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ASSESSMENT OF NATURAL RADIONUCLIDE CONTENTS AND IMPACTS IN THE MUD SOIL OF IDO-IJESA, SOUTH- WESTERN NIGERIA.

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ABSTRACT

There has been great concern about the health risks associated with exposure to natural radioactivity present in soil and building materials, which could be traceable to either natural or artificial sources. Thus in this work, the natural radionuclide contents of the mud soil of Ido-Ijesa in South West Nigeria; which is commonly used as building material were analyzed . The analysis was carried out by means gamma ray spectrometry using NaI (TI) as the detector. The radioisotopes identified in the samples of the material include those of the series headed by ^{238}U and ^{232}Th as well as the singly occurring radioisotope ^{40}K. The mean activity concentrations of the radionuclides were found to be 23.39±3.20, 19.37±2.60 and 165.14±7.10 Bq/kg for ^{226}Ra, ^{232}Th and ^{40}K respectively. The activity index of this material was found to be 0.24±0.03. This is less than the requirement of 1 for material used in bulk amounts. Assessment of the radiological impact was made by calculating the radium equivalent activity, external and internal hazard indices and the annual effective dose equivalent and all were found to be within acceptable limit.

Key words: Radium, mud soil, radionuclide, hazard, dose equivalent,

1. Introduction

People in developing countries spend most of their time indoors. For this reason, it is very important to have knowledge of the constitution of the immediate environment within the premises. It is very well known that people are irradiated mainly by natural sources of ionizing irradiation, which result from background levels of the radioactivity contained in the soil and building materials.

A comprehensive analysis was done on the mud soil at Ido-Ijesa, a settlement located in the south-western part of Nigeria. The town is blessed with a soil type whose constitution is such that it has been tapped as a source in molding bricks for building and has served this purpose for generations. According to Beck (1972) showed 50-80% of the total gamma flux at the earth's surface arises from ^{40}K, a singly occurring radionuclide and the ^{238}U and ^{232}Th series in top soil. Gamma radiation emitted from these naturally occurring radioisotopes, called terrestrial background radiation, represent the main source of irradiation of human body and contribute to the total absorbed dose via ingestion, inhalation and external irradiation.

Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions and appear at different levels in the soil of each region in the world. Since these radionuclides are not uniformly distributed, the knowledge of their distribution in soil plays an important role in radiation protection and measurement. Also, the radioactivity of soils is essential for understanding changes in the natural background.

This study is aimed at determining the activity level and the resulting human impact due to naturally occurring radionuclides in mud-soil of Ido-Ijesa, South Western Nigeria.The measured radioactivity concentration would thereafter translate to the calculation of the impact indices in order to assess the radiological implication of the use mud-soil as the major building material in the area.

2. Materials and Method

Thirty-five samples of mud soil were collected from undistributed sites, within the study area in Ido-Ijesa. After removing the stones and some grasses and leaves, the samples were dried in an oven at a temperature of 50°c for 24 hours to ensure that as much moisture as possible was removed from the samples; they were then crushed to pass through a 2 mm sieve to homogenize them. Representative samples were packed into polyethylene cylindrical containers of 95mm diameter and 38mm height.

The packed samples were tightly sealed and kept for 28 days to attain a state of secular equilibrium between radon and its decay products. The samples were thereafter counted for a period of 36000s, using a gamma spectrometry system with Nal (TI) as the detector.

The scintillation detector, a 3×3 inch Nal (TL), a product of Princeton Gamma. Tech. USA was placed in a lead shield to reduce the effect of background radiation. Energy and efficiency calibrations of the detector were carried out using a standard source traceable to Analytical Quality Control Services (AQCS), USA; which contains ten radionuclides of γ-emitters with energies ranging from 59.54 to 1836 keV.

Radium equivalent activity

The exposure due to the γ radiation, defined in terms of the radium equivalent activity Ra_{eq} is given by equation (2) (Faheem et al., 2008):

$$Ra_{eq} = A_{Ra} + 1.43\, A_{Th} + 0.077\, A_k \leq 370 \quad (2)$$

According to this formula, 1Bq/Kq of 2^{26}Ra, 0.7Bq/Kg of ^{232}Th, and 13Bq/Kg of ^{40}K yield the same γ- ray dose. The radium equivalent activity for the material analyzed in this work was calculated and a value of 62.83 Bq/Kg, was obtained. This value is much less than the upper limit of 370 Bq/Kg. (UNSCEAR,)

Dose in air, annual effective dose, and the corresponding external and internal hazard indices

