Determination of External and Internal Hazard Indices from Naturally Occurring Radionuclide in Rock, Sediment and Building Samples collected from Sikiti, Southwestern Nigeria.

Ibrahim Ayodeji Bello[1*] Nnamdi Nobert Jibiri[2] Hameed Adavize Momoh[3]

1. Kabba College of Agriculture, Ahmadu Bello University Zaria, Nigeria
2. Department of Physics, University of Ibadan, Nigeria
3. Nigeria-Korea Friendship Institute, Kogi State Polytechnic Lokoja, Nigeria

* E-mail of the corresponding author: dbell1066@yahoo.com

Abstract

A study of natural radioactivity of Rock, Sediment, and Building samples collected from different areas of Sikiti settlement, in southwestern Nigeria was carried out via gamma-ray spectrometry, using NaI (Tl) detector. The mean Activity concentration of ^{40}K, ^{226}Ra and ^{232}Th in Rock samples was 935.05 ± 702.08 BqKg^{-1}, 3.04 ± 5.44 BqKg^{-1} and 271.69±301.04 BqKg^{-1} respectively. Mean Activity concentration of ^{40}K, ^{226}Ra and ^{232}Th in Building samples was 426.95±129.19 BqKg^{-1}, 28.15 ± 16.93 BqKg^{-1} and 107.30±23.83 BqKg^{-1} respectively, while Sediments samples had 426.03±137.50 BqKg^{-1}, 28.52±10.03 BqKg^{-1} and 30.32±15.35 BqKg^{-1} concentrations respectively. The external and internal hazard indices for rock samples were above permissible limit (i.e. >1). Also the external and internal hazard indices for sediment and building material samples were below permissible limit (i.e. <1). Therefore, rocks, sediments, and building materials found in Sikiti settlement may be used by farmers, miners and residents of the area with a lot of caution, to prevent radiation exposure which may result from long term cumulative effect.

Keywords: rock, sediment, clay, building materials, activity concentration, internal hazard index, external hazard index, radiation exposure, sikiti, oyo state

1. Introduction

Natural sources of radiation constitute 80% of collective radiation exposure to the word population (UNSCEAR, 2000). These radionuclide have different sources: they include earth crust, rocks, soils, plants, water, sediments, minerals and air (Faweya and Oniya, 2012). The great interest expressed worldwide for the study of naturally occurring radionuclide and environmental radioactivity has led to the performance of extensive surveys in many countries of the world (Bello, A.I., 2012).

Natural radioactivity concentration mainly depends on geological and geographical conditions and appears at different levels in soil of each geological region. Exposure to natural sources of radiation is mainly due to cosmic and gamma rays emitted from soil, rocks, building materials, food and water sediment (Alaamer, 2008). Some radioactivity studies have previously been carried out on soil and sediment samples in some parts of Nigeria (Adewuyi, G. O, *et al.*, 2011, Alaamer, 2008, and Jibiri, N. N, *et al.*, 2000).

The exposure of naturally occurring radionuclide from elevated radiation area in Sikiti, Southwestern Nigeria can be useful for the assessment of public dose rates and performance of epidemiological studies, as well as to keep reference data records. Data collected from Sikiti settlement could be compared with that from other radioactivity studies in Nigeria.

Sikiti settlement is the study area and is located on latitude 7.63333^0 and longitude 3.516667^0 east of the Greenwich meridian. It can be accessed through Eruwa-Lanlate road, about 103.7Km from Ibadan (Oyo State Capital, Nigeria) and farming and mining activities take place around the settlement.

The objective of the present study is to determine the external and internal hazard indices from radiation elevated areas of Sikiti settlement in Southwestern Nigeria.

