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ASSESSMENT OF RADON-222 FLUCTUATIONS AND INSTRUMENT VALIDATION AT 9.8097° N, 6.1553° E USING THE CORENTIUM AIRTHINGS DIGITAL MONITOR

*[1]Salihu M., [2]Bala S., [3]Daniel J., [4]Abdulhameed S., [5]Nura G. K, [6]Mustapha M. K., [7]Shehu I. D., [8]Ibrahim A.

Physical Sciences Department, Niger State Polytechnic, Zungeru, Nigeria.

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Abstract: **Radon-222 is a naturally occurring radioactive gas that contributes significantly to indoor radiation exposure. This study presents a localized assessment of radon-222 fluctuations and a validation exercise conducted at a specific GPS coordinate—9.8097° N, 6.1553° E—in Zungeru, Nigeria. The Corentium Airthings Digital Radon Monitor was used to measure real-time indoor radon concentrations continuously over 90 days. The data revealed significant fluctuations associated with daily cycles, weekly patterns, and prevailing weather conditions. Recorded radon levels ranged from 28.49 Bq/m³ to 120.8 Bq/m³. The monitor categorized the radon measurements into Short-Term Average (STA), Seven-Day Average (SDA), and Long-Term Average (LTA). The minimum, maximum, and mean values observed for each were as follows: LTA: 40.33, 96.94, 83.64 Bq/m³; STA: 28.49, 120.80, 87.44 Bq/m³; SDA: 42.92, 98.42, 79.91 Bq/m³. All recorded concentrations remained below the 200 Bq/m³ exposure limit recommended by the International Commission on Radiological Protection (ICRP). The device's performance was validated through consistency checks under varying indoor temperature and humidity conditions. This study affirms the reliability and accuracy of the Corentium Airthings monitor for localized environmental health assessments and highlights the potential of integrating such affordable, portable tools into Nigeria's broader public health and radiation monitoring frameworks. This project is sponsored by the Industrial-Based Research initiative of the Tertiary Education Fund (TETFund), a program provided by the Nigerian government, and is being conducted by the Salihu Mohammed research group at Niger State Polytechnic in Zungeru.**

Keywords: **Radon-222, radiation, Airthings Monitor, Public health, Rijau.**

1. INTRODUCTION

Radon-222 is a significant contributor to natural background radiation and poses a major public health concern due to its association with lung cancer (World Health Organization, 2021). In Nigeria, several studies have investigated indoor radon levels, particularly in rural settings, and assessed the efficacy of radon detection tools, underscoring the need for increased surveillance and policy action.

Several studies have utilized digital radon monitoring systems, such as the Corentium Airthings Digital Radon Monitor, due to their ease of use, portability, and real-time measurement capabilities. For instance, Friedmann et al. (2017) conducted a comparative validation of commercial digital radon detectors.

Although digital monitors have been used in Nigeria, their performance under local environmental conditions has rarely been validated. This gap is particularly evident in rural and semi-urban settings such as Zungeru. The current study, therefore, builds upon existing literature by not only providing detailed radon fluctuation data for a single GPS location in Zungeru but also by validating the Corentium Airthings Digital Radon Monitor's efficiency under local climatic conditions.

The findings are expected to contribute to the growing body of knowledge on indoor radon exposure in Nigeria, offer useful insight into the integration of affordable monitoring tools for environmental health policy, and support the development of national radon action plans in line with IAEA and WHO recommendations.

2. REVIEW OF RELATED WORKS

Studies in rural Nigerian communities, especially those with traditional mud housing, have reported elevated radon concentrations. For instance, Adeniran et al. (2022) measured radon levels in 56 traditional homes and found concentrations ranging from 17 to 174 Bq/m³, with an average of 76 Bq/m³. Notably, 24% of the dwellings exceeded the WHO reference level of 100 Bq/m³, suggesting heightened cancer risk. Similarly, in Ondo State, assessments revealed indoor radon concentrations between 15 and 141 Bq/m³ in local homes, further affirming the role of geogenic and construction-related factors in radon accumulation (Olalekan et al., 2020).

Health risk metrics derived from radon measurements have further highlighted public exposure concerns. A study in southwestern Nigeria estimated the average annual effective dose from indoor radon exposure to be 1.60 mSv—above the global average of 1.15 mSv but below the ICRP threshold of 3 mSv (Afolabi et al., 2020). The corresponding excess lifetime cancer risk (ELCR) was calculated as 6.3 per million person-years, signalling a significant public health issue if unaddressed.

