GSAR Journal of Applied Medical Sciences ISSN: 2584-2323 (Online)

GSAR Journal of Applied Medical Sciences
ISSN: 2584-2323 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/gsarjams-home/

Policy Paper: Mitigating Public Health Risks from Radon Emissions in Serbian Building Materials

By

Fathya Shabek[1] Ramadan Abdalla Drenba[2] Aco Janićijević[1]

[1]Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, 11120 Belgrade, Serbia
[2]Vinča Institute for Nuclear Sciences, University of Belgrade, Mike Petrovic Alasa 12-14,11001 Belgrade, Serbia

Article History

Received: 15/12/2025
Accepted: 22/12/2025
Published: 24/12/2025

Vol – 2 Issue –12

PP: -22-26

Abstract

Radon (^{222}Rn) is a radioactive noble gas that occurs naturally as a radioactive decay product of uranium-series isotopes present in the Earth's crust (the lithosphere). Radon is the second-leading cause of lung cancer worldwide, coming second only to tobacco smoking, and is a major environmental health risk. Granite is a dense igneous rock that is a popular building material because it is durable, has an attractive aesthetic, and is reasonably priced.

Granite may contain a variable supply of radium-226 (^{226}Ra) which is a parent radionuclide compound of radon. In Serbia, the use of granite in residential and commercial buildings is rapidly increasing, raising supposable concerns about the contribution these structural materials have radon concentrations indoors. This study assesses the radon and thoron (^{220}Rn) exhalation rates for ten samples of granite used frequently in Serbia and examines the indoor radon concentrations with three different ventilation rates (0.63, 0.20, and 0.13 h^{-1}).

The indoor radon concentrations were calculated for each ventilation rate using a standard room model, and a risk assessment of indoor radon was done using the UNSCEAR and ICRP models. The results reveal radon exhalation rates from <161 to 5220 ± 200 $\mu Bq/m^2/s$, while

In-low ventilation cases showed concentrations of radon up to 150 Bq/m^3. The estimated annual-effective dose varied within the range of 0.05-3.79 mSv and lifetime lung cancer risk ranged from 35-2,653 cases per million people. These results support the need for regulatory action, for better ventilation approaches, and public health recommendations .

Keywords: *Radon exhalation; granite building materials; indoor air quality; lung cancer risk; Serbia; health risk assessment; radon mitigation; exposure recommendations.*

1.0 Introduction:

The Unseen Health Threat in Serbian Buildings

A significant and preventable public health threat exists within Serbia's building stock, directly linked to the unregulated use of common construction materials. This policy paper addresses the quantifiable lung cancer risk posed by radon-emitting granite and presents an essential regulatory framework to protect the Serbian public.

Radon (^{222}Rn) is a colorless, odorless, radioactive gas, a natural decay product of uranium found in rocks and soil. Its primary health risk stems from its radioactivity. When inhaled, its decay products lodge in lung tissue and emit alpha particles that damage cellular DNA. This process is a direct cause of lung cancer, leading the World Health Organization (WHO) to classify radon as the second-leading cause of the disease worldwide, surpassed only by smoking.

The context for this issue in Serbia is particularly pressing due to the rapidly increasing use of granite in both residential and commercial construction. While valued for its durability, granite can contain variable amounts of radium-226, the parent radionuclide of radon, raising public health concerns about its contribution to indoor radon concentrations. The scientific evidence gathered locally confirms this is not a theoretical problem but a quantifiable risk that requires a proactive policy response.

2.0 The Scientific Evidence: Quantifying the Radon Risk from Granite in Serbia

Effective public health policy must be grounded in local,

*Corresponding Author: **Fathya Shabek.***

© Copyright 2025 GSAR Publishers All Rights Reserved

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

empirical data. The recommendations outlined in this paper are based on the findings from a recent Serbian study that measured radon emissions from ten commonly used granite samples and modeled the associated health risks for building inhabitants. This research provides a clear, quantitative basis for regulatory action.

