An Overview of Environmental Radioactivity Investigation in Republic of Macedonia

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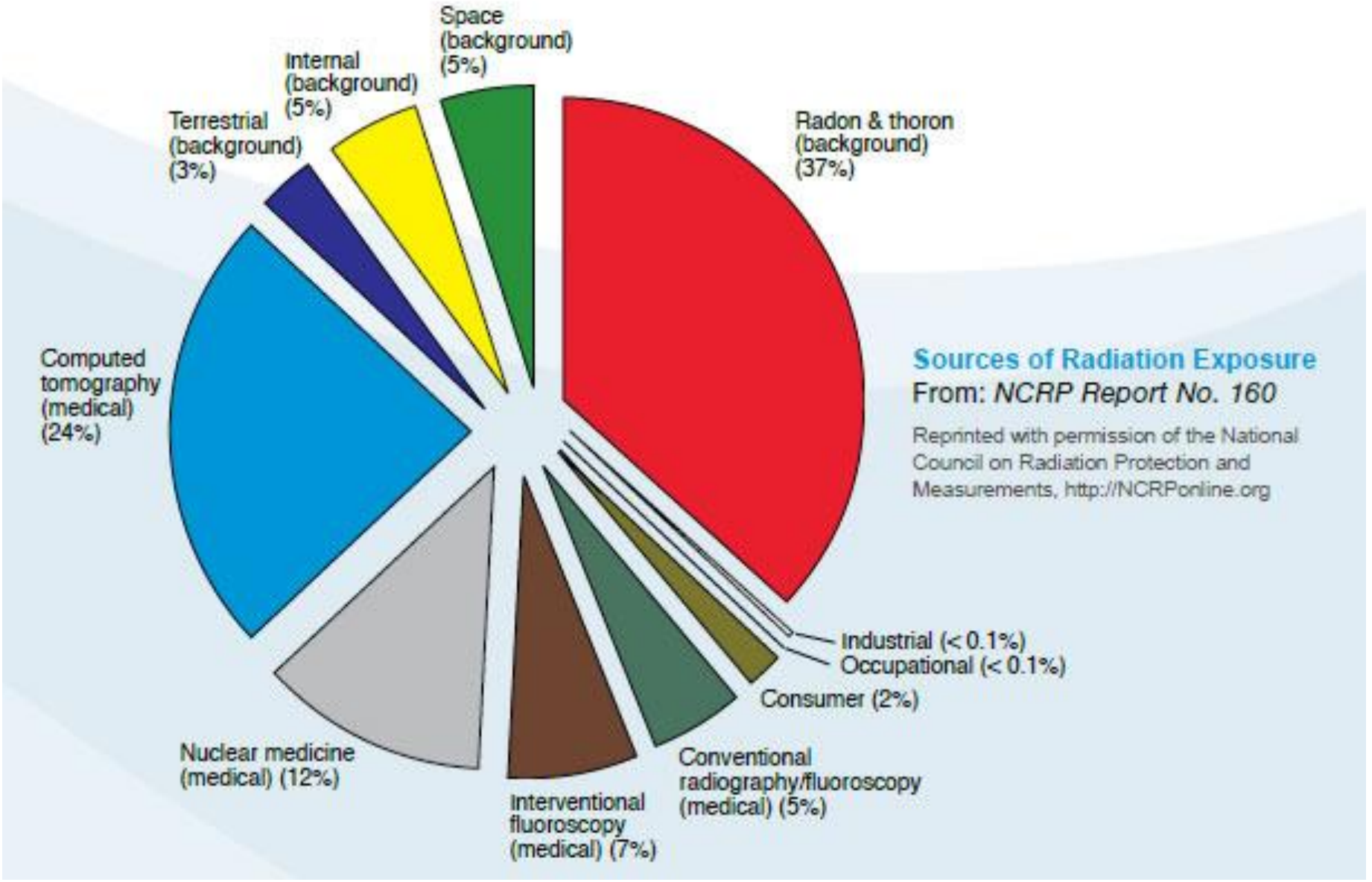
Environmental Radioactivity Investigation

Large-scale surveys, have been performing in a many countries over the world in order to:

estimate average exposures to different radioactive sources


Space (background) (5%)
Internal (background) (5%)
Terrestrial (background) (3%)
Radon & thoron (background) (37%)
Computed tomography (medical) (24%)
Industrial (< 0.1%)
Occupational (< 0.1%)
Consumer (2%)
Nuclear medicine (medical) (12%)
Conventional radiography/fluoroscopy (medical) (5%)
Interventional fluoroscopy (medical) (7%)
Sources of Radiation Exposure
From: NCRP Report No. 160
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Environmental Radioactivity Investigation in Republic of Macedonia

During last several years, a number of studies on environmental radioactivity issue in Republic of Macedonia appeared as well in international literature.