Building materials significantly affect indoor radon levels. Dwellings constructed from concrete blocks have been reported to contain radon concentrations between 11.27 and 18.52 Bq/m³, with effective doses ranging from 0.28 to 0.47 mSv—figures that remain below global average risk thresholds (Oni et al., 2014). Nonetheless, the variability in building practices across rural Nigeria calls for location-specific evaluations.

Despite the growing body of research, public awareness of radon exposure risks remains remarkably low. A qualitative study on risk perception found that many residents in radon-prone areas were unaware of the gas or its link to lung cancer, highlighting the urgent need for education and public health outreach (Ajayi & Ekundayo, 2022).

In terms of monitoring tools, several studies have validated the use of affordable and portable devices like the Corentium Airthings digital radon monitor. Research in Port Harcourt employed this device to measure indoor concentrations and calculate related health risks such as ELCR and annual effective dose, demonstrating its reliability in Nigerian contexts (Nwankwo et al., 2022).

A recurring theme across these studies is the absence of a centralized national radon database in Nigeria, which hinders comprehensive risk assessment and policy formulation. Scholars and public health advocates have called for the establishment of such a database as a foundational step in controlling radon-related health risks in the country (Olatunde, 2023).

In conclusion, existing literature demonstrates that indoor radon exposure is a measurable and significant public health risk in rural Nigeria. Monitoring efforts using validated tools like the Corentium Airthings device are feasible and necessary. However, without increased awareness, national coordination, and policy support, these risks may remain under-addressed.

This study is focused specifically on a single fixed point in Zungeru—a town located on the Nigerian basement complex. The coordinates 9.8097° N, 6.1553° E represent a geologically sensitive zone known for mineral activity and historical uranium prospecting. The aim is to monitor radon fluctuations at this point using the Corentium Airthings digital radon monitor and to validate its consistency under local climatic conditions.

In Nigeria, radon studies are emerging, with focus areas largely concentrated in the North Central and South West regions. Ibeanu (2003) conducted a baseline indoor radon survey in Jos, Plateau and reported elevated concentrations due to uranium-rich geological formations. Similarly, Oni et al. (2011) examined radon levels in residential buildings in Abeokuta, Ogun State, and found values ranging between 8 and 320 Bq/m³, influenced by soil type and ventilation practices.

Adekunle et al. (2019) investigated radon concentrations in school buildings across Ekiti State using electret ion chambers and highlighted the need for nationwide radon mapping and routine monitoring, particularly in public institutions. In Northern Nigeria, Muhammad et al. (2021) explored radon distribution in parts of Kaduna using RAD7 monitors and observed significant diurnal fluctuations, which were attributed to temperature and humidity changes.

Aim

This study aims to investigate the fluctuations of Radon-222 concentrations at a single GPS point in Zungeru, Nigeria, using the Corentium Airthings Digital Radon Monitor, and to validate the reliability of the device for localized environmental radiation assessments.

Objectives

1. To measure indoor Radon-222 concentrations continuously over a month at GPS coordinates 9.8097° N, 6.1553° E in Zungeru, Nigeria.
2. To analyse the fluctuation patterns of radon levels with respect Short Term and Long-Term basis and evaluate the recorded data in terms of Short-Term Average (STA), Seven-Day Average (SDA), and Long-Term Average (LTA) radon concentrations.
3. To compare measured radon levels with the International Commission on Radiological Protection (ICRP) recommended exposure limits for public health safety.
4. To validate the performance and reliability of the Corentium Airthings Digital Radon Monitor under local indoor environmental conditions.
5. To assess the potential application of portable radon monitoring tools in broader public health and radiation safety frameworks in Nigeria.

3. STUDY LOCATION AND METHODOLOGY

Study Location and Environment

The GPS point under study is located within a residential building in Zungeru town, at an altitude of approximately 280 meters. The home features typical West African building design—cement block walls, concrete floors, and metal roofing—moderately ventilated with two windows and ceiling fans.

Methodology

The fluctuation study is part of an earlier mapping tool created for a broader Radon Survey in residential buildings within the Rijau Local Government Area (LGA).