In order to evaluate the dose rates in air, equation 3 was used:

$$\dot{D} = \sum A_x \times C_x \qquad (3)$$

Where A_x (Bq/Kg) refers to the activity of 226Ra, 232Th and 40K, as calculated by Equation I and C × (nGy/hour per Bq/Kg) is the corresponding conversion factors. The C × value used are in this work are 0.427, 0.662 and 0.043, for 226Ra, 232Th and 40K respectively (Ref). The annual effective dose equivalent due to the activity in the soil and building materials is calculated using equation 4:

$$E = T \times Q \times D \times Q_F \times 10^{-6} \qquad (4)$$

Where the value of Q is 0.7Sv/Gy/year for environmental exposure to γ- rays of moderate energy, T is time in hours in one year, i.e. 8760 hours, Q_f is the occupancy factor (0.8), and D is the dose rate given in Equation 3. The dose rate in air and the annual effective dose equivalent obtained are 28.92 nGy/hour and 0.035 mSv/year, respectively. This value fall within the permissible dose equivalent limit of ImSv/year; (ICRP 60, 1990). The external hazard index (H_{ex}) and the internal hazard index (H_{in}) were also determined using equations 5 and 6:

$$H_{in} = \frac{A_{Th}}{259\left(\frac{Bq}{Kg}\right)} + \frac{A_{Ra}}{370\left(\frac{Bq}{Kg}\right)} + \frac{A_k}{4810\left(\frac{Bq}{Kg}\right)} \qquad (5)$$

$$H_{in} = \frac{A_{Th}}{259\left(\frac{Bq}{Kg}\right)} + \frac{A_{Ra}}{185\left(\frac{Bq}{Kg}\right)} + \frac{A_k}{4810\left(\frac{Bq}{Kg}\right)} \qquad (6)$$

For radon and its short progenies to produce negligible hazardous effects to respiratory organs from materials to be used in construction, both the external and internal hazard Indies should be less than unity. The values of 0.17 ± 0.02 and 0.16 ± 0.02 for the external and internal hazard index, respectively, were obtained, these values are much less than unity, indicating that the aforementioned hazardous effect due to the use of this material is negligible.

3. Results and Discussion

The results of measurements for 35 mud soil sample collected at different locations in Ido-Ijesa district are presented in Table 1. The activity concentrations of the radionuclides in Bqkg^{-1} range between 14.38 ± 2.50 and 32.72 ± 5.00 for ^{226}Ra, 12.50 ± 1.50 and 28.42 ± 4.30 for ^{232}Th and from 130.42 ± 6.00 and 230.12 ± 12.00 for ^{40}K. Table 2 presents comparison of radium equivalent activity, dose in air, annual effective dose and the corresponding external and internal hazard incises in the soil samples investigated in this work with those in previous works.

The radium equivalent activity values ranged from 48.70 to 91. 08 Bqkg^{-1} these values are less than 370 Bqkg^{-1}, thus the material may be considered acceptable for safe use. The mean absorbed dose in air obtained was 29.39nGyh^{-1} (min. 22.39 nGyh^{-1} and max 41.88 nGyh^{-1}) this is comparable to the world average of 57 nGyh^{-1}.

The calculated values of external hazard index index have mean values of 0.17 ± 0.024 ± 0.03 respectively. Since these values are lower than unity, it can be said that the radiation hazard is negligible. The calculated values of annual effective dose range from 0.028 to 0.015 mSvy^{-1}, this is much lower than the world average of 0.48 mSvy^{-1}.

Table1: Activity concentration, radium equivalent activity and calculated absorbed dose rate, Effective dose rate for soil samples

Sample No.	Ra-226 (Bqkg^{-1})	Th-232 (Bqkg^{-1})	K-40 (Bqkg^{-1})	Ra_{eq} (Bqkg^{-1})	Absorbed dose rate (nGy h^{-1})	Effective dose rate (mSv y^{-1})
1.	21.20± 2.40	17.25± 1.50	152.52± 6.00	57.43	26.49	0.032
2.	23.92± 2.50	18.27± 1.70	164.62± 6.20	62.72	28.95	0.036
3.	22.32± 2.30	21.38± 2.00	173.50± 7.40	66.25	30.46	0.037
4	23.72± 2.50	20.55± 1.40	150.32± 5.50	64.68	29.64	0.036
5	18.75± 2.50	15.35± 1.00	152.71± 6.00	52.46	24.30	0.030
6	24.90± 2.90	12.50± 1.50	183.33± 8.00	56.89	26.70	0.033
7	20.32± 2.50	17.21± 1.50	151.62± 5.80	56.61	26.11	0.032
8	28.30± 3.80	18.54± 1.40	191.51± 8.90	69.56	32.26	0.040
9	29.05± 4.00	22.43± 1.90	157.05± 6.30	73.22	33.52	0.041
10	23.40± 3.00	19.78± 2.00	153.71± 6.10	63.52	29.17	0.036
11	25.69± 4.00	21.54± 3.10	156.25± 7.00	68.52	31.39	0.038
12	24.72± 3.40	23.42± 3.60	223.54± 10.50	75.42	34.89	0.043
13	23.42± 3.4	22.48± 3.10	165.98± 7.50	68.27	31.28	0.038
14	22.30± 3.50	17.58± 3.60	155.87± 7.20	59.44	27.42	0.034
15	21.45± 2.80	21.38± 2.90	171.20± 7.80	65.21	29.96	0.037
16	23.80± 3.00	23.42± 3.10	152.41± 7.00	69.03	31.50	0.039
17	24.85± 2.90	15.50± 2.00	133.70± 5.40	57.31	26.42	0.032
18	20.20± 2.70	18.71± 2.90	183.70± 7.80	61.11	28.30	0.035
19	17.35± 2.40	12.58± 2.00	173.48± 7.00	48.70	22.85	0.028
20	25.50± 3.50	18.05± 2.40	165.71± 6.90	64.07	29.59	0.036

