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An Overview of Radon Concentration in Southwestern Nigeria

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Review Article

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Abstract

Without a doubt, radon is a harmful gas that is the greatest cause of lung cancer in nonsmokers and the second biggest cause of lung cancer in smokers. However, due to a lack of knowledge and limited research, this poisonous gas has received little attention in the southwestern area of Nigeria. As a result, a few studies have been compiled with the goal of policymakers using it as a baseline for radon monitoring in the region, which may also be used as a reference for future studies.

Keywords: Radon Concentration; Southwestern Nigeria; Ground water

Introduction

Many years ago, radon gas has been considered as one of the major concern of radiation exposure. Radon is a radioactive noble gas that originates naturally in rocks, soil, and groundwater as Uranium decomposition (UNSCEAR 2006). Also Radon, can gain access to the buildings through openings in the concrete foundation walls structure, and radon gas concentration levels can rise to critical levels if building ventilation rates are inadequate. The presence of high levels of radon in a building can negatively affect residents' health. Radon, as a noble gas, is quickly released after inhalation; nevertheless, radon progeny interact with other molecules in the air, as well as dust, aerosols, or smoke particles, and readily deposit in the lungs' airways. The progenies; 218Po and 214Po emit ionizing radiation in the form of alpha particles, which can damage the cells lining the airways [1]. Radon is so paramount that it is inevitable in the human environment, due to the sources, making it to become second in concern cause of lung cancer among nonsmokers, and it is a major public health concern [2]. According to reports, radon gas in homes causes not less than 21,000 lung cancer deaths in the United States each year [3]. According to another study, radon causes roughly 1100 deaths per year in the United Kingdom [4]. Small amounts of radon gas can cause lung cancer, and there is no evidence that there is a safe limit of radon gas exposure. Many smokers will develop cancer as a result of their exposure who would not have had lung cancer otherwise. This is due to the fact that radon and cigarette smoking work together to induce lung cancer.

S/N	Study Area	Type of Sample	Radon concentration	Samples Size/ Technique Used	References
1	Ado Ekiti	Outdoor radon conc.	2.22 – 92.50 Bq/m^3 Means value: 29.57Bq/m^3 Annual effective dose to lung: 0.22 – 9.14msvy^{-1}	Track detectors (CR-39)	Oni OM, et al. [5]
2	Ado Ekiti 2	Indoor radon conc.	geometric mean: 24.70 Bq m^{-3} radon conc. 29.08 - 320.27 Bq m^{-3}	Solid State Nuclear Track Detector	Adeola AM and Ajayi IR [6]
3	Oke Ogun	Indoor radon conc. (In Soil)	3±5,25±7&212±99Bq^{-1} of 40$_k$, 232$_{th}$ & 238u respectively Radon: 148Bqm^{-3} – 627Bqm^{-3} Mean 2.82±99Bqm^{-3}	Cr – 39 detector was used. 116 rooms (samples)	Ademola AK, et al. [7]
4	Ibadan 2	Indoor radon conc. (ground water)	2.18 -76.75Bq/L Standard deviation 1.57-70.64Bq/L	Alpha Guard (11 L.G.A)	Ademola JA, et al. [8]
5	Ibadan 1	Indoor radon conc. (selected Houses)	8.76±0.01Bqm^{-3} 13.46±4.43Bqm^{-3} Overall mean value 10.45Bqm^{-3}	RAD7 (50 locations)	Usikalu, et al. [9]
6	Oduduwa University Ile-Ife Osun State)	Indoor radon conc. (In Sat)	163±895 - 16725±2332 Bqm^{-3}	RAD7	Oni EA, et al. [10]
7	Ijero Ekiti	Indoor radon conc. (Ground water)	0.168 – 78.Bq/L	RAD7 / RAD H$_2$0 40 sample (H$_2$0)	Akinnagbe DM, et al. [11]
8	Ogbomoso 1	Indoor radon conc. (around water)	0.6 – 2.62BqL^{-1} Mean value: 1.86BqL^{-1} Effective doses: 6.25×10^{-3} – 1.93×10^{-2} msvy^{-1}	RAD7 30 locations	Oni EA, et al. [10]
9	Ogun State	Indoor radon conc.	19Bqm^{-3} – 160Bqm^{-3}	RAD7& (4 locations)	Adewoyin OO [12]
10	Ogun State 2	Indoor radon conc.	1.23± 0.21 – 12.68±18.11.Bq/L	Alpha Guard Detector & Aquakit (10 location)	Fatoki OO, et al. [13]
11	Ondo State (Akoko Region)	Indoor radon conc.	12.61 – 57.50 Bq/L	Liquid scintillation (17, locations)	Oniya, et al. [14]
12	Ogbomoso 2	Indoor radon conc.	Cased radon conc: 30.39 KBqm^{-3} 65.98KBqm^{-5} uncased well radon conc: 3.30 – 33.95 KBqm^{-3}	RAD7 300 local$_2$ for both cased & uncased well	Isola GA, et al. [15]
13	Ogbomoso	Indoor radon conc.	Radium content 23.40 – 453.00 Bqkg^{-1}	RAD7 45 Samples	Lawal MK, et al. [16]
14	Lagos	Indoor radon conc. (around water)	10.8±5.18Bq/L^{-1} 30.412.04BqL^{-1}	RAD7 6 samples	Mostafa Mostafa, et al.

