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Mapping of Uranium-238 Deposit and its Contribution to Indoor Radon Gas in Ota, Ogun State, Nigeria

Adewoyin, O. O., Omeje, M., Onumejor, C. A., Adagunodo, T. A., Ndubuisi, A., Nwaluka, V. O., Akinpelu, A., Joel, E. S.

Department of Physcis, Covenant University, PMB 1023, Ota, Ogun State, Nigeria

Corresponding author's e-mail: olusegun.adewoyin@covenantuniversity.edu.ng

Abstract. In the present study, the distribution of uranium-238 was mapped from the background radiation of the area of study in order to determine its contribution to the concentration of indoor radon. The background radiation was studied using the handheld gamma spectrometer (RS 125) while the indoor radon concentration was measured with a Durridge RAD7 instrument. The results obtained showed variation in the distribution of 238U, 232Th and 40K in the study area with values ranging between 17.9 ± 0.3 and 58.05 ± 0.3, 2848 ± 10541 ± 0.8 and 3.25 ± 0.2 and 11.48 Bq/kg respectively. Furthermore, the indoor radon concentration was determined for the office on the ground floor, the result obtained was noted to be between 20 and 160 Bqm^{-3} which is far higher than the result obtained for the office on the first floor which is BDL-19 Bqm^{-3}. In each cases, the results are lower than the international recommended safe limit of 200 Bqm^{-3}. Therefore, it can be concluded that the background radiation from the soil in the premises and under the building contributes to the high concentration of indoor radiation in the office.

Keywords: uranium-238, radon concentration, background radiation, RAD7, gamma spectrometer

1. INTRODUCTION

Studies have shown that the main source of human exposure to ionizing radiation is natural radioactivity due to its health implications [1, 2]. These radioactive substances consist mainly of ^{238}U, ^{232}Th and ^{40}K [3]. These substances can hardly be avoided since they are found in geological formations like soils, water, plants and so on. Among the radioactive materials, ^{238}U is known to disintegrate to ^{226}Ra, which in turn gives birth to ^{222}Rn, popularly known as Radon [4]. The health risk associated with radon gas has made it a subject of concern for researchers in the last few years. This is because a high concentration of this gas in workplaces and homes presents a high level of hazard to the occupants. According to the report by the International Agency for Research on Cancer (IARC), radon has been classified to be in the first place on human carcinogen and second place in the cause of lung cancer [5]. Radon gas contributes significantly to the indoor air contamination all around the world [6]. The variation in the levels of radon in homes and places of work is due largely to the uneven distribution of geological features [7, 8], the characteristics of the building and some other environmental indicators.

Zhou et al. (2019) observed that the radiological hazard common in uranium mines is the inhalation of radon and its progeny [1]. Studies on epidemiology conducted on humans exposed to radon at work and at homes revealed that the health risk associated with radon gas increases with increasing exposure [3]. The primary source of indoor radon is the ground on which the building is sited, from where radon penetrates with soil gas through cracks and faults in the foundation by pressure-driven convection [9]. Similarly, another source of radon could be domestic water from drilled wells or the escape of this gas from building materials. It is very important to control the level of radon exposure at home as a result of the high occupancy factor. It is worthy of reporting that all indoor environments, such as school, offices and so on, subject people to radon exposure. Moreover, the health risk associated with exposure to radon-222, especially by working class men and women is a subject of concern and it is on this basis that this study is conducted to investigate the contribution of uranium-238 in the environment to the concentration of radon in some of the offices at the administrative block of a pharmaceutical company.

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2. GEOLOGY AND GEOGRAPHICAL LOCATION OF THE STUDY AREA

The study site is situated at Sango Ota, Ogun State in southwest Nigeria. It lies within the latitude 6° 38□N to 6° 41□N and longitude 03° 8□E and 3° 12□E. It is accessible through Agbara –Atan road, off Badagry–seme express road it is also accessible via Iyana Ipaja to if road. The study area for this project is within the eastern Dahomey basin which is in the sub-humid tropical region of southwest Nigeria. It extends along the mainland edge of the inlet of Guinea. It has a distinct wet and dry period, the dry season is from November-March while the wet portion of the year runs between April and October. There has been extensive discussion on the geology of this study area by various authors such as [10, 11]. They discussed the types of rocks in this area from the formation of early tertiary to late cretaceous in age. The basin stratigraphy has also been put in six lithostratigraphic formations which are Benin Formation, Ilaro, Oshosun Akinbo, Ewekoro and Abeokuta from the youngest to the oldest [12] discussed the formation of Abeokuta to consist of the Araromi, Ise and Afomo Formations. This formation is mainly made out of poorly arranged grit mud stone with shale clay layers and siltstone.

