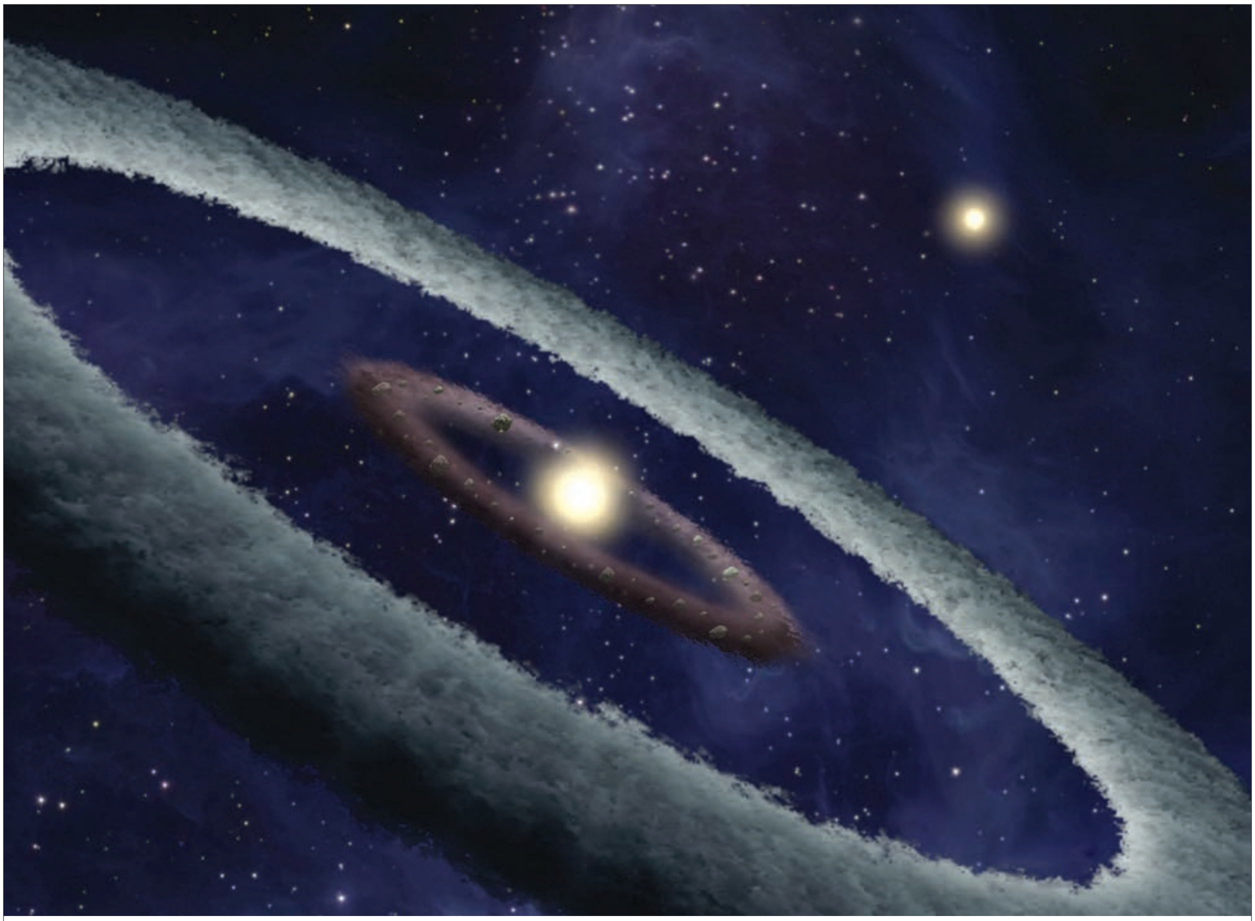

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Measurement of Gamma Radioactivity Level in Bedrocks and Soils of Quarry Sites in Ogun State, South-Western, Nigeria

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ABSTRACT

The abundance of crystalline rocks in Ogun State has resulted in increasing number of quarry activities and sites. These rocks which have been observed to be rich in Naturally Occurring Radionuclides (NOR) are the primary terrestrial sources of radiation in the environment. This study measured the gamma radioactivity level in bedrocks and soils of quarry sites in Ogun State, South-Western, Nigeria. Measurements of radiation were made randomly at 10 locations in each of the 20 quarry sites using fluke-victoreen ASM-990 survey meter. The measured dose rates above the bedrocks and soils of the quarries ranged from 2.3-19.4 and 2.7-19.4 nGy h^{-1} which corresponding to annual effective dose ranges of 2.60-23.81 and 3.31-22.30 µSv y^{-1}, respectively using occupancy factor. Similarly, the result of linear regression between the measured absorbed dose rate on top of the bedrocks and top of the soils in the 20 quarry sites revealed that there is a strong positive correlation ($R^2 = 0.80$) which implies that, the radiation from the soil of the study area are derived from the underlying rocks. The mean absorbed doses of this study were low compared to values from other studies and world recommended value of 70 µSv y^{-1}. However, no matter how low, all levels of ionizing radiation are hazardous to human health. Hence, there will be need for continuous monitoring of the radiation level in and around the quarry sites.

