ISSN:
Print - 2277 - 0593
Online - 2315 - 7461

Journal of Natural Science, Engineering and Technology

ABSORBED DOSE RATES ABOVE SOILS AND ROCK OUTCROPS IN SELECTED AREAS OF ABEOKUTA, NIGERIA

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ABSTRACT

Outdoor absorbed dose rates were measured in selected areas of Abeokuta in Nigeria; some with rock outcrops and others with soil overburden. Measurements were carried out using a Geiger Muller Survey Meter and a Global Positioning System (GPS). Result shows absorbed dose rates ranged from 1.0×10^3 to 1.3×10^3 nGy/hr among the rock outcrop areas and from 0.6×10^3 to 0.8×10^3 nGy/hr among the soil -covered areas. The average absorbed dose rate was 1180 ±3 nGy/hr for the rock outcrop areas and 689 ±3 nGy/hr for the soil -covered areas and assuming 0.4 occupancy factor, the corresponding average annual effective dose rates were calculated to be 2.89 ± 0.01 mSv/yr for the rock outcrop areas and 1.69 ± 0.01 mSv/yr for the soil –covered areas based on occupancy factor of 0.4. The mean annual effective dose rates for both the rock outcrop and soil covered areas were found to be higher than 1mSv/yr, the recommended dose limit for the public.

Keywords: Radiation Dose, Geiger Muller, background radiation, outdoor radiation exposure

INTRODUCTION

The environment is permeated with a background of ionizing radiation of both natural and artificial origins. Natural sources of radiation account for about 80% of the total radiation exposure received by the world's population (UNSCEAR, 2000). The terrestial components of the natural background radiation are mainly due to radioactive decays of ^{40}K and the radionuclides in the decay series ^{234}Th and ^{238}U (Brahmanandhan *et al*., 2007; Habshi1980). Concentrations of these radionuclides vary from one location to another (Diab *et al*., 2008; Jibiri and Okeyode, 2011) and from one material to another depending on the local geology and mineralization. Available data shows that concentrations of the primordial radionuclides are higher in rocks than soils (UNSCEAR 1993), although there are exceptional cases. Also, granitic rocks generally contain more radioactivity than sedimentary rocks.

In this present study, absorbed dose rate measurements were carried out at some selected locations with soil overburdens and others with rock outcrops. The purpose of this study is to examine to what extent such measurements can be used to delineate surface material type.

MATERIALS AND METHODS

Study Area

Abeokuta is the capital city of Ogun state, Southwestern Nigeria. It is situated between latitudes 3□ 20"and 3□ 54" and longitude 7□ 9" and 7□ 39" on the east bank of the Ogun River, around a group of rocky outcroppings that rise above the surrounding wooded savanna. Abeokuta means “Refuge Among Rocks” in the local language and it was so called because the caves of the outcrop rocks provided shelter and save havens for the early settlers from invaders (Britannica, 2012: Dimeji, 2010). The geology of Abeokuta comprises a rock sequence that starts with the Precambrian Basement and consists of quartzites and biotite schist, hornblende-biotite, granite and gneisses. The sedimentary rock sequences are from Cretaceous to Recent; the oldest of them, the Abeokuta formation, consists of grey sand intercalated with brown to dark grey clay. It is overlain by the Ewekoro formation, which typically contains thick limestone layers at its base (Jones, 1964). Figure 1 shows the locations of the sampling points.