The primary findings of the study reveal a tangible health risk stemming directly from these building materials:

- Radon Exhalation Rates: Measured rates from the granite samples demonstrated a wide variance, ranging from <161 to 5220 ± 200 μBq/m²/s.
- **Indoor Concentrations:** In modeled scenarios with low ventilation, indoor radon concentrations originating from the granite reached levels up to 150 Bq/m³, exceeding the reference benchmark recommended by the WHO.
- **Annual Effective Dose:** The estimated annual radiation dose for inhabitants exposed to these concentrations varied significantly, from 0.05 mSv to a concerning 3.79 mSv.
- **Lifetime Cancer Risk:** The associated lifetime lung cancer risk was calculated to be between 35 to 2,653 cases per million people, a statistically significant public health burden. The vast difference between the low and high ends of these ranges—from a negligible risk to a risk factor of 2,653 cancer cases per million—is driven almost entirely by the type of granite used. This finding proves that material selection is a critical public health control point that is currently unregulated.

The primary findings of the study reveal a tangible health risk stemming directly from these building materials:

- **Radon Exhalation Rates:** Measured rates from the granite samples demonstrated a wide variance, ranging from <161 to 5220 ± 200 μBq/m²/s.
- **Indoor Concentrations:** In modeled scenarios with low ventilation, indoor radon concentrations originating from the granite reached levels up to 150 Bq/m³, exceeding the reference benchmark recommended by the WHO.
- **Annual Effective Dose:** The estimated annual radiation dose for inhabitants exposed to these concentrations varied significantly, from 0.05 mSv to a concerning 3.79 mSv.
- **Lifetime Cancer Risk:** The associated lifetime lung cancer risk was calculated to be between 35 to 2,653 cases per million people, a statistically significant public health burden. The vast difference between the low and high ends of these ranges—from a negligible risk to a risk factor of 2,653 cancer cases per million—is driven almost entirely by the type of granite used. This finding proves that material selection is a critical public health control point that is currently unregulated.

While radon gas is the transport medium, the primary agents of DNA damage in lung tissue are its short-lived decay products, specifically polonium-218 and polonium-214. The concentration of radon gas, however, is the key metric used to assess and regulate exposure risk. These figures demonstrate that radon from building materials is not a peripheral issue but a direct contributor to health risks, a problem that is exacerbated by modern construction practices.

Modern construction trends, while highly beneficial for energy conservation, can unintentionally increase public health risks from indoor pollutants like radon. The drive for greater energy efficiency has led to the construction of more airtight buildings, which, without corresponding improvements in mechanical ventilation, can become traps for indoor contaminants. This creates a dangerous policy paradox: regulations and incentives promoting energy efficiency, when pursued in isolation, are actively increasing the public's exposure to a known carcinogen.

This conflict between energy efficiency and indoor air quality is direct and measurable. Airtight building envelopes, improved insulation, and reduced natural ventilation rates—often as low as 0.1 to 0.2 air changes per hour (ACH) in modern designs—effectively save energy. However, they also prevent the dilution and removal of radon emitted from interior materials like granite flooring and countertops, allowing the gas to accumulate to hazardous levels.

The Serbian study's modeling powerfully illustrates this effect: a reduction in ventilation rates from a modest 0.63 h^{-1} to 0.2 h^{-1} can cause indoor radon concentrations to triple. This finding is particularly alarming given the increasing use of granite for interior finishes in Serbian apartments and public buildings, where energy-saving improvements are encouraged but radon mitigation measures are not concurrently enforced.

4.0 The Serbian Regulatory Gap

A Comparison with International Standards

A robust regulatory framework is essential for protecting the public from preventable environmental health hazards. An evaluation of Serbia's current radon policies, contrasted with established international guidelines, reveals a critical gap in protection that leaves the population unnecessarily vulnerable. To date, national radon policy in Serbia has primarily focused on the geological mapping of radon-prone areas—a useful but incomplete strategy that fails to address the systematic testing and regulation of building materials themselves.