Table 1: Measurement of radon concentration in south/western Nigeria.

Summary of the Results

This section presents the studies conducted by different researchers in south-western Nigeria and summarized in Table 1. Adewoyin OO, et al. [12] measured radon concentration in Ogun state, Nigeria. The present study is a concern with the concentration of radon in some departments of a pharmaceutical company in Ota, Ogun State. The equipment used is Durridge RAD 7 for the indoor radon measurement. The measurement of radon concentration was captured within 8 days in 4 different departments in the main administrative building of the company (one office on the downstairs and three on the first floor). The results obtained for the four locations ranged between 19 and 160 Bqm^{-3} which is still below the world permissive limit of 200 Bqm^{-3} as recommended by the International Commission on Radiological Protection (ICRP). However, the departments on the downstairs floor is said to be high in radon-222 concentration, with a value of 160 Bqm^{-3}. Therefore, it can be concluded that, since the highest concentration of radon-222 observed in this study is below the international recommendation permissive level, then, the workers of the departments considered for this study are safe.

Another study was also cited in that same location reporting Radon-222 concentrations in groundwater from 10 local government areas (LGAs) of Ogun State were measured using AlphaGUARD radon detector and AquaKIT. The mean activity concentration of radon from 1.23 ± 0.21 to 12.68 ± 18.11 $Bq.l^{-1}$ with geometric means (GMs) of 1.22– 6.39 $Bq.l^{-1}$. The radon concentrations of all the samples were below the World Health Organization and European Commission guidance level of 100 $Bq.l^{-1}$, with 17% higher than 11.1 $Bq.l^{-1}$, recommended by the United States Environmental Protection Agency. Mean annual effective dose due to ingestion ranged from 0.020 ± 0.004 to 0.254 ± 0.353 $mSv.y^{-1}$ (adults), 0.041 ± 0.007 to 0.509 ± 0.705 $mSv.y^{-1}$ (children) and 0.024 ± 0.004 to 0.297 ± 0.411 $mSv.y^{-1}$ (infants). That of inhalation varied from 0.303 ± 0.053 to 3.108 ± 4.440 $\mu Sv.y^{-1}$. The average value of annual effective doses of some of the LGAs was high when compared with the International Commission for Radiological Protection recommended limit of effective dose of 0.1 mSv for 1-year period of consumption of drinking water.

