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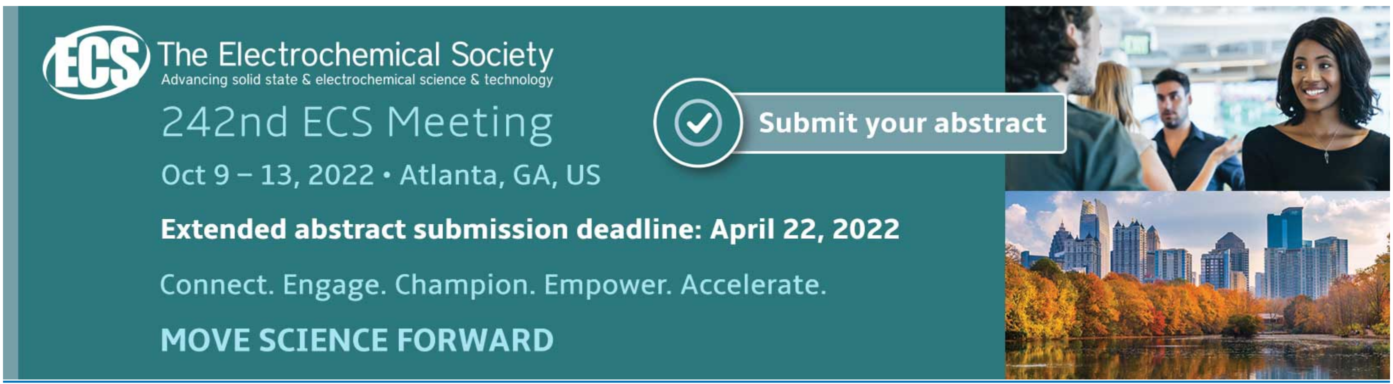

Radiological Hazard Assessment of Sharp-Sand from Ilorin-East, Kwara State, Nigeria

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Abstract. Measurement of activity concentration of primordial radionuclides ^{40}K, ^{232}Th, ^{238}U and the corresponding gamma dose rate over a major sharp-sand field in Ilorin, Nigeria, was carried out using Super Spec RS125 gamma ray spectrometer. The RS125 gamma spectrometer gives in-situ measurement of radioactivity concentration. Measurements were taken in 50 locations. The peak values of the measured activity concentrations of ^{40}K, ^{238}U, ^{232}Th, the dose rate (D) and the resulting annual effective dose (AED) are 688.60, 48.17, 30.86 Bqkg^{-1}, 49.50 nGyh^{-1} and 0.06 mSvy^{-1} respectively, while their corresponding lowest values are 31.30, 1.24, 0.41 Bqkg^{-1}, 4.70 nGyh^{-1}, and 0.01 mSvy^{-1} respectively. The estimated mean values of ^{40}K, ^{232}Th, ^{238}U, the gamma dose rate (D) and AED are 454.48, 13.52, 11.63 Bqkg^{-1}, 32.96 nGyh^{-1} and 0.04 mSvy^{-1} respectively. Consequently, the mean values of the measured radionuclides and the hazard parameters i.e. dose rate and annual effective dose are within the permissible levels. This follows that the risk of radiation exposure for this location is comparatively less, but the general public may not be safe from exposure to indoor ionizing radiation since no amount of radiation is safe for stochastic effects.

Keywords: Background Radiation, ^{40}K, ^{232}Th, ^{238}U Conversion factors, Activity Concentration.

1. Introduction

Life on earth is continuously unavoidably open to ionizing radiations from natural and manmade sources [1 – 3]. Exposure to a high concentration of ionizing radiation has been linked with somatic and genetic effects that are damaging to vital organs of the human body that are radiosensitive. It can result to death in severe cases [1, 4 - 8]. Naturally occurring radionuclides that gives off ionizing radiation are present everywhere in the environment. So they are present in soils, rocks, sand, water, and other minerals mined from the earth for building and construction purposes [2, 4, 9-11]. Data on the distribution of these radionuclides existing in a typical building entity helps to assess the potential risks the usage of such materials can cause mankind. The major source of the natural background radiation is the activity of radionuclides in the soil [12]. Disintegration of rocks through natural process, by rain and flows bring about radionuclides in the soil. In addition to the natural sources, soil radioactivity is also affected by human-made activities [2, 11].

