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DETERMINATION OF NATURAL RADIOACTIVITY IN SOIL SAMPLES OF SOME LOCATIONS IN AKURE, ONDO STATE, NIGERIA.

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Abstract – This study assesses the level of natural radioactivity due to radionuclides, ^{238}U, ^{232}Th and ^{40}K, in 16 soil samples collected from 16 locations in Akure township, Ondo State, Nigeria. The activity concentrations of ^{238}U, ^{232}Th and ^{40}K varied from 0.15 to 4.41 Bq kg^{-1}, 4.21 to 9.92 Bq kg^{-1}, and 167.79 to 419.52 Bq kg^{-1}, respectively, with mean values of 1.29±1.39 Bq kg^{-1}, 6.98±1.82 Bq kg^{-1} and 278.16±69.40 Bq kg^{-1} respectively, measured from all the soil samples studied. The mean total absorbed dose rate was obtained and the value is 16.89 nGy.h^{-1} . This average calculated absorbed dose rate in air was found to be much lower than the world average of 57 nGy h^{-1}. The outdoor annual effective dose equivalent ranged from 12.82 to 30.25 μSv.y^{-1} with mean of 20.71 μSv y^{-1}. This is considered to be low when compared to natural external radiation of about 2000 μSvy^{-1} to which no harmful effect is expected directly.

Index Terms – Naturally occurring radioactive materials, Soil samples, Gamma-ray spectrometry, ^{238}U, ^{232}Th and ^{40}K, Natural radiation dose, Annual effective dose equivalent, Absorbed dose rate.

1 INTRODUCTION

This study was carried out to determine the presence and availability of the less soluble and less mobile naturally occurring radioactive materials; ^{238}U, ^{232}Th and ^{40}K, because their presence would determine the availability of their more soluble and more mobile daughter products (such as Ra-226 for U-238 and Ra-228 for Th-232).

Soils are naturally radioactive, primarily because of their mineral content. The main radionuclides are ^{238}U, ^{232}Th and their decay products, and ^{40}K. The radioactivity varies from one soil type to the other depending on the mineral makeup and composition[1]. Soil consists of mineral and organic matter, water and air arranged in a complicated physiochemical system that provides the mechanical foothold for plants in addition to supplying their nutritive requirements[2].

Natural radioactivity is common in the rocks and soils that make up our planet just like it is in the water and the oceans and virtually every material on earth. we inhale and ingest radionuclides every day of our lives and radioactive materials have been ubiquitous in earth since its creation[3].

Tzortis and Tsertos defined natural radioactivity as being composed of cosmogenic and primordial radionuclides.

Cosmogenic radionuclides, such as 3H, 7Be, 14C, and 22Na, are produced by the interaction of cosmic-ray particles (mainly high-energetic protons) in the earth's atmosphere. Primordial radionuclides (also called terrestrial background radiation) are formed by the process of nucleosynthesis in stars. Only those radionuclides with half-lives comparable to the age of the earth, and their decay products, can still be found today on earth, e.g. ^{40}K, and the radionuclides from the ^{238}U and ^{232}Th series. Gamma radiation from these radionuclides represents

the main external source of irradiation of the human body[4].

While Merril and Thomas mentioned another form which is the anthropogenic radionuclides and described them as man-made radionuclides released into the environment through, for example, the testing of nuclear weapons, nuclear reactor accidents (e.g. Chernobyl) and in the radio-isotope manufacturing industry (^{137}Cs, ^{90}Sr and ^{131}I) [2].

The high geochemical mobility of radionuclides in the environments allows them to move easily and to contaminate mainly the environment with which human come in contact. U-238, in particular is easily mobilized in ground water and surface water. As a result, uranium and its decay product enter the food chain through irrigation water, and enter the water supply through ground water, well and surface water streams and rivers[5]. The ubiquitous gaseous ^{222}Rn formed from the decay of uranium enters the atmosphere through emanation from the soil and building materials[6].

2 STUDY LOCATION

Akure is the capital city of Ondo state, in south-western region of Nigeria. the city lies between Latitude 7º 15' 0" N and Longitude 5º 11' 42" E. Akure has an average elevation of 353 meters above sea level and an approximate population of 420,594 and the people are of the Yoruba ethnic group.

3 MATERIALS AND METHODS

SAMPLE COLLECTION AND PREPARATION: Soil samples were collected from sixteen different locations within Akure township. The samples were collected at a depth of about 10cm deep (topsoil) and sun dried for about 48 hours after which they were packed in polythene bags of non radioactive material sealed and labeled F1-F16 (with respect to their locations) for easy identification and to prevent mix-up. The samples were ground to fine powder, sieved and thereafter kept sealed in a polythene bag. For each bag, an average of 300-400 gram of sample in powder form was taken and kept for about 30 days to ensure that parent and daughter nuclei would be in a state of equilibrium before the assessment of the concentration was carried out.

4 RESULTS

Table 1 represents the activity concentration of radionuclides for each soil sample measured in Bqkg^{-1}. Table 2[7] shows the reported values of gamma activity in soil samples (Bqkg^{-1}), from the work conducted worldwide, this is necessary to serve as a comparison with this present study.

