Measurement of Natural Radioactivity in Soil Samples From Ladoke Akintola University of Technology, Ogbomoso South-West, Nigeria.

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Abstract- *Studies on the gamma radiation level and the radionuclide distribution in the soil of Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Oyo state were carried out. This study is to provide a baseline data on the radiation level as well as the distribution of some naturally occurring radionuclides present in the University that was established in 1990 with population of about thirty thousands. The analysis was carried out through the use of a well calibrated NaI(TI) detector system. The range of activity concentration of (^{40}K, ^{234}U and ^{232}Th) were found to be (50.23±1.41 to 183.55±1.42, 9.81±3.11 to 22.70±3.15 and 9.07±0.95 to 34.42±0.78) Bq/kg respectively. The mean absorbed dose rate and annual effectively dose equivalent (AEDE) were calculated and found as presented: 23.06μSvy^{-1} and 23.16μSvy^{-1} respectively. The values obtained were below the safety limit of 1mSv/y as recommended by the International Commission on Radiological Protection.*

Index Terms: LAUTECH, Natural Radioactivity, Nigeria, Soil

1 INTRODUCTION

The global interest in the study and survey of naturally occurring radiation and environmental radioactivity had been essentially based on the importance of using the results from such studies for the assessment of public radiation exposure rates and the performance of epidemiological studies, as well as reference radiometric data relevant in studying the possible changes in environmental radioactivity due to nuclear, industrial and other human technology-related activities (UNSCEAR, 2000).

It has been established that out of the total radiation dose that the world population receives, about 96.1% is from natural sources and the remainder is from human –made sources (Chougankar *et al.*, 2003). The natural environmental radioactivity in a location and its associated external exposure due to gamma

radiation depends primarily on its geological and geographical conditions (Akinloye et al., 2012; Eke et al., 2015). It is related to the composition of each lithologically separated area and the content of the rock from which the soil originates (Whicker, 1983; Wollenberg and Smith, 1990). Therefore, specific concentration levels of terrestrial radiation differ in the soil of each region of the world (Akhtar *et al*., 2004; Tufail *et al*., 2007; Shiva Prasad *et al*., 2008).

In Nigeria, half of the land area of 923 768 km^2 is underlain by crystalline rocks or basement complex and the remaining half by sedimentary rocks. The basement complex is of Precambrian age and composed primarily of metamorphic and igneous rocks such as granites, gneisses and migmatites (Rahaman, 1988). The study of the distribution of radionuclides in the human environment allows the understanding of the radiological implications of these elements due to the gamma- ray exposure of the body and irradiation of lung tissues from inhalation radon and its daughters. Hence, this study is necessitated by the fact that no previous work has been conducted to provide a database on the distribution of radionuclides and their concentrations within Ladoke Akintola University of Technology Oyo State.

The University was established by former old Oyo state government in 1990 located in Ogbomoso, South-Western, Nigeria. Since radiation cannot be felt by the human sense organs, it is important that the total emitting-NORMs in the mentioned institution of over thirty thousand population be determined in order to safeguard the live of people and ensure radiation-pollution free environment. This study is to estimate the activity concentration of radionuclides, absorbed gamma dose rates and annual effective dose rates in the soil samples from LAUTECH for her record data in case of any changes in future.

2. MATERIALS AND METHODS

2.1 Sample Collection, Preparation and Analysis.

Seventy soil samples were collected at different locations within the premises of Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria as presented in (Fig.1)

The samples were air-dried, crushed and homogenized. The homogenized samples were packed and hermatically sealed in plastic container with the aid of (PVC) tape to prevent the escape of airborne ^{222}Rn and ^{220}Rn from the samples. All the samples were weighed and stored for Twenty-eight days prior to measurement in order to attain radioactive secular equilibrium between radon and its decay products.

