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ACTIVITY CONCENTRATIONS OF RADIONUCLIDES NORMS IN SOIL SAMPLES AROUND COLLEGE OF EDUCATION (TECHNICAL) KABBA, KOGI STATE, NORTH CENTRAL, NIGERIA

Obajemu Gilbert*1, Alilu Saliu Olakanm*2, Issa Ismail*3

*1,2,3College Of Education (Technical), Kabba, Kogi State, North Central Nigeria.

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ABSTRACT

Generally, soil contains some natural radionuclide that emit radiation to the environment which eventually will cause a lot of health effect and excess radiological burden to human being at high concentration above the screening level. In this studies, the activities concentrations of naturally occurring radionuclide **^{226}Ra, ^{232}Th** and **^{40}k** were determined in soil samples from College of Education Technical, Kabba, Kogi State using a well calibrated and shielded Canberra 3 x 3 inch NaI(Tl) detector at the Department of Pure physics, Ladoke Akintola University of Technology, Ogbomosho. The results shows that samples from the study area have activity concentrations ranging between 7.99±0.65 to 28.27± 1.41Bq/kg with mean value of 12.65±0.69Bq/kg for ^{226}Ra, 13.41±0.69Bq/kg to 22.66±0.89Bq/kg with means value 16.26±0.75Bq/kg for ^{232}Th and 197.57±12.51 to 376.2±3.84Bq/kg for ^{40}k. The Radium equivalent in samples ranges from 48.41 to 81.98Bq/kg with mean value of 55.62Bq/kg. Also the external hazard index was found between 0.09 to 0.22 with mean value of 0.14. The value of absorbed dose rates in the samples ranges from 22.95 to 46.64nGy/h with mean value of 28.35nGy/h. The annual effective dose rate in the studied areas varies from 28 - 57μSv/y with mean value of 35 μSv/y .The obtained values of natural radioactivity and gamma-absorbed dose rates due to the activity concentration of ^{226}Ra, ^{232}Th and ^{40}k of soil in air when compared with the international standard shows that none of the studied samples is considered a radiological hazard

Keywords: Natural Occurring Radioactive Materials (Norms), Radioactivity Concentrations.

I. INTRODUCTION

It is observed that some natural radioactivity exist in soil sample called Naturally Occurring Radioactive Materials (Norms).The main contributions of ionizing radiations due to NORMS as a result of human exposure arises from natural sources, such as cosmic rays, the nuclides in the earth's crust and the natural radioactivity of human body as well as the natural nuclides in the earth's crust. Those found to be the main sources of human radiation exposure are Potassium-40 (^{40}k), Thorium-232 (^{232}Th) and Uranium-235 (U-235) with its decay products from the latter nuclides.

The three heavy nuclides (Uranium-238,Th-232,and K-40) decay to produce other elements which in turn decay further through a chain which includes several elements eventually to end in stable isotopes of lead. An example of significant daughter nuclides in these decay chains is Radium-226 from the U-238 chain which is soluble in water. Natural radiation and radioactivity represent a continuous exposure of beings on the earth and produce a natural background that must be considered in every measurement of a radiation level or the radioactivity in sample or source. Creature on the earth are continually exposed to external radiation from cosmic rays and a number of natural occurring radionuclides that produce external gamma radiation or can be incorporated into the body to produce internal radiation doses. These sources vary widely depending on location and the surrounding environment. The remote sensing of environmental radioactivity is achieved mainly through the detection of gamma radiation. The gamma radiations are the most penetrating radiations from natural and man-made source. Spectrometers, on the other hand, measure both the intensity and energy of radiation, and this enables the source of radiation to be diagnosed. A gamma ray spectrometry is thus a powerful tool for monitoring the radiation environment.

The ionizing radiation is capable of removing electrons from atom and damaging living cells and the DNA of those cells, they possess sufficient energy to initiate ionization. Generally, radiation exposure cause adverse health effects, including genetic defect in the children of exposed parents such as cancer and the likes.It is

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therefore necessary to evaluate the concentrations of these terrestrial radionuclides to ascertain the radiation dose that can be incurred by both staff and students of the college.