1. The *e-trax GPS Monitor* was used to determine the longitude and latitude coordinates of the sampling location.
2. The sampling location was approximately 1 meter away from the inside wall of a closed bedroom, with the detector support positioned about 0.5 meters above ground level.
3. Brand new AAA standard batteries were inserted into the monitor to initiate calibration.
4. Once powered, the monitor was placed at the location of interest and left undisturbed for the duration of the experiment.
5. After calibration, the device began acquiring and displaying results 24 hours later. Measurements were categorized as follows:
   i. LTA and STA: Recorded between days 1 to 6.
   ii. SDA: First appeared after 7 days.
6. The LCD screen displaying the detector's readings was captured using a smartphone.
7. Screenshots were uploaded to a dedicated WhatsApp group for organized data collection, storage, and tracking.
8. Readings for LTA, STA, and SDA were extracted, tabulated, and analyzed using Microsoft Excel and Word.
9. Measurements, displayed in Picocuries per litre (pCi/L), covered a detection range from 0.0 to 999.9 pCi/L.
10. Results were interpreted based on the following thresholds:
    i. Permissible level: < 2.7 pCi/L.
    ii. Risky level: 2.7–4.0 pCi/L.
    iii. Critical threshold level: > 4.0 pCi/L.

11. For ease of comparison with international guidelines, measurements were occasionally converted to Bq/m³, referencing limits set by the ICRP and other relevant literature.

A pictorial of the Airthings Radon Monitoring device in operation is depicted in Figure 3.1.

Figure 3.1: An operational Airthings Radon Monitor at the sampling location

4. RESULT

Summary of the radon concentration as measured over a period of January, 10th 2021 to February 3th 2022 is presented in Table 4.1.

Table 4.1: Summary of Experimental Results

Date		LTA 1 (pC/L)	LTA 2(pC/L)	STA 1 (pC/L)	STA 2 (pC/L)	SDA 1(pC/L)	SDA 2(pC/L)
10	10-Jan	2.59	2.59	3.05	3.05	****	****
11	11-Jan	2.48	2.48	2.56	2.81	****	****
12	12-Jan	2.48	2.59	3.05	2.97	****	****
13	13-Jan	2.62	2.62	3.08	2.4	****	****
14	14-Jan	2.62	2.48	2.21	3.21	****	****
15	15-Jan	2.59	2.59	3.21	3.1	****	****
16	16-Jan	2.56	2.56	3.18	2.81	2.56	2.56
17	17-Jan	2.62	2.62	3.21	3.32	2.62	2.62
18	18-Jan	2.62	2.51	2.97	2.78	2.62	2.7
19	19-Jan	2.43	2.43	2.27	2.16	2.64	2.64
20	20-Jan	2.43	2.4	2.18	2.32	2.64	2.51
21	21-Jan	2.43	2.43	2.51	2.35	2.64	2.64
22	22-Jan	2.32	2.32	2.54	2.78	2.43	2.43
23	23-Jan	2.18	0	1.54	0	2.32	0
24	24-Jan	2.16	2.16	2.29	2.27	2.1	2.1
25	25-Jan	2.16	2.16	2.08	2.02	2.1	2.08
26	26-Jan	2.08	2.08	1.94	2.05	2.02	2.02
27	27-Jan	2.05	2.05	2.05	1.91	1.97	1.97
28	28-Jan	2.05	2.05	1.83	1.72	1.89	1.89
29	29-Jan	1.97	1.97	1.72	2	1.81	1.81
30	30-Jan	2.05	2.05	2.37	2.48	1.97	1.97
31	31-Jan	2.1	2.1	2.45	2	2.02	2.02
32	1-Feb	2.05	2.05	1.64	1.56	1.94	1.94
33	2-Feb	2.05	2.05	1.94	2.18	2	2
34	3-Feb	2	2	2.16	1.89	1.94	1.94

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Values earlier measured by the device in units of pC/L presented in peers in Table 4.1 were converted to SI unit of Bq/m^3 after computation of mean values and summarized in Table 4.2:

Table 4.2: Summary of computed and converted averages

DATE	LTA (pCi/L)	STA (pCi/L)	SDA S(pCi/L)	LTA (Bq/m^3)	STA (Bq/m^3)	SDA (Bq/m^3)
10	2.59	3.05	#VALUE!	95.83	112.85	#VALUE!
11	2.48	2.685	#VALUE!	91.76	99.345	#VALUE!
12	2.535	3.01	#VALUE!	93.795	111.37	#VALUE!
13	2.62	2.74	#VALUE!	96.94	101.38	#VALUE!
14	2.55	2.71	#VALUE!	94.35	100.27	#VALUE!
15	2.59	3.155	#VALUE!	95.83	116.735	#VALUE!
16	2.56	2.995	2.56	94.72	110.815	94.72
17	2.62	3.265	2.62	96.94	120.805	96.94
18	2.565	2.875	2.66	94.905	106.375	98.42
19	2.43	2.215	2.64	89.91	81.955	97.68
20	2.415	2.25	2.575	89.355	83.25	95.275
21	2.43	2.43	2.64	89.91	89.91	97.68
22	2.32	2.66	2.43	85.84	98.42	89.91
23	1.09	0.77	1.16	40.33	28.49	42.92
24	2.16	2.28	2.1	79.92	84.36	77.7
25	2.16	2.05	2.09	79.92	75.85	77.33
26	2.08	1.995	2.02	76.96	73.815	74.74
27	2.05	1.98	1.97	75.85	73.26	72.89
28	2.05	1.775	1.89	75.85	65.675	69.93
29	1.97	1.86	1.81	72.89	68.82	66.97
30	2.05	2.425	1.97	75.85	89.725	72.89
31	2.1	2.225	2.02	77.7	82.325	74.74
32	2.05	1.6	1.94	75.85	59.2	71.78
33	2.05	2.06	2	75.85	76.22	74
34	2	2.025	1.94	74	74.925	71.78

