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Survey of Indoor Radon Levels at Several Districts in Ghana

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ABSTRACT

Indoor radon concentration measurements in some dwellings in four districts in Ghana have been monitored between 3months and 1 year using LR-115 type II Cellulose Nitrate films in the bare mode. The annual average indoor radon concentrations vary from 9.40 ±6.30 to 144±93.80 (Bqm^{-3}) in the bedrooms. Annual effective doses were calculated, using ICRP-65 conversion values, and the average annual effective dose varied from 0.25 ± 0.08 to 4.33±0.47 mSv. Radon concentration levels and annual effective doses were found to be within recommended limits.

Introduction

It has been found that radon, which is a topic of health concern, is a ubiquitous indoor air pollutant in dwellings to which all persons are exposed. [10], [19]. Radon is a naturally occurring odourless, colourless, tasteless inert gas which is imperceptible to our sense. It is produced continuously from the decay of naturally occurring radionuclide such as U-238, U-235, Th-232. The isotope Rn-222, produced from the decay of U-238, is the main source (approximately 55%) of internal radiation exposure to human life [7]. Worldwide average annual effective dose from ionizing radiation from natural sources is estimated to be 2.4 mSv, of which about 1.0 m Sv is due to radon exposure [21]. Radon being a gas can migrate by mechanism of diffusion and convection through pore spaces in the soil, fractures in the rocks and along with weak zones [23] such as shear, faults, thrust, etc. The mechanism for entry of radon from the soil gas into a house is convectional flow through cracks at soil -foundation interface, often driven by a pressure differential between the structure and the surrounding soil. [9]. The indoor radon concentration level is also influenced by its exhalation from building materials, ventilation pattern, architectural style of building, water, burning gas, etc.[12]

Over the last few decades, there has been an increased concern about the public exposure associated with the enhanced natural radiation in the environment especially radon. In Ghana many research scientists are engaged in the measurement of indoor radon levels in dwellings for health risk assessments and its control.[5][4][16],[14][15][13][17][18]. It is an established fact that radon is a carcinogen [7][6][24][22]. The residential radon is regulated by an action level of radon concentration between 100 and 300 Bqm^{-3}) based on WHO and ICRP recommendations.[8][25].

Risk assessment has been defined by the National Research Council (NRC) of USA as "the characterization of the potential adverse health effects of human exposures to environmental hazards"[11]. A reference level for radon represents the maximum accepted radon concentrations in a dwelling and is not a rigid boundary between safety and danger. It represents a level at which one should consider taking action to reduce the radon concentration. Various countries have established regulations and indoor reference levels. These regulations vary greatly between countries, in terms of both the coverage of the regulations and the actual radon levels included. In Ghana, there are no specific regulations relating indoor radon levels in either homes or workplaces, therefore the objective of this work is to bring together some national data on radon to help in the development of a national database for radon mapping needed to help identify the geographical areas where the population is at most risk of exposures above the reference levels established by WHO, ICRP and raise public awareness about the associated health risk.

Materials and Method

The houses surveyed were mostly made up of concrete. Houses surveyed were single storey houses. Each house comprises two to three rooms, each room having at least two windows. Most of the houses surveyed were partially ventilated. In order to select houses for this survey, we approached the dwellers in their district.

Analysis

In the investigations the indoor 222Rn concentration has been studied in some dwellings of Dome, Kwabenya, Prestea, Biakpa. The houses were chosen randomly. The passive method has been used to measure the level of indoor radon concentration in the dwellings. The LR-115 type 2 strippable plastic track detectors having a size of 2.5 cm x 2.5 cm in a specialized made envelope were fixed in rooms in the bare mode for a period of three months to one year to assess the variations of indoor radon concentration levels. The exposed detectors were etched in 2.5 M NaOH solution for 90 minutes in a constant temperature bath (60^{o}C). After etching the detectors were thoroughly washed in distilled water and counted using the spark counter. The track density so obtained was converted into the units of Bqm^{-3} using the calibration factor (1 tracks $cm^{-2}d^{-1}$ /Bqm^{3}). The radon concentration was calculated using the formula:

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Table 1. Maximum and minimum indoor radon concentrations of the studied area with their corresponding arithmetic mean and geometric mean in Bq/m^3

