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RADIO ELEMENTS AND RADIATION DOSE LEVEL MEASUREMENTS AT UMAR SULEIMAN HALL OF AHMADU BELLO UNIVERSITY, ZARIA

Zaharaddeen N. Garba[1]*, Saad Yusrah Maiyaki[1], Musa Jibril[2], Abdullahi Muhammad Vatsa[2], Usman Adamu[3] and Nuraddeen Nasiru Garba[2]
[1]Department of Chemistry, Ahmadu Bello University Zaria, Nigeria
[2]Department of Physics, Ahmadu Bello University Zaria, Nigeria
[3]Department of Physics, Kaduna State University, Nigeria
*Corresponding author's e-mail: dinigetso2000@gmail.com; Tel: +2348039443335

ABSTRACT
Radiation is energy that travels in the form of waves or particles and is part of our everyday environment. People are exposed to radiation from cosmic rays, as well as to radioactive materials found in the soil, water, food, air and also inside the body. An in-situ measurement of the indoor and outdoor background radiation level was carried out at the Umar Sulaiman Hall of the Ahmadu Bello University Zaria using a portable Gamma Ray Spectrometer. A total of 30 rooms were surveyed across the five blocks randomly selected within the Hall. The measured dose rate for the entire rooms ranges from 0.154 mSv/hr to 0.194 mSv/hr, which is less than the recommended limit of 1 mSv/y. The mean concentration of ^{40}K, ^{238}U, and ^{232}Th were also measured and found to be within the ranges 12.62 Bq/Kg to 13.24 Bq/Kg, 100.40 Bq/Kg to 150.18 Bq/Kg, and 101.52 Bq/Kg to 167.96 Bq/Kg respectively. ^{40}K values were all found to be far less than the worlds average value of 420 Bq/Kg , ^{238}U values were mostly 3 times higher than the worlds average value of 33 Bq/Kg and that of ^{232}Th were also about 2 times higher than the worlds average value of 45 Bq/Kg. The results showed that radiation dose levels are due to only natural sources and pose no any significant health threat to the students living within Umar Sulaiman Hall.
Keywords: Radiation; Gamma Ray Spectrometer; Environment; Umar Suleiman Hall; Ahmadu Bello University Zaria

INTRODUCTION

Radiation is the energy that travels in the form of waves or particles and is part of our everyday environment. People are exposed to radiation from cosmic rays, as well as to radioactive materials found in the soil, water, food, air and also causing water pollution (WHO, 2009). Radiation with the highest level of energy includes forms like ultra violet radiation, X-rays and gamma rays. Radiation is also known as the spontaneous emission of unstable nuclei from quantity energy (NRC 2006). In chemistry, radiation chemistry is also known as physical chemistry which studies chemical transformations in materials exposed to high energy radiations. It uses radiation as the initiator of chemical reaction, as a source of energy that disrupts the sensitive energy balance in stable system. The highest fraction of the natural radiation we receive comes from the radioactive gas radon (Nsiah-Akoto *et al.*. 2013). Lately, interest has grown in the use of neutrons, heavy ion beams and electrons of very low energy (much less than 0.1MeV) for medical, research and agricultural purposes. Exposure to very high levels of radiation, such as being close to an atomic blast, can cause acute health effects such as skin burns and acute radiation syndrome (radiation sickness). It can also result in long term health effects such as cancer and cardiovascular disease. Exposure to low levels of radiation encountered in the environment does not cause immediate health effects, but is a minor contributor to our overall cancer risk (NRC 2006). In Nigeria today, research indicates that majority of the common fresh water sources are polluted with radioactive materials, resulting to serious outbreak of diseases (Galadima *et al.,* 2011; Okibe *et al.,* 2018; Garba *et al.,* 2021). This prompted a strong need to measure the amount of radiation dose in the Environment and compare them with the standard limits set by ICRP.

The principal aim of this study is therefore to provide a baseline information and also generate a database on the natural background radiation dose levels of the densely populated Umar Suleiman Hall, Ahmadu Bello University Zaria, Kaduna State, Nigeria.

MATERIALS AND METHODS

The materials used in this work are global positioning system Garmin [GPS Map76] used for locating each latitude and longitude of the survey points as well as a portable gamma ray spectrometer used in measuring the distribution or spectrum of the intensity of gamma radiation versus the energy of each photon.

The study was conducted at Umar Suleiman Hall located at Ahmadu Bello University Zaria. The Hall consists of 15 blocks with a total number of 720 rooms. Out of 15 blocks, 6 blocks were selected for the indoor and outdoor dose rate measurement.

