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Natural Radioactivity Concentration and Its Health Implication on Dwellers in Selected Locations of Ota

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Abstract. Elevated background ionizing radiation has its health effects on people who reside in such areas, this necessitate the need for constant monitoring. The activity concentrations of K-40, Th-232 and U-238 were measured in three different selected study areas in Ota using RS-230 gamma spectrometer. The highest activity concentrations for the three radionuclides were recorded in the Industrial Estate. The mean dose rate recorded was 45.37 $nGyh^{-1}$, 37.12 $nGyh^{-1}$ and 33.33 $nGyh^{-1}$ for Industrial Estate, Obasanjo Estate and Atan respectively. The mean outdoor annual equivalent dose estimated was 0.056 $mSvy^{-1}$, 0.045 $mSvy^{-1}$ and 0.041 $mSvy^{-1}$ respectively for the three locations. The estimated excess lifetime cancer risk ranged from 0.14 x 10^{-3} – 0.277 x 10^{-3} for the study areas. The radiological variables estimated in this study were all within world average recommended limit. The study concluded that the locations considered in this work are safe for dwellers and that industrial activity has influence on the background radiation.
Keywords: Radioactivity, Radiation dose, Health implication, Ota

1. Introduction

Naturally occurring radionuclides in the environment has its health implications on humans that reside in areas with high concentrations. Natural radionuclides are part of the earth's original crust (primordial radionuclides), they also occur through the interaction of cosmic rays (cosmogenic radionuclides) and human activities such as industrial, research and domestic activity (artificial or anthropogenic radionuclide) [1, 2]. Cosmogenic and Primordial radionuclides naturally found in the environment are over sixty in number, including terrestrial background radiation from nucleo-synthesis of stars. A good example of some common primordial radionuclides that forms the major background radiation and activity concentrations in our environment are the non-serial potassium-40, the series uranium-238, Thorium-232 and their progenies. Some industrial activities make use of radionuclides as part of technological processes for productions or service deliveries, quality control and lots more, this increase radiation burden above the background level in the environment. Radioactivity in the environment is one of the major sources of exposure to human. Exposure to radiation found in the environment is inevitable [1, 2, 3]. The soil and parent rocks could give out radiation because they possess the ability to retain and accumulate radionuclides of primordial origin. As the retained radionuclides in the soil/parent rocks decays, it releases radiation to the environment and serves as a continuous exposure source to human [4]. According to [5], most of the radioactivity concentrations in the environment come from igneous rock like granite, followed by the sedimentary rocks, while the least contribution comes from phosphate rocks and some shale. The natural and artificial radiation sources add up to form background radiation that gets to human on daily basis. If the background radiation in an environment is higher than the set limit it can lead to adverse radiological effects [3]. The knowledge of radiation level in an area is very important for effective radiological impact assessment from both cosmogenic and terrestrial exposure sources. The surest way to know if an environment is free of radiological hazard is to monitor and measure the radiation levels that can be subjected to radiological evaluations using the required parameters. Health risks related to natural radioactivity are of great concern and require assessment in order to estimate the risks. Assessment of radionuclides concentrations in water, rocks and soils in different parts of the world and in Nigeria have been on for several decades and it is on the increase due to increased human activities, town and city expansion. Developmental activities of human have the tendency to also increase the exposure rate, including the health risk associated to radiation exposure. Some of the indigenous studies on radiological assessment include the work of [1, 6-12] to mention a few. The need to monitor our environment at interval for possible radiation risk studies cannot be over emphasized, especially in growing regions and industrial areas where the detailed production activities of the industries are not known. It is paramount to monitor the radiation dose in order to evaluate the radiological implications of the radionuclides on the dwellers in these areas. Hence, the present study measured the activity levels three promodial radionuclides and and evaluated their health implications to those in the areas.

