Radiation Science and Technology
2026, Vol. 12, No. 2, pp. 25–30
https://doi.org/10.11648/j.rst.20261202.11

Research Article

Determination of Radon Level in Residentials Around a Mine Site and Exposure Risk of Population in Burkina Faso

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Abstract

Residential radon concentrations vary widely by geographic area. The higher concentration of radon is expected globally in the grounds where uranium, radium and thoron are present. Mining processes like drilling and blasting increase radon release. So the main consequence of exposure to high amount of radon are cancers of respiratory system. Radon enters the human organism mainly through inhaled atmospheric air mainly in houses. Therefore, the concentrations of radon were measured in twenty un (21) houses around the gold mine site of Bissa Golg in the Kuilsé region of Bukina Faso, using the radiation detector PCE-RD 75. Also dose exposure and cancer risk were evaluated. The results showed that activity concentrations of indoor radon in the area ranged between 11.47 to 100.27 Bq/m^3. The annual effective doses corresponding to the activity concentrations ranged between 0.69-6.07 mSv with a mean value of 2.97 mSv. This average value of the annual effective dose of radon is lower than the ICRP recommended limit with mitigation required above 10 mSv/yr. The average cancer risk index is 1.04. These results indicate that there is no need remedial action about radon exposure for the population around the studied site.

Keywords

Indoor Radon, Annual Effective Dose, Cancer Risk, Mining Area

1. Introduction

Naturally occurring radioactive materials (NORMs) are intrinsic to the Earth's crust and mainly originate from primordial radionuclides such as uranium (^{238}U) and thorium (^{232}Th). Due to their long half-lives, these radionuclides persist in the environment and contribute significantly to natural background radiation (UNSCEAR, 2020). Radon (^{222}Rn), a key decay product of ^{226}Ra in the ^{238}U series, is of particular concern because it is colorless, odorless, and highly mobile. Globally, radon and its progenies contribute about 50-55% of the natural

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Received: 30 August 2026; **Accepted:** 14 September 2026; **Published:** 28 September 2026

radiation dose to humans (ICRP publication 115, 2010; WHO, 2026) [9]. Its ability to diffuse through fractured rocks, soil, and building materials, combined with the absence of sensory detection, makes its control particularly challenging, especially in enclosed settings like underground mines with inadequate ventilation.

Outdoor radon concentrations are generally low, typically in the range of 5 -15 Bq/m^3, owing to atmospheric mixing and dilution [1, 2]. In contrast, radon concentrations in underground gold mines can reach several hundred to several thousand Bq/m^3, depending on geological conditions, mining activities and ventilation [3, 4]. In South Africa underground mines, concentrations of 300-1000 Bq/m^3 have been reported in the Orkney region, while substantially higher values have been reported in other mining regions (NNR, 2013, cited in Botha [5]). Drilling and blasting may cause transient increases in radon concentrations, while inadequate ventilation promotes the accumulation of radon and its shorts lived progeny. The inhalation of these progeny, particularly their alpha emitting components, represents an important source of radiation dose to the respiratory tract [3, 4, 6].

The International Commission on Radiological Protection (ICRP) and the European Union Basic Safety Standards (EU-BSS) recommend a workplace radon reference level in range of 100-300 Bqm^{-3}, with mitigation required above 300 Bqm^{-3} (ICRP 37, 2007) [7].

However, Burkina Faso and many African countries, lack approved comprehensive legislation, monitoring systems, and public awareness campaigns to manage radon exposure in in workplace and residencial [8]. Some studies have already conducted on radon concentration in homes, but they remain very insignifiant. In Burkina Faso, several mines, particularly gold mines, are in operation, and others are in the process of starting up. It is therefore necessary to monitor the radon levels in workplace and in house located near these mining sites.

The aim of this study was to investigate the possible effect of human activities of this area on the indoor radon concentration and the risk of public exposure to it.

Therefore, the novelty of this study is the assessment of indoor radon exposure and their impact on the health of residents in this area.