2. Materials and Methods

2.1 Sample Collection

A Digital Survey meter (RAD EYE PRD) was first used to take the environmental area survey of the sampling locations. Also, the geographical location of each sample was determined by a hand held Global Positioning System (Etrex Vista). The building material (Clay) and sediment samples were collected at a depth of 10cm. The rock samples were collected by cracking the surface of the parent rock with the use of hammer. Finally, the collected samples were bagged, labeled and taken to Radiation and Health Physics Laboratory, at the University of Ibadan for preparation, measurement and analysis.

2.2 Sample Preparation

The samples were sun dried, crushed and sieved with 2mm mesh, to increase the total exposed area. An electronic balance was used to weigh 150g of each sample. Each sample was packed into a cylindrical plastic container of diameter 6.7cm. This could sit on the 7.6cm x 7.6cm NaI(Tl) detector. The plastic containers were tightly covered, sealed with masking tape and left for about 28days in order to attain secular equilibrium between radium and its gaseous decay progenies.

2.3 Sample Measurement

Gamma ray spectroscopic systems which consist of a shielded 7.6cm x 7.6cm NaI(Tl) detector, coupled to a Canberra series 10-plus multichannel analyzer (MCA), was used to analyze the samples collected. The radiation source was placed close to the detector in order to increase the intensity reaching the detector hence; the counting system may exhibit high detection efficiency (Ehiedu, 2009).

This was achieved by placing the sample container directly on top of the detector for counting. Each of the 28 samples was counted for a period of 3600 seconds, after which the area under each photo peak of interest was computed using firmware algorithm of the MCA, which subtracts counts due to Compton scattering of higher peaks and other background effects from the total area. The counting for an empty container was also done for the same period of time, to obtain background count. The net count was obtained by subtracting the background count from the gross count. The net count was later used for subsequent analysis, since the number of pulses under the peak is proportional to the intensity of the radiation reaching the detector volume.

The net count was obtained using the expression below:

$$N_S = N_g - N_b \qquad (1)$$

Where $N_s =$ Sample counts (Net counts), N_b= Background counts, N_g = Gross counts.

The activity concentration ($Bqkg^{-1}$) of each radionuclide was obtained using:

$$Sample\ activity\ (C) = \frac{N_s}{\varepsilon ytm} \qquad (2)$$

Where ε = efficiency detector, y = gamma yield, m = mass of the sample, t = counting time.

2.4 External Hazard Index (H_{ex})

A widely used hazard index (reflecting external exposure) called the external hazard index H_{ex} is defined as follows (UNSCEAR, 2000):

$$H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_K/4810 \qquad (3)$$

Internal Hazard Index (H_{in})

Radon and its short-lived product are also hazardous to the respiratory organs. The internal exposure to radon and its daughter progenies is quantified by the internal hazard index H_{in}, which is given by the equation:

$$H_{in} = C_{Ra}/185 + C_{Th}/259 + C_K/4810 \qquad (4)$$

The values of the indices (H_{ex}, H_{in}) must be less than unity for radiation hazard to be negligible (Diab et al., 2008).

3. Results and Discussion

The mean activity concentration of ^{40}K, ^{226}Ra and ^{232}Th in the rock samples are 935.05 ± 702.08 $BqKg^{-1}$, 3.04 ± 5.44 $BqKg^{-1}$ and 271.69 ± 301.04 $BqKg^{-1}$ respectively; shown in table 1. Also, for the building material samples, the mean activity concentration of ^{40}K, ^{226}Ra and ^{232}Th are 465.95 ± 129.19 $BqKg^{-1}$, 28.15 ± 16.93 $BqKg^{-1}$ and 107.30 ± 23.83 $BqKg^{-1}$ respectively; shown in table 2. Finally, the mean activity concentration of ^{40}K, ^{226}Ra and ^{232}Th in the sediment samples are 426.03 ± 137.50 $BqKg^{-1}$, 28.52 ± 10.03 $BqKg^{-1}$ and 30.32 ± 15.35 respectively; shown in table 3.

