

Estimation of Lifetime Fatality Risk from Indoor Radon in Some Offices in a Nigerian University

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Abstract: This study aims at estimating the lifetime cancer risk from the determination of ²²²Rn concentration level in some offices in Ogbomoso, Southwestern Nigeria. The measurement of the indoor ²²²Rn concentration levels at some offices in Ladoke Akintola University of Technology (LAUTECH) Ogbomoso, Nigeria was carried out using an active electronic radon gas detector, safety Pro3 (model HS71512) between February and July 2011. The result of the measurement showed that the average radon concentration is $26.3 \pm 4.17 \text{ Bq/m}^3$. This value translated to an annual effective dose of 0.13 mSv/y and lifetime fatality risk of 9.94×10^{-6} . These values which were found to be higher than values reported for some countries were however lower than the world average value and below the recommended action level. Thus, the results of this work have shown that the exposure to indoor radon at the offices considered is of low risk of fatal cancer occurrence due to radon inhalation.

Key words: Active radon gas detector, cancer risk, LAUTECH, radon inhalation

INTRODUCTION

Radon has long been recognized as a cause of lung cancer and it was identified as a human lung carcinogen (WHO, 2009; IARC, 1988). The main source of information on risk of radon-induced lung cancer has been epidemiological studies of underground miners (ICRP, 1993). Recent studies have also provided informative data on risks at lower levels of exposure (Lubin and Boice, 1997; NRC, 1999; EPA, 2004).

In addition, recent combined analyses of data from case-control studies of lung cancer and residential radon exposures have demonstrated raised risks (Lubin and Boice, 1997; Bochicchio *et al.*, 1998; Field *et al.*, 2000). Radon and its decay products get trapped in the tracheobronchial system during inhalation, thereby irradiating the bronchial tissues and therefore constitutes a significant radiation hazard to human lungs and occurrence of lung cancer (Yu *et al.*, 2000). For this reason, all exposure should be kept below recognized standards to the general public and unnecessary exposure should be minimized.

The radioisotope ²²²Rn which is a naturally occurring odourless, colourless, tasteless inert gas, produced from the decay of U-238, is the main source (approximately 55%) of internal radiation exposure to man (ICRP, 1993). An average value of 2.4 mSv has been estimated as the worldwide annual effective dose from ionizing radiation from natural sources. Of this value, 1 mSv is due to radon exposure (UNSCEAR, 2000).

Various researchers have reported that exposure to high level of environmental radioactive pollutant at the workplace and public sector are important risk factor for lung cancer in workers (Bochicchio *et al.*, 1998; Field *et al.*, 2000). It was estimated (WHO, 2009; EPA, 2004) that about 14% of the 164,000 lung cancer deaths in the United States each year are attributable to exposure to radon-correlating to approximately 15,000 to 22,000 lung cancer deaths each year. About 160 of these deaths have been attributed to radon dissolution exposure in ingested water, and approximately 700 deaths are from exposure to outdoor air (mostly exposure from mines). The majority of the radon-caused deaths occur from inhalation of radon and radon progeny.

These reported cases, among others, are however from parts of the world with more time spent indoors than in Africa where due to the climate, time spent indoors are less. For Africa and other continents with similar climate, records and data on health-related effects of radon inhalation and ingestion is very scanty. This work hitherto aims at providing information on the radon concentration level and lung cancer risk due to ²²²Rn inhalation in offices in Nigeria.

