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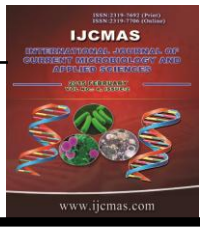

Original Research Article

Difference between the Effective Dose of Radon 222 in Old and New Dwellings; Minab City, Iran

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Keywords

Radon 222, Effective dose, Residential, Indoor air

A B S T R A C T

^{222}Rn is one of radioactive, colorless, odorless elements and has a half -life of 3.83 days is that its' long-term exposure can cause lung cancer in humans. Building materials such as granite stone are one of the main sources of ^{222}Rn gas emissions in indoor air. The ^{222}Rn concentration of indoor and outdoor air of 17 new (Al-Mahdi) and 17 old Dwellings (Pari-Taghi) in two seasons, winter 2013 and spring 2013 was measured by portable Radon meter RTM1688-2 model and the effective dose was calculated by UNSCEAR equation. Then the difference between the effective doses of ^{222}Rn in new and old Dwellings was statistically analyzed. The mean concentration of ^{222}Rn in indoor air of Pari-Taghi (25 ± 3 Bq/m^3) and Al-Mahdi (42 ± 6 Bq/m^3) Dwellings is less than the standards of WHO and EPA. The effective dose of ^{222}Rn in Al-mahdi and Pari-Taghi are 1.06 ± 0.15 and 0.64 ± 0.07 mSv/y, respectively. Effective dose by residents of Al-Mahdi is 5% more than the standard ICRP (1mSv/y) but the effective dose by the residents of the region Pari-Taghi is less than 37 %. Due to greater use of granite in the new Dwellings materials, the concentration of ^{222}Rn and as its consequent, effective dose in new Dwellings is more relative to old Dwellings.

Introduction

Radon 222 (^{222}Rn) is the product of decay radium- 226 (^{226}Ra) in the chain of uranium (^{235}U). It is radioactive, odorless, colorless, with a half-life of 3.83 days (Al-Khateeb *et*

al., 2012; Ju *et al.,* 2012). The alpha ray emitted from ^{222}Rn and its' daughters (^{218}Po and ^{214}Po), in the long term can damage the DNA of lung cells and cause lung cancer) Kávási *et al.,* 2010; Zeeb and Shannoun, 2009). During the day all humans are exposed to ^{222}Rn in air atmosphere (Radiation and Assembly, 1982). The World Health Organization (WHO, 2009) has approved the direct relation between lung cancer increasing and the concentration of ^{222}Rn in the indoor air (Torres-Durán *et al.,* 2014). Environmental Protection Agency (EPA) has announced deaths from indoor air of ^{222}Rn approximately 21,000 people a year, that is 10 times as many deaths from air pollution (Environmental Protection Agency, 2010). WHO and EPA have been proposed guidelines and standard limit 148 Bq/m^3 and 100 Bq/m^3 for ^{222}Rn in indoor air, respectively (Environmental Protection Agency, 2010; World Health Organization, 2009). Global mean of air ^{222}Rn concentration of indoor and outdoor are to the 48 Bq/m^3 and 15 Bq/m^3 respectively (FARID, 2012). United Nations Scientific Committee on the effects of atomic radiation (UNSCEAR), stated the effective dose from natural radiation 2.5 mSv/y that 1 mSv/y is due to ^{222}Rn in air [United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2000] Committee on Radiation Protection (ICRP) expressed the maximum effective dose from inhalation of ^{222}Rn for ordinary people 1 mSv/y ((Protection, 1994). More than 50 percent of the annual effective dose by individuals due to ^{222}Rn is (1.3 mSv /y) (Magill and Galy, 2005; Richard and E, 1987). ^{222}Rn of indoor air (air in homes, apartments, etc.) can result from Dwellings materials (Granite), soil of floor ground, water- rich of ^{222}Rn (warm-water pools) or also the entry of ^{222}Rn from the outdoor air into the indoor air (Saeid Motesaddi, 2014; Somlai *et al.,* 1998). As stated before, the Dwellings materials can be one of the most important sources of indoor air ^{222}Rn. On the other hand, in the new Dwellings for more beauty the particular granite stones are used. Hence in this study tried to calculate and evaluate the effective dose of ^{222}Rn in different old and new Dwellings.

