RAP CONFERENCE PROCEEDINGS, VOL. 9, PP. 53–56, 2024
ISSN 2737-9973 (ONLINE) | DOI: 10.37392/RAPPROC.2024.12
RAP-PROCEEDINGS.ORG

LESSONS LEARNED FROM THE 2022 CAMPAIGN OF THE MEASUREMENT OF INDOOR RADON CONCENTRATION IN DWELLINGS IN ALBANIA

Gerti Xhixha[1], Blerim Rrakaqi[2*], Kozeta Tushe[3], Merita Xhixha (Kaçeli)[4], Njomza Elezaj[5], Ylli Kaçiu[6], Nazim Gashi[7]

[1]Faculty of Natural Sciences, University of Tirana, Tirana, Albania
[2]College Rezonanca, Prishtina, Kosovo
[3]Institute of Applied Nuclear Physics, University of Tirana, Tirana, Albania
[4]University Aleksandër Moisiu, Durrës, Albania
[5]Faculty of Mathematical and Natural Sciences University of Prishtina, Prishtina, Kosovo
[6]University for Business and Technology, Prishtina, Kosovo
[7]Division of Data, Analytics, Planning and Monitoring, UNICEF, New York, USA

Abstract. *Indoor radon concentration in Albania has been investigated to study the influence of measuring indoor radon concentration between living room and bedroom using the CR-39 Solid State Nuclear Track Detectors (SSNTDs). Approximately 60% (out of 69 measurement locations) of the indoor radon measurements were performed in houses, while the remainder in apartments. The average bedroom-living room indoor radon concentration in houses were found to vary from 13 to 454 Bq/m³ with an arithmetic mean of 68 Bq/m³ (median 49 Bq/m³), while in apartments from 24 to 144 Bq/m³ with an arithmetic mean of 54 Bq/m³ (median 47 Bq/m³). The relatively lower concentrations found in apartments is mainly due to apartment floor height, varying from 1st to 7th floor. The ratio of radon concentrations between bedroom/living rooms showed values varying from 0.3 to 4.1 in houses and 0.5 to 3.7 in apartments. The distribution is positively skewed with median value of 1.0 in houses and 1.1 in apartments. The slight difference between houses and apartments can be an indication that the lifestyle is a factor determining bedroom radon concentrations. However, these results support our proposal that radon concentration measured in living room and/or bedroom is representative for the determination of environmental radon exposure of the population in dwellings.*

Keywords: *indoor radon concentration, living room, bedroom, floor*

1. INTRODUCTION

Radon and its progeny on average accounts for about half of all human exposure due to radiation from natural sources [1]. In Albania, several radon concentration measurement campaigns have been carried out in indoor environments, which have made possible the realization of the preliminary map of radon concentration in dwellings based on 247 measurements [2]. The legislation of the Republic of Albania addresses the problem of exposure to radon in indoor environments in the V.K.M. No. 957 [3]. The average annual concentration of radon in the internal environments of workplaces, residential buildings and public buildings should not exceed 300 Bq/m³. However, many studies have shown that long-term exposure to radon in indoor environments at concentration levels of 100 Bq/m³, has resulted in an increased risk of lung cancer [4]. Therefore, it is advisable to measure the indoor environments in order to measure the radon concentration. In general, during national survey campaigns in Albania, testing of radon concentration in indoor environments is carried out by the method of CR-39 passive detectors which are mainly exposed for a period of three months. The primary factor affecting the radon concentration is due to seasonal variation during the measurement period [5-10]. In Albania we apply corrections for measurement periods during spring-summer and autumn-winter only. Other secondary factor affecting radon concentrations is the floor heigh as reported in Tushe et al. (2016) [2], which is overpassed by considering ground-floor data only [11]. On the other hand, the effect on positioning the detector within the dwelling is not investigated yet in Albania. This problem is already studied in various countries [12-15].

This study aims to determine the role of positioning the detector within the dwellings by randomly choosing location in Albania and positioning a pair of detectors both in living room and bedroom. The results obtained from this study will serve as a guide in support of campaigns for the measurement of radon in indoor environments and mainly for the assessment of the annual concentration of radon in indoor environments.

2. MATERIALS AND METHODS

Indoor radon concentration in Albania has been investigated through various campaigns during 1999

* blerim.rrakaqi@rezonanca-rks.com

and 2014, building the first steps toward the realization of the distribution map of radon. The 2022 campaign is a continuation of these campaigns aiming to further study the influence of measuring indoor radon concentration between living room and bedroom. This study is extended throughout the country in order to have a representative result comprising geological and seasonal characteristics of different populated areas. The concentration of indoor radon was investigated for long-term measurement using the passive measurement technique using the CR-39 Solid State Nuclear Track Detectors (SSNTDs). The CR-39 detectors are placed in 69 locations both in living rooms and bedrooms of houses and apartments located on different floors (1st to 7th floor). The detectors were exposed for 3 months at each location during winter and spring seasons and then were collected for reading following the procedure explained in Tushe et al. (2016) [2].