21	20.30±2.60	19.72±1.60	144.85±5.70	59.65	27.33	0.034
22	29.90±4.00	18.42±3.00	181.68±8.00	70.23	32.52	0.040
23	23.42±3.50	17.53±2.30	133.44±5.00	58.76	26.97	0.033
24	20.62±3.40	15.32±1.50	145.50±5.50	53.73	24.85	0.030
25	26.30±4.20	17.28±2.50	182.30±8.10	65.05	30.19	0.037
26	24.48±3.50	18.53±3.00	180.51±8.00	64.88	30.03	0.037
27	31.42±4.20	26.30±4.30	167.20±6.50	81.90	37.37	0.046
28	25.57±3.50	24.03±3.30	156.08±7.50	71.95	32.84	0.040
29	19.82±3.50	18.44±3.00	143.90±7.00	57.27	26.30	0.032
30	14.38±2.50	21.88±3.40	155.28±7.00	57.62	26.33	0.032
31	15.08±2.00	18.24±3.40	156.65±7.50	53.23	24.52	0.030
32	19.29±3.50	20.33±3.50	130.42±6.00	58.40	26.63	0.033
33	32.72±500	28.42±4.30	230.12±12.00	91.08	41.88	0.051
34	27.77±4.30	15.70±3.00	184.50±8.00	64.43	30.01	0.037
35	22.55±3.50	19.78±3.30	175.58±7.90	64.36	29.69	0.036
MEAN	**23.39±3.20**	**19.37±2.60**	**165.14±7.10**	**63.80**	**29.39**	**0.036**

Table 2: Comparison of Radium equivalent activity, dose in air, annual effective dose and the corresponding external and internal hazard indices in the soil samples under investigation with those in previous works.

References	Ra_{eq}	Absorbed dose rate	Effective dose rate	H_{ex}	H_{in}
Current Study	63.80	29.39	0.036	0.17 ± 0.02	0.24 ± 0.03
Ryuta et al., 2009 LUSI mud	43±4	20±2	0.10±0.01	0.12±0.02	0.15±0.02
Faheem et al, 2008 Soil	149±40	72.6±42.7	0.30±0.26	0.41±0.27	0.51±0.34
Awodugba et al, 2007 Cement	620.87±25	282	2.471	1.678±0.07	2.66±0.11
Requirement	370	57	0.48	1	1

4. Conclusion

This study has presented the results of the measurement of the activity concentrations of terrestrial gamma emitters for mud samples from Ido-Ijesa, Osun State, South Western Nigeria. The analysis was undertaken by mean of gamma – ray spectrometry using NaI (TL) as the detector. The results obtained indicated that, samples from the study area have activity concentrations ranging from 14.38±2.50 – 37.72±5.0 $Bqkg^{-1}$ for 226Ra, 12.50±1.50 – 28.42±4.30 $Bqkg^{-1}$ for 232Th and 130.42±6.00 – 230.12±12.00 $Bqkg^{-1}$ for 40K. the value of the absorbed dose rate in the samples range from 22.85 to 41.88 $nGyh^{-1}$ with a mean value of 29.39 $nGyh^{-1}$. The annual effective dose rates in the air varied from 0.028 to 0.051 $mSvy^{-1}$ with an average value of 0.03 $mSvy^{-1}$.

The values obtained for the natural radioactivity and γ-absorbed dose rates due to the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K of mud in the study area show that none of the studied mud samples can be considered to constitute radiological hazard and the mud can be safely used in construction and for other uses without posing any significant radiological threat to the population.

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