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An Investigation of the Amount of Dose Rate Due to Radioactive Count within Sokoto Metropolis

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ABSTRACT

This paper aims to unveil the level of risk to biological system due to ionizing radiation within Sokoto metropolis. It is known to cause cancer and other related ailments. Thirty (30) randomly sampled points were measured with the aid of Dose Rate Meter, Rados [RDS-120]. The energy deposited to biological systems by gamma-ray flux was measured in micro sivert per hour (μ Sv/hr). We found a significant total amount of dose rate at 2.95 μ Sv/hr with an arithmetic mean of 0.10 μ Sv/hr with an annual exposure rate of 864.0 μ Sv/yr. An amount which is quite significant above the world wide effective dose rate of 70 μ Sv/yr. This result indicates a radiation hazards contributed by either primordial radionuclides or cosmogenic radionuclides which suggest for mitigation actions and calling for further research.

Keywords: Dose-rate, RDS-120, Sokoto, Gamma-Ray, Cancer

I. INTRODUCTION

Background radiation could be as a result of naturally occurring radiation emitted by soil, ground water, building materials, radioactive substance in the body (especially potassium 40) and cosmic rays from the outer space [1]. Radiations have also been widely applied to various purposes such as agriculture, biology, industry, medicine, and electric power generation [2]. The rocks we see and the soil beneath our buildings are naturally the main sources of radioactivity which is typically four or five times more concentrated indoor than outdoor premises. Building materials, water and Natural gas are additional sources of these menaces [1]. By definition, primordial radionuclides are radioactive sources that have been on earth surface since time immemorial. For the purpose of radiation protection, radiations from uranium-238 and thorium-232 decay series, and potassium-40 are found almost throughout the earth in relative concentrations [3]. Due to the varying concentrations of each type of radioactive sources in different parts of the world, this dose rate which is an energy deposited by gamma-ray flux level varies across the world [4]. The safety and danger continues to vary from one part of the world to another, with the ill effects on humans or nature also varying. In some parts of the globe, high concentrations of radioactivity can have detrimental health effects [5], and hence it is of health importance to be able to determine amount and concentration of the background radiation, and to establish the distinction between safe and unsafe levels as well as to determine causes of each type of radiation maladies. The analysis of domestic water shows that the natural radioactivity in them varies over a wide range of significance, mainly depending on the geological make-up of the soil. The radiotoxicity of Uranium isotopes (238U, 234U and 235U) are non-negligible [2]. Furthermore, several radionuclides in the radioactive decay chain taking from 238U and 235U are significantly radiotoxic. The most radiotoxic and most important among them is radium, which is a known carcinogen and exists in several isotopic forms. The predominant radium isotopes in groundwater are 226Ra, an alpha emitter with a half-life of 1600 years, and ^{228}Ra, a beta emitter with a half-life of 5.8 years [6]. The present work is aimed at to measure the dose rate with the aid of Dose Rate Meter, Rados [RDS-120] from CERT, Zaria.Thereby finding the annual dose exposure by an individual from the gamma-ray flux within the typical urban dwelling of Sokoto city.

A. Radiation in Sokoto

The occurrence of oceanic upwelling of North African coast during the upper Cretaceous to Eocene times is well documented. A high organic productivity which resulted in the development of economic phosphate deposits in the Tethyan belt. This belt stretches across the North African and Arabian Plates and is known as the Tethyan Phosphogenic Province [7]. Phosphate deposition in the Sokoto basin was derived from the incursion of phosphate rich water from the Tethys Sea. The Tethys Sea during the late Paleocene covered parts of Libya, Sudan, Niger Republic, Chad and Mali [8,9,10]. The Sokoto phosphate belongs to the Tethyan Phosphogenic Province. The Phosphate was precipitated from sea water during the deposition of the Dange and Gamba Formations. The presence of the oolites indicates the occurrence of acretionary growth phases during the phosphate sedimentation. The calcite found in the phosphate was precipitated from sea water as microsporite. Some of the phosphate was also formed through the process of diagenesis as a partial replacement of carbonate mud by apatite [11,12].

During the regression of the Tethys Sea due to sea level changes, the microsporite was broken up by biological and physiochemical processes. This would have occurred when in a semi-lithified state to be subsequently transported ultrabasinnaly. The bioturbations on the nodules indicates phosphate deposition in shallow water probably within the upper shore face environment. The lack of structural traps from tectonism via differential displacement of faulted blocks hindered economic phosphate accumulations [10].

B. The Study Area

The metropolis of Sokoto, comprising majorly Sokoto-North and South local government areas, while little parts of Wamako, Kware, Bodinga and Dange-Shuni local government areas are found entrapped at the outskate of the metropolis, but constitutes the study area of this research. Sokoto state lies on the Latitude 13.0833333^0, Longitude 5.25^0, and Altitude 895 (feet). It is in the extreme northwest of Nigeria, bordering Niger and Benin Republics. It has an annual average temperature of 33.3^oC [13, 14].

C. Radioactive Decay

Radioactive decay is as could be concluded a random process and has been observed to follow the statistical distribution of equation one (1) below [15]. This essentially means that, the rate of decay of radioactive nuclei in any sample depends only on the number of decaying nuclei in the sample. Mathematically this can be written as follows:

$$\frac{dN}{dt} \propto -N$$

or

$$\frac{dN}{dt} = -\lambda N \qquad (1)$$

Where dN represents the number of radioactive nuclei in each measured sample points in the time.

where dt . λ is the proportionality constant which is generally referred to in so many literatures.