MATERIALS AND METHODS

Measurement: This study employed the use of an active electronic device (Pro3 radon gas detector, model HS71512) for the measurement of indoor ²²²Rn in some offices at the Ladoke Akintola University of Technology,

Table 1: Values of indoor radon concentration, effective dose and fatality risk (February to July 2011)

Office identity	Radon concentration (Bq/m ³)			Annual exposure WLM, MJ.h/m ³		Annual effective dose (mSv)	Lifetime fatality risk (×10 ⁻⁵)
	Range		Annual mean value	Annual exposure			
	Min	Max		(×10 ⁻²)	(×10 ⁻¹)		
OF1	25.9	26.6	26.86 (1.560)	3.4	1.2	0.13	1.02
OF2	25.8	27.7	28.90 (1.105)	3.6	1.3	0.14	1.09
OF3	26.7	30.2	27.80 (1.254)	3.5	1.2	0.14	1.05
OF4	35.3	37.1	36.28 (0.662)	4.6	1.6	0.18	1.37
OF5	23.3	25.0	23.72 (1.072)	3.0	1.1	0.12	0.89
OF6	25.8	28.0	27.00 (0.787)	3.4	1.2	0.13	1.02
OF7	21.5	24.7	23.24 (1.292)	2.9	1.0	0.11	0.88
OF8	20.0	24.1	22.80 (1.455)	2.9	1.0	0.11	0.86
OF9	20.3	24.6	22.98 (1.603)	2.9	1.0	0.11	0.87
OF10	21.6	25.9	23.48 (1.482)	2.9	1.0	0.11	0.87

Values in parentheses are the standard deviations

Table 2: National and international environmental values for ²²²Rn concentration indoors and recommended upper limits

Environmental values	²²² Ra concentration (Bq/m ³)
National and international	
El-Minia City, Egypt	123
Cairo, Egypt	24-55
Belgium	48
Czech Republic	140
Cyprus	7
Finland	120
Kazakhstan	10
Poland	41
Romania	45
United States	46
Upper limit	
EPA	148
ICRP	200-400
Sweden	400
CNSC occupational	148
Exposure	70
CNSC public exposure	600-1000
Threshold range	

El-Gamal and Hosny (2008); EPA: US Environmental Protection Agency; ICRP: International Commission on Radiological Protection; CNSC: Canadian Nuclear Safety Commission

Ogbomoso, Nigeria, situated on latitude 8°8'0" North and longitude 4°16'0" East. The detector has a dimension 4.7×3.1×2.1 inches and an accuracy of ±20% or 1 pCi per litre. The detector consists of an ionization chamber with sensor. 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. However, the displayed readings in pCi/L by the detector were converted to Bq/m³ by multiplying the value by 37.

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. New values of the indoor radon concentration are displayed if the level of the radon differs from the stored value, previously determined from the 48 h sampling.

Sampling: The study took place at the campus of Ladoke Akintola University of Technology, Ogbomoso (coordinate 8°8'0" N and 4°16'0" E), Nigeria. Sampling

was conducted in ten offices of the same building materials, dimension and age. The study took place from February to July, 2011. The dimension of the offices was within a floor area of 21 m², a gross volume of 63 m³ and a net volume of about 56.38 m³ (obtained by subtracting the volume of fixtures). The windows of the offices were usually kept closed especially after work hour, a typical practice in other workplaces in Nigeria. However, natural ventilation condition involving opening of windows and doors were employed throughout the period of measurement.

The radon gas detector was suspended where the ventilation slits will not be blocked and 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.*, 1998; Doi *et al.*, 1994).

RESULTS AND DISCUSSION

The results of the study for the radon concentration recorded for the period February to July, 2011 are summarized in Table 1. The concentration of ²²²Rn in the offices ranged between 20.0 and 30.3 Bq/m³. The values are below the range of the intervention level of 200-600 Bq/m³ as recommended by International Commission on Radiological Protection (ICRP, 1993).

The overall average of the concentration of the indoor ²²²Rn in the offices measured in the University was 26.3±4.17 Bq/m³. This value is above the reported indoor ²²²Rn concentration for Cyprus and Kazakhstan (UNSCEAR, 2000). The radon level measured in this work is between the range of 24 and 55 Bq/m³ reported for Cairo, Egypt (Maged and Ashraf, 2005). However, the values in this study is lower than the world average of 40 Bq/m³ (UNSCEAR, 2000) and for values of indoor radon level in most countries as shown in Table 2.