Materials and methods

Area study

Minab city with a population of over 90 Thousands in East of Hormozgan province and is located at a distance of 100 km from the city of Bandar Abbas (the center of province). The city locates at the geographic coordinates 27° 11'53" N and 54° 22'7" E and a height of 45 meters above sea level (Figure 1) (Hassan *et al.,* 2011).

Measurement concentration of ^{222}Rn

First, a newly established region of al-Mahdi (less than 4 years of construction) and an old area called Pari-Taghi (more than 25 years of construction) was selected. ^{222}Rn concentration in air is measured in Bq/m^3, by the portable device RTM1688-2 made by SARAD company in Germany (Figure 2).

The sensitivity of this device in 150 minutes of continuous measuring is 6.5 cts/ min× KBq/m^3 (Ursulean *et al.,* 2012). High sensitivity with alpha spectrometry analysis, leads to a short response time even at low concentrations. According to the measuring instructions provided by the company SARAD, continuous measurement more than 2 hours the device should be placed in slow mode to increase the accuracy (GmbH, June 2007). Measuring at two stages in the winter of 2013 and spring of 2013 was performed. At each stage, the measurement of ^{222}Rn concentration was done in 17 houses of Pari-Taghi and Al-Mahdi (within

the distance of approximately 2500 meters). Due to the measurement of ^{222}Rn concentration in indoor air guideline, measuring was designed for 24 consecutive hours of each house (Environmental Protection Agency). In all Dwelling units are placed at a height of 1 meter and in the living room. After completion of the measurement of ^{222}Rn concentration in indoor air, outdoor air measurements concentration of ^{222}Rn was carried out for 4 hours (background) near the entrance of the house. In sum, at both stages, the 34 measurements of ^{222}Rn were done in indoor air of both areas. Also 34 measurements were done on the background air of both Al-Mahdi and Pari-Taghi areas.

Calculation effective dose of ^{222}Rn

Estimation of annual effective dose by the indoor air ^{222}Rn (E_{Rn}) was conducted by UNSCEAR equation;

Equation 1 E_{Rn} (mSv/y) $=C_{Rn} \times 0.4\times7000\times9\times10^{-6}$

In this equation: Geometric mean concentrations of indoor air ^{222}Rn (Bq/m^3), 0.4 is equilibrium factor of decay products of ^{222}Rn, 7000 (h/y) is equal to 80% of the year (the settlement) and 9 is (nSv/Bq.m^3.h) feed conversion ratio of ^{222}Rn concentration to annual effective dose and 10^{-6} conversion ratio of nano Sv /mSv [United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2000].

Calculation of the risk of lung cancer

To calculate the probability of a lung cancer cases per million people (CPPP) by effective dose from ^{222}Rn, equation 2 was used (Ismail and Jaafar, 2010; Mansour *et al.*, 2005).

Equation 2

$CPPP = E_{Rn}\times18\times10^{-6}$ mSv^{-1}.y

Statistical analysis

Statistical analysis of the data and determination of the difference between effective doses by the old and new dwellings by Paired Samples Test, were performed in software EXCEL and SPSS16.

Result and Discussion

The mean and the annual range of ^{222}Rn concentration in indoor air of Pari-Taghi areas are 25±3 Bq/m^3 and 45 ± 6 -8 ± 1 Bq/m^3, respectively. The mean and range concentrations of background air of ^{222}Rn are 12±2 and 21±3-7±1 Bq/m^3, respectively. The highest and lowest concentrations of ^{222}Rn in the indoor air of dwellings is 8 (45 ± 6 Bq/m^3) and 15 (8 ± 1 Bq/ m^3) (Table 1). The mean and annual ranges concentration of ^{222}Rn indoor air of Al-Mahdi is 42 ± 6 Bq/m^3 and 67±10 -14±2, respectively. Also the mean and range of annual background air of ^{222}Rn is 17 ± 3 and 25±4-9±1 Bq/m3, respectively. The highest and lowest concentrations of ^{222}Rn indoor air of the dwelling No. 2 are (67 ± 10 Bq/m^3) and 14 (14 ± 2 Bq/m^3) (Table 2).

