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Evaluation of Radon Concentration in Soil Sample from Boreholes in Kaltungo Local Government Area of Gombe State, Nigeria

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ABSTRACT
The evaluation of radon concentration in soil sample from boreholes in Kaltungo local Government area of Gombe state, Nigeria have been carried out. A total of fifteen (15) soil samples were collected from different boreholes sites in five (5) different locations and were analyzed using Gamma spectrometry (Sodium Iodide with thallium NaI (TL) detector. The mean result of Radon activity concentration obtained varies from 0.86± 0.05 to 1.71± 0.03 Bqm^{-3} and the annual effective dose rate ranged from 0.0039 to 0.0077WLm/y respectively. The result shows variations in the radon concentration with various depths which indicates a relative dependence of radon concentration with depths. Comparing the results with the WHO recommended value of 100 Bqm^{-3} indicate that the mean values for all the boreholes soil samples were below the world recommended value. Also the mean values for all the boreholes soil samples were below the world average radon concentration of 40Bqm^{-3} (UNSCEAR). The values of AEDE obtained in various borehole soil samples were less than the ICRP world average. Therefore, the soil samples in each of the borehole may not pose any health threat to the residents.

Keywords:
Radon activity,
Soil sample,
Boreholes,
Annual effective dose.

INTRODUCTION

Evaluation of natural radioactivity in the residential area is of very important from different point of view especially for human health. Radon is created in the soil by radioactive decay of radium and then emitted from the ground into the atmosphere environmental assessment of radon gas (Rn) are key to the assessment of air pollution. Radon is one of the sources of radiological contamination in water and the largest contributor of the total radiation received by the general public from natural radioactive sources (Alghamdi *et al*, 2019). Naturally occurring radioactive materials enters the human body either by inhalation of radioactive gas like radon or ingestion of primordial radionuclides as well as their radioactive progenies (Oniya, 2001; Faweya, *et al* 2018; Yusuf *et al*, 2012). As product of radium decay, radon is natural radioactive gas without odour, colour, or taste. It cannot be detected without special equipment, it is an alpha-emitting noble gas that is found in various concentration in soil, air rocks and in water as a results of migration from rocks and soil in contact with the water (Kitto *et al* ,1996). Radon is un-stable radionuclides that disintegrates through short lived decay products before reaching the end product of stable lead. The short lived decay product of radon are responsible for most of the hazard by inhalation (UNSCEAR, 2000).

The terrestrial element of the natural environment depends on the composition of the soil and rocks which contain natural radionuclides.

Generally, the soil contains a small concentration of ^{238}U, whereas the granitic rocks have tens of ppm of ^{238}U, Decay of ^{238}U into a sequence of shorter lived radionuclides in inevitably creates ^{226} Ra which has a half-life of 1,620years. ^{226}Ra decay directly into ^{222} Rn through alpha particle emission being noble gas, Rn is a chemically unreactive and it moves freely in the air spaces between rocks and soil. It becomes a risk factor for cancer and lung cancer because of indoor accumulation .soil movement may cause an increase in background radiation levels, soil transferred by the wind and sandstorm causes many problem regarding health, especially to the respiratory system. Therefore exposure dose for the public should remain with the lower limits, and assessment of Rn sources are of the particular importance.

Several literatures by different authors have indicated the interchangeability and possible relationships between radon and soil in different strata as one of the means and source of contributing to radon levels in the environment. Therefore there is a need to evaluate the source contributing to radon level in our environment.

MATERIALS AND METHODS

Sample location

The research was carried out in Kaltungo Local Government area of Gombe State, Nigeria. Its headquarters are in the town of kaltungo in the west of the area on the A345 high way at 9.48'51" N11 18'32"E. It has an area of 881km^2 and a population of over 3,351,949 national population commission (2006). The average annual rainfall is 1000 mm and falls with a very short time 3-4 months in a year. The study area is of significant interest as it plays host to the region.

Sample Collection

A total of fifteen soil sample of borehole sources at different locations in Kaltungo Local Government of Gombe state. In the research 15 samples were collected at surface level of 0-10m ,10-20m, 20-30m depth from various sites of the streets (three samples for each location).

Sample Preparation

The materials used are grinder, marineh beaker, digital meter balance, 2mm sieve and the sample were each contained in their planches (flat disk) stored in desiccator and counted. The collected samples were stored for a period 3 month to make sure the samples attained the radioactive equilibrium between ^{226}Ra with its decay products in the uranium series. In the laboratory, all samples were grinded and dried in the oven (105) ^{0} ^{C} for 3 months to be free from moisture a mesh was used to sieve the soil. The soil samples were stored for three weeks to maintain a radioactive balance between the ^{226}Ra and its daughter of 4.8 cm and height of 10 cm coated with ba 0.5 cm thicker compressed sponge to flush out dust and thoron. The detector captured alpha- particle tracts emitted by ^{222}Rn (T1/2=3.82 days) of gas produced by decay of ^{226}Ra. Unexposed control (1cm*1cm), CR-39 Detectors were used for calculations of the backgrounds in the same environment of the experiment.

