuous irradiation of the environment. The irradiation of the environment is responsible for the exposure of humans to the dangerous radiations and such exposure above permissible levels can cause cell and gene mutation that leads to cancer [7, 8]. Most houses in Nigeria are built with stones and sand derived from subsurface rocks and river beds. However, it is a well established fact that the amount of radioactive substances (that can emit life-threatening radiations) domiciled in these stones and sands has not been adequately assessed and documented [9]. Although human exposure to ionizing radiation cannot be totally prevented, radiation regulatory bodies such as the World Health Organization (WHO) cautions that exposure of a person to radiation in a year must be 1 mSv or less.

The major contributor to man's exposure to ionizing radiation is the natural sources. Exposure to the natural radiations will, for as long as the earth exists, continue to occur. High-speed particles/rays that travel from cosmic bodies to the earth's surface and radiations resulting from the spontaneous decay of primordial radionuclides present in the Earth's crust are two identifiable natural sources by which humans are easily exposed to ionizing radiations.

In addition, man's industrial activities have been reported as capable of altering the amount of radiation the public can be exposed to. Anthropogenic activities such as chemical processing, manufacturing, mining, oil drilling and production add a significant amount of radioactive substances to the environment, thus increasing human exposure to the ionizing radiation. In particular, the categories of people most susceptible to the increased radiation exposure are people engaged in radiation-related occupations. These include miners, workers engaged in mineral processing, radiologists and aircraft flight crews [10, 11]. The radiation from cosmic source that reaches the earth's surface comprises much more of protons and neutrons (98%) and much less of electrons (2%) [12]. On the earth's surface, the energy of the cosmic rays, with muons as the primary entity encapsulating the rays, ranges from 1GeV to 20 GeV. About 80% of the radiation dose is absorbed or ingested from the air, and ingested cosmic energy is part of this absorbed dose. However, the impact of cosmic radiation is higher as vertical distance from the ground level increases in addition to factors such as longitude and latitude. Aircraft passengers and crews are therefore exposed to more cosmic radiation than at the ground level. Besides, radiations from the disintegration of radioisotopes embedded in the rock and soil brings about the exposure of humans to ionizing radiation within the environment. Radionuclides domiciled in the soil within 15-30 cm depth, when they decay, emit radiations that reach the earth's surface [13]. However, the major radioactive constituents of the soil include all natural radioisotopes and their associated progeny whose half-lives are comparable and close to the age of the earth. In order to protect the public against the negative health impacts of radiation especially ionizing radiation, accurate assessment of exposure rates becomes imperative. Global standards have therefore been set by world's regulatory bodies to ensure compliance with permissible exposure limits. Compliance is achievable through accurate evaluation of exposure levels in an area or locality. Therefore, information on the ionizing radiation level contributed by the soil, geology and other sources within the environment is of paramount importance.

Many studies have been carried out, as reported in the literature, to assess ionizing radiation levels and their causes in different places, mainly for the purpose of monitoring public health.

Avwiri and Ebeniro [14] measured the radiation in the environment in an industrial area in Rivers State, Nigeria and found the background ionizing radiation level to have an average value of 0.14 mRh^{-1}, which is slightly above the normal value of 0.013 mRh^{-1}.

Farai and Jibri [15] conducted a nationwide survey of radiation from the soil. They employed gamma spectrometry to carry out in-situ measurement of the radiation. The mean annual effective dose equivalent obtained within the environment was 0.27 mSv/yr.

Akinloye [16] measured the radiation exposure rates within some buildings in Ogbomoso, Nigeria and found that the indoor radiation rate ranged from 1.57 to 1.89 μRh^{-1}. These values of radiation within the buildings are not above the normal radiation level and therefore safe.

Farai and Vincent [13] in their study assessed the radiation levels in the environment within Abeokuta in Nigeria. They used the thermoluminescent dosimetry technique and found that the equivalent radiation dose resulting from exposure to the irradiated environment in the city was between 0.19 and 1.64 mSv/yr. They obtained the mean value of the equivalent dose as 0.45 mSv/yr.