The mean indoor air Concentration of ^{222}Rn relative to WHO and EPA standards are 16.8 % and 25 %, respectively. The mean indoor air Concentration of ^{222}Rn in any dwellings is not more than WHO and EPA standard (Figure 2).

The mean concentration of ^{222}Rn indoor air relative to WHO and EPA standards are 28.3% and 42 %, respectively (Figure 3). Like the Pari-Taghi area, Al-Mahdi the concentration of ^{222}Rn indoor air of all dwellings is less than the WHO guideline

and EPA standard limit. Paired Samples Test showed that there is significant difference between the concentrations of ^{222}Rn in the indoor and outdoor, in Pari-Taghi with p value = 0.007 and Al-Mahdi with p value = 0.003 (p value<0.05). Significant difference between concentration ^{222}Rn in old (Pari-Taghi) and new dwellings (Al-Mahdi) indicate that both is source ^{222}Rn.

The annual mean effective dose of ^{222}Rn in Pari-Taghi and Al-Mahdi and are 1.06 ± 0.15 and 0.64 ± 0.07 mS/y, respectively. Effective dose by residents of the Al-Mahdi is 5% more than standard ICRP (1mSv/y) but effective dose by residents Perry is 37% less. The mean effective dose in Al-Mahdi is 65% more than Pari-Taghi (p value<0.05). This significant difference can only be due to the difference in air conditioning and dwellings materials (Kitto *et al.*, 2009; Organization, 2009).

Table.1 The mean concentration of 222Rn (M±SE) of indoor and outdoor air of dwellings in Pari-Taghi, Minab city in Bq/m3

	Winter 2013		Spring 2013		Annual mean	
Dwellings	[1]outdoor	[2]Indoor	outdoor	Indoor	outdoor	Indoor
1	19±2	39±5	17±2	27±4	18±2	33±4
2	26±3	47±6	5±1	37±5	15±2	42±5
3	5±1	11±1	11±1	18±2	8±1	14±2
4	11±1	24±3	16±2	34±4	13±2	29±4
5	13±2	29±4	15±2	18±2	14±2	23±3
6	17±2	37±5	5±1	9±1	11±1	23±3
7	26±3	48±6	16±2	34±4	21±3	41±5
8	21±3	51±7	12±2	39±5	16±2	45±6
9	3±0.4	9±1	11±1	27±4	7±1	18±2
10	12±2	19±2	5±1	17±2	8±1	16±2
11	4±1	26±3	3±0.4	14±2	3±0.6	20±3
12	8±1	28±4	6±1	5±1	7±1	16±2
13	16±2	23±3	9±1	29±4	12±2	26±3
14	15±2	7±1	17±2	36±5	16±2	21±3
15	11±1	9±1	11±1	7±1	11±1	8±1
16	15±2	35±5	14±2	19±2	14±2	27±4
17	21±3	47±6	5±1	9±1	13±2	28±4
GM[3]	14±2	28±4	10±1	22±3	12±2	25±3
SD[4]	7.02	14.73	4.87	11.39	5.95	13.06

The mean and annual ranges concentration of ^{222}Rn indoor air of Al-Mahdi are 42 ± 6 Bq/m^3 and 67±10 - 14±2, respectively. Also the mean and range of annual background air of ^{222}Rn is 17 ± 3 and 25±4-9±1 Bq/m3, respectively. The highest and lowest concentrations of ^{222}Rn indoor air of the dwelling No. 2 are (67 ± 10 Bq/m^3) and 14 (14 ± 2 Bq/m^3) (Table 2).