The average values for external hazard indices (H_{ex}) are 1.25 ± 1.18, 0.59 ± 0.11 and 0.28 ± 0.08 for rock, clay and sediment samples respectively. Furthermore, average values for internal hazard indices are 1.26 ± 1.18, 0.66 ± 0.14 and 0.36 ± 0.10 for rock, clay and sediment samples respectively. The external (H_{ex}) and internal (H_{in}) hazard indices for rock samples are higher than unity. While external (H_{ex}) and internal (H_{in}) hazard indices for clay and sediment samples are lower than the criterion level of unity.

4. Conclusion

The gamma-ray spectrometer NaI(Tl) detector was used to determine the external (H_{ex}) and internal (H_{in}) hazard indices from naturally occurring radionuclides (^{40}K, ^{226}Ra and ^{232}Th) present in Rock, Sediment and Building material (clay) samples from Sikiti settlement, Southwestern Nigeria. From the above results, the calculated external (H_{ex}) and internal (H_{in}) hazard indices of rock samples are above permissible limit of 1. Hence, rocks found in Sikiti settlement should be handled/used with caution to avoid excessive exposure of the people to radiation.

Finally, the calculated external (H_{ex}) and internal (H_{in}) hazard indices for sediment and building material (clay) samples were below permissible limit of unity hence, the use of these materials have no immediate negative health implications on the inhabitants, but caution should be taken against long term cumulative effects.

Table 1. Internal (H_{in}) and External (H_{ex}) Hazard Indices from Rock Samples

SAMPLES	^{40}k (Bq kg^{-1})	^{226}Ra (Bq kg^{-1})	^{232}Th (Bq kg^{-1})	H_{in}	H_{ex}
1	311.16±7.70	4.60±1.359	36.58±1.80	0.230783	0.218361
2	579.07±9.17	11.49±1.547	46.33±1.89	0.361392	0.330338
3	1343.07±12.46	BDL	201.41±3.06	1.559568	1.056886
4	1540.28±13.18	BDL	320.99±3.72	1.559568	1.559568
5	401.95±8.23	14.34±1.618	35.80±1.79	0.299324	0.260561
6	35.26±5.80	BDL	174.99±2.89	0.682969	0.682969
7	243.72±7.29	BDL	630.11±5.03	2.483519	2.483519
8	1464.09±12.90	BDL	134.76±2.62	0.824694	0.824694
9	2113.58±15.06	BDL	171.42±2.87	1.101259	1.101259
10	1318.33±12.37	BDL	964.46±6.14	3.997858	3.997858
MEAN±SD[a]	**935.05±702.08**	**3.04±5.44**	**271.69±301.04**	**1.259825±1.18**	**1.25160±1.18**

[a]Standard Deviation

Table 2. Internal (H_{in}) and External (H_{ex}) Hazard Indices from Building Material Samples

SAMPLES	**^{40}K (Bq kg^{-1})**	**^{226}Ra (Bq kg^{-1})**	**^{232}Th (Bq kg^{-1})**	**H_{in}**	**H_{ex}**
1	577.40±9.166	31.933±2.003	108.00±2.424	0.709648	0.623341
2	476.47±8.639	16.561±1.672	121.10±2.523	0.65615	0.61139
3	698.79±9.763	60.14±2.499	95.46±2.326	0.838944	0.676396
4	445.02±8.468	14.42±1.620	57.31±1.998	0.39176	0.352783
5	386.98±8.143	21.71±1.789	130.15±2.589	0.700303	0.641623
6	331.53±7.819	11.88±1.557	130.22±2.589	0.635953	0.603828
7	500.84±8.769	45.80±2.261	115.04±2.478	0.795845	0.672061
8	310.60±7.694	22.74±1.812	101.15±2.37	0.578058	0.516594
MEAN±SD[a]	**465.95±129.19**	**28.15±16.93**	**107.30±23.83**	**0.663333±0.14**	**0.587252±0.11**

[a] Standard Deviation

Table 3. Internal (H_{in}) and External (H_{ex}) Hazard Indices from Sediment Samples