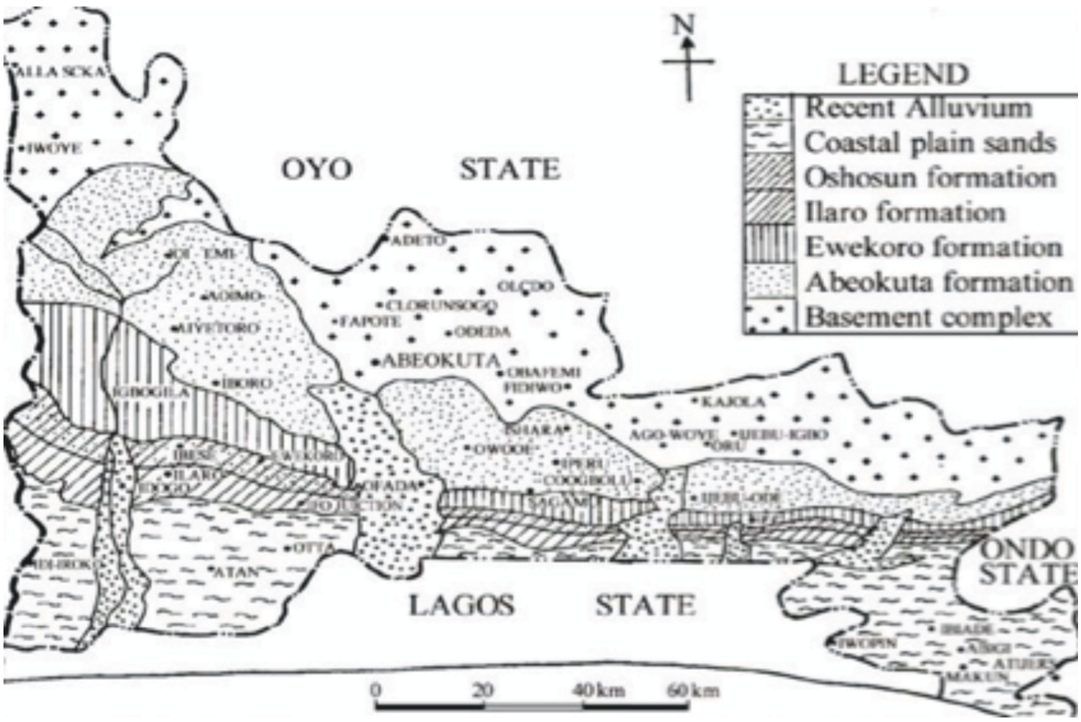

Figure 1: Geological map of the study area [12]

3. METHODOLOGY

The instrument used for this work are the handheld Gamma Spectrometer (RS-125) and the Durridge RAD7 electronic radon detector. The background radiation of the premises was surveyed in order to map the activity concentration of uranium-238 in the area of study. Similarly, indoor radon accumulation levels were measured continuously on hourly basis at the different sampling locations in the pharmaceutical company. It has a large detector for survey or search and also an integrated design, direct assay readout, a data storage and lastly a scan mode. Before the commencement of measurement, the gamma spectrometer is allowed for 15 to 30 minutes in order to re-condition itself with the background radiation of the area of study, this will ensure precise results. At all measurement points the radiation detector is kept 1 m above the ground level and measurements taken four (4) times at each station and their mean calculated in order to acquire very accurate data. At each measurement station the location coordinates were noted, an interstation spacing of 15 m was maintained all through the survey. Readings were taken at an interval of 90 seconds at each station. 15 stations were surveyed around the administrative block. It takes 45 seconds for the RAD7 sniffing process to take place, during this process, air sample passes through the small drying tube and flows into the measurement chamber for radon concentration readout. The equipment is set up in the location of interest for 48 hours, during which it measures the concentration of radon at the investigated location. At the expiration of the 48 hours, a print-out comes from the printer of the RAD 7 that captures information such as time and date of the measurement, serial number of the machine, the average test values, the bar diagram of each reading and the cumulative spectrum of alpha energy.