II. MATERIALS AND METHODS

Descriptions of Study Area

Kabba is located in Kogi State, Kabba/Bunu Local Government Area in the Southern Guinea Savannah Agro-ecological zone of Nigeria with latitude 7 0 51'N and longitude 6 0 04'E. It has climate that is typical of humid tropics with rainfall that spans the month of May to October. The dry season extends from November to April. The vegetation of the area is dominated by tall grasses and shrubs. Also, human activities have influenced the vegetation in the area (Babalola *et al*., 2021)

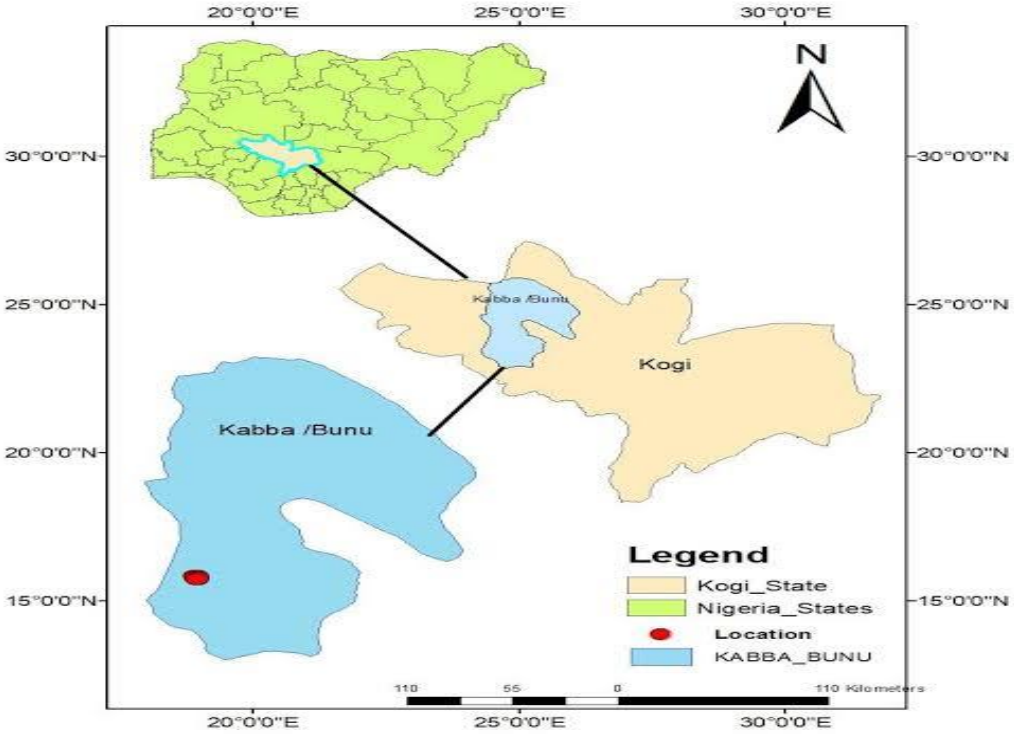

Figure 1: Map of Nigeria Showing Kabba as the study location (research gate)

Sample Preparation

The collected samples were brought into laboratory, Ladoke Akintola University of Technology, Ogbomosho and were left opened for minimum of 24 hours to dry under ambient temperature. They were grind to fine powder and packed into a plastic container of height 7cm by 6cm diameter. Each container accommodated approximately 300g of sample. They were carefully sealed (using Vaseline, candle wax and masking tape) to prevent radon escape.

The samples went through 3 stages of sealing, use of Vaseline (smeared on the inner part of the plastic's cover in other to prevent escape of ^{222}Ra which is one of the daughter product of Uranium in the decay series), the use of candle wax (melted round the space between the lid and container), and use adhesive tape (wound round the joints between containers and covers) ensuring that it is air tight. They were then stored for 29 days to allow for secular equilibrium between thorium and radium and their decay products. Table 3.0 show the site location of each collected sample point and their GPS Reading.

