



Statistical Measures of Variation in Gama- Emitting Radionuclide Concentration in Soil Samples Randomly Collected in Five Towns in Boripe Local Government Area, Osun State, Nigeria

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Abstract: Health, people say is wealth. Man has been facing serious challenges of complicated health disorders nowadays which may be pathogenically induced or through radiations from radioactive substances. The knowledge of natural radioactivity present in soil enables us to assess any possible radiological hazard to mankind by coming in contact with soil using the radiation health hazard indices. This study measured variations in Radionuclide concentration in soil samples collected in ten different locations in five major towns within Boripe Local Government area, Osun state, Nigeria. Radiological implications were measured using gamma ray spectrometry. The radio-nuclides of interest are Potassium (K-40), Uranium (U-238) and Thorium (Th-232). The analysis of variance was carried out using a non-parametric KruskalWallis H test. The results of the analysis showed that the difference in activity concentrations measured in the five selected towns are not statistically significant as the null hypotheses were retained in all cases; which indicate that the selected towns have equal risk of radionuclide emission hazard. The study further revealed that the radiation concentrations and doses due to radionuclides in the environment surveyed are very low and almost insignificant to cause any serious health problems to the people living in the areas when compared with the recommended world tolerance level.

Keywords: Radionuclide, gamma-ray, spectrometry, activity, variation, kruskal walis

1. Introduction

The knowledge of radionuclide distribution levels in the environment is important in assessing the effects of radiation exposure due to natural and man-made sources. Natural radioactivity is widespread in the earth environment and it exists in various geological formations such as earth crust, rocks, soils, plants, water and air. (Avwiri et al, 2012). The long term exposure to radionuclide like radium and thorium through inhalation has severe health effects such as chronic lung diseases, acute leucopenia, anemia and necrosis of the

mouth Radium causes bone weakening, cranial and nasal tumors. Other diseases caused by radioactivity exposure include lung cancer, pancreas, hepatic, bone, skin, kidney cancers, cataracts, sterility, atrophy of the kidney and leukemia. Other diseases caused by radioactivity exposure include lung cancer, pancreas, hepatic, bone, skin, kidney cancers, cataracts, sterility, atrophy of the kidney and leukemia. (Taskin *et al.*, 2009).

The main external source of terrestrial gamma irradiation to which the human population is exposed is the naturally occurring radio-nuclides belonging to the decay

series of ^{238}U and ^{232}Th and the nuclide ^{40}K , which exist at trace levels in the undisturbed earth's crust. This terrestrial background radiation contributes about 23% of the average annual dose to humans from all radiation sources (ICRP, 1991) and depends on geographical conditions and local geological characteristics. Therefore it appears at different levels in the rocks and soils of each locality in the world (UNSCEAR, 2000). It has been established that soil results from the weathered rocks that occupy a confined region. The composition of the activity concentration of ^{238}U , ^{232}Th and ^{40}K in the soil depend on the parent rock from which the soil originates.

The soil, apart from covering the earth's surface is the template on which human being exists, not that alone, a large percentage of the land or cultivable and over 70% of the population live by farming. The farmers plant both cash and food crops. The farmers and cattle keepers use the grassy portion of the land area as pasture for grazing animals especially during the dry season (November-March) when there is whittle grass in the northern part of the country.

Man often makes use of soil excavated during road or drainage constructions for blocks, Ceramics, Pottery, and filling of house foundation during construction. Apart from the activities of man in his environment that may contribute to exposure of people to radiation. Radiation could be from natural sources, i.e. natural disintegration of neighbouring rocks and the natural radioactivity levels in rocks depend upon the type of rock.

Large amount of data concerning the distribution of these primordial radio-nuclides in crystalline rock from different continental and oceanic island sites have been published. Out of the three types of rock that we have; igneous rocks (which are mainly of silicates and free silica) of granite composition are known to be rich in Uranium and thorium. The Uranium and thorium concentration in igneous rocks vary with the percentage of silica as with ^{40}K . The concentration of ^{40}K in sedimentary rocks depends upon the relative amounts of the feldspars, micas and clay minerals that make up the minerals aggregate sediments, with the exception of some phosphate rocks that contain Uranium and thorium and decay nuclides in concentrations far exceeding the average abundance in the earth's crust (Jaworowski, 1982, UNSCEAR 2000). In essence, the type of rock that predominates in an area, determines the type, and concentration of radionuclides in that environment in which if it is higher than the permissible dosage can have adverse effect on the populace directly or indirectly.

