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The Effects of Internal Wall Covering Materials on Hazards of Indoor Radon Concentrations in Houses of Iran

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Abstract

Background: Radon gas emanating from underground can concentrate indoor and reach levels, which represent a risk to people's health. According to WHO (World Health Organization) and EPA (Environmental Protection Agency), radon is the second leading cause of lung cancer in the world. Due to the direct correlation of lung cancer and radon exposure, it is ideal to evaluate the hazards of radon accumulation in the Iran dwellings with different materials by direct measurement of the radon concentrations using accurate, simple and fast method. The aim of this study was to measure variation of radon concentrations with different covering materials on internal building surfaces including walls, which are used in Iran dwellings.

Methods: A special chamber with changeable walls of different covering materials (gypsum, wallpaper, oil dye, plastic dye, wood board, and Belka) was made. Radioactive lantern mantles were used for elevating the radon (^{220}Rn) levels in the chamber artificially. Ventilation in the chamber had been such way that accumulation of radon could be possible. Active measurement by Prassi portable radon gas surveyor was performed for staging purposes.

Results: The average radon concentration for wood and plastic dye was 869.0±66.7 and 936.8±60.6 (bq/m³), respectively, while that for wallpaper and gypsum was 449.2±101.7, 590.9±49.0 (bq/m³), significantly lower than other covers. The average radon concentration for oil dye and Belka cover was 668.3±42.3, 697.2±136.7 (bq/m³), respectively.

Conclusion: Individuals living in a house with internal wall covering materials of gypsum and wallpaper receive an average annual dose smaller than one living in a house with internal wall covering materials of wood board and plastic dye. Using wallpaper and gypsum as an internal cover for the dwellings suggested.

Keywords: Internal wall covering material; Hazard; Indoor; Radon; House; Iran

Introduction

According to WHO (World Health Organization) and EPA (Environmental Protection Agency), radon is the second leading cause of lung cancer in the world. Radon gas emanating from underground is the immediate decay product of Radium (^{226}Ra and ^{224}Ra), deriving from the uranium series of natural radionuclides and thorium. Radon is a noble gas and decays to isotopes of solid elements, the atoms of which attach themselves to the dust particles present in air. The origin of radon in the atmosphere is due to the presence of uranium and thorium in the rocks and soil of the Earth's surface.[1,2]

Short-lived decay products of radon are the most important contributors to human exposure to ionizing radiation from natural sources. This contribution represents 50% of the total annular human dose.[3] This significant level of radon radiation implies the need to control it in the workplace and/or housing. The attributable risk of radon inhalation could be estimated from the excess lung cancer rate observed among radon exposed miners and among the atomic bomb survivors.[4]

Indoor radon concentrations depend on many factors such as building materials, indoor-outdoor temperatures,

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relative humidity, airflow and ventilation rate as well as geological formations. It is important to evaluate the role and contribution of the different dwelling materials that can act as radon sources or radon absorber inside buildings for work and residence.

A common classification of materials based on the potential risk to radon exposure must be established based on the internal wall covering materials in Iran. The health risks of indoor elevated levels of radon have been well documented in many studies worldwide.[4-9] Previously, the radon variations in dwellings around the hot springs in Iran, Namin and Sar-Ein were measured using the passive method with poly carbonate films during the winter season.[10] The measurements showed that the radon levels in a majority of dwellings were exceeded the ICRP recommendation value for future homes.[4] Based on a recent study, lung and bronchus cancer are the third occurring fatal cancers in Ardabil.[11] A report published by the Ministry of Health and Medical Education of Iran found gastric and lung cancer are the most common terminal cancers in Iran, and their prevalence are highest in the Ardabil province.[12] Different studies by local and Tehran medical research centers have verified these findings.[13-15] However most previous studies have focused on radon measurement in the real dwellings with different building materials, which is a costly and very complex process.[2,10,16-18]

Due to the direct correlation of lung cancer and radon exposure it is ideal to evaluate the hazards of radon accumulation in the dwellings with different materials by direct measurement of the radon concentrations by using accurate, simple and fast method. The aim of this study was to measure radon concentration in a special chamber with different changeable walls, which simulate real dwellings in Iran with different covering materials on internal building surfaces. According to best of our knowledge, this is the first survey of radon in a simulated condition using common wall covering materials in Iran with active method.