Radiation dose level measurement was conducted using a portable Gamma Ray Spectrometer. Random selection of rooms from each of the selected 6 blocks to be measured was done. The measurement was conducted on 5 rooms from each of the 6 blocks selected. It was carried out holding the device at least one meter above the ground level (Garba *et al.,* 2019). The measurement was repeated three times in each location in order to get the mean average level for further analysis. The sampling locations were recorded using the Global Positioning System.

The total annual effective dose rate was calculated using equations below (Garba *et al.,* 2019);

$$IAE=D_{in} \times T \times OF \times Q \quad (1)$$

$$OAE=D_{out} \times T \times OF \times Q \quad (2)$$

where IAE and OAE are the indoor and outdoor annual effective doses respectively, D_{in} and D_{out} are the mean absorbed dose rate in indoor and outdoor, T is the time converter from hours to year, OF is the occupancy factor, that is the fraction of time spent indoor and outdoor which are 0.8 and 0.2 respectively, Q is the conversion factor of 0.7 SvGy, which converts the absorbed dose rate in air to human effective dose received (UNSCEAR 2000).

The Total Annual Effective dose (TAE) was obtained by summing the indoor and outdoor dose rates

$$TAE\ (mSv/y) = OAE + IAE \quad (3)$$

Where; TAE is Total Annual Effective dose, OAE is Outdoor Annual Effective dose, IAE is Indoor Annual Effective dose.

Measurements of the Radio Elements

The measurements of the radio elements Uranium, Thorium and Potassium was conducted at the Umar Suleiman Hostel using the portable Gamma Ray Spectrometer. It was carried out the same way that of dose rate was done and at the same location, that is, the random selection of rooms from the selected 6 blocks in the hostel but here the measurement was taking only once. The sampling locations were recorded using the global positioning system. The Gamma Ray Spectrometer gave the values of Uranium and Thorium in parts per million (ppm) and that of Potassium in percentage (%). Therefore, a conversion was carried out for the radio elements from the unit given by the device to Becquerel per kilogram (Bq/Kg).

RESULTS AND DISCUSSION

The results of the measurements of the radiation dose level obtained in indoor and outdoor of the selected 6 blocks at Umar Suleiman Hall are hereby presented in the Table 1 below

Table 1: Indoor and Outdoor Dose Rates (mSv/y)

S/N	Blocks	Location	Indoor Mean Dose	Outdoor Mean Dose	Total Dose
1	Block F5	ROOM 11	0.038	0.138	0.176
2		ROOM 22	0.037	0.134	0.171
3		ROOM 33	0.036	0.134	0.170
4		ROOM 44	0.040	0.146	0.186
5		ROOM 01	0.036	0.155	0.191
6	Block A4	ROOM 06	0.036	0.153	0.189
7		ROOM 13	0.036	0.146	0.182
8		ROOM 20	0.038	0.150	0.188
9		ROOM 32	0.034	0.137	0.171
10		ROOM 45	0.035	0.152	0.187
11	Block A5	ROOM 10	0.032	0.122	0.154
12		ROOM 18	0.036	0.154	0.190
13		ROOM 21	0.033	0.153	0.186
14		ROOM 25	0.037	0.157	0.194
15		ROOM 35	0.037	0.142	0.179
16	Block A6	ROOM A	0.036	0.154	0.190
17		ROOM 09	0.036	0.118	0.154
18		ROOM 24	0.038	0.141	0.179
19		ROOM 17	0.034	0.157	0.191
20		ROOM 30	0.035	0.132	0.167
21	Block A7	ROOM 15	0.038	0.137	0.175
22		ROOM 20	0.035	0.134	0.169
23		ROOM 04	0.032	0.151	0.183
24		ROOM 31	0.036	0.147	0.183
25		ROOM 48	0.033	0.155	0.188
26	Block F6	ROOM 02	0.037	0.144	0.181
27		ROOM 08	0.040	0.138	0.178
28		ROOM 12	0.035	0.131	0.166
29		ROOM 27	0.042	0.132	0.174
30		ROOM 32	0.038	0.138	0.176

The average dose obtained from the measurement showed that the background radiation level within the study area is generally low. The minimum dose was recorded at Block A5 ROOM 10 with a total average of 0.154 mSv/y while the maximum dose was obtained from the same block at ROOM 25 with an average of 0.194 mSv/y. However, comparing the mean dose from the six different blocks revealed that Block A4 has the highest mean total dose with 0.183 mSv/y while Block F6 recorded the lowest dose with 0.175 mSv/y (Fig. 1). The minimum and maximum values obtained clearly indicate that background radiation was not evenly distributed in all points across the hostel.