Nyango [17] measured the background radiation within the University of Jos Campus environment and reported a mean equivalent dose of 2.059 mSv/yr.

Agba and Tyovenda [18] measured the background radiation in Akwanga, Nigeria. The values of the indoor radiation they obtained were between 1.04 and 1.75 mSv/yr and the values of the outdoor radiation lied between 0.24 and 0.44 mSv/yr. They obtained the indoor annual average equivalent radiation dose within the city as 1.29±0.13 mSv/yr and the outdoor annual average equivalent radiation dose within the city as 0.31±0.14 mSv/yr.

Agbalagba and Meindinyo [19] studied the effect of oil spillage in terms of the level of radiation it can cause in a spilled area. The study was carried out in Ughelli, Delta State, Nigeria. Using a radiation meter and a geographical positioning system (GPS), they obtained the measured values of the mean radiation which lied between 0.010 mRh^{-1} equivalent to 0.532 mSv/y and 0.019 mRh^{-1} equivalent to 1.010 mSv/y. They showed that the annual rate of human exposure to the radiation in the spilled area was between 0.013±0.006mRh^{-1} equivalent to 0.692±0.080 mSv/y and 0.016±0.005 mRh^{-1} equivalent to 0.851±0.100 mSv/y).

Kuroda [20] asserted that the irradiation of any environment stems from two sources namely the decay of natural radionuclides in the soil and rock (that is potassium-40, thorium-232, uranium-238, radium-226, etc) and the propagation of cosmic rays in the form of massless photons to the earth. He maintained that background environmental radiation is almost the same all around the world, with radiation levels lying between 0.008 and 0.015 mRh^{-1}.

Olarinoye et al. [21] carried out their study in three institutions of learning in Minna, Niger State, Nigeria, in order to investigate the level of gamma radiation in the area. They measured the gamma radiation using a portable radiation meter. The average dose rate they obtained was 0.154 µSv/hr, while the average annual effective dose obtained was 0.189 mSv/yr. This value was found to be below the global permissible value of 1 mSv/yr for categories of people not engaged in radiation-related occupations.

Jwanbot et al. [22] measured the ionizing radiation within some science laboratory buildings in University of Jos, Nigeria. They obtained values ranging from 2.081 mSv/yr to 2.733 mSv/yr.

Omudu and Ebeniro [23] reported that natural radionuclides which include the uranium isotopes (^{234}U, ^{235}U, ^{238}U), thorium-232, potassium-40, and their progeny tend to accumulate in various concentrations in clays, shales and sandstones that contain micas, alkali feldspar, clay minerals, glauconite, or uranium-rich waters. Besides, Agbalagba et al. [1] further reported that anthropogenic industry activities such as chemical processing, manufacturing, oil drilling and production lead to accumulation of chemical wastes and contaminants on soil surface that add significantly to the soil radioactive contents and increase the background ionizing radiation.

Avwiri et al. [24] in their study revealed the cancer-effect of soil-borne radiation. They showed that the ingestion of food crops obtained from radionuclide-contaminated soil can lead to internal radiation doses which can cause cancer fatality. The estimated effective dose due to ingestion of food crops ranges from 26.82µSv/y (rice) to 283.39µSv/y banana). The radiation doses obtained in banana, yam, cassava, and plantain were higher than the reference level of 70µSv/y and some literature values. Cancer and hereditary risks were assessed from the estimated annual effective doses. Their results show that about 15 out of 1,000,000 may suffer from cancer fatality, while about 39 out of 1,000,000 may suffer hereditary effects.

Alsaffar et al. [25] report that the public can be exposed to radiation from the soil. This is because the roots of crops absorb radionuclides. Consumption of the food crops becomes the means by which the radionuclides could find their way into humans. Their results show that the Transfer Factor (TF) is an important parameter that encapsulates the effect of the physicochemical properties of soil, environmental conditions and types of radionuclides.