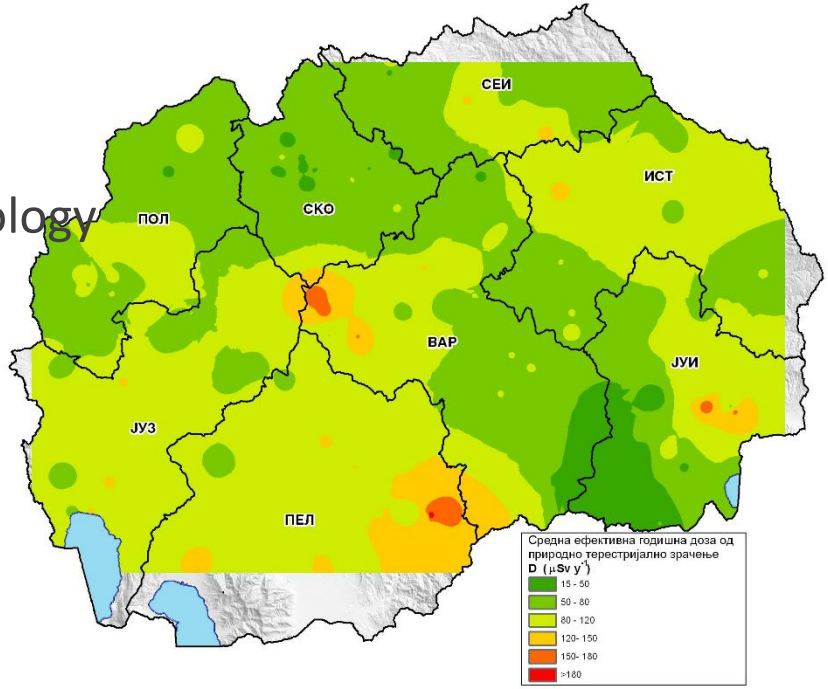
- Terestrial radioactivity (soil and building materials)
- Specific activity of ^{137}Cs in mushrooms
- Indoor Radon and Thoron concentration
- Radioecological- determined radionuclide concentration distribution in the environment
- Dosimetric- estimated effective dose (Sv)

Terrestrial Radioactivity – annual effective dose

- 213 samples from undisturbed soils at a depth od 0-20 cm due whole country territory (2008 – 2010).
- The estimated annual effective dose due to the natural radionuclides in the soil: ^{226}Ra, ^{232}Th and ^{40}K is

  (83 ± 29) µSv y^{-1} or

  79*/1.4µSv y^{-1}
- Regional variability correlated to the geology



Zdenka Stojanovska and Dusan Nedelkovski. 2008. **Initial investigation of the natural radioactivity in the soil in some locations in Macedonia from radiation protection point of view**. Physica Macedonica 58, 67-74.

Specific activity of ^{40}K, ^{226}Ra and ^{232}Th in cements and its row materials

Sample	N	^{226}Ra (Bq kg-1) AM ± SD	^{232}Th (Bq kg-1) AM ± SD	^{40}K (Bq kg-1) AM ± SD
Gypsum	16	5,9 ± 1,1	1,4 ± 0,44	11,0 ± 5,2
Fly ash I	20	140 ± 89	80 ± 15	540 ± 99
Fly ash II	29	85 ± 17	129 ± 18	786 ± 134
Pozzolana I	17	64 ± 12	69 ± 15	105 ± 43
Pozzolana II	28	80 ± 27	171 ± 48	349 ± 168
Clinker	42	31 ± 6	20 ± 3	234 ± 46
CEM I	19	30 ± 4	20 ± 3	222 ± 36
CEM II/A-M	28	45 ± 7	29 ± 3	272 ± 45
CEM II/B-M	19	50 ± 6	34 ± 4	295 ± 43