2. Materials and Methods

2.1. The Study Area

The study area is Sabcé village close to Bissa Gold mine site. Sabcé is located in the Bam province of Burkina Faso. The Bam province with an area of 3931 km^2 is in Kuilsé Region in the North-center part, approximately 85 km from Ouagadougou, the Capital City at a latidude 13° 10′ 51″ N and a longitude 1° 30′ 59″ W.

Bam province belongs to two geological eras: Inferior precambrian formations (Anttebirimian) represented by compound gneisses with biotites and amphiboles, and compound gneisses and granites; those of mean Precambrian (Birimian) represented by the plutonic rocks and the volcanogenic rocks. The plutonic rocks consist of granites with biotites.

2.2. Radon Concentration Measurement

Radon concentrations were measured in houses around the gold mine site of Bissa Golg using the radiation detector PCE-RD 75. The houses were selected roundomly in an area of eight (08) km^2 approximately. The PCE-RD 75 detecteors were placed in the different houses for measurement.

The radon detector accurately measures the radon concentration in indoor air within a range of 2 Bq/m^3 to 20 kBq/m^3 with a resolution of 1 Bq/m^3 and an accuracy of ±10%. Detectors are placed in each home for at least one hour to obtain reliable concentration data.

According to the recommendation of the World Health Organization (WHO, 2009), the annual average concentration of radon inside buildings should be less than 100 Bq / m^3.

2.3. Radon Concentration Measurement

The annual effective dose due to indoor radon exposure was calculated based on the radon concentration (CRn) and using the following relation [10, 11].

$$D(mSv) = C_{Rn}.F.O.T.D \quad (1)$$

Where,

C_{Rn} is the radon concentration in Bq/m^3,

F: equilibrium factor is taken to be 0.4,

O: the occupancy factor is estimated that people spends 80% of their time indoor,

T=24 hours x365 days=8760 hours/y which is the number of hours in a year,

D: dose conversion factor converts radon concentration into effective dose, 9 nSv (Bq/m^3/h) [12, 13].

According to the recommendation of the World Health Organization (WHO), the annual average concentration of radon inside buildings should be less than 100 Bq/m^3.

2.4. Effective Dose Equivalent

The radiation produced by radon is alpha particle and the critical tissue expose by radon for lung tissue. The calculation of effective dose equivalent was done by using weighting factors for alpha particle for lung tissue based on ICRP, 2007.

The weighting factor for alpha particle is 20 and the weighting factor for lung tissue is 0.12 [12, 15].

Equivalent dose is the dose received by occupants. The effective dose equivalent was calculated by using annual exposure dose D in mSv, weighting factors for alpha particle (W_R) and for lung tissue (W_T).

The effective dose equivalent was estimated by the following relation [14]:

$$E(mSv/y) = D.W_R.W_T \quad (2)$$

2.5. Lung Cancer Risk (LCR)

The impact of radon indoor exposure on the health of residents was quantified by the lung cancer risk (LCR) given by the following equation [16]:

$$LCR = Exp(0.00087352.C_{Rn}) \quad (3)$$

where, C_{Rn} is the radon concentration in Bq/m^3.

3. Results and Discussions

3.1. Radon Concentration

The indoor radon concentration of houses around the gold mine site of Bissa Golg was studied.

The radon concentration of samples and the average radon concentration values are presented in Figure 1.

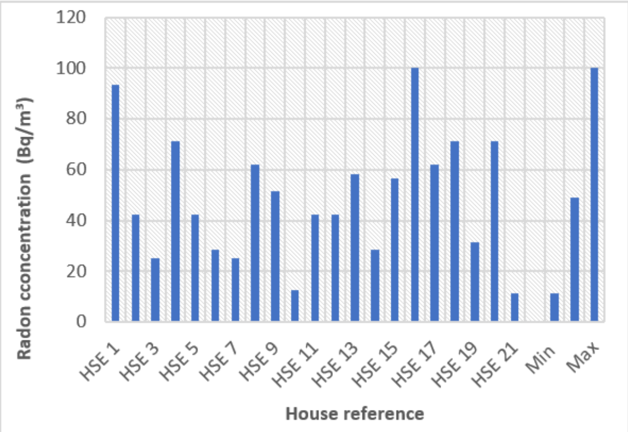

Figure 1. *Radon Concentration.*

Maintaining safe level of radon concentration in the housess is one of the sustainability plans for safe physical life environment. House radon concentration ranges from 11.47 to 100.27 Bq/m^3. The average radon concentration is 49,12 Bq/m^3. House 16 recorded the highest value of 100.27 Bq/m^3. This house is in the middle of many houses. The high value may be due to the lack of ventilation.