4. RESULT AND DISCUSSION

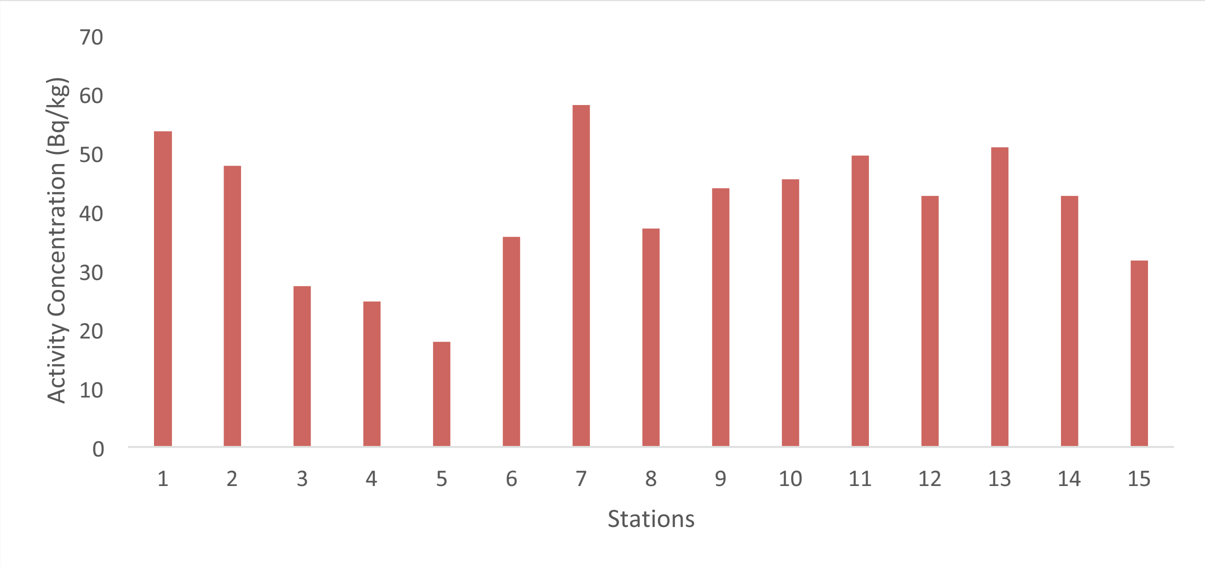

Figure 2: Distribution of 238U in the Area of Study

The distribution of uranium-238 in the study area is presented in Figure 2. It can be observed that the deposit of uranium-238 ranged between 17.9 ± 0.3 and 58.05 ± 0.3 Bqkg-1 as seen in stations 5 and 7 respectively. This variation in the distribution of 238U reported in this study could be due to anthropogenic sources or variation in the geological compositions of the study area [5].