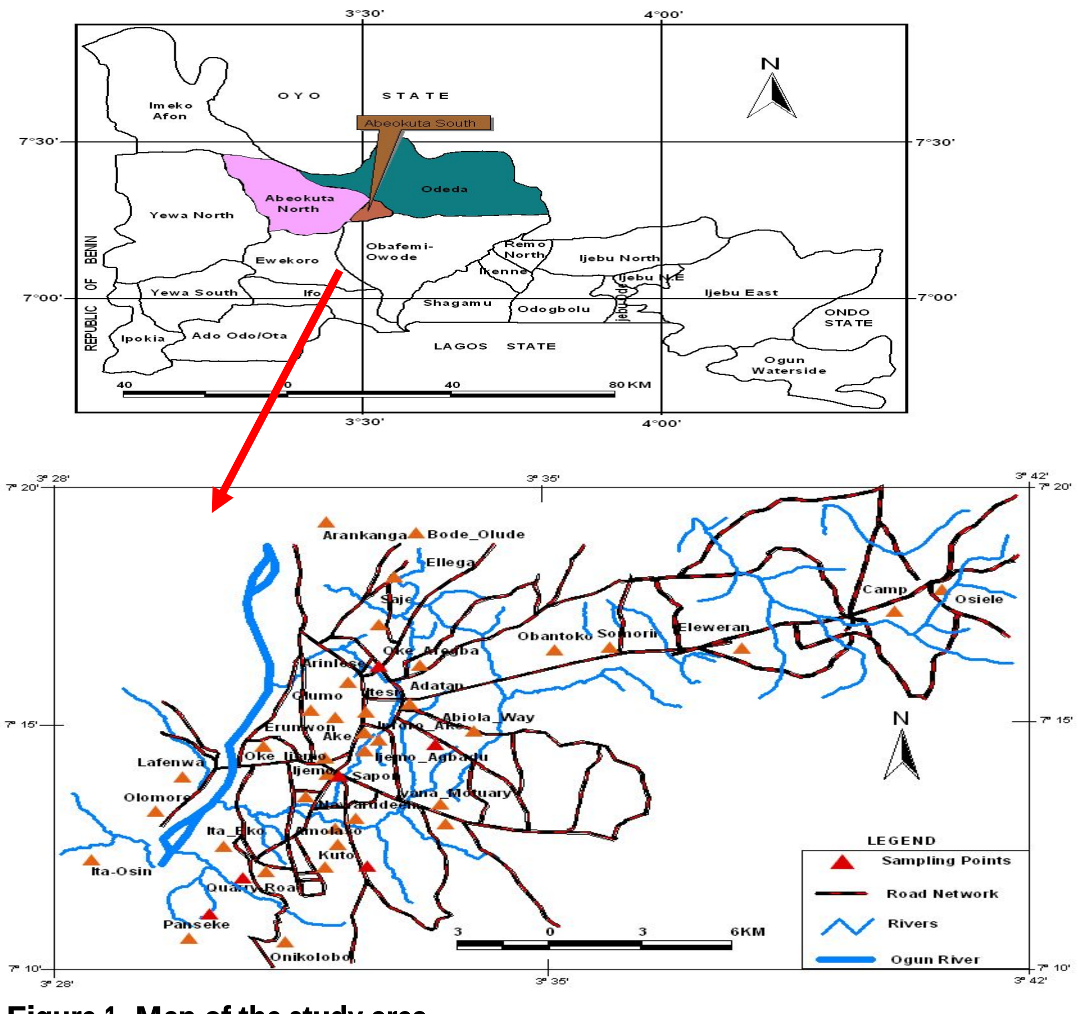

Figure 1. Map of the study area

Absorbed Dose Rate Measurement

Absorbed radiation dose at selected locations comprising areas of soil overburdens and outcrop areas, were measured using a survey meter. The Inspector is a Geiger-Müller detector incorporating a large-area 45 mm diameter pancake-geometry Geiger tube with mica window, sensitive to alpha, beta, gamma radiation and X-rays. The large digital display shows count rates and dose rates in Cpm and mRad/hr, respectively. Five readings were taken at each location and the average computed.

Effective Dose Rate Calculation

The annual effective dose rates H_E(mSv/y) that would be received in the study areas were derived from the expression:

$$H_E(mSv/yr) = D(nGy/hr) \times 8760(hr/y) \times 0.4 \times 0.7(Sv/Gy) \times 10^{-6} \quad \ldots\ldots (1)$$

(UNSCEAR, 2000)

where $D(nGy/hr)$ is the total absorbed dose in air, $8760(hr/y)$ is the number of hours per year (24×365), $0.7(Sv/Gy)$ is the conversion from absorbed dose in air to effective dose in tissues. The occupancy factor (Outdoor) used in this work is $0.4(10/24)$ hours which is the fraction of the time spent outdoor by the people in these areas. The effective dose rates calculated for the outcrop and soil covered areas are shown in Tables 1 and 2 respectively.

RESULTS AND DISCUSSION

Results of the measured absorbed doses and the coresponding effective doses at the selected locations are presented in Tables 1 and 2 as shown below. The distribution of the absorbed doses are also presented in histograms (Figures 2 and 3).

DISCUSSION

Looking at Tables 1 and 2, the absorbed dose rates ranged from 1000 in (Nawarudeen) to 1340 nGy/hr (Saje I) with the mean of 1180± 80.8(nGy/hr) in the rock Outcrop areas and 560 nGy/hr at (Lanfenwa and Panseke) to 820 nGy/Hr at (Ago – Oko and Osiele) with the mean of 689± 70(nGy/hr) soil covered areas.

