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DOSE ASSESSMENT DUE TO TERRESTRIAL GAMMA RADIATION IN IBADAN, SOUTH WESTERN NIGERIA

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ABSTRACT

The activities of primordial radionuclides in surface soil at Ibadan, South-Western Nigeria have been measured with a 7.6cm x 7.6cm NaI(TL) detector. The mean absorbed dose rate, annual effective dose and the collective effective dose at Ibadan were evaluated from measurement of ^{40}K; ^{238}U; ^{232}Th activities and their mean values found to be 0.070 ± 0.008 $\mu Gy.h^{-1}$, 86.1 $\mu Sv.y^{-1}$ and 344.2 man $Sv.y^{-1}$, respectively.

Key words: soil; dose; effective; collective; ^{40}K; ^{238}U; ^{232}Th; exposure

INTRODUCTION

Gamma radiation is present in the terrestrial environment due to the decay processes of some naturally occurring radionuclides (Aberto et al., 1995; Bohlinger and Hendricks, 1981; Ibrahiem et al., 1993; Jaworoski, 1982; Mollah et al., 1987; Tso and Li, 1992). Some of the natural sources include ^{40}K, ^{238}U and ^{232}Th in soils and rocks and those from primary and secondary components of cosmic radiation. There are other sources which can increase the radiation burden of the environment, such sources are known to be artificial; they include the fission-product from nuclear weapon test, nuclear emissions from industries (power plant) and nuclear waste dumps. The distribution and availability of these radionuclides depend mainly on geological processes, atmospheric conditions and human activities (Ivanovich and Harmon, 1982). The radioactivity level of any environment is desired in order to be able to assess the health effects to a given population. According to ICRP (1991), an annual effective dose limit of 1 mSv for individual member of the public was recommended and to prevent deterministic effects, a dose of 15 m Svy^{-1} for the eye lens and 50 $mSvy^{-1}$ for the skin. This study provides a reference base of absorbed dose from natural sources at Ibadan, southwestern Nigeria (with an estimated population of 4 million) (NPC, 1991) as a baseline in case of any gross contamination of the area in the future.

MATERIALS AND METHODS

Fourteen soil samples (0-5cm) were collected within Ibadan metropolis from undisturbed locations. The samples were air dried under a laboratory with mean temperature of 27°C and mean relative humidity of about 70% for three days (IAEA, 1989). The dry samples were homogenised and sieved through a 2.00 mm mesh. The samples were carefully weighed and sealed in a plastic container for a 40-day ingrowth's period to avoid radon diffusior and ensure secular equilibrium between ^{238}U, ^{232}Th and their respective progenies (Alberto et al., 1995). The samples were then analysed in the laboratory with a 7.6cm x 7.6cm NaI (TL) detector with a resolution of about 8.0% at 0.662 MeV 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 miltichannel analyser. The gamma energies of 1.46MeV, 1.7MeV and 2.62MeV were used in the analysis of ^{40}K, ^{238}U and ^{232}Th, respectively. The background distribution due to the naturally occurring radionuclides in the detector environment and the IAEA standard sources RGK-1 (K_2SO_4), RGU-1 (U-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 radionuclides

Absorbed dose rate (D) was obtained using the Beck et al (1972) formula:

$$D\ (nGyh^{-1}) = \{0.051(a/m)_u + 0.076(a/m)_{th} + 0.0048(a/m)_k\} \times 8.73 \quad (1)$$

where $(a/m)_i$ are the activity of natural radionuclides at 1.0m above the ground.

The mean annual effective dose to man (H) was calculated using the conversion factor of 0.7

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$SvGy^{-1}$ for dose rates in air and an outdoor occupancy ratio of 0.2 (IAEA, 1989)

The collective effective dose equivalent (S_E) was calculated for the city using

$$S_E = NH \quad (2)$$

where N is the population of the City and H is the mean annual effective dose equivalent to each individuals (ICRP, 1991).

RESULTS

The activity of naturally occurring radionuclides and the estimated absorbed dose rates for fourteen locations within Ibadan metropolis are presented in Table.1. Fig 1 shows the distribution of absorbed dose within Ibadan. ^{40}K activity range from 46.1 $Bqkg^{-1}$ at NTC to 1096.3$Bqkg^{-1}$ at Eleyele with mean activity of 355.0 ± 19.7 $Bqkg^{-1}$. ^{238}U activity range from 9.6

Table 1 : The Specific Activities of Radionuclides and the Dose Rates at 1m above the ground.

