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Measurement of Indoor Radon Concentrations and Health Hazard Exposure to Occupants of Buildings at Ijebu-Imushin Area, Ogun State, Nigeria

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Abstract

Lung cancer has been linked to exposure to the naturally occurring ionizing radiation from radon gas (22Rn). Radon is ubiquitous in our environment. However, the level of Concentration of this gas is influenced by the geological, geographical and meteorological conditions of a particular environment. The indoor radon concentration is also influenced by factors such as Air-conditioning system, ventilation and age of building. In this study, the level of indoor radon concentrations was measured using radon detector Rn-35 model, in 30 different buildings for both bricks buildings and cement buildings located within Ijebu-Imushin situated at Ijebu- East, Ogun State, Nigeria. Buildings were chosen to vary between those bricks buildings and cement buildings. The results of the measurements showed that the indoor radon concentrations for all the buildings varied betweeno.48 to 1.68pCiL-1. These values were found to be lower than the recommended limit by International Commission on Radiological Protection (ICRP). The annual dose rate for the occupants of buildings ranged from 0.005mSy -1 to 0.123mSy -1which were below the recommended ICRP international limit. Hence, there was no reasonable risk of adverse health effect and lung cancer induction to the occupants of the buildings at Ijebu- Imushin.

Keywords: Radon, Concentration, Dose, Lung Cancer

Introduction

Radon is a colourless and odourless gas that is naturally occurring in the environment. It is formed from the radioactive decay of uranium and can seep into buildings through cracks in the foundation, walls, and floors. Radon exposure

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is a significant public health concern because it is a known carcinogen and is the second leading cause of lung cancer after smoking (Richard, 2021).

Radon is a gas produced by the radioactive decay of radium. Radioactive decay is a natural, spontaneous process in which the atomic nucleus of one element decays or breaks down to form another element by losing or emitting out nuclear particles (protons, neutrons, electrons, etc.) (Barca et al., 2021). When radium decays to form radon gas, its nucleus emits two protons and two neutrons tied up together to form an alpha particle (or 4He nucleus). Radon itself is radioactive because it also decays, losing an alpha particle and forming polonium. Uranium and thorium are the first elements in a long series of decays that produce radon. Uranium and thorium are referred to as the parent elements, and radium and radon are called daughters. Radium and radon also form other daughter elements as they decay.

[11] Uranium has a half-life of 4.4 billion years and forms the longest half-life of radon isotopes (222Rn) that is only 3.8 days. 232Th is an element that, like uranium isotopes, is distributed throughout the environment. It has a very long half-life (1.41×10 10 yr) and decays by emission of an alpha particle creating a series of radioactive daughters, many of which emit alpha radiations too. One of these daughters is the second most important radon isotope, 220Rn that has a half-life of 55 seconds. If, for instance, a jar was filled with 222Rn, in 3.8 days only half of the radon would be left.

But the newly made daughter products of radon would also be in the jar, including polonium, bismuth, and lead. Also, polonium has radioactive isotopes: from 222Rn decay it is produced 218Po that decays with a half-life of 3.04 min emitting an alpha particle of 6.11 MeV. It is mainly 218Po and 216Po (from 220Rn decay, 216Po emits alpha of 6.7 MeV), both produced by radon in the air, that by breathing enter the people's lungs, stick to the lungs and/or bronchial tissue where the emitted energetic alpha particles could hurt the cells and causes cancer illness. The radon's daughters are the main responsible for the cancer risk: many studies have been done and the World Health Organization – International Agency for Research on Cancer classified radon and its decay products as carcinogenic elements of group 1, that means the group of the most dangerous ones (WHO-IARC, 2008).

Materials and Methods

Indoor radon is a radioactive gas that poses a significant health risk when present in high concentrations. In order to assess and mitigate this risk effectively, it is crucial to measure radon concentrations and exposure levels in various types of buildings.

This research design aims to outline a comprehensive approach to measure indoor radon concentrations and assess the exposure of occupants in buildings at Ijebu-Imushin, Ogun State, Nigeria.

Radon detector (Rn -35 model) was used in this research work to determine the indoor radon concentrations in bricks and cement buildings

- **Population of the study**

The population of this study typically includes bricks and cement buildings that are inhabited by occupants.)

Additionally, the study population includes the occupants of these buildings, such as homeowners, tenants, employees, students, patients, and visitors. The focus would be on assessing the radon exposure levels experienced by these occupants in relation to the measured radon concentrations within the buildings. Overall, the population for this study consists of bricks and cement buildings and their respective occupants, selected to provide a comprehensive understanding of indoor radon concentrations and occupant exposure levels in different settings.

- **Sample and sampling Techniques**

Sample selection and sampling techniques are crucial in research studies to ensure the representativeness and generalizability of the findings.

In the context of this study, random sampling technique was implemented. The random sampling helped to select 30 different buildings and it was ensured that each building and its occupants have an equal chance of being included in the study. This enhances the representativeness of the sample and reduces bias.

Estimation of annual effective dose

The unit of the indoor radon gas concentration value obtained with the monitor is in pCi/L. The average value of the radon is then converted to the required unit of Bqm-3. This can be done by multiplying the average value by 37.