3. Results and Discussion

The results obtained for indoor radon concentration levels in living room and bedroom are shown in Figure 1. The data show a lognormal distribution confirmed using the Kolmogorov-Smirnov test, evidencing the various factors affecting radon concentration indoor. The statistical analysis of each distribution is summarized in Table 1, showing the results from bedroom and living room measurements separately in houses and apartments. The average indoor radon concentration in living room were found to vary from 13 to 454 Bq/m^3 with an arithmetic mean of 63 Bq/m^3 (median 43 Bq/m^3), while in bedroom from 22 to 399 Bq/m^3 with an arithmetic mean of 60 Bq/m^3 (median 40 Bq/m^3). These results show similar distributions and radon concentrations levels for both living room and bedroom. The maximum concentrations in living room (454 Bq/m^3) and bedroom (399 Bq/m^3) corresponds to the same building. The concentrations of radon above 100 Bq/m^3 [4] found in living room generally corresponds to such levels in bedrooms with some exceptions.

The average indoor radon concentration in living rooms were found to vary from 24 to 144 Bq/m^3 with an arithmetic mean of 54 Bq/m^3 (median 47 Bq/m^3) in apartments, while in houses the average indoor radon concentration vary from 13 to 454 Bq/m^3 with an arithmetic mean of 68 Bq/m^3 (median 49 Bq/m^3). Similar behavior was found in bedrooms where in apartments the average indoor radon concentration varied from 25 to 123 Bq/m^3 with an arithmetic mean of 47 Bq/m^3 (median 41 Bq/m^3), while in houses the average indoor radon concentration varied from 22 to 399 Bq/m^3 with an arithmetic mean of 67 Bq/m^3 (median 47 Bq/m^3). The relatively lower concentrations found in apartments is mainly due to apartment floor height, varying from 1st to 7th floor relative to houses where the floor height vary from 1st to 2nd floor.

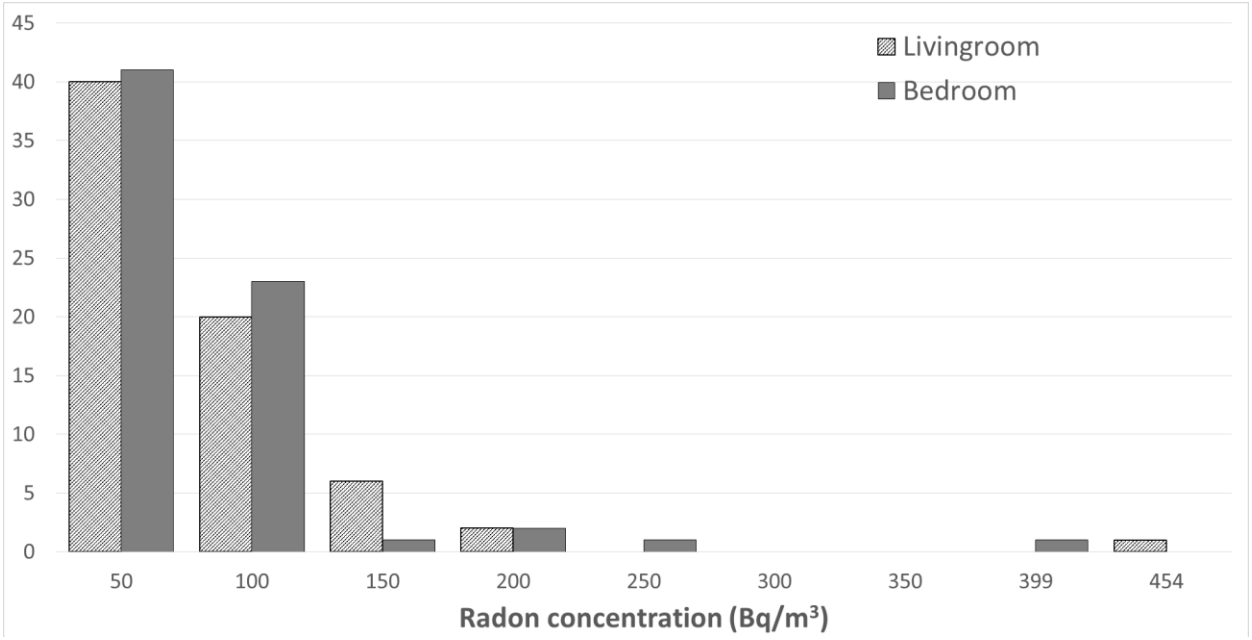

Figure 1. Distribution of indoor radon concentration in living room and bedroom

Table 1. Statistical analysis of radon concentration (Bq/m^3) in living room and bedroom both in houses and apartments

