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Assessment of Indoor Radon Concentration Levels in Offices of University of Nigeria, Enugu Campus, Nigeria

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ABSTRACT

Background: Indoor radon concentration levels are an essential component for assessing radiation exposure to populations. Indoor Radon levels have not been reported for offices of academic staff of The University of Nigeria, Enugu, which is located on a hilly rocky plain.

Purpose: To establish potential for radiation hazards to persons using offices for extended periods of time.

Materials and Methods: Four offices were randomly selected from each of the five faculties in the campus, making a total of twenty surveyed offices. Short term Electret Ion Chamber Technology (EIC) with the trade name E-PERM™ was employed for the measurement of radon concentration in the offices.

Results: Average indoor radon concentration in the offices range between 2.5 Bq m^{-3} to 21.3 Bq m^{-3} with an arithmetic mean of 11.8 Bq m^{-3}.

Conclusion: Indoor Radon levels in University of Nigeria, Enugu Campus offices is currently within acceptable safe limits.

INTRODUCTION

Radon (^{222}Rn) is a natural radioactive, colourless and odourless gas. It is a decay product of Uranium-238 (^{238}U) found in soil and rocks. ^{222}Rn is the most significant natural isotope of the radioactive element radon. Both Actinon (^{219}Rn) in ^{235}U series and thoron (^{220}Rn) in the ^{232}Th series have short half life and therefore contributes less to human exposure except where the concentration of ^{232}Th is high[1]. Exposure to ^{222}Rn due to inhalation by people living and working indoors varies depending on the local geology, building construction and household life styles. It is estimated that of the 2.4mSv annual effective dose, 1.275mSv is contributed by radon[2]. Radon has been implicated in several epidemiological studies to predispose humans to lung cancer[3, 4]. This has necessitated several studies on radon concentration throughout the world[5, 6, 7].

University of Nigeria, Enugu campus is located on a hilly rock plain and since its establishment over thirty- five years ago there has not been any study to assess indoor radon concentration either in the offices or in residential quarters. This study was therefore conducted to assess indoor radon concentration in offices of academic staff of University of Nigeria, Enugu Campus. This is because most academic staff spend long hours in their offices.

MATERIALS AND METHODS

A total of 20 offices were surveyed for indoor radon concentration. Four offices were surveyed in each of the five Faculties in the Enugu Campus of University of Nigeria. All the offices are located on the ground floor with a minimum of one glass window and a wooden door. All the offices had cement floor and were built with cement, sand and concrete walls with the exception of two offices constructed with wooden walls. The ceiling height of the offices range between 3.4m and 4.5m. Authorization was obtained and the aim of the study explained to the lecturers concerned and their consent obtained.

An Electret Passive Environmental Radon Monitor (E-PERM^{Tm}) was used for the radon monitoring. It is an integrating ionization chamber manufactured by Rad Elec Inc. Fredrick MD 21791 USA. The monitor had been applied for indoor radon concentration assessment in our locality[8]. The scientific principle of operation of E-PERM^{Tm} has been described by Kotrappa *et al*[9]. The product has been subjected to several blind testing for quality, efficiency and reliability and found to display high degree of precision[10, 11, 12] and is approved by the United States Environmental protection Agency USEPA[13].

The model of the radon monitor used for this study has been described and documented by Kotrappa *et al*[14]. It consists of three major components; the Electret, the Chamber and the Voltage Reader (Figure 1). An Electret is a charged polytetrafluoroethylene (PTFE) Teflon^{TM} disk carrying a quasi-permanent electric charge. The electret is 0.152cm thick and employed for short-term radon measurement of two to seven days (2-7days). The charge on the electret usually produces a strong electrostatic field capable of attracting ions of opposite signs thus serving as a quantitative sensor. The drop in the surface voltage after a known period of time is a measure of time integrated ionization during that time interval.

The E-PERM^{TM} Chamber is made of electrically conducting plastic with a total volume of 210ml and has an annular filter over six small holes in a recess close to the top of the chamber. The filter and the small holes ensure response to ^{222}Rn while excluding ^{220}Rn and other environmental ions. The electret with its holder is screwed to the bottom of the chamber when it is to be put to use. The top of the chamber has a spring-loaded screw cap which is closed when the E-PERM ^{TM} is not in use but opened during monitoring.

The Voltage Reader (electret surface potential voltmeter) is a portable electromechanical device which reads out the electret voltage digitally in volts. It usually displays zero before every reading. The reading is done before the electret is sent out for radon monitoring and then after the stipulated time period. It is powered by a 9V battery and holds the reading for about 4 minutes before shutting off.

Figure 1: E-PERM^{TM} Chambers in Tamper resistant box with spring loaded top open.

Two chambers containing electrets, with known initial voltages were housed in tamper resistant twin box (fig 1). With the windows and doors closed the spring loaded tops of the E-PERMS^{Tm} were unscrewed before the tamper tape was locked. Each of the offices was surveyed with the tamper resistant twin box mounted at a minimum height of 1m above the floor away from the walls. The exact time and date of installation was recorded. The E-PERMs^{Tm} was left for three days in the offices before collection (short term electrets). The spring loaded tops were screwed down to off position and the time of collection recorded. The final voltage was measured for each of the electrets. Rad-Elec's winsper software was employed to compute the mean volts for the two electrets in each twin box and also to convert the volts to ^{222}Rn concentration in Bqm^{-3}. The offices were coded x_1 to x_{20} to mask their identities.