SAMPLES	^{40}K (Bq kg^{-1})	^{226}Ra (Bq kg^{-1})	^{232}Th (Bq kg^{-1})	H_{in}	H_{ex}
1	172.65±6.809	8.40±1.465	39.71±1.827	0.234616	0.211915
2	506.88±8.801	22.11±1.798	20.99±1.625	0.305925	0.246174
3	460.19±8.551	22.50±1.807	45.59±1.886	0.393339	0.332517
4	456.74±8.532	34.39±2.051	46.52±1.895	0.460463	0.367518
5	482.70±8.672	22.50±1.807	6.62±1.451	0.247573	0.186752
6	622.23±9.391	40.97±2.174	32.26±1.749	0.475385	0.364664
7	468.47±8.595	30.11±1.967	37.48±1.804	0.404854	0.323473
8	530.70±8.926	41.28±2.180	46.63±1.896	0.513533	0.401956
9	287.35±7.552	28.76±1.939	11.02±1.506	0.257753	0.180013
10	272.37±7.459	34.15±2.046	16.38±1.571	0.304457	0.212154
MEAN±SD[a]	**426.03±137.50**	**28.52±10.03**	**30.32±15.35**	**0.35979±0.10**	**0.282713±0.08**

[a] Standard Deviation

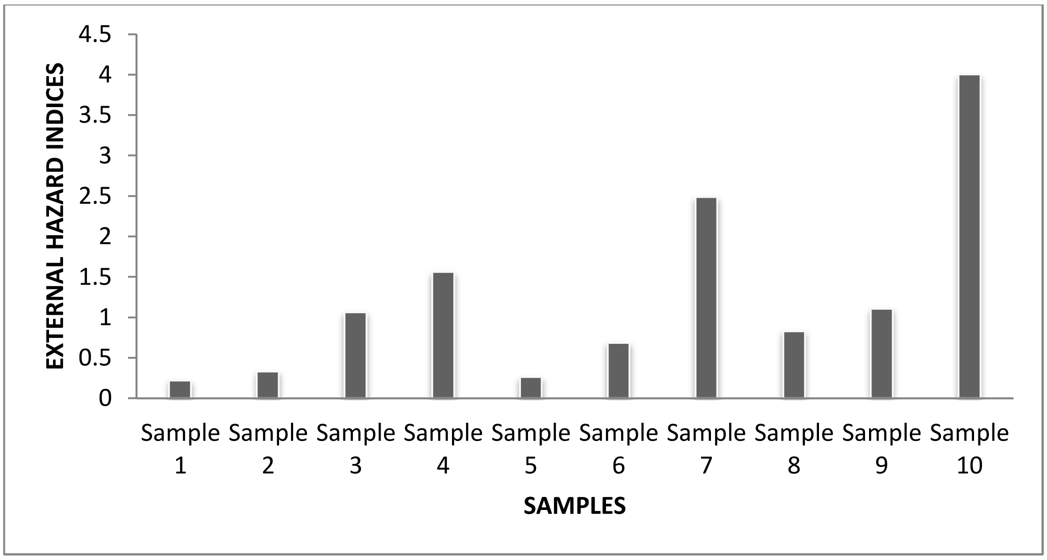

Figure1. External (H_{ex}) Hazard Indices from Rock Samples

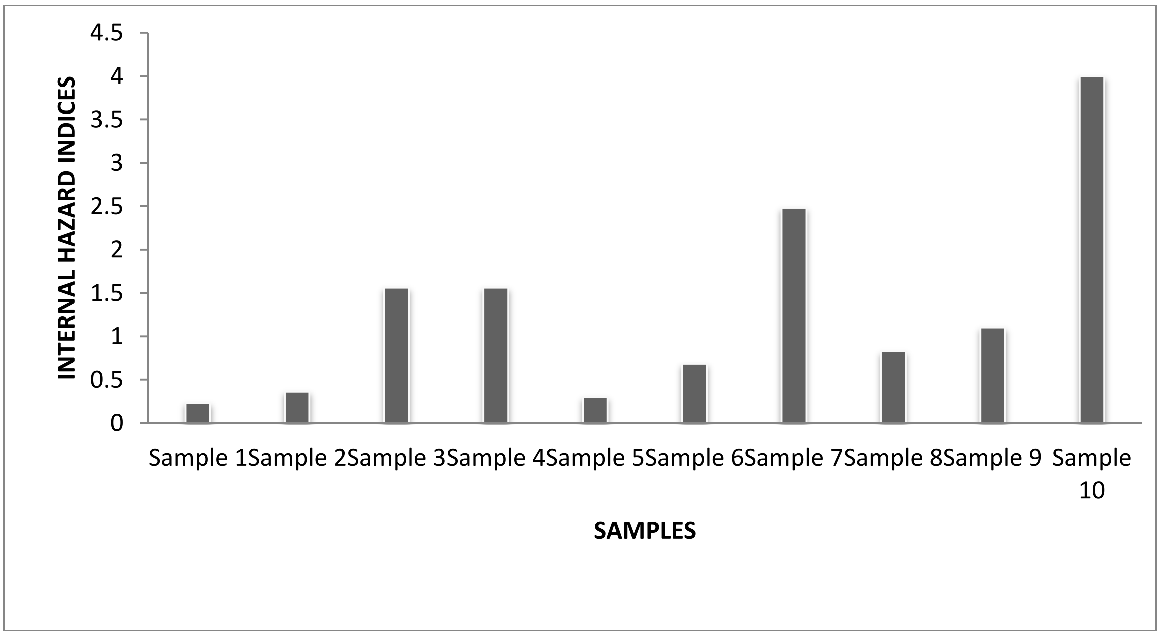

Figure2. Internal (H_{in}) Hazard Indices from Rock Samples

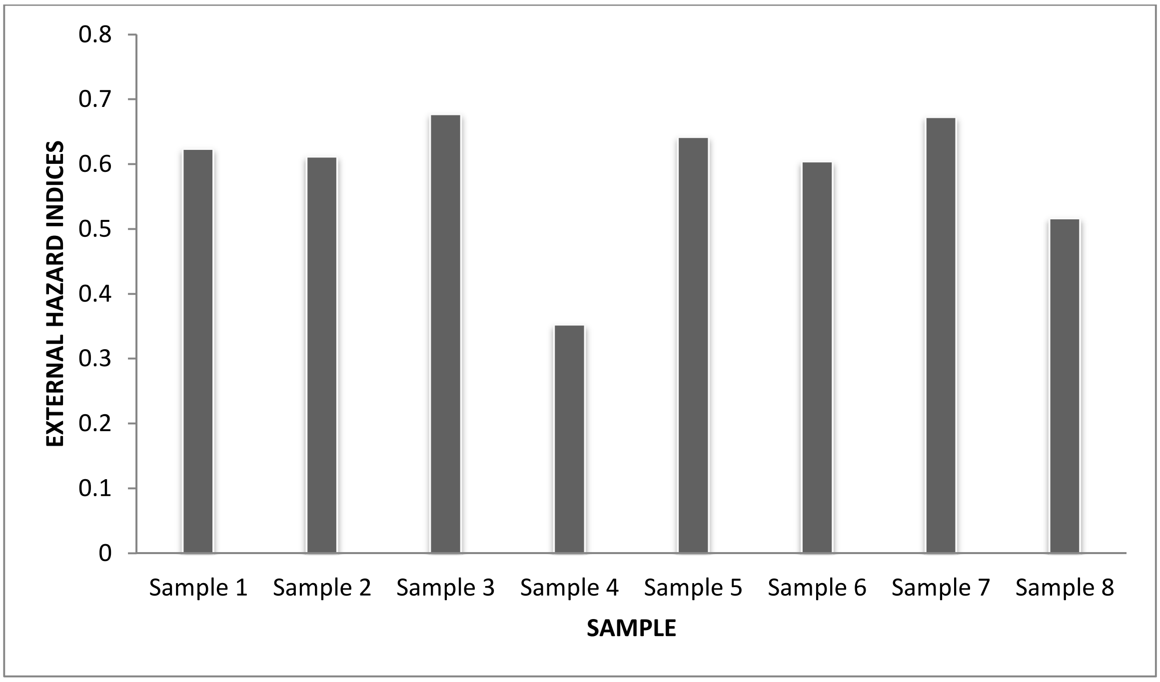

Figure3. External (H_{ex}) Hazard Indices from Building material Samples

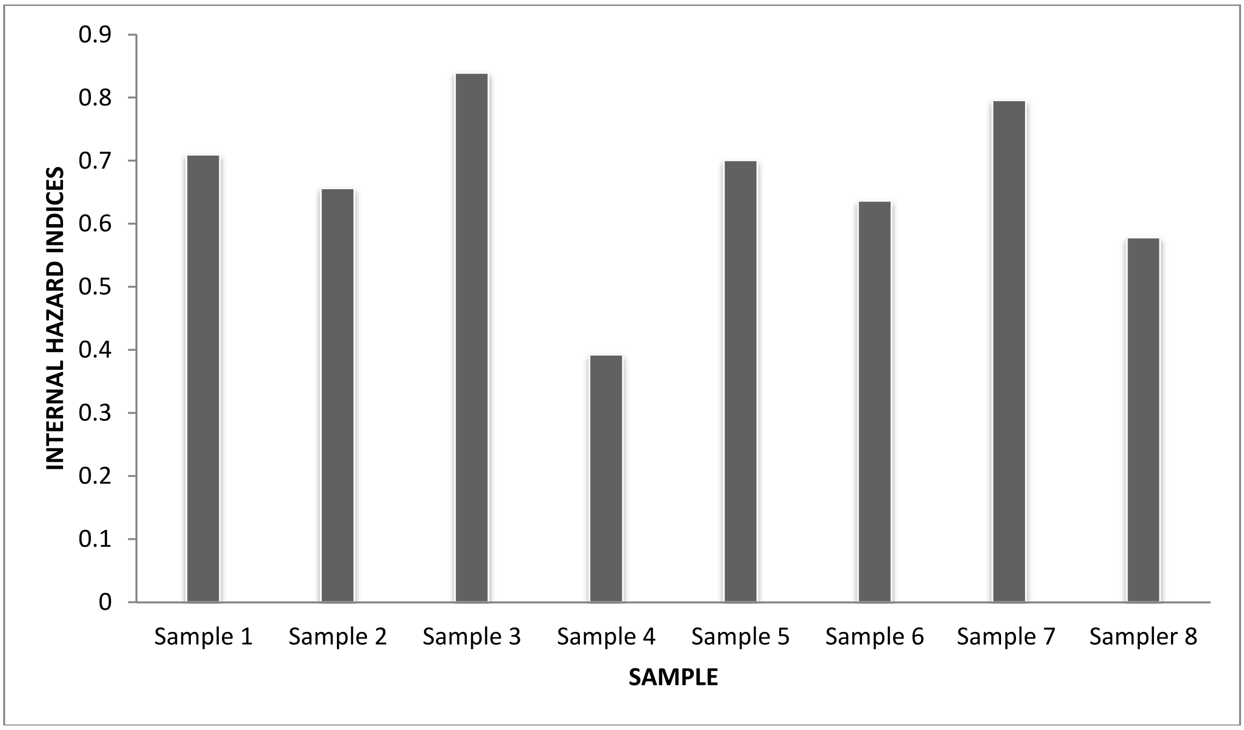

Figure4. Internal (H_{in}) Hazard Indices from Building material Samples

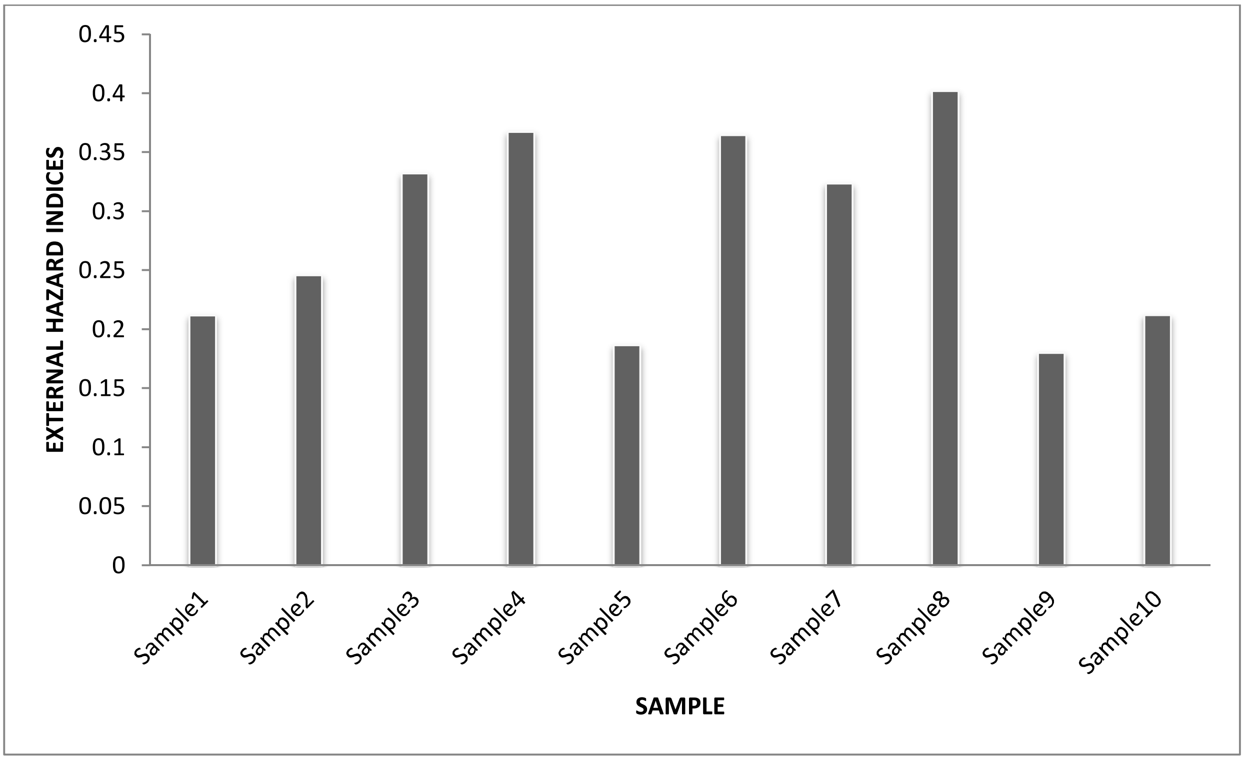

Figure5. External (H_{ex}) Hazard Indices from Sediment Samples