2. Materials and Methods

2.1. Materials

i) Radalart as the radiation detector and counter
ii) Garmin Etrex 10 GPS (Global Positioning System)

2.1.1. Radalart

The Radalart is an instrument that measures the various components of radiation and monitors personal radiation exposure. It application includes:

i) Monitoring possible radiation exposure while working with radionuclides
ii) Ensuring compliance with regulatory standards
iii) Checking for leakage from X-ray machines and other sources
iv) Providing an audible alarm if the radiation goes above a preset alert level.
v) Screening for environmental contamination or environmental sources of radioactivity
vi) Connecting to a computer or data logger to record and tabulate radiation data

Figure 1. *Showing a Radalart 100.*

2.1.2. Global Positioning System (G.P.S)

Figure 2. *Showing Garmin Etrex 10 G.P.S.*

The Global Positioning System (GPS) consists of components that are designed to organize the different measured data. The GPS information is important for generation of maps and for specifying positions and coordinates precisely. Only three satellites are used to precisely define position on the ground surface. The fourth one functions to check and validate the original information and also facilitates computation of altitude. There are three major segmented components of a GPS. These three segments function together to provide precise information on the location of a place. The three segments are (i) the *Space Satellites* which circle the earth, and transmit data with respect to precise position of a place; (ii) the *Ground Control* (Control Segment) which consists of terrestrial stations and antenna for monitoring; and (iii) *User Equipment* which is made up of a transmitting and receiving system (Figure 2).

2.1.3. The Study Area

The radiation assessment was undertaken at Edwin Clark University, Kiagbodo, Delta State, in the Niger Delta of Nigeria (Figure 3). The population of Kiagbodo (the host community of the university) has increased remarkably in the last few years as a result of the relative peace in the area and surge in economic activities in the community owing to the increasing numbers of students being admitted into the University each year. In spite of the fact that manufacturing companies which utilize radioactive materials do not yet exist in the community, the geology of the area is, however, a major contributor to the environmental radiation level in the area. Besides, the study area is characterized by wet plains that make it fertile and suitable for agricultural purposes. The Niger Delta region of Nigeria is located in the Gulf of Guinea between longitudes 5.05°E and 7.17°E and latitudes 4.15°N and 7.17°N. It has the largest mass of wetland in Africa and the third largest wetland in the world. It consists of flat swampy terrain crisscrossed by meandering streams, rivers and creeks. Within the 70,000 km^2 total wetland in Nigeria, it occupies an area covering about 20,000 km^2. The wetlands are known to have been formed primarily by sedimentary processes mainly through sediment depositions. The Niger Delta represents about 7.5% of the total land mass of Nigeria and is characterized by an annual mean rainfall lying between 2400 and 4000mm [26].

Figure 3. *Map of Kiagbodo (the Survey Area).*

2.2. Method

The study was carried out in Edwin Clark University Kiagbodo, Delta State. Radiation monitor (Radalert 100) was used to measure the background ionizing radiation and the ETREX Germin Global Position System (GPS) was used to determine the coordinates of the sample area. The instrument (Radalert) is capable of measuring gamma dose rates in the range 0-20 mR/hr. This is because of its high sensitivity. The measurement was taken for outdoor and indoor points. A total of 40 points were surveyed (20 outdoor and 20 indoor points) across Edwin Clark University for background environmental radiation. The locations include the Security Check Point, Administrative Building, Power House, Health Center, Biology Lab, Chemistry Lab, Physics Lab, Faculty of Science, Faculty of Humanities, Sociology & Management Sciences etc. The measurements of the dose rates were carried out in-situ in order to determine the ionization radiation levels from the soil and rocks within the University and its environs.