2. Material and Methods

Ota is one of the most popular towns in Ogun State, western Nigeria. It has population estimate of 163,783 dwellers living around and inside the town [13]. Ota is the capital of the Awori Yoruba ethnic group and also the local government head-quarter of Ado-Odo/Ota local Government Area. As of 1999, it has the third largest concentration of industries in Nigeria. Ota is also well known as the home of former Nigerian president Olusegun Obasanjo's farm, the Canaanland compound of the mega church Winners' Chapel, and the Africa Leadership Forum. The main occupation of Ota dwellers is trading and farming. Three locations in Ota town were selected for the study to represent Industrial, Mixed (mixture of residential and industrial) and residential areas. Figure 1 shows the map of Ota town with the study areas highlighted. Selected area name and code are Industrial Estate-IE, Obasanjo Estate-OE, and Atan-AT, representing industrial, Mixed and residential areas respectively.

RS 230 BGO Super Spec gamma ray spectrometer was used for the measurement. The performance level of the BGO (Bismuth Germanate Oxide) detector in the spectrometry used is 3 times higher than the performance of the common sodium iodide (NAI) crystal used in larger portable units. The spectrometer is auto-stabilizing on naturally occurring (40-K, 232-Th and 238-U) radioactivity and does not require any test sample or sources. This portable hand held radiation survey spectrometer was held at about 1m above the ground at each time of measurement. In order to measure the activity concentration, the features of the device was taken to assay mode of operation. At each study area, five (5) locations were selected five (5) measurements were taken at each sampling point. Once the setup is completed, a five (5) minutes waiting was observed to allow for auto-stabilizing of the device on naturally radio element of the study area background. The activity concentration of K-40, Th-232 and U-238 were recorded as displayed on the radiation detector along with the dose rate DR_A. This allows a readout of K in percentage (%), Th and U in part per million (ppm). This was converted to $Bqkg^{-1}$ using the standard conversion factor.

