TEERAS 2017

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Book of Abstracts

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pert on radon, will give help, advise and guidelines on different radon issues to the municipalities.
The introduction of the new legislation has contributed to the public awareness about radon. We can notice a significant spin-off effect among people in general, property managers, local authorities as well as radon professionals.
In addition to the results achieved so far, some of the challenges concerning the new legislation and lessons learned will be presented.

OP29

RESULTS OF THE NATIONAL RADON INDOORS SURVEY IN BULGARIA

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Faculty of Medical Sciences, Goce Delcev University of Stip, 10-A Krste Misirkov st., 2000 Stip, Republic of MacedoniaPurpose: To present the results of the annual average indoor radon concentrations from National survey in Bulgarian regions. Variability of measured data between 28 regions was investigated in order to achieve the preliminary assessment the distribution of indoor radon concentration through Bulgarian territory. Argument: The National survey on average radon concentration in Bulgarian dwellings was carried out from 2015 to 2016, with the co-operation of the Regional Health Inspectorate under the National Radon Program. Data were collected through personal interviews with residents and deployment of alpha track detectors for one year through two phases. The first phase was from March 2015 to December 2015 and second from December 2015 to April 2016 approximately. For each region 100 detectors were distributed and spread to villages in regions depending on the population. The measurements were completed in 2775 dwellings. The distribution of indoor radon levels has been found to be log-normal with a geometric mean (GM) of 81.6 Bq•m−3 and a standard deviation of 2.1. The highest value of the radon concentration found was 1314 Bq•m−3 in the Sliven region. Region with high GM of 184 Bq•m−3 and a standard deviation of 1.7 is Yambol in Southeast Bulgaria. In about 6% of the houses, the radon concentration was found to be in excess of the recommended reference value of 300 Bq•m−3, suggested by the Council of the European UnionCommission in in new EU Directive 2013/59/Euratom. Conclusion: The data from National survey are the first systematic results and are received to complete the National Program, which will finish in 2017. The preliminary results clearly show that the national action plan to address long-term risks from radon exposures should

be developed taking into account the results achieve in this program and in accordance with the new Directive 2013/59/Euratom.

OP30

The radon-reducing effect of introducing binding requirements for preventive measures in new buildings in Norway

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Results from two national surveys of radon in newly built homes in Norway, performed in 2008 and 2016, were used in this study to investigate the effect of the 2010 introduction of national limit values and specific requirements for radon prevention measures upon construction of new buildings. The specific radon prevention measures are comprised of a radon membrane installed over the entire footprint of the building as well as an inactive standby radon sump, which may be turned into an active soil depressurization system when indoor radon concentration exceeds the Action Level. The Action Level is 100 Bq/m3 and the Upper Limit Value is 200 Bq/m3.In both surveys, homes were randomly selected from the National Building Registry. The overall result is a considerable reduction of radon concentration after the implementation of the new regulations, but the results varies between the different dwelling categories. A substantial and statistically significant reduction is found for detached houses where the average radon concentration is almost halved from 76 (n=92) to 40 Bq/m3 (n=486). The fraction of detached houses which have at least one frequently occupied room with a radon concentration above the Action Level (100 Bq/m3) has fallen from 23.9% to 6.4%, while the fraction above the Upper Limit Value (200 Bq/m3) has been reduced from 7.6% to 2.5%. In 2008 the average radon concentration measured in terrace houses was 44 Bq/m3 (n=41) and in 2016 it was 29 Bq/m3 (n=221), but the reduction is not statistically significant. For apartment blocks, it is not possible to draw any conclusions due to insufficient number of measurements.

OP31

Radon in schools, a high variability in concentrations, awareness and sustainability of remediation

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Radon measurements and mitigation in schools has been applied in