3. Results

Table 1 shows the background ionization radiation obtained for outdoor and indoor locations at Edwin Clark University and its environs with the soil, rocks and prevailing geology as the major contributor to the observed radiation levels in the area.

Table 1. *Outdoor Radiation Level.*

S/N	SAMPLED LOCATION	GEOGRAPHICAL LOCATION	DOSE RATE (µSv/hr)
1	Security Check Point	N05°22.815 E005°53.783	0.193
2	Admin Block	N05°22.803 E005°53.796	0.159
3	HSMS Lecture Hall	N05°22.789 E005°53.324	0.145
4	Science Lecture Hall	N05°22.772 E005°53.891	0.119
5	Power House	N05°22.774 E005°53.913	0.119
6	Health Center	N05°22.639 E005°53.880	0.119
7	Faculty of HSMS	N05°22.740 E005°53.864	0.166
8	Biology Laboratory	N05°22.730 E005°53.920	0.112
9	Chemistry Laboratory	N05°22.745 E005°53.923	0.117
10	Physics Laboratory	N05°22.745 E005°53.921	0.143
11	Biochemistry Laboratory	N05°22.722 E005°53.925	0.187
12	Computer Laboratory	N05°22.708 E005°53.918	0.115
13	University Auditorium	N05°22.751 E005°53.913	0.146
14	University Cafeteria	N05°22.746 E005°53.969	0.159
15	Male Hostel	N05°22.752 E005°53.972	0.159
16	University Library	N05°22.764 E005°53.946	0.186
17	University ICT	N05°22.726 E005°53.873	0.106
18	Law Faculty	N05°22.709 E005°54.014	0.133
19	Female Hostel	N05°22.646 E005°54.069	0.199
20	Staff Quarters	N05°22.545 E005°54.097	0.153
MEAN			0.14675 ± 0.029171

Table 2. *Indoor Radiation Level.*

S/N	SAMPLED LOCATION	GEOGRAPHICAL LOCATION	DOSE RATE (μSv/hr)
1	Security Check Point	N05°22.812 E005°53.774	0.153
2	Admin Block	N05°22.747 E005°53.915	0.106
3	HSMS Lecture Hall	N05°22.784 E005°53.343	0.133
4	Science Lecture Hall	N05°22.771 E005°53.894	0.126
5	Power House	N05°22.769 E005°53.916	0.190
6	Health Center	N05°22.627 E005°53.890	0.146
7	Faculty of HSMS	N05°22.753 E005°53.870	0.150
8	Biology Laboratory	N05°22.745 E005°53.921	0.112
9	Chemistry Laboratory	N05°22.748 E005°53.921	0.119
10	Physics Laboratory	N05°22.746 E005°53.923	0.159
11	Biochemistry Laboratory	N05°22.723 E005°53.927	0.199
12	Computer Laboratory	N05°22.707 E005°53.919	0.119
13	University Auditorium	N05°22.748 E005°53.918	0.138
14	University Cafeteria	N05°22.740 E005°53.970	0.133
15	Male Hostel	N05°22.597 E005°53.028	0.193
16	University Library	N05°22.712 E005°53.900	0.199
17	University ICT	N05°22.718 E005°53.859	0.139
18	Law Faculty	N05°22.711 E005°54.012	0.143
19	Female Hostel	N05°22.638 E005°54.066	0.106
20	Staff Quarters	N05°22.553 E005°54.073	0.133
MEAN			0.130197 ± 0.029746