Plants take up radio-nuclides from soil through the process of nutrient adsorption, transpiration and translocation, so also the herbivores they collect plant materials through which radionuclide species concentrate on specific animal tissues, therefore reducing the concentration of these radio-nuclides in soils of different localities depend on the degree of grazing and cultivation. Therefore, this study is aimed at measuring the natural radioactivity concentration and establishes the degree of variations of these substances among the selected towns which were randomly selected in Boripe Local Government area in Osun state, Nigeria.

2. Materials and Methods

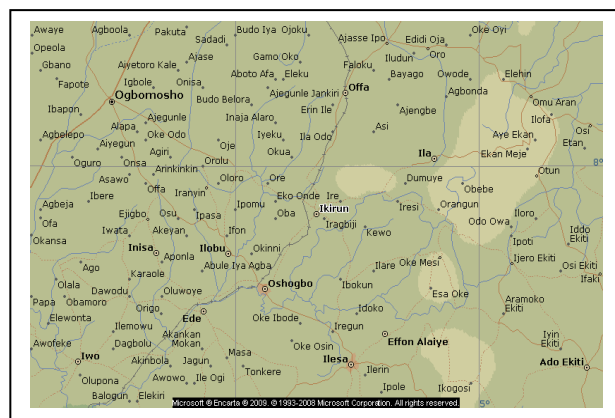
Different soil samples were collected from five different towns within Boripe Local Government area. Two samples were randomly collected from each location and analyzed in laboratory. The data were collected from original source; hence, the source of information is primary data collected through personal observations method. For the purpose of analysis, the data was divided into five groups using town as stratification factor. The geographical positions of the towns were ascertained using GPS. The locations and areas of collection were as shown in Table 2.1.

Table 2.1: Sample code and locations.

Sample Code	Location	Group
1	Local Government School, Iragbiji	1
2	Seventh-Day Adventist Church, Iragbiji	
3	St Lukes Anglican church, Aagba	
4	Central Mosque, Aagba	2
5	Baptists Primary School, Ada	
6	Jesus emperor Petrol station, Ada	3
7	SLT department, Osun State Poly	
8	Post Office Iree, Nigeria	4
9	Community High School Eripa.	
10	Rinsayo Guest Inn, Eripa	

Figure 1: Map of Nigeria showing areas of sampling location.

3. Extraction of Radio-Nuclides



The soil samples collected from different locations as shown in the Table 2.1 were homogenized, air-dried and scard through a 2mm mesh. The samples were carefully packed in thick plastic containers and kept for four weeks to ensure secular equilibrium between the natural radionuclide and their respective progeny (Ibrahim *et al*, 1993) before the laboratory analysis, and also to avoid radon diffusion and ensure secular equilibrium between ^{238}U , ^{232}Th and their respective progenies (Albert *et al*, 1995).

The samples were then analyzed in the laboratory with a 7.6cm x 7.6cm NaI (TL) detector with a resolution of about 8.0% at 0.662MeV gamma ray energy from ^{137}Cs . The detector was placed inside a lead shielded counting chamber

and was coupled to a Canberra series 10 plus multi channel analyzer. The gamma energies of 1.46MeV, 1.7MEV and 2.62MeV were used in the analysis of ⁴⁰K, ²³⁸U and ²³²Th, respectively. The background distribution due to the naturally occurring radionuclide in the detector environment and the IAEA standard sources (RGK – 1CK₂SO₄), RGU – 1(V – ore) RGTh – 1 (Th – ore) used for the calibration of

the detector were determined by counting an empty plastic container for 36000s in the same manner in which the samples were counted. The counting uncertainty automatically computed by the MCA was used as the uncertainty in the determination of the radionuclide.

Absorbed dose rate (D) was obtained using ICRP – international commission of radiology protection. The Beck et al (1972) formula, $D \text{ (nGyh}^{-1}\text{)} = (0.051(a/m)_{\text{u}} + 0.076(a/m)_{\text{th}} + 0.0048\{a/m\}_{\text{k}} \times 8.73$. Where (a/m), are the activity of natural radionuclide at 1.0m above the ground. The mean annual effective dose to main (H) was calculated using the conversion factor of 0.7 SvGy⁻¹ for dose rates in air and an outdoor occupancy ratio of 0.2 (IAEA, 1989). The collective effective dose equivalent [SE] was calculated for the local government area using $SE = NH$, where N is the population of the L.G.A and it is the mean annual effective dose equivalent to each individuals (ICRP, 1991).

