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Short Communication

Analysis of Seasonal Variation of Indoor Radon Concentration in Dwellings in Mitrovica, Kosova

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Abstract:

The seasonal variation analysis of indoor radon concentration has been carried out in selected public buildings in Mitrovica. Measurements were performed with Continuous Radon Monitor Model CRM-510. Mitrovica has been chosen for this study since it is a post-industrial town in which many former industrial objects are been used for other public purposes. According to the findings of this study the estimated annual average indoor radon concentration in the houses surveyed depend on season and ranges from 184.3 Bqm^{-3} to 299.4 Bqm^{-3}. Nevertheless, in particular, higher values of radon concentration have been found in Battery Factory which range from 450.4 Bqm^{-3} to 660.2 Bqm^{-3}. The season/annual ratios for different type of dwellings varied from 1.01 to 1.9. The mean annual estimated effective dose received by the residents of the studied locations was estimated to be 1.60 mSvy^{-1}. to 4.01 mSvy^{-1}. The annual estimated effective dose is close to the recommended action level.

Keywords: Indoor, seasonal measurement, radon, concentration, exposure dose, dwelling

1.0 Introduction:

Radon and its short-lived decay products in the atmosphere are the most important contributors to human exposure from natural sources. It is well known that inhalation of the short-lived decay products of 222 Rn (Radon), and to a lesser extent the decay products of 220 Rn (Thoron), and their subsequent deposition along the walls of the various airways of the bronchial tree provide the main pathway for radiation exposure of the lungs. This exposure is mostly produced by the alpha particles emitted by several of these radionuclide, although some beta particles and gamma radiation are also emitted (UNSCEAR 2000). The risk posed by Radon is so high that only tobacco smoking is a higher cause for lung cancer (USEPA, 2003).

Although radon is used as a tracer in studying movement of air and water masses on local and global scales, as a tool in mineral exploration, as an indicator of activity of fault zones and as an earthquake precursor, we are mostly concerned about its negative aspects. It has become clear that, on the world wide average, breathing air contaminated by radon and thoron contributes more than half to the effective dose a member of the general public receives from all natural radioactive sources of ionizing radiation. (Janja Vaupotic *et al*., 2008)

Radon's half-life of 3.8 day is long enough for it to enter into the indoor environment and to cause an increase in indoor concentrations, but it is relatively too long to be inhaled into the respiratory tract and to irradiate cells (Yuji Yamada *et al*., 2006). The measuring units for Radon-222 are Bqm-3. Measuring the concentration of radon was done in total of 17 rooms, and came up with values which are between 119 Bqm-3 and 564 Bqm-3. In order to reduce the concentration of radon, we have built a ventilation pump, and then we performed repeated measurements and finally came with results between 130-170 Bqm-3 Measurements were done during March, April and December of 2009.

The city of Mitrovica is surrounded with mines of Trepqa. These mines contain high level of Lead which leads to many people being diagnosed with lung cancer. The main purpose of this research is to calculate the concentration of radon and take the necessary steps in protecting and reducing the number of people being affected by lung cancer as a consequence of high concentration of radon on the environment.

2.0 Methods:

We only measured the level of Radon in public buildings in the city of Mitrovica, which are frequented by an average of 9500 people a day altogether, mainly children. Measurements are performed in different levels of buildings including: undergrounds, ground floor, first and second floors that have a maximum altitude of 10 m above the surface of the earth. The level of Radon-222 was measured using the following instrument; Continuous Radon Monitor Model CRM-510 made from FEMTO-TECH, INC. USA.

Figure 1: Map of the Republic of Kosova

CRM-510 is a portable instrument and collects data for four straight days in a 'passive' position. The instrument does measurements of Rn-222 level, and registered the temperature, relative humidity, and atmospheric pressure. This instrument does the records only the alpha particles.

Figure 2: Radon Monitor Model CRM-510

CRM-510 was placed at 1-1.5 meter height, and 30–40 cm distance from walls, the measured of Radon concentration for 24 straight hours and a specified position. In order to better elaborate the results, we take in consideration the temperature, relative humidity and atmospheric pressure, which for this location are. Temperature 13°C-23°C, Relative humidity 43%-56% and Atmospheric pressure 85kPa-88kPa. After performing all these procedures, we have gained the results for indoor concentration of Radon in the air, and equivalent dose.

3. 0 Results and Discussion:

Indoor air radon concentration is expressed in Bqm^{-3} presented in the table 1.

Table1. Indoor Air Radon Concentration in Closed Buildings in Mitrovica

Sr.No.	Place	Room	Floor	C_{Rn222} (Bqm^{-3})		
				March	**July**	**December**
1)	[a]E. School	V-a	**B**	279	245	295
2)	[a]E. School	VI-d	**G**	221	202	265
3)	[a]E. School	III-a	**G**	234	212	253
4)	[a]E. School	IX-c	**I**	202	176.2	119
5)	Gymnasium	10-a	**B**	270	262	285
6)	Gymnasium	11-c	**G**	293	290	299
7)	Gymnasium	11-f	**G**	260	255	263
8)	Gymnasium	12-a	**I**	248	240	280
9)	Kindergarten	Room-1	**B**	260	235	287
10)	Kindergarten	Room-3	**G**	206	184.3	218
11)	Kindergarten	Room-5	**G**	231	221	243
12)	Kindergarten	Kitchen	**I**	198	180	208
13)	[b]B. Factory	Room A1	**B**	643	650	664
14)	B. Factory	Room A2	**B**	623	638	660
15)	B. Factory	Room B1	**G**	563	550	570
16)	B. Factory	Room C5	**I**	495	499	409
17)	B. Factory	Room C7	**II**	450	457	492

B = basement, **G** = ground floor, **I** = first floor, **II** = Second floor, [a]**E. Scholl** = Elementary School 'Migjeni', [b]**B. Factory** = Battery Factory.

