

Research Article

Ensuring Effective Radon Management for Curative Layout Design of Malaysian Buildings

Abdullah Mohd Noh¹ *, Nordin Ayoub², Zaharuzaman Jamaluddin³, Kamisah Supian⁴, Norhafizah Mohamad Nonudin⁵, Youssef Aboubaker Abdulla⁶, Zidan Mohamed Houmani⁷, and Amir Heberd Abdullah⁸

¹ University of Selangor; abdullahmnoh@gmail.com;  0009-0000-4241-5421

² University of Selangor; nordin@unisel.edu.my

³ University of Selangor; zaharuzaman@unisel.edu.my

⁴ University of Selangor; kamisah@unisel.edu.my

⁵ SKS 13 Shah Alam; norhafizahnonudin@gmail.com

⁶ University of Sebha; you.omer@sebhau.edu.ly

⁷ University of Tripoli; houmani67@yahoo.com

⁸ Universiti Teknologi Mara; amirhe2831@uitm.edu.my

* Correspondence: abdullahmnoh@gmail.com; 0173339917.

Abstract: *There are some residential buildings that have a high indoor Radon concentration because of their layout design or building age which may require finding solutions to avoid its inhalation by the occupants. These unhealthy buildings may require more Radon inspection and then provide solutions for remediation to save human lives in the long term. A few residential buildings of the double-storey bungalow, single-storey semi-detached, double-story terrace, and five-storey apartment were included in this study for Radon monitoring. The monitoring was carried out using two different Airthings detectors that are recently being used in many current studies to measure passively and continuously indoor Radon concentration levels for a defined period of time and to identify rooms of a building with a high level of Radon concentration. The amount of average Radon concentrations and the graphs of Radon accumulation in each room showed some of the affected rooms require finding the most effective proposed solution to avoid Radon inhalation. One of the Radon accumulation graphs for the storeroom shows a high Radon concentration level of 130 Bq/m³ exceeding a healthy level of 100 Bq/m³ compared to other rooms in the same building that show a healthy level. Any early hazard indication of considerable Radon concentration level should not be disregarded as it is known as one of the main causes of lung cancer. It should be given high attention in order to minimize any possibility of Radon contribution to respiratory disease which is being reported by the Ministry of Health in 2022 to be the first-highest cause of death in local government hospitals. There is a possibility of reducing this considerable percentage of mortality through effective Radon management system which require the public to understand it as one of the preventive and practical methods to avoid lung cancer in the long term.*

Keywords: inhalation; management; radon.



Copyright: © 2023 by the authors. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. INTRODUCTION

Radon is a natural radioactive gas that can be found outside and inside the buildings. When released into the air, it can accumulate to higher concentrations and long-term exposure to its elevated

levels can pose a high risk not only to adult but also to children (Zheng, Xin, Ya, Fang, Qing, Philip, & You, 2022). In Malaysia, the presence of indoors Radon can vary depending on various factors including building age and design. Radon can flow into buildings and accumulate in enclosed spaces such as storeroom and lower levels of buildings especially for improper ventilation case. There are many old and modern commercial and residential buildings that have a possibility of radon accumulation because of their layout design. Monitoring Radon concentration inside the buildings such as home, school, and office may provide significance information regarding its level (Rydock, Næss-Rolstad, & Brunsell, 2001; Mohamed, & Marlia, 2018). Radon inhalation was found to be one of the risk factors that affect the human respiratory system and usually it takes many years to develop lung cancer. It is very important to include radon as a factor to be taken into account when calculating lung cancer risk (María, Alberto, Juan, & Alberto, 2016). According to Health Facts 2022 report published by Ministry of Health Malaysia, the respiratory system diseases are the first highest cause of death in government hospitals and pneumonia disease represents 12.2% of the total cause of death in Malaysia as presented by Department Statics Malaysia in 2019. There are many causes of respiratory system diseases, including inhalation of indoor and outdoor radon. The aims of the study are to investigate the concentration amount of radon in the inhaled air inside the residential buildings and identify a specific room with its high level of concentration for disease prevention purposes.

