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The radon factor: real or imaginary

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ABSTRACT

Worldwide data clearly indicate that radon contributes a major proportion to background radiation. Interest in radon gas and its short-lived decay daughters is real because of the possible link between sustained exposure to radon gas and the development of lung cancer. In Ghana, research data on radon concentration in various parts of the country have been obtained for more than a decade. Our recent research includes indoor radon level measurements in the district of Dome in the Dome-Kwabenya constituency. In this District, radon concentrations varying from 278Bq/m^3 to 749Bq/m^3 have been measured. These values translate to annual effective dose range of 8.42 to 22.41mSv per year. Our calculations, using the BEIR III model, lead to the prediction of a lung cancer risk of 2.03 x 10^{-5} to 4.06 x 10^{-5} for various age groups. In this Paper, we compare our recent data with previous data from our laboratory. We conclude that the radon factor in calculations of background radiation in Ghana is real. Therefore, serious effort must be made to bring all results together for the establishment of a national data base and reference level for the country.

Introduction

Uranium is present in trace amounts everywhere on earth crust being distributed in soil, water and natural gas. Radon, the ubiquitous gaseous daughter product of natural uranium series, finds its way into a place by diffusion from floor, walls and ceilings, tap water and cooking gas. Concentration of radon in a place varies according to the soil and meteorological conditions. Radon and its short-lived decay products in dwellings represent the main source of public exposure from the natural radiation contributing to nearly 50% of global effective dose to population (UNSCEAR, 1993). Lung cancer hazard from inhalation exposure to radon is due to alpha-dose deposited by short-lived radon decay products (Cross, 1984). It is now well established that indoor exposure to radon and progenies causes significant health hazard to humans. In view of the dominant part played by radon in the lifetime radiation exposure to the general public, monitoring of radon and its progeny in dwellings has become significant. In Ghana, research data on radon concentration in various parts of the country have been obtained for more than a decade. (Oppon et al., 1990, Andam et al., 2007, Asumadu-Sakyi et al., 2010, Quarshie et al.,2010, Nsiah-Akoto et al., 2011).

In the present work, radon concentrations at 20 houses selected randomly, situated in Dome Township, were monitored using solid state nuclear track detectors (SSNTD) for a period of 3months and the results obtained are reported and compared with previous results from other work done in the same study area twenty years ago the BEIR III model used to calculate the lung cancer risk of the populace. The objective of this work is to determine the annual exposure of the population to the radon and also their lifetime risk to lung cancer.

The present study area is located in the southern part of Ghana, precisely Greater Accra Region of Ghana, in the Dome-constituency. Dome was chosen for this study because previous research was done there in 1989 (Oppon et al, 1990) which gave some results that needs to be re-investigated. Also the Dome area was chosen because the houses there are representative of typical Ghanaian homes. The population in this town is about 29618. (Ghana Statiscal Service, 2000). The Dome town is situated between Latitude5°39'0"North and longitude 0°13'48"East (248m of elevation).

The houses in the area surveyed were mostly made up of sandcrete. The construction material consists of sand and cement. The houses surveyed were single storeys with three to five rooms having at most two windows. Most of the houses surveyed were partially ventilated.

Materials and method

A wide variety of well-established techniques are available for the measurement of radon, and their progeny levels either by active or passive methods (Harley, 1992). While active methods are useful for rapid estimation of concentration, passive methods are useful for long-term time integrated measurements. For the passive method, SSNTDs have been used widely, since they are less expensive, more reliable, unaffected by widely varying climatic conditions. LR-115, CN-85 and CR-39 are the normally used SSNTD for indoor radon monitoring. In the present study, LR-115 type II strippable films were used. A specially designed envelope (Figure 1) was used for keeping the films. LR-115 films of size 2.5 cm X 2.5 cm are fixed envelope and suspended in the dwellings from the ceiling at a height of 2m from the ground. The period of exposure was 90 to 95 days. After

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exposure, the films were etched in 2.5M NaOH at 60°C for 90mins. The etched tracks were then counted using a microfiche reader. From the counts and number of days of exposure, track density was calculated and from this the radon gas concentration was calculated using the already established calibration factor for LR-115 type II.