In Nigeria, several authors have reported the activity concentrations of ^{238}U, ^{234}Th and their progenies together with the non-series ^{40}K, in different samples of materials from different parts of the country including Ilorin [2, 6 - 18]. Most of the results from these assessments show that the level of human exposure to radiation hazards are low compared to the limits recommended by several commission around the globe [1]. However, in a work conducted by [14] in 2013, it was discovered that the an individual in Ilorin, Kwara State received annual effective dose between 0.81 and 1.74 $mSvy^{-1}$ leading to a mean of about 1.30 $mSvy^{-1}$ which is higher than the recommended limits of 1 $mSvy^{-1}$ recommended by [1]. This finding consequently demands for detail radiological monitoring to be carried out in the area, particularly on materials used for building and construction purposes. Hence the goal of this study is to carry out radioactivity measurements using a well calibrated hand held Super Spec RS125 Gamma spectrometer, estimate the annual effective doses (AED) and the dose rate (D) in order to appraise the level of the radiological health hazard to human life in Ilorin, Kwara State.

2. Materials and Method

The study area is Ilorin-east LGA in Kwara State, Nigeria. Figure 1 is the map of the area under study having latitudes between 8º20' N and 8º50' N and longitudes between 4º25' E and 4º65'E. Ilorin town is predominantly disposed by sedimentary rock, which incorporates alluvial deposits with primary and secondary laterites [19]. Other researchers have discussed the geology of this area [2, 11, 13 and 19].

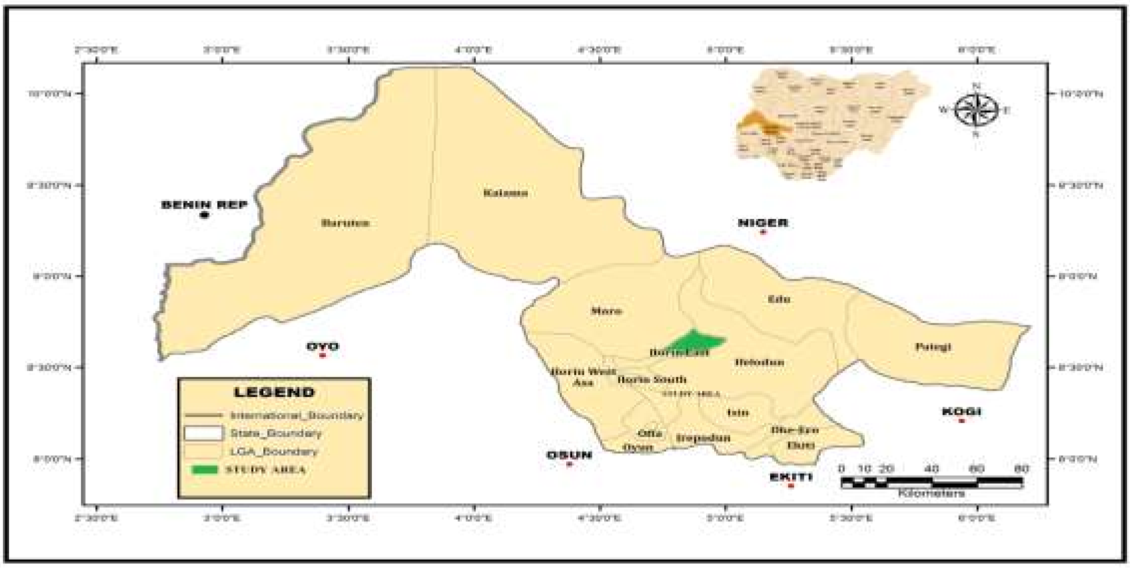

Figure 1: Study areas map

On-site measurement for activity concentration of radioelements ^{40}K, ^{232}Th, ^{238}U, and the gamma dose rate was taken above the sharp sand major source Ilorin-east, Kwara State Nigeria. The data were taken in 50 sampling points using well calibrated handheld NaI gamma detector device known as Super Spec RS-125 gamma spectrometer. This device was held at about 1 meter above the ground level all through the radioactivity measurement [11, 13]. The elevation and coordinate of each sampling location was recorded with the help of a global positioning system. Readings were taken multiple times (4 times) and the mean was calculated to increase the accuracy of the results [11]. More information about this device, method employed and conversion process can be found in [11, 13].