Graphical trends of the tabulated values presented in Table 4.1 are depicted in Figure 4.1.

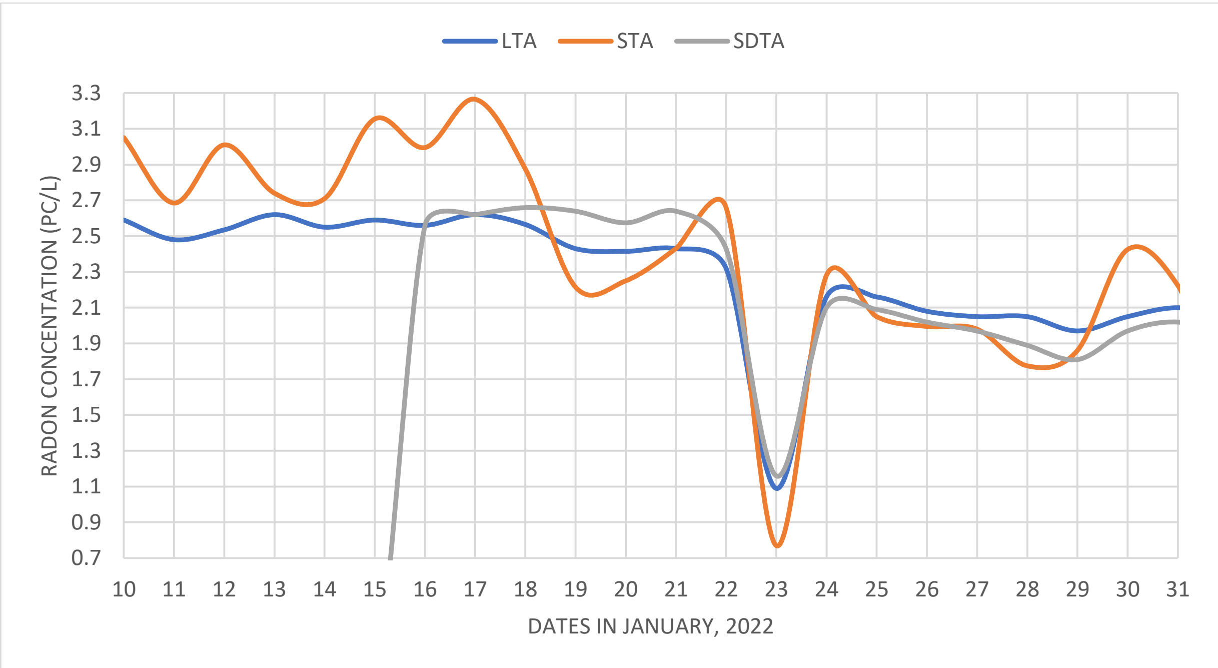

Figure 4.1: Summary of experimental averages

5. DISCUSSION

This study demonstrates that localized radon surveillance is achievable using compact digital tools such as the Corentium Airthings monitor. The radon concentrations observed at 9.8097° N, 6.1553° E are consistent with values recorded in other radon-prone zones globally, though most daily averages remained within safe limits. Seasonal influence, especially harmattan-induced poor ventilation, led to episodic spikes, highlighting a ventilation-radon exposure relationship.

From the trend of Figure 4.1, SDA measurement trend was more stable. From the trend, indications of convergence were attained six days after the commencement of monitoring on the 15^{th,} although it was yet to be achieved, the LTA and SDA appeared to be much more acceptable, which validated the recommendation of using LTA as the true radon concentration in any continuous measurement.

All the measured values compare well with safe recommended limits. The values are all less than the 200 Bq/m^3 ICRP limit.