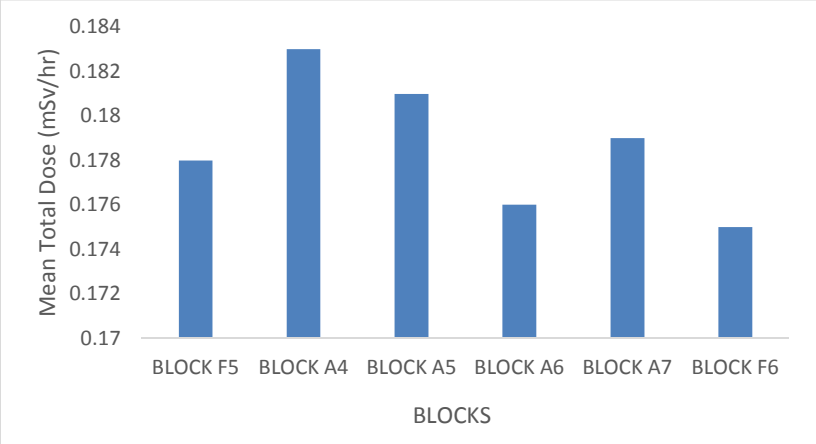

Figure 1: Mean total dose from the six blocks

Generally, the dose rate levels in all the Blocks surveyed within Umar Sulaiman Hostel are comparable to one another and could simply be attributed to natural sources as there is no any significant indication of radiation enhancement artificially even though the study area is located just about 2Km away from a nuclear facility. The total mean dose rate of the surveyed areas is found to be lower than 1.0 mSv/y recommended by ICRP. Furthermore, the results obtained in this work were in agreement with results from previous studies conducted in other locations close to the study area as can be seen in Table 2.

Table 2: Comparison of dose rate from this work with related works

S/N	Total Dose	Location	Reference
1	0.154	Minna	Olarinoye *et a*l 2010
2	0.932	Makurdi	Sanmbo et al,. 2018
3	0.130	Calabar	Ushie et al., 2015
4	0.152	Zaria	Garba et al., 2019
5	0.179	Present work	Garba et al.,

Results of the measurements of radioelements Uranium, Thorium and Potassium (U, Th and K) obtained from Umar Suleiman Hall Ahmadu Bello University, Zaria are also presented (Table 7-12).

Table 3: Indoor and Outdoor Radio Elements (Bq/Kg) in Block F5

S/N	Location	Radio-Elements Indoor			Radio-Elements Outdoor		
		K	U	Th	K	U	Th
1	ROOM 01	14.38	79.04	103.53	11.87	129.68	117.33
2	ROOM 11	8.87	167.96	94.19	13.36	106.21	86.48
3	ROOM 22	12.49	116.09	91.35	14.51	79.04	107.59
4	ROOM 33	14.04	82.75	136.61	10.26	95.10	128.30
5	ROOM 44	14.29	123.50	111.65	8.56	127.21	103.12

The measured concentration of Thorium (^{232}Th) ranged from 86.48 Bq/Kg to 136.61 Bq/Kg. The observed lowest value was found in room 11 while the highest value in room 33 with the calculated mean value of 119.18 Bq/Kg. Therefore, the mean value is compared to the world average value of 45 Bq/Kg where, it was noticed that the mean value is higher.

The measured values of ^{40}K ranged from 8.56 Bq/Kg to 14.51 Bq/Kg. Room 44 has the lowest value and room 22 has the highest value. The mean value was calculated to be 13.07 Bq/Kg which when compared to the world value of 420 Bq/Kg, the mean value is way less than the world average value.

The concentration of Uranium (^{238}U) recorded ranges from 74.04 Bq/Kg to 167.96 Bq/Kg. Room 22 has the lowest value and room 11 has the highest value. Mean value was calculated as 110.66 Bq/Kg, where when compared to the world recommended value of 33 Bq/Kg is about 3 times higher.

Table 4: Indoor and Outdoor Radio elements (Bq/Kg) in Block A4

S/N	Location	Radio Elements Indoor			Radio Elements Outdoor		
		K	U	Th	K	U	Th
1	ROOM 06	13.30	109.92	112.87	13.33	98.80	135.20
2	ROOM 13	11.13	107.45	130.73	12.21	113.62	122.61
3	ROOM 20	13.30	133.38	114.09	13.21	111.15	124.64
4	ROOM 32	14.17	56.81	132.76	13.08	103.74	105.15
5	ROOM 45	12.74	117.33	102.72	15.90	107.45	113.27

The measured values of ^{232}Th ranged from 102.72 Bq/Kg to 135.20 Bq/Kg, where room 45 has the lowest value and room 6 has the highest. The mean value was calculated to be 119.40 Bq/Kg which was lower upon comparison to the world average value of 45 Bq/Kg.

The concentration of ^{40}K recorded ranged from 11.31 Bq/Kg to 15.90 Bq/Kg. Room 13 has the lowest value and room 45 has the highest value.