Concentrations in all houses, with the exception of house 16, are below 100 Bq/m^3 which is the value recommended by the WHO, and 300 Bq/m^3 that also is the ICRP reference value. The highest values, 93.24 Bq/m^3 and 100.27 Bq/m^3, were recorded in houses 1 and 16, respectively. These two houses pose a potential risk to the residents, and efforts should be made to improve their ventilation. This ventilation effort should be applied to all houses in the area to minimize the risk.

3.2. Comparison of Radonconcentration with Previous

Figure 2 below shows a comparison of the average concentration value from our study with those of previous studies and with the WHO and ICRP reference values. Example of concentrations values taken from the following references [17-21].

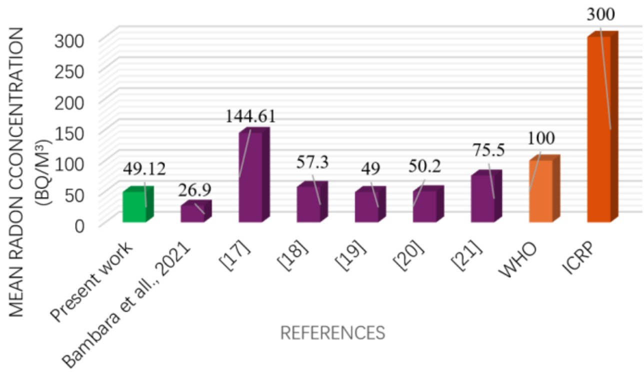

Figure 2. *Comparison of radon concentration with previous studies.*

Comparing the results of our study with those of some previous work, we find that the average value of 49.12 is close to the average values of some of them. However, it is practically double the average radon concentration value of (Bambara et al., 2021), which was 26.9. These studies were conducted in Ouagadougou, approximately 85 km from our study area. Furthermore, two critical values were recorded in our measurements: 93.24 Bq/m^3 and 100.27 Bq/m^3, recorded in houses 1 and 16, respectively. This could be explained by the fact that our study area is near an active mining site, which could release gas trapped in underground rocks into dust that subsequently accumulates in houses, especially those with poor ventilation. Also, the average radon concentration value in our study is two levels lower than that recommended by the WHO.

3.3. Effective Doses

Table 1 shows the radon concentration already discussed in section 3.1, the results on effective doses and cancer risk.

Table 1. *Radon concentration and effective doses.*

Sample ID	Radon Activity (Bq/m^3)	D (mSv/an)	ET (mSv/an)	LCR
HSE 1	93.24	2.35	5.65	1.08
HSE 2	42.55	1.07	2.58	1.04
HSE 3	25.16	0.63	1.52	1.02
HSE 4	71.41	1.80	4.32	1.06
HSE 5	42.55	1.07	2.58	1.04
HSE 6	28.49	0.72	1.73	1.03
HSE 7	25.16	0.63	1.52	1.02
HSE 8	62.16	1.57	3.76	1.06
HSE 9	51.43	1.30	3.11	1.05
HSE 10	12.58	0.32	0.76	1.01
HSE 11	42.55	1.07	2.58	1.04
HSE 12	42.55	1.07	2.58	1.04
HSE 13	58.46	1.47	3.54	1.05
HSE 14	28.49	0.72	1.73	1.03
HSE 15	56.61	1.43	3.43	1.05
HSE 16	100.27	2.53	6.07	1.09
HSE 17	62.16	1.57	3.76	1.06
HSE 18	71.41	1.80	4.32	1.06
HSE 19	31.45	0.79	1.90	1.03
HSE 20	71.41	1.80	4.32	1.06
HSE 21	11.47	0.29	0.69	1.01
Min	11.47	0.30	0.69	1.01
Max	100.27	2.53	6.07	1.09
Mean	49.12	1.24	2.97	1.04

