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Radon Concentration Level in Selected offices at Bells University of Technology, Ota, Ogun State

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Abstract. Radon, a radioactive gas that emanates naturally from the earth crust is accountable for about 50% of the effective dose of ionizing radiation received by humans. Most radon susceptiveness occurs in homes and work places, it comes from the natural disintegration of uranium in soil, rock and water and escalate to the air that we breath, hence it is important to monitor the actual level of exposure in most buildings. This work analysed the indoor radon concentration in air at twenty different offices of different building at Bells University of Technology using Rad7 detector. The mean measured radon concentration ranges from 0-56.7 Bq/m^3 for all the study locations. The mean absorbed dose, equivalent dose and effective dose were calculated with the radon concentration which are 0.152 mGy/y, 3.045 mSv/y and 0.365 mSv/y respectively. The results obtained are below the world set limit as recommended by International Commission on radiological protection, except for office 7 which slightly exceed the recommended limit. Thus, the study concluded that good ventilation is very important in the reduction of radon concentration level in our work places.

Keywords: Radon concentration, Rad7, Absorbed dose, Radionuclides, Bells University.

1. Introduction

Radiation is a natural phenomenon that occurs naturally often times. It is a process in which a body emits energy that travels through empty space in the form of waves or particles to be absorbed by another body. The exposure of human to background radiation that emanates from Naturally Occurring Radionuclides is one of the scientific subjects that attracts public attention because exposure to high level of radiation can cause somatic and genetic effects which can result to the damage of some radiosensitive organ of the body and it can eventually lead to death [1,2]. The decay of some naturally occurring radionuclide such as radon, thorium, uranium and potassium are responsible for most background radiation that humans are exposed to on daily bases. Considering all the natural sources of radiation to mankind, inhalation of radon, thoron and their progenies are responsible for about 50% of global effective dose [3].

Radon gas is a naturally occurring radionuclide that emanates from the earth crust as a result of the natural breakdown of uranium in soil, rock and water. It is a member of the noble gases group in the periodic table with atomic number 86. It is colourless, odourless and tasteless, these properties make it difficult to identify its presence in an environment. Radon is soluble

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and obtained from the decay series of Radium 226 which is one of the decay products of Uranium 238 decay series [4]. Radon also decays further to yield solid radioactive short-lived daughters which are direct sources of dangerous ionising radiation to the lungs [5]. Radon is present everywhere but the level of concentration differs from one location to another. The geographical location, soil composition, construction type and ventilation of a building are some of the factors that affects the level of radon in a building and the lower the concentration in homes, the lower the risk. In buildings radon is regarded as the major air pollutant with harmful effects on the health of occupants. Soil, building materials (sand, gravel, rocks, cement, bricks) water sources and natural energy sources which may contain traces of uranium-238 are the main sources of indoor radon [6]. Radon concentration in the outdoor air is usually very low compared to the indoor radon. It can amass by confinement effect, becoming very high concentration which represent a health risk [7].

According to the World Health Organisation, radon exposure is the second cause of lung cancer after cigarette smoking, 16% lung cancer death in Canada are caused by radon inhalation. Smokers who live in homes with high radon level have a risk of lung cancer 10 times higher than non-smokers. The two leading causes of lung cancer mortality in the United states are attributed to smoking and radon exposure according to estimates [8]. Radon exposure account for approximately 9-15% of yearly cases of lung cancer in Europe [9]. In 2020, lung cancer was the leading cause of death by cancer in the world with 1,796,144 registered death [10]. Exposure to radon is attributed to DNA damage and high genomic tumor instability as shown in Figure 1, but its exact carcinogenesis mechanism in lung cancer remains unknown. It is a major risk factor for lung cancer after smoking [11]. The genetic material of the cell such as DNA and RNA may directly or indirectly be damaged. In direct effect, it can help to break the DNA double strands while the indirect effects are the generation or reactive oxygen species. The level of radionuclides presents in soil, water, air and food had been researched [12,13] using different methods to determine the radon concentration but the radon concentration of the selected offices in Bells have not been determined. Therefore, it is expedient to carry out this research work.