After the secular equilibrium period was attained, samples were then analyzed for 36000 s using a well calibrated gamma spectrometer using Nal(TI) scintillation detector at radiation laboratory, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. The scintillation detector, is a 3x3 inch Nal(TI), a product of Princeton Gamma Tech. USA, placed in a lead shield to reduce the effect of background radiation. Energy and efficiency calibrations of the detector were carried out using a standard source traceable to Analytical Quality Control Services (AQCS), USA, which contains ten

radionuclides of gamma emitters with energies ranging from 59.54 to1836kV.

The activity concentration of ^{238}U was determined from the 63.3 keV peak of ^{234}Th, ^{226}Ra was determined from the average activity concentration of 295.3 keV of ^{214}Pb and 1764.5 keV of ^{214}Bi. The activity concentration of ^{232}Th was determined from the average concentration of ^{212}Pb (238.6 keV), ^{228}Ac (911.1keV) and ^{208}Tl (2614.7keV), and that of ^{40}K (1460.0keV). The activity concentration of ^{235}U was determined from the 185.7 keV gamma lines, which were corrected by removing the contribution from the 186.2 keV of ^{226}Ra using the following Equation 1:

$$A\ (^{238}U) = \frac{N_{186} - A(226_{Ra}).f_E(226_{Ra}).n_{186}.M.T_c}{n_{186}.f_E(235_U).M.T_c} \quad (1)$$

Where N_{186} is the total counts for the 186 keV doublets. A(^{235}U) and A(^{226}Ra) are the activity concentrations of ^{235}U and ^{226}Ra respectively, n_{186} is the detection efficiency of the 186 keV line, $f_E(^{235}U)$ and $f_E(^{226}Ra)$ are the emission probabilities of the 185.7 keV gamma lines of ^{235}U and ^{226}Ra respectively. T_c is the counting time and M is the mass of the sample.

The Minimum Detectable Activity (MDA) for each radionuclide ^{226}Ra, ^{232}Th and ^{40}K was calculated using the following Equation 2:

$$MDA = \frac{1.645\sqrt{N_B}}{f_E.n(E).t_C.M} \quad (2)$$

Where, 1.645 is the statistical coverage factor at 95% confidence level, N_B is the background counts at the region of interest, t_C is the counting time, f_E is the gamma emission probability, n(E) is the photopeak efficiency and M is the mass of the sample. The MDA for each of the radionuclide were calculated as 0.12 Bq/kg for ^{226}Ra, 0.11 Bq/kg for ^{232}Th and 0.9 Bq/kg for ^{40}K respectively.

2.2 Calculation of the Absorb Dose Rate and Annual Effective Dose

The absorbed rate at 1 m above the ground (in $nGyh^{-1}$) due to U-Th series and ^{40}K was calculated using the following Equation 3:

$$D(^{nGy}_{h}) = \sum_{i=1}^{n} A_i.DCF \quad (3)$$

Where DCF are the dose coefficient in $nGyh^{-1}$ per Bq/kg taken from UNSCEAR (2000) report (UNSCEAR, 2000) and A_i are the activity concentrations of the radionuclides.

The annual effective dose equivalent, HE, from external exposure to gamma rays from the soil samples was calculated from the absorbed dose rate using the Equation 4 (UNSCEAR, 2000):

$$H_E = D(nGyh^{-1})*8760(h)*0.2*0.7(Sv/Gy) \quad (4)$$

Where 0.2 is the occupancy factor for the outdoor, 8760 is the total time of the year in hours and 0.7 Sv/Gy is the conversion factor for external gamma irradiation.

3 RESULTS AND DISCUSSION

The results obtained for the activity concentrations of radionuclides present in LAUTECH soil samples are presented in Table 1. The results show that three natural radionuclides namely ^{40}K, ^{226}Ra and ^{232}Th are present in the soil samples analyzed and no traces of artificial radionuclides were not detected. The