In ADO-EKITI Solid State Nuclear Track Detectors (CR-39) were used for the measurement of outdoor 222 radon concentration in 30 locations in the township of Ado-Ekiti Nigeria, Adeola AM [6]. The annual effective dose of radon and its daughters being exposed to the residents was estimated from the results of the measurement. The concentrations of radon ranges from 2.22 to 92.50 Bq m^{-3} with an average mean of 29.57 Bq m^{-3}. The annual absorbed dose ranges from 0.09 to 3.81 mSv y^{-1} with a mean of 1.18 mSv y^{-1}. The estimated annual effective dose to the lung ranged from 0.22 to 9.14 mSv y^{-1} with a mean of 2.88 mSv y^{-1}. The values measured for Radon concentration were found to fall below the risk level of the ICRP reference level. Also, a further study was carried out by Oni EA, et al. [10] on the activity of radon concentration in groundwater from Ado-Ekiti and accessed using a well-calibrated active electronic radon detector (RAD7) manufactured by Durridge Company Inc. E.A. The study was segmented into two area; the radon concentration in well water and in borehole water. The radon concentration values in samples from Ado-Ekiti were in the range of 3.09±1.30 BqL^{-1} to 32.03±2.32 BqL^{-1} with an average value of 13.59 BqL^{-1}. The recorded value of radon concentrations are within the recommended permissive level of 4-40 BqL^{-1} recommended by United Nation Scientific Committee on the Effect of Atomic Radiation. All the radon concentration values were found to be below the recommended risk level of 100 BqL^{-1} set by the European Commission for drinking purpose. The US Environment Protection Agency has proposed that the allowed maximum contamination level (MCL) for radon concentration in water is 11 BqL^{-1} in which about 53% of samples were above the maximum contamination level. The higher value of radon concentration can be ascribed to the nature of basement rock in the study locations and also could be linked to hilly nature of the area. In ONDO STATE many study have been conducted in which three of the studies will be review. The first study is within the AKOKO region of Ondo state where radon was measured in some building of different types of building materials in Akoko region of Ondo state, Nigeria, by Adeola AM, et al. [6]. The test was conducted using Accustar alpha track long term passive test devices containing CR-39solid-state nuclear track detector foil. The detectors were exposed for six months. After removal the detectors were subsequently etched electrochemically and counted with a computer-aided image analysis system. The study show that radon concentration ranges between 15.00 Bqm^{-3} to 141.00 Bqm^{-3} with a mean of 35.54 Bqm^{-3} and geometric mean of 29.95 Bqm^{-3}. Annual exposure varied between 0.10 WLM to 0.17 WLM with a mean of 0.13 WLM, annual effective dose varied between 0.38 $mSvy^{-1}$ to 0.69 $mSvy^{-1}$ with a mean of 0.50 $mSvy^{-1}$ and lifetime fatality risk varied between $0.50x10^{-4}$ to $0.85x10^{-4}$ with a mean of $0.64x10^{-4}$ in bedroom, living room, store and lobby. This research shows that soil obtained from study area are greatly rich in radon concentrations recorded in the sample obtained. The second is also within the AKOKO region but the research work investigates radon concentration levels in ground water samples from the Akoko region of Ondo state, Nigeria and the estimation of annual effective dose due to ingestion of water from these sources. A total of seventeen groundwater (borehole and hand dug wells) samples collected from different locations within the study area were collected using standard methods. The radon concentrations in all the samples were analyzed using Liquid Scintillation

Counter (LSC). The activity concentration of radon in the water samples ranged `from 12.61 Bq/L to 57.50 Bq/L and 10.30 Bq/L to 41.89 Bq/L with mean values of 28.01Bq/L and 25.34Bq/L respectively for Boreholes and wells. The annual effective dose due to ingestion of raon from the borehole samples were found to have mean values of 0.20, 0.40 and 1.40 mSv/y for adults, children and infants respectively. For well water samples, mean values of 0.19, 0.37 and 1.29 mSv/y were found. The results of radon activity concentration were compared with the maximum contaminant level of 11.1 Bq/L set by United States Environment Protection Agency and it was observed that 94% of the samples exceeded the value. Also, all of the annual effective doses estimated were above 0.1 mSv/y set by the World Health Organisation for intake of radionuclides in water. The geology of the study area may be a factor responsible for the observed trend. It is recommended that water sources in the region should be treated before consumption.