[1] 4 hour mean
[2] 24 hour mean
[3] Geometric mean
[4] Standard deviation

Table.2 The mean concentration of ^{222}Rn (M±SE) of indoor and outdoor air of dwellings in Al-Mahdi, Minab city in Bq/m^3

Dwellings	Winter 2013		Spring 2013		Annual mean	
	outdoor	Indoor	outdoor	Indoor	outdoor	Indoor
1	19±3	71±11	13±2	56±8	16±2	63±10
2	21±3	59±9	26±4	74±11	23±4	67±10
3	13±2	84±13	11±2	48±7	12±2	66±10
4	16±2	59±9	27±4	17±3	21±3	38±6
5	11±2	37±6	4±1	5±1	7.5±1	21±3
6	14±2	19±3	8±1	28±4	11±2	23±4
7	9±1	53±8	21±3	74±11	15±2	64±10
8	29±4	17±3	29±4	64±10	29±4	40±6
9	34±5	76±11	33±5	35±5	33±5	56±8
10	19±3	46±7	11±2	15±2	15±2	30±5
11	11±2	58±9	7±1	33±5	9±1	45±7
12	13±2	39±6	26±4	19±3	20	29±4
13	14±2	15±2	4±1	17±3	9±1	16±2
14	9±1	4±1	16±2	24±4	12±2	14±2
15	17±3	19±3	5±1	55±8	11±2	37±6
16	18±3	68±10	21±3	64±10	19±3	66±10
17	34±5	47±7	17±3	37±6	25±4	42±6
GM	17±3	45±7	16±2	39±6	17±3	42±6
SD	8	24	9	22	9	23

Figure.1 Minab city in East of Hormozgan province and south of Iran

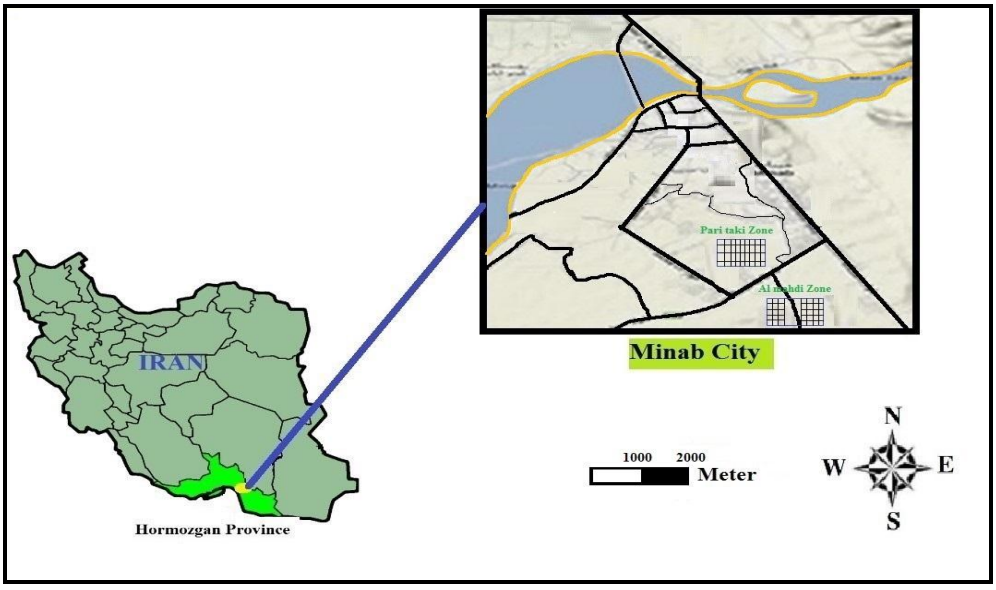


Table.3 The annual effective indoor air of ^{222}Rn in dwellings of Al-Mahdi and Pari-Taghi

