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The Radon Health Hazards Education in Ghana

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ABSTRACT

Radiation and radioactive isotopes constitute a natural part of our environment. High concentrations of these radioactive isotopes in the environment can be a threat to our health. The largest fraction of the natural radiation we receive comes from the radioactive gas radon, which disintegrates by emitting alpha particles. Although it cannot be detected by human senses, radon and its radioactive by-products are a health concern because they can cause lung cancer when inhaled over many years. Radon is present everywhere in the rock, soil, water and air because of the ubiquitous nature of its parent radioactive element uranium in geological terrain. In this paper, we highlight the need for measurement of radon in the environment, and the possible health hazards due to radon gas, especially from building materials and water in Ghana. We present preliminary results from our recent work and suggest remedial measures to avoid high intake of radon. In the preliminary results, using the BEIR III model to calculate the distribution of lung cancer cases per year in Dome in 2009 between the different age groups from radon exposure of 2.03 WLM per year gave a total of 5 cases per year.

Introduction

Radon belongs to the noble gas series in the periodic table. There are three natural isotopes of radon namely, radon (222Rn), thoron (220Rn) and actinon (219Rn) resulting from the radioactive decay of the uranium, thorium and the actinium series. 222Rn is formed from the decay of 226Ra, the immediate parent from the 238U series, while its isotope 220Rn decays from 224Ra, a member of the 232Th series. Actinon results from the decay of 223Ra from 235U series and is normally neglected because its presence is negligible in the atmosphere. Radon being a gaseous element in the natural radioactive series gets diffused into the atmosphere from the earth's crust.

The major source of radon in the atmosphere (at least 80%) is from emanations from soil and from rock formations close to the ground surface. Radon emitted into the atmosphere originates from the top layer of the soil. Sources of global atmospheric radon are presented in Table 1.(Ludin et al, 1971) Recent advances in the application of soil-gas survey, related to structural geology have shown the potential of radon measurements in soil gas for studying fault activity and seismic hazard (Amponsah et al., 2008; Ciotoli et al., 2007; Ciotoli et al., 1998). Soil gas infiltration is recognized as the most important source of residential radon. Other sources, including building materials and water from wells, are of less importance in most circumstances. The presence of radon in the free atmosphere was first noted by Elster and Geitael (Elster, 1901) and Gish, (1951) around 1901. Radon is a major contributor to the ionizing radiation dose received by the general population.

Recent studies on indoor radon and lung cancer in Europe, North America and Asia provide strong evidence that radon causes a substantial number of lung cancers in the general population. Current estimates of the proportion of lung cancers attributable to radon range from 3 to 14%, depending on the average radon concentration in the country concerned and the calculation methods.

Table 1 Source of Global Atmospheric Radon (Ludin et al., 1971)

Source	(Million Ci per year)	(Becquerel/annum)
Emanation from soil	2000	7.4E+13
Ground water (potential)	500	1.85E+13
Emanation from oceans	30	1.11E+12
Phosphate residues	3	1.11E+11
Uranium mill tailings	2	7.4E+9

The latest report on World Health Organization (WHO) on the biological effects of alpha radiation, BEIR VI, estimates the radiation dose due to the exposure of radon to be 0.025 $mSvy^{-1}$ per Bqm^{-3}(WHO, 2009). This is equivalent to a probability of lung cancer of approximately 2 x 10^{-6} per Bqm^{-3} per year per person. The analyses indicate that the lung cancer risk increases proportionally with increasing radon exposure. A national reference level for radon represents the maximum accepted radon concentration in a residential dwelling and is an important component of a national programme. For homes with radon concentrations above these levels, remedial actions may be recommended or required. In view of the latest scientific data, WHO proposes a reference level of 100 Bqm^{-3} to minimize health hazards due to indoor radon exposure, however, if this level cannot be reached under the prevailing country-specific conditions, the chosen reference level should not exceed 300 Bqm^{-3} which represents approximately 10 mSv per year according to recent calculations by the International Commission on Radiation Protection.

Until the late 1970s, radon and its progenies were regarded as radiation health hazards only encountered in the mining and milling of uranium .This dramatically changed as a result of widespread indoor measurements of radon in parts of the world.

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Attention to the problem of radon exposure and the associated health risks has thus been growing around the world (BEIR VI, 1999, WHO, 2009). Nowadays radon and its progeny are known to be carcinogenic especially in high radon concentration areas such as mines, caves, cellars, ancient tombs and energy conserved air tight houses. There is a consensus among several organizations, including International Commission on Radiological Protection (ICRP), International Agency for Research on Cancer (IARC), World Health Organization (WHO), United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), National Radiological Protection Bodies of Germany, the Nordic countries, USA and UK, that there is a strong link between exposure to radon and the occurrence of lung cancer. Based on the scientific information and cohort studies, ICRP and WHO recommends the need to limit the exposure due to radon and its daughter products.