activity concentration of these radionuclides ranged from 50.23±1.41 $Bqkg^{-1}$ to 183.55±1.42 $Bqkg^{-1}$ with an average value of 116.79±1.40 $Bqkg^{-1}$ for ^{40}K, 9.81±3.11 $Bqkg^{-1}$ to 22.70±3.15 $Bqkg^{-1}$ with an average value of 12.45±2.94 $Bqkg^{-1}$ for ^{226}Ra and 9.07±0.95 $Bqkg^{-1}$ to 34.42±0.75 $Bqkg^{-1}$ with an average value of 12.67±0.79 $Bqkg^{-1}$ for ^{232}Th respectively. For ^{40}K radionuclide, the lowest value was recorded at the University farm while the highest value was recorded at the ceramic studio, this considerable value may be due to the presence of the radioactive minerals and clay soil in the location. For ^{232}Th radionuclides, the lowest value was recorded at Bee house while the highest value was recorded at mechanical engineering workshop and values could be link to the presence of monazite and other radioactive minerals in the location. For ^{226}Ra, radionuclide, the lowest values was recorded at LAUTECH Chapel while the highest value was recorded at ceramic studio. The highest activity concentration could be attributed to the geological location. Ra were below detectable limit at three location could be linked to the geological strata of the area since no artificial radioactive material was found in any of the analyzed samples assayed.

The results obtained for the estimated absorbed dose rates and effective dose rates are presented in Table 2. The results show that the absorbed dose rates ranged from 9.97 to 32.92$nGyh^{-1}$ with an average mean of 23.06 $nGyh^{-1}$. This value falls below the recommended mean value of 51 $nGyh^{-1}$. Similarly, the effective dose rate obtained based on the soil samples analyzed ranged from 12.04μSvy^{-1} to 40.40μSvy^{-1} with an average value of 23.16μSvy^{-1}. This value also falls below the world average values of 70μSvy^{-1} (UNSCEAR, 2000).

4 CONCLUSION

This study has presented the results of the activity concentrations of terrestrial gamma emitters for soil samples from LAUTECH, Ogbomoso, Nigeria. The obtained values of natural radioactivity of absorbed dose rates due to the activity concentrations of ^{40}K, ^{232}Th and ^{226}Ra in soil samples have determined and found lower than the world average values. Hence, this implies that the study area is suitable and safe and could not be considered to constitute radiological hazard to the University community.

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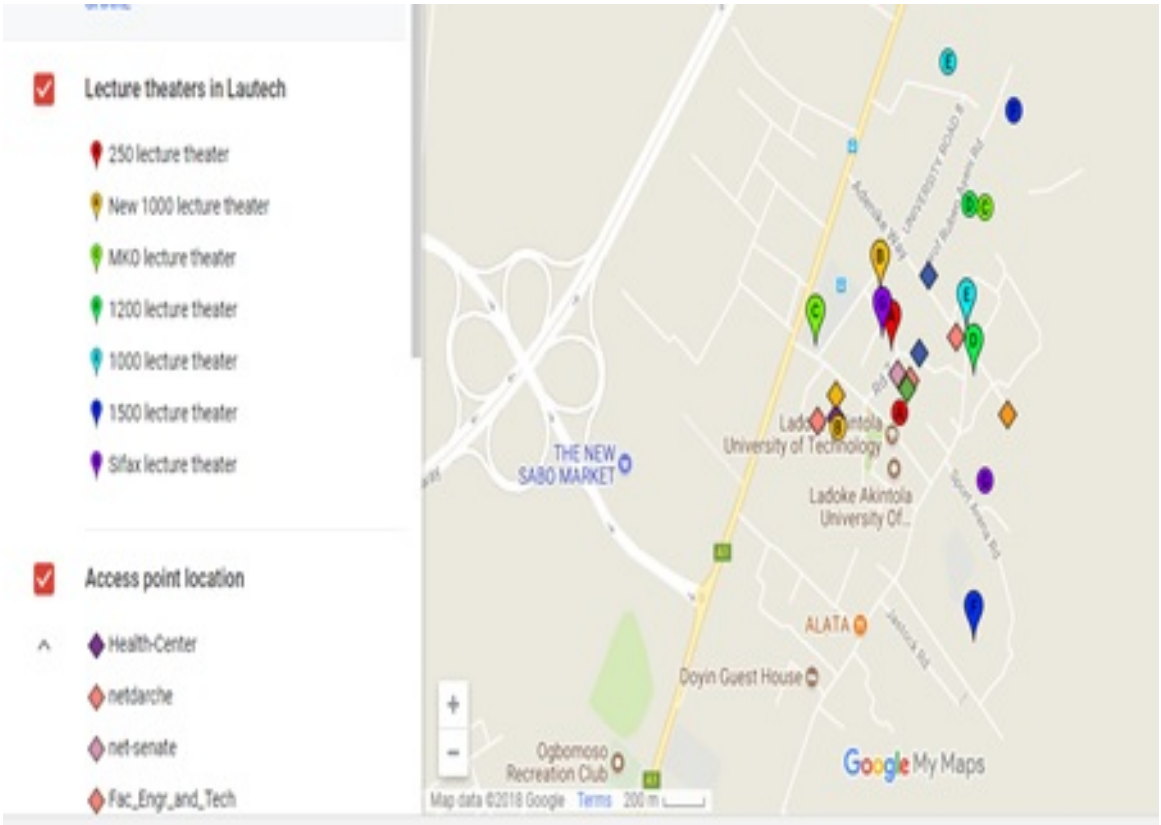