	Dome	Kwabenya	Prestea	Biakpa
GM ± SE	56.76±1.68	8.35±0.55	48.68±2.70	68.48±1.49
AM±SD	91.85±81.86	9.40±6.30	144.00±93.80	80.43±49.99
MINIMUM	5.20	7.50	0.36	31.00
MAXIMUM	336.40	34.00	909.10	194.00
ANNUAL EFFECTIVE DOSE	2.78±0.29	0.28±0.08	4.33±0.47	2.41±0.26

GM: Geometric Mean, AM: Arithmetic Mean, SE: Standard Error, SD: Standard Deviation

$$Concentration\ (kBqm^{-3}) = \frac{\rho - \rho_B}{\varepsilon\ T(hrs)} \quad (1)$$

Where ρ is the track density

ρ_B is the background track density

ε is the calibration factor $1(Tracks \bullet m^3 / cm^2 kBq \bullet h)$ of the LR-115 (Type II)

$T(hrs)$ is the exposure time in hours.

Annual Effective Dose

The annual effective dose in mSv/y at any location depends upon the occupancy factor. The indoor occupancy factor for residents was calculated using the following equation:

63hr/wk x 52wk/yr = 3276hr/yr (2)

So the residents occupancy time will be 3276hr/8760hr = 0.37≈ 0.4

The expected annual effective doses received by the residents of the surveyed area were calculated using equation (3) the UNSCEAR model [20][21]

E = CRn x H x F x D x T (3)

Where

CRn: is the radon concentration (Bq/m^3)

H: is the occupancy factor (0.4)

F: is the equilibrium factor (0.4)

T: is hours in a year (8760)

D: is the dose conversion factor (9 x10-6m Sv/h per Bq/m^3).

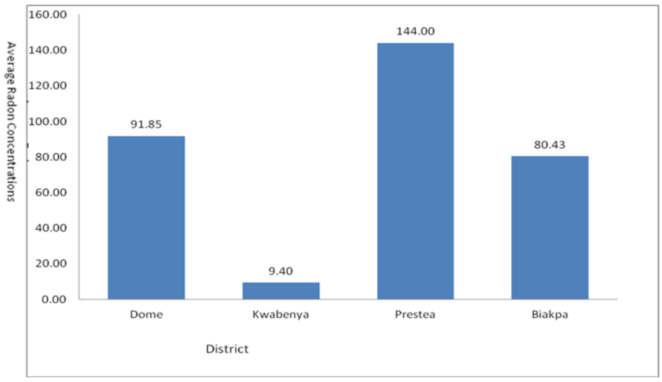

Figure 1. A graph showing the average indoor radon concentration of the various district

Results

The results obtained are as shown in table 1 and Fig. 1. The diagram shows the mean indoor radon concentration levels in the dwellings of Dome, Kwabenya, Prestea and Biakpa. As may be seen in the fig.1, the indoor radon concentration varied from district to district. Geometric mean values and their standard errors for the various districts Dome, Kwabenya, Biakpa, Prestea, were found out to be (56.76±1.68, 8.35±0.50, 68.48±1,49, 48.68±2.70) Bqm^{-3} respectively. Annual effective doses in these areas were also calculated according to ICRP 65 and the result recorded were (2.78±0.29, 0.28±0.08, 4.33±0.47, 2.41±0.26) mSv/y respectively.

Discussion

The geometric and the arithmetic mean radon concentration levels recorded in the dwellings of the four districts are given in table 1. The arithmetic mean radon concentration varied from 9.40 ±6.30 to 144±93.80 (Bqm$^{-3)}$. The maximum mean value 144.00±93.80 Bqm^{-3} is found in Prestea. The higher average value of radon in Prestea area may be due to the mining activity in the area. The dwellings of Kwabenya district showed the lowest average indoor radon concentration. Variations in the indoor radon concentration level in the various districts were mainly due to the geology of the area, the living habits of the inhabitants and ventilation methods. All the values obtained from this survey were higher than that of the world average value of 40 Bqm−3 except Kwabenya. Geometric mean, Arithmetic mean and standard errors have been calculated and are given in Table 1.

Conclusions

Indoor radon concentration levels survey has been carried out in four districts, namely, Dome, Kwabenya, Prestea and Biakpa. Although, arithmetic mean indoor radon concentration levels are above the world average radon concentration of 40 Bqm−3 [20] yet they are within acceptable limits. With historical radon survey data and recent mini surveys in the country, a preliminary radon map for Ghana will be developed to help in the identification of areas potentially prone to high radon levels.

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