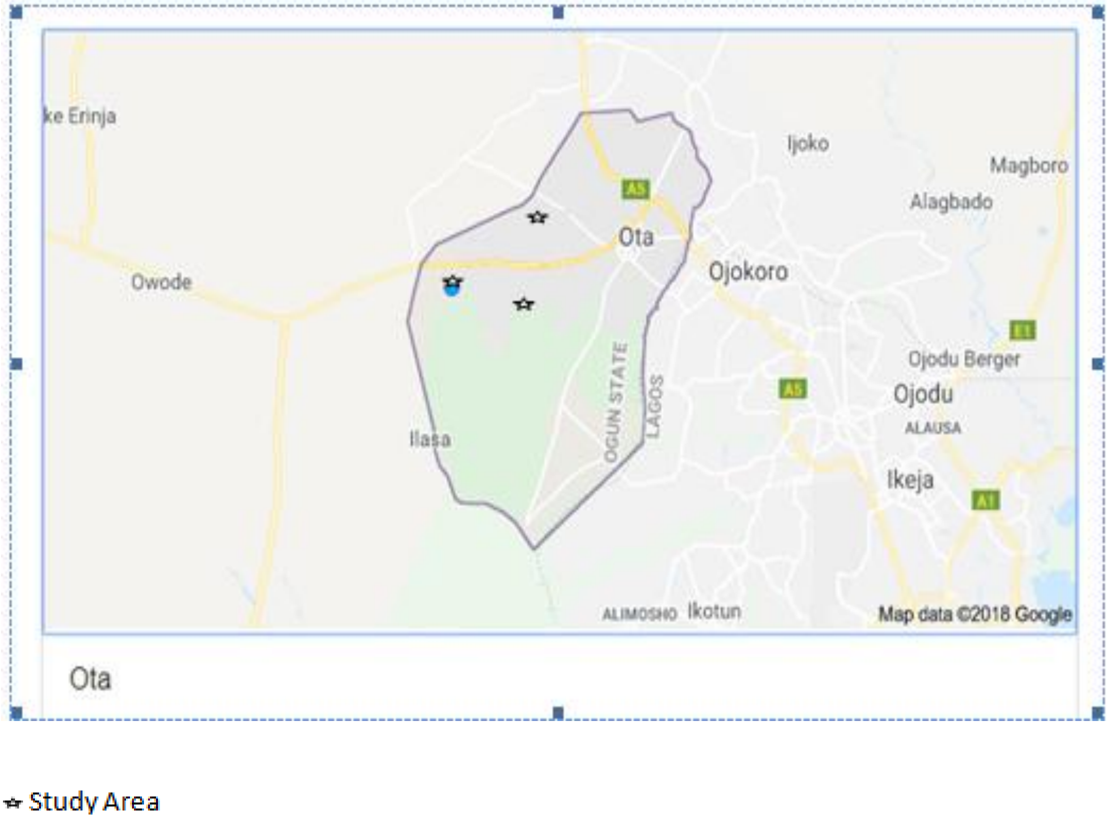

Figure 1 Map of study area

2.1. Dose calculations

2.1.1 Annual outdoor effective dose rate

The radiation dose rate that gets to the members of the public within an exposed area is referred to as outdoor effective dose rate (AEDR). It can be calculated using two main factors; one of the factors is used to convert DR_A ($nGyh^{-1}$) in air to biological outdoor effective dose rates (Svy^{-1}), popularly referred to as outdoor occupancy factor given as 0.2, while the other factor consider the total exposure time spent by an individual within the outdoor radiation area [14-15]. The AEDR in this current study was calculated using equation 1

$$AEDR = T * f * Q * D_A * \varepsilon \qquad 1$$

where T is the time given as 8766h/y, f is the outdoor occupancy factor given as 0.2, Q is the quotient of the effective dose rate given as 0.7(SvG/y), D_A is the absorbed dose rate in air (nGyh-1) and ε is a factor converting nano (10^{-9}) into the micro (10^{-6}).

2.1.2 Excess lifetime cancer risk ELCR

ELCR is defined as the probability that an individual will develop cancer over his lifetime of exposure to radiation and it is given as equation 2

$$ELCR = AEDR \times DL \times RF \qquad 2$$

where DL is the average lifespan (70 years) and RF is risk factor (Sv^{-1}) which is 0.057, for stochastic effects from low-dose background radiation [17].

3. Results and discussions

The range, mean activity concentration measured from the study areas is presented in Table 1. At the Industrial Estate the mean activity concentration ranged from 15.56 $Bqkg^{-1}$ to 23.71 $Bqkg^{-1}$, 40.92 $Bqkg^{-1}$ to 52.86 $Bqkg^{-1}$ and 62.60 $Bqkg^{-1}$ to 350.56 $Bqkg^{-1}$ for U-238, 232-Th and K-40 respectively. At the Obasanjo Estate (OE) the mean activity concentration in $Bqkg^{-1}$ ranged between 15.56 to 19.51, 30.86 to 48.88, and 31.31 to 93.90 for U-238, 232-Th and K-40 respectively. In Atan area the range for the mean activity concentration of U-238, Th-232 and K-40 in $Bqkg^{-1}$ were 12.60-21.24, 30.61-43.06 and 25.04-131.46 respectively. The highest mean activity concentration and radiation dose rate was recorded in Industrial Estate, while Atan had the least concentration and radiation dose. The elevation in the activity measured Industrial Estate may be due to contribution from anthropogenic sources due to several companies sited in the area. K-40 has the highest activity concentration but 232-Th has the highest contribution to the radiological implication on health of the dwellers in the three study locations. The mean activity concentration measured in all the locations are within the recommended limit except for mean concemtration of 232-Th in the Industrial Estate that exceeded the world average value of 45 $Bqkg^{-1}$ in soil and its environs [15, 16]. Figure 2 is the spatial variation of the three radionuclides in the study areas. The dose rate (DR) world average limit is given as 59 $nGyh^{-1}$ [15], the dose rate measured was found to be within the recommended limit for all the study locations. The radiological parameters estimated, the outdoor annual equivalent dose rate (AEDR) and excess lifetime cancer risk (ELCR) for the study areas are presented on Table 2 and Figures 3 and 4 are pictorial representation of the variation of the parameters within the study area. The mean AEDR estimated in $mSvy^{-1}$ is 0.056, 0.045 and 0.041 for Industrial Estate, Obasanjo Estate and Atan respectively. The mean AEDR obatined for all the locations are lower than the recommended limit of 0.08 $mSvy^{-1}$ [15]. The mean ELCR obtained for the study areas was 0.22 x 10^{-3}, 0.18 x 10^{-3} and 0.16 x 10^{-3} for the Industrial Estate, Obasanjo Estate and Atan respectively which is also lower than the world average limit of 0.29 x 10^{-3}. This implies that dwellers in these areas are safe for now but these values can increase with time as the industrial activities increase in the area.