The annual effective dose received by the occupants of the offices for the using the assumed recommended value of 2000 hours per year at work and an equilibrium factor of 0.4 (IAEA, 2003) was found to vary from 0.11 to 0.18 mSv, which are below the range of action level (3-10 mSv/y) recommended by ICRP. The lifetime fatality risks estimated by this work were found to range between 0.86×10^{-5} and 1.09×10^{-5} . This measurement thus indicated that the lung cancer fatality risk due to indoor radon from offices of the University is very low.

CONCLUSION

The indoor ^{222}Rn concentration level have been measured in some offices at the campus of Ladoko Akintola University of Technology, Ogbomoso, Nigeria. The most applied natural ventilation condition involving opening of doors and windows during office hours was employed throughout the period of the measurement spanning six consecutive months. The measured radon concentration level with value below the world average translated to the estimation of radon exposure and annual effective dose which values corresponded to low fatality risk of cancer cases among occupants of the offices.

REFERENCES

- Bohicchio, F., F. Forastiere, D. Abeni and E. Rapiti, 1998. Epidemiologic studies on lung cancer and residential exposure to radon in Italy and other countries. *Radiat Prot Dosimetry*, 78(1): 33-38.
- Doi, M., K. Fujimoto, S. Kobayashi and H. Yonehara, 1994. Partial distribution of Thoron and Radon concentration in the indoor air of a traditional Japanese wooden house. *Health Physics*, 66: 43-49.
- El-Gamal, A. and G. Hosny, 2008. Assessment of lung cancer risk due to exposure to radon from coastal sediments. *Eastern Mediterranean Health J.*, 14(6): 1257-1269.
- Environmental Protection Agency (EPA), 2004. Assessment of Risks from Radon in homes Office of Radiation and Indoor Air. US Environmental Protection Agency.
- Field, R.W., D.J. Steck, B.J. Smith, C.P. Brus, J.S. Neuberger, E.F. Fisher, C.E. Platz, R.A. Robinson, R.F. Woolson and C.F. Lynch, 2000. Residential gas exposure and lung cancer: The Iowa radon lung cancer study. *Am. J. Epidemiol.*, 151(11): 1091-1102.
- International Atomic Energy Agency (IAEA), 2003. Safety reports series No. 33: Radiation protection against radon in workplaces other than mines. Vienna.
- International Agency for Research on Cancer (IARC), 1988. Man-made Fibres and Radon. Lyon, France: IARC Press; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, 43.
- ICRP, 1993. Publication 65, Protection against Radon-222 at home and at work, *Annals of the ICRP*, Oxford, U.K., Pergamon, 123(2): pp.
- Katase, A., Y. Metsumoto, T. Sakae and K. Ishibashi, 1998. Indoor Concentration of Rn-220 and its Decay Products. *Health Phys.*, 54: 283-286.
- Lubin, J.A. and J.D. Boice, 1997. Lung cancer risk from residential radon: Meta analysis of eight epidemiological studies. *J. Nat. Cancer Inst.*, 89(1): 49-57.
- Maged, A.F. and F.A. Ashraf, 2005. Radon exhalation rate of some building materials used in Egypt. *Environ. Geochem. Health*, 27(5-6): 485-489.
- National Research Council (NRC), 1999. Committee on the Health Risks of Exposure to Radon (BEIR VI). Health Effects of Exposure to Radon. Committee on the Biological Effects of Ionizing Radiations, Board of Radiation Effects Research, Committee on Life Sciences, National Research Council. National Academy Press, Washington, DC.
- UNSCEAR, 2000. Sources and Effects of Ionizing Radiations. United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes. Vol. 2, Effects. United Nations Sales Publication, New York.
- World Health Organization (WHO), 2009. WHO Handbook on Indoor Radon. A Public Health Perspective. WHO Press, Switzerland.
- Yu, K.N., T. Cheung, E.C.M. Young, W.N. Mui and K.K. Tang, 2000. The effects of covering materials on indoor Rn concentrations in offices in Hong Kong. *J. Environ. Radioactiv.*, 47: 183-188.