Statistical data	Living room			Bedroom		
	All	Apartment	Houses	All	Apartment	Houses
No. measurements	69	25	44	69	25	44
Min.	13	24	13	22	25	22
Max.	454	144	454	399	123	399
AM	63	54	68	60	47	67
Median	48	47	49	46	41	47
Skewness	5	1.8	4.1	5	2.4	3.9
Curtosis	27	3.2	20.5	27	7.9	18.3

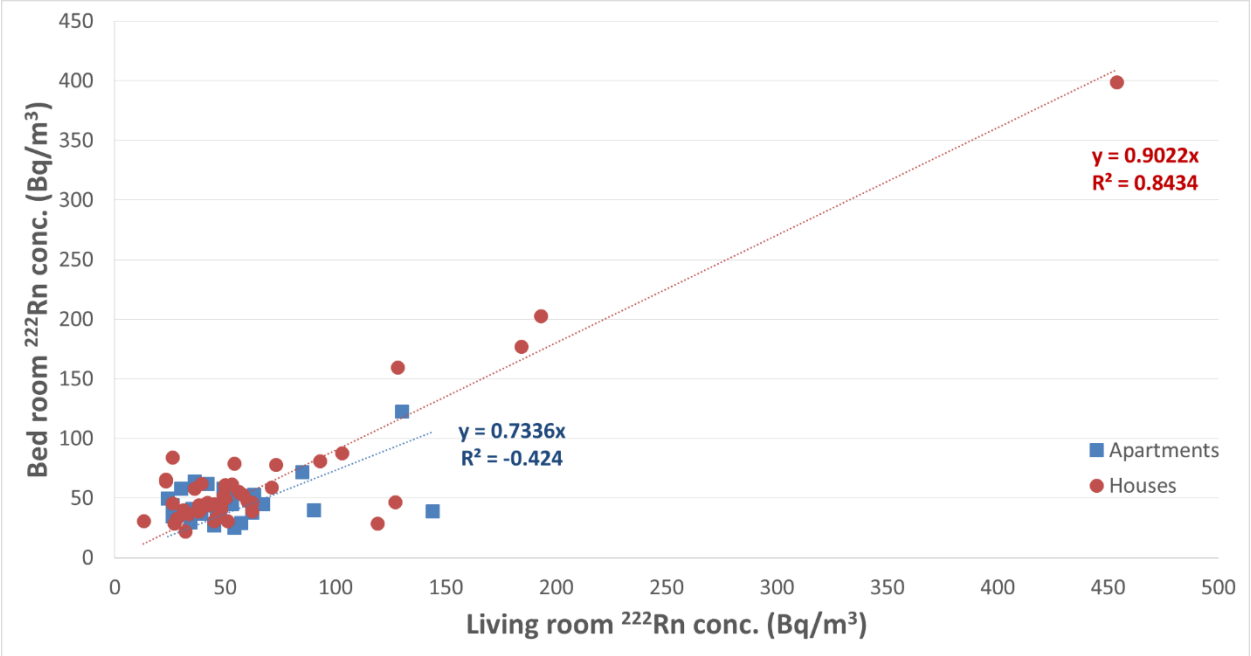

Figure 2. The ratios of radon concentrations between both bedrooms/living rooms in houses and apartments

The ratios of radon concentrations between bedrooms/living rooms (for each pair of measurements separately in houses and apartments) are shown in Figure 2. The ratio of radon concentrations between bedroom/living rooms showed values varying from 0.3 to 4.1 in houses and 0.5 to 3.7 in apartments. The distribution is positively skewed with median value of 1.0 in houses and 1.1 in apartments. The slight difference between houses and apartments can be an indication that the lifestyle is a factor determining bedroom radon concentrations. However, these results support our proposal that radon concentration measured in living room and/or bedroom is representative for the determination of environmental radon exposure of the population in dwellings.

4. Conclusion

Indoor radon concentration levels are measured in both living rooms and bedrooms in 69 dwellings around Albania. From the analysis of these results, we suggest that the national survey can be performed either by placing a detection in living room or bedroom. The slight differences in concentration levels in living rooms and bedrooms could be indication that the lifestyle which seems to be an interesting point for future studies.

