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Research Article

Indoor radon levels in schools of Ferizaj, Kosovo[#]

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Abstract: Measurements of indoor radon concentration were carried out in all public schools of Ferizaj using portable radon monitor PRM-145. The average radon concentration has been found to vary from 20.8 Bqm^{-3} to 725.4 Bqm^{-3}. The arithmetic and geometric means of indoor radon concentrations were 237.8 $Bqm^{3}$and 141.56 Bqm^{-3}, respectively.

The mean annual estimated effective dose received by the residents in the examined rooms was estimated to be from 0.14 $mSvy^{-1}$ to 4.51 $mSvy^{-1}$. The effective dose in a number of classrooms of two schools is found to be above the dose limits recommended by International Commission of Radiation Protection (ICRP).

1. INTRODUCTION

The human population is permanently exposed to ionizing radiation from natural sources where about 50% of the total dose belongs to radon and its decay products. Prolonged exposure to elevated radon concentrations causes an increased risk of lung cancer [1]. In recent decades, many epidemiological studies have been conducted in order to confirm causal association of the number of lung cancer cases with chronic exposure to indoor radon. [2-5]. The World Health Organization (WHO) estimates that radon causes between 6% and 15% of lung cancers worldwide and it is "the second leading cause of lung cancer after cigarette smoking" [6]. Recent studies have showed that children have greater risk than adults for certain types of cancer from radiation. For younger age groups, the risk coefficient for lung cancer from inhaled radon daughters is about a factor of 2 (age at exposure less than 20 years) to 4 (children 0 - 10 years old) [7. 8]. For these reasons, increased interest has been observed in indoor radon measurements in kindergartens and schools and the results have been recently reviewed [9]. Therefore, the International Committee for Radiological Protection (ICRP) recommendations emphasized the importance of controlling radon exposure in dwellings and work places arising from existing exposure situations [10].

Sporadic measurements of radon concentrations in Kosovo dwellings and work places conducted some years ago indicated that high radon levels could be found in some schools [11, 12]. The aim of this study was to carry out a preliminary survey of radon levels in all public schools in Ferizaj. Ferizaj municipality is located in the southern part of Kosovo, Figure 1.

2. MATERIAL AND METHODS

Measurements of indoor radon concentration were carried out in 11 elementary and high public schools using portable radon monitor PRM-145. Portable radon monitor is a computerised instrument for monitoring the total alpha activity of radon ^{222}Rn and its short-life products ^{218}Po and ^{214}Po. Radon concentration in air was measured

Figure 1. *Map for Kosova.*

with 0.7 dcm^3 alpha scintillation cells. The cells have inner walls covered with scintillator – zinc sulphide activated by silver, except one, which is transparent and serves as an optic link with the photomultiplier tube [13]. To ensure continued confidence in the accuracy of the measurements, a calibration of the instrument is performed as recommended by the manufacturer..

All radon measurements in old and more recently built buildings were taken on rooms in the ground floor under closed conditions in order to obtain more representative and reproducible results. Many studies indicate that a radon level for an upper floor room is not likely to exceed levels found on the first floor. In all measuring rooms we had an agreement with school officials so they lock all doors and windows 12 -14 h prior taking air samples, usually in the morning. Samples of air within room are taken up to 1.5 m from floor and 20 – 60 cm from walls. Air was pumped in cell using a simple manual hand pump. After taking the air samples in, the cells were placed in calm environment and waited for three hours prior putting them into measuring instrument. Measuring time for each cell, time which cell stays in container is 30 min. Since radon levels in some schools have been found to vary significantly from room to room, in order to establish more accurate results for the day-time radon levels, the measurements were repeated in rooms where radon concentrations exceeded 200 Bqm^{-3}. These measurements were carried out during spring. 2014.

The total annual effective dose E_{Rn} caused by inhalation of the radon and its decay products is calculated from:

$$E = DCF \;\; C_{in} \;\; t_{in} \;\; EF_{in} \qquad (1)$$

where DCF is radon dose conversion factor [mSv/(hBqm^{-3})], C_{in} - annual average indoor radon concentrations (Bqm^{-3}), t_{in} - average annual indoor exposures, (h) and indoor radon-daughters equilibrium factor EF_{in} = 0.4, [4].

The annual effective dose for children is calculated assuming their 2.000 h annual indoor stay in the schools. The dose conversion factor value for radon inhalation has been recommended by different organizations on the basis of studies concerning the risks the lung cancer from residential and occupational exposure to radon. On the basis of the recent epidemiological data ICRP [5] recommended the value 10 nSv/hBqm^{-3} whereas UNSCEAR [4] the value 9 nSv/hBqm^{-3} which is applied in our calculations.