The dose of radon in $mSv/y$is then obtained using the formula: (Akabbuogu et al., 2019).

$AE[\mathrm{mSv/yr}] = (CRn * D * F * T)$ (1)

AED [mSv/yr] represents the annual dose of radiation in millisieverts per year. CRn represents the radon concentration in Becquerels per cubic meter (Bq/m^3). D represents the duration or time of exposure in hours.

F represents a conversion factor that converts the radon concentration to a dose. It may include

T represents a factor related to the specific exposure scenario or location. By summing the product of CRn, D, F, and T over a range or set, the total annual dose of radiation in millisieverts per year was calculated. This equation suggests considering multiple exposure scenarios or locations with different radon concentrations, durations, conversion factors, and exposure factors and aggregates their contributions to the annual dose.

Results and Discussion

The results of measurement of indoor radon concentrations and health hazard Exposure to the occupants of buildings at Ijebu-Imushin area, Ogun State are given in Tables 1 and 2. In Table 1, the highest and the lowest concentrations were 0.66pCiL-1for BULD C13 and BULD C14 for cement buildings with downstairs while 0.48 for BULD C1U respectively. For Table 2, the highest concentration was 1.86pCiL-1 for BULD B16 while the lowest concentration 0.66pCiL-1for BULD B1U and BULD B2U.

By comparing Table 1 and 2, the highest concentration for buildings with cement was 0.66pCiL-1which is equivalent to the concentration for buildings with bricks 0.66pCiL-1. This shows that buildings with bricks have the highest concentration value of 1.86pCiL-1.

Table 1: Radon Gas Concentrations to occupants of cement buildings at Ijebu-Imushin

S/N	BUILDING	LATITUDE	LONGITUDE	CONCENTRATIONS ($pCiL^{-1}$)	CONCENTRATIONS (Bqm^{-3})
1.	BULD C1U	6.7923	4.0034	0.48	17.76
2.	BULD C2U	6.7871	4.0086	0.51	18.87

3.	BULD C3U	6.7872	4.0087	0.51	18.87
4.	BULD C4U	6.7853	4.0097	0.51	18.87
5.	BULD C5U	6.7889	4.0010	0.51	18.87
6.	BULD C6	6.7868	4.0092	0.57	21.09
7.	BULD C7	6.7870	4.0074	0.60	22.20
8.	BULD C8	6.8033	3.9481	0.60	22.20
9.	BULD C9	6.7869	4.0087	0.60	22.20
10.	BULD C10	6.7868	3.9286	0.63	23.31
11.	BULD C11	6.7867	4.0116	0.63	23.31
12.	BULD C12	6.7903	4.0087	0.63	23.31
13.	BULD C13	6.7872	4.0086	0.66	24.42
14.	BULD C14	6.7860	4.0095	0.66	24.42

Note: BULD C1U – BULD C5U stands for upstairs buildings with cement.

Table 2: Radon Gas Concentrations to occupants of bricks buildings At Ijebu-Imushi

S/N	**BUILDING**	**LATITUDE**	**LONGITUDE**	**CONCENTRATIONS ($pCiL^{-1}$)**	**CONCENTRATIONS (Bqm^{-3})**
1	BULD B1U	6.7886	4.0092	0.66	24.42
2	BULD B2U	6.7923	3.9304	0.66	24.42
3	BULD B3U	6.7866	4.0111	0.69	25.53
4	BULD B4U	6.7896	4.0092	0.69	25.53

5	BULD B5U	6.7933	4.0006	0.69	25.53
6	BULD B6	6.7845	4.0113	0.72	26.64
7	BULD B7	6.7861	3.9280	0.78	28.86
8	BULD B8	6.7903	4.0087	0.81	29.97
9	BULD B9	6.7891	4.0093	0.84	31.08
10	BULD B10	6.7894	4.0093	0.84	31.08
11	BULD B11	6.7883	4.0105	0.84	31.08
12	BULD B12	6.7914	4.0057	0.84	31.08
13	BULD B13	6.7869	4.0078	0.87	32.19
14	BULD B14	6.7895	4.0102	0.99	36.63
15	BULD B15	6.7905	4.0093	1.08	39.96
16	BULD B16	6.7870	4.0070	1.86	68.82

NOTE: BULD B1U – BULD B5U stands for upstairs buildings with bricks.

Conclusion

The highest radon gas concentration was1.86 pCi/L, which is well below the EPA's action level. This location is not at risk.

The lowest radon gas concentration was0.48 pCi/L, which is well below the EPA's action level. This location is not at risk from radon exposure.

By and large, the radon gas concentrations in the table are relatively low. However, there are a few locations with higher radon levels that should take steps to reduce radon levels in their homes.

The average value of 0.78pCi/L was obtained for radon gas concentrations to both occupants of bricks and cement buildings at Ijebu-Imushin). This is slightly lower than the average indoor radon. However, it is still below the EPA's action level of 4pCi/L, which is the level at which homeowners should take steps to reduce radon levels in their homes.

Recommendations

- Cracks and gaps in foundation and basement should be sealed.
- Install a radon gas mitigation system
- Ventilation should be improved at homes.

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