The effective dose of radon varies between 0.29 mSv per year and 2.53 mSv per year, with an average value of 1.24 mSv per year. The average effective dose is higher than the UNSCEAR 2000 [13, 14] normal background level of 1.1 mSv per year. Furthermore, the effective dose in houses 1 and 16 is more than twice the UNSCEAR 2000 [13, 14] normal background level. However, these values are below the limits recommended by ICRP 2014 [22], where remediation action is required. As for the equivalent effective dose, it varies from 0.69 mSv per year to 6.07 mSv per year. The average equivalent effective dose is 2.97 mSv per year. It is almost three times higher than the overall average annual effective dose of radon received by inhalation from all sources, which is 1 mSv per year. It is also noted that the effective dose for houses 1 and 16, which are 5.65 mSv per year and 6.07 mSv per year, are respectively five and six times of 1 mSv per year but less than the limit of the recommended action level (3-10 mSv per year) as reported by the ICRP-1993 [23]. The Lunch Cancer Risk range was from 1.01 to 1.09 with an average of 1.04 which is almost equal to one.

4. Conclusions

This study aimed to evaluate radon concentration in homes surrounding a mining site in Burkina Faso. In most of the sampled houses, the concentration was below 100 Bq/m^3, but in some cases, particularly houses 1 and 16, the radon concentration was high, at 93.24 Bq/m^3 and 100.27 Bq/m^3 respectively. The average effective dose is higher than the UNSCEAR 2000 [13, 14] normal background level of 1.1 mSv per year but less than the limit of the recommended action level (3-10 mSv per year) as reported by the ICRP-1993.

Although the average effective dose is below the recommended limits, it is necessary to be careful about radon concentration evolution to protect residents against the risks of prolonged radon exposure.

Abbreviations

HSE	House
WHO	World Health Organization
ICRP	International Commission on Radiological Protection

Author Contributions

Kabore Karim: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing

Bambara Telado Luc: Data curation, Validation, Writing – review & editing

Derra Moumouni: Formal Analysis, Investigation

Inoussa Zongo: Formal Analysis, Validation

Francois Zougmore: Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Nero, A. V. (1989). Earth, Air, Radon and Home. Physics Today, 42, 32–39.

[2] Di Carlo, G., et al. (2020). A geogenic approach for the Radon monitoring and the exposure assessment at a regional scale: The results of the Rad_Campania project. Advances in Geosciences, 52, 87–96. https://doi.org/10.5194/adgeo-52-87-2020

[3] Evangelista, H., Pereira, E. B., Fernandes, H. M., & Sampaio, M. (2002). Radon Dynamics and Reduction in an Underground Mine in Brazil. Implications for Workers' Exposure. Radiation Protection Dosimetry, 98(2), 235–238. https://doi.org/10.1093/oxfordjournals.rpd.a006716

[4] Skubacz, K., et al. (2019). Modelling of radon hazards in underground mine workings. Science of the Total Environment, 695, 133853. https://doi.org/10.1016/j.scitotenv.2019.133853

[5] Botha, R. (2022). [Presentation on dosimetry / radon exposure in South African underground mines]. NORM X Conference, Session 7, International Atomic Energy Agency (IAEA). Table 2, “Radon-in-air levels observed in operational South African underground mines”, citing NNR (2013).

[6] El-Hussein, A., Ahmed, A. A., & Mohammed, A. (1998). Radiation dose to the human respiratory tract from inhalation of radon-222 and its progeny. Applied Radiation and Isotopes, 49(7), 783–790. https://doi.org/10.1016/S0969-8043(97)10002-1

[7] ICRP, The 2007 Recommendations of the International Commission on radiological Protection. ICRP Publication 03. Ann. ICRP 37, 2007. pp. 2-4.

[8] Bambara Telado Luc, Kabore Karim, Derra Moumouni, Beogo Cedric, Ousmane Ibrahim Cisse, Francois Zougmore. Assessment of Indoor Radon Concentration in Residential Buildings at Ouagadougou and Estimation of the Annual Effective Dose, Burkina Faso. *Radiation Science and Technology.* Vol. 7, No. 2, 2021, pp. 41-46. https://doi.org/10.11648/j.rst.20210702.14

[9] WHO, 2023, Ionizing radiation and health effects.