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Purpose: This paper reports the results of the international collaboration on direct measurements of radon (Rn) and thoron (Tn) progeny in indoor environments (dwellings and schools) in some parts of the whole of Balkan region (Serbia with Kosovo, Republic of Srpska, Slovenia and Macedonia).Argumentations: Direct and time integrated measurements of Rn and Tn progeny were carried out using direct Radon and Thoron Progeny Sensors (DTPS and DRPS), which are basically deposition based progeny sensors, in which the deposited progeny activity is detected by SSNTDs. These are passive detectors meant for long term time integrated measurements. The progeny or the decay products of Rn and Tn are the major dose givers. While assessing the inhalation doses to the public, passive long term measurements are essential. Large scale Rn and Tn decay product monitoring was carried out in dwellings (appr.300) during a period 2011-2013, in each house for minimum 6 months up to one year (Serbia with Kosovo, Republic of Srpska, Slovenia) and/or 68 schools (Republic of Srpska, Macedonia). In Kosovo 40 houses were monitored for 2 two different seasons, one during December – May 2011 and the other May – December 2012. In Slovenia 100 houses were monitored for progeny concentration during 2011-2012. The results are further discussed. Conclusion: The overall analysis of around 400 detectors deployed showed tBoth EETC and EERC obtained using DTPS and DRPS respectively showed a log normal distribution pattern. The overall GM of EETC was obtained as 0.69 Bq/m3 with a GSD of 2.0;The GM of EERC was obtained as 11.02 Bq/m3 with a GSD of 2.6; In Kosovo during the winter December to May 2011, the EERC and EETC were twice that during May to December 2012.A remarkable finding is the positive correlation between EERC and EETC, while there is none for the parents Rn and Tn. . The average EERC and EETC were measured as 11.31 ± 3.2 and 0.34 ± 0.22 Bq/m3 respectively. Decay product monitoring was carried out in 43 schools of Macedonia. The geometric mean values (and geometric standard deviation) of EERC and EETC were 27 Bq/m3(1.4) and 0.75 Bq/

m3(1.4) respectively. The results are further discussed.

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RADON CONCENTRATION AND EFFECTIVE DOSE MEASUREMENTS AT THE IRT-SOFIA RESEARCH REACTOR SITE

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Results from indoor radon measurements in the buildings within the Nuclear Scientific Experimental and Educational Centre (NSEEC) protected site at the Institute for Nuclear Research and Nuclear Energy are presented. The distribution of radon levels in the ground floors and basements of the constructions within the site is an important part of surveillance radiation activities during the operation and maintenance of the NSEEC facilities. The aim of this study was to identify radon high-risk areas and to evaluate the equivalent dose rates in different workplaces on the basis of measured radon concentrations using active sampling of indoor air. The ABPM 201-L and ABPM 203-M monitors were employed as active alpha-beta detector units. The inspected buildings included the IRT reactor structure and several auxiliary formations wherein the laundry facilities and the 60Co gamma irradiator GOU-1 are installed as well as the Central Alarm Station (CAS) premises. Besides the reactor hall and the primary cooling loop area, special attention was given to the premises of the First Class Radiochemical Laboratory (radiochemical niches, glove boxes etc. for radiopharmaceuticals as well as a technological conveyor line passing through four hot cells for treatment of high specific activity radioactive isotopes) located in the IRT reactor basement. The data prior and during the dismantling activities related to the reactor refurbishment project and after their partial accomplishment are taken into account. After the analysis of the experimental data it can be concluded that the existing ventilation and air conditioning system satisfies the demands to radon concentration levels. The geological and radiological characteristics of the nuclear site are well documented and provide grounds for measured low contribution to outdoor radon concentration. The results from this work contribute to the radiological assessment program and update the background of the natural radioactivity map in the area of Sofia city.

P28

Field experience with Direct Radon and Thoron Progeny Sensors (DRPS/ DTPS) results being distributed in the Balkan Region

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Abstract

Purpose: This paper reports the results of the international collaboration on direct measurements of radon (Rn) and thoron (Tn) progeny in indoor environments (dwellings and schools) in some parts of the whole of Balkan region (Serbia with Kosovo, Republic of Srpska, Slovenia and Macedonia).

Argumentations: Direct and time integrated measurements of Rn and Tn progeny were carried out using direct Radon and Thoron Progeny Sensors (DTPS and DRPS), which are basically deposition based progeny sensors, in which the deposited progeny activity is detected by SSNTDs. These are passive detectors meant for long term time integrated measurements. The progeny or the decay products of Rn and Tn are the major dose givers. While assessing the inhalation doses to the public, passive long term measurements are essential. Large scale Rn and Tn decay product monitoring was carried out in dwellings (appr.300) during a period 2011-2013, in each house for minimum 6 months up to one year (Serbia with Kosovo, Republic of Srpska, Slovenia) and/or 68 schools (Republic of Srpska, Macedonia). In Kosovo 40 houses were monitored for 2 two different seasons, one during December – May 2011 and the other May – December 2012. In Slovenia 100 houses were monitored for progeny concentration during 2011-2012. The results are further discussed.