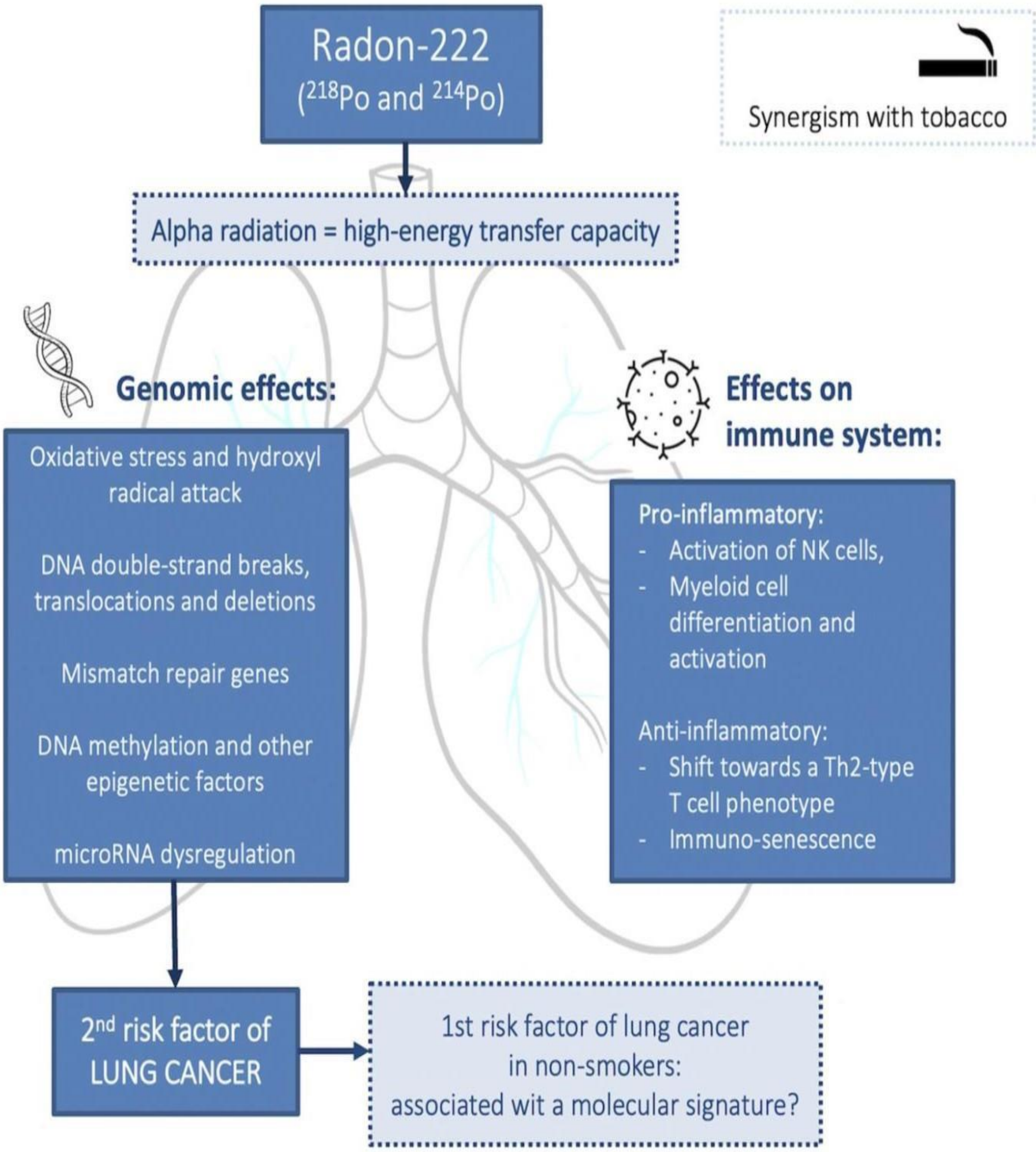

Figure 1: Radon mechanisms of carcinogenesis in lung cancer.