RESULTS AND DISCUSSION

The Radon activity and annual effective dose in soil sample from boreholes in Kaltungo LGA, Gombe State

The results of the radon activity concentrations in some selected borehole soil samples in Kaltungo LGA, Gombe State is presented in Tables 1. The measured radon activity concentration and their respective mean and standard deviations in the soil samples for different borehole points at different depth are presented. The respective visual representations and mean values are shown in Figures 1 to 4 respectively. The percentage concentration for the radon with depth in the borehole soil are presented in Figures 2(a-e).

Table 1: Radon Activity Concentration in Kaltungo LGA of Gombe State

S/No	Sample ID	GPS		Sample1 (0-10m) (Bq/m^{-3})	Sample 2 (10-20 m) (Bq/m^{-3})	Sample3 (20-30 m) (Bq/m^{-3})	Mean Value (Bq/m^{-3})	AEDE
		Latitude	Longitude					
1	LPS	N9^{O} 46'50''	E 11^{o} 16'59''	1.31	0.40	0.88	0.86±0.05	0.0039
2	TCS	N9^{O} 49'39''	E 11^{o} 18'60''	0.72	0.80	1.20	0.91±0.03	0.0040
3	KLS	N9^{O} 48'55''	E 11^{o} 17'03''	0.85	1.94	1.15	1.31±0.06	0.0059
4	LDTS	N9^{O}49'35"	E 011^{0}19'18"	1.09	1.99	0.56	1.21±0.07	0.0054
5	PSR	N10^{O} 82'68"	E 11^{0}34'02.88	1.41	1.81	1.93	1.71±0.03	0.0077

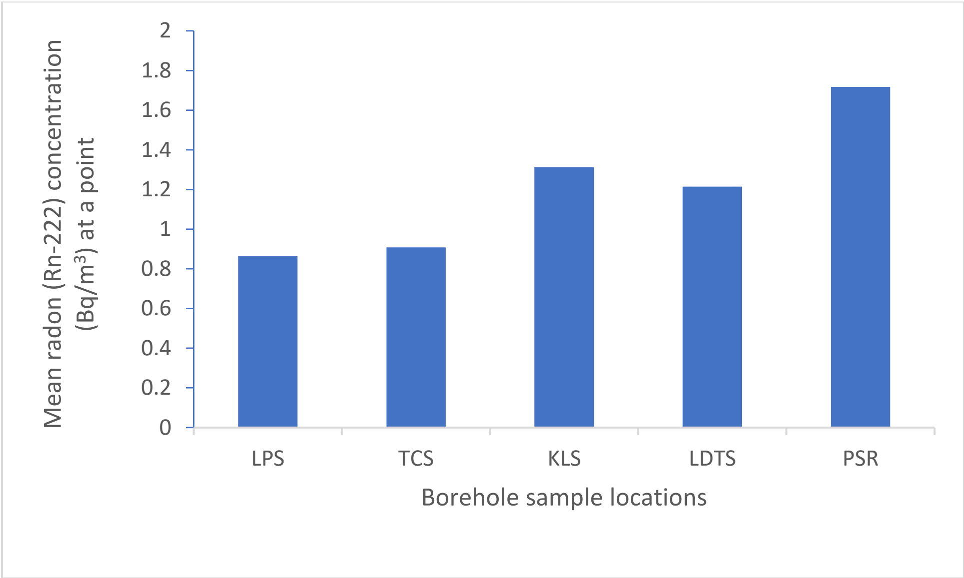
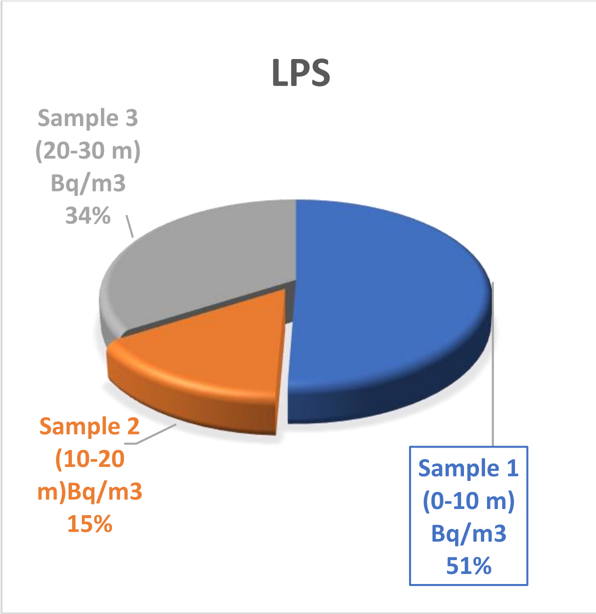
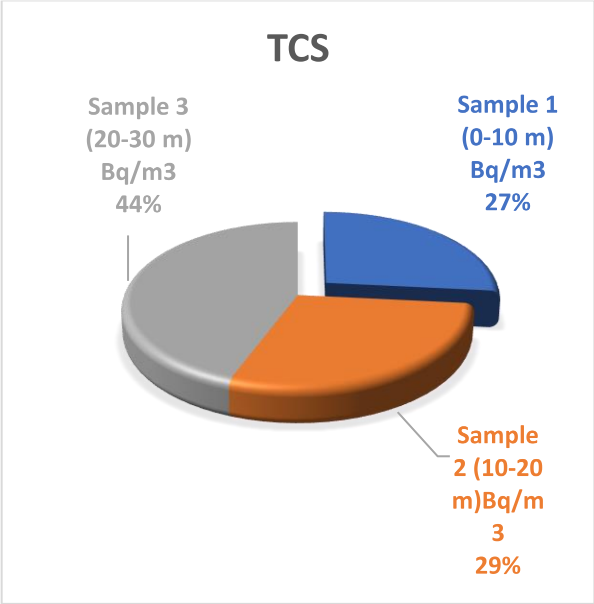