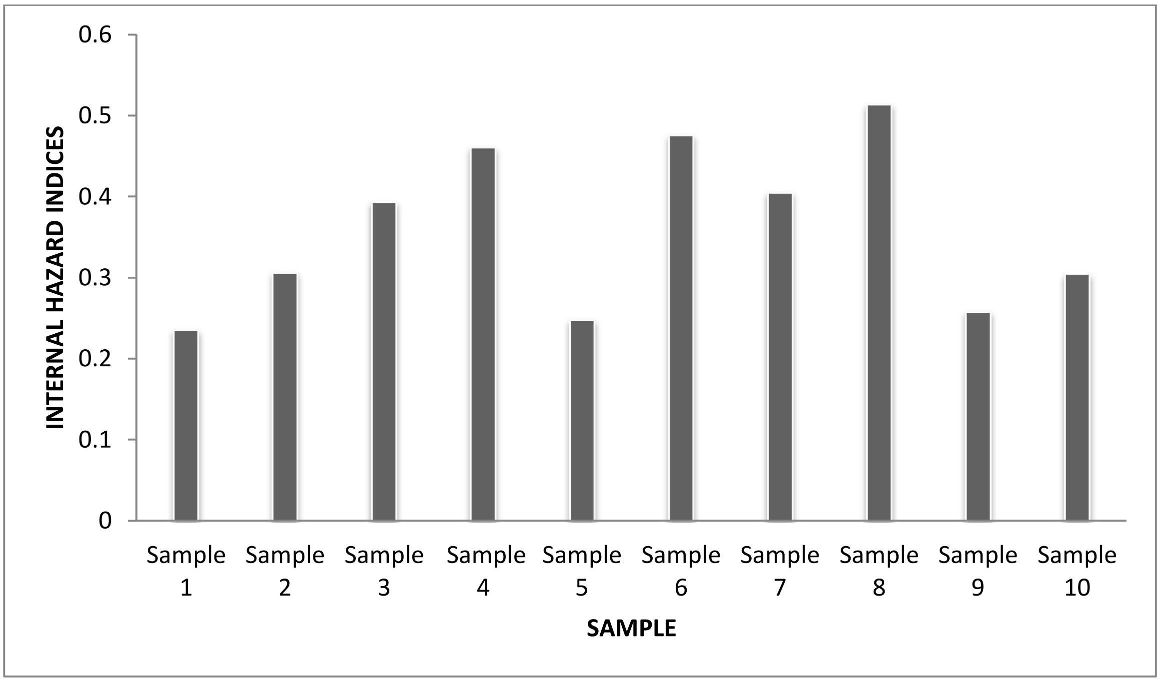

Figure4. Internal (H_{in}) Hazard Indices from Sediment Samples

5. Acknowledgement.

The management and staff of Department of Physics, University of Ibadan, Ibadan and Kabba College of Agriculture, Ahmadu Bello University, Zaria, are acknowledge and appreciated for their supports and contributions towards the success of this research work.

References:

Adewuyi, G. J. (2002). Effect of Industrial discharge on the water quality of Soderu river in Ewekoro Southwestern Nigeria. *UNIQWA. Res. Chron* , 4:206-222.

Alaamer, A. (2008). Assessment of human exposures to natural source of radiation in Soil of Riyad, Saudi Arabia. *Turkish J. Eng. Env. Sci* , 32: 299-234.