II. METHODS AND MATERIALS

Sampling and Measurement

The data collection in this project shall be carried out within Sokoto metropolis, outdoor, indoor of homes and enclosed workplaces. A total of 30 sample points were measured and recorded within an interval of 20 minutes for three consecutive times so that the mean value of any measured point will be recorded. Open fields like football pitches, parks, farms and gardens were used for outdoor measurements, whereas houses, churches and mosques were used in indoor inspection to account for both indoor and outdoor presence of the dose rate, three counts of the RDS-120 is ensured for in and outdoor before the mean is taken. To account for fairness between all the sample points, we adopted the random sampling method which gives all the samples in question an equal chance of being chosen with no sample point considered in preference to the other. The instrument is held 3.5 feet above the ground at every sample point due to 5 feet average human height, and the arithmetic mean of the three readings was found by the relationship below.

$$X = \frac{x_1 + x_2 + x_3 + \dots\dots\dots\dots + x_n}{n}$$

or

$$X = \frac{\sum_{n=1}^{n} x_1}{n} \qquad (3)$$

Where the symbol Σ means adding up set of data in this case set of measurements from all the sample points $x_1, x_2, x_3, x_{4,}$ up to x_n and n at the denominator remains the total number of samples so added.

III. RESULTS AND DISCUSSION

Table 1: The Measured Background Radiation for Homes and Workplaces in Sokoto Metropolis. From table 1 below, we could see that sample point number 10 in the serial arrangement has the highest dose rate of 0.13 μ Sv/hr in this research followed by sample point with serial number 27 and dose rate 0.12 μ Sv/hr respectively. Below is graphical analysis of the table *above.* Fitted line is physically used to investigate the relationship between two variables: here, radioactive dose rate (μ Sv/hr) and the time interval of 20 minutes per of every reading as discussed above. The two conditions have enabled a fitted line plot which displays the as the response on the Y-axis, then a linear model that best describes the relationship was used to visualize the fitted line plot showing that every increase in time of 20 minutes interval paves way for a variation in the reading of another radioactive dose rate (μ Sv/hr).

Table I: Measured Background Radiation

S/N	Sample Points Identity	Time/minute	Background Radiation (μSv/hr)
1	Sok_1	20	0.08
2	Sok_2	40	0.10
3	Sok_3	60	0.07
4	Sok_4	80	0.10
5	Sok_5	100	0.08
6	Sok_6	120	0.10
7	Sok_7	140	0.10
8	Sok_8	160	0.10
9	Sok_9	180	0.08
10	Sok_{10}	200	0.13
11	Sok_{11}	220	0.10
12	Sok_{12}	240	0.11
13	Sok_{13}	260	0.10
14	Sok_{14}	280	0.10
15	Sok_{15}	300	0.11
16	Sok_{16}	320	0.08
17	Sok_{17}	340	0.10
18	Sok_{18}	360	0.08
19	Sok_{19}	380	0.10
20	Sok_{20}	400	0.10
21	Sok_{21}	420	0.08
22	Sok_{22}	440	0.10
23	Sok_{23}	460	0.11
24	Sok_{24}	480	0.11
25	Sok_{25}	500	0.11
26	Sok_{26}	520	0.10
27	Sok_{27}	540	0.12
28	Sok_{28}	560	0.11
29	Sok_{29}	580	0.09
30	Sok_{30}	600	0.10

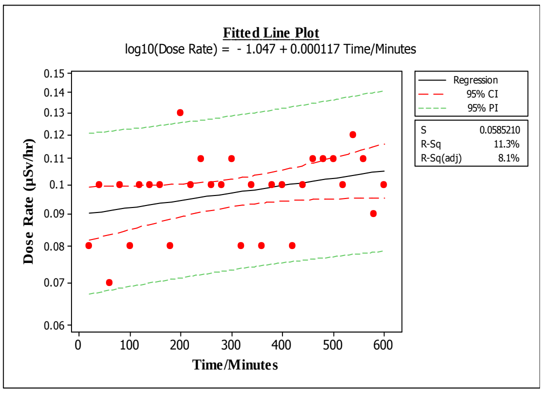

Figure 1: A fitted line plot of dose rate in Sokoto

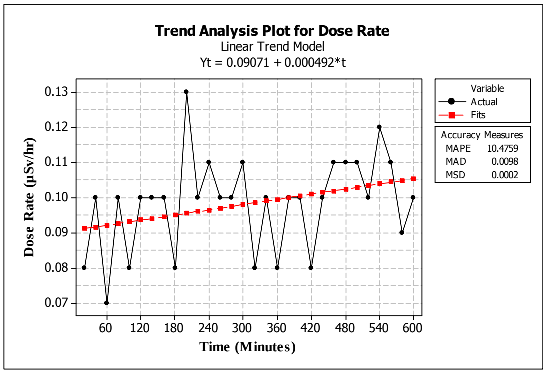

Figure 2: A trend plot of dose rate in Sokoto metropolis

IV. CONCLUSION

The significant annual exposure rate of 864.0 μ Sv/yr. of dose rate in every environment is an indication of health implication that either primordial radionuclides or anthropogenic activities giving rise to the dose rate is prominent, one of which commonly causes bone cancer [16] While low dose rate seems to produce insignificant exposure hazards, multiple and cumulative exposure showing the vast variation of the data in this work with increase in time intervals eventually leads to the risk of major cancer as no safe level of prolonged exposure to radiation is established[17, 18].

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