References

1. *Sources and effects of ionizing radiation*, vol. 1, UNSCEAR Report (A/55/46), UNSCEAR, New York (NY), USA, 2000.
Retrieved from: https://www.unscear.org/docs/publications/2000/UNSCEAR_2000_Report_Vol.I.pdf
Retrieved on: Jan. 10, 2024
2. K. B. Tushe et al., "First step toward the geographical distribution of indoor radon in dwellings in Albania," *Radiat. Prot. Dosim.*, vol. 172, no. 4, pp. 488 – 495, Dec. 2016.
DOI: 10.1093/rpd/ncv494
3. Qeveria e Shqipërisë. (Nëntor 25, 2015). *Vendim nr. 957 për miratimin e rregullores "Për nivelet e lejuara të përqendrimit të radonit në ndërtesa dhe në ujë, nivelet drejtuese të radionuklideve në materialet e ndërtimit, si dhe nivelet e lejuara të radionuklideve në produktet ushqimore dhe kozmetike"*.
(Government of Albania. (Nov. 25, 2015). *Decision no. 957 on the approval of the regulation "On the permitted levels of radon concentration in buildings and water, the guiding levels of radionuclides in building materials, as well as the permitted levels of radionuclides in food and cosmetic products"*.)
4. The Council of European Union. (Dec. 5, 2013). *Council Directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom.*
Retrieved from: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2014:013:0001:0073:EN:PDF
Retrieved on: Jan. 10, 2024
5. F. Bochicchio et al., "Annual average and seasonal variations of residential radon concentration for all the Italian Regions," *Radiat. Meas.*, vol. 40, no. 2 – 6, pp. 686 – 694, Nov. 2005.
DOI: 10.1016/j.radmeas.2004.12.023
6. P. Bossew, H. Lettner, "Investigations on indoor radon in Austria, Part 1: Seasonality of indoor radon concentration," *J. Environ. Radioact.*, vol. 98, no. 3, pp. 329 – 345, Dec. 2007.
DOI: 10.1016/j.jenvrad.2007.06.006
7. Z. Daraktchieva, "New correction factors based on seasonal variability of outdoor temperature for estimating annual radon concentrations in UK," *Radiat. Prot. Dosim.*, vol. 175, no. 1, pp. 65 – 74, Jun. 2017.
DOI: 10.1093/rpd/ncw270

8. K. Kozak et al., "Correction factors for determination of annual average radon concentration in dwellings of Poland resulting from seasonal variability of indoor radon," *Appl. Radiat. Isot.*, vol. 69, no. 10, pp. 1459 – 1465, Oct. 2011.
DOI: 10.1016/j.apradiso.2011.05.018
9. V. Giagias, D. Burghele, C. Cosma, "Seasonal variation of indoor radon in dwellings from Athens, Greece," *Rom. J. Phys.*, vol. 60, no. 9 – 10, pp. 1581 – 1588, 2015.
Retrieved from: https://rjp.nipne.ro/2015_60_9-10/RomJPhys.60.p1581.pdf
Retrieved on: Jan. 10, 2024
10. Z. Stojanovska et al., "Seasonal indoor radon concentration in FYR of Macedonia," *Radiat. Meas.*, vol. 46, no. 6 – 7, pp. 602 – 610, Jun.-Jul. 2011.
DOI: 10.1016/j.radmeas.2011.04.022
11. G. Cinelli, "Digital version of the European Atlas of natural radiation," *J. Environ. Radioact.*, vol. 196, pp. 240 – 252, Jan. 2019.
DOI: 10.1016/j.jenvrad.2018.02.008
12. H. A. Ghany, "Variability of radon levels in different rooms of Egyptian dwellings," *Indoor and Built Environ.*, vol. 15, no. 2, pp. 193 – 196, Apr. 2006.
DOI: 10.1177/1420326X06063218
13. S.U. Rahman, J. Anwar, M. Matiullah, "Measurement of indoor radon concentration levels in Islamabad, Pakistan," *Radiat. Meas.*, vol. 43, suppl. 1, pp. S401 – S404, Aug. 2008.
DOI: 10.1016/j.radmeas.2008.04.046
14. H. J. Jeon et al., "A preliminary study for conducting a rational assessment of radon exposure levels," *Environ. Sci. Pollut. Res.*, vol. 24, pp. 14491 – 14498, Jun. 2017.
DOI: 10.1007/s11356-017-9030-5
15. K. Badhan, R. Mehra, R. G. Sonkawade, "Studying the variation of indoor radon levels in different dwellings in Hoshiarpur district of Punjab, India," *Indoor and Built Environ.*, vol. 21, no. 4, pp. 601 – 606, Aug. 2012.
DOI: 10.1177/1420326X11419983