For the corresponding annual effective dose rates, it ranged from 2.45 in (Nawarudeen) to 3.29 mSv/yr at (Saje I) with the mean of *2.89± 0.20(mSv/yr)* in the rock Outcrop areas and 1.37 in (Lafenwa and Panseke) to 2.01 mSv/yr in (Ago-Oko and Osiele) with the mean of 1.69 ± 0.17(mSv/yr) in the soil covered areas.

Figures 2 and3 showed that the frequency curve for both *areas with rock outcrop* and *areas with Soil Overburden* were almost normally distributed, but the curves for the soil covered areas were positively skewed.

The values obtained in this study is high even higher than the values obtained by Ajayi (2002) in the evaluation of absorbed dose rate and annual effective dose due to terrestrial gamma radiation in rocks in parts of southwestern Nigeria. The rock outcrop areas have higher values of radiation doses as compared with the soil covered areas, although, the soil covered areas also have bedrock underlay which also contribute to the radiation doses of the areas.

Table 1: Absorbed dose rates in areas with rock outcrops and the corresponding effective dose rates

S/N	Sample locations	Locations Latitude	Longitude	Absorbed dose rates (104nGy/hr)	Annual Effective dose (mSv/y)
1.	Ake	07.16213	003.35272	0.116	2.85
2.	Amolaso	07.13982	003.34797	0.112	2.75
3.	Arakanga	07.20440	003.34587	0.122	2.99
4.	Arinlese	07.17234	003.34977	0.114	2.80
5.	Bode – Olude	07.20220	003.36179	0.120	2.94
6.	Elega	07.19343	003.35785	0.108	2.65
7.	Erunwon	07.16531	003.34758	0.120	2.94
8.	Idi – Ape	07.15711	003.34572	0.118	2.89
9.	Ijemo	07.15634	003.35335	0.126	3.09
10.	Ijemo – Agbadu	07.15854	003.35270	0.112	2.74
11.	Imo	07.15204	003.34529	0.110	2.70
12.	Iporo Ake	07.16079	003.35528	0.126	3.09
13.	Isabo I	07.14471	003.35035	0.114	2.80
14.	Isabo II	07.14492	003.34972	0.104	2.55
15.	Isale Ijehun	07.15911	003.34438	0.118	2.89
16.	Itesi	07.16625	003.35303	0.116	2.85
17.	Itoko	07.16927	003.35122	0.130	3.19
18.	Kugba	07.17430	003.35787	0.114	2.80
19.	Kuto	07.13633	003.35022	0.120	2.94
20.	Nawarudeen	07.14500	003.35110	0.100	2.45
21.	Oke – Aregba	07.17578	003.36225	0.124	3.04
22.	Olumo	07.16676	003.34329	0.126	3.09
23.	Oke – Ijemo	07.15855	003.34456	0.118	2.89
24.	Saje I	07.18172	003.36091	0.134	3.29
25.	Saje II	07.17895	003.36096	0.128	3.13

Average *1180± 81 (nGy/hr)* *2.89± 0.20(mSv/yr)*

Table 2: Absorbed dose rates in areas with Soil Overburden and the corresponding effective dose rates

S/N	Sample Locations	Locations Latitude	Longitude	Absorbed dose rates (104nGy/hr)	Annual Effective dose (mSv/y)
1.	Abiola Way	07.16248	003.37185	0.074	1.82
2.	Adatan	07.16853	003.35920	0.066	1.62
3.	Adigbe	07.12378	003.32610	0.066	1.62
4.	Ago – Oko	07.15638	003.34943	0.082	2.01
5.	Asero	07.17210	003.37229	0.076	1.86
6.	Camp	07.18755	003.43700	0.076	1.86
7.	Car Wash	07.17076	003.39131	0.076	1.86
8.	Eleweran	07.18047	003.41707	0.062	1.52
9.	Idi – Aba	07.14334	003.37364	0.076	1.86
10.	Ijaye	07.14853	003.35883	0.066	1.62
11.	Isale – Ake	07.16520	003.35702	0.072	1.77
12.	Ita – Oshin	07.13674	003.36494	0.072	1.72
13.	Ita – Eko	07.13946	003.33029	0.068	1.67
14.	Iyana Mortuary	07.14730	003.36580	0.068	1.67
15.	Lafenwa	07.15733	003.32958	0.056	1.37
16.	Obantoko	07.17700	003.39131	0.066	1.62
17.	Olorunsogo	07.15296	003.35709	0.068	1.67
18.	Olomore	07.14647	003.31610	0.068	1.67
19.	Onikolobo	07.11752	003.33147	0.064	1.57
20.	Osiele	07.19266	003.45426	0.082	2.01
21.	Panseke	07.12097	003.32184	0.056	1.37
22.	Quarry Road	07.13489	003.34268	0.058	1.42
23.	Sapon	07.15388	003.34628	0.072	1.77
24.	Somorin	07.17844	003.40159	0.066	1.62
25.	FUNAAB	07.23027	003.43965	0.068	1.67
	Average			689 ± 70 (nGy/hr)	1.69 ± 0.17(mSv/yr)