2. Study Area

The study area location is in Bells University of Technology situated in Ado-odo, Ota local government,which is one of the towns in Ogun state, Nigeria with Latitude 6.68 Longitude 3.17 and Altitude 10000m as shown in Figure 2. The selected offices are situated in different buildings which include; Physics laboratory building, Chemistry laboratory building, Biology laboratory building and College of Natural and Applied Science building (COLNAS). The selected buildings are constructed withred bricks.

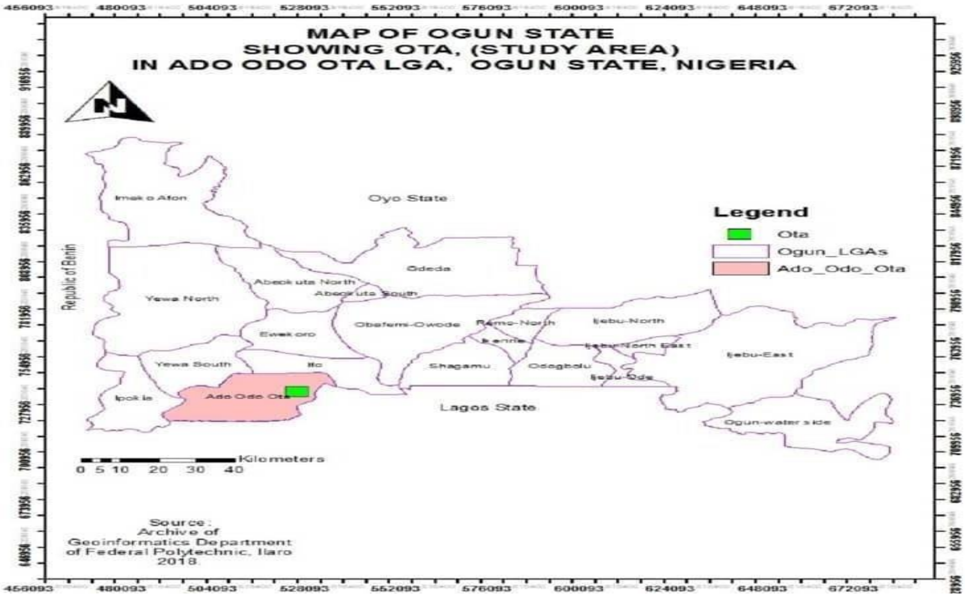

Figure 2: Map of Ogun State showing Ota in Ado odo Ota local government Area

3. Materials and Method

The instrument used in this study is the Durridge Rad7 radon monitor detector. It can be used to measure the concentration of Radon over a period of time. Rad7 is an instrument used for measuring the concentration of radon over a period of time, it comprises of an inlet filter and an outlet which serves as the exhaust. When the instrument is switched on, it will display the following; mode: Auto, Thoron: off, pump: Auto, Format: short, Unit: pCi/L or Bq/m^3 hence after the MENU botton is pressed it will display "Test: Start" and it will start counting, at the end of the stipulated time, the result that is being displayed by the detector include; radon concentration in Bq/m^3 ,temperature in ^{o}C and Humidity in %.

A Durridge Rad-7 Radon detector instrument as shown in Figure 3 below was used to measure radon concentration in twenty different offices at Bells University of Technology. The mode of measurement was short term because the readings were taken within 7 days. The instrument was placed in twenty different offices of some Lecturers and Technologists situated at the ground floor. Five offices at COLNAS building, seven offices at Chemistry laboratory building,six offices at Physics laboratory building and two offices at Biology laboratory building. The detector was placed at each of the offices at different time during the day for a period of two hours, the detector has been programmed to display result at the interval of one hour, at the endof the stipulated time, the result that is being displayed by the detector include; radon concentration in Bq/m^3, temperature in ^oC and Humidity in %.