Figure 1: Map of the study area

Table 1. Activity concentrations of the radionuclides at different locations

Sample ID	Sample locations	^{40}K (Bqkg^{-1})	^{226}Ra (Bqkg^{-1})	^{232}Th (Bqkg^{-1})
1	Student affairs building	124.23±1.38	11.21±4.85	14.42±0.12
2	Senate building	113.58±1.41	10.01±2.20	11.42±0.77
3	URP studio	140.45±1.37	18.08±3.61	23.51±0.21
4	Ceramic studio	125.96±1.39	22.70±3.15	12.87±0.75
5	New laboratory complex	113.21±1.41	12.92±3.11	13.98±0.77
6	250lecture theatre hall	122.45±1.37	10.37±2.57	11.11±0.76
7	750lecture theatre hall (MKO)	125.44±1.39	12.03±2.47	17.03±0.76
8	1200lecture theatre hall	87.23±1.45	11.81±2.83	12.41±0.83
9	Engineering workshop	122.02±1.07	12.90±2.16	10.86±0.78
10	Post office	183.55±1.42	12.54±2.76	BDL
11	Post graduate school	125.96±1.39	10.66±2.96	BDL
12	High-rise building	125.44±1.39	11.31±2.17	10.06±0.78
13	MEE workshop 1	100.67±1.42	10.14±2.13	11.26±0.76
14	MEE workshop 2	124.25±1.38	11.21±4.85	34.42±0.78
15	Amazing delicacy	140.45±1.37	10.08±3.61	11.51±0.81
16	Health centre	122.04±1.37	20.37±2.57	21.11±0.76
17	New ICT building	125.44±1.39	22.03±2.47	17.03±0.76
18	Old ICT building	87.23±1.45	25.81±2.83	18.41±0.83
19	1200lecture theatre hall	142.02±1.37	12.30±2.76	10.46±0.18
20	1000lecture theatre hall (FAG	103.55±1.42	12.54±2.76	BDL
21	Lautech bakery	125.96±1.39	12 .66±2.96	13.03±0.77
22	Lautech back gate	113.58±1.41	13.01±2.25	11.42±0.17
23	1000 lecture theatre hall (FPAS)	140.45±1.37	10.08±3.61	12.51±0.31
24	The great hall	87.23±1.45	11.81±2.83	12.41±0.83
25	1000lecture theatre hall (SIFAX)	125.96±1.39	10.66±2.96	13.03±0.77
26	Lautech main gate	142.45±1.37	10.37±2.57	11.11±0.76
27	Architecture studio	87.23±1.45	10.81±2.03	9.41±0.83
28	Adeojo LT hall	113.23±1.41	12.92±3.10	13.18±0.77
29	Ghana house (FAG)	124.25±1.30	11.21±4.15	13.42±0.78