The mean value was set to be 13.24 Bq/Kg where upon comparison, were found to be far below the recommended limit.

The measured concentration of ^{238}U ranged from 56.81 Bq/Kg to 133.38 Bq/Kg. The observed lowest limit was in room 32 while the highest was in room 20, with the calculated mean value 105.97 Bq/Kg.

Table 5: Indoor and Outdoor Radio Elements (Bq/Kg) in Block A5

S/N	Location	Radio Elements Indoor			Radio Elements Outdoor		
		K	U	Th	K	U	Th
1	ROOM 10	12.46	276.63	35.32	15.31	297.64	27.20
2	ROOM 18	11.63	86.45	145.35	11.87	140.79	119.77
3	ROOM 21	12.37	123.50	114.49	13.61	113.62	104.75
4	ROOM 25	12.37	113.62	88.91	14.14	113.62	123.02
5	ROOM 35	14.79	92.63	123.83	12.18	143.26	121.39

The concentration values of ^{238}Th recorded ranged from 27.20 Bq/Kg to 145.35 Bq/Kg. The room with the lowest and highest value are room 10 and room 18 respectively. With Mean value of 100.40 Bq/Kg, it is higher than the world average value of 45 Bq/Kg. Here, ^{40}K ranged from 11.63 Bq/Kg to 15.31 Bq/Kg. The observed lowest value was in room 18 while the highest was in room 10 with a calculated mean value of 13.07 Bq/Kg. Hence, the mean value is far below the world average value of 420 Bq/Kg. For ^{238}U, the values ranged from 86.45 Bq/Kg to 297.64 Bq/Kg. The mean value was calculated to be 150.18 Bq/Kg, higher than the world average of 33 Bq/Kg.

Table 6: Indoor and Outdoor Radio Elements (Bq/Kg) in Block A6

S/N	Location	Radio Elements Indoor			Radio Elements Outdoor		
		K	U	Th	K	U	Th
1	ROOM 09	12.71	121.03	106.37	10.88	113.62	76.73
2	ROOM A	16.52	70.40	124.64	15.38	82.75	140.07
3	ROOM 24	13.76	93.86	135.60	11.78	104.98	120.99
4	ROOM 17	13.02	49.40	140.88	13.55	113.62	134.79
5	ROOM 30	11.63	132.15	99.88	8.56	133.38	103.12

Table 7: Indoor and outdoor Radio Elements (Bq/Kg) in Block A7

S/N	Location	Radio Elements Indoor			Radio Elements		
		K	U	Th	K	U	Th
1	ROOM 15	12.68	51.87	112.06	13.27	98.80	135.20
2	ROOM 20	14.48	85.22	140.07	10.26	97.57	128.70
3	ROOM 04	11.28	123.50	112.06	11.32	132.15	89.73
4	ROOM 31	17.22	97.57	111.65	12.40	138.32	103.94
5	ROOM 48	15.14	71.63	103.53	9.42	149.44	132.76

Table 8: Indoor and Outdoor Radio Elements (Bq/Kg) in Block F6

S/N	Location	Radio Elements Indoor			Radio Elements Outdoor		
		K	U	Th	K	U	Th
1	ROOM 02	8.87	149.44	122.61	13.67	104.98	113.27
2	ROOM 08	10.82	180.31	105.97	13.73	109.92	92.97
3	ROOM 12	12.59	128.44	94.19	13.95	65.46	116.52
4	ROOM 27	12.90	149.44	131.54	13.08	62.99	126.27
5	ROOM 31	17.14	51.87	103.53	9.42	149.44	132.76

From table 11 and 12, the same trend was observed as above with only the mean value ^{40}K less than the recommended world value with the mean values of both ^{238}U and ^{232}Th higher than their world average values.

CONCLUSION

Radiological studies were carried out in Umar Suleiman hall of Ahmadu Bello University Zaria inorder to determine whether or not the hall has some potential radiological risk due to natural radioactivity, where dose rates and radio elements (Uranium, thorium and Potassium) where measured. The radiation dose levels measured for all the selected five rooms from the blocks A4, A5, A6, A7, F5 and F6 were all found to be less than the recommended world limit of 1mSv/y which is within the limit. For the radio elements, Potassium (^{40}K) values from all the sampling locations measured were found to be far below the world average value of 420 Bq/Kg. Thorium (^{232}Th) values from all the blocks measured were observed to be about 2 times higher than the worlds average value of 45 Bq/Kg with Uranium (^{238}U) values from all the located blocks measured also higher than the world average value of 33Bq/Kg. Further research should be carried out on this study area, in order to assess the radiation dose level of the other blocks so as to have a full baseline for the whole hostel.

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