[10] UNSCEAR, 2000. Exposure of the public and workers from various sources of radiation, ANNEX B, 2008, pp. 223-293.

[11] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2000. Sources and Effects of Ionizing Radiation, Vol. I Annex A: Dose Assessment Methodologies, New York, 2000.

[12] Norafatin Khalid, Amran Ab Majid, Redzuwan Yahaya and Muhammad Samudi Yasir, 2014. Radiological Risk Assessment of Environmental Radon. The 2013 UKM FST Postgraduate Colloquium, AIP Conf. Proc. 1571, 169-176 (2014); https://doi.org/10.1063/1.4858649

[13] Mirsina Mousavi Aghdam, Stefania DaPelo, Valentina Dentoni, Viviana Fanti, Alessandra Bernardini, Paolo Randaccio, Daniele Chiriu, 2019. Measurements of Indoor Radon Levels and Gamma Dose Rates. Proceedings of the 5th World Congress on New Technologies (NewTech'19) Lisbon, Portugal - August, 2019 Paper No. ICEPR 149. https://doi.org/10.11159/icepr19.149

[14] ICRP, The 2007 Recommendations of the International Commission on radiological Protection. ICRP Publication 103. Ann. ICRP 37, 2007. pp. 2-4.

[15] Amin S. A., S. D. Alalgawi and H. M. Hashimn, 2015. Indoor-radon concentrations and effective dose estimation in Al-Karkh side of Baghdad dwellings. IJST (2015) 39A4: 491-495, Iranian Journal of Science & Technology. http://ijsts.shirazu.ac.ir

[16] Abd-Elmoniem Ahmed Elzain, 2014. A Study Of In Door Ra Don Lev Els And Radon Effective Dose In Dwellings Of Some Cities Of Gezira State In Sudan. Nuclear Technology & Radiation Protection: Year 2014, Vol. 29, No. 4, pp. 307-312.

[17] M. R. Usikalu, C. A. Onumejor, J. A. Achuka, A. Akinpelu, M. Omeje & T. A. Adagunodo, Monitoring of radon concentration for different building types in Covenant University, Nigeria Cogent Engineering (2020), 7: 1759396.

[18] Usikalu, M. R., Onumejor, C. A., Akinpelu, A., & Ayara, W. A. (2018). Improvement on indoor radon accumulation rate in CST laboratories at Covenant University, Ota, Nigeria. International Journal of Mechanical Engineering and Technology (IJMET), 9(10), 135-148. https://doi.org/12909/1/IJMET_09_10_012

[19] armoshenko, I. V., Onishchenko, A. D., Malinovsky, G. P. et al. Radon concentration in conventional and new energy efficient multi-storey apartment houses: results of survey in four Russian cities. Sci Rep 10, 18136 (2020). https://doi.org/10.1038/s41598-020-75274-4

[20] Li, Cong, Jun Deng, Gangtao Sun, Fang Wang, Jie Yu, Qi Xiao, Shi Liu, and Wenshan Zhou. 2025. "Investigation and Analysis of Indoor Radon Concentrations in Typical Residential Areas in Central China" Atmosphere 16, no. 10: 1169. https://doi.org/10.3390/atmos16101169

[21] Danielle Vienneau, Seçkin Boz, Lukas Forlin, Benjamin Flückiger, Kees de Hoogh, Claudia Berlin, Murielle Bochud, Jean-Luc Bulliard, Marcel Zwahlen, Martin Röösli, Residential radon - Comparative analysis of exposure models in Switzerland, Environmental Pollution Volume 271, 15 February 2021, 116356. https://doi.org/10.1016/j.envpol.2020.116356

[22] ICRP, 2014. Radiological Protection against Radon Exposure. ICRP Publication 126. Ann. ICRP 43(3).

[23] CRP (1993) Protection against Radon-222 at Home and at Work. ICRP Publication 65. https://journals.sagepub.com/doi/pdf/10.1177/ANIB_23_2