30	Bee house (FAG)	123.15±1.42	12.54±2.76	9.07±0.95
31	Lautech stadium	100.17±1.42	11.74±2.93	13.86±0.76
32	Feedmill (FAG)	140.45±1.37	11.08±3.61	12.51±0.81
33	Pre degree complex	142.45±1.37	10.37±2.57	11.11±0.76
34	Student union building	125.44±1.39	12.03±2.47	17.03±0.76
35	Poultry research house	141.45±1.37	10.07±2.57	11.21±0.76
36	Open distance learning	140.45±1.37	11.08±3.61	13.51±0.81
37	GTBank building	86.65±1.47	12.85±2.55	16.19±0.77
38	General studies building	125.96±1.39	11.66±2.96	13.03±0.77
39	Anatomy laboratory	142.41±1.37	10.37±2.17	11.11±0.76
40	Firstbank building	87.23±1.45	11.81±2.83	12.41±0.83
41	Lautech farm house	50.23±1.41	9.92±3.11	12.98±0.77
42	Lautech chapel	87.23±1.45	9.81±2.83	10.21±0.83
43	Sport complex	113.23±1.41	12.32±3.11	13.98±0.77
44	Convocation building	125.96±1.3	12.66±2.96	13.03±0.77
45	FAA studio	103.55±1.42	11.54±2.76	12.07±0.95
46	CAD centre	100.67±1.42	12.14±2.93	10.16±0.76
47	Lautech sec. school	147.45±1.37	10.37±2.57	11.11±0.76
48	Cooperative building	134.25±1.38	11.21±4.85	10.42±0.78
49	Security post	150.23±1.41	12.92±3.11	13.98±0.77
50	Skyebank building	125.96±1.39	11.16±2.16	12.03±0.77
51	Acada building	98.75±1.42	11.66±2.97	13.17±0.78
52	X-ray building	73.45±1.47	20.83±2.77	21.57±0.78
53	FPAS building	113.23±1.41	12.92±3.11	13.98±0.77
54	Central mosque	99.27±1.42	11.96±2.82	13.13±0.77
55	URP 500l studio building	150.23±1.41	11.92±3.11	13.98±0.77
56	BIOSSA building	100.67±1.42	12.14±2.93	13.16±0.16
57	Chemistry shed	113.23±1.41	12.92±3.11	13.18±0.17
58	FET building	147.45±1.37	10.37±2.57	11.11±0.76
59	300l physics lab	103.55±1.42	10.54±2.76	11.07±0.95
60	SLT lab	87.23±1.45	12.81±2.83	13.41±0.83
61	Management sci. building	125.96±1.39	10.66±2.96	13.03±0.17
62	PASSA secretariat	134.25±1.38	11.21±4.85	14.42±0.78
63	MTH new building	86.65±1.47	12.85±2.55	13.19±0.77
64	300l chemistry lab	125.96±1.39	12.66±2.96	13.03±0.17
65	Fluid and mechanics lab	98.75±1.42	11.26±2.97	14.13±0.72
66	Alumni park	100.67±1.42	12.74±2.93	12.86±0.76
67	FSE Processing Unit	86.65±1.47	12.85±2.55	13.19±0.77
68	FESSA building	142.25±1.37	10.37±2.57	11.11±0.76
69	Agricultural laboratory	73.45±1.40	12.83±2.77	12.57±0.78
70	Zenith bank building	103.55±1.42	11.54±2.76	13.07±0.95

