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Measurement of Radon Concentration in Dwelling Houses in Rahovec City, Republic of Kosovo

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Abstract: Radon concentration measurements have been carried out in the selected dwelling houses in Rahovec city, using continuous radon monitor Model CRM-510. This study has covered a region of Kosovo which has not investigated before for radon concentration and the scope of this study is to contribute on Kosovo Radon Map, which is not still completed. Also, has been analysed the impact of age of buildings, type of walls and windows on selected dwelling houses chosen for radon concentration measurements. The average radon concentration on living room has been found to vary from 103.7 ± 19.8 Bq/m3 to 207.1 ± 48.1 Bq/m3. The annual effective dose is found to be lower than action levels of annual effective dose recommended by International Commission of Radiation Protection (ICRP).

Keywords: Radon Concentration, Indoor, dwelling houses, effective dose, exposure dose.

I. INTRODUCTION

Natural radiation has always been part of environment and it's main components are: cosmic radiation, radiations from radionuclides found in rocks, soil, food and air that we breathe.

In our modern times, more and more attention must be paid to the protection against environmental radiation, since it is well known that concentrations of radon and its decay products significantly increase health risk to the population. Based on the scientific studies, world health organization (who) concluded that there exists clear evidence that radon causes the lung cancer among the general population in concentrations found in dwelling houses [1]. According to the report of scientific council of united nations for the impact of atomic radiation (uncear) [2], 85.4 % of annual effective dose of the earth's population, comes from natural radiation, whereas according to the 2008 report of idaho state university (isu) radon causes on average 55 % of the annual effective dose per capita in usa [3].

Radon is a natural radioactive gas. The main source of radon (^{222}Rn) is soil, which contains radium (^{226}Ra), which on the other side through alpha decay gives the gaseous radon. Radon runs toward the Earth's surface, emerges, mixes with the air and runs away toward the atmosphere. Since we breathe the air, we breathe the radioactive gas radon as well [4]. Half-life of radon is 3.824 days and through its decay the short-living daughters are created ^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Po, and the long-lived stable daughter ^{210}Pb with the half-life 22.3 years [5]. Radon decays through alpha decay into the ^{218}Po, where the energy of the emitted alpha particle is 5.49 MeV. Polonium is a metal whose atoms are sticked to the particles of dust or deposited on the surfaces that they reach, i.e., the walls of premises, furniture and certainly the interior of the lungs [6, 7].

Similar studies are done for different regions of Kosovo; their conclusions are that the radon concentration for dwelling did not exceed 400 Bq/m^3 [8, 9, 10]. Also, has been performed studies about radon concentration in underground working places, which shows that the average of radon concentration for miners varied from 191 Bq/m^3 up to 597 Bq/m^3 [11] and for Gadime cave workers were exposed to radon concentration from 400 Bq/m^3 up to 1700 Bq/m^3 [12].

This study is covering the area which has not investigated before and it will contribute to increase information of radon concentration for indoor environment in state level. Thus, the scope of this study is to contribute on Kosovo Radon Map, which is not still completed.

II. MATERIALS AND METHODS

In southwest Kosova, bordering the municipalities of Gjakova, Klina, Suhareka, and Prizren, lies the Municipality of Rahovec. The municipality covers an area of approximately 276 km2 and contains 35 villages. By North its bordered with the municipality of Klina with a border distance of 45 kilometers, by North Eastern it is bordered with the municipality of Malisheva with a border distance of 16 kilometers, by South Eastern with municipalities of Suhareka and Mamusha, by South it is bordered with municipality of Prizren with a border line of 25 kilometers, by West it is bordered with the municipality of Gjakova with a border distance of 28 kilometers, and it

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has a distance of 60 kilometers with Prishtina (Kosovo capital city). In 2014 the town had a total population of 23,200 and the population of the municipality was 58,214. Location of Rahovec town and homes under the study are presented on figure 1.

For this study eight dwelling houses in region of Rahovec city are selected to measure radon concentration and more or less those cover the area in homogeneity. All surveys were performed at first floor of private home and those places are used by owners like as living room.

