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Evaluation of background radiation of Maryland School complex, Lagos, Nigeria

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Abstract. The background radiation of Maryland School Complex was taken using RS-125 hand-held gamma spectrometer. The average concentration of the measured radionuclides were 19.16, 46.14, 165.00 Bq/kg for ^{238}U, ^{232}Thand ^{40}K, respectively. The average value of measured dose rate and the estimated dose rate were 44.93 and 43.55Bq/kg. The mean values of the estimated radiological parameter were 53.45, 213.78µSv/y for indoor and outdoor annual effective dose. The excess lifetime cancer risk averaged 0.17, the hazard indices were 0.26 and 0.32 for external and internal respectively. The annual gonadal dose and radium equivalent were 303.90 µSv/y and 97.85 Bq/kg, while the gamma representative index was 0.69. The mean concentration of radionuclides measured and the estimated radiological parameter were within the recommended values. This therefore follows that the risk of exposure to ionizing radiation for both the staff and the students of the community is within acceptable limits.
Keywords: Radionuclides, Dose rate, Hazard indices, Excess lifetime cancer risk, Maryland school complex

1. Introduction

One of the scientific subjects that drawn the attention of the public is human exposure to ionizing radiation.It has been observed that exposure of human population arises mostly from radiation of natural origin [1-6]. Radiation is a form of wave energy that spreads out from a source. While the non-ionizingradiationdoes not have enough energy to produce ions, the ionizing radiation has enough energy to penetrate matter and produce ionswhich can result in various radiation effects in living cells such as induction of malignancies, genetic effects, Leukemia and mental retardation in children among others [5, 7 – 11]. Exposure to ionizing radiation can occur through the natural and man-made radioactive sources. Natural source includes cosmic ray from the atmosphere, terrestrial radiation from plants, soils and rocks and by consumption of water and food andinhalation of air. Man-made sources of exposure can occur through the application of medicine such as the use of X-ray for diagnosis and treatment of diseases, the use of nuclear gauge, smoke detector in industry are potential means of exposure [8 – 11]. However, exposure to ionizing radiation comesthrough naturalradionuclides materials which account for approximately 85 % of human exposure [1 – 3]. Onumejor et al [4] monitored the background radiation of ten schools in Ota, Nigeria, and the result showed that the mean dose rates were within the permissible limit except for a particular location that required further evaluation. Environmental monitoring of the radioelement is therefore of utmost importance to avoid public over exposure to ionizing radiation. Thus, this paper is aimed at measuring the concentrations of the three primordial radionuclides in the study

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areas to assess the radiation dose exposure from the environmental sources and the health risk such exposure poses to the public.

2. Material and Method

The concentration of ^{40}K, ^{232}Th, ^{238}U and the gamma dose rates were measured in-situ using hand-held RS-125 gamma-ray spectrometer and geographical positioning system to mark the coordinates of the sampling location. The RS-125super-spec gamma-ray spectrometer is an instrument that is very reliable and efficient in determining the background radiation of a physical environment because of its adaptability in the geophysical field and ease of operation. The total count gamma ray is determined by the amount of radiation at the source, the scope of the detector, and the efficiency of the background energy of the equipment, its detection limit spanned between 0.8 MeV and 1.2 MeV and its very efficient in measuring radiation of terrestrial origin. The measurement of potassium is direct and is recorded in % while that of uranium and thorium are recorded in ppm [1-3]. The measured concentrations were changed to Bequerel per kilograms using the factors reported by [9, 12].

Sampled Location and Procedure

Thirty-five sampled points were strategically mapped out in all the seven government schools in Maryland school complex, Maryland-Ikeja, Lagos state, Nigeria. The schools consist of two senior secondary schools (MES, IMS), two junior secondary schools(MEJ, IMJ) and three primary schools(SAP, IMP, SFP) with five sampled points in each of the school. In each of the sampled point, gamma spectrometer was held at 1metre above the ground by putting the instrument at a marked point measured with a metre rule to measure the activity concentration of each of the radioelement. Five reading of the dose rate was taken at each sampled point with the mean reported, after which the assay mode reading was also taken at average time of 90 seconds for each of the five reading and the average value reported. The gamma spectrometer was switched off after taken reading in each sampling point before proceeding to the next sampled point, for the auto-stabilization of the equipment [3]. The dose rate mean value and assay mode reading were determined to reduce experimental error [12].

Radiological impact parameters

The first major step that needs to be taken in evaluating the health risk is to estimate the absorbed dose rate. This is the quantity that related directly to the biological effects, the clinical and radiological effects together[13].