From radiation protection point of view, the primary process of health risk assessment is estimating the absorbed dose rate. With regard to the radiological, biological effects and clinical effects are undeviatingly connected to the absorbed dose rate [1, 2, and 13]. The outdoor absorbed dose rates in air at a height of 1 m above the ground surface to which the workers in the area and farmlands are exposed were estimated equation 1 [20].

$$D = 0.462C_U + 0.604C_{Th} + 0.041C_K \quad (1)$$

C_U, C_{Th}, C_K are the activity concentration in $Bqkg^{-1}$ ^{238}U, ^{232}Th and ^{40}K respectively.

The ruthlessness of any radiological hazard is mainly dependent on the annual radiation dose incurred by an individual living or working in the radiation vicinity. In order to estimate the annual effective dose both outdoor and indoor, the following were considered: The conversion coefficient from absorbed dose to effective dose equally the indoor and outdoor occupancy factors. Using the dose rate data obtained from the measured activity radionuclides, with 0.7 $SvGy^{-1}$ as the conversion factor considering that adult in Nigeria, on the average, spent approximately 20% of their time outdoor, and ~ 80% indoor [2, 9]. This is calculated using equation 2.

$$AED = D\ (nGy^{-1}) \times 24\ h \times 365\ d \times 0.7\ SvGy^{-1} \times 0.2 \quad (2)$$

3. Results and Discussion

On-site measured values of the activity concentrations of the radioelements ^{40}K, ^{232}Th, ^{238}U, the gamma dose rate (D) and AED together with their corresponding statistical summary are shown in Tables 1. From the Tables 1, the peak values of the activity concentration of ^{40}K, ^{238}U, ^{232}Th, the D and the resulting AED are 688.60, 48.17, 30.86 $Bqkg^{-1}$, 49.50 $nGyh^{-1}$ and 0.06 $mSvy^{-1}$ respectively, while their corresponding lowest values are 31.30, 1.24, 0.41 $Bqkg^{-1}$, 4.70 $nGyh^{-1}$, and 0.01 $mSvy^{-1}$ respectively. The estimated mean values of ^{40}K, ^{232}Th, ^{238}U, the gamma dose rate (D) and AED are 454.48, 13.52, 11.63 $Bqkg^{-1}$, 32.96 $nGyh^{-1}$ and 0.04 $mSvy^{-1}$ respectively.

According to [20 – 22] publications, the acceptable values for general public are given as 420.00, 32.00, 45.00 $Bqkg^{-1}$, 59.00 $nGyh^{-1}$ and 1 $mSvy^{-1}$ respectively for exposure to ^{40}K, ^{238}U, ^{232}Th, D and AED. It follows that most of the measured values of the activity concentrations of the primordial radionuclides lies within the recommended safe limits. Consequently, the mean values of the two hazard parameters evaluated are within the permissible levels as shown in Table 1 and Figures 2 and 3. The result reveals that radiation risk from this exposure is comparatively less, but the general public may not be safe from exposure to indoor ionizing radiation since there is no amount of radiation that is safe when considering stochastic effects.

Table 1. Dose Rate, Activity Concentration and Annual Effective Dose of Radionuclide Heads

SAMPLE CODE	Latitude °N	Longitude °E	D ($nGyh^{-1}$)	^{40}K ($Bqkg^{-1}$)	^{238}U ($Bqkg^{-1}$)	^{232}Th ($Bqkg^{-1}$)	AED ($mSvy^{-1}$)
IES1	8.618483	4.770233	4.70	31.30	4.94	2.03	0.01
IES2	8.618483	4.770167	28.70	532.10	6.18	5.28	0.03
IES3	8.618467	4.770133	32.20	375.60	23.47	10.15	0.04
IES4	8.618500	4.770100	35.30	469.50	18.53	10.15	0.04
IES5	8.618483	4.770050	28.80	532.10	1.24	9.34	0.03
IES6	8.618467	4.770017	27.30	406.90	9.88	8.12	0.03
IES7	8.618450	4.769983	30.40	469.50	8.65	10.56	0.04
IES8	8.618450	4.769967	28.80	438.20	3.71	13.40	0.03
IES9	8.618417	4.769933	36.30	563.40	1.24	18.68	0.04
IES10	8.618383	4.769883	43.30	563.40	19.76	16.24	0.05
IES11	8.618367	4.769867	40.80	563.40	23.47	10.15	0.05