2. METHOD & MATERIAL

While there is limited available data on radon levels in Malaysian buildings, it is generally believed that the risk of radon exposure in Malaysia may require to be conducted and assessed its levels in specific areas and buildings for comprehensive nationwide data to be available. To determine radon levels in a specific building, radon management of detecting and avoiding are necessary. This can be done using specialized equipment designed to measure radon concentrations over a period of time. If elevated levels of radon are detected, various mitigation measures can be employed to reduce exposure, such as improving ventilation, sealing cracks, and installing radon mitigation systems. Radon detection typically involves the use of specialized equipment designed to measure the concentration of radon gas in the air. There are a few common methods used for radon detection include Radon testing kits, continuous Radon monitors, active Radon detectors, and professional Radon testing. Most of Radon measurements in Malaysia involve the use of a continuous radon monitor (Nisar, Ihsan, Jalil, & Tabassum, 2017). Continuous radon monitors (CRMs) are electronic devices that provide real-time measurements of radon levels. They are typically more expensive than testing kits but offer immediate results in digital and graphs forms. CRMs are often used by professionals for short-term testing in homes or buildings. In the current Radon testing, the activities of Radon detecting or monitoring inside each room was implemented through passive alpha spectrometry detection devices for a specified period, typically for seven sequence days or a complete one week. The indoor concentration level was measured in different rooms inside residential buildings in Klang Selangor. One of the monitoring building is a double story building consist five rooms, two halls, three bathrooms, kitchen, and storeroom. The Airthings Wave Radon detector was used to measure the amount of Radon gas, room temperature, and room humidity (Abdullah, Nordin, Siti Zurina, Norhafizah, & Mardhiyati, 2019). Any high Radon reading should be avoided by implementing some recommended solution that applicable in Malaysia (Abdullah, Nordin, Siti Zurina, Norhafizah, & Mardhiyati, 2021). Detection and avoidance are the two main process of the proposed Radon management system in this study to control its indoor inhalation.

3. FINDINGS

Radon can be found in the environment including air, water, and soil. The possibility of radon causing harm to the lungs depends on its concentration level in the inhaled air. The results of study showed some of the rooms inside the buildings have a potential of radon accumulation more than a healthy level of 100 Bq/m^3 . The concentration of Radon in one room may slightly differ from another room except for the storeroom. Figure (1) illustrates one of a digital reading of Radon level and its accumulation graph inside the storeroom for one week monitoring period that exceeds the healthy level of 100 Bq/m^3 . There are possibilities of Radon accumulation occurs inside this room during the whole one week with highest recorded levels of 130 Bq/m^3 and average weekly reading of 66 Bq/m^3 . Long staying in the storeroom may cause significant health effects as explained by World Health Organization to be the main cause of lung cancer for non-smoker persons (Hajo, & Ferid, 2009). Maintaining the indoor and outdoor radon reading at healthy and safety level is one activity of effective Radon management system for environmental sustainability. There are many suggested methods for radon mitigation that recommended by United State Environmental Protection Agency (EPA) and some of them may not be applicable in Malaysia because of building design that requires finding alternative practical methods to replace the recommended one by EPA. One of the proposed solutions to avoid radon inhalation was to keep opening the door regularly (Abdullah, Nordin, Siti Zurina, Norhafizah, & Mardhiyati, 2021). This basic method for Radon mitigation is the most effective one that keep average monthly Radon reading at 31 Bq/m^3 inside the storeroom as illustrated in Figure (1). Implementing the right strategy of Radon management system may help control its levels in indoor environments and then play a significant role in disease prevention. It is important to note that radon management practices may vary depending on regional geology, building types, and local regulations. Consulting with radon mitigation professionals, such as certified radon inspection officer or local health authorities, can provide tailored guidance and assistance in implementing effective radon management strategies for specific situations.



Figure 1. Radon monitoring inside storeroom at ground floor of two stories residential building.