Absorbed Dose

Calculating the absorbed dose rate (nGy/hr) is essential in assessing the radiological hazard. It was obtained using equation 1[14 - 19].

$$D\ (nGy/hr) = DCF_K C_K + DCF_U C_U + DCF_{Th} C_{Th} \tag{1}$$

$DCF_K C_K + DCF_U C_U + DCF_{Th} C_{Th}$are dose factors and radionuclides concentration^{40}K, ^{238}U, and ^{232}Th in the samples respectively[12, 15- 17].

Annual Effective Dose for External Exposures (AED)

The annual effective dose received by the public was obtained with equation 2 [14 - 19].

$$AED_{outdoor\ external\ exposure}\ (\mu Svy^{-1}) = D\times 8760\times 0.7\times 0.2\times 10^{-3} \tag{2}$$

Excess Lifetime Cancer Risk (ELCR)

The excess lifetime cancer risk (ELCR) was calculated using equation 3 [14]

$$ELCR = AED\times ADL\times RF \tag{3}$$

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AED is the Annual Equivalent Dose, ADL is the average duration of life (taken as 70 years) andRF is cancerrisk factor.Considering the mean lifespan of human to be 70 years, the estimated ELCR values are based on the probability of humans to develop cancer over a lifetime[12, 19 -22].

Radium Equivalent Activity Index (Ra_{eq})

The radium equivalent (Ra_{eq}) activity is the weighted plus of the concentrations of ^{238}U, ^{232}Th and ^{40}K. It was calculated using the equation 4.

$$Ra_{eq} = C_U + 1.43C_{Th} + 0.077C_K \quad (4)$$

C_U, C_{Th}, $C_K$have their usual meaning [15- 19].

Radiation Hazard Indices

Equations 5 and 6 were used to quantify the external (H_{ext}) and internal radiation hazard (H_{int})

$$H_{ext} = \left(\frac{C_U}{370}\right) + \left(\frac{C_{Th}}{259}\right) + \left(\frac{C_K}{4810}\right) \quad (5)$$

$$H_{int} = \left(\frac{C_U}{185}\right) + \left(\frac{C_{Th}}{259}\right) + \left(\frac{C_K}{4810}\right) \quad (6)$$

Annual Gonadal Equivalent Dose (AGED)

The AGED for the residents was estimated with equation 7

$$AGED = 3.09C_U + 4.18C_{Th} + 0.314C_K \quad (7)$$

C_U, C_{Th}, and $C_K$have their meaning [12 – 19].

Representative gamma- Index (Iγ)

This is used to obtain the hazard related with the natural radionuclide in specific samples investigated. The representative Ɣ- index was calculated with equation 7.

$$I_\gamma = \frac{C_u}{150} + \frac{C_{Th}}{100} + \frac{C_k}{1500} \leq 1 \quad (8)$$

C_U, C_{Th}, and $C_K$have their usual meaning [13 - 21].

3. Results and Discussion

Table 1 shows the mean background radiation of the measured radionuclides and the evaluated radiological parameter. Figure 1 shows the mean value of the radiological parameters estimated, compared with the average world values.From Table 1 the mean dose rate (DR) measured with the instrument ranges from 39.67 to 48.39 Bq/kg, the calculated dose rate (DE) ranges from 38.73 to 46.99 Bq/kg, the two values are within the same range showing the accuracy of the instrument and the measurements [15]. The activity of ^{238}U, ^{232}Th and ^{40}K ranges from 15.93 to25.94Bq/kg, 39.66 to 51.28Bq/kg and 137.72 to 187.80Bq/kg respectively. The ^{232}Th measured in the School Complex are above the recommended average except for IMP and SFP. The mean annual effective dose for indoor (E_{in}) and the annual effective dose for outdoor (E_{out}) range from 190 to 230.65µSv/y and 47.53 to 57µSv/y respectively. The excess lifetime cancer risk ranges from 0.15 to 0.19 µSv/y hazard indices ($H_{EX,}$ H_{IN}) which are the hazard due to external and internal exposure ranges from 0.23 to 0.28. The annual gonadal dose equivalent ranges from 293.30 to 328.20µSv/y, the Radium equivalent activity estimated ranges from 94.88 to 105.40Bq/kg and the gamma index ranges from 0.62 to 0.75. The activity of the radionuclides measured were all within the permissible limit and do not poses radiological threat to both the staff and the students of the invetigated schools. The radiological parameters evaluated were all below the world average[23], implying no serious concern on the exposure to radiation in the study area.