Key words: Crystalline rock, terrestrial, naturally occurring radionuclides, environment, quarry site, Abeokuta

INTRODUCTION

Ionizing radiation is produced when heavy elements such as uranium-238 and thorium-232 decays. The interaction of this ionizing radiation with specific biological material will result in the production of ion pairs which will affects the fundamental structures of biological materials. Human beings have always been exposed to ionizing radiation due to the naturally occurring radionuclides in the bedrocks, soil, sediments and rivers (Frissel, 1994). Terrestrial sources of radiation are responsible for most of man's exposure to radiation, most of it by internal exposure while cosmic rays contribute just under half of man's external exposure (Saleh *et al.*, 2007).

The radiation from rock and soil and the associated exposures of the populations depends on the geographical and geological conditions of the region (UNSCEAR, 2000; Olarinoye *et al.*, 2010). Apart from, geographical and geological factors, some human activities can also enhance the natural radiation background levels (Sujo *et al*., 2004; Rose *et al*., 1995). These activities include burning of fossil fuel, mining, milling and quarrying operations (Saleh *et al*., 2007; Karangelos *et al*., 2004). These operations bring large amounts of buried materials containing naturally occurring radionuclides to the surface of the environment. Such materials are called Naturally Occurring Radioactive Materials (NORM). By ingesting and inhaling the radionuclides in the NORM or by just staying close to large volumes of NORM, people are inadvertently exposed to enhanced level of radiation which can result in health hazard (Saleh *et al*., 2007; Turhan and Gunduz, 2007).

According to Petropoulos *et al*. (2002) and UNSCEAR (1993) report, exposures to ionizing radiation result in health problems after few years. The largest contributor to radiation exposure is Radon. ^{222}Rn (Radon) is a decay product of ^{238}U (Uranium-238) which is commonly found in rocks and soils. As it escapes from rock and soil of which it is trapped, it can dissolve in water and diffuse in air (Okeyode and Akanni, 2009). This study determined the gamma radioactivity level in the bedrocks and soils of the quarry sites in Ogun State.

MATERIALS AND METHODS

Study area: Ogun State is considered for this study because it is one of the States with highly concentrated quarry sites in the Southwest Nigeria. This may be as a result of its proximity to Lagos (the economics nerve centre of Nigeria), with geology consisting mainly of coastal plain sand. The study area is within latitude 6°40'N and 7°40'N and Longitudes 3°20'E and 4°00'E. The Local Government Areas (LGAs) that fall within the study area include Abeokuta North, Abeokuta South, Odeda and Obafemi Owode. The quarries considered for this study are distributed within these LGAs. (Fig. 1). The geology of the study area is a subset of the basement complex geology of