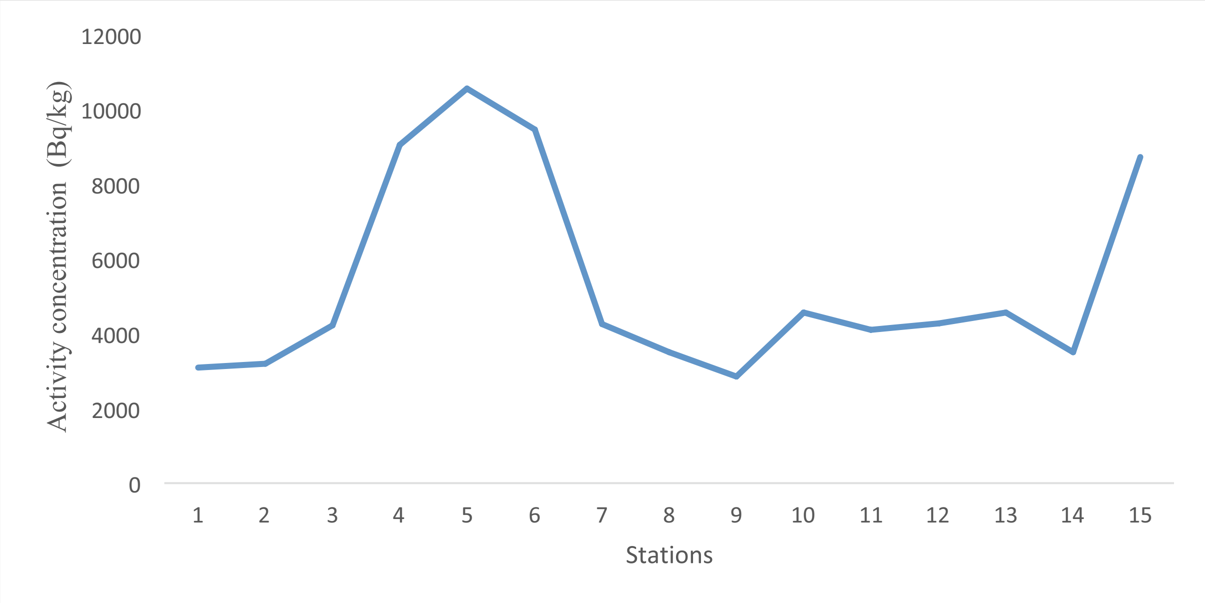

Figure 3: Distribution of 232Th in the area of study

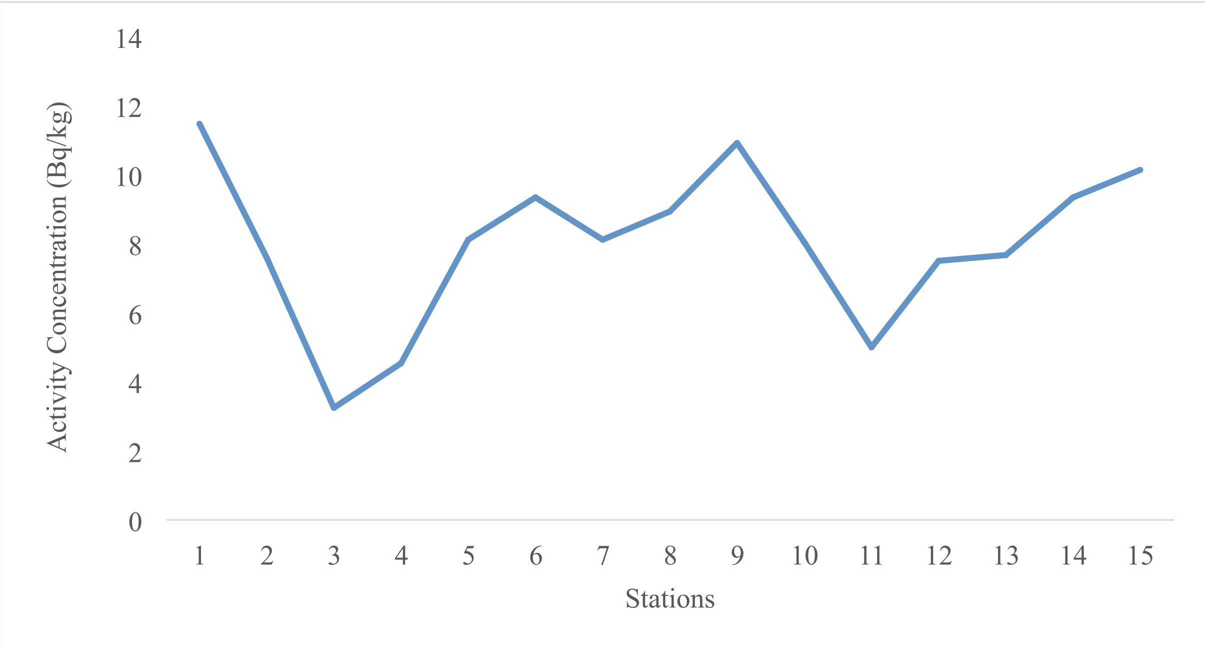

Figure 4: Distribution of 40K in the Area of study

Figures 3 and 4 present the activity concentrations of Thorium-232 and Potassium-40 in the study area. It could be seen that their activity concentrations ranged between 2848 ± 0.8 and 10541 ± 0.8 Bq/kg and between 3.25 ± 0.2 and 11.48 Bq/kg respectively. For the Thorium-40, the highest value was recorded at station 5 while the lowest was noted at station 9. Similarly for Potassium-40, the lowest and highest activity concentrations was observed at stations 3 and 1 respectively. The variations in the distribution of activity concentrations of these radionuclide materials could be as a result of uneven geological compositions or as a result of introduction of foreign geological materials during the process of construction of the buildings [9][4].

Radon Distribution in the Study Area