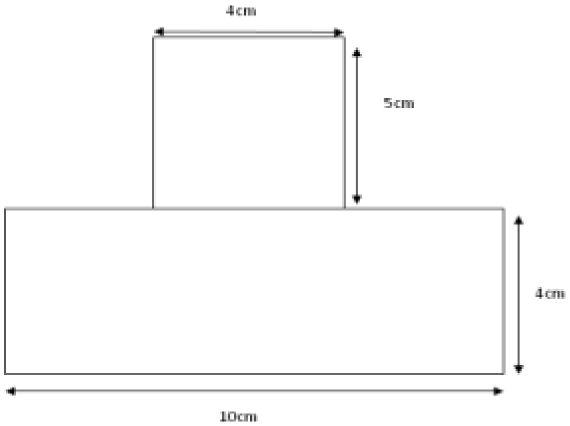

Figure 1: Outline of the specially made envelope

Results and discussion

The present survey shows that the indoor radon concentration obtained varies from (278.1 to 740.1) Bq m^{-3} with an overall mean value and standard error of (466.9 ± 1.2) Bq m^{-3} which is within the recommended ICRP action level of 200-600 Bq m^{-3} (ICRP, 1993) but higher than the Global average value of 40 Bqm^{-3} (UNSCEAR, 2000) and the WHO and ICRP recommended value for indoors (WHO, 2009 and ICRP, 2007). An annual exposure of (2.03±0.08) WLM was recorded. The annual effective dose from the corresponding measured indoor radon concentration in the different houses varied from (8.42 to 22.41) mSv y^{-1} with a mean value and standard error of (14.13± 0.22) mSv y^{-1} which is above the recommended ICRP intervention level of (3-10) $mSvy^{-1}$. (ICRP, 1993).

Comparison of the 1989 and 2009 Indoor Radon Concentration **Levels for Dome and the other previous studied areas from our laboratory**

Table 1: Studied Area, Number of Houses, Average Radon Concentration, Range and the Number of Houses with Concentrations above 200 and 400 Bqm^{-3}

The average, the range of the radon gas concentration as well as the number of houses with radon concentration above 200 and 400 Bqm^{-3} are presented in table 1. The values 200 and 400 Bqm^{-3} are the action levels proposed by the USEPA for indoor and outdoor radon gas concentrations respectively. Comparisons of the 1989 data from Dome to the 2009 data from Dome are presented in Figure 1 and 2 respectively. The results show that the indoor radon concentration levels for the year 2009 has changed considerably. The variations of the indoor radon concentration levels between the 1989 and 2009 data is mainly due to the different ventilation conditions, high temperature and high humidity which are known to contribute to the radon level indoors. The different ventilation conditions, high temperature and high humidity are due to structural changes that have taken place over the past 20 years and this can also be attributed to the other previous study areas when compared to the present study.

As indicated in figure 4, Prestea show higher activities of the indoor radon levels. The lowest indoor radon levels were observed at Kwabenya. The large variations of the indoor radon activity between the different dwellings of these towns can be explained by the different ventilation rates, nature of soil underneath and particularly the geological considerations. All the houses have radon activity in the range of the intervention level (200-600) Bq/m^3 as recommended by the ICRP 1993. In most of the studied dwellings, the annual effective dose received by the residents lies in the range of the action level (3-10) $mSvy^{-1}$ recommended by ICRP.

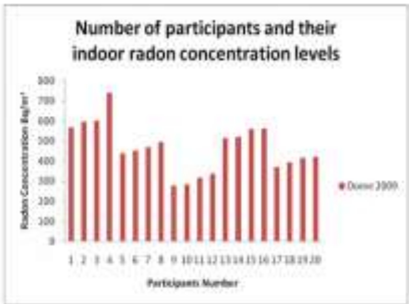

Figure 2: A bar chart showing the number of participants in the 2009 survey and their corresponding radon concentration