Figure 1: Mean Radon (Rn-222) activity concentrations (Bq/m^3) in soil samples at a certain depth in different borehole points.



(a)



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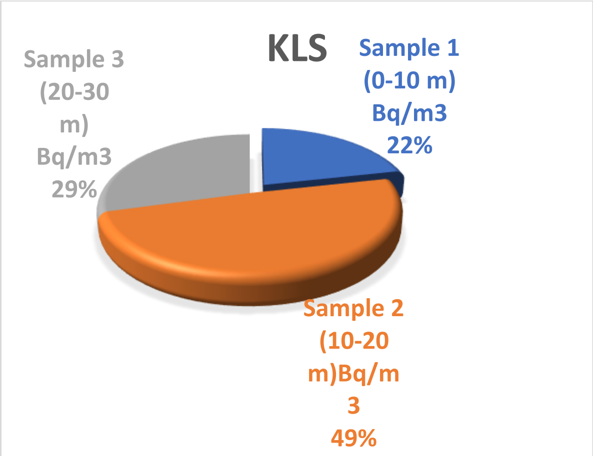

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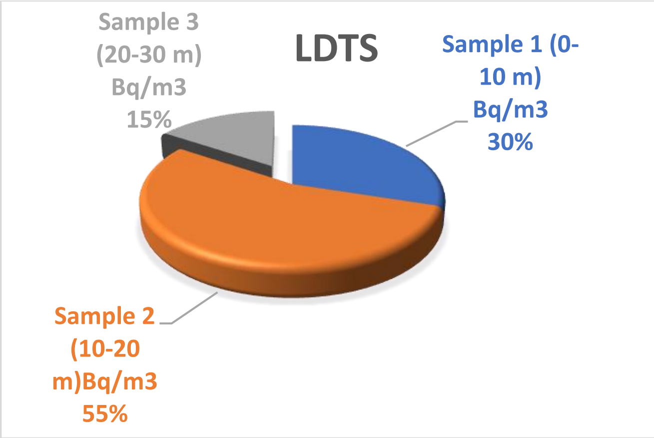