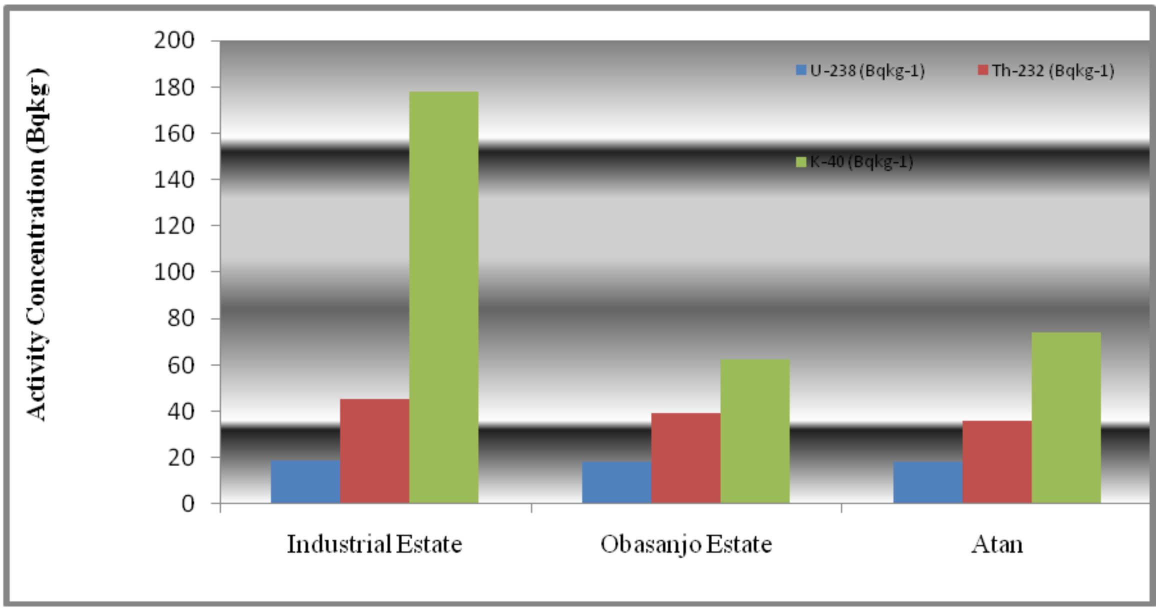

Figure 2 Spatial Variation of the mean activity concentration for the three locations