3.1. Statistical Tool

Kruskal wallis H test for independent samples and descriptive statistics tools were used. Kruskal wallis test is somewhat an extension of One-way analysis of variance F-test (ANOVA). It provides an alternative means of finding significance of difference between more than two means. It starts by substituting the rank in the overall data set for each measurement value. The smallest value gets a rank of 1, the second smallest gets a rank of 2, etc. Tied observations get average ranks; thus if there were four identical values occupying the fifth, sixth, seventh and eighth smallest places, all would get a rank of 6.5. The sum of the ranks R_i is calculated for each group i ($i = 1, 2, \dots, k$) of size n_i , then the test statistic H from (1) below is calculated, which basically represents the variance of the ranks among groups, with an adjustment for the number of ties. H is approximately χ^2 distributed, with the degrees of freedom equal to the number of groups k minus 1 (Tanja, 2010).

The test statistic is given as:

$$H = \frac{12}{n(n+1)} \sum \frac{R_j^2}{n_j} - 3(n+1).....(1)$$

Where

R_j^2 = the rank sum associate with jth sample

n_j = the number of observations comprising the jth sample

K = number of samples.

$n = n_1 + n_2 + \dots + n_k$ = total number of observations over all samples.

For large samples, H is approximately chi-square distributed with $K-1$ degrees of freedom.

3.2. Hypotheses

for all towns

$$H_{0i} : \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 \text{ for at least one town}$$

Versus :

$$H_{1i} : \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5$$

Where

$i = 1, 2, \text{ and } 3$

Since the study has three treatments which are the extracted radionuclide elements..

μ_1 - the mean concentration for Iragbiji.

μ_2 - the mean concentration for Aagba.

μ_3 - the mean concentration for Ada

μ_4 - the mean concentration for Iree.

μ_5 - the mean concentration for Eripa.

3.2.1 Decision criteria

Reject H_0 if P Value < 0.05, otherwise do not reject

3.3. Statistical Package

The statistical package used for the analysis is IBM SPSS version 20.

3.4. Data Presentation and Analysis

The results of the radionuclide concentration in soil samples in Boripe Local Government area in Osun state with their affected areas is as shown in Table 3.1 below:

Table 3.1: Radio nuclide concentration in soil samples

Sample Code	Location	K-40	U-238	TH-232	K-40
1	Local Government School, Iragbiji	7.47±4.94	2.15±2.74	4.52±2.61	7.47±4.94
2	Seventh Day Adventist Church, Iragbiji	11.57±5.24	3.06±2.91	3.34±2.00	11.57±5.24
3	St Lukes Anglican church, Aagba	5.99±4.56	7.72±3.25	9.33±2.84	5.99±4.56
4	Central Mosque, Aagba	8.62±8.01	1.89±2.37	9.73±3.04	8.62±8.01
5	Baptists Primary School, Ada	5.76±4.36	NIL	1.06±1.89	5.76±4.36
6	Jesus emperor Petrol station, Ada	4.36±4.41	2.54±2.88	3.65±2.28	4.36±4.41
7	SLT department, Osun state Polytechnic, Iree	6.00±4.31	1.67±2.3	4.69±2.62	6.00±4.31
8	Post Office Iree, Nigeria	10.03±8.13	6.22±2.98	1.75±2.03	10.03±8.13

9	Community High School Eripa.	7.35±4.28	3.43±3.06	6.34±2.59	7.35±4.28
10	Rinsayo Guest Inn, Eripa	5.37±4.2	1.21±2.11	3.46±2.35	5.37±4.2

Source: Field work, 2013

Table 3.2: ANOVA for K-40

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of K40 is the same across categories of GROUPS.	Independent-Samples Kruskal-Wallis Test	.181	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 3.2: Shows that the null hypothesis is retained; hence there is no significant difference in the content of K-40 in the soil of the five towns.

Table 3.3: ANOVA for U-238

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of U238 is the same across categories of GROUPS.	Independent-Samples Kruskal-Wallis Test	.416	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

The null hypothesis is retained in Table 3.3 above indicating insignificant difference in U-238 contents in the soil of the five towns.

Table 3.4: ANOVA for TH-232

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of U238 is the same across categories of GROUPS.	Independent-Samples Kruskal-Wallis Test	.416	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

The null hypothesis is also retained as shown in Table 3.4; signifying there is no significant difference in the contents of TH-232 in the soil of the five towns.