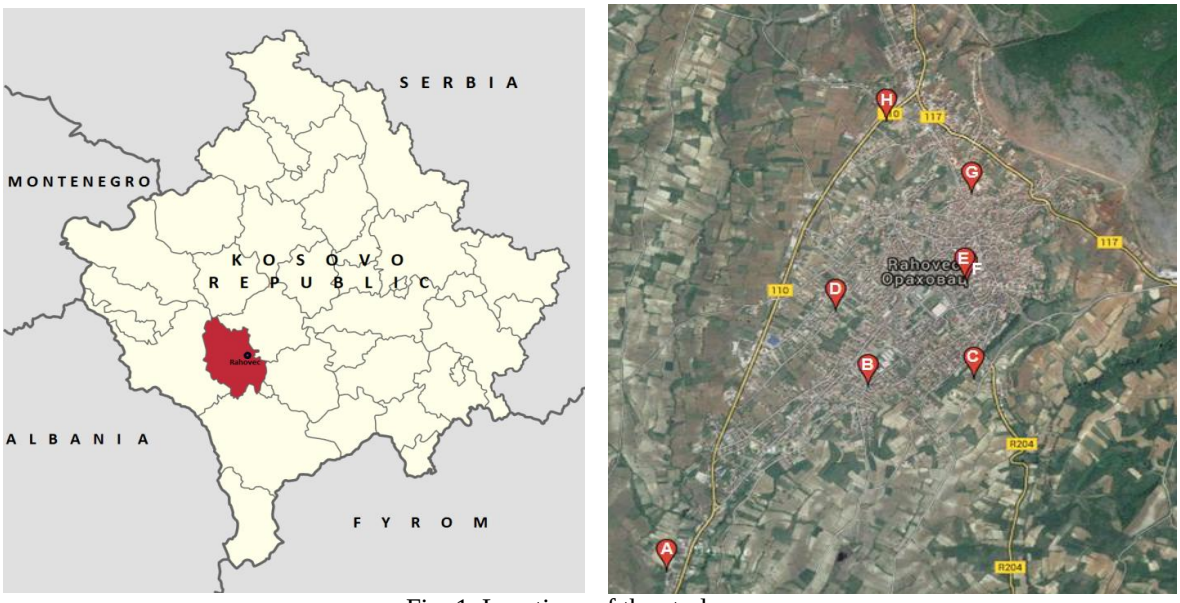

Fig. 1. Locations of the study area

To analyse relationship between radon concentration and different characteristics of homes where measurements were performed, is prepared Table #1.

Measurements of radon concentration were carried out with the Continuous Radon Monitor (CRM) Model 510 (manufactured by femto-TECH, USA), that operates according to the principle of the ionizing chamber. The device provides up to 96 hours of continuous measurement of radon concentration and the determination of other secondary parameters, such as environment temperature, relative air humidity and atmospheric pressure. The counter is placed at the height of breathing organs (~1.0 m), turned on and left at least 44 hours (up to 96 hours) in one position.

TABLE I SPECIFICITIES OF THE 8 HOUSES WHERE INDOOR RADON MEASUREMENTS WERE PERFORMED

Variables	Categories	% [Number]
Building age	0-25	62.5 [5]
	25-50	25.0 [2]
	> 50	12.5 [1]
Walls	stone	12.5 [1]
	brick	87.5 [7]
Window type	wooden	37.5 [3]
	PVC	62.5 [5]

To ensure continued confidence in the accuracy of the measurements, a calibration of the instrument is performed as recommended by the manufacturer. The last calibration included technical maintenance, determination of background level and conversion factor. Conversion factor, as per calibration, that is utilized by the instrument to evaluate the data is $(8.10 \pm 0.3) \times 10^{-3}$ CPM per Bq/m^3.

III. RESULTS AND DISCUSSIONS

Results of measurements of radon concentration and other additional environmental parameters like temperature, relative air humidity and atmospheric pressure are shown in the Table #2. Also, annual effective dose is calculated and presented on the same table.

According to UNSCEAR report [2], the annual effective dose E (mSv/y) to the public from radon concentration and its progeny is estimated by the following equation:

$$E = C \cdot F \cdot H \cdot T \cdot D$$

where:
C –Radon Concentration (Bq/m^3);
F – is equilibrium factor (0.4)
H – is occupancy factor (0.8)
T – Time in hours in year (8760 h/y)
D – Dose conversion factor (9.0×10^{-6} mSv Bq/m^{3}h), it is effective dose received by adults per unit of radon concentration per unit of air volume.