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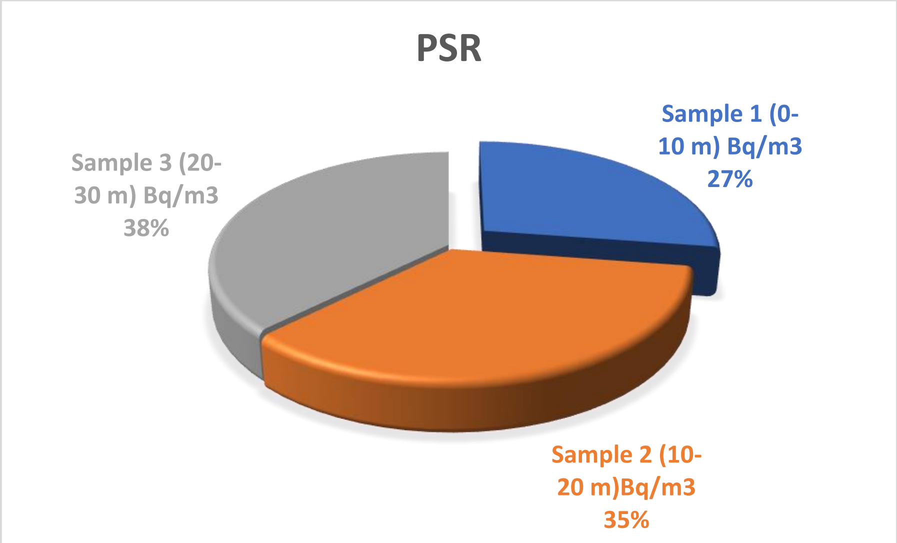

(e)

Figure 2 (a-e). The percentage concentration for radon in the borehole soil samples at different borehole.

Table 2: The annual effective dose from soil samples for different borehole of Kaltungo LGA

S/No	Sample ID	AEDE (WLM/y)
1	LPS	0.0039
2	TCS	0.0040
3	KLS	0.0059
4	LDTS	0.0054
5	PSR	0.0077

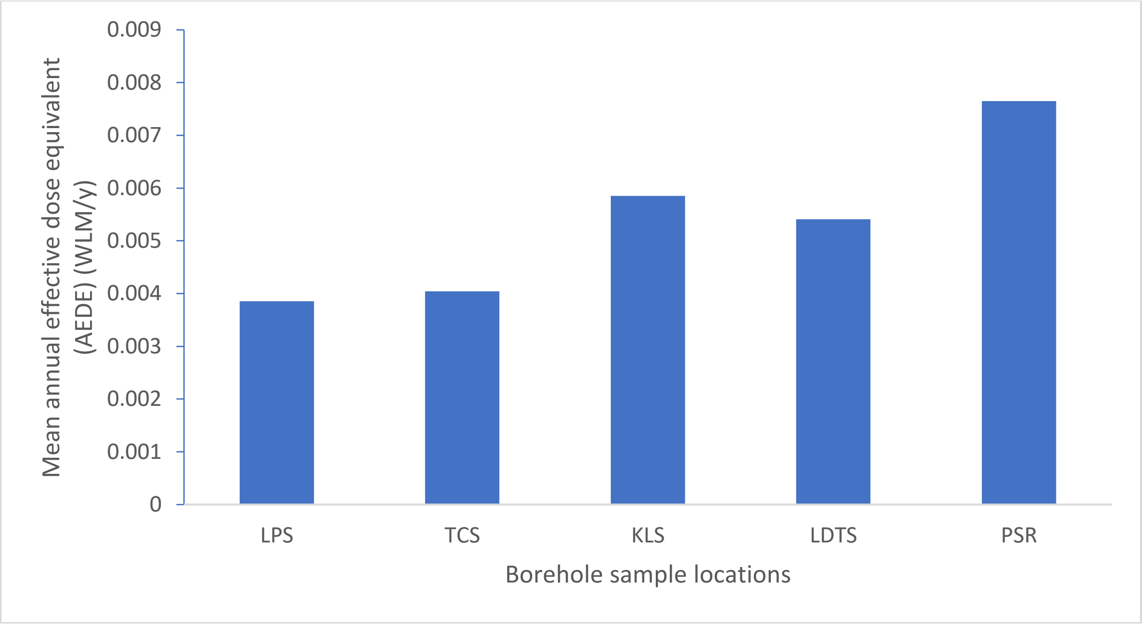

Figure 3: Mean annual effective dose equivalent (WLM/y) in soil samples at a certain depth in different borehole points

The assessment of radon activity concentrations in some selected borehole soil sample in Kaltungo LGA, Gombe State have been carried out. The radon activity concentration measured, their respective mean value and standard deviations in the soil samples for different borehole points at different depth are presented in Table 1. The respective visual representations and mean values are shown in Figures 1 and 2 respectively.