RESULTS AND DISCUSSION

The indoor radon concentration levels in all the offices surveyed range between 2.5$\pm$ 0.66 Bqm^{-3} to 21.3Bqm^{-3}. A bar chart representing the indoor radon concentration levels in the offices surveyed is shown in figure 2. From the result indoor radon concentration level was observed to be above 15Bqm^{-3} in x_{10}, x_{11}, x_{12}, x_{14}, x_{16} and x_{19}. These offices, though not from the one faculty were observed to have their windows permanently closed. The arithmetic mean of indoor radon concentration was noted to be 11.8 Bqm^{-3}. This value is less than the mean value of 93 Bqm^{-3} reported by Synnott *et al*[15] in their survey of indoor radon concentration in Irish schools. The value is also less than 42.75 ± 9.28Bqm^{-3} reported by Rahman *et* *al*[6] in the survey of indoor radon concentration observed in schools in the Rawalpindi region of Pakistan. It is however more than the 10Bqm^{-3} reported as the world average indoor radon concentration[2]. Majority of the offices (60%) yielded radon concentrations in the range of 11 to 21Bqm^{-3} which is higher than the world average.

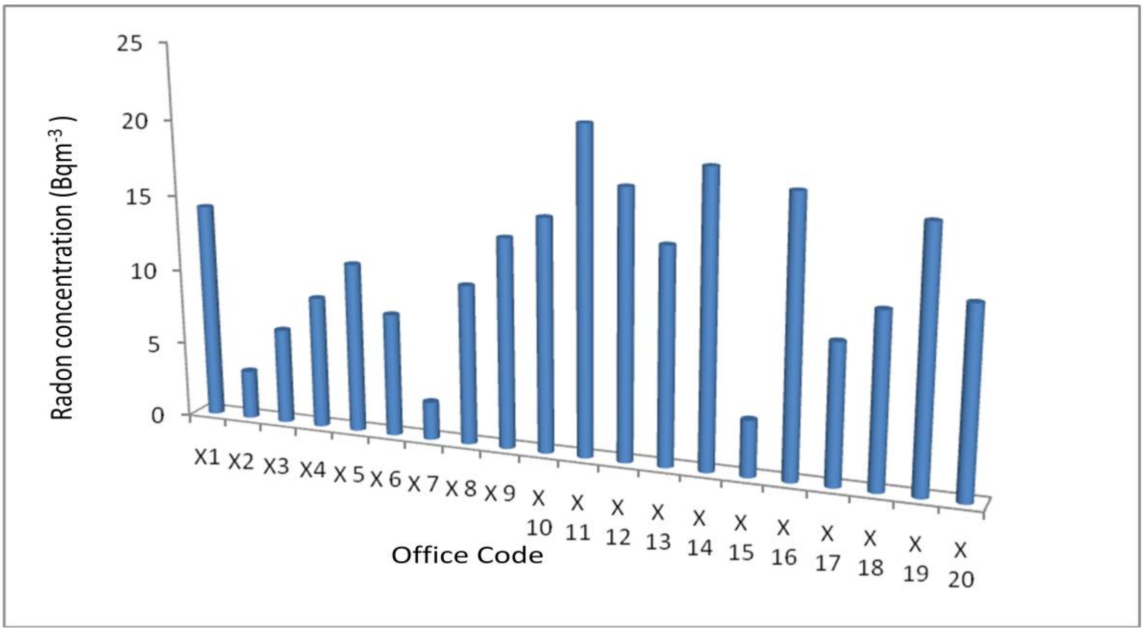

Figure 2: Bar charts showing indoor radon concentration in the surveyed offices.

The random errors associated with the E-PERM^{TM} radon monitor consist of the following; E1 associated with the electret thickness and chamber volume. This had been addressed by a study by Sun et al[12] in which several electrets were randomly selected from a pool and tested for sensitivity and reliability. Also, they introduced into randomly selected chambers a known quantity of the gas. The result revealed error margins of less than 5%. For the E2 associated with the reading of the electrets, the electret voltage reader has been found to display an accuracy of not more than 1volt over the range of 200-700 volts encountered in this study[14]. The difference between initial and final readings is required to compute the ^{222}Rn concentration. The fractional error arising between the two readings is less than 5%. The error (E3) associated with natural gamma background is assumed to be known with certainty of 10%. This therefore suggests that the readings obtained in the current study are acceptable.

The annual effective dose E was calculated using the UNSCEAR model[6]. According to the model, effective dose “E” is given as

$$E = C \times F \times H \times T \times D \qquad (1)$$

Where C is the radon concentration in (Bqm^{-3}), F is the equilibrium factor (0.4), H is the occupancy factor (0.3), T is the number of hours in a year (8760hy^{-1}) and D is the dose conversion factor (9.0 x 10^{-9} nSv Bqm^{-3}h^{-1}). The average annual effective dose in the offices was 0.11mSv. This value is below the recommended action level of 3-10mSvy^{-1} by ICRP[16].

CONCLUSION

Indoor radon concentration have been measured in 20 offices of five faculties in University of Nigeria, Enugu Campus, Nigeria, because there has not been national survey to establish radon levels in dwellings in Nigeria. It was also carried out because many lecturers spend long hours in their offices. The measured indoor radon concentration in the offices range between 2.5 to 21.3Bqm^{-3} with arithmetic mean of 11.8Bqm^{-3}. This mean value is higher than the world's average value of 10Bqm-3[2]. The mean annual effective dose due to indoor radon concentration in the offices is 0.11mSv. This is below the action level.

Appreciation

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