*Corresponding Author: **Fathya Shabek.**
© Copyright 2025 GSAR Publishers All Rights Reserved

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

The following table provides a clear comparison between international benchmarks and the current regulatory landscape in Serbia:

Current Status in Serbia	International Benchmark	Guideline /Standard
No specific national reference level for buildings cited	WHO: 100 Bq/m³ EU Basic Safety Standards: 300 Bq/m³	**Indoor Radon Reference Level**
No radon exhalation testing requirements for building materials	Some countries (e.g., Sweden, USA) have rigorous material screening and regulate radon exhalation rates	**Building Material Regulation**
Radon mitigation measures are not enforced in construction, especially alongside energy-saving improvements	Countries like Canada and Norway incorporate radon mitigation techniques into new construction codes	**Building Codes**

absence of specific regulations for radon exhalation from building materials means that products with potentially high radioactivity can be imported and used in enclosed indoor settings without any radiological assessment.

This leaves the Serbian public vulnerable to preventable long-term radon exposure, creating a health risk that is inconsistent with established European public health standards and scientific understanding.

This identified gap necessitates the adoption of clear, actionable policy recommendations to safeguard public health.

5.0 Actionable Policy Recommendations for Public Health Protection

Based on the scientific evidence and regulatory analysis, this paper recommends a decisive, three-pronged policy approach.

The integrated implementation of the following recommendations—updating building codes, setting material standards, and mandating certification—will bridge the current regulatory gap and establish a modern, protective framework for the Serbian public.

1. **Update National Building Codes**

Purpose:

To formally integrate radon risk management into the design, construction, and renovation of buildings.

Implementation:

Amend the Serbian building code to mandate the consideration of radon as an indoor air contaminant. This update should include provisions for radon-resistant new construction techniques, especially in areas identified as high-risk through geological mapping.

Furthermore, it should establish clear guidelines for radon testing and mitigation in existing buildings that are undergoing major renovation, particularly those involving energy-efficiency upgrades.

2. **Establish a National Standard for Radon Exhalation from Building Materials**

Purpose:

To prevent the use of high-emission materials in indoor environments where they can pose a health risk.

Implementation:

Create and enforce a legal limit on the radon exhalation rate for building materials sold and used in Serbia, with a particular focus on those used extensively for interior finishes, such as granite. This standard should be developed in alignment with European best practices to ensure that materials contributing significantly to indoor radiation doses are identified and their use appropriately managed.

3. **Implement a Mandatory Material Testing and Certification Program Purpose:**

To provide a transparent and enforceable mechanism for ensuring compliance with the new national standard.

Implementation:

Develop a program that requires importers and domestic producers of materials like granite to test their products for radon exhalation rates at accredited laboratories.

Materials that meet the national standard would receive a certification label. This program would provide builders, architects, and consumers with the transparent information needed to make informed, safe choices, empowering the market to prioritize public health.

6.0 Conclusion:

A Proactive Approach to Safeguarding Serbia's Future

Radon emitted from common building materials, particularly granite, poses a scientifically verified and significant lung cancer risk to the Serbian population. This risk is compounded by modern, energy-efficient construction practices that can trap the radioactive gas indoors, leading to dangerously high concentrations. The current national regulatory framework has not kept pace with these realities, creating a public health protection gap that leaves citizens vulnerable to a preventable, long-term hazard.

This is a solvable problem.

The evidence is clear, the risks are quantifiable, and the policy solutions are well-established in international practice. By updating national building codes, establishing a standard for radon exhalation from materials, and implementing a mandatory testing and certification program, Serbia can effectively mitigate this unseen threat.

Adopting these evidence-based recommendations is not merely an investment; it is a fundamental responsibility of governance, essential for safeguarding the long-term health of the Serbian people and aligning national building standards with established European safety benchmarks.

