Assessment of Radiation Related Health Risks of Quarry Sites in the Vicinity of Lapai, North Central Nigeria.

***M.T. Tsepav, A. Yakubu, A. S. Gene and Usman Abbas**

Abstract- Humans are exposed to radiation in their environment with or without their consent since natural radiation is an unpreventable event which comes, sometimes, with health related risks. There is therefore the need to continuously monitor our environments for risk assessment of radiation induced health hazards. It is for this reason that four quarry sites in Lapai and its environs were investigated for ionising radiation emissions using a Geiger Muller Counter (Digilert Nuclear Radiation Monitor, Cesium 137 Gamma). The results showed average exposure dose rate values to be 0.00091mR/hr for Bakajeba Site, 0.00033mR/hr for Dangana Site, 0.0003mR/hr for Takalafiya Site and 0.00048mR/hr for Lambata Site respectively. The equivalent dose rates were also calculated to be 0.0080mSv/yr in Bakajeba, 0.0029mSv/yr in Dangana, 0.0026mSv/yr in Takalafiya and 0.0042mSv/yr in Lambata respectively. Both the Exposure Dose Rate and Equivalent Dose Rate levels were observed to be lower than the normal world average level of 0.013mR/hr and 1.0mSv/yr respectively recommended by International Commission on Radiological Protection.

KeyWords: Ionising, Radiation, Risk, Assessment, Equivalent Dose

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1 INTRODUCTION

Radiation is energy in motion, in the form of waves or streams of particles. Radiation has always been present and is all around us in many forms [1]. Ionizing radiations such as alpha (α), beta (β), and gamma (γ), have the ability to knock electron out of its orbit around atoms, upsetting the electron/proton balance and potentially damaging cells [1]. Many materials found in the earth's crust contain small but measurable amounts of naturally occurring radioactive materials (NORM) which are sources of man's exposure to ionizing radiation.

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Radiation concentrations could be higher in areas where there are industrial activities such as mining which expose radiation at levels much higher than those exposures present in the crust. Among the operations which may lead to significant increase in exposure to natural radiation sources are mining of ore and extraction of rare earth elements (REEs) which have the potential to increase the radiation dose received by workers and the general public.

The resultant effects of quarry activities are the extensive devastation of the environments in terms of deforestation, destruction of nearby farm lands with stone pebbles, gaseous pollution from the use of explosives and release of toxic metals into the surrounding environments among others. The natural radiations from granitic bodies and other geological formations are other sources of environmental hazard [2], [3].

Human exposure to ionizing radiation from natural sources is an unending and unpreventable phenomenon on earth. Some exposures to natural radiation sources are modified by human activities such as natural radionuclide released into the environment in mineral processing areas, use of phosphate fertilizer processors, fossil fuel combustion and quarry activities causing enhanced natural radiation exposures. The radiation can cause injuries and clinical symptoms, which may include a chromosomal transformation, cancer induction, free radical formation, bone necrosis and radiation catractogenesis [4]. The injuries and clinical symptoms could be caused at both high doses and prolonged low dose exposure because of the lethal effects of ionizing radiation, the practice has being to monitor and assess the level of exposure and keep one's exposure to ionizing radiation as low as reasonably achievable.

The study areas are Bakajeba, Dangana, Takalafiya and Lambata. The dominant rocks in the vicinity of the study areas are granite rocks which are usually mined for roads and buildings construction. Granite is an igneous rock made mostly of quartz crystals and range from pink to gray, to almost black depending on the amount of other minerals that were in the magma. Granite is a great material for construction because it is strong and resistance to acid unlike marble. The process of granite extraction produces massive amounts of dust and increased levels of natural radionuclides that have been reported in various concentrations in different components of the environments. It include those that were formed with the parent bedrocks during the earth formation e.g., Uranium (U), Thorium (Th), Potassium (K) series and Radon [5]. Both have been linked to incidences of lung cancers, including silicosis and mesothelioma, [6] Regulations regarding the amounts of dust and gas emitted from granite quarries have been enacted in many countries, beginning in the 1970sleading to significant decrease in cases of lung cancer among quarry workers [6].