Location	^{40}K ($Bqkg^{-1}$)	^{238}U ($Bqkg^{-1}$)	^{232}Th ($Bqkg^{-1}$)	Absorbed Dose ($\mu Gy.h^{-1}$)
Orita Chal.	169.3	24.4	60.6	0.058
Ijebu Ode Rd.	163.5	10.1	65.2	0.055
Express Road	564.0	13.9	61.6	0.071
Yidi	187.9	55.4	63.7	0.075
New Gbagi Mkt	304.9	33.4	26.7	0.045
Oke Imole Area	209.2	22.0	62.1	0.060
U. I. 2nd Gate	809.8	28.1	112.7	0.121
Eleiyele	1096.3	9.6	27.9	0.069
Govt. House	68.0	76.9	134.9	0.127
UTC Stores	284.4	12.3	81.2	0.071
NTC	46.1	11.7	90.4	0.067
Child. H. Sch	198.7	24.3	40.9	0.046
Oja Oba Area	205.5	56.8	29.7	0.054
Adeoyo Hosp.	661.1	18.0	27.5	0.054
Mean	355.0 ± 19.7	31.0 ± 5.9	63.0 ± 7.5	0.070 ± 0.008

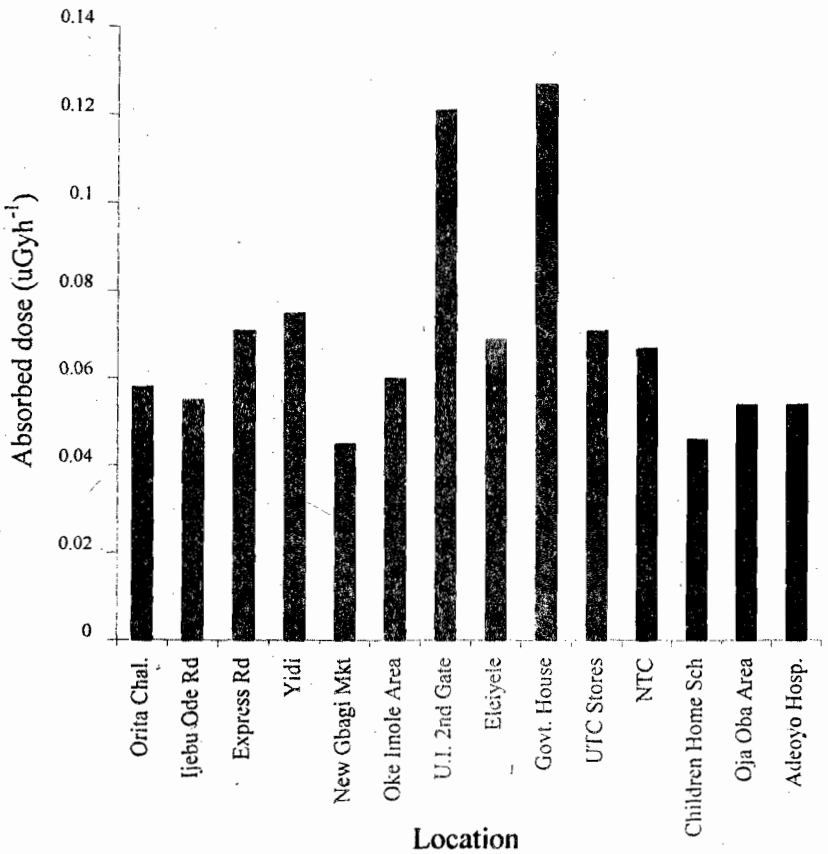

Fig 1: The distribution of absorbed dose within Ibadan

$Bqkg^{-1}$ at Eleyele to 76.9 $Bqkg^{-1}$ at Government House with mean activity of 31.0 ± 5.9 $Bqkg^{-1}$. ^{232}Th activity range from 26.7$Bqkg^{-1}$ at New Gbagi Mkt to 134.9$Bqkg^{-1}$ at Government House with mean activity of 63.0 ± 7.5 $Bqkg^{-1}$. The estimated absorbed dose due to the three radionuclides was estimated using Equation 1 and it ranges from 0.045 ± 0.005 $\mu Gy.h^{-1}$ to 0.126 ± 0.021 $\mu Gy.h^{-1}$ with mean 0.070 ± 0.008 $\mu Gy.h^{-1}$. The annual effective dose to individual ranges from 57.3 $\mu Sv.y^{-1}$ to 161.6 $\mu Sv.y^{-1}$ with mean value of 89.1 $\mu Sv.y^{-1}$. The collective effective dose for Ibadan was estimated to be 356.4 man $Sv.y^{-1}$ using Equation 2.

DISCUSSION AND CONCLUSION

The estimated annual effective dose due to naturally occurring radionuclides for Ibadan, Southwestern Nigeria was found to be 89.1 $\mu Sv.y^{-1}$. For comparison, this value is about 27.3% higher than the value (70.0 $\mu Sv.y^{-1}$) estimated for the world average by UNSCEAR (1988) and about 78.2% higher than the value (50.0 $\mu Sv.y^{-1}$) estimated for Lagos, South-western Nigeria by Jibiri and Farai (1998). The high effective dose observed at Ibadan, when compared to that obtained for Lagos is due to the fact that the cities are located in different geological zones. Extrusive granite rocks characterize the geology of Ibadan while Lagos is situated on a sedimentary basin. The result is in trend with the result of Wollenberg and Smith (1990) that there is a relationship between radioactivity levels and local geology of an area. This means that people living in Ibadan area receive a dose that is higher than that received by people living in normal areas when compared with the world average value given by UNSCEAR (1988). Nevertheless, the effective dose value stated in this work is about 9% of the value (1.0 $mSvy^{-1}$) stated by ICRP (1991) as maximum permissible effective dose to the public. Hence, there is no significant health hazard to the people of Ibadan. However, this study provides data helpful for future assessments in case of gross contamination of the area in the future.

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