The radon concentrations in the soil samples for LPS borehole ranges between 0.40 (10-20 m) – 1.31 (0-10 m) Bqm^{-3} with the mean value of 0.86±0.05 Bqm^{-3}. In TCS, the result shows that the radon concentrations in samples ranges from 0.72 (0-10 m) – 1.20 (20-30 m) Bqm^{-3} and a mean value of 0.91±0.03 Bqm^{-3} while KLS borehole, the results of radon concentrations in the soil samples obtained ranges from 0.85 (0-10 m) – 1.94 (10-20 m) Bqm^{-3} with a mean value of 1.31±0.06 Bqm^{-3}. Also in LDTS and PSR boreholes, the result obtained ranges from 0.56 (20-30 m) – 1.99 (10-20 m) Bqm^{-3} with a mean value of 1.21±0.07 Bqm^{-3} and 1.41 (0 -10 m) – 1.93 (20-30 m) Bqm^{-3} with a mean value of 1.72±0.03 Bqm^{-3} respectively. The results show variations in the radon concentrations with various depths which indicates a relative dependence of radon concentration with depths. From the topmost (near the top surface) to 20 m in the sampled boreholes, the percentage of radon concentrations increases (22-55%) as the depth increases, except in LPS borehole samples where there was slight decrease in the percentage concentration of radon. The percentage concentration as shown in Figures 2 (a-e) for radon in the study areas are in line with the reports of Durrani and Ilic (1997) which indicated that radon concentrations depends on many parameters such a depth, porosity and moisture content of the soil. A continuous increase in radon concentration with depth (20- 30 m) were obtained in LPS, TCS and PSR respectively. The mean values for each borehole were obtained as presented in Figure 1 and the range shows that LPS borehole samples has the least mean value of 0.86±0.05 Bqm^{-3} while PSR has the highest mean value of 1.72±0.03 Bqm^{-3}.

A comparison of radon concentration in borehole soil samples with different depths from different locations show that the radon concentrations (0.03 -2.28 $kBqm^{-3}$) in soil samples of Hamirpur district, HP, of India reported by (Mehra and Bala, 2013) is higher than the present study. Mittel et al., (2015), reported a range of 941-10,050 Bqm^{-3} with the approximate mean value of 4561 Bqm^{-3} in soil sample of Northern Rajasthan, India, these results were higher than the results obtained in the present study. This may be attributable to the lithology of the area and the permeability of the soil. The radon concentrations of all the samples were below the values reported by Usikalu et al., (2017) for selected houses in Ibadan, Oyo state, Nigeria with a range of 8.76 ± 0.01 - 13.46±4.43 Bqm^{-3} and mean of 10.45 Bqm^{-3}. In the same trend, values of 19 – 160 Bqm^{-3} reported by Adewoyin et al., et al (2019) in a Pharmaceutical Company in Ota, Ogun State, Nigeria were higher than the values obtained in borehole soil samples for the study areas. Then, the general public and workers of the selected areas of study may be considered safe with respect to values obtained.

All the values obtained were below the ICRP action level of 200-600 Bqm^{-3} and also less to the reference level of 148 Bqm^{-3} set by the USEPA for the USA

(USEPA, 2004). Comparing the results with the WHO recommended value of 100 Bqm^{-3} (WHO, 2009) indicate that the average values for all the boreholes were below the recommended value. Also the mean values for all the borehole soil samples were below the world average radon concentration of 40 Bqm^{-3} (UNSCEAR, 2000).

The annual effective dose equivalent (AEDE) was estimated using the radon concentration values from each of the borehole soil samples, the results show a highest value of 0.0077 WLM/y in PSR and a least value of 0.0039 WLM/y in LPS. Also in the borehole soil samples from TCS and PSR, a close difference of 0.0001 was obtained in AEDE values as shown in table 2. The annual effective dose equivalent from all the borehole soil samples under study were considerably less than the values of 0.15 WLM and 0.23 WLM reported by Abd-Elzaher (2012) in different districts (Elmandara region and Kingmaryut region) in Alexandria city of Egypt and Orgun et al. (2008) reported 0.1 to 0.9 WLM/y for rural dwellings in Ezine of Canakhale in Turkey, these results were less than the values obtained in the present study. Also the results in the present study were less than the range of 0.036 – 0.273 WLM reported by Upadhyay et al. (2007) in LPG bottling company. The WLM can be converted into annual effective dose by using the dose conversion factors (0.16 WLM/mSv).

CONCLUSION

The study on the assessment of radon activity carried out in Kaltungo LGA with 15 soils samples taken from borehole points revealed the presence of radon in all samples. The result obtained when compared to world various permissible value were found to be below the standard limit recommended by various agencies/organizations such as ICRP, NCRP, World Health Organisation (WHO) and UNSCEAR. As a result, exposure of the inhabitants of the study area to radon may not pose a serious health threat to their lives and the environment since the concentration of radon activity is below standard limit recommended. It was observed that some locations have higher radon activity level compared to others which may be due differences in depths and moisture contain of the area. In addition, it was observed that the result of AEDE indicates no significant effects on the health of the resident of the area. Periodic monitoring is recommended to enable continuous check on the radon activity level within the study area, so it does not become toxic.

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