Figure 3: Durridge Rad7 Radon monitor detector

Absorbed Dose

This is a measure of the amount of energy deposited in a substance especially a material or tissue as a result of exposure of ionizing radiation. The unit of absorbed dose in the International system of unit is gray. Absorbed dose helps to quantify the potential harm that radiation can cause. It was calculated using equation (1)

$$D = C_{Rn} \times Fe \times O \times F_c \text{ (mGy)} \quad (1)$$

where D is absorbed dose, C_{Rn} is radon concentration in Bq/m^3, F_e is the equilibrium factor 0.4, O is the occupancy factor, it is estimated to be 2628 hy^{-1} in this study since normal working hours per day in Nigeria is 8 hours and F_c is dose conversion factor which is 9 nSvh^{-1}[12].

Equivalent Dose

This is an important parameter used in assessing radiation exposure risk, setting radiation protection standards and ensuring the safety of the person working around the sources of ionizing radiation. The equivalent dose can be defined as the product of the absorbed dose (Gy) with the radiation weighting factor (W_R). The radiation weighting factor considers the type of radiation and its ability to cause biological damage. It was calculated using equation (2)

$$H = D \times W_R \quad (2)$$

where H is equivalent dose (Sv), D is absorbed dose (Gy) and W_R is radiation weighting factor

Annual Effective Dose

Effective dose is the concept used in radiological protection to assess the potential biological harm resulting from exposure to ionizing radiation while considering the sensitivities of various tissues and organs in the body. The annual effective dose to the lung is determined from the annual absorbed dose, the radiation weighting factor which has a value of 20 for alpha particles and the tissue weighting factor for the lung is 0.12 [13]. It was calculated using equation (3)

$$E = D \times W_R \times W_T \tag{3}$$

where D is absorbed dose, W_R is radiation weighting factor and W_T is tissue weighting factor.

4. Result and Discussion

The results of the average radon concentration are presented in Table 1 and Figure 4. It showed the measured average indoor radon concentration determined in twenty different offices in Bqm^{-3}, it also indicates the temperature and the humidity of each of the offices at the period when the measurement is taken. The twenty offices include; six offices in the physics laboratory, seven offices in chemistry laboratory building, two offices in biology laboratory building and five offices at COLNAS building. All the offices examined are at the ground floor, some of the offices are well ventilated while some are poorly ventilated. The average radon concentration ranged from 0.00 to 56.65 Bqm^{-3} while the average radon concentration for all the twenty offices is 15.29 ± 16.11 Bqm^{-3}. The highest radon concentration level was determined in office 7 which is one of the offices in the physics laboratory although the radon concentration is below the WHO standard it could still have some health implications on someone with low immune system if the exposure is prolong. The high value recorded may be as a result of the poor ventilation in the office and also during the period of taking the measurement, the door was totally closed all through, there was no in and out movement during the period of the measurement. The temperature and the humidity of the office are 31.8°C and 68% respectively. Comparing all the results obtained in Table 1 with the world recommended limit of 100 Bq/m^3[14], the results are below the recommended limit as indoor radon concentration are expected to be As Low As Reasonable Achievable (ALARA) [15]. Figure 4 shows the graphical representation of radon concentration in Bqm^{-3} for each of the twenty offices. The radiological parameters such as absorbed dose, equivalent dose and the effective dose estimated are presented in Table 2 and Figure 5. The absorbed dose ranges from 0.00-0.536 mGy/y, the equivalent dose ranges from 0.00- 10.72 mSv/y while the annual effective dose ranges from 0.00-1.286 mSv/y. The estimated parameters obtained in this study is comparable with other past studies [16,17]. In Japan, the average annual effective dose by inhalation was reported as 0.64 mSv/y [17]. The recommended worldwide average for annual effective dose is 1.15 mSv/y [18] however, the highest recorded value for the annual effective dose was in office 7 with 1.286 mSv/y which is slightly above the WHO recommended dose. Working in office 7 for long period of time may result in some health conditions associated with radon accumulation.

