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Effects of ventilation on indoor radon concentrations in offices in Ladoke Akintola University of technology ogbomoso, Nigeria

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ABSTRACT

Radon and its progenies are potential health hazards. The levels of radon concentration in homes and workplaces have been found to depend on meteorological and geological conditions, construction materials, and ventilation. The variation of radon concentration with ventilation conditions in ten offices at the campus of Ladoke Akintola University of Technology, Ogbomoso, Nigeria, has been studied in this work. The measurement of Radon-222 concentrations at each of the locations was done using an active electronic radon gas detector (pro series 3, model HS71512). The statistical variation of the five ventilation conditions with Radon-222 was determined at 0.05 level of significance, using analysis of variance. The Radon-222 concentrations for various ventilation conditions ranged from 20.0 to 51.8Bq m^{-3}. The average concentration of indoor radon in the offices was measured to be 37.0 ± 8.39 Bq m^{-3}. Natural mode of ventilation was discovered to be the most efficient way to lower the radon levels which were observed to depend significantly on the ventilation conditions. Despite the significant effect of ventilation on the indoor radon level, the radon concentration values in all the ventilation conditions investigated however were lower than the recommended intervention level of between 200 – 600 Bq m^{-3}.

Introduction

Radon gas is by far the most important source of indoor ionizing radiation as it solely contributes about 55% of the global effective dose to population(UNSCEAR,1993). Radon is ubiquitous noble gas and an indoor air pollutant in homes and workplaces (Samet & Eradze, 2000).

The concentration of radon and its decay products have been found to be higher in indoor air than the open atmosphere because of additional radon from building materials and the low rate of air exchange between indoors and outdoors. The concentration of radon and its decay products have been reported to show large temporal and local fluctuations in the indoor atmosphere due to meteorological variables (Ramachandran et al, 1990, and Singh et al, 2001). In poorly ventilated space, the radon concentration has been noticed to be able to reach level of great concern (Shakir Khan M. et al, 2008). Indoor radon level is dependent on the ventilation rate. The behavior of the radon progeny is similar to thoron progeny (Doi M., 1994). Radon and thoron in the environment come from two sources which are terrestrial and extra-terrestrial (Singh, 1998). In addition to radiation exposure which affects internal and external part of human body, internal exposure occurs through the inhalation of radon gas (UNSCEAR, 2000). When radon gas is inhaled into the lung, alpha particles emitted by short-lived decay products of radon are capable of damaging the cellular DNA. Sequel to the fact that humans spend about 80% of their time indoor, cellular mutagenesis studies, experimental research in animals, and occupational epidemiologic studies have established inhalation of radon gas as a human lung carcinogen (IARC,1988; NRC,1999).

From available literature, few researches have been carried out on investigating radon level in environmental samples, homes and offices in Nigeria. Among such are the report of Obed *et al*., 2010; Farai & Sanni, 1992. Thus, determination of indoor radon concentration level is imperative, especially in countries like Nigeria with scanty data on indoor radon and its associated health risk.

Having understood that radon concentrations in dwellings depend on meteorological and geological conditions, lifestyle, construction materials, and ventilation (Yu et al., 1998), this work which is a pioneer effort in the study area aims at determining the effect of natural and artificial ventilation conditions on indoor radon concentration at offices in Ogbomoso, Southwest, Nigeria.

Materials and Method

Measurement

In this work, an active electronic device, the safety siren pro series 3 radon detector (Model HS71512) of dimension 4.7” x 3.1” x 2.1” with an accuracy of ± 20% or 1 pCi/L was employed. Calibration of the detector is done after 12 months of use by the manufacturer. The detector was designed to be plugged into a standard household main outlet. The detector consists of an ionization chamber sensor and an automated air sampler. It has a full scale reading display ranging between 0.0 and 999.9, showing the level of radon gas in pico Curie per litre of air (pCi L^{-1}). The detector is designed to take sample for two days (48 h) before an accurate result can be displayed. Subsequently, for the same location, readings are updated every hour, if there is a change in the level of radon gas. Otherwise constant value is displayed.

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Sampling

Sampling was conducted in ten offices within Ladoke Akintola University of Technology, Ogbomoso, Nigeria, with geographical coordinate 8º 8/ 0// N and 4º 16/ 0// E. At each office, five readings were taken for each of the ventilation conditions. In limiting the source of variation in this work to the ventilation conditions alone, efforts were taken to ensure that the choice of the offices was for building of the same age (7 years), constructed from same building materials and also that the materials for the interior (paint, asbestos, carpet) were the same. Sampling was carried out at same period of the year; ruling out the contribution of season as a factor of variation. The dimension of the offices was within a floor area of 21 m^2, a gross volume of 63 m^3. The windows of the offices were usually kept closed especially after work hour, a typical practice in other offices in Nigeria.