In order to investigate the influence of background radiation on the concentration of indoor radon in the area of study, the only office on the ground floor was examined. Another office on the first floor was also investigated which was used as a control for this study. Figure 5 presents the indoor radon concentration in the office on the ground floor. The concentration of radon was noted to range between 20 and 160 Bqm^{-3}. The highest value in this result is much closer to the international recommended safe limit of 200 Bqm^{-3}. The occupants of the office of this nature could be at risk of lung cancer and other related sicknesses if they are exposed over a long period of time. Similarly, the result of the indoor radon concentration measured on the first floor is presented in Figure 6, the result observed ranged from values below detectable limits (BDL) to 19 Bqm^{-3}. This result is far below the recommended safe limit of 200 Bqm^{-3}. These results revealed that background radiation due to underground soil can contribute to the indoor concentration of radon.

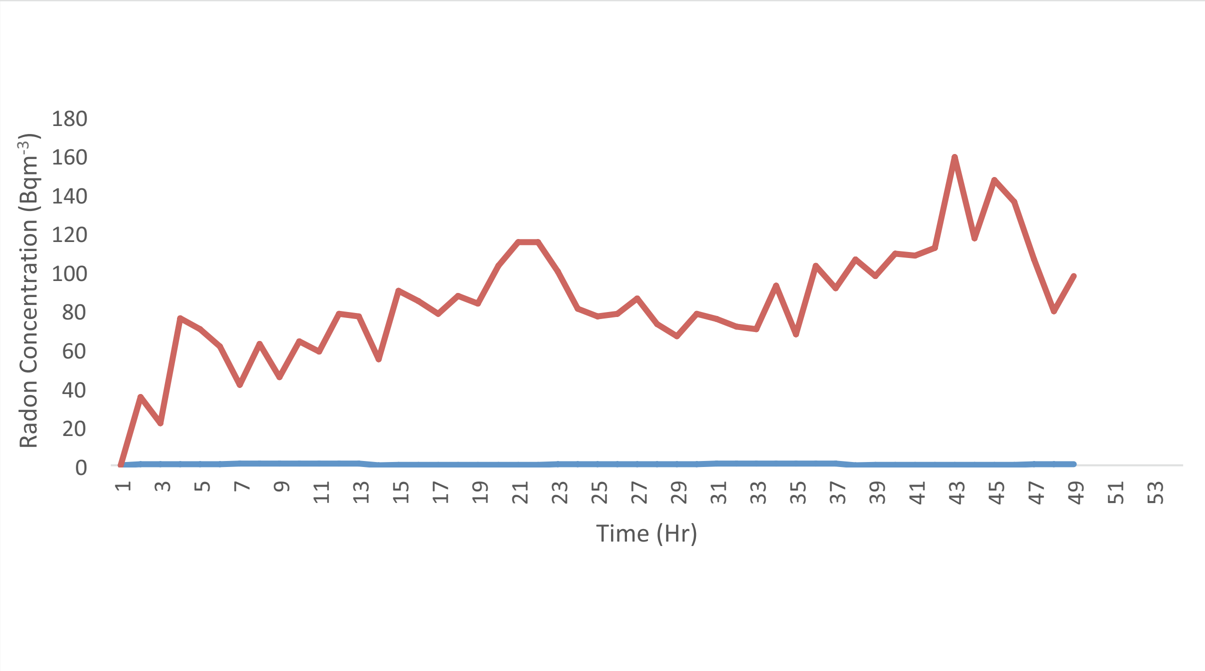

Figure 5: Indoor Radon Concentration on the Ground floor.