4. DISCUSSION

The high concentration of radon may require finding and implementing the most practical method for its mitigation (Abdullah, Nordin, Siti Zurina, Norhafizah, & Mardhiyati, 2021) and avoiding any possibility of its accumulation in the future buildings. The right layout design of residential buildings should be considered as one of requirement for Radon management system that may provide health benefit to the household in long term. This preliminary finding results requires continues of Radon monitoring in other residential buildings to avoid its inhalation especially when its level exceed 100 Bq/m³ that been reported 3.8% of lung cancer mortality was attributable to radon exposure of over this value (Alberto, Leonor, Marta, Montserrat, Santiago, María, Julia, Juan, & Mónica, 2021). Radon testing and detecting, mitigation and avoiding, standard introducing and education are some proposed elements require for a comprehensive Radon management system.

5. CONCLUSION

It is important to follow the specific instructions provided by professional guidance or seek good management system to ensure accurate and reliable results of Radon detecting and avoiding. Radon levels can fluctuate over time, so it may be necessary to conduct most effective Radon management system for multiple tests at different times or seasons to get a more comprehensive understanding of radon exposure in a particular building. If elevated radon levels are detected, mitigation measures can be implemented to reduce exposure and ensure a healthier indoor environment. For any concern about radon levels in a specific building in Malaysia, it is advisable to consult with local environmental or radiation protection agencies or seek the assistance of professionals specializing in radon testing and mitigation as one of a process in Radon management system. These professional bodies may able to provide more accurate information and guidance based on the specific location and circumstances.

Acknowledgments: We are grateful to OM ABDO Enterprise for fully sponsoring this short study and willing for dissemination of knowledge.

References

- Abdullah Mohd Noh, Nordin Ayoub, Siti Zurina Mat Noor, Norhafizah Zahari, Mardhiyati Mohd Yunus. (2019). Radon Concentration in Workplace Indoor Air. *Journal of Occupational Safety and Health*, 16(1), 19-26.
- Abdullah Mohd Noh, Nordin Ayoub, Siti Zurina Mat Noor, Norhafizah Zahari, Mardhiyati Mohd Yunus. (2021). Ideal Practice for Avoiding Radon Accumulation in X-Ray Room. *Korean Journal of Radiology*, 19th AOCR Abstract Book, S92.
- Alberto Ruano-Ravina, Leonor Varela Lema, Marta García Talavera, Montserrat García Gómez, Santiago González Muñoz, María Isolina Santiago-Pérez, Julia Rey-Brandariz, Juan Barros-Dios, Mónica Pérez-Ríos. (2021). Lung cancer mortality attributable to residential radon exposure in Spain and its regions. *Environmental Research*, 199, 111372.
- Hajo Zeeb & Ferid Shannoun. (2009). *WHO handbook on indoor Radon: a public health perspective*. WHO Press.
- J. P. Rydock, A. Næss-Rolstad, J. T. Brunsell. (2001). Diurnal variations in Radon concentrations in a school and office: implications for determining Radon exposure in day-use buildings. *Atmospheric Environment*, 35(16), 2921-2926.
- María Torres-Duran, Alberto Fernandez-Villar, Juan Miguel Barros-Dios, Alberto Ruano-Ravina. (2016). Residential Radon: The Neglected Risk Factor in Lung Cancer Risk Scores. *Journal of Thoracic Oncology*, 11 (9), 1384-1386.

Mohamed Yasreen Mohamed Ali, Marlia M. Hanafiah. (2018). Potential factors that impact the Radon level and the prediction of ambient dose equivalent rates of indoor microenvironments. *Science of the Total Environment*, 626, 1-10.

Nisar Ahmad, Ihsan Ullah Khan, Jalil ur Rehman, Tabassum Nasir. (2017). An overview of Radon concentration in Malaysia. *Journal of Radiation Research and Applied Sciences*, 10(4), 327-330.

Zheng Su, Xin-Hua Jia, Ya-Guang Fan, Fang-Hui Zhao, Qing-Hua Zhou, Philip R. Taylor, You-Lin Qiao. (2022). Quantitative evaluation of radon, tobacco use and lung cancer association in an occupational cohort with 27 follow-up years. *Ecotoxicology and Environmental Safety*, 232, 113233.