dwellings	Pari-Taghi area			Al-Mahdi area		
	Lung cancer risk	^{222}Rn concentration (Bq/m^3)	Effective dose (mSv/y)	Lung cancer risk	^{222}Rn concentration (Bq/m^3)	Effective dose (mSv/y)
1	14.97	33±4	0.83±0.1	28.80	63±10	1.60±0.25
2	19.05	42±5	1.06±0.12	30.16	67±10	1.68±0.25
3	6.58	14±2	0.37±0.05	29.94	66±10	1.66±0.25
4	13.15	29±4	0.73±0.1	17.24	38±6	0.96±0.15
5	10.66	23±3	0.59±0.07	9.53	21±3	0.53±0.07
6	10.43	23±3	0.58±0.07	10.66	23±4	0.59±0.1
7	18.60	41±5	1.03±0.12	28.80	64±10	1.60±0.25
8	20.41	45±6	1.13±0.15	18.37	40±6	1.02±0.15
9	8.16	18±2	0.45±0.05	25.17	56±8	1.40±0.2
10	8.16	16±2	0.45±0.05	13.83	30±5	0.77±0.12
11	9.07	20±3	0.50±0.07	20.64	45±7	1.15±0.07
12	7.48	16±2	0.42±0.05	13.15	29±4	0.73±0.1
13	11.79	26±3	0.66±0.07	7.26	16±2	0.40±0.05
14	9.75	21±3	0.54±0.07	6.35	14±2	0.35±0.05
15	3.63	8±1	0.20±0.02	16.78	37±6	0.93±0.15
16	12.25	27±4	0.68±0.1	29.94	66±10	1.66±0.25
17	12.70	28±4	0.71±0.1	19.05	42±6	1.06±0.15
Mean	11.58	25±3	0.64±0.07	19.16	42±6	1.06±0.15

Figure.2 A portable device Radon meters RTM1688-2 model for measuring the concentration of ^{222}Rn in in water, soil and air, made by SARAD Germany

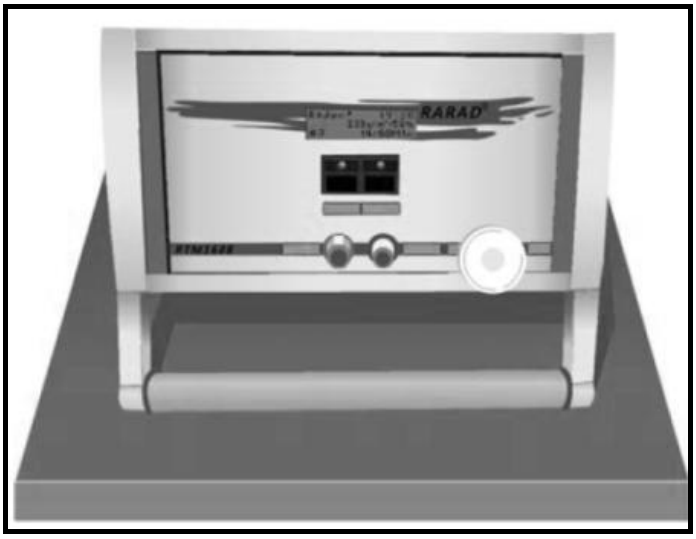


Figure.2 Comparison of concentration ^{222}Rn indoor air and background on the WHO and EPA standards in Pari-Taghi (old dwellings)