Conclusion: The overall analysis of around 400 detectors deployed showed t
• Both EETC and EERC obtained using DTPS and DRPS respectively showed *a log normal distribution pattern.*
• The overall GM of EETC was obtained as 0.69 Bq/m3 with a GSD of 2.0;
• The GM of EERC was obtained as 11.02 Bq/m3 with a GSD of 2.6;
• In Kosovo during the winter December to May 2011, the EERC and EETC were twice that during May to December 2012.
• A remarkable finding is the positive correlation between EERC and EETC, while there is none for the parents Rn and Tn. . The average EERC and EETC were measured as 11.31 ± 3.2 and 0.34 ± 0.22 Bq/m3 respectively. Decay product monitoring was carried out in 43 schools of Macedonia. The geometric mean values (and geometric standard deviation) of EERC and EETC were 27 Bq/m3(1.4) and 0.75 Bq/m3(1.4) respectively. The results are further discussed.

Key words: Balkan region, Radon, Thoron, Dwellings, Schools, Progeny, Direct Radon Progeny Sensors , Direct Thoron Progeny Sensors (DRPS/ DTPS)

P29

First Evolution of Radon Concentrations Spatial Distribution based on the geological parameters and multiple linear regression method in schools of Sjenica community, Western Serbia (Balkan area)

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Abstact

Purpose: The paper deals with the analysis of radon survey in 34 schools over Sjenica community, in West Serbia, aiming at *systematically continuation* of previously performed surveys (2008-2010) in the 340 schools in South Serbia, as the project activities (Serbian Ministry of Education Since and Technical Development) considering optimization of the de-

sign of a national survey and improving the knowledge of radon distribution in Serbia. In addition , the results of this survey triggered, based on Sjenica (Pestar) region complex geology and measured annual Rn concentrations, an attempt of the explanation of radon spatial variation in Sjenica community by multivariable linear regression (MLR) method in total of 36 public buildings investigated (beside schools, the kindergarten and meterological station).

Argumatation: Schools are workplaces which are subject to Rn regulations (EC 2014,BSS).Among other, the BSS require establishing reference levels for long-term indoor Rn concentration, not exceeding 300 Bq/m3 for both dwellings and workplaces. The 36 public buildings were surveyed the whole year in the Sjenica community in West Serbia by long term measurements with CR-39 detectors (commercially named Gamma 1, Landaurer, Sweden). Sjenica community is the largest community of 1059 km2 surface in Serbia and it was found that indoor radon (Rn) lower than 100 Bq/m3 are most probable and although with lower probability,that Rn higher than action level of 300 Bq/m3could occur in 14% of the buildings , indicating potential of the investigated area as high natural background area. The highest measured indoor Rn concentration was 1130 Bq/m3.

Conclusion: The predictive model was developed, in order to determine *how geological parameters best merge to explain the indoor radon concentrations.* The results of this investigation highlight that it is possible to predict indoor radon concentrations using the geological data to an acceptable level of accuracy with a limited number of measurements. There is potential of the investigated area *as high natural background area.*

Key words: Sjenica (Pestar), geology, schools, radon, spatial analysis, multivariable regression method

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Case study in schools of Eastern Macedonia: factors affecting radon concentrations

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Abstract

Purpose: This paper presents indoor radon concentrations, impact factors and potential sources in 29 schools in the Eastern part of Republic of Macedonia.

Argument: The radon concentrations were measured with nuclear track detectors exposed in two ground floor rooms of each school in period of one school year semester starting from January and to June in 2016. The radon concentrations in 3 of 56 rooms exceed the National action level. The geometric mean value of measured radon concentrations for all rooms was 96 Bq/m3; GSD=2.47. There was no correlation between radon and location altitude. Also, no effect of type of room and type of windows on radon concentration was found. Ground floor buildings and buildings with one floor had higher radon concentrations, than buildings with two floors. The radon concentration in building without basement was higher than that in buildings with basement, as well as higher in stone buildings than brick buildings. Relation between radon concentration and lithostratigrafic units was confirmed. The highest radon concentration was obtained on locations with andesite and breccia bed rock.

Conclusion: The impact level of each of the examined factors on radon variations were quantified by a determination factor (R2) The highest R2 value was related with factor: basement. The individual factor effect on radon variation as well as explanations of the obtained results are discussed in this paper

Key words: ground floor, schools, indoor radon, factors.