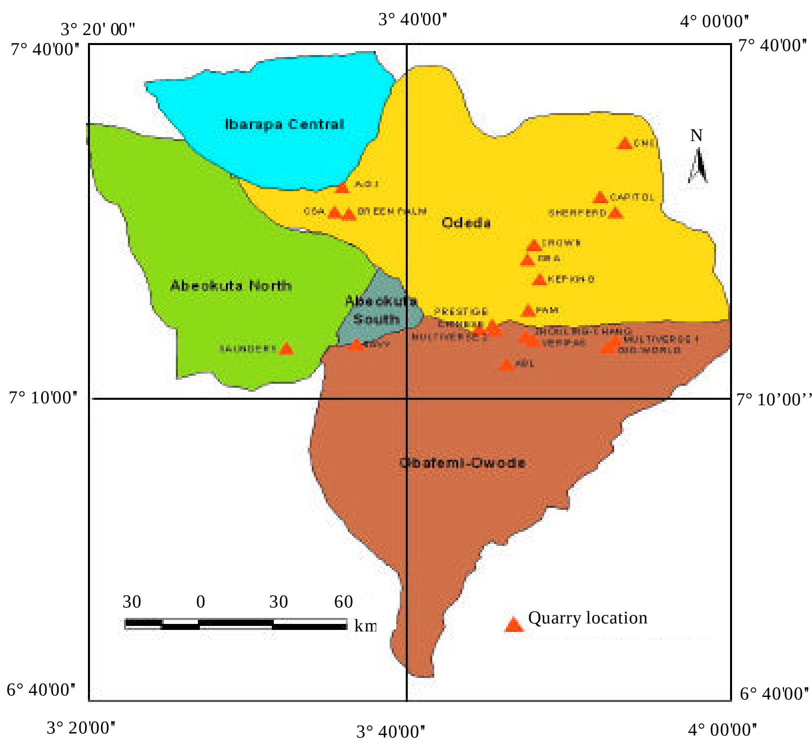

Fig. 1: Map of the study area

south western Nigeria described by Jones and Hockey (1964). The area comprises of varieties of gneisses and older granites which in terms of field occurrence, can be mapped as early phase granodiorite and quartz diorite (Gbadebo, 2011).

Measurement technique: A rapid method of measuring the radiation absorbed dose in each of the quarry site was employed in the study using a portable survey meter specified as the fluke victoreen ASM-990 advanced survey meter. The survey meter is run by two 1.5 D.C. batteries and has temperature range of 10 to 50°C. The humidity limits ranged from 0 to 95% non-condensing. Measurements were made randomly in 10 points at each quarry site, 3 readings were taken and average calculated at each point considered. At each point, the survey meter was held at about 1.0 m above the ground level, switch on and μrad h^{-1} range was selected. Measurements were made for period of three months covering the 20 quarry sites and the measured radiation dose rate in μrad h^{-1} was converted to μGy h^{-1} using the relation:

$$1.0 \text{ rad} = 1.0\times10^{-2} \text{ Gy}$$

Thus, 1.0 μrad h^{-1} = 10.0×10^{-9} Gy h^{-1}. A value of 0.7 Sv/Gy was used for the conversion from radiation dose in air to effective dose received by the public and 0.2 was used for outdoor occupancy factor. Hence, the annual dose rate in μSv y^{-1} was calculated using:

$$E = D\ (\text{nGy h}^{-1})\times(8760\ \text{h y}^{-1})\times0.2\times0.7\ (\mu\text{Sv y}^{-1})$$

RESULTS

The range and mean of the Absorbed Dose Rate (ADR) and Annual Effective Dose (AED) of the measurements on the bedrock of the quarry sites were shown in Table 1 and 2. The result ranged from 2.20 nGy h^{-1} recorded at Sheperd quarry site to 19.40 nGy h^{-1} recorded at Multiverse quarry site. The results also revealed that Navy quarry had the highest average value of 12.31 nGy h^{-1}. The corresponding AED ranged from 2.67-23.81 μSv y^{-1} with highest mean value of 15.03 μSv y^{-1}.

The measurements on the soil of the quarry sites showing the range and mean of the ADR and AED were presented in Table 3 and 4. The ADR ranged from 2.70 nGy h^{-1} recorded at Shouling-Zhang quarry site to 19.40 nGy h^{-1} obtained at Chinese-Prestige quarry site while the highest mean value of 11.34 was recorded at Kepxing quarry site. Similarly, the corresponding AED ranged from 3.31-23.48 μSv y^{-1} with highest mean value of 13.94 μSv.

The result of linear regression line between the measured absorbed dose rate on top of the bedrocks and top of the soils in the 20 quarry sites, Fig. 2 revealed that there is a strong positive

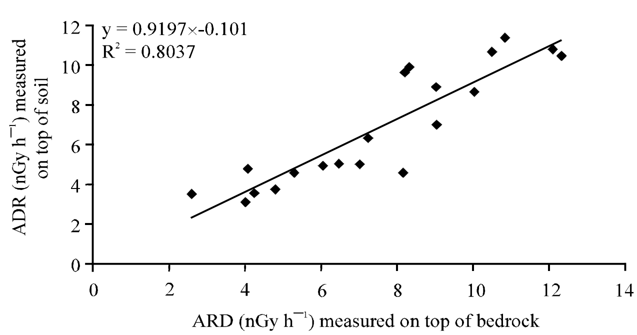

Fig. 2: Absorbed dose rate (ADR) with linear regression line showing positive correlation between measured ADR on top of bedrock and soil of the quarry sites

Table 1: Range and mean of the measured absorbed dose rate (nGy h^{-1}) in bedrock of the 20 quarry sites