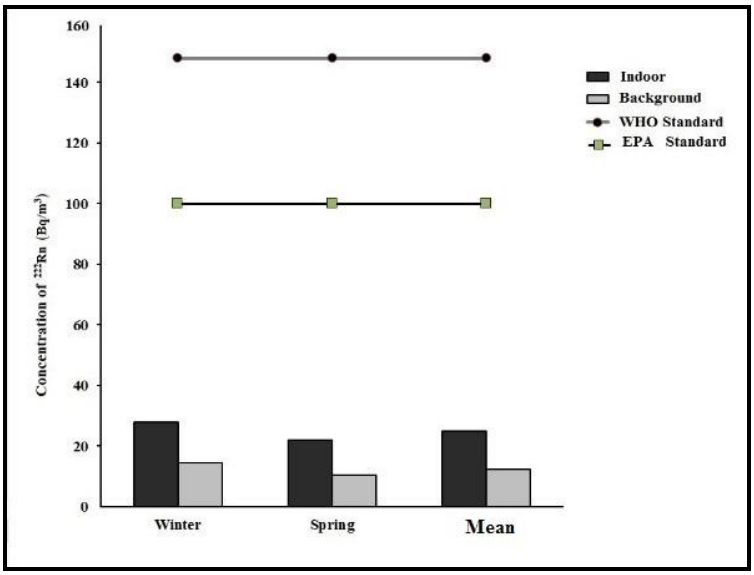
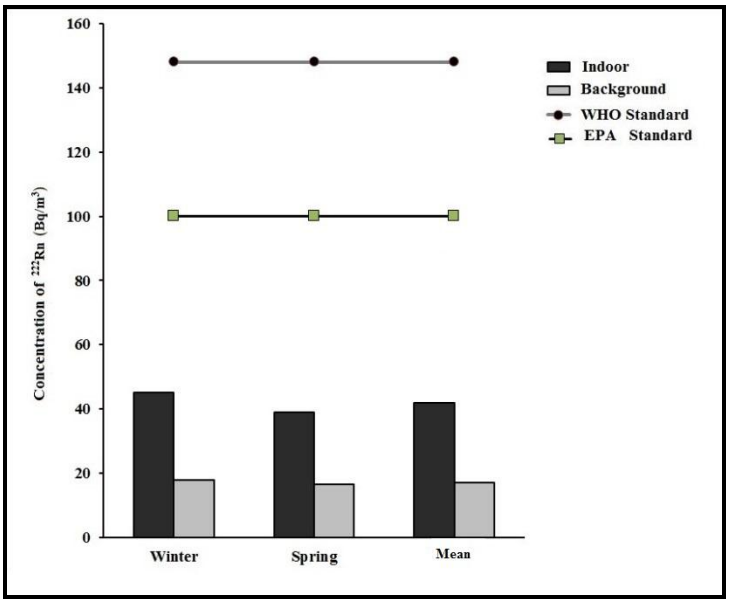


Figure.3 Comparison mean concentration of ^{222}Rn in indoor and outdoor air on the WHO and EPA standards in the dwellings area of Al-Mahdi



Since the statistical analysis didn't show any significant difference between the background concentrations of ^{222}Rn of Al-Mahdi (17 ± 3 Bq/m^3) with Pari-Taghi area (12 ± 2 Bq/m^3) (p value>0.05). So, cannot know the more of ^{222}Rn concentration in outdoor air in Al-Mahdi as the reason for the more indoor air concentrations of ^{222}Rn in the area of Al-Mahdi. However, in recent years the use of different stones particularly granite stone in kitchen floor and housing construction has increased a lot. From 17 dwellings area just in three dwellings in Al-Mahdi, 15, 6 and 4, granite stones were not used. Also in Pari-Taghi area just in two dwellings 17 and 8 granite was used. Mean risk of lung cancer in Al-Mahdi and Pari-Taghi is 19.16 and 11.58 which is much lower than the standard ICRP (170-230 lung cancer) (Table 3) (Protection and ICRP, 1994).

New and old Dwellings in the city of Minab are ^{222}Rn sources. Unlike the Pari-Taghi, the effective dose by Al-Mahdi is more than standard ICRP (1mSv/y) limit. Use of granite stones in the new Dwellings lead to increasing the concentration of ^{222}Rn and then to increasing the effective dose and the risk of lung cancer.

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References

Al-Khateeb, H.M., Al-Qudah, A.A., Alzoubi, F.Y., Alqadi, M.K., Aljarrah, K.M. 2012. Radon concentration and radon effective dose rate in dwellings of some villages in the district of Ajloun, Jordan. *Appl. Radiat. Isotopes*, 70: 1579–1582.

Environmental Protection Agency, EPA Indoor Radon and Radon Decay Product Measurement Device Protocols.http://www.epa.gov/ radon/ pubs/devprot3.htm

Environmental Protection Agency, 2010. Consumer's Guide to Radon Reduction.

FARID, S.M. 2012. A study on the radon concentrations in tobacco in Jeddah (Saudi Arabia) and the associated health effects. *Med. J. Islamic World Acad. Sci.*, 20: 84-93.