*Corresponding Author: **Fathya Shabek.**

© Copyright 2025 GSAR Publishers All Rights Reserved

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

References

1. World Health Organization, WHO Handbook on Indoor Radon: A Public Health Perspective, Geneva, Switzerland: WHO Press, 2009.
2. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Sources and Effects of Ionizing Radiation: Report to the General Assembly with Scientific Annexes, New York, NY, USA: United Nations, 2020.
3. International Commission on Radiological Protection (ICRP), "Lung cancer risk from radon and progeny and statement on radon," Annals of the ICRP, vol. 40, no. 1, pp. 1–64, 2010, doi:10.1016/j.icrp.2010.10.001.
4. Darby, S. et al., "Radon in homes and risk of lung cancer: Collaborative analysis of individual data from 13 European case-control studies," BMJ, vol. 330, no. 7485, pp. 223–227, 2005, doi:10.1136/bmj.38308.477650.63.
5. Krewski, D. et al., "A combined analysis of North American case-control studies of residential radon and lung cancer," J. Toxicol. Environ. Health A, vol. 69, no. 7, pp. 533–597, 2006.
6. Field, R.W. et al., "Residential radon gas exposure and lung cancer: The Iowa Radon Lung Cancer Study," Am. J. Epidemiol., vol. 151, no. 11, pp. 1091–1102, 2000.
7. Zhang, Z., et al., "Radon exhalation from building materials: Influence factors and risk assessment," J. Environ. Radioact., vol. 225, p. 106449, 2021.
8. Stranden, E., "Radon in the indoor air," Radiat. Prot. Dosim., vol. 7, no. 1–4, pp. 55–58, 1984.
9. UNSCEAR, Effects of Ionizing Radiation, Annex B: Exposures from Natural Radiation Sources, New York, NY, USA: United Nations, 2000.
10. Durrani, S.A. and Ilic, R., Radon Measurements by Etched Track Detectors: Applications in Radiation Protection, Earth Sciences and the Environment, Singapore: World Scientific, 1997.
11. Tufail, M., et al., "Radon exhalation from granite samples," Radiat. Prot. Dosim., vol. 145, no. 1, pp. 68–73, 2011.
12. Barbosa, S.M., et al., "Radiological risk assessment of ornamental granite," Radiat. Prot. Dosim., vol. 148, no. 3, pp. 310–317, 2012.
13. Zunic, Z.S., et al., "Radon exhalation from building materials in Serbia," Radiat. Meas., vol. 66, pp. 94–99, 2014.
14. Šabek, M., et al., "Granite building materials as a source of indoor radon in Serbia," Atmosphere, vol. 15, no. 8, p. 1495, 2024.
15. Khan, A.J., et al., "Radon exhalation from building materials," Environ. Int., vol. 22, pp. 433–437, 1996.
16. Steck, D.J., "Field study of radon in granite countertops," Health Phys., vol. 103, no. 1, pp. 72–79, 2012.
17. Rehman, S.U., et al., "Measurement of radon exhalation rate from building materials using active and passive techniques," Radiat. Prot. Dosim., vol. 162, no. 1–2, pp. 34–39, 2014.
18. Henschel, D.B., "Indoor radon reduction methods," EPA/625/5-87/019, U.S. Environmental Protection Agency, 1988.
19. Porstendörfer, J., "Properties and behaviour of radon and thoron and their decay products in the air," J. Aerosol Sci., vol. 25, no. 2, pp. 219–263, 1994.
20. Chen, J., "A review of radon doses," Radiat. Prot. Dosim., vol. 160, no. 1–3, pp. 199–208, 2014.
21. Bochicchio, F., "Radon epidemiology and nuclear track detectors: Methods, results and perspectives," Radiat. Meas., vol. 40, no. 2–6, pp. 177–190, 2005.
22. National Research Council, Health Risks of Radon and Other Internally Deposited Alpha-Emitters (BEIR IV), Washington, DC, USA: National Academies Press, 1988.
23. National Research Council, Health Effects of Exposure to Radon: BEIR VI, Washington, DC, USA: National Academies Press, 1999.
24. Lubin, J.H., "Respiratory cancer and radon," Ann. Oncol., vol. 22, no. 11, pp. 2394–2400, 2011.
25. Trevisi, R., et al., "Indoor radon levels in energy-efficient buildings," Radiat. Prot. Dosim., vol. 148, no. 1, pp. 1–7, 2011.
26. Petropoulos, N.P., et al., "Radiological impact from building materials in Greece," J. Environ. Radioact., vol. 85, pp. 223–240, 2006.
27. Maged, A.F., "Natural radioactivity in granite," Radiat. Prot. Dosim., vol. 145, no. 1, pp. 91–96, 2011.
28. Al-Jarallah, M.I., et al., "Natural radioactivity in building materials used in Saudi Arabia," Radiat. Prot. Dosim., vol. 95, no. 3, pp. 253–256, 2001.
29. Veiga, R., et al., "Measurement of natural radioactivity in Brazilian building materials," Radiat. Meas., vol. 46, pp. 153–157, 2011.
30. Mahur, A.K., et al., "Assessment of radiological hazards due to natural radioactivity in building materials," Radiat. Prot. Dosim., vol. 130, no. 4, pp. 532–537, 2008.
31. Denman, A.R., et al., "Influence of ventilation on indoor radon levels," Radiat. Prot. Dosim., vol. 145, pp. 351–354, 2011.
32. Sundal, A.V., et al., "Radon in dwellings and influencing factors in Norway," Atmos. Environ., vol. 38, pp. 5930–5938, 2004.
33. Vaupotič, J., et al., "Indoor radon in energy-efficient houses," Radiat. Prot. Dosim., vol. 148, pp. 89–94, 2011.
34. Miles, J.C.H., "Mapping radon-prone areas by lognormal modelling of house radon data," Health Phys., vol. 97, pp. 295–302, 2009.
35. EU Council Directive 2013/59/Euratom, "Basic safety standards for protection against the dangers arising from exposure to ionising radiation," Official Journal of the European Union, L 13, 2014.