With the measurements of radiations from various rock aggregates, surface and sub-surface soils within and around quarry sites, the effects of aggregate sizes, soil distribution and proximity of the quarry sites on the radiation concentrations could be assessed and the possible health implication also inferred and appropriate recommendations proffered.

We therefore sought to evaluate the level of radiation emitted from quarry sites in Lapai and its environs to ascertain the level and trend of contamination over time so as to protect quarry workers and inhabitants of the vicinity from the dangers associated with the exposure to radiation especially the ionizing radiations.

Several works have been carried out on similar ventures. For instance, [7] measured the outdoor radiation level in Abeokuta, Nigeria using Thermoluminescent Dosimetry and reported that the human equivalent dose due to outdoor exposure in the city ranged between 0.19 to1.64 mSv/yr with a mean equivalent dose of 0.45 mSv/yr and the mean dose of extraterrestrial radiation estimated to be 0.18mSv/yr in the city. A nationwide survey conducted by [8] of terrestrial radiation using the technique of in-situ gamma spectrometry showed that the annual mean effective dose equivalent was 0.27mSv/yr. Another nationwide study on the assessment of natural radioactivity in Taiwan by [9] revealed that the adult effective dose in Taiwan was 1.56mSv/yr, which is safe when compared to the maximum permissible level of 1mSv/wk recommended by International Commission on Radiological Protection.

[10] reported an increase in the background radiation of the southern parts of Nigeria due to north-easterly wind that moves dust particles from the Sahara region to the coastal parts of Nigeria. [11] studied the external environmental radiation in the Trans-Amadi industrial area of Port Harcourt, Rivers state, Nigeria. [12] also reported how human activities have led to the depletion of the ozone layer, increased the cosmic rays reaching the earth's surface thereby affecting the background radiation. [13] made a research in very high background radiation areas of Ramsars (Iran) using a typical Geiger Muller counter and reported the range of 260 maximum dose (MGY^{-1}) and the minimum of 0.61 (MGY^{-1}) which was far above the recommended value for Iranian workers which was 20mSv/year and the International Committee Radiation Protection recommendation for the annual background radiation dose rate of 0.6mSv/year.

An external background ionizing radiation study was carried out by [14] within the Asa Dam Industrial Layout of Ilorin in Kwara State. The study was carried out in 5 stations within the industrial area using two Digilert Nuclear Radiation Monitors. The study revealed that the external background ionizing radiation to be averagely 0.0134 mR/hr with a deviation of about 22% which was relatively higher than the standard background radiation of 0.011 mR/hr. The result suggested the possibility of the presence of radionuclide sources in the environment.

The results of the radionuclides analysis in the bedrock (i.e., limestone and shale) and soil samples collected from locations around Ewekoro cement factory by [5] indicated an average total specific activity values of 7.78±2.74, 8.99±3.90 and 17.63±1.98 Bq kg^{-1} for ^{238}U, ^{232}Th and ^{40}K, respectively in the surface soils while average total specific activity values of 8.07±2.88, 8.25±3.18 and 16.52±1.98 Bq kg^{-1} for ^{238}U, ^{232}Th and ^{40}K, respectively were obtained for subsurface soils. Similarly, the average total specific activity values of 91.30±2.33, 5.75±2.57 and 35.86±7.06 Bq kg^{-1} for ^{238}U, ^{232}Th and ^{40}K, respectively were obtained for limestone bedrock type while values of 3.74±11.42, 5.95±2.26 and 348.20±61.82 Bq kg^{-1}, for ^{238}U, ^{232}Th and ^{40}K, respectively were obtained for the shale bedrock type. From the results, geogenic source of the radionuclides with some anthropogenic implications were inferred.

2 MATERIALS AND METHODS

2.1 The Radioactive Decay Law

The radioactive decay law states that the activity of a radioactive sample decreases exponentially with time [15]. If we consider the number of nuclei (dN) decaying in a short time dt.

Then:

$$dN = - \lambda N dt \quad (1)$$

where λ= decay constant.

Or

$$N_t = N_o e^{-\lambda t} \quad (2)$$

where N_o is the number of nuclei present initially, N_t is the number of nuclei present at time t.