The annual effective doses calculated by radon concentrations on surveyed living rooms under this study were 1.6, 7.9 and 4.1, for minimum, maximum and mean value, respectively.

According to ICRP 2011 [13] the action levels of annual effective dose from radon concentration in dwellings should be set within a range 3-10 mSv/y.

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Buildings under the study are built in different years. Radon concentration is grouped on homes which are relatively new, with 25 years old. In second group are homes from 25 to 50 years old and on last group are homes with more than 50 year old. All results of radon concentration versus age of homes when they are building are presented on figure nr 2. On the same figure are presented mean, standard deviation, maximum and minimum for three groups of data.

TABLE III MEASUREMENT RESULTS PER SITE

Location	Value	Relative Humidity [%]	Atmospheric Pressure [kPa]	Temperature [^{o}C]	Radon concentration (C_{Rn}) [Bq/m^3]	Annual effective dose [mSv/year]
House "A"	Min	65	82	23	119	3.0
	Max	69	88	27	203	5.1
	Mean ± std.	67±1	86±1	25±1	168.0±11	4.2
House "B"	Min	54	86	14	135	3.4
	Max	65	89	17	191	4.8
	Mean ± std.	59±1	87.1±2	15±6	156±8	3.9
House "C"	Min	76	89	15	64	1.6
	Max	79	89	16	142	3.6
	Mean ± std.	77.3 ± 1.1	89.0 ± 0.1	15.3 ± 0.5	103.7 ± 19.8	2.6
House "D"	Min	75	89	15	62	1.6
	Max	80	90	16	148	3.7
	Mean ± std.	77.4 ± 0.9	90 ± 0.2	15.8 ± 0.4	105.7 ± 20.7	2.7
House "E"	Min	64	87	14	142	3.6
	Max	76	88	16	258	6.5
	Mean ± std.	72.1 ± 2.9	87.6 ± 0.5	15.0 ± 0.6	198.4 ± 29.1	5.0
House "F"	Min	61	88	14	119	3.0
	Max	75	88	18	316	8.0
	Mean ± std.	68.7 ± 3.5	88.0 ± 0.0	15.9 ± 1.1	207.1 ± 48.1	5.2
House "G"	Min	61	87	15	107	2.7
	Max	76	88	18	258	6.5
	Mean ± std.	65.9 ± 3.0	87.8 ± 0.4	16.9 ± 0.8	179.7 ± 40.1	4.5
House "H"	Min	60	89	20	78	2.0
	Max	78	90	26	279	7.0
	Mean ± std.	65.4 ± 4.3	89.7 ± 0.5	23.6 ± 2.0	168.1 ± 51.3	4.2

The mean of radon concentration of the first group is the lowest compared to older homes; the same is for oldest homes. Presented data shows that the mean of radon concentration is higher on oldest buildings compared to new buildings.

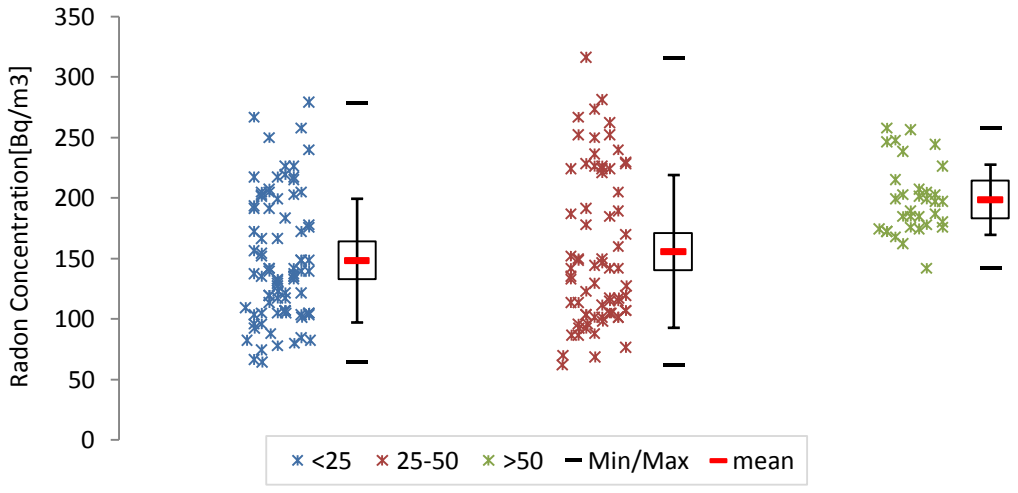

Fig.2. Impact of buildings age on radon concentration

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Based on same idea, has been analysed the impact of walls and windows on radon concentration. There are homes made by brick walls and stone walls. The types of windows were topic of this study, in some times wooden windows are used and in other times polyvinyl chloride (PVC) are used.