Table 1: Average radon concentration level in the study locations

Offices	Radon Concentration (Bq/m^3)	Temperature(°C)	Humidity (%)
1	5.20	29.2	76
2	3.31	28.1	74
3	3.25	28.2	77
4	8.11	28.9	60
5	7.31	30.9	65
6	8.11	31.5	64
7	56.65	31.8	68
8	10.80	28.1	76
9	39.25	32.1	69
10	40.65	30.6	74
11	14.90	32.4	71
12	28.50	28.2	59
13	4.07	33.8	66
14	0.00	31.9	66
15	2.71	30.9	75
16	9.47	33.1	68
17	2.71	32.6	65
18	10.80	34.9	63
19	12.15	30.4	77
20	37.95	30.7	75
Minimum	0.00	28.1	59
Maximum	56.65	33.8	77
Mean	15.29	30.9	69

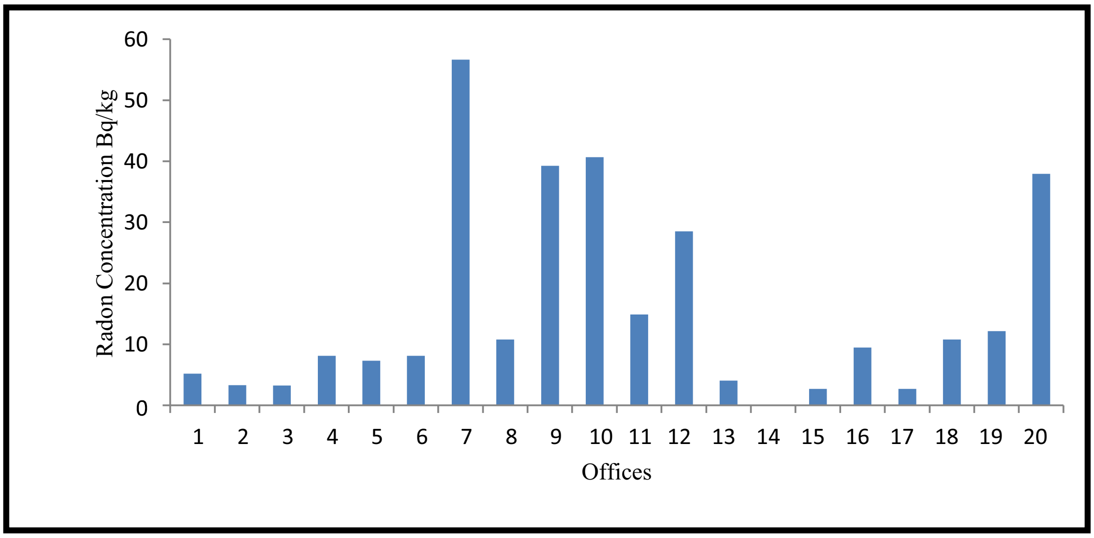

Figure 4: Radon concentration level in the locations

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Table 2: Estimated Radiological Parameters for some offices in Bells University

Offices	Absorbed Dose (mGy/y)	Equivalent Dose (mSv/y)	Effective Dose (mSv/y)
1	0.049	0.980	0.118
2	0.029	0.580	0.069
3	0.031	0.620	0.074
4	0.077	1.540	0.185
5	0.069	1.380	0.166
6	0.077	1.540	0.185
7	0.536	10.720	1.286
8	0.102	2.040	0.245
9	0.371	7.420	0.890
10	0.385	7.700	0.924
11	0.141	2.820	0.338
12	0.270	5.400	0.648
13	0.039	0.780	0.094
14	0.000	0.000	0.000
15	0.026	0.520	0.062
16	0.089	1.780	0.214
17	0.026	0.520	0.062
18	0.102	2.040	0.245
19	0.115	2.300	0.276
20	0.359	7.180	0.862
Mean	0.152	3.045	0.365