The radon gas detector was suspended where the ventilated slot will not be blocked such that it is at least 1.2 m above the floor, a height in the breathing zone of a seated person. The detector was at least 0.9 m from windows, doors, or any other potential openings in the exterior walls. No other objects were placed within 0.1 m of the detector. These positions, which were fixed throughout this work, were maintained since radon level had been discovered to depend remarkably on the sampling position (Katase et al, 1988; Doi et al, 1994).

During the sampling period, five ventilation conditions (two natural and three artificial) which included the operation of an air conditioner, operation of an electric fan, opening/closing of windows and doors were maintained to provide different environmental conditions. These conditions are shown in Table 1. The air conditioner with the cooled temperature set to 18 ºC is a window unit with a capacity of 750 W. The electric fan was hung closed to the ceiling and operated to full capacity. When the air conditioner and the electric fan were employed for the artificial conditions, they were switched on for about 2 hrs before commencement of the measurements.

Result and Discussion

The displayed result of the radon concentration measured by the detector in pCi L^{-1} was converted to Bq m^{-3} by multiplying it by a constant value of 37 (EPA, 2003). The results of radon concentration in the offices for the five ventilation conditions are shown in Table 2. The values are average of the measurements in each office for each ventilation conditions. All the values present a minimum of 22.8 Bq m^{-3}, maximum of 50.2 Bq m^{-3} and an average of 37.04 ± 8.39 Bq m^{-3} . The values were found to be lower than the recommended upper limit of indoor radon concentration value ranging between 200 - 400 Bq m^{-3} as recommended by International Commission on Radiological Protection (ICRP, 1993) and lower than the reference level of 148 Bqm^{-3} set by USEPA for USA . This value is above the reported indoor Rn concentration for Cyprus and Kazakhstan (UNSCEAR, 2000). The radon level measured in this work is similar to that reported for Cairo, Egypt (Maged and Ashraf, 2005) between the range of 24 - 55 Bq/m^3. However, the values in this study is lower than the world average of 40 Bq/m (UNSCEAR, 2000).

The radon levels varied significantly, showing the lowest value under condition B and the highest value under condition A which signifies absence of ventilation. The radon levels were observed to be lowered by other ventilation conditions investigated.

Table 1: Definition of Ventilation Conditions

Ventilation Type	Condition	Air Conditioner	Electric Fan	Windows and Door
Natural	A	Off	Off	Closed
	B	Off	Off	Opened
Artificial	C	On	On	Closed
	D	On	Off	Closed
	E	Off	On	Closed

Table 2: Average radon concentrations (Bq m^{-3}) in offices for different ventilation conditions

Condition	OFFICE1	OFFICE2	OFFICE3	OFFICE4	OFFICE5	OFFICE6	OFFICE7	OFFICE8	OFFICE9	OFFICE10
A	47.0 ± 3.08	46.2 ± 1.05	47.7 ± 1.42	50.2± 0.47	43.7 ± 1.61	46.2± 1.05	43.6± 1.85	45.3± 0.67	45.4± 0.66	44.7 ± 1.32
B	26.9 ± 1.56	28.9 ± 1.11	27.8 ± 1.25	36.3 ± 0.66	23.7± 1.07	27.0± 0.79	23.2± 1.29	22.8± 1.45	23.0± 1.60	23.5 ± 1.48
C	34.2 ± 1.62	35.2 ±1.47	34.4 ± 1.49	37.7± 0.92	23.7± 1.07	35.2± 1.47	25.6± 1.36	33.5± 1.70	33.1± 1.77	33.5 ± 1.09
D	36.8 ± 3.70	35.8 ± 1.31	45.4 ± 0.99	36.3 ± 0.75	27.9± 1.22	35.8± 1.31	27.9± 1.22	38.0± 1.18	34.4±1.96	35.0 ± 1.17
E	46.3 ± 2.07	45.2 ± 1.24	46.6 ± 1.24	45.6 ± 0.90	43.6± 1.51	45.2± 1.24	43.4± 1.47	44.1± 1.10	44.1± 1.10	43.5 ± 0.90

Number of repeated measurement for each office per condition (n) =5

The highest reduction in radon levels was found under condition B which is a natural ventilation condition in which both windows and door were opened. This is the most practiced method except during harsh weather condition when air conditioners are used. In this case the windows are usually closed giving rise to either of the artificial conditions C, D or E. In all the artificial ventilation conditions considered in this study, the use of fan is preferable to that of air conditioner since it resulted in lower value of radon concentration level.

Furthermore, variation in the concentration of radon for different ventilation conditions was subjected to test of significance. Using the analysis of variance (ANOVA), the result of statistical analysis however showed ($p < 0.05$) that the ventilation has significant effects on the radon level.

Conclusion

In this work, ten offices were selected for detailed measurement of radon concentrations under different ventilation conditions. Five ventilation conditions (two natural and three artificial) were considered. Natural ventilation condition was observed to be the most efficient way to lower the radon levels. For all the conditions studied, the radon concentration values were however observed to be lower than the recommended action level.

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