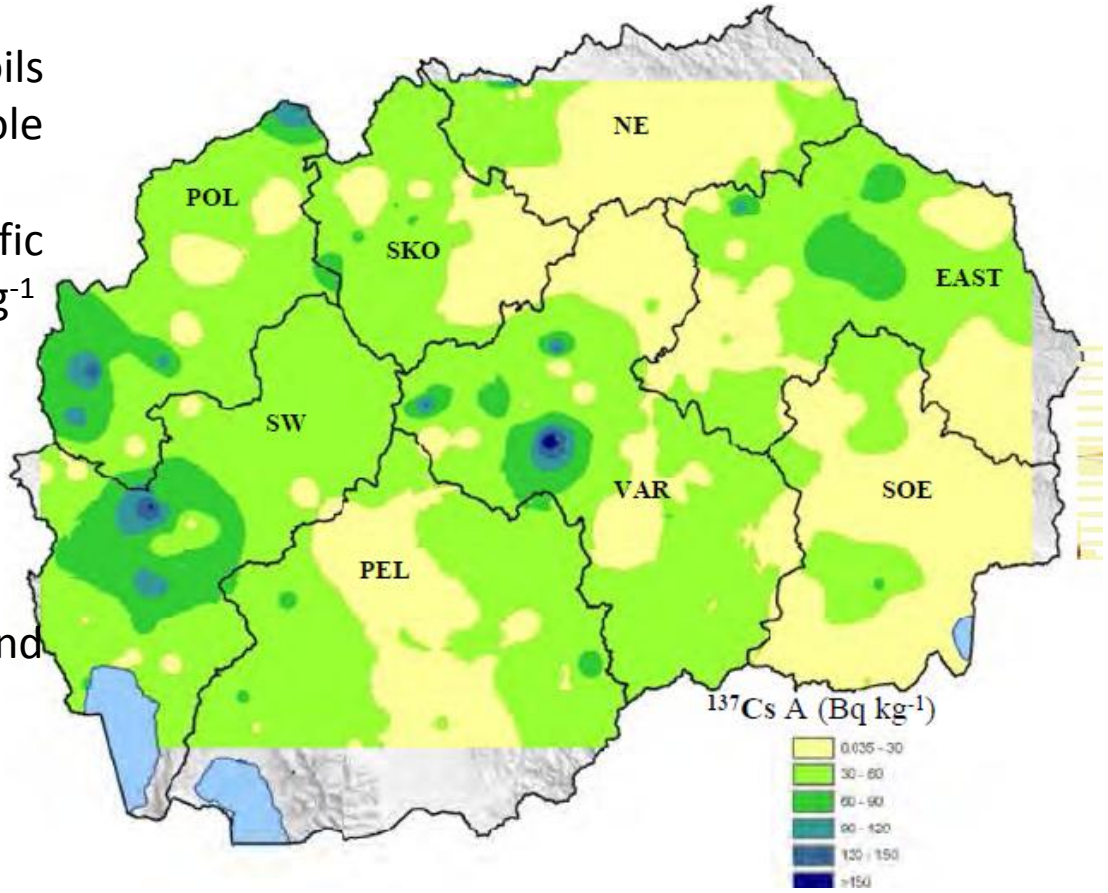
Annual effective dose

D_E = (200 ± 89) μSv

Zdenka Stojanovska, Dusan Nedelkovski, Mimoza Ristova, 2010. **Natural radioactivity and human exposure by raw materials and end product from cement industry used as building materials**. Radiation measurement 45, 969-972.

Specific activity of ^{137}Cs in soil

- 213 samples from undisturbed soils at a depth od 0-20 cm due whole country territory
- Arithmetic mean value of specific activity: 38 Bq/m^3 (0,23 -178) Bq kg^{-1}
- Estimated dose: (14 ± 11) µSv y^{-1}
- Regional variability of results
- Correlation with altitude and longitude of the areas



Zdenka Stojanovska, Blazo Boev, Mimoza Ristova 2011. **Spatial Distribution of 137Cs in the soils of the Republic of Macedonia**. Proceedings of the 3. International workshop on the UNESCO-IGCP Project (77-83)

Specific activity of ^{137}Cs in mushrooms