When an individual is exposed to radon and its progenies, the part of the body that receives the highest dose of ionizing radiation is the bronchial epithelium, although the extra thoracic airways and the skin may also receive appreciable doses. In addition, other organs, including the kidney and bone marrow, may receive low doses. Radon is soluble in water and its solubility decreases rapidly with increasing temperature [(510, 230, 169 cm3/kg at 0°C, 20°C and 30°C respectively), (NCRP Report #97,1988)]. Radon is extremely volatile and is readily released from water. If an individual drinks water in which radon is dissolved, various organs of the stomach might also be exposed. Of late, more scientific research work is geared-up in many countries to find out whether there is any correlation of stomach cancer vis-à-vis the radon exposures due to ingestion. Below are the estimates of the proportion of lung cancer attributable to radon in selected countries (Table 2).(WHO) and estimates of the preliminary results of the proportion of lung cancer attributable to radon in Dome township in 2009,Table 3 (Nsiah-Akoto , 2010). Other countries, Ghana inclusive are still continuing their studies and yet to report their values. As per WHO 2009 report, the worldwide average indoor radon concentration has been estimated at 39 Bqm^{-3}.Various countries have established regulations and indoor reference levels. These regulations vary greatly between countries. Some of the countries and their action levels are:

- The European Union (EU) accepts the recommended action levels included in the ICRP-65 of between 500 and 1500 Bqm-^{3} (ICRP, 1993).
- The USA uses a reference level of 148 Bqm-^{3} for dwellings and a level of 400 Bqm^{-3} for workplaces (USEPA, 2004).
- In the UK the Health and Safety Executive (HSE) (Kavasi et al., 2006), has adopted a radon action level of 400 Bqm^{3} for workplaces (Kendall et al., 2005).
- The action level for workplaces in Hungary is 1000 Bqm-^{3}. (Kavasi et al., 2006).
- Israel uses a mandatory reference level of 200 Bqm^{-3} for existing schools and day care centers (Akerblom, 1999).
- The new reference level above which an action should be taken is now 100Bqm-^{3}. (WHO, 2009).

In Ghana, there are no specific regulations relating indoor radon levels in either homes or workplaces, therefore a national radon map is needed to help identify the geographical areas where the population is at most risk of exposures above the reference levels established by WHO and raise public awareness about the associated health risk of radon.

Table 2 : Estimates of the proportion of lung cancer attributable to radon in selected countries

Country	Mean indoor Rn (Bqm^{-3})	% of lung cancer attributed to radon	Estimated deaths due to radon induced cancer
Canada	28	7.8	1400
Germany	49	5	1896
Switzerland	78	8.3	231
UK	21	3.3	1089
France	89	5	1234
USA	46	10-14	15400-21800

Table 3: Distribution of Lung Cancer Cases Due to Indoor Radon Exposure between Different Age Groups for the Dome Township in 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

Radon Measurements

There are several techniques that have been used for radon measurements .These techniques include scintillation cells, ionization chambers, solid state nuclear track detectors (SSNTDs) , solid state surface barrier detectors, thermo luminescent dosimeters, electret ion chamber , and electrostatic precipitation technique (Durrani et al., 1997). Most of the time in national survey programs for monitoring environmental radon levels, the techniques normally make use of SSNTDs (CR-39 and LR-115) because they are versatile, simple in handling and processing, low cost and in-sensitive to beta and gamma radiation. During recent years, numerous papers have appeared in literature demonstrating the ever interest in monitoring radon in the indoor environments in Ghana (Nsiah-Akoto et al.,2011, Asumadu –Sakyi et al.,2010, Oppon et al.,1990, Andam et al.,2007, Quashie et al.2010).

Remedial Measures

In buildings, where indoor-radon activity concentrations have been identified as exceeding the action level, it is prudent to implement remedial measures. The most obvious remedy is to increase the ventilation of the home / building which allows the radon to escape. Another method is to prevent the entry of radon into a building after taking into account the economic feasibility, but it poses major difficulty in determining how the gas enters the building. The mitigation technique that should be adopted is dependent on, for example, (i) whether it is a new or existing building, (ii) building construction details, (iii) the requirement of magnitude of the reduction in indoor radon activity concentrations and, (iv)the associated costs. Some of the recommended mitigation techniques are pumping of radon from underground to outside and sealing the floors

Materials and Methods

Indoor radon concentration were studied in various houses in the Dome environ. The houses were carefully chosen so that the construction and operation do not vary significantly. The dwellings under study were built, in general, using cement, sand, and stones as the construction materials. Several of these materials are expected to contribute significantly as sources of indoor radon. Most of the houses in the study area are poorly ventilated. The passive methods using the SSNTDs which are sensitive to alpha particles emitted by radon were utilized. Cellulose nitrate LR- 115 type II (strippable) alpha particle detectors with a thickness of 13 μm on a 100 μm polycarbonate backing and produced by Kodak Pathé of France were used. On the average, about 40 LR-115 Type II detectors were distributed to the houses at Dome, in the Ga-East District of Accra. These houses were chosen to be representative of typical Ghanaian homes. In each house, at least two detectors were placed in different bedrooms at a height of about 3m above the floor with the help of a masking tape. The exposure time in all houses was from December 2009 to March 2010.

Results

Table 3 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 table 3 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

Table 3: Distribution of Lung Cancer Cases Due to Indoor Radon Exposure between Different Age Groups for the Dome Township in 2009/2010

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Conclusions

The total radiation dose to the population, from naturally occurring radioactive material (NORM) is contributed due to intake of radon isotopes and their progeny is 50%. Due to the intake of radon gas, the radioactive radon progeny species are deposited in the respiratory organs and hence the lung organ receives almost the entire dose. There is a consensus among internationally reputed scientific organizations which include, ICRP, that there is a strong link between exposure to radon and the occurrence of lung cancer and hence recommended that there is a need to limit the exposure due to radon and its daughters.

In spite of this, it is considered necessary to have more monitoring programs to measure radon content in air, indoors and ground water, taking into account the new scientific findings.

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