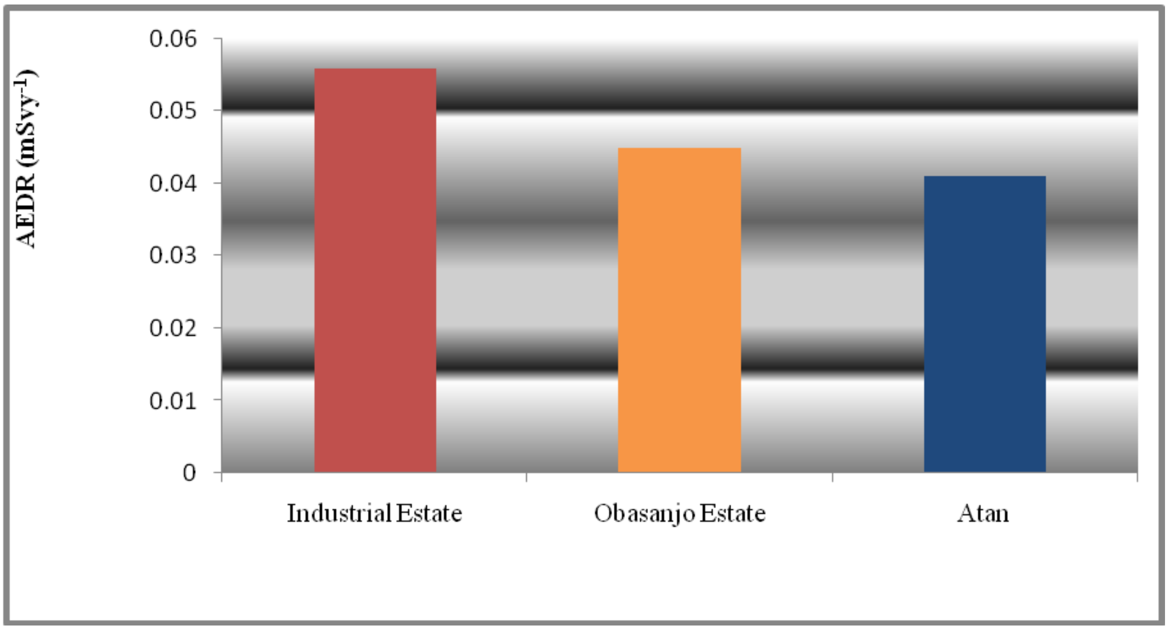

Figure 3 Mean absorbed dose rate

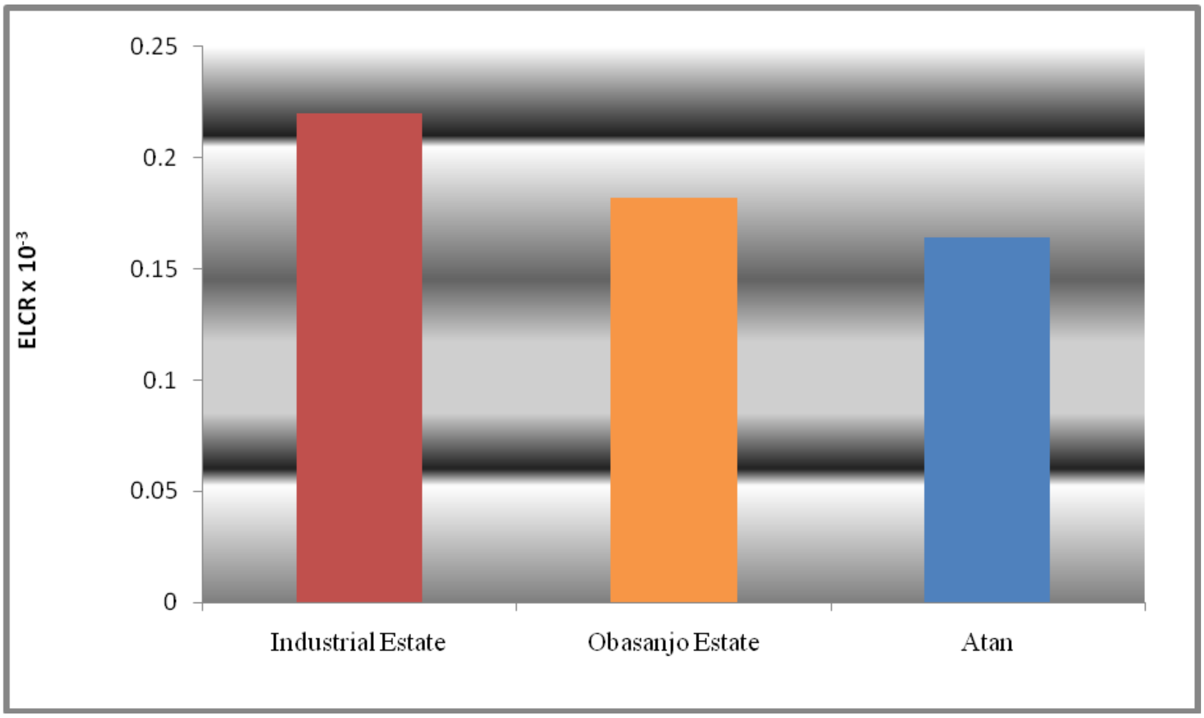

Figure 4 Mean estimated lifetimedose cancer risk

Table 1 Measured activity concentration

Sampling Areas	**Range Mean**	**U-238 ($Bqkg^{-1}$)**	**Th-232 ($Bqkg^{-1}$)**	**K-40 ($Bqkg^{-1}$)**
IE	Range	17.29-35.82	30.86-53.59	62.60-93.90
	Mean	23.71	40.92	93.90
	Range	8.65-29.64	32.07-51.16	0.00-93.90
	Mean	20.50	41.41	62.60
	Range	0.00-30.88	46.28-58.87	187.80-532.1
	Mean	15.56	52.86	350.56
	Range	7.41-24.70	32.48-58.87	62.60-156.50
	Mean	15.81	47.97	100.16
	Range	2.47-33.35	33.70-48.72	219.10-375.60
	Mean	17.29	42.31	281.7
OE	Range	3.71-33.35	41.41-54.00	31.30-125.20
	Mean	19.51	48.88	93.90
	Range	3.71-45.70	19.89-39.38	0.00-93.90
	Mean	18.03	31.42	50.08
	Range	4.94-37.05	24.36-36.95	0.00-187.8
	Mean	19.51	30.86	93.90
	Range	12.35-41.99	29.23-47.10	0.00-31.30
	Mean	19.51	39.22	31.31
	Range	6.18-23.47	31.26-57.65	0.00-93.90
	Mean	15.56	45.55	43.82
Atan	Range	0.00-34.00	22.74-92.30	0.00-125.20
	Mean	15.31	43.06	56.34
	Range	7.41-34.58	23.14-41.82	0.00-93.90
	Mean	20.50	30.61	25.04
	Range	8.65-43.23	25.58-47.50	93.90-187.80
	Mean	19.27	38.49	131.46
	Range	0.00-23.47	28.01-39.79	31.30-62.60
	Mean	12.60	33.05	43.82
	Range	2.47-33.36	28.014-41.82	0.00-187.80
	Mean	21.24	35.00	112.68

Table 2 Estimated radiological parameters

Sampling Areas	**Range Mean**	**DR ($nGyh^{-1}$)**	**AEDR (Outdoor) $mSvy^{-1}$**	**ELCR x 10^{-3}**
IE	Range	39.10-41.10	0.048-0.050	
	Mean	41.24	0.051	0.2019
	Range	33.70-43.80	0.041-0.054	
	Mean	39.12	0.048	0.1916
	Range	51.90-56.00	0.064-0.069	
	Mean	56.50	0.069	0.2767
	Range	33.70-48.50	0.050-0.056	
	Mean	42.64	0.052	0.2088
	Range	40.70-56.10	0.041-0.670	
	Mean	47.36	0.058	0.2319
OE	Range	41.80-46.70	0.051-0.057	
	Mean	44.98	0.055	0.2203
	Range	24.40-40.10	0.030-0.049	