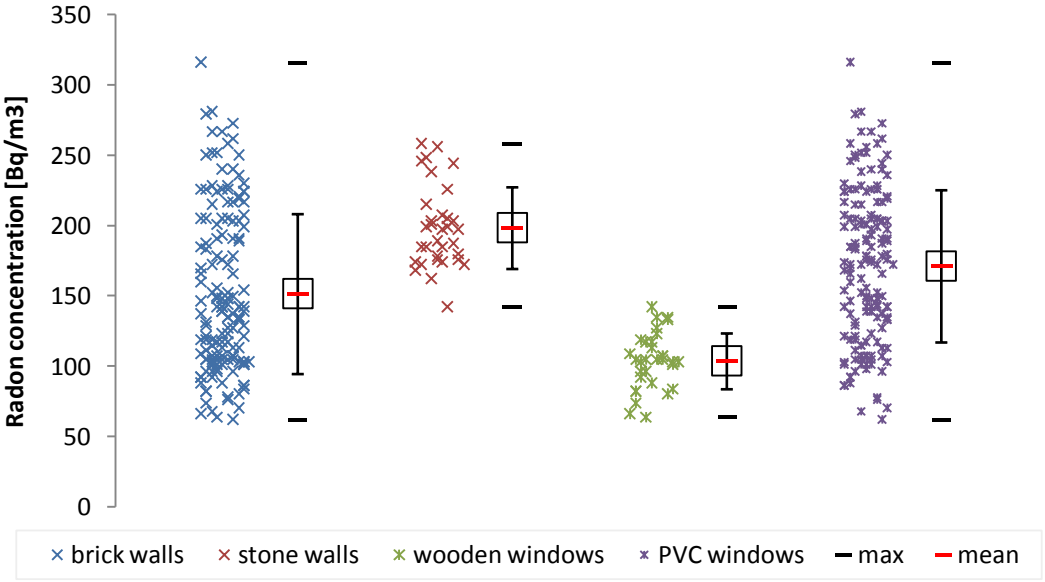

Fig. 3. Radon concentration dependence by type of walls (brick and stone) and by types of windows (wooden and PVC)

The mean value of radon concentration is affected by type of walls; radon concentration is higher in homes made with stone walls. More detailed analysis of radioisotopes on building materials should be done in future.

Also from Fig. 3, we can conclude that on the homes with PVC windows radon concentration is higher than in homes with wooden windows. The reason for this result on windows type is that PVC windows can block the air inside the living room compared to wooden windows.

IV. CONCLUSION

The results for radon concentration, recorded in 8 dwelling houses of Rahovec city, Kosovo, vary from a minimum 62 Bq/m^3 to a maximum of 316 Bq/m^3. Calculated annual effective doses are given in table 2. It is seen that the annual effective are in range from 1.6 mSv up to 8.0 mSv. According to these results, we can conclude that the values of radon concentration (C_{Rn}) and average annual effective doses are within the scope of international standards [13] and do not represent any risk for public health within the dwelling houses and its environment.

Detailed analyses are focused on age of homes, type of walls and windows. By this paper is proven that all three parameters mention above have impact on radon concentration.

So, the radon concentration is higher on older homes compared to new ages homes. Also, homes which were made by stone walls have higher radon concentration compared to homes with brick walls and homes with PVC windows have higher radon concentration than if wooden windows are used.

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BIOGRAPHY

Sehad Kadiri was born in Prizren, Kosovo, in 1982. He received the diploma in Engineering physics and the M.Sc. from the University of Prishtina. Actually is PhD candidate in Polytechnic University of Tirana, Albania. His main areas of research include general radiation protection, dosimetry of ionizing radiation, metrology of ionizing radiation, shielding design, and radiation protection in medicine. He is currently head of the Radiation Protection Service / Institute of Occupational Medicine in Obiliq, Kosovo.

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