Table 2.1: Samples Collection Site With Their GPS Reading

SAMPLE ID	LOCATION	GPS READING
COETKB01	Administrative Block	07.760575N° 06.093401E
COETKB02	Lecture Theatre	07.453760N

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		06.054650E
COETKB03	School Library	07.769358N 06.109275E
COETKB04	Lecture Hall	07.758730N 06.096375E
COETKB05	Department Of Agric	07.769080N 06.108651E
COETKB06	Home Economic Department	07.760835N 06.095146E
COETKB07	Department Of Physics	07.769477N 06.108558E
COETKB08	Department Of Technical Education	07.770397N 06.108518E
COETKB09	ICT Center	07.769089N 06.108143E
COETKB10	Department Of Physical And Heath Education	07.770431N 06.108524E

Instrument and Counting Procedure

The gamma spectrometry system consists of a 3 x 3 inch NaI(Tl) detector a product of Princeton Gamma Tech., USA. The detector is housed in a cylindrical lead shield to reduce the effect of background radiation. The detector was coupled to a Gamma Spectacular (model GS-2000 Pro) multichannel analyzer and further linked to a computer for display. Data acquisition and analysis of gamma-ray spectra were achieved using Theremino software. Energy calibration of the detector was carried out using the RSS8 gamma source set traceable to Spectrum Techniques LLC, USA. It was accomplished by measuring the spectra of point sources emitting gamma-rays of precisely known energies and obtaining the measured peak positions of particular energies for 36000 s. The efficiency calibration of the detector was also carried out using a reference standard source consisting of known radionuclide activities: ^{40}K (578.4 keV), ^{238}U (20.9 keV) and ^{232}Th (10.47 keV).An empty container was counted for 36000 s so as to determine the background gamma-ray distribution count. The sealed samples after attaining a state of secular equilibrium were each placed on the detector for analysis one after the other. Each sample was counted for the same period of time as that of the empty container. The characteristicsof the radionuclides used in determining the activity concentrations of the sample are 1460.0 keV (^{40}K), 1764.5 keV of ^{214}Bi(^{238}U), and 2614.7 keV of ^{208}Tl(^{232}Th).

The activity concentration A (Bqkg^{-1}) of each identified radionuclide in the sample was estimated using:

$$A = \frac{C_{net}}{P_\gamma \times \varepsilon \times m \times t}$$

where C_{net} is the net peak count for each radionuclide present in the sample after subtracting the background count from the gross count, Pγ is the absolute gamma ray emission probability of the identified radionuclide, ε is the obtained full energy peak efficiency for each identified radionuclide, m is sample mass and t is the counting time. The Energy calibration region of the detector is show on table 2 while the Gamma source and Gamma spectrometry Setup are show in Plate 1 and Plate 2 below.

Table 2.2: Energy calibration of the Detector

Detector and Country of Manufacturer	NaI(Tl) 3 x 3 inch, Princeton Gamma Tech. USA
MCA (model) and Country of	Gamma Spectacular (GS-2000-Pro), Australia

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Manufacturer	
Bias Voltage	750V (DC)
Calibration source and Country of Manufacturer	RSS8 gamma source set, Spectrum Techniques LLC, USA
Activity determination energy level	1460.0keV (^{40}K), 1764.5 keV of ^{214}Bi (U-238), 2614.7keV of ^{208}Tl (Th-232)

Figure 2: Gamma Source

Figure 3: Gamma Spectrometry Set-U

III. RESULTS AND DISCUSSION

A total of 10 soil samples collected at random across Kogi State college of Education Technical, Kabba were surveyed for their radionuclide concentrations. The specific activities of ^{226}Ra ^{232}Th and ^{40}k obtained is presented in table 3.1

Table 3.1: Radioactivity Concentration (Bq/kg)

SAMPLE CODE	^{40}k ±		^{226}Ra ±		^{232}Th ±	
COETKB01	202.88	11.71	12.12	0.82	16.12	0.75
COETKB02	199.86	12.16	13.54	0.58	14.14	0.71
COETKB03	255.44	6.58	8.93	0.40	22.66	0.89
COETKB04	298.29	4.47	12.21	0.66	18.28	0.80
COETKB05	376.20	3.84	28.27	1.41	17.30	0.78
COETKB06	314.55	3.91	8.49	0.67	16.73	0.77
COETKB07	219.79	9.58	12.32	0.54	13.41	0.69
COETKB08	247.86	7.10	11.87	0.53	13.86	0.70
COETKB09	269.66	5.75	10.74	0.62	14.08	0.71
COETKB10	197.57	12.51	7.99	0.65	15.49	0.74

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RANGE	176.34	6.76	20.28	1.01	4.87	0.2
MEANS	258.21	7.76	12.65	0.69	16.26	0.75