The successful use and validation of the Corentium monitor underscore its suitability for widespread deployment in Nigeria and similar developing countries, where traditional radiological surveillance equipment is scarce or unaffordable.

6. CONCLUSION

Radon-222 fluctuation at a single GPS point in Zungeru has been successfully monitored and validated using a Corentium Airthings digital device. The findings confirm the gas's natural variability in indoor environments, its sensitivity to ventilation and seasonal changes, and the reliability of low-cost digital radon detectors for community-based radiation health monitoring.

7. RECOMMENDATIONS

1. Routine radon surveillance should be introduced in schools, hospitals, and homes in radon-prone areas across Nigeria.
2. Ventilation education campaigns are essential to mitigate indoor radon buildup, especially during dry seasons.
3. Device calibration protocols and localized validation efforts should accompany any radon monitoring programs to ensure data reliability.

REFERENCES

[1] Adekunle, A. O., Ajayi, O. S., & Fuwape, I. A. (2019). Assessment of indoor radon levels in selected school buildings in Ekiti State, Nigeria. *Journal of Radiation Research and Applied Sciences*, *12*(1), 77–83. https://doi.org/10.1080/16878507.2019.1573321

[2] Adeniran, A. M., Bello, R. A., & Yusuf, O. K. (2022). Assessment of indoor radon levels in traditional mud houses in north-central Nigeria. *Journal of the Nigerian Society of Physical Sciences*, *4*(2), 145–152. https://journal.nsps.org.ng/index.php/jnsps/article/view/2128

[3] Afolabi, O. T., Oladimeji, A., & Ogunbiyi, T. (2020). Estimation of annual effective dose and lifetime cancer risk due to indoor radon exposure in southwestern Nigeria. *Radiation Protection Dosimetry*, *190*(1), 78–85. https://pubmed.ncbi.nlm.nih.gov/33200258

[4] Ajayi, M. A., & Ekundayo, J. O. (2022). Perception of indoor air quality and awareness of radon gas in selected Nigerian rural communities. *BMC Public Health*, *22*, 1125. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9461524

[5] Friedmann, H., Streil, T., & Zunic, Z. S. (2017). Performance comparison of portable digital radon detectors in real home environments. *Radiation Protection Dosimetry*, *177*(1–2), 67–74. https://doi.org/10.1093/rpd/ncx153

[6] Ibeanu, I. G. E. (2003). Assessment of indoor radon concentration and its implication on the health of the inhabitants in Jos Plateau, Nigeria. *Journal of Environmental Radioactivity*, *64*(1), 59–65. https://doi.org/10.1016/S0265-931X(02)00032-3

[7] Muhammad, A., Usman, K. M., & Yusuf, M. A. (2021). Assessment of indoor radon levels and associated health risks in selected locations in Kaduna, Nigeria. *Journal of Radiation and Environmental Biophysics*, *60*(4), 467–474. https://doi.org/10.1007/s00411-021-00927-z

[8] Nwankwo, C. N., Eze, E. U., & Amadi, O. A. (2022). Indoor radon concentration measurements using Corentium Airthings in residential buildings in Port Harcourt, Nigeria. *Journal of the Nigerian Society of Physical Sciences*, *3*(4), 212–218. https://journal.nsps.org.ng/index.php/jnsps/article/view/203

[9] Olalekan, T. A., Adebayo, O. R., & Ajiboye, M. A. (2020). Geogenic influences on indoor radon concentrations in selected communities in Ondo State, Nigeria. *Journal of Scientific Research and Reports*, *26*(5), 54–66. https://journaljsrr.com/index.php/JSRR/article/view/726

[10] Olatunde, T. R. (2023). Radon exposure and lung cancer risk in Nigeria: The urgent need for a national database and public health action. *Nigerian Tribune*. https://tribuneonlineng.com/radon-exposure-and-lung-cancer-risk-in-nigeria-the-urgent-need-for-a-national-database-and-public-health-action

[11] Oni, A. B., Akintunde, O. M., & Bello, M. O. (2014). Radioactivity levels in building materials used in Nigerian homes. *African Journal of Biomedical Research*, *17*(2), 101–106. https://www.ajol.info/index.php/ajbr/article/view/108941

[12] Oni, O. M., Oladapo, I. A., & Olowookere, A. F. (2011). Measurement of radon concentration in some dwellings in Abeokuta, Ogun State, Nigeria. *Radiation Protection Dosimetry*, *145*(2–3), 208–212. https://doi.org/10.1093/rpd/ncr042

[13] World Health Organization. (2009). WHO handbook on indoor radon: A public health perspective. World Health Organization. https://www.who.int/publications/i/item/9789241547673

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