The gamma absorbed dose rate in air can be calculated using the [8,9] equations given as

$$D = 0.042\ SK + 0.429\ SU + 0.666\ STh \quad (1)$$

where D is the total absorbed dose in air due to the specific activity concentration SK, SU and STh in Bq/kg, respectively. D is measured in nGy hr-1. The absorbed dose rate in air due to each radionuclide at each collection site was calculated using the equation above. The values obtained are presented in Table 3.

The absorbed gamma dose rates in air are usually related to human absorbed gamma dose in order to assess the effectiveness of the gamma dose in causing damage to human tissues. One can make an assessment of the outdoor effective dose equivalent to the population by considering two factors. The first is a conversion factor which converts the absorbed dose rate in air to human effective dose equivalent while the second factor gives a measure of the proportion of the total time for which an individual is exposed to a radiation field either indoors or outdoors [10]. The United National Scientific Committee on Effect of Atomic Radiation (UNSCEAR), has recommended 0.7 Sv/yr as the value of the first factor and 0.2 as the outdoor occupancy factor. Equation (2) [11] was used to determine the outdoor human effective dose equivalent to the population.

$$E_{air} = TQ\check{D}_{air}\varepsilon \quad (2)$$

where E_{air} is the annual effective dose rate (μSvy1), T is the time being 8760 hy-1, Q is the quotient of the effective dose rate and absorbed dose rate in air (0.7SvGy-1), ε is the conversion factor [12]. The outdoor annual effective dose equivalents obtained for the samples are presented in Table 4.

Table 1: Activity Concentration of Radionuclides for each Soil Sample (in Bq kg-1)

LOCATION	SAMPLE	^{40}K Bq/kg	^{238}U Bq/kg	^{232}Th Bq/kg
Odo-Ile	F1	362.24	0.22	5.05
Green Park	F2	227.66	0.61	6.31
Oyemekun	F3	291.68	0.15	6.31
Ijoka	F4	217.77	0.51	6.12
Adegbola	F5	234.37	0.23	4.21
Stadium Road	F6	231.4	0.34	4.81
Iwalewa	F7	210.68	0.52	7.81
Orita-Obele	F8	167.79	0.62	4.71
Arakale	F9	373.18	2.06	6.52

Ondo Road	F10	419.52	2.59	8.91
Stateline	F11	289.36	3.12	8.61
Oluwatuyi	F12	281.29	0.45	9.92
Isikan	F13	268.33	0.69	9.01
Awule	F14	346.54	0.58	6.11
Onyearugbulem	F15	221.53	3.64	9.01
Oke-Ijebu	F16	307.17	4.41	8.31
Summation		**4450.51**	**20.74**	**111.73**
Mean		**278.16**	**1.29**	**6.98**
Standard Deviation		**69.40**	**1.39**	**1.82**

Table 2: Reported values of gamma activity in soil samples ($Bqkg^{-1}$), from the work conducted worldwide (Table Source: [7]).

Region (country)	**238U**	**232Th**	**40K**	**Reference**
Tripoli, Libya	10.5	9.5	270	Shenber (1997)
Istanbul, Turkey	21	37	342	Karahan and Bayulken (2000)
Russiafa, Jordan	48.3-523.2	8.7-27.1	44-344	Al-Jundi (2002)
Kalpakkam, India	5-71 (16)	15-776 (119)	200-854 (406)	Kannan et al. (2002)
Syria	19	24	336	Al- Masri et al. (2006)
World Average	40	40	370	UNSCEAR (2000)

Table 3: Gamma Absorbed Dose Rate due to each location ($nGyh^{-1}$)

Samples	**Absorbed Dose Rate ($nGyh^{-1}$)**
F1	18.67176
F2	14.02587
F3	16.51737
F4	13.44105
F5	12.74607
F6	13.06812
F7	14.2731
F8	10.45002
F9	20.89962
F10	24.66501
F11	19.22586
F12	18.61395
F13	17.56653
F14	18.87276
F15	16.86648
F16	20.32749
Summation	**270.23106**
Mean	**16.88944125**
Standard Deviation	**3.693908892**

Table 4: Annual Effective Dose Equivalent (μSvy^{-1})

Sample	**Annual Effective Dose Equivalent (μSvy^{-1})**
F1	22.89905
F2	17.20133
F3	20.2569
F4	16.4841
F5	15.63178
F6	16.02674
F7	17.50453
F8	12.8159
F9	25.63129
F10	30.24917
F11	23.57859
F12	22.82815
F13	21.54359
F14	23.14555
F15	20.68505
F16	24.92963
Summation	**331.4114**
Mean	**20.71321**
Standard Deviation	**4.53021**