IES12	8.618350	4.769833	37.10	469.50	1.24	26.80	0.04
IES13	8.618350	4.769817	30.20	313.00	18.53	13.40	0.04
IES14	8.618317	4.769783	32.30	438.20	24.70	4.47	0.04
IES15	8.618317	4.769750	21.60	438.20	8.65	0.41	0.03
IES16	8.618267	4.769733	37.30	532.10	1.24	23.14	0.04
IES17	8.618317	4.769717	26.70	500.80	1.24	9.74	0.03
IES18	8.618317	4.769767	33.30	375.60	13.59	17.05	0.04
IES19	8.618333	4.769767	37.00	344.30	24.70	17.46	0.04
IES20	8.618367	4.769800	26.10	313.00	1.24	18.27	0.03
IES21	8.618367	4.769817	35.70	500.80	6.18	17.86	0.04
IES22	8.618383	4.769867	30.80	375.60	1.24	22.74	0.04
IES23	8.618400	4.769900	26.00	344.30	1.24	16.65	0.03
IES24	8.618433	4.769917	35.60	469.50	14.82	13.80	0.04
IES25	8.618450	4.769950	31.30	375.60	18.53	10.15	0.04
IES26	8.618450	4.769983	43.00	313.00	48.17	13.40	0.05
IES27	8.618483	4.770017	24.70	406.90	1.24	10.56	0.03
IES28	8.618500	4.770050	36.10	563.40	25.94	2.03	0.04
IES29	8.618517	4.770067	22.50	406.90	13.59	0.41	0.03
IES30	8.618533	4.770100	24.40	438.20	3.71	6.50	0.03
IES31	8.618533	4.770133	20.70	281.70	12.35	6.09	0.03
IES32	8.618567	4.770133	37.70	469.50	7.41	21.52	0.04
IES33	8.618583	4.770083	39.80	469.50	24.70	14.21	0.05
IES34	8.618567	4.770050	31.70	375.60	1.24	26.80	0.04
IES35	8.618567	4.770017	49.50	688.60	1.24	30.86	0.06
IES36	8.618533	4.769983	30.50	406.90	9.88	14.21	0.04
IES37	8.618550	4.769967	37.30	594.70	1.24	18.68	0.04
IES38	8.618517	4.769950	31.70	469.50	1.24	17.86	0.04
IES39	8.618500	4.769917	39.40	500.80	19.76	14.21	0.05
IES40	8.618483	4.769883	38.00	563.40	11.12	14.62	0.05
IES41	8.618467	4.769850	27.00	344.30	4.94	14.62	0.03
IES42	8.618450	4.769833	26.40	406.90	4.94	10.56	0.03
IES43	8.618450	4.769783	26.40	438.20	1.24	12.59	0.03
IES44	8.618400	4.769767	45.30	657.30	1.24	26.39	0.05
IES45	8.618367	4.769733	38.90	500.80	1.24	26.80	0.05
IES46	8.618400	4.769700	34.30	594.70	19.76	0.41	0.04
IES47	8.618233	4.769783	46.00	500.80	43.23	9.74	0.06
IES48	8.618383	4.769667	38.90	500.80	1.24	26.80	0.05
IES49	8.618400	4.769667	34.30	594.70	19.76	0.41	0.04
IES50	8.618283	4.769667	46.00	500.80	43.23	9.74	0.06
Min			4.70	31.30	1.24	0.41	0.01
Max			49.50	688.60	48.17	30.86	0.06
Median			32.80	469.50	8.03	13.40	0.04
STDEV			7.90	110.48	11.91	7.75	0.01
SKEW			-0.66	-0.92	1.34	0.22	-0.57
KURT			2.15	3.24	1.60	-0.40	2.04
Mean			32.96	454.48	11.63	13.52	0.04