*Corresponding Author: **Fathya Shabek.**

© Copyright 2025 GSAR Publishers All Rights Reserved

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

36. Daraktchieva, Z., et al., "Radon in schools and public buildings," Radiat. Prot. Dosim., vol. 141, no. 4, pp. 375–378, 2010.
37. Mudd, G.M., "Radon sources and risks: A review," Environ. Geol., vol. 43, pp. 755–764, 2003.
38. Akerblom, G., "Radon in homes—a review," Radiat. Prot. Dosim., vol. 7, pp. 49–54, 1984.
39. Steinhäusler, F., "Radiation risk due to indoor radon in Austria," Health Phys., vol. 58, no. 2, pp. 139–148, 1990.
40. Sohrabi, M., "World high background natural radiation areas," Radiat. Meas., vol. 42, no. 9, pp. 1531–1542, 2007.
41. Bochicchio, F., et al., "Indoor exposure to thoron in Europe," Radiat. Prot. Dosim., vol. 117, no. 4, pp. 433–436, 2005.
42. Jelle, B.P., "Natural stone as a source of radon," J. Build. Phys., vol. 35, pp. 324–343, 2012.
43. Cevik, U., et al., "Natural radioactivity of building materials in Turkey," Radiat. Prot. Dosim., vol. 113, pp. 223–228, 2005.
44. Cho, B.W., et al., "Radon emanation and exhalation from granite building materials," Appl. Radiat. Isot., vol. 68, pp. 2000–2004, 2010.
45. Singh, S., et al., "Analysis of granite tiles for natural radioactivity," Environ. Earth Sci., vol. 66, pp. 1783–1790, 2012.
46. Gaidolfi, L., et al., "Radon exhalation and health risk assessment," Environ. Sci. Pollut. Res., vol. 29, pp. 65432–65442, 2022.
47. Persily, A.K., "Ventilation and indoor air quality in schools," Indoor Air, vol. 28, no. 3, pp. 414–425, 2018.
48. Chen, J., and Rahman, N.M., "Radon exposure from granite countertops," Radiat. Prot. Dosim., vol. 138, pp. 157–162, 2010.
49. Fleischer, R.L., "Radon from the solid state into the gas phase," J. Environ. Radioact., vol. 5, no. 1, pp. 17–29, 1987.
50. Harley, N.H., and Chittaporn, P., "Modeling indoor radon due to building materials," Health Phys., vol. 48, pp. 413–420, 1985.
51. Khan, A.J., "Radon emissions from granite: A comparative study," Environ. Int., vol. 22, no. 1, pp. 433–437, 1996.
52. Markkanen, M., "Radiological risks from natural radioactivity in building materials," STUK-B-STO 32, Finnish Centre for Radiation and Nuclear Safety, 1995.

*Corresponding Author: **Fathya Shabek.**
© Copyright 2025 GSAR Publishers All Rights Reserved

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.