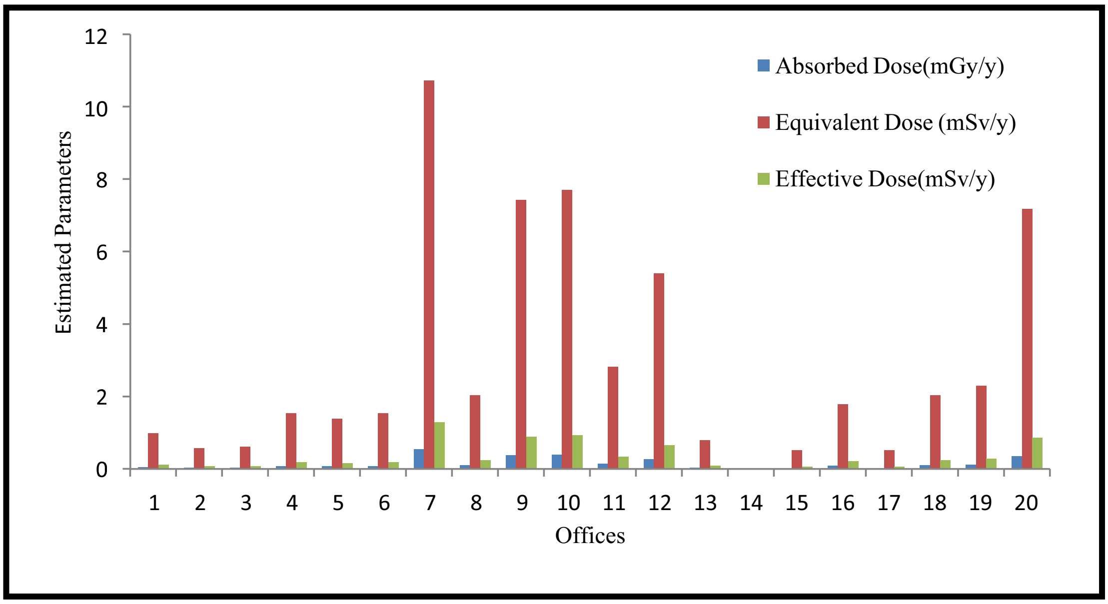

Figure 5: Estimated radiological parameters

5. Conclusion and Recommendation

The concentration of radon in twenty different offices at Bells University were measured. The results obtained varies from one office to the other although the results are below the WHO set limit of 100 Bqm^{-3}. However, the estimated annual effective dose for office 7 is slightly higher than the recommended limit of 1.2 mSv. This might likely pose health risk for the staff working in such office after prolonged exposure. Hence, there should be proper implementation of a good ventilation system such as opening of windows and doors or the use of chimney in our offices and living environment.

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References

[1] Bhaskaran, R., Damodaran, R. C., Kumar, V. A., Panakal J. J., Bangaru, D., Natarajan, C., & Mishra, R. (2017). Inhalation dose and source term studies in a tribal area of Wayanad, Kerala, India. *Journal of Environmental and Public Health*,

[2] Yang, J., & Sun, Y. (2022). Natural radioactivity and dose assessment in surface soil from Guangdong, a high background radiation province in China. *Journal of Radiation Research and Applied Sciences*, **15(1):** 145-151.

[3] United Nations Scientific Committee on the Effects of Atomic Radiation. (2000). Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 Report*, Volume I: Report to the General Assembly, with Scientific Annexes-Sources*. United Nations.

[4] Usikalu, M. R., Fuwape, I. A., Jatto, S. S., Awe, O. F., Rabiu, A. B., & Achuka, J. A. (2017). Assessment of radiological parameters of soil in Kogi State, Nigeria. *Environmental Forensics*, **18(1):** 1-14.

[5] Hinrichs, A., Fournier, C., Kraft, G., & Maier, A. (2022). Radon Progeny Adsorption on Facial Masks. *International Journal of Environmental Research and Public Health*, **19(18):** 11337.

[6] Khalid, N., Majid, A. A., Yahaya, R., &Yasir, M. S. (2014). Radiological risk of building materials using homemade airtight radon chamber. American Institute of Physics, *AIP Conference Proceedings* **1584(1):** 207-210.

[7] Jonathan, R. M., Luc, B. T., Ali, D., Nièssan, K., Soumaila, O., & Zougmore, F. (2023). Evaluation of Radon Concentration and the Health Risk in the Offices of the Institute of Science

and Technology of the “ÉcoleNormaleSupérieure”, Burkina Faso. *World Journal of Nuclear Science and Technology*, **13(3):** 41-54.

[8] Usikalu, M. R., Onumejor, C. A., Achuka, J. A., Akinpelu, A., Omeje, M., &Adagunodo, T. A. (2020). Monitoring of radon concentration for different building types in Covenant University, Nigeria. *Cogent Engineering*, **7(1):** 1759396.

[9] Darby, S., Hill, D., Auvinen, A., Barros-Dios, J. M., Baysson, H., Bochicchio, F., & Doll, R. (2005). Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case-control studies. *BMJ*, **330(7485):** 223

[10] Ferlay, J., Colombet, M., Soerjomataram, I., Mathers, C., Parkin, D. M., Piñeros, M., ... & Bray, F. (2019). Estimating the global cancer incidence and mortality in 2018: GLOBOCAN sources and methods. *International Journal of Cancer*, **144(8):** 1941-1953.

[11] Appleton, J. D. (2013). Radon in air and water. Essentials of medical geology. *Editor: OlleSelinus*, 227-263.

[12] Gad, A., Saleh, A., & Khalifa, M. (2019). Assessment of natural radionuclides and related occupational risk in agricultural soil, south-eastern Nile Delta, Egypt. *Arabian Journal of Geosciences*, **12:** 1-15.

[13] Mishra, A. P., Khali, H., Singh, S., Pande, C. B., Singh, R., & Chaurasia, S. K. (2023). An assessment of in-situ water quality parameters and its variation with Landsat 8 level 1 surface reflectance datasets. *International Journal of Environmental Analytical Chemistry*, **103(18):** 6344-6366.

[14] Luc, B. T., Karim, K., Moumouni, D., Cedric, B., Cisse, O. I., & Zougmore, F. (2021). Assessment of Indoor Radon Concentration in Residential Buildings at Ouagadougou and Estimation of the Annual Effective Dose. Radiation Science and Technology, **7:** 41-46.

[15] Telado Luc, B., Karim, K., Moumouni, D., Cedric, B., Ibrahim Cisse, O., & Zougmore, F. (2021). Assessment of indoor radon concentration in residential buildings at Ouagadougou and estimation of the annual effective dose. *Radiat. Sci. Technol.*, **7(2):** 41.

[16] Mahmud, J. A., Siraz, M. M., Alam, M. S., Das, S. C., Bradley, D. A., Khandaker, M. U., & Yeasmin, S. (2023). A study into the long-overlooked carcinogenic radon in bottled water and deep well water in Dhaka, Bangladesh. *International Journal of Environmental Analytical Chemistry,* https://doi.org/10.1080/03067319.2022.2163895

[17] Finne, I. E., Kolstad, T., Larsson, M., Olsen, B., Prendergast, J., & Rudjord, A. L. (2019). Significant reduction in indoor radon in newly built houses. *Journal of Environmental Radioactivity*, **196:** 259-263

[18] Marsh, J. W., Harrison, J. D., Laurier, D., Blanchardon, E., Paquet, F., & Tirmarche, M. (2010). Dose conversion factors for radon: recent developments. *Health Physics*, **99(4):** 511-516.

[19] Tsuruoka, H., Inoue, K., Hosokawa, S., & Fukushi, M. (2016). Measurement of radon and thoron concentrations in the Tokyo Metropolitan University Arakawa Campus building. *The Journal of Japan Academy of Health Sciences*, **19(1):** 40-48.

[20] CRP (2009) International Commission on Radiological Protection Statement on Radon ICRP Ref.00/902/09

[21] Morakinyo, R. O., Usikalu, M. R., & Orosun, M. M. (2022). Evaluation of background radiation of Maryland School complex, Lagos, Nigeria. *IOP Conference Series: Earth and Environmental Science,* **993(1):** 012015.