Table 3.1 shows that, the activities concentrations of ^{40}k in all the samples range from 199.86 $\pm 12.16 Bq/Kg$ to 314.55$\pm$ 3.91Bq/Kg with a mean value of 258.21 $\pm$7.76Bq/Kg. The highest activity for ^{40}k was found in sample (COETKB 005) representing Department of Agric, the lowest activities for ^{40}k is (COETKB002) representing the school library. The activity concentration of ^{226}Ra in all the surveyed samples range between 7.99$\pm$0.65 to 28.27.27Bq/Kg with an average of 12.65Bq/kg .The highest activity concentrations of ^{226}Ra was found in sample (COETKB005) representing Department of Agric and the lowest activity concentration was found in (COETKB10) representing Department of physical and Health Education while the range of Th-232 in all the samples is between 13.41$\pm$0.69 to 22.66$\pm$ 0.89Bq/Kg with a mean value of 16.26$\pm$ 0.75Bq/Kg. The highest activities concentration was found in sample (COETEKB03) representing the school library and the lowest activity concentrations is in sample (COETKB07) representing Department of physics. The mean activities obtained from this analysis are comparable to the world average concentrations as reported by UNCEAR (2000) which are 35Bq/kg for Ra-222; 30Bq/Kg for Th-232 and 400Kq/Kg for K-40.Also, from the result obtained, absorbed dose rate (D) were calculated for radionuclide activity in the surface soil and present in table 4.3.The absorbed dose delivered by those radionuclide ranges from 22.95 to 46.64nGy/h with a mean value of 28.35nGy/h. The annual effective dose was estimated and ranging from 28 to 57µSv with a mean value of 35µSv. Also the external hazard index were found to range from 0.08 to 0.22 with mean value of 0.14. The mean value of annual effective dose and external hazard index obtained in the present studied is small compared to that by United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR)(2000). The activity concentration obtained from this study was compared with previous literature and the comparison result is presented in Table 3.2 while comparison of Annual Effective Dose Rate of the present study with others is present in Table 3.3

Table 3.2: Comparison of Activity concentrations of ^{226}Ra ^{232}Th and ^{40}k (Bq/Kg) of the present studies with others

^{226}Ra	^{232}Th	^{40}k	Region	Reference
12.68	16.27	258	Kabba	Present study
34.80	41.80	432.70	Bostwana	Murty *et al.* (2008)
30.60	63.00	152.20	West Coast India	Karunakara *et al* (2005)
32.00	81.00	412	Zambia	Malanca *et al* (1993)
46.00	49.00	650	Spain	Baeza *et al* (1992)
33.00	28.00	310	Japan	Megumi et al(1992)
32.00	40.00	420	World Average	UNSCEAR(2000)

Table 3.3: Comparison of Annual Effective Dose of the present study and others

Region	E(µSv)	Reference
Russiafacity (Jordan)	20 - 290	Al-Jundi (2003)
Greece	220-760	Probonnas and Kritidis (1993)
Nildeta (Egypt)	9- 117	Brahim *et al.* (1993)
Kalpakkam (India)	29 - 681	Kannan *et al.* (2002)
COET Kabba	28 - 57	Present study

The Radium Equivalent (Ra_{eq}), External Hazard Index (H_{ex}), Absorbed Dose Rate (D) and Annual Effective Dose Rate (E) of the studied is presented in table 3.4.

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Table 3.4: Radium Equivalent (Ra_{eq}), External Hazard Index (H_{ex}), Absorbed Dose Rate (D) and Annual Effective Dose Rate (E)

SAMPLE ID	Ra(eq) Bq/Kg	H_{ex}	(nGy/y)	E(μSv/y)
COETKB01	50	0.137	23.79	29.1
COETKB02	49.14	0.132	23.12	28.35
COETKB03	61	0.09	28.46	34.9
COETKB04	61.31	0.166	29.12	35.71
COETKB05	81.98	0.22	46.64	57.19
COETKB06	56.63	0.153	36.28	44.44
COETKB07	48.41	0.136	22.95	28.14
COETKB08	50.76	0.137	24.19	29.66
COETKB09	51.63	0.139	24.7	30.29
COETKB10	45.35	0.142	24.26	29.75
RANGE	36.63	0.078	23.69	29.05
MEAN	55.62	0.15	28.35	35

The Effective Dose Rate against sample codes is presented in Figure 4.