3. RESULTS AND DISCUSSION

The radon levels and annual average effective doses have been estimated for 11 public schools in Ferizaj. The number of schools with concentrations exceeding the action level (200 Bqm^{-3}) was 2, or about 20 % of the total number of location measured. The largest average values are found in technical high school "Pjeter Bogdani" - 725.4 Bqm^{-3} and elementary school "Bilall Shala" – 462.7 Bqm^{-3} and the lowest one in elementary school " Astrit Bytyqi " – 20.8 Bqm^{-3}. These high values of radon concentrations can be explained by the fact that these two schools are very old buildings with wooden floor and poor ventilation and the major contribution to the total indoor radon activity comes from radon escaping the underlying soil although there are no experimental data on the radon concentrations in surface soil in Ferizaj. The histogram showing the distribution of numbers of rooms that have radon concentrations within 50 Bqm^{-3} intervals in Ferizaj's schools is presented in Figure 2.

Radon concentration distribution parameters are shown in Table 1. The calculated arithmetic and geometric means of radon concentrations in these rooms are 237.8 Bqm^{-3} and 141.6 Bqm^{-3}, respectively. However, as is evident from these figures the results fit well the typical lognormal distribution, and corresponding value of geometric mean standard deviation is relatively low.

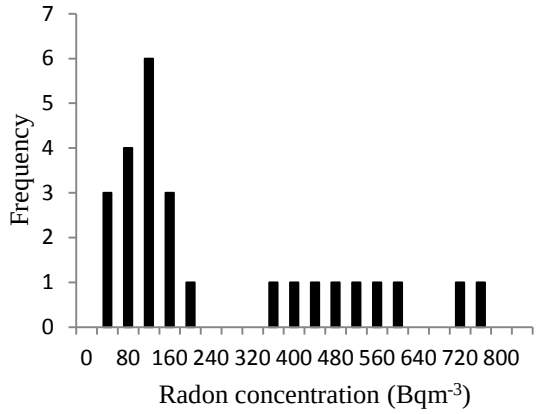

***Figure 2**. Distribution of radon concentrations in schools in Ferizaj.*

***Table 1** Statistical parameters of radon concentration distribution in Ferizaj schools*

Parameter	Value
Arithmetic mean (Bqm^{-3})	237.80
Arithmetic mean standard deviation (Bqm^{-3})	228.73
Geometric mean (Bqm^{-3})	141.56
Geometric mean standard deviation (Bqm^{-3})	1.3
Median (Bqm^{-3})	119.89
Minimum concentration (Bqm^{-3})	20.84
Maximum concentration (Bqm^{-3})	725.44

In Figure 3 are presented values of the annual average effective doses for schools in Ferizaj. The effective doses received by the residents of the examined rooms are estimated to be from 0.14 $mSvy^{-1}$ to 4.51 $mSvy^{-1}$. The annual average effective doses in a number of classrooms of two schools (technical high school "Pjeter Bogdani" - 4.51 $mSvy^{-1}$ and elementary school "Bilall Shala"- 2.9 $mSvy^{-1}$) are found to be at the level at which EPA [14] recommends schools take action to reduce it. Taking into account the at least twofold higher risk of radiation to children than for adults mentioned above, such exposure needs a proper action to mitigate the radon concentrations in these schools.

Finally, it should be noted that this measurement technique is quite suitable for the identification of locations with high instant levels of radon concentrations which then must be monitored systematically.

4. Conclusion

The radon levels and annual average effective doses have been estimated for 11 public schools in Feriaj.

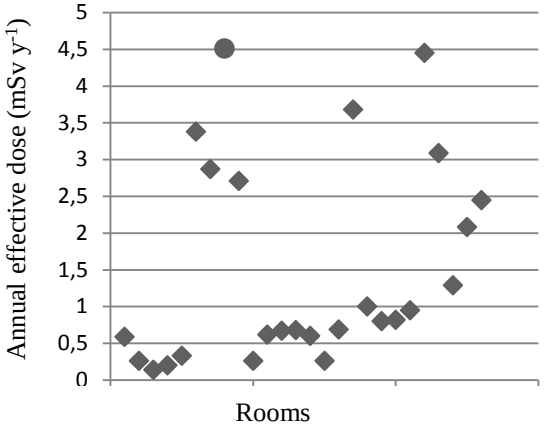

***Figure 3.** The annual average effective doses for different schools in Ferizaj.*

Measurements of radon concentration are conducted using portable radon monitor PRM-145. From results obtained it can be concluded:

- The radon concentration varies from 20.8 Bqm^{-3} to 725.4 Bqm^{-3} in Ferizaj schools. The results of measurements indicate that in 9 or about 80 % of observed rooms, the indoor radon concentration was lower than the reference level for public buildings. The median and average of indoor radon concentrations were 119.9 Bqm^{-3} and 237.8 Bqm^{-3}, respectively.
- The annual average effective dose received by the residents in the examined rooms was estimated to be from 0.14 $mSvy^{-1}$ to 4.51 $mSvy^{-1}$. The effective dose in a number of classrooms of two schools is found to be above the dose limits recommended by International Commission of Radiation Protection [5]. Considering that it is only part of their total inhalation doses, not including indoor exposure in their houses and outdoor exposure to radon and its decay products results that the survey of indoor radon concentration in public buildings (school, hospitals and work places) should be continued.

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