Nanomaterial Containing Wall Paints Can Increase Radon Concentration in Houses Located in Radon Prone Areas

Haghani M.[2] , Mortazavi S. M. J.[1, 2*], Faghihi R.[3], Mehdizadeh S.[3], Moradgholi J.[4], Darvish L.[5], Fathi-Pour E.[5], Ansari L.[5], Ghanbar-pour M. R.[3]

ABSTRACT

Background: Nowadays, extensive technological advancements have made it possible to use nanopaints which show exciting properties. In IR Iran excessive radon levels (up to 3700 Bq m–3) have been reported in homes located in radon prone areas. Over the past decades, concerns have been raised about the risk posed by residential radon exposure.

Objective: This study aims at investigating the effect of using nanomaterial containing wall paints on radon concentration in homes.

Methods: Two wooden model houses were used in this study. Soil samples from Ramsar high background radiation areas were used for simulating the situation of a typical house in radon-prone areas. Conventional water-soluble wall paint was used for painting the walls of the 1st house model; while the 2nd house model was painted with the same wall paint with montmorillonite nanoclay.

Results: Three days after sealing the house models, radon level was measured by using a portable radon survey meter. The mean radon level inside the 1st house model (conventional paint) was 515.3 ± 17.8 Bq/m^3 while the mean radon concentration in the 2nd house model (nano-painted house model) was 570.8 ± 18.5 Bq/m^3. The difference between these means was statistically significant ($P<0.001$).

Conclusion: To the best of our knowledge, this study is the first investigation on the effect of nano-material containing wall paints on indoor radon concentrations. It can be concluded that nano-material-containing wall paints should not be used in houses with wooden walls located in radon prone areas. Although the mechanism of this effect is not clearly known, decreased porosity in nano-paints might be a key factor in increasing the radon concentration in homes.

Keywords
Radon, Radon Prone Areas, Wall Covering, Paint, Nano-montmorillonite, Nanoclay

Introduction

Radon, a radioactive gas produced by the disintegration of uranium in Earth's crust, can escape into the air and accumulate to harmful concentrations in residential places. However, outdoor radon is rapidly diluted and hence is not a common concern [1]. The most common isotopes of radon are Radon-222 (radon) and radon-220 (thoron). Although there is no large scale data on the incidence of radon-related lung cancers in Iran, long-term exposure to high concentrations of indoor radon has been reported to be the second leading cause of

[1]The Center for Radiological Research, Shiraz University of Medical Sciences, Shiraz, Iran
[2]Department of Medical Physics and Medical Engineering, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran
[3]Radiation Research Center, Mechanical Engineering School, Shiraz University, Shiraz, Iran
[4]Ph.D student of nanomaterials, Department of Materials Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran
[5]Master Student, Student Research Committee, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran

*Corresponding author: Prof. Mortazavi S. M. J., Ph.D
Medical Physics & Medical Engineering Department, The Head
The Center for Research on Radiological Sciences, The Head
Medical Physics & Medical Engineering Department
School of Medicine, Zand Street
Shiraz University of Medical Sciences
E-mail: mmortazavi@sums.ac.ir

adults' lung cancer [2]. It has been shown that basic factors such as air change rate, indoor temperature and moisture have significant effects on the concentration of indoor radon. In a case study, minimum indoor radon concentrations were obtained at temperatures between 20 and 22 °C and a relative humidity of 50-60% [3]. According to World Health Organization (WHO) the basic health hazard from high radon exposure is an increased risk of lung cancer [4]. Some studies show that the vast majority of radon induced lung cancers are caused by exposure to low and moderate indoor radon levels [5]. In the Unites States, Environmental Protection Agency (EPA) has reported that each year radon causes about 20,000 cases of lung cancer [6]. Although it has been reported that the radon health risk is proportional to its concentration, down to the Environmental Protection Agency's action level of 148 Bq m–3, recent studies show that inhalation of even low concentrations of radon poses a risk of developing lung cancer [7]. In IR Iran excessive radon levels (up to 3700 Bq m–3) have been reported in homes located in some radon prone areas. Montmorillonite which occurs mainly in bentonite is a very soft phyllosilicate clay. Nanotechnology is believed to provide new solutions for the millions of people in developing countries who have no access to very basic services such as safe water, reliable energy, health care and education. The most common used nanoclay in materials applications is plate-like montmorillonite. The main goal of this study was to investigate the effect of nano-montmorillonite containing wall paints on radon concentration in homes.

Materials and Methods

House Model

Two wooden model houses were designed in this study. Ramsar soil samples were used for simulating a typical house in radon-prone areas with radon levels over the EPA's action level (148 Bq/m^3 or 4 pCi/l). These cube house models had a volume of 27000 cubic centimeters (dimesions 30 × 30 × 30 cm).