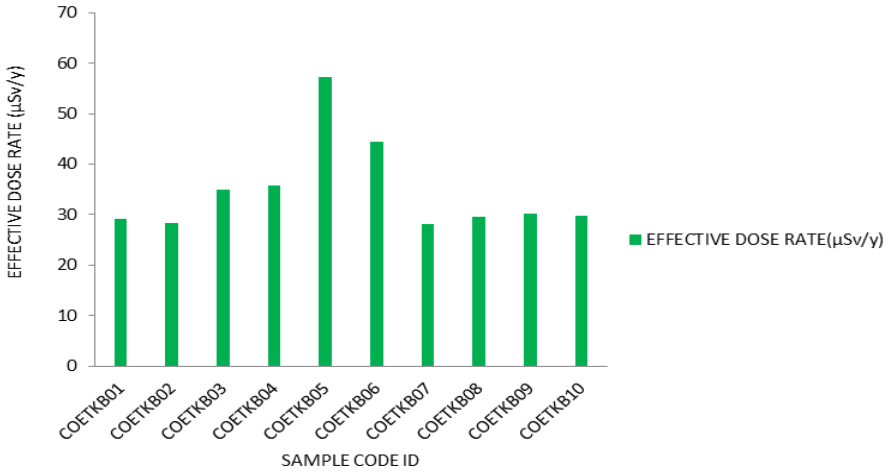

Figure 4: Effective Dose Rate against sample codes

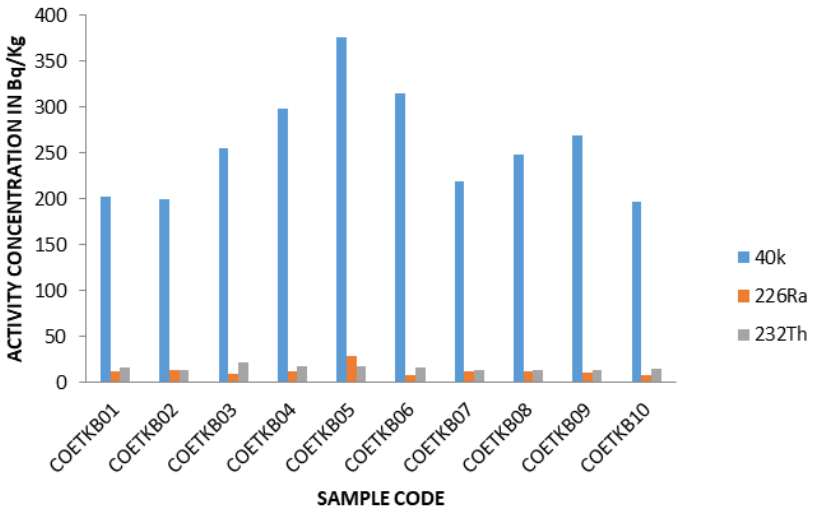

Figure 5: Activity Concentration of ^{226}Ra ^{232}Th and ^{40}k against sample Code

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IV. CONCLUSION

This study has presents of the activity concentrations of NORMs for soil samples from college of Education Technical, Kabba .The results shows that samples from the study area have activity concentrations ranging between 7.99±0.65 to 28.27± 1.41Bq/kg with mean value of 12.65±0.69Bq/kg for ^{226}Ra, 13.41±0.69Bq/kg to 22.66±0.89Bq/kg with means value 16.26±0.75Bq/kg for ^{232}Th and 197.57±12.51 to 376.2±3.84Bq/kg for ^{40}k. The Radium equivalent in samples range from 48.41 to 81.98Bq/kg with mean value of 55.62Bq/kg. Also the external hazard index was found between 0.09 to 0.22 with mean value of 0.14. The value of absorbed dose rates in the samples ranges from 22.95 to 46.64nGy/h with mean value of 28.35nGy/h. The annual effective dose rate in the studied areas varies from 28 - 57μSv/y with mean value of 35 μSv/y .The obtained values of natural radioactivity and gamma-absorbed dose rates due to the activity concentration of ^{226}Ra, ^{232}Th and ^{40}k of soil in air when compared with the international standard shows that none of the studied samples is considered a radiological hazard.

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