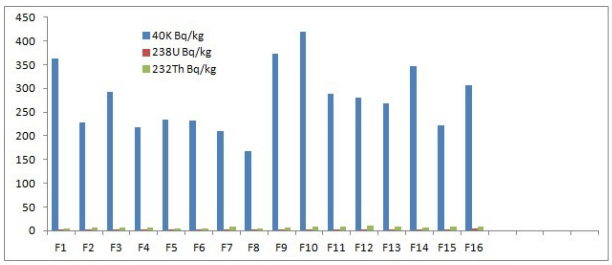

Figure 1: Activity Concentration of each radionuclide against Sample Locations

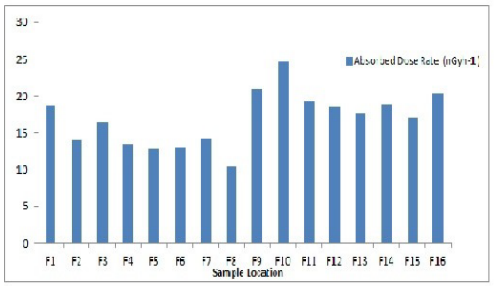

Figure 2: Absorbed Dose Rate (nGyh^{-1}) Against Sample Location

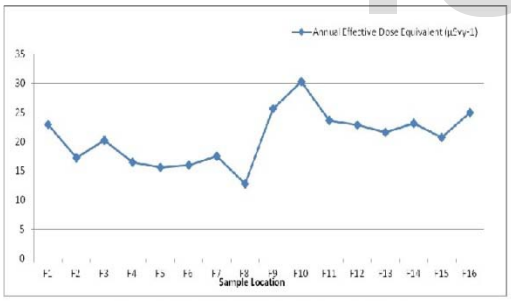

Figure 3: Graph of Annual Effective Dose Equivalent (μSvy^{-1}) against Sample Location

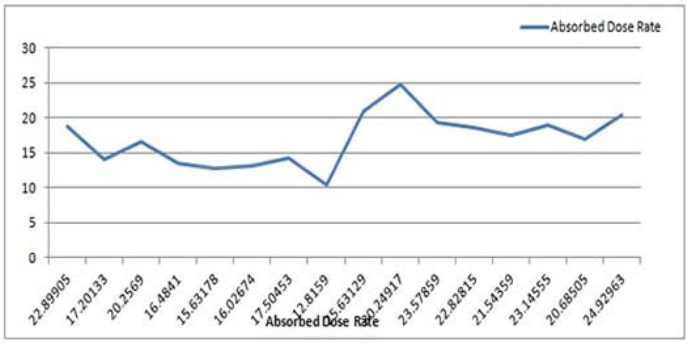

Figure 4: Annual Effective Dose Equivalent (μSvy^{-1}) against Absorbed Dose Rate (nGyh^{-1})

DISCUSSION

The radionuclide analysis of soil samples carried out across the sixteen locations within Akure township revealed that the basic composition of the radioactive element of soils in UI include: ^{40}K, ^{238}U and ^{232}Th.From the result, it is concluded that Ondo Road area in Akure has the highest concentration of ^{40}K with a value of 419.52 Bq/kg with the lowest concentration of 167.79 Bq/kg in Orita-Obele area; Oke-Ijebu has the highest concentration of 4.41 Bq/kg for ^{238}U while Oyemekun area has the lowest with 0.15 Bq/kg; and Oluwatuyi area has the highest concentration of 9.92 Bq/kg for ^{232}Th with the lowest being 4.21 Bq/kg at Adegbola area.

Fig. 2 shows the absorbed dose rate for the three radionuclides found in the soil samples. It could be seen that Location F8 (Orita-Obele) has the lowest absorbed dose rate value while Location F10 (Ondo Road) has the highest absorbed dose rate value. The same locations have the highest peaks in fig. 3 and fig. 4 for the annual effective dose equivalent. This could be because both locations have the lowest and highest values respectively for the activity concentration of ^{40}K regardless of their activity concentration values for ^{238}U and ^{232}Th.

CONCLUSION

The world standard average for the absorbed dose rate is 70 (nGyh^{-1}) [13], and from the study carried out for the 16 locations in Akure, a mean of 16.89 (nGyh^{-1}) was obtained which is lower than the specified average which implies that the areas are safe. This value is about 24% of the world average [13] and about 1.51(nGyh^{-1}) less than the value obtained for some locations in Ekiti and Ondo States (in Nigeria) in a similar study [14]. This shows that the background radiation burden on the populace of these locations and its consequent health hazard is not

significant.

Also, the world standard average for the annual effective dose equivalent is 70 (μSvy^{-1}), and a mean of 70.67 (μSvy^{-1}) was obtained which is still a safe value.

Furthermore, the presence of the radionuclides is not hazardous in those locations as there is no continuous production of the nuclides. This study would be beneficial for the locations and also for research purposes if repeated annually at the areas to determine the effects ,if any the presence of radionuclides will have on the locations. . The data obtained in this work can reliably serve as the regional baseline data for the assessment of any future environmental radioactivity contamination or pollution from nuclear accidents, nuclear weapons tests, radioactive waste dumps or industrial emissions in the region studied in respect of dose rate.

In all, the study shows that the areas covered have a background radiation level which is within the natural limits and do not pose a great health risk to the inhabitants of those communities.

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CONFLICT OF INTEREST

The author(s) declare(s) that there is no conflict of interests regarding the publication of this article.

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