	Mean	30.76	0.038	0.1506
	Range	32.60-35.90	0.040-0.044	
	Mean	32.84	0.040	0.1608
	Range	31.00-38.10	0.038-0.047	
	Mean	36.16	0.044	0.1771
	Range	31.00-39.90	0.038-0.049	
	Mean	40.88	0.050	0.2002
Atan	Range	28.40-38.00	0.029-0.046	
	Mean	30.28	0.037	0.1483
	Range	22.50-37.60	0.028-0.046	
	Mean	30.46	0.037	0.1492
	Range	34.00-37.00	0.042-0.045	
	Mean	39.16	0.048	0.1918
	Range	26.40-29.80	0.032-0.037	
	Mean	29.42	0.036	0.1441
	Range	32.80-39.20	0.040-0.048	
	Mean	37.34	0.046	0.1828

4. Conclusion

The in-situ activity concentrations of U-238, Th-232 and K-40 and dose rate were measured in Industral Estate, Obasanjo Estate and Atan using RS-230 Super Spec gamma ray spectrometer. The measured mean values of U-238, Th-232 and K-40 are all within the world average recommended limits except for concentration of Th-232 that exceeded the recommneded in Industrial Estate. Industrial area recorded the highest mean concentration of K-40, U-238, Th-232 and dose rate values. Obansajo area, which is a mixture of industrial and domestic areas have the next, while Atan area being residential zone recorded the least activity concentration. The same trend was observed in the estimated radiological health parameters. Industrial Estate recorded the highest values of annual equivalent dose rate and excess lifetime cancer risk. It is radiological safe for the dwellers in these study areas for now but this can increase as the industrial activities increase in the area which can elevate the radiation burden of the dwellers. Thus, it can be concluded that industrial activities have influence on the background radiation, activity concentration, concentration of NORM (naturally occurring radioactive materials) and radiation dose rate in an environment.

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