Bello, A. I. (2012). *External Dose Assessment from the Measured Radioactivity in Rock, Sediment and Clay samples of Sikiti, Oyo State, Nigeria.* Ibadan, Nigeria: Unpublished M.Sc. Thesis, University of Ibadan,.

Diab, H. N.-T. (2008). Evaluation of natural radioactivity in a cultivated area around a fertilizer factory. *Nulea. Rad. Phys* , 53-62.

Ehiedu, S. (2009). Determination of natural radionuclides in fish and sediment samples collected from oil exploration area in river Igbokoda, Ondostate. *Unpublished M.Sc. Project, Department of Physics, University of Ibadan.*

Faweya, E. a. (2012). *Radiological Safety Assessment and Physico- Chemical Characterization of soil mixed with Mine Tailings used as Building materials from Oke-Kusa Mining sites in Ijero, Nigeria.* Ijero, Nigeria: Nature and Science 2012; 10(5): 64-71.

Jibiri, N. F. (2007). Estimation of annual effective dose due to natural radioactive element in ingestion of foodstuffs in tin mining area of Jos-Plateau, Nigeria. *J. Eviron Radioact.* , 93:31-40.

United Nations Scientific Committee on Effects of Atomic Radiation, (2000). *Sources and Effects of Ionizing Radiation (Report to the General Assembly)* . New York: United Nation: UNSCEAR .

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar