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MEASUREMENT OF RADON-222 GAS CONCENTRATION AND INVESTIGATING ITS EFFECTS ON LUNG CANCER IN SOME SELECTED OFFICES IN FEDERAL UNIVERSITY OF LAFIA, NASARAWA STATE, NIGERIA.

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ABSTRACT

Radon gas and its ephemeral radioactive decay products constitute the principal origin of public exposure to naturally occurring radiation, thereby contributing almost half of the worldwide effective dose received by the populace. Radon (^{222}Rn) and its isotopes have been acknowledged as a global predicament that notably causes lung cancer, although it remains unfamiliar to the majority of individuals. The research aimed to investigate the concentration of Radon gas with the help of an inspector alert, a nuclear radiation monitor with inbuilt Geiger-muller tube for the measurement of ^{222}Rn concentration in the 14 investigated offices in the take-off site, Federal University, Lafia to estimate the effective dose to the occupants from ^{222}Rn. The dosimetry measurements were made with the inspector alert on count per minute (cpm) mode and the radon concentration ranged from 43.50$\pm$10.00cpm to 67.00$\pm$32.00cpm at the administrative offices (A block) and 49.50$\pm$ 10.00cpm to 77.00$\pm$ 42.00cpm at the departmental head offices (B block) in faculty of science. The annual effective dose to the occupants varied from 0.09 mSv/yr to 0.14 mSv/yr with a mean value of 0.10 mSv/yr at the A block, conversely, the lowest effective doe rate at B block was 0.10 mSv/yr while 0.16msv/yr at the highest, averaging 0.12 mSv/yr. Concentration was found to be lower than the reference value (3-10 mSv/yr) of the international council on radiological protections (ICRP) as the approximate safety standard, hence it may not result to any risk of lung cancer to the occupants and the members of public within the investigated offices. A continuous monitoring program of such is recommended for implementation and the methodology is suitable for further applications on other buildings within the University.

Keywords: Radon gas, Radiation Concentration, Administrative Offices, Dose Rate, Geiger-Mueller tube

1.0 INTRODUCTION

Radon and its transient radioactive decay products within residential structures constitute the primary origin of public exposure to natural radiation (Paatero *et al*., 2023; Silverman, 2016), thereby contributing nearly half of the worldwide effective dose to the population (Holm, 2000). Radon (^{222}Rn) a naturally occurring radioactive noble gas, can be found in the outdoor atmosphere as well as within various indoor environments, including workplaces (Vennart, 1991), it serves as an unavoidable origin of radiation exposure, presenting a potential health risk both domestically and occupationally (Grzywa-Celińska *et al*., 2020; Maier *et al*., 2021; Radebe *et al*., 2023). Soil is widely regarded as the primary origin of indoor radon concentration (Dvorzhak *et al*., 2021), even though construction materials (specifically quartz, cement, and so on) can play a notable role in elevating the degree of inherent radioactivity in confined areas like warehouses and poorly ventilated residences (Ndjana Nkoulou II *et al*., 2022). Radon gas has the capability to effortlessly permeate from the soil into the atmosphere or buildings (Nunes *et al*., 2023). It has the potential to become entrapped in inadequately ventilated spaces, leading to an escalation in its concentration to higher levels (Cucu & Dupleac, 2022). The inhalation of alpha particles emitted by the isotope radon (^{222}Rn) and its subsequent decay products within residential buildings is a pervasive global issue and a significant contributing factor to the development of lung cancer (Riudavets *et a*l., 2022; Ruano-Ravina *et a*l., 2023). Consequently, it is of paramount importance to evaluate the extent of exposure to radon (^{222}Rn) and its progeny in various types of habitations, particularly residences, workplaces, and educational institutions, in order to ensure the maintenance of optimal standards. Recent calculations have indicated that a rise in radon concentration of 100Bq/m3 is approximately associated with a 16% escalation in the likelihood of contracting lung cancer (Riudavets *et al*., 2022; Ruano-Ravina *et al*., 2023).

The process of radon gas decomposition results in the formation of radioactive particles (Nunes *et al*., 2023). These particles, namely alpha, beta, and gamma particles, exist in a solid state (Hu & Huang, 2021). They possess an electric charge that enables them to be drawn towards various objects, such as ceilings, walls, and airborne dust particles (Dhar *et al*., 2021; Hu & Huang, 2021). Upon inhalation, these particles become trapped within the lungs, wherein the alpha particles emit minute bursts of energy (Coll *et al*., 2023). This energy has the potential to inflict harm upon the lung tissues, ultimately increasing the risk of developing lung cancer (Coll *et al*., 2023; Truta-Popa *et al*., 2011).

Over the course of an individual's lifespan, the objective is to examine the inherent ambient radiation levels (specifically radon gas) present in certain office environments. This investigation will allow for the determination of the contribution of indoor radon radiation exposure rates, thereby facilitating the identification and mitigation of potential risks associated with lung cancer resulting from the inhalation of air containing alpha particles emitted during the alpha decay of radon. It is important to note that lung cancer currently stands as the primary cause of cancer-related mortality for both men and women on a global scale. Exposure to radon in residential and associated environments constitutes the second most prominent factor contributing to the development of lung cancer in individuals who do not engage in smoking. The degree to which this inquiry will be conducted correlates with the health hazard (specifically the causation of cancer), which will be prioritized in terms of the calibre of indoor air and the level of ionizing radiation to which the occupants of the offices at the take - off site in Federal University of Lafia (figure 1) are exposed.

However, the scope of this research is limited to the examination of radiation levels, the scrutiny and discourse of outcomes regarding the impacts of radiation on substance (the human form), as well as the exploration of methods to curtail it to an admissible threshold within the designated office spaces where authorization has been accorded for this study.

2.0 MATERIALS AND METHODS

An inspector alert (figure 2), with in-built Geiger-Muller tube, manufactured by IOSPECTRA USA (S/N 35440), was employed for the purpose of monitoring nuclear radiation in the study area. (figure 2) depicts the implementation of this device. The device preference was due to its easy access, suitable for usage and do not require any form of power supply while carrying out measurements. The areas of interest covered the administrative offices, identified as A block in Table 1, as well as the departmental head offices situated within the faculty of science, designated as B block, presented in Table 2, both of which are situated within the confinement of the university, figure 1.

figure 1: Aerial view of Federal University of Lafia, take off site (https://earth.google.com)

The administrative offices that were involved in the matter were the office of the Vice Chancellor (VC) (A1) and the office of the secretary to the Vice Chancellor (A2), as well as the senate chamber (A3), the offices of the Registrar and the Bursar (A4 & A6), and their respective Secretaries' offices (A5 and A7). Likewise, the investigation included the offices of the heads of seven departments, namely Physics (B1), Chemistry (B2), Computer Science (B3), Zoology (B4), Microbiology (B5), Botany (B6), and Mathematics (B7).

figure 2: Inspector Alert for the detection of nuclear radiation

The detector functions in the mode of count dose rate in order to ascertain the background radiation level emanating from the four different angles present within the offices under investigation. By means of ionization, the Geiger tube generates an electric current pulse whenever radiation passes through it. These pulses are subsequently electrically identified and recorded in Counts Per Minute

(CPM). The inspector's alert was positioned at an elevated level of one meter above the ground, in close proximity to the surrounding walls at each of the four corners. The device was activated, and measurements were recorded and an audible beep that signifies the statistical reliability of the data displayed on the liquid crystal display (LCD) of the monitor. Readings were conducted at the mentioned dosage rate on four separate occasions in every office. With the help mathematical relations, conversions were made via computations to convert the readings in CPM, ranging from dose rate (D.R) measured in $\mu Sv/hr$, to absorbed dose rate (A.D.R) in nGy/hr and then to the final and required dose on humans, effective dose measured in mSv/yr.The mean from the readings were obtained, along with their calculated precisions, and subsequently recorded for analytical purposes. The computational analysis was obtained using the theories(Bamikole & Musa, 2017):

The first reading in count per dose (CPM)

- Dose rate ($\mu Sv/hr$)
  100 CPM $= 1\mu Sv/hr$
  Then, CPM $= 10^{-2}\mu Sv/hr$
  Hence, D.R $= \text{CPM} \times 10^{-2}\mu Sv/hr$
- For the Absorbed dose (nGy/hr)
  Given that: $10^{3}nGy/hr = 1\mu Sv/hr$
  Therefore, A.D.R = D.R($\mu Sv/hr$) $\times 10^{3}nGy/hr$
- Lastly, the Effective dose (mSv/hr)
  A.D.R×t×C×C×OF.

Where t represents the total number of hours a staff spent at the office per year, so t = 1400hr/yr, C is the conversion coefficient found to be 0.7, while O.F is the indoor occupancy factor measured at 0.2.

3.0 RESULTS AND DISCUSSION

Based on the analysis conducted in tables 1 and 2 on the findings presented in table 3 and figure 3, it is evident that the office of the Vice Chancellor's Secretary (A2) exhibits the highest radiation concentration (0.14msv/yr).

Table 1. The concentration values of radon gas are documented in the raw data that has been gathered from the administrative offices located in the four corners.

OFFICE	COUNT DOSE RATE (CPM)
VC (A1)	46.00
	52.00
	36.00
	40.00.
	43.50± 10.00
SECRERARY TO THE V.C (A2)	60.00
	60.00
	58.00
	90.00
Mean	67.00± 32.00
SENATE CHAMBER (A3)	48.00
	56.00
	48.00
	54.00
Mean	51.50± 8.00
REGISTRAR (A4)	56.00
	62.00
	66.00
	28.00
Mean	53.00± 38.00
SECRETARY TO THE REGISTRAR (A5)	44.00
	32.00
	46.00
	66.00
Mean	47.00± 34.00
	50.00
BURSER	62.00

(A6)	
	60.00
	48.00
SECRETARY TO THE BURSER	54.00
(A7)	46.00
	54.00
	86.00
Mean	60.00$\pm$ 40.00

This occurrence can be attributed to inadequate ventilation within the office space, as well as the selection of specific construction materials utilized in the construction of said office. Additionally, the presence of certain objects (such as jewelry, wrist chains, and tiger-rings) contaminated with lead (^{210} pb), holding radon (^{222}Rn), and other radioactive elements as constituents in their raw materials for production may also contribute to this outcome.

Table 2. Measured values from the departmental head offices depicting the radon concentration.

DEPARTMENTS	COUNT DOSE RATE (CPM)
PHYSICS (B1)	52.00
	66.00
	48.00
	38.00
Mean	51.00$\pm$ 28.00
CHEMISTRY (B4)	52.00
	64.00
	68.00
	66.00
Mean Mean	62.50$\pm$ 16.00
COMPUTER-SCIENCE (B10)	50.00

	54.00
	44.00
	50.00
Mean	49.50± 10.00
ZOOLOGY (B13)	76.00
	62.00
	54.00
	54.00
Mean	61.50± 22.00
MICROBIOLOGY (B15)	28.00
	70.00
	76.00
	54.00
Mean	57.00± 48.00
BOTANY (B17)	66.00
	64.00
	98.00
	38.00
Mean	66.50±60.00
MATHEMATICS (B7)	80.00
	52.00
	94.00
	82.00
Mean	77.00± 42.00

Moreover, the vice chancellor's office exhibits the lowest level of concentration. This phenomenon is attributed to the sufficient ventilation in the office which facilitates air exchange between the indoor and outdoor environments. Consequently, the concentration and intensity of radiation in this particular office are effectively reduced. Conversely, other offices such as chemistry, A7, A6, and A4 display elevated levels of radon concentration. These offices record respective dose rates of 0.12msv/yr, 0.11msv/yr, and 0.11msv/yr.

Other variables could potentially impact the levels of radon in enclosed areas (Celen *et al*., 2023). Of these variables, the state of ventilation stands out as a recognized factor that influences the concentration of radon in a given setting (ICRP 1993).

Table 3. Radiation values from the measurements carried out at the administrative building.

Code	Count Dose Rate (CPM)	Dose rate $(\mu Sv/hr)$	absorbed Dose Rate (nGy/hr)	Effective Dose Rate (mSv/yr)
A1	43.50±10.00	0.44	440.00	0.09
A2	67.00±32.00	0.67	670.00	0.14
A3	51.50±8.00	0.52	520.00	0.10
A4	53.00±38.00	0.53	530.00	0.11
A5	47.00±34.00	0.47	470.00	0.09
A6	55.00±14.00	0.55	550.00	0.11
A7	60.00±40.00	0.60	600.00	0.12

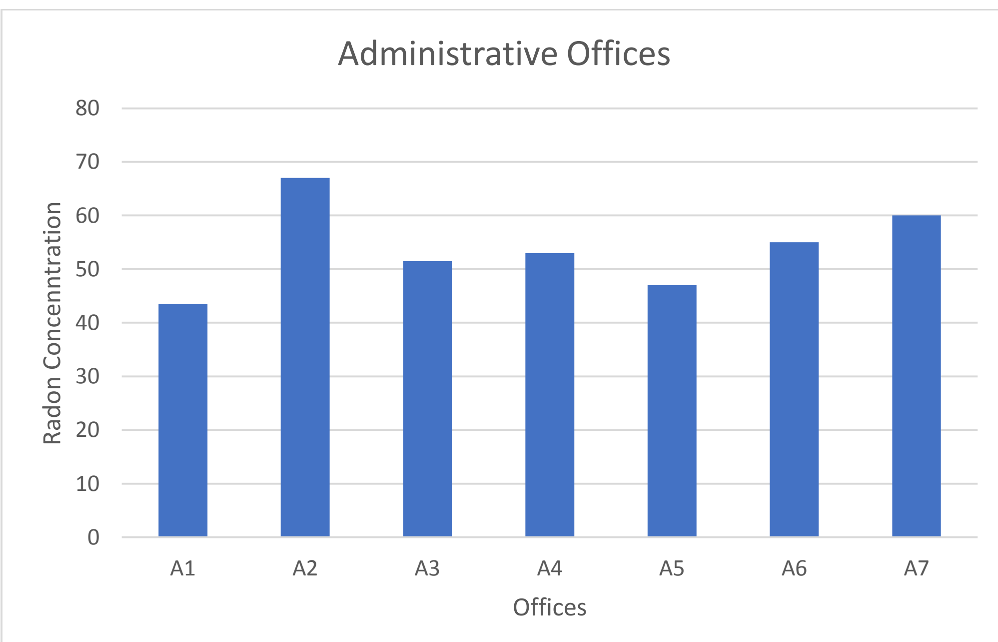

figure 3: Bar chat depicting the measured radiation values from the administrative offices

In a similar manner, Mathematics (B3) exhibits the utmost degree of radiation (0.16 mSv/yr) out of all the faculty of science offices, as observed in both table 4 and (figure 4) respectively. Other offices within the faculty, namely B2 and B7, demonstrate higher concentration values (0.13 mSv/yr in both). The offices with the lowest concentration levels are B1 and B4, both possessing a measure of 0.10 mSv/yr. They are followed by B6 and then B5, which register radiation levels of 0.11 mSv/yr and 0.12 mSv/yr, respectively.

Table 4. Values of the radiation concentration obtained from the departmental head offices in faculty of science.

Code	Count Dose Rate (CPM)	Dose rate ($\mu Sv/hr$)	absorbed Dose Rate (nGy/hr)	Effective Dose Rate (mSv/yr)
B1	51.00±28.00	0.51	510.00	0.10
B2	65.60±16.00	0.60	660.00	0.13
B3	77.00±42’00	0.77	770	0.16
B4	49.50±10.00	0.50	500	0.10
B5	61.50±22.00	0.62	620	0.12
B6	57.00±48.00	0.57	570	0.11
B7	66.50±60.00	0.66	660	0.13

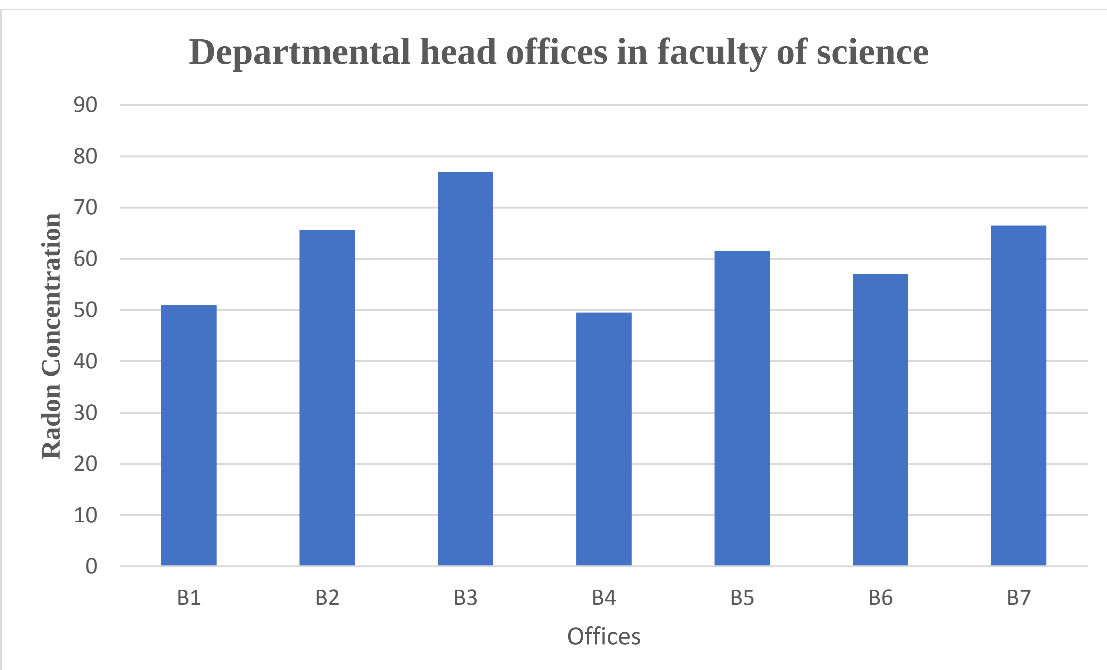

figure 4: Plot from the measurement of the radiation concentration in the departmental head offices in faculty of science

4.0 CONCLUSION AND RECOMMENDATIONS

4.1CONCLUSION

The annual limit of radiation dose, as established by regulatory agencies such as International Commission on Radiological Protection (ICRP), National Council on Radiation Protection and Measurement (NCRP), Nuclear Regulatory Commission (NRC), etc., serves as the appropriate safety standard for controlling and restricting the potential harmful effects of radiation (e.g., cancer risk). The effective dose for members of the public must not exceed 1mSv/yr (100mrem/yr). It can be observed that none of the findings from this investigation surpass the aforementioned values. Consequently, it can be concluded with greater certainty that all occupants of the examined offices are currently safe from the potential risk of lung cancer resulting from close proximity to inhaled radon gas (^{222}Rn) and its decay products. **4.2RECOMMENDATIONS**

In in order to maintain this state of radiation safety, it is therefore recommended that a continuous monitoring quality assurance program should be implemented to ensure that the state of the offices remains safe. Furthermore, the methodology adopted in assessing and conducting this research should be applied for future research in other buildings within the university.

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