Environmental Monitoring and Soil Sampling

Before soil sampling, environmental monitoring in Talesh Mahalleh, a well-known district in High Background Radiation Areas (HBRAs) of Ramsar, was performed using a RDS -110 (RADOS. Inc., Finland) multi purpose survey meter. Absorbed dose rates in air were measured at one meter above the ground level. Soil sampling locations were recorded by a Global Positioning System (GPS). Soil samples sent to the National Radiation Protection Department (NRPD) of the Iranian Nuclear Regulatory Authority for gamma spectroscopy. Concentrations of Ra-226, Th-232 and K-40 radionuclides in soil samples were measured.

Preparation of Nano-Paint

In each experiment 300 cc conventional wall paint was mixed with 200 cc tap water. While the walls of the 1st house model were painted with this conventional water-soluble paint, 6 g nano-montmorillonite was added to the paint used for the 2nd house model. Nano-montmorillonite (Cloisite® 20A) was obtained from Southern Clay Products Inc (Gonzalez, TX).

Radon Measurements

In each house model 222 g soil from Ramsar HBRAs' was used. Radon level measurement was performed by using a PRASSI portable radon gas survey meter that was provided by Radiation Research Center of Shiraz University. House models were sealed for 3 days, before radon measurements.

Results

Three days after sealing the house models, the mean radon level inside the 1st house model (conventional paint) was 515.3 ± 17.8 Bq/m^3 (ranged 491.0 – 551.3 Bq/m^3) while the mean radon concentration in the 2nd house model (nano-painted house model) was 570.8 ± 18.5 Bq/m^3(ranged 545.2 – 607.7 Bq/m^3). The difference between these means was statistically significant (P<0.001). The mean radon concentration in each house model is summarized in Table 1.

Discussion

Although there are some old and new published reports on the effect of wall covering on radon concentration, to the best of our knowledge, this study is the first investigation on the effect of nano-material containing wall paints on indoor radon concentrations [8, 9]. In this study nano-montmorillonite paint significantly increased the radon level in our house model. According to some old reports, the majority of paints used for the internal walls of houses decreased radon emanation from building materials but increased the concentration of radon inside the material itself at the same time [8]. It was also reported that wallpaper, gypsum and plaster may increase the indoor radon concentration based on their radium contents [8]. In a more recent study that was conducted in 2011, the effect of different interior wall materials on ambient radon concentrations was investigated. In contrast with the present study that used non-material containing paints, the above-mentioned study did not study the effect of nan-materials. This report showed that the average radon levels for wood and plastic paint were 869.0 ± 66.7 and 936.8 ± 60.6 Bq/m^3, respectively. On the other hand, the mean radon concentrations for wallpaper and gypsum were 449.2 ± 101.7 and 590.9 ± 49.0 Bq/m^3, respectively. Furthermore, the mean radon concentrations for oil paint and Belka were 668.3 ± 42.3 and697.2 ± 136.7 Bq/m^3, respectively[9]. It is worth mentioning that in our study walls of the house model were wooden and hence we did not intend to study the role of the paint on blocking radon emanation from walls' building materials. On the other hand, we know that radium decay produce nongaseous radon daughters which are negatively charged micro-particles that can be attracted electro-statically to dust particles. Therefore, it could be hypothesized that charged radon progeny might be captured in the pores of the wall coverings.

Table 1: The mean radon level in two identical house models painted with conventional and nano-based paint.

Environment	Exp Date	No. of Measurements	Mean±SD Radon Concentration (Bq / m^3) (Range: min-max)		Significance (P-Value)
			Conventional Paint	Nanoclay Paint	
House Model	June 1, 2013	24	515.3 ± 17.8 (491.0 – 551.3)	570.8 ± 18.5 (545.2 – 607.7)	< 0.001

Nowadays, extensive technological advancements have made it possible to use nanopaints which show exciting properties such as blocking radiofrequency (RF) radiation, altering the infrared (IR) reflecting or absorbing properties of buildings to improve energy efficiency (to absorb IR energy on cool sunny days and reflect it on hot days), preventing the growth of pathogens such as bacteria or viruses and even repelling or neutralizing toxic chemicals, acids or other corrosive agents. However, our finding might raise concerns about the hazards of using nanopaints in radon prone areas.

Although it is well known that the rate of radon exhalation from any building material per unit activity concentration of Ra-226 is determined by basic factors including the porosity and density of that building material, the diffusion coefficient, the water content, the age and the composition of the material, there is no report on the role of factors such as density and porosity of the paint on the wooden walls on radon concentration. In this light, it can be hypothesized that nanomaterials in the paint decrease its porosity and hence increase the indoor radon level. Further research is needed to confirm this hypothesis.

Conclusion

In this study we showed that nano-montmorillonite containing paint significantly increased the radon level in the house model. Although the mechanism of this effect is not clear, we believe that anomaterials in the paint decrease its porosity and hence increase the indoor radon level. Further research is needed to confirm this hypothesis and to answer many other questions about the role of nano-wall coverings in alterations of indoor radon level.

Acknowledgment

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Conflict of Interest

None

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