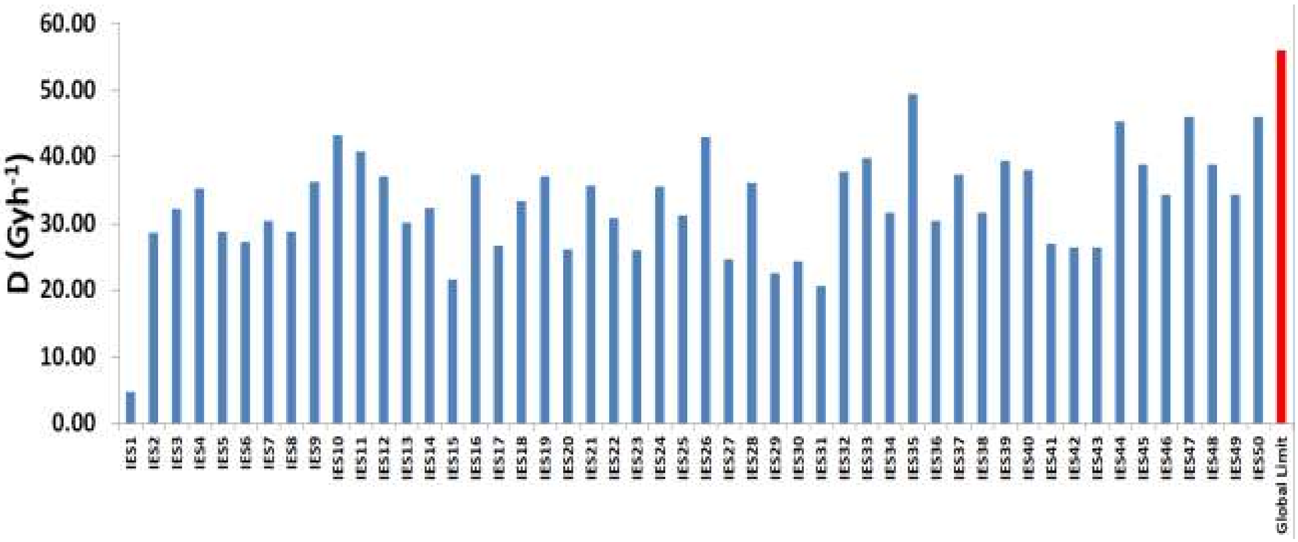

Figure 2: Absorbed Dose for the Locations

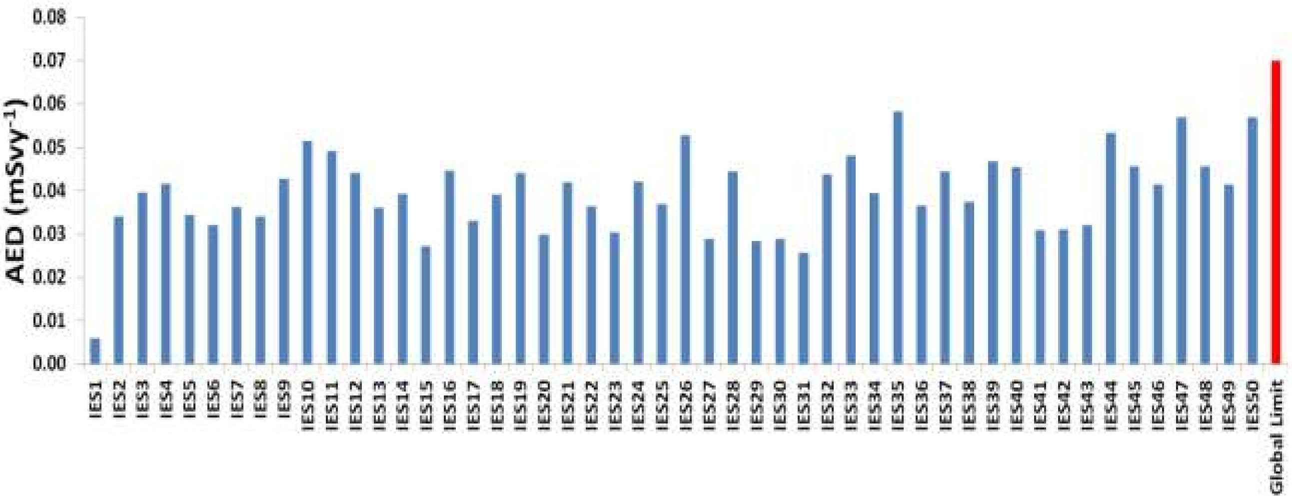

Figure 3: Annual Effective Dose for the Locations

4. Conclusion

A well calibrated gamma spectrometer Super-Spec (RS-125) was used to measure the activity concentrations of ^{232}Th, ^{40}K, ^{238}U and gamma doses rate over sharp-sand elds in Ilorin-west and Ilorin-south, North central Nigeria. The result of the measured activities of ^{40}K, ^{238}U, ^{232}Th, the gamma doses and the estimated annual effective reveals that the risk of radiation exposure is comparatively low for these locations when compared to the recommended limit. Although the general public may not be safe from exposure to indoor ionizing radiation since there is no value of radiation too low to produce stochastic effects.

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