Materials and Methods

Radon surveys were carried out in a special cubic chamber (30×30×40cm) with different changeable walls. The walls had different covering materials on the internal surfaces. Six sets of walls with the most common materials in Iran including gypsum, wallpaper, oil dye, plastic dye, wood, and Belka (kind of cover with special glue and resin) were prepared. The chamber artificially elevated levels of ^{220}Rn. Radioactive lantern mantles were used for elevating the radon levels in the chamber. Measurements were performed for each set of the walls with Prassi portable radon gas surveyor (Tabesh Research Center, Shiraz University, Shiraz, Iran). All experiments were performed comparing the surveys of different wall sets.

To avoid the variability inherent to the assay used, all measurements were performed for five independent experiments. Mean values and standard deviations (SD) were calculated, and any statistical significance of the differences between sets was evaluated. A computer program (SPSS software, ver.10.0, Chicago, IL, USA) was used for statistical analysis. Data were analyzed by Mann-Whitney U test following bonferroni correction. All hypotheses tested used a criterion level of p=0.05.

Results

Table 1 illustrates the average±SD of radon concentration for each set of wall covering materials. The average radon concentration for wood and plastic dye was much higher than wallpaper and gypsum. The wallpaper cover had significantly lower radon concentrations relative to wood (p=0.008), plastic dye (p=0.008), oil dye (p=0.014) and Belka (p=0.028). While wood board had the highest levels of radon concentrations relative to gypsum (p=0.008), wall paper (p=0.008), oil dye (p=0.008). There was no significant statistical differences between wood and Belka (p=0.077), also, wood and plastic dye (p=0.119). The measurements showed that dwellings with gypsum and wallpaper in their internal surfaces has the least hazards of lung cancer from radon accumulation as opposed to wood and plastic dye (p=0.05).

Table 1: Radon concentrations for each set of wall covering materials

Cover	Radon concentration Average±SD (Bq/m^3)
Wall paper	449.2±101.7
Gypsum	590.9±49.0
Oil dye	668.3±42.3
Belka	697.2±136.7
Wood	869.0±66.7
Plastic dye	936.8±60.6

Discussion

Active measurements of the radon concentrations in a simulated condition were performed with different common wall covering materials in Iran. It can be explained that radon concentration has direct correlation with lung cancer probability and the risk of lung cancer analysis indicates that about 3-15% of the total observed lung cancer rate among populations might be associated with the environmental exposure to radon daughters.[4] Proportional hazard model showed that this relative fraction might be nearly the same for smokers and non-smokers, and for males and females.

In the real condition internal wall dwelling materials affects the radon concentrations and its hazards of inhalation. Two factors may explain the observed trend in the radon concentrations: radon absorption and emanation by the covering materials. Previous studies worldwide showed that radon concentrations depend on many factors such as geological formations, indoor-outdoor temperatures, relative humidity, and airflow and ventilation rate.[17-19] In addition, a study in Iran showed that beside geological formations, internal wall covering materials affect radon concentration in the dwellings.[16] Nevertheless, at this study the authors did not indicate the classification of materials based on the potential risk to radon exposure. However, we have studied effects of the most common internal materials which are used in Iran dwellings such as gypsum, wallpaper, oil dye, plastic dye, wood and Belka on the radon concentrations.

Moreover, the results of our measurements can be used to estimate annual average radon concentrations in Iran dwellings. As could be seen from Table 1, dwellings with gypsum and wallpaper have the least lung cancer probability from radon accumulation as opposed to wood and plastic dye. It means that a person who are living in a house with internal wall covering materials of plastic dye and wood board walls, receive an average annual dose higher than one living in a house with internal wall covering materials of gypsum and wallpaper.

In Netherland, de Graaf[19] found that the use of concrete and replacing wood for the construction of floors and bricks for the construction of walls reduce radon concentrations in dwelling. The use of sand lime bricks and gypsum blocks for inner walls caused a further reduction in the radon concentrations.[17,18] However, the shifts from wood to concrete for the construction of floors started long before in the Europe, but in some places in Iran especially northern, we still have old wooden dwellings, which increase occupant hazards of radiation from radon inhalation because of the radon gas leakage from the ground.

Using wallpaper and gypsum as an internal wall covering material in dwellings decrease the hazards of the radon concentrations, and lung cancer probability. Therefore, it is suggested that the residential rooms reconstructed using gypsum and wallpaper as internal materials for covering the walls to avoid the health hazards due to radon inhalation. Higher concentrations of radon and lung cancer probability are prospected in dwellings with internal wall covering materials of plastic dye and wood.

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Conflict of interest: None declared.

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