The half- life is the time required for one half of the atoms in any starting sample of a radioisotope to decay. If the half-life of a radioactive nuclide is known, its decay constant can be calculated using:

$$\lambda = 0.693/T_{1/2.} \quad (3)$$

This relationship expresses radioactive decay based on statistics and probability, from an examination of the behavior of a large number of individual situations. It is however, worth noting that it does not give any indication when a particular nucleus would undergo decay, but only the amount of time needed for a certain proportion of the nuclei in the sample to decay [16].

2.2 Materials and data collection

The main materials used were Geiger Muller counter (Digilert) and Stop watch. The Digilert nuclear radiation monitoring meter contains a Geiger-Muller tube capable of detecting alpha α, beta β, gamma γ and x-rays radiations within the temperature range of 0^oC to 50^0C in a given environment. A 137 Cesium (Gamma) source of specific energy had been used to calibrate the instrument to read accurately in milli Roentgens per hour (mR/hr). Measurements of the dose rate were carried out in units of count per minute (CPM) and milli Roentgens per hour (mR/hr), respectively. The analysis of the amount of radiation emitted was based on the related parameters such as average count per minute (CPM) which is divided by the device sensitivity value (1000) referenced to Cesium 137 to obtain dose rate in milli Roentgens per hour (mR/hr).

The measurements of radiations emitted from rocks were carried out at the four identified quarry sites. The background radiations were done directly in an undisturbed manner within the villages, while the measurement of the radiations emitted from rocks at the quarry sites was carried out directly from the exposed rocks. The Geiger-Muller tube was held at a standard height of 1.0m above the ground with its sensor vertically downward in order to sense the radiation coming out from the rocks. The meter was set in count per minute (CPM) mode and a stopwatch was used to observe the count for the period of 20 minutes interval. The radiation level was recorded at each point. Five readings were taken at interval of 20 minutes at each of the sites and the average mean value calculated. The background reading from villages was then deducted from the average mean value to obtain the actual mean radiation levels emitted by rocks at the quarry sites. The average mean values were then divided by 20 minutes to get the average count per minute (CPM).

The generated data was then converted to equivalent dose rate in milli sievert per year (mSv/yr) using the relations:

$$X = (\sigma \times 24 \times 365/1000) \text{ mSv/yr} \qquad (4)$$

where: X = equivalent dose in milli sievert per year (mSv/yr)

σ = Dose rate (mR/hr).

3 RESULTS AND ANALYSIS

The measurements made in the vilages as well as on quarry sites are presented in Table 1. The results obtained in these study areas are displayed as the average radiation levels emitted by each quarry sites with their locations and are shown for the measured parameters of activity in count per minute (CPM), Exposure Rate in milli Roentgens per hour (mR/hr) and Equivalent Dose rate milli Sievert per year (mSv/yr).

In order to have better evaluation of the different quarry sites and show significant relationships between the radiations emitted, a plot of dose rate in mR/hr and Equivalent Dose in mSv/yr were bar charted as shown in Figures 1and 2 respectively.

From the evaluated radiation levels, the Bakajeba quarry site has the highest dose rate of 0.00091mR/hr and equivalent dose rate of 0.0080mSv/yr compared to that generated from other sites at Dangana, Takalafiya and Lambata with dose rates of 0.00033mR/hr, 0.0003mR/hr, 0.00048mR/hr respectively and Equivalent Dose rates of 0.0029mSv/yr, 0.0026mSv/yr, 0.0042mSv/yr respectively. The highest value obtained at Bakajeba site compared to the other three sites, may be as a result of the high content of Uranium, Thorium, Potassium and Radon in the bedrock at the site.

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Table 1: Radiation Measurements at villages and Quarry Sites

Quarry Sites	**Time Interval (minutes)**	**Average Background count in village A**	**Average background count at sites B**	**Radiation emitted by Rocks B – A= C**	**Activity (count per minute)**	**Dose Rate (mR/hr)**	**Equivalent Dose (mSv/yr)**
Bakajeba	20	18.60	36.80	18.20	0.91	0.00091	0.0080
Dangana	20	12.40	19.00	6.60	0.33	0.00033	0.0029
Takalafiya	20	17.80	23.80	6.00	0.30	0.00030	0.0026
Lambata	20	14.00	23.60	9.60	0.48	0.00048	0.0042

Even though Bakajeba site had the highest recorded radiation level, it was still below the recommended normal world average level of 0.013mR/hr and 1.0mSv/yr respectively [17]. By these results, all the sites investigated do not indicate any immediate health side-effects on the workers and the resident villagers. Accumulated effects cannot however, be ruled out as ionizing radiations have the tendency of remaining in the body for a while especially if the body's cells cannot recover from their actions quickly.