GmbH, S., June 2007. APPLICATION NOTE AN-003_EN: Measurement of the Radon concentration of water samples.

Hassan, V., Arash, R., Mehdi, J., Ahmad, R., Ali, H.-B.A., Wali, Y.A., Ali, D., AbdulRasool, M., Abbas, P. 2011. Demonstration of malaria situation analysis, stratification and planning in Minab District, southern Iran. *Asian Pacific J. Trop. Med.*, 4: 67–71.

Ismail, A.H., Jaafar, M.S. 2010. Indoor radon concentration and its health risks in selected locations in Iraqi Kurdistan using CR-39 NTDs, Bioinformatics and Biomedical Engineering (iCBBE), 2010 4th International Conference on. IEEE, Pp. 1–8.

Ju, Y.-J., Ryu, Y.-H., Dong, K.-R., Cho, J.-H., Lee, H.-K., Chung, W.-K., 2012. Study on measurement and quantitative analysis of Radon-222 emitted from construction materials. *Ann. Nucl. Energy*, 49: 88–95.

Kávási, N., Somlai, J., Szeiler, G., Szabó, B., Schafer, I., Kovács, T. 2010. Estimation of effective doses to cavers based on radon measurements carried out in seven caves of the Bakony Mountains in Hungary. *Radiat. Measurements*, 45: 1068–1071.

Kitto, M.E., Haines, D.K., Arauzo, H.D. 2009. Emanation of radon from household granite. *Health Phys.,* 96: 477-482.

Magill, J., Galy, J. 2005. Radioactivity Radionuclides Radiation, 1 ed. Springer, Berlin Heidelberg NewYorK.

Mansour, H., Abdulla, H., Muhamad, N., Othman, M., Qader, S. 2005. Measurement of indoor radon levels in Erbil capital by using solid state nuclear track detectors. *Radiat. Measurements,* 40: 544–547.

WHO, 2009. WHO handbook on indoor radon: a public health perspective. World Health Organization, Geneva.

Protection, I.C.O.R., 1994. Age-dependent doses to members of the public from intake of radionuclides: part 2 ingestion dose coefficients: a report of a Task group of Committee 2 the International commission on radiological protection. Elsevier Health Sciences.

ICRP, 1994. ICRP Publication 66: Human Respiratory Tract Model for Radiological Protection. Elsevier Health Sciences.

Radiation, U.N.S.C.O.T.E.O.A., Assembly, U.N.G., 1982. Ionizing radiation: sources and biological effects: 1982 report to the General Assembly, with annexes, United Nations.

Richard, C.C., E, S.J. 1987. Environmental radon. Springer.

Saeid Motesaddi, Y.F., Ali Alizadeh, Seyed Mohsen Mohseni, Saeedeh Jafarzadeh, 2014. Effective dose of Radon222 and thoron220 in the indoor air of Genow hot springs of Bandar Abbas. *Adv. Environ. Biol.,* 8: 453–459.

Somlai, J., Horvath, M., Kanyar, B., Lendvai, Z., Németh, C. 1998. Radiation hazard of coal-slags as building material in Tatabánya town (Hungary). *Health Phys.,* 75: 648–651.

Torres-Durán, M., Barros-Dios, J.M., Fernández-, A., Ruano-Ravina, V.A. 2014. Residential radon and lung cancer in never smokers. A systematic review. *Cancer Lett. J. Environ. Radioactivity,* 345: 21–26.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 2000. Sources and Effects of Ionizing Radiation; United Nations Scientific Committee on the Effects of Atomic Radiation, USA.

Ursulean, I., Coreţchi, L., Chiruţă, I., Virlan, S. 2012. Estimation of indoor radon concentrations in the air of residential houses and mines in the republic of moldova, Paper presented at the First East European Radon Symposium–FERAS.

World Health Organization, 2009. Sets radon action level of 2.7 - less lung cancer risk than EPA 4.0. Global Press Release Distribution.

Zeeb, H., Shannoun, F. 2009. WHO handbook on indoor radon, A PUBLIC HEALTH PERSPECTIVE. World Health Organization, Geneva, Switzerland.