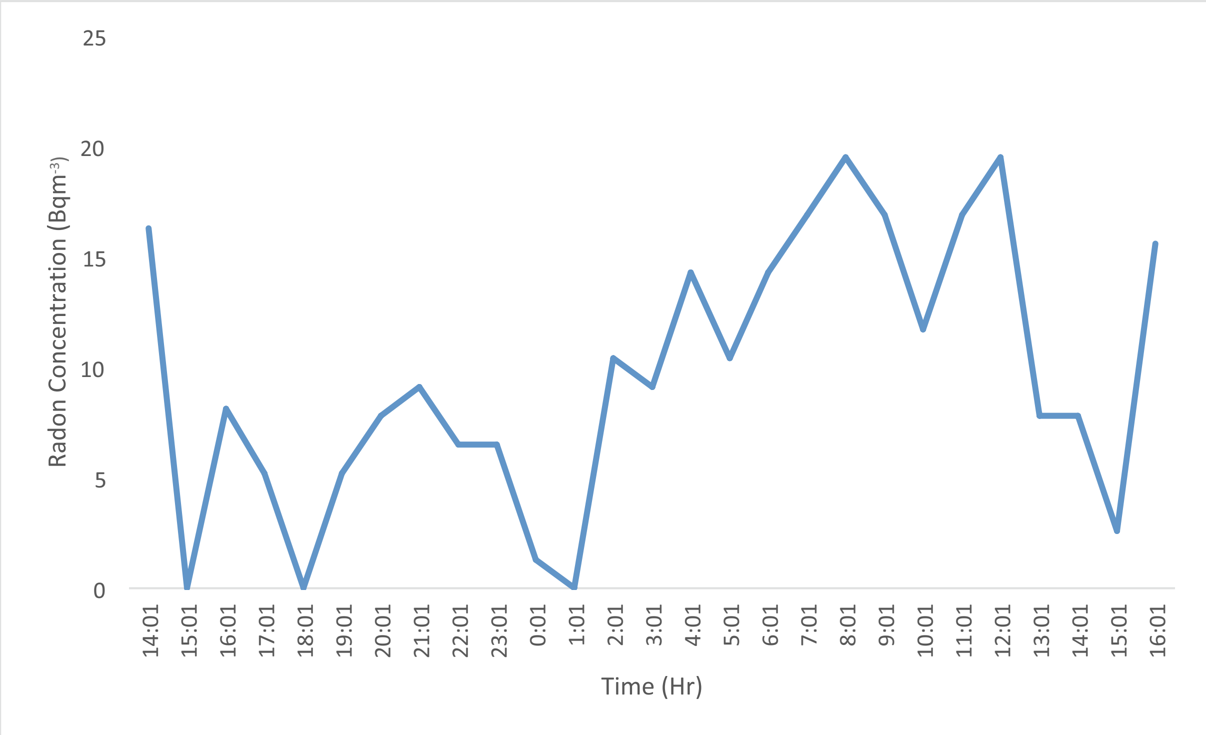

Figure 6: Indoor Radon Concentration on the First floor

5. CONCLUSION

The background radiation of the area of study was investigated in order to map the distribution of uranium-238 and observe its contribution to the concentration of indoor radon in the study area. The background radiation was studied using the handheld gamma spectrometer (RS 125) while the indoor radon concentration was measured with the aid of a Durridge RAD7. The results obtained showed variation in the distribution of 238U, 232Th and 40K in the study area with values ranging between 17.9 ± 0.3 and 58.05 ± 0.3, 2848 ± 10541 ± 0.8 and 3.25 ± 0.2 and 11.48 Bq/kg respectively. Furthermore, the indoor radon concentration was determined for the office on the ground floor, the result obtained was noted to be between 20 and 160 Bqm-3 which is far higher than the result obtained for the office on the first floor which is BDL-19 Bqm-3. Therefore, it can be concluded that the background radiation from the soil under the building contributes to the high concentration of indoor radiation in the office.

ACKNOWLEDGEMENTS

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