Name of quarry	Location	Range	Mean
OBA	Odeda	5.60-11.60	9.03
AGI	Saje-Abeokuta	4.00-5.70	6.46
CROWN	Odeda	2.40-7.40	4.02
NAVY	Navy-Abeokuta	8.40-11.50	12.31
KEPXING	Ilaho-Onigbogbo	9.50-11.07	10.83
CSA	Omo-Ologede	7.60-8.80	8.30
GREENPALM	Igboora road	4.60-7.20	6.06
FAM	Bantum village, Osiele	5.30-9.90	7.02
SAUNDERS	Oke-Ata	8.70-16.60	12.01
SHEPERD	Olugbo	2.20-5.10	4.08
ABL	Kajola	7.00-13.70	10.49
VERITAS	Omo-Ologede 3	2.30-2.70	2.62
CAPITOL	Olodo	3.86-6.30	5.28
CNC	Olowu/Ilugun	3.10-5.80	4.80
SHOULING – SHANG	Aberu-Obafe	2.40-8.40	4.26
MULTIVERSE-2	Alaguntan	6.20-9.70	7.26
MULTIVERSE	Oloparun	3.10-19.40	8.14
JIABAO	Obele	9.20-12.30	10.04
GIO-WORLD	Obafemi-Mile 20	6.50-16.00	9.04
CHINESE-PRESTIGE	Idi-Osan	2.60-13.70	8.21

Table 2: Range and mean of the measured annual effective dose (µSv y^{-1}) in bedrock of the 20 quarry sites

Name of quarry	Location	Range	Mean
OBA	Odeda	6.87-14.24	11.14
AGI	Saje-Abeokuta	6.14-9.08	7.93
CROWN	Odeda	2.95-9.08	4.93
NAVY	Navy-Abeokuta	10.31-14.11	12.54
KEPXING	Ilaho-Onigbogbo	11.66-16.08	13.45
CSA	Omo-Ologede	9.32-10.80	10.19
GREENPALM	Igboora road	7.24-8.83	7.44
FAM	Bantum village, Osiele	6.50-12.15	8.60
SAUNDERS	Oke-Ata	10.68-20.37	15.03
SHEPERD	Olugbo	2.67-6.26	5.00
ABL	Kajola	8.59-16.81	12.93
VERITAS	Omo-Ologede 3	2.82-3.80	3.21
CAPITOL	Olodo	4.66-7.73	6.48
CNC	Olowu/Ilugun	3.80-7.11	5.89
SHOULING – SHANG	Aberu-Obafe	2.95-10.31	5.53
MULTIVERSE-2	Alaguntan	7.61-11.90	8.91
MULTIVERSE	Oloparun	3.80-23.81	9.99
JIABAO	Obele	11.29-15.10	12.32
GIO-WORLD	Obafemi-Mile 20	6.50-16.00	9.04
CHINESE-PRESTIGE	Idi-Osan	3.80-16.81	12.76

correlation (R^2 = 0.80) between the rock and soil of the quarries which implies that, the radiation from the soil of the study area are derived from the underlying rocks.

Table 3: Range and mean of the measured absorbed dose rate (nGy h^{-1}) in soil of the 20 quarry sites

Name of quarry	Location	Range	Mean
OBA	Odeda	5.80-8.30	6.96
AGI	Saje-Abeokuta	5.10-7.70	5.00
CROWN	Odeda	2.90-3.80	3.10
NAVY	Navy-Abeokuta	7.90-15.10	10.46
KEPXING	Ilaho-Onigbogbo	6.30-18.20	11.34
CSA	Omo-Ologede	7.80-12.10	9.92
GREENPALM	Igboora road	3.40-3.70	4.92
FAM	Bantum village, Osiele	3.80-9.00	5.00
SAUNDERS	Oke-Ata	8.90-12.40	10.76
SHEPERD	Olugbo	4.00-5.20	4.80
ABL	Kajola	9.00-11.80	10.66
VERITAS	Omo-Ologede 3	3.20-3.90	3.50
CAPITOL	Olodo	3.90-5.90	4.56
CNC	Olowu/Ilugun	3.20-4.20	3.78
SHOULING – SHANG	Aberu-Obafe	2.70-5.40	3.54
MULTIVERSE-2	Alaguntan	4.80-8.00	6.26
MULTIVERSE	Oloparun	3.30-5.80	4.56
JIABAO	Obele	7.20-11.20	8.64
GIO-WORLD	Obafemi-Mile 20	5.50-18.60	8.84
CHINESE-PRESTIGE	Idi-Osan	4.00-19.40	9.66