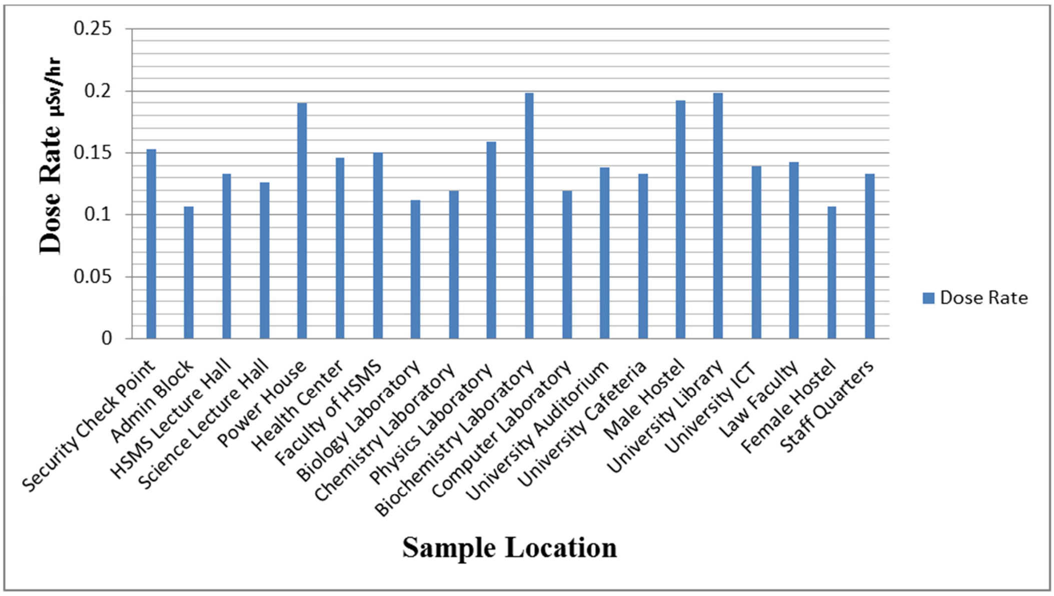

Figure 4. *Outdoor Dose Rates for the Sampled Locations.*

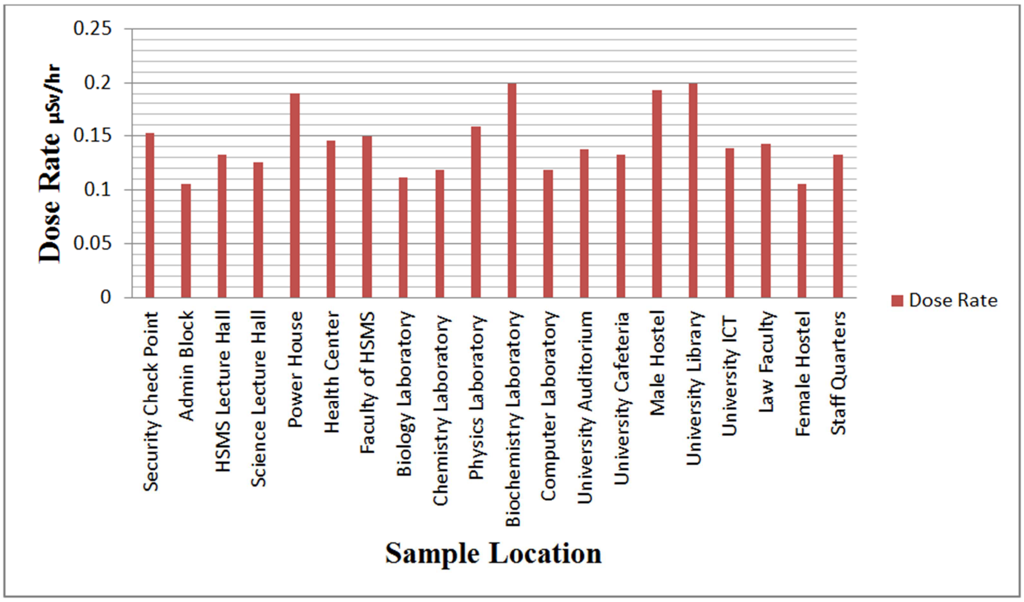

Figure 5. *Indoor Dose Rates for the Sampled Locations.*

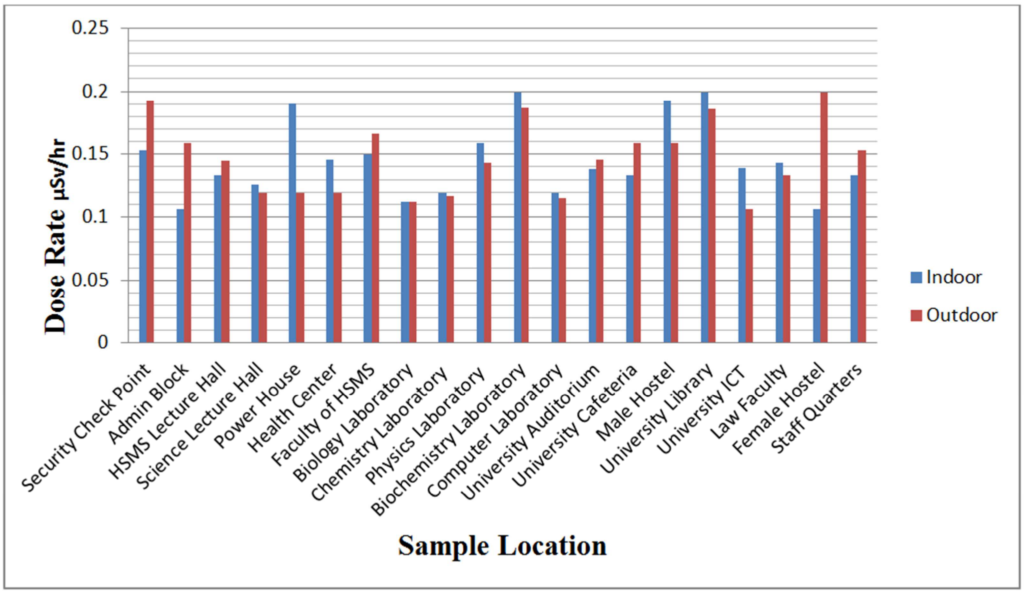

Figure 6. *Comparison of Outdoor and Indoor Dose Rates for the Sampled Locations.*

4. Discussion

The dose rate obtained at each point is presented in Tables 1 and 2. The outdoor dose rate ranges between 0.106 µSv/hr and 0.199 µSv/hr, while for the indoor measurement, the least dose rate is 0.106 µSv/hr and the maximum dose rate is 0.199 µSv/hr. Generally, the outdoor dose rates and the indoor dose rates are comparably close in their range of values, a situation attributable to the fact that the major contributors to the radiation levels in the sampled locations are the in-situ rocks, soil and prevailing geology, and no radiation generators were found to exist within and around the university. The outdoor and the indoor mean dose rates for the surveyed areas are found to be comparably close with values of 0.14675 µSv/hr and 0.130197 µSv/hr respectively, arising from the fact that the outdoor and indoor locations have similar geology. However, these dose rates have no public health consequences. According to Battle et al. [27], most radiation studies have furnished quantitative information that shows that no health risk occurs when the critical value of radiation exposure is not exceeded. The mean effective dose rates for the outdoor and indoor points studied are 0.14675 µSv/hr and 0.130197 µSv/hr. The results obtained in the study area therefore clearly show that the radiation level did not exceed the normal background level or the global permissible value of 1 mSv/yr, recommended by the International Commission on Radiological Protection (ICRP) [28]. The values are clearly below the limit value set by ICRP for the categories of the public not engaged in radiation-related occupations.

5. Conclusion

Measurement of radiation levels has been conducted at Edwin Clark University Kiagbodo. Outdoor and indoor surveys were conducted. The radiation levels measured in the study area was due to the prevailing geology as the major natural source of radiation in the area. The results also show that there is no trace of deposit of radioactive minerals around the surveyed area. The values of dose rate determined in this study have been found to be lower than the global average indoor and outdoor dose rate.

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