Thirdly, another researcher Faweya EB, et al. [17] use another detector apart from the one the previous researcher make used of which is gamma-ray spectrometer to measure Dose due to radioactivity content of soil samples from sixteen waste dump sites in Ondo, the result is as follow; The weighted average value of radon emanation coefficient, mass exhalation rate, concentration in soil gas and surface exhalation rate were 10.5%, 15.2 μBq $kg\,s^{-1}$, 2.2 kBq m^{-3} and 18.8 mBq $m^{-1}s^{-1}$. The weighted mean concentrations obtained were 354 ± 53, 58±14 and 23 ± 2Bq kg^{-1} for 40K, 226Ra and 232Th respectively. Radium equivalent activity (119.11Bq kg^{-1}), Outdoor external dose (54.26 nGy h^{-1}), Indoor external dose (107.04 nGy h^{-1}), and total average annual effective dose (0.59 mSv y^{-1}) were obtained. From the measured γ-rays spectra, elemental concentrations were determined for 232Th (mean 5.8ppm), 226Ra (mean 4.8ppm) and 40K (mean 1.1 %). Thorium was lower than world average 7.4ppm by a factor of 1.3; radium was higher than the world average (2.8 ppm) by factor 1.7 while potassium was relatively equal to world average (1.3 %). The total excess lifetime cancer risk ELCR was found to be 1.95 x 10^{-3} which was slightly higher than the world average. In addition, a good correlation was found between the radium concentration and radon exhalation rate in the area. The next reported work was on Assessment of radon concentration in groundwater within Ogbomoso, SW Nigeria by Oni EA and Adagunodo TA [18]. The study is aimed at investigating the level of radon and to determine the health effect connected to radon in drinking water. A total of thirty (30) water samples were randomly investigated in Ogbomoso using an active electronic device RAD 7, produced by Durridge Company USA. The radon concentrations within the study area vary from 0.60 to 2.64 Bq L^{-1}, with the mean value of 1.86 Bq L^{-1}. The committed annual effective doses due to ingestion vary from 6.25 × 10^{-3} to 1.93 × 10^{-2} mSv y^{-1}, with mean values of 0.02 mSv y^{-1}. The radon concentrations in water samples of Ogbomoso are lower than the threshold as set by both United States Environmental and Protection Agency, and European Commission of 11 and 100 Bq L^{-1} respectively. Another similar work from the same location (Ogbomosho), the study focuses on the radon concentration in underground water samples collected across Ogbomoso land. A total of 300 water samples were collected, comprising of 160 water samples from uncased and 140 samples from cased well. The samples were analyzed using a well calibrated active electronic radon detector RAD7 (DURRIDGE Company Inc., USA). The study show that radon concentration of the uncased well is ranges from 3.30 $kBqm^{-3}$ to 33.95 $kBqm^{-3}$, while the radon concentration for the cased well fell in the range 30.39 $kBqm^{-3}$ to 65.98 $kBqm^{-3}$. The results obtained from the two categories of water samples tested, showed that the cased well sources had the highest concentration of radon compared with the risky level set by local and international bodies. Therefore, right measures should be put in place to reduce the level of concentration of radon in the water within the study area before consumption. Concerted effort should also be made by the health workers to enlighten the residence on the potential harmful effect of radon to human health. Another study was conducted by Usikalu, et al. [9] to investigate the radon concentration in selected houses in three local government areas of Ibadan. The indoor radon was measured in both mud and brick houses. Fifty houses were considered from the three Local government areas. A calibrated portable continuous radon monitor type (RAD7) manufactured by Durridge company was used for the measurement. A distance of 100 to 200 m was maintained between houses in all the locations. The living room was kept closed during the measurements. The mean radon concentration measured in Egbeda is 10.54 ±1.30 Bqm^{-3}; Lagelu is 16.90 ± 6.31 Bqm^{-3} and OnaAra is 17.95 ± 1.72 Bqm^{-3}. The average value of the annual absorbed dose and annual effective dose for the locations in the two local government areas were; 0.19 $mSvy^{-1}$ and 0.48 $mSvy^{-1}$ respectively. The radon concentration for location 10 in Ono-Ara local government exceeded the recommended limit. However, the overall average indoor radon concentration of the three local governments was found to be lower than the world average value of 40 Bqm^{-3}. Therefore, it is necessary to know the danger pose by accumulation of radon on the occupant. Also in Ibadan, another study was carried out to measure the Radon concentration in groundwater collected from the eleven Local Government Areas (LGAs) of Ibadan, Nigeria, was analyzed. Annual effective doses due to ingestion and inhalation of radon from drinking water were calculated. The arithmetic means of radon concentration for the eleven LGAs range from 2.18 to 76.75 Bq l^{-1} with a standard deviation of 1.57 and 70.64 Bq l^{-1}, respectively. The geometric means varied from 1.67 to 49.47 Bq l^{-1} with geometric standard deviation of 2.22 and 3.04, respectively. About 58% of the 84 water samples examined had a higher concentration of radon than the 11.1 Bq l^{-1} recommended by United States Environmental Protection Agency (USEPA); the Arithmetic means of six (6) LGAs and Geometric Means of three LGAs were higher than the set limit value, However the Arithmetic Means and Geometric means of all the LGAs with about 93% of the water sampled were lower than the 100 Bq l^{-1} recommended by the World Health Organization and EURATOM drinking water directive. The amount of radon in the area varies depending on the geological formation. The AMs of the annual effective dose due to ingestion of radon in water ranged from 0.036 to 1.261 mSv y^{-1}, 0.071 to 2.521 mSv y^{-1} and 0.042 to 1.471 mSv y^{-1} for adult, child and infant, respectively and the GMs in the range of 0.026 to 0.813, 0.055 to 1.625 and 0.032 to 0.948 mSv y^{-1}, respectively. The Arithmetic means of 10 LGAs and Geometric Means of 7 LGAs were high than the action level of 0.1 mSv y^{-1} from the consumption of water for the duration of one year for all the three set of people. The annual effective dose attributable to radon inhalation in drinking water varied from 0.533 to 18.82 Sv y^{-1} and 0.411 to 12.13 Sv y^{-1}, respectively, respectively, contributing less to the overall dose. Oni EA and Adagunodo TA [18] assess the radon concentration in groundwater within Ogbomoso, with a total of thirty (30) water samples were randomly investigated in Ogbomoso using an active electronic device RAD 7, produced by Durridge Company USA. The radon concentrations within the captured area vary from 0.60 to 2.64 Bq L^{-1} , with the mean value of 1.86 Bq L^{-1}. The committed annual effective doses due to ingestion vary from 6.25 × 10-3 to 1.93 × 10-2 mSv y^{-1}, with mean values of 0.02 mSv y^{-1}. The radon concentrations in water samples of Ogbomoso are lower than the risk level set by both United States Environmental and Protection Agency, and European Commission of 11 and 100 Bq L^{-1} respectively. Another study from the same ogbomoso focuses on the radon concentration in underground water samples collected across Ogbomoso land by Isola GA, et al. [15]. The detector used was alpha spectrometry technique to sniff and grab out radon gas concentration. The detector is capable of accurately measuring radon gas concentration in a water sample within 30 min making it an appropriate means of detecting radon gas having its half-life of 3.8d also eliminates the need for noxious chemicals. The radon concentration ranges from 3.30 – 60.21 $kBqm^{-3}$ and annual effective dose 0.001 - $0.013mSvy^{-1}$.