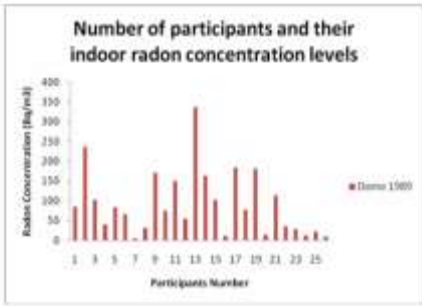

Figure 3: A bar chart showing the number of participants in 1989 survey and their corresponding indoor radon concentration

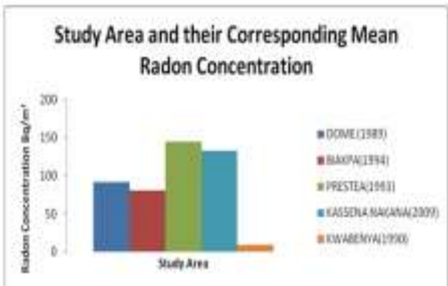

Figure 4: A bar chart showing previous study areas and their corresponding mean indoor radon concentrations

Table 2 summarizes the distribution of lung cancer cases due to indoor radon exposure between the different age groups. The population lung cancer risk due to enhanced indoor radon concentrations could only be estimated using indirect methods. This is because of the absence of quantitative epidemiological studies of the occurrence of lung cancer. The BEIR III reports suggest a latent period of 10years before the risk of getting lung cancer become effective. The results in the above table, 4.2 seem to agree with the information that the incidence of lung cancer is rare after the age of 45. (Saccomano et al., 1974).

In Dome, the population is about 29,618 (Ghana Statistical Service, 2002). Out of this 30% are between the ages 35-44, 20% are in the age range 45-44 and 10% are in the range 55-64.

Using the BEIR III model to calculate the distribution of lung cancer cases per year in Dome between the different age groups from radon exposure of 2.03 WLM per year gave a total of 5 cases per year, which means out of every 1481 persons, one person might die out of lung cancer induced by inhalation of radon indoors within their lifetime.

Conclusions

The results of the present research led to the following conclusions: the mean radon concentration for the three month period was (466.9±1.2) Bqm^{-3} with a range of (278.1-740.1) Bqm^{-3}. The mean Rn-222 annual effective dose rate of (14.13±0.22)$mSvy^{-1}$ and an annual exposure of (2.03±0.08) WLM were obtained. 14 houses had a mean radon concentration above 400 Bqm^{-3}. This indicates that the average annual indoor radon level recorded was more than the Global average value of 40 Bqm^{-3} (UNSCEAR, 2000).

Also using the BEIR III model for lung cancer risk, 5 cases of lung cancer risk per year was estimated. Considering the past survey, Kwabenya had the lowest indoor radon concentration of (9.4±0.5) Bqm^{-3} and an annual effective dose of (0.28±0.08) $mSvy^{-1}$. It was concluded that that the high radon activities in the present and past survey depend on many factors inside the dwellings:

1. Ventilation plays an important role so far as the problem is concerned
2. The soil underneath the dwelling and the type of building materials also contribute to the high radon activity in the rooms
3. High temperature, humidity and living habits of the inhabitants were also a factor

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Table 1: Studied Area, Number of Houses, Average Radon Concentration, Range and the Number of Houses with Concentrations above 200 and 400 Bqm^{-3}

Area	Number of houses	Average radon Concentration Bqm^{-3}	Range Bqm^{-3}
Dome(2009)	20	466.9	278.1-740.1
Dome(1989)	26	91.8	5.2 - 336.4
Kwabenya	20	9.4	5-34
Biakpa	14	80.4	31 - 194
Prestea	39	118.9	0.4-909.1
Kassena -Nakana	45	132.7	35.3-244.2

Table 2: Distribution of Lung Cancer Cases Due to Indoor Radon Exposure between Different Age Groups for the Dome Township for the year 2009

Age Group	Effective Exposure Duration	Effective Rn Exposure	Lung Cancer Risk Per Year x10-5	Population ($x10^4$)	Cases Per Year
35-44	29.5	2.03	2.03	0.8885	2
45-54	39.5	2.03	4.06	0.5924	2
55-64	49.5	2.03	4.06	0.2962	1