The distribution of radon concentration is showed in figure3. Average values of radon concentration and Average Equivalent dose for each building showed in table II.

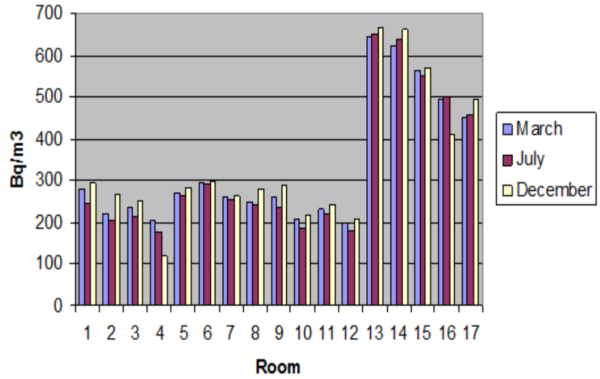

Figure 3: The distribution of radon concentration in closed buildings for each month in Mitrovica. (The numbers on the horizontal axis are the same as in table 1)

If we compare the average values of the premises, it thus appears that these values are smaller than the values allowed by the ICRP. According to the ICRP (International Commission on Radiological Protection) the value 600 Bqm-3 should not be passed for a closed space (Vaupotic, 2003). Also in addition dwelling constructed after 1980 seem to present higher average radon concentration than older constructed dwelling *(Manousakas et al. 2010)*. It is attributed to the higher ^{226}Ra content to cement used for concrete production, due to the addition of fly ash (Papaefthymiou and Gouserti, 2008).

Table 2: Average values of radon concentration and Average Equivalent dose for each building

Buildings	**Average value of Radon contraction** $Bq \cdot m^{-3}$	**Equivalent Dose mSv/yr**
E. School	225.66	1.62
Gymnasium	270.40	1.94
Kindergarten	222.60	1.60
B. Factory	557.50	4.01

The effective dose caused by exposure to the decay products of radon was estimated using the following equations:

$$H_{Rn} = EERC \cdot t \cdot DCF_{Rn} \quad (0.1)$$

Where:
HRn: Annual effective dose for radon decay products (mSv/yr).
EERC: Equilibrium equivalent radon concentration (Bq/m3).
t: Time in hours of indoor exposure in a year (=2000 h).
DCFRn: Dose conversion factor for radon (=9 nSv/h/Bq-m3).

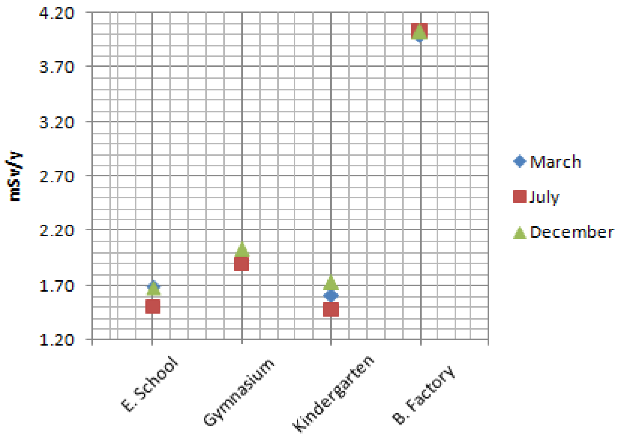

Figure 4: Average Values of Equivalent Dose for each Building

Approximately same results are presented in paper of Jing Chen (2010) and Karpinska *et al.* (2004). In this study, EERC was calculated using an equilibrium factor of 0.4 for radon. The dose conversion factors DCFRn and EERC are provided by the UNSCEAR report (UNSCEAR, 2000). Example we can calculate using the data shown in first row (average value) of Table II. Average of values of radon concentration and Equivalent dose for each building, the effective dose in indoor environments was estimated to be 1.62 mSv/yr (=225.66 · 0.4 · 2000 · 9/1,000,000) for radon decay products. The distribution of average equivalent dose is showed in figure 4.

4. Conclusion:

Indoor air radon (222Rn) concentrations obtained in March, July and December in 17 rooms. Average values were calculated both independently from each other, and also a total average value was derived for all buildings together. The average value of radon in Elementary school "Migjeni" is 225.66 Bqm-3, and equivalent dose is 1.62 mSv/yr, in Gymnasium the radon is 270.4 Bqm-3, the equivalent dose is 1.64 mSv/yr in Kindergarten the value of radon is 222.6 Bqm-3, the equivalent dose is 1.60 mSv/yr and in the Factory of Battery the average value is 557,50 Bqm-3, and the dose is 4.01 mSv/yr.

The main purpose of these measurements was to determine the concentration of radon in the above-mentioned buildings, but especially Factory of Battery. The workers in this building where spend a good amount of time. It was essential to let the staff know about these values and take the needed steps to prevent any health complication.

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