Another study to assess the radon concentration in groundwater in Ijero, Ekiti State by Akinnagbe DM, et al. [11] using the RAD7/RAD H20 driven alpha spectrometry equipment. The radon concentrations in the samples varies from 0.168 Bq/L to 78.509 Bq/L obtained from stream and borehole samples, respectively. Out of the samples, 18 had radon concentrations which is more than 11.1 Bq/L, which is the set limit. It was observed that all the samples of radon concentration are below 100 Bq/L, which is recommended by the European Union to be the upper limit value, above which remedial action is required and None of the samples had an annual effective dose higher than the maximum permissible limit of 0.2 mSv/y if consumed by children and 0.1 mSv/y if consumed by adults.

Discussion

The availability of radon concentration measured in different states in southwestern Nigeria exhibits variations that may be attributed to different geological structures and building materials from different sources. Ventilation condition and presence of nearby fault line and environmental influence. The literature shows that a complete map of radon concentration is not available for any state in southwestern Nigeria, it will be completed if the level of radon concentration is available for all radon sources. Most of the reported work is about the concentration of radon in underground water followed by soil, building materials, and lastly within the building (houses). The study is conducted across thirteen (13) locations in the southwest. In Ogun, Ogbomoso, and Ibadan report shows that no fewer than two studies were carried out because of the interest of the researcher in these aforementioned locations. Negligible data have been reported in Ogun State, and Ibadan in S/W. In most of the studies, RAD-7was used to measure the radon concentration followed by CR-39, Liquid scintillation, AlphaGUARD and AquaKIT. The reported indoor radon concentration was ranged between minimum and maximum values of $2.22Bq/m^3$ to $160Bqm/m^3$ while for selected house ranged between $8.76Bq/m^3$ to $13.46Bq/m^3$. In case of underground water the reported radon concentration was ranged from 0.6Bq/l to 76.75Bq/l. The value of radon concentration in soil varies from 3Bq/Kg – $2332Bq/m^3$. The studies conducted in south/western Nigeria shows that some factors contribute the high value of radon concentration in soil and all the sample values are below the permissible level < 2.7 PCi/L, risky level 2.7 – 4.0 PCi/L and critical threshold level >4 PCi/L [3].

Conclusion

The majority of investigations on radon concentration in south western Nigeria have been conducted in Ogun, Ogbomoso, and Ibadan, according to the reviewed and gathered data. In Ogbomoso, there have been scanty reports. However, high radon concentration has been reported in soil samples from Ogbomoso. The detector mostly used by the researcher is RAD7, because of the high accuracy within short time i.e. within 30mins, due to the half-life of radon which is 3.8days. The recommendation is that, there should be cross ventilation within the building and sealed the cracks. It is also recommended that underground water should be expose to the atmosphere in order for the radon to be diluted with air also air purifier should be installed in the building usually carbon filter. Moreso, based on the available fact, it can be concluded that there is need for more attention as a serious awareness to be created on the radon in the region. Since is the leading cause of lung cancer among nonsmoker, Area with high radon concentration needs further monitoring and this will serve as a guide for policy maker in the region.

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