4. Results and Discussion

The results of this study have clearly revealed that the differences in the concentration of radio-nuclides measured are not significantly different among the selected towns in the Local Government area. There are not enough statistical evidences to show that the differences in the concentration of radio-nuclides among the towns are significantly different. This implies that the towns have equal risk of radio-nuclide hazard.

The descriptive statistics in appendices A, B, and C and Table 3.1 showed that the activity concentrations measured ranged from $4.36 \pm 4.41\%$ Bq/kg to $12.57 \pm 5.28\%$ Bq/kg for ^{40}K , $1.2 \pm 2.11\%$ Bq/kg to $7.72 \pm 3.25\%$ Bq/kg for ^{238}U and $1.06 \pm 1.89\%$ Bq/kg to $10.22 \pm 3.10\%$ Bq/kg to $10.22 \pm 3.10\%$ Bq/kg for ^{232}Th . These results showed that the activity concentration in the areas studied did not exceed the permissible level when compared with Ajayi *et al.*, (2008) and Arogunjo, (2002). Hence, the environment is safe from the hazardous implications of the radionuclides as at the time the data used for this study were collected.

5. Conclusion

Elucidating the results of the analysis, it is concluded that Gamma-emitting radionuclide under study are equally distributed in the selected towns in the Local Government area as shown in tables 3.2,3.3, and 3.4 and that the concentrations in the area studied did not exceed the permissible level. It is however recommended that adequate and regular monitoring exercise should be carried out by researchers for early detection and checkmating of any accidental outburst of radionuclide radiation which may expose the dwellers of the community to the risk of radiological hazards.

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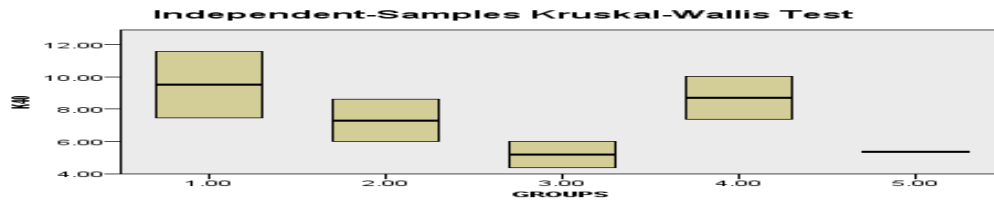
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APPENDICES

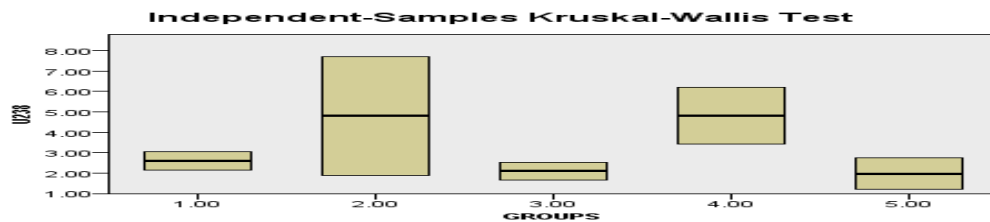
Appendix A: Descriptive Statistics for K-40



Total N	10
Test Statistic	6.256
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	.181

1. The test statistic is adjusted for ties.
 2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

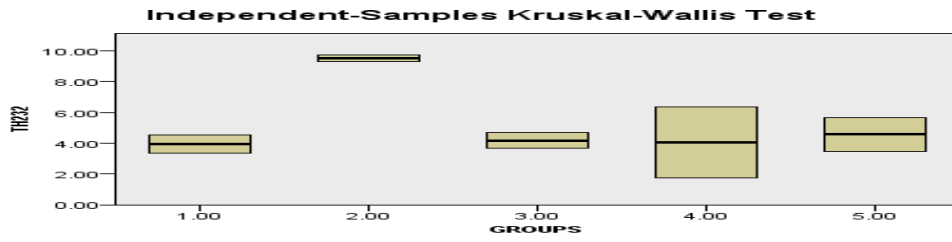
Appendix B: Descriptive Statistics for U-238



Total N	10
Test Statistic	3.927
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	.416

1. The test statistic is adjusted for ties.
 2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Appendix C: Descriptive Statistics for T-232



Total N	10
Test Statistic	4.691
Degrees of Freedom	4
Asymptotic Sig. (2-sided test)	.321

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.