Table 1: Mean activity concentrations and calculated radiological parameters

Sampled Schools	DR (nGy/h)	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	DE (nGy/h)	E_{out} (mSv/y)	E_{in} (mSv/y)	ELCR (10^{-6})	H_{EX}	H_{IN}	AGDE (μSv/y)	Ra_{eq} (Bq/kg)	Iɣ
MES	47.19	20.75	49.09	187.80	46.99	57.67	230.65	0.19	0.28	0.34	328.20	105.40	0.75
IMS	44.87	14.70	45.43	184.67	42.06	51.62	206.49	0.17	0.25	0.29	293.30	93.88	0.67
IMJ	47.65	15.93	51.28	162.76	45.31	55.61	222.43	0.18	0.28	0.32	314.67	101.79	0.73
MEJ	48.39	25.94	45.19	147.11	45.03	55.26	221.06	0.18	0.27	0.32	293.44	94.88	0.67
SAP	44.45	17.91	49.49	156.50	44.76	54.93	219.73	0.18	0.27	0.32	311.35	100.73	0.72
IMP	39.67	15.93	39.66	178.41	38.73	47.53	190.10	0.15	0.23	0.28	271.05	86.39	0.62
SFP	42.30	22.97	42.87	137.72	41.96	51.50	206.02	0.17	0.26	0.32	293.44	94.88	0.67
WL		33.0	45.0	412.0	57.0	1000.0	1000.0	0.2	1.0	1.0	1000	370	1.0

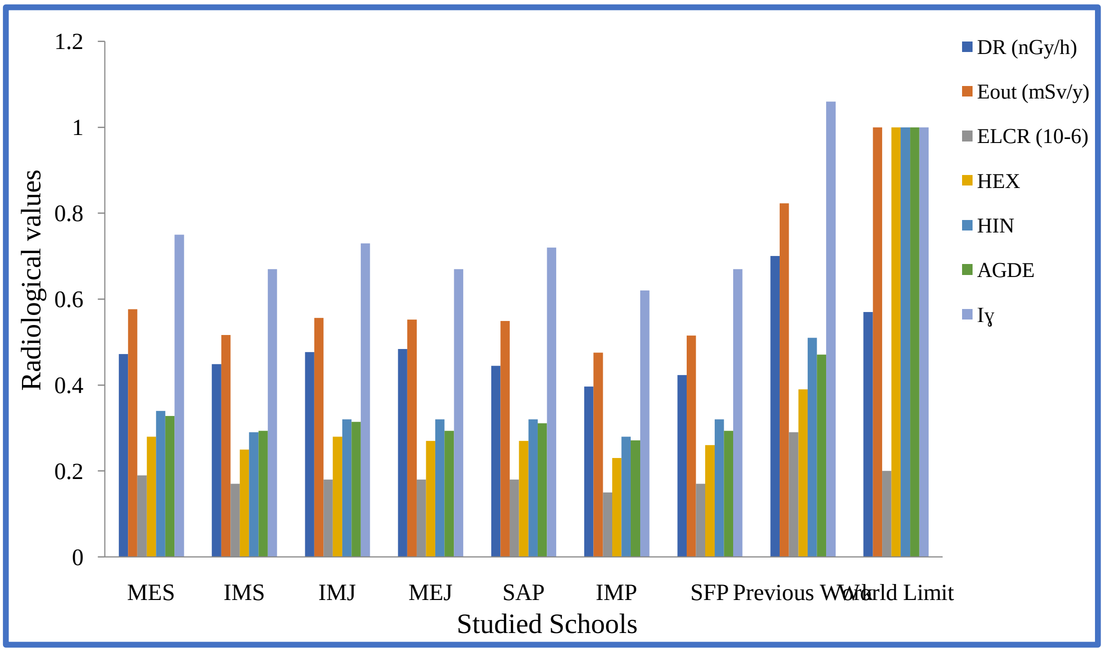

Figure 1: The mean radiological parameters for the study area

4. Conclusion

The measurements of radioactivity concentrations of radionuclides(^{40}K, ^{238}U, ^{232}Th) over Maryland School Complex were conducted using RS-125 hand-held gamma spectrometer with geographical positioning system. The mean activity concentration of the primordial radionuclides measured were (14.70, 45.43, 184.67), (15.93, 51.28, 162.76), (25.94, 45.19, 147.11),(17.91, 49.49, 156.50), (15.93, 39.66, 178.41), (22.97, 42.87, 137.72) Bq/kg for MES, IMS, IMJ, MEJ, SAP, IMP, SFP respectively. The activity concentration of ^{232}Th were above the recommended value in all the schools except for IMP and SFP. Further monitoring of the schools will be needed to avoid exposure of students and staff to carcinogenesis diseases because of exposure to thorium above the threshold limit.The estimated radiological quantites were within world average values. This follows that the risk of exposure to ionizing radiation for both the staff and the students of the community is within acceptable limits.

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