Table 2. Absorbed Dose and Effective Dose Rate at different locations

Sample ID	Sample locations	Absorbed dose rates ($nGyh^{-1}$)	Effective Dose Rates (μSvy^{-1})
1	Student affairs building	19.68±2.21	24.15±2.71
2	Senate building	16.72±1.51	20.52±1.85
3	URP studio	29.32±1.74	35.98±2.14
4	Ceramic studio	23.63±1.90	29.00±2.33
5	New laboratory complex	19.64±1.90	24.10±2.33
6	250lecture theatre hall	17.05±1.66	20.92±2.04
7	750lecture theatre hall (MKO)	21.85±1.62	26.82±1.99
8	1200lecture theatre hall	17.01±1.82	20.88±2.23
9	Post office	17.94±1.49	22.02±1.83
10	Engineering workshop	13.25±1.24	16.26±1.51
11	Post graduate school	9.97±1.32	12.24±1.62
12	High-rise building	16.88±1.50	20.72±1.84
13	MEE workshop 1	16.11±1.47	19.77±1.80
14	MEE workshop 2	32.92±2.65	40.40±3.25
15	Amazing delicacy	17.96±2.14	22.04±2.63
16	Health centre	27.92±1.66	34.26±2.04
17	New ICT building	26.07±1.62	31.98±1.99
18	Old ICT building	26.96±1.82	33.09±2.23
19	1200lecture theatre hall	18.28±1.36	22.43±1.67
20	1000lecture theatre hall (FAG)	9.81±1.24	12.04±1.52
21	Lautech bakery	19.45±1.83	23.87±2.25
22	Lautech back gate	18.00±1.13	22.09±1.39
23	1000 lecture theatre hall (FPAS)	18.63±1.81	22.86±2.22
24	The great hall	17.01±1.82	20.88±2.23
25	1000lecture theatre hall (SIFAX)	18.59±1.83	22.81±2.25
26	Lautech main gate	17.91±1.66	21.98±2.04
27	Architecture studio	14.60±1.48	17.92±1.82
28	Adeojo LT hall	19.11±1.89	23.45±2.32
29	Ghana house (FAG)	19.01±2.34	23.33±2.87

30	Bee house(FAG)	16.65±1.87	20.43±2.29
31	Lautech stadium	18.50±1.82	22.70±2.23
32	Feedmill(FAG)	19.05±2.14	23.38±2.63
33	Pre degree complex	17.91±1.70	22.05±2.09
34	Student union building	21.80±1.62	26.75±1.99
35	Poultry research house	17.80±1.66	21.84±2.04
36	Open distance learning	19.71±2.14	24.19±2.63
37	GTBank building	19.93±1.66	24.46±2.04
38	General studies building	19.02±1.83	23.34±2.25
39	Anatomy laboratory	17.91±1.42	21.98±1.83
40	Firstbank building	17.01±1.82	20.88±2.23
41	Lautech farm house	14.99±1.90	18.40±2.33
42	Lautech chapel	14.70±1.82	18.04±2.23
43	Sport complex	19.38±1.90	23.78±2.33
44	Convocation building	19.45±1.83	23.87±2.25
45	FAA studio	17.37±1.87	21.32±2.29
46	CAD centre	16.24±1.82	19.93±2.23
47	Lautech sec. school	18.12±1.70	22.24±2.09
48	Cooperative building	17.46±2.65	21.43±3.25
49	Security post	21.23±1.90	26.05±2.23
50	Skyebank building	18.90±1.49	23.19±1.83
51	Acada building	17.94±1.85	22.02±2.27
52	X-ray building	26.33±1.76	32.31±2.16
53	FPAS building	19.64±1.90	24.10±2.33
54	Central mosque	18.07±1.75	22.18±2.15
55	URP 500l studio building	20.81±1.90	25.54±2.33
56	BIOSSA building	18.22±1.42	22.36±1.74
57	Chemistry shed	19.11±1.50	23.45±1.84
58	FET building	18.12±1.66	22.24±2.24
59	300l physics lab	16.31±1.74	20.02±2.14
60	SLT lab	18.10±1.82	22.21±2.23
61	Management sci. building	18.60±1.39	22.83±1.77
62	PASSA secretariat	20.11±2.65	24.68±3.25
63	MTH new building	17.95±1.66	22.03±2.04
64	300l chemistry lab	19.45±1.44	23.87±1.77
65	Fluid and mechanics lab	18.41±1.81	22.59±2.22
66	Alumni park	18.28±1.82	22.43±2.23
67	FSE Processing Unit	17.95±1.66	22.03±2.04
68	FESSA building	17.90±1.66	21.97±2.04
69	Agricultural laboratory	16.96±1.76	20.81±2.16
70	Zenith bank building	18.03±1.87	22.13±2.29

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