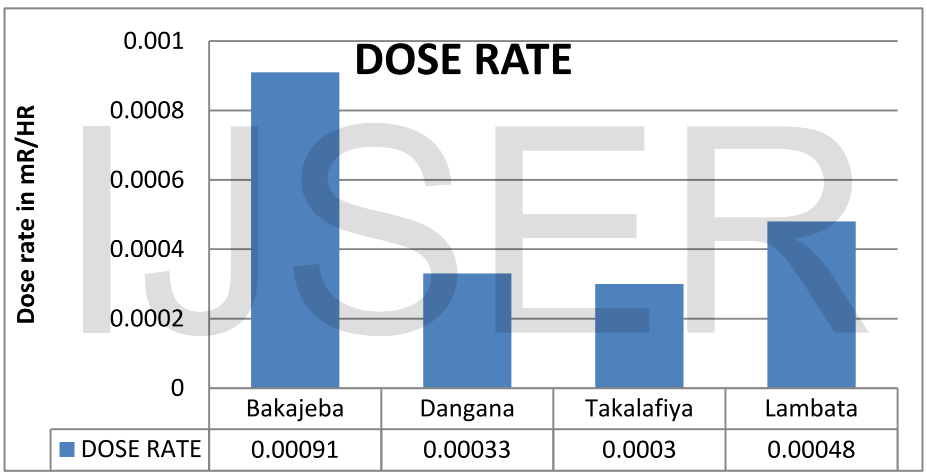

Figure 1: Exposure rate in mR/hr

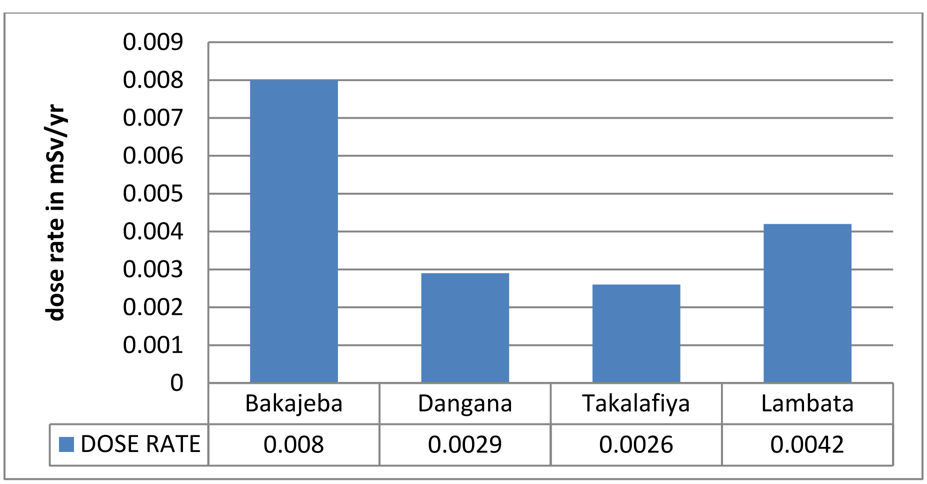

Figure 2: Equivalent dose rate in mSv/yr

4 CONCLUSION

The exposure to radiation is an unpreventable thing and so continuous monitoring is necessary, especially among quarry workers and the vicinities where mining activities are carried out. In line with this, an assessment of radiation emitted from some quarry sites in Lapai and its environs was conducted using Geiger Muller (Digilert Nuclear Radiation Monitor, Cesium 137 Gamma). The evaluated radiation levels generated from all the sites investigated do not indicate any immediate health implications. The highest radiation exposure dose rate and equivalent dose rate of 0.00091mR/hr and 0.0080mSv/yr obtained was found to be below the recommended average value of 0.013mR/hr and 1.0mSv/yr respectively [17]. Continuously exposing the workers and villagers within the quarry sites to this radiation may however, cause health problems in the long run on the quarry workers and resident villagers and the need for continuous monitoring is strongly advised.

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