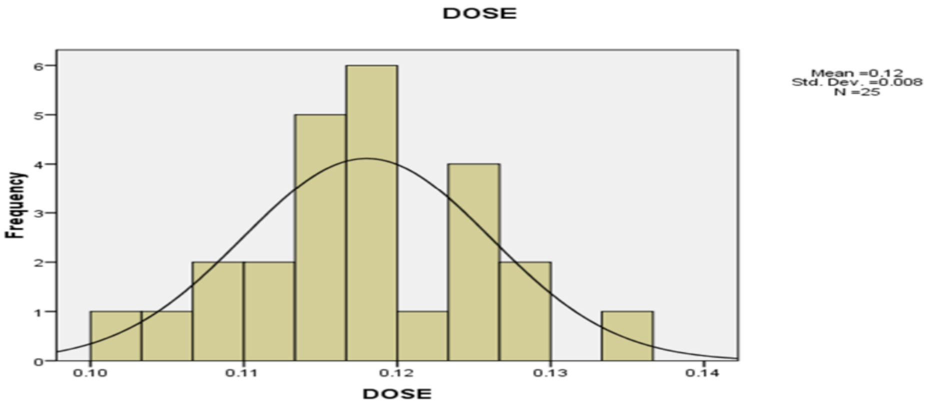

Figure 2. The frequency distribution of the *Absorbed dose rates* (10^4 nGy/h) *in areas with rock outcrop*

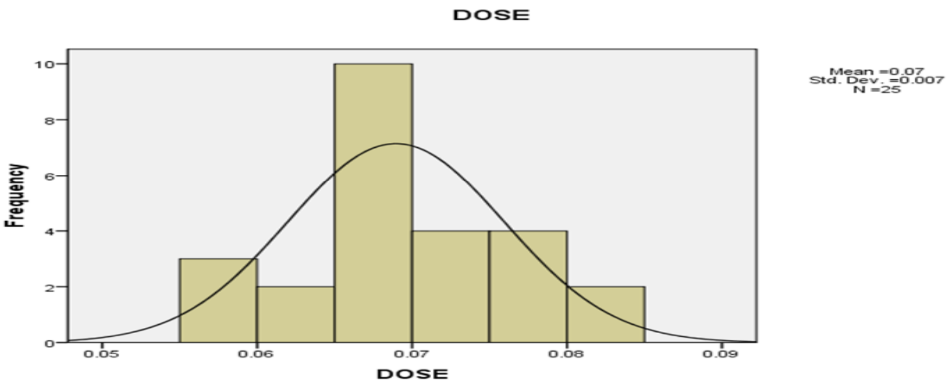

Figure 3. The frequency distribution of the *absorbed dose rates* (10^4 nGy/h) *in areas with Soil Overburden*

Generally, it has been known from different studies done by authors from Nigeria (Jibiri *et al.*, 2009; Jibiri, 2000), that Abeokuta town is known to have high radiation dose. This can be attributed to the basement complex rocks present everywhere (Jibiri, 2000).

This study shows that rocks outcrop areas in Abeokuta enhance high level of radiation.

Hence, it has been revealed that locations with rock outcrops are exposed to higher level of radiation than locations with soil overburdens since the annual effective dose rate is above 1mSv/yr which is the recommended dose limits for the public (ICRP, 2007).

CONCLUSION

The result of the annual effective dose rates for both areas with rock outcrop and areas with soil overburdened were higher than 1mSv/yr which is the recommended dose limits for the public. It can be concluded that rock outcrop areas enhance exposure to radi-

ation than soil overburdened areas, since locations with rock outcrops had higher values of annual effective dose rates than soil covered areas.
Further study with other much sensitive survey meters will be ensured to investigate the radiological status of the study.

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(Manuscript received:8th April, 2013 ; accepted 25 November, 2013).