Table 4: Range and mean of the measured annual effective dose equivalent (μSv y^{-1}) in soil of the 20 quarry sites

Name of quarry	Location	Range	Mean
OBA	Odeda	6.75-10.19	8.54
AGI	Saje-Abeokuta	6.26-8.22	7.21
CROWN	Odeda	3.39-4.66	3.80
NAVY	Navy-Abeokuta	9.70-18.53	12.84
KEPXING	Ilaho-Onigbogbo	7.73-22.30	13.91
CSA	Omo-Ologede	9.60-14.84	12.18
GREENPALM	Igboora road	4.17-8.71	6.14
FAM	Bantum village, Osiele	4.66-11.05	7.44
SAUNDERS	Oke-Ata	11.05-15.22	13.21
SHEPERD	Olugbo	4.91-6.38	5.96
ABL	Kajola	11.05-14.48	13.08
VERITAS	Omo-Ologede 3	3.92-4.79	4.29
CAPITOL	Olodo	4.79-7.20	5.59
CNC	Olowu/Ilugun	3.93-5.15	4.64
SHOULING-SHANG	Aberu-Obafe	3.31-6.62	4.34
MULTIVERSE-2	Alaguntan	5.89-9.82	7.68
MULTIVERSE	Oloparun	4.05-6.50	5.62
JIABAO	Obele	8.83-13.75	10.60
GIO-WORLD	Obafemi-Mile 20	5.50-18.60	8.84
CHINESE-PRESTIGE	Idi-Osan	4.00-23.48	9.66

DISCUSSION

Previous studies have shown that naturally occurring radionuclides become trapped in the earth's crust during the formation of the parent rocks (Gessel and Prichard, 1975; Florou and Kritidis, 1992; Gundersen *et al*., 1992; Shiva *et al*., 2008) and end up in soils as part of rock cycle through weathering (USEPA, 2007). It is also possible that the radionuclides may show a distinct variation in the radiation level in any environment based on many factors such as geographical and local geology of the area investigated (Gbadebo, 2011). The Absorbed Dose Rate (ADR) of the *in situ* measurements of the bedrocks in the twenty quarry sites ranged between 2.20-19.40 nGy h^{-1} with mean of 7.52 nGy h^{-1}. This result is similar to earlier report by Gbadebo and Ayedun (2010) while Annual Effective Dose rate (AED) ranged between 2.60 and 23.81 μSv y^{-1} with average of 8.89 μSv y^{-1}. Similarly, the absorbed dose rate in soil ranged between 2.70 and 19.40 nGy h^{-1} with the average of 6.81 nGy h^{-1}, whereas the annual effective dose ranged between 3.19-22.30 μSv y^{-1} with the mean of 8.29 μSv y^{-1}. The result showed a strong positive correlation between the measured ADR on the bedrocks and soils of the quarry sites which imply that soil of the quarry sites derived their radiation from the underlying rock. Similarly, the absorbed dose rate and annual effective dose measured in the bedrock and soils of the quarry sites falls within the same range and could be attributed to natural source as there are no other sources of radiation around the study area.

The average AED of the measured bedrocks and soils of this study area is in agreement with Obed *et al.* (2005) which reported a dose rate of 24.60 μSv y^{-1} in 18 cities across Nigeria and Odunaike *et al.* (2008) which reported a mean value of 24.60 μSv y^{-1} in radiation measurements in quarry sites and five villages in Abeokuta North Local Government Area. Also, the average AED of this study is higher than 18.90 μSv y^{-1} reported by Olarinoye *et al.* (2010) measured in two tertiary institutions in Minna, Nigeria. However, none of the values from the measured bedrocks and soils of the quarry sites in this study area near the extraneous value of 9.3×10^{4} μSv y^{-1} obtained for an in-situ measurement in the exposure to high background radiation level in the mining area of Jos, plateau by Ademola (2008). Also, the mean values of the measured radiation were lower than the world average value of 70 μSv y^{-1}. The low values of the measured radiation may be due to high geochemical mobility of radionuclides in the environment but it may have cumulative effects on the health of the quarry workers and nearby residents.

CONCLUSION

The mean absorbed dose of this study was low compared to values from other studies and world recommended value. However, it has been observed that no matter how low, all levels of ionizing radiation are hazardous to human health. Therefore, there is a need for a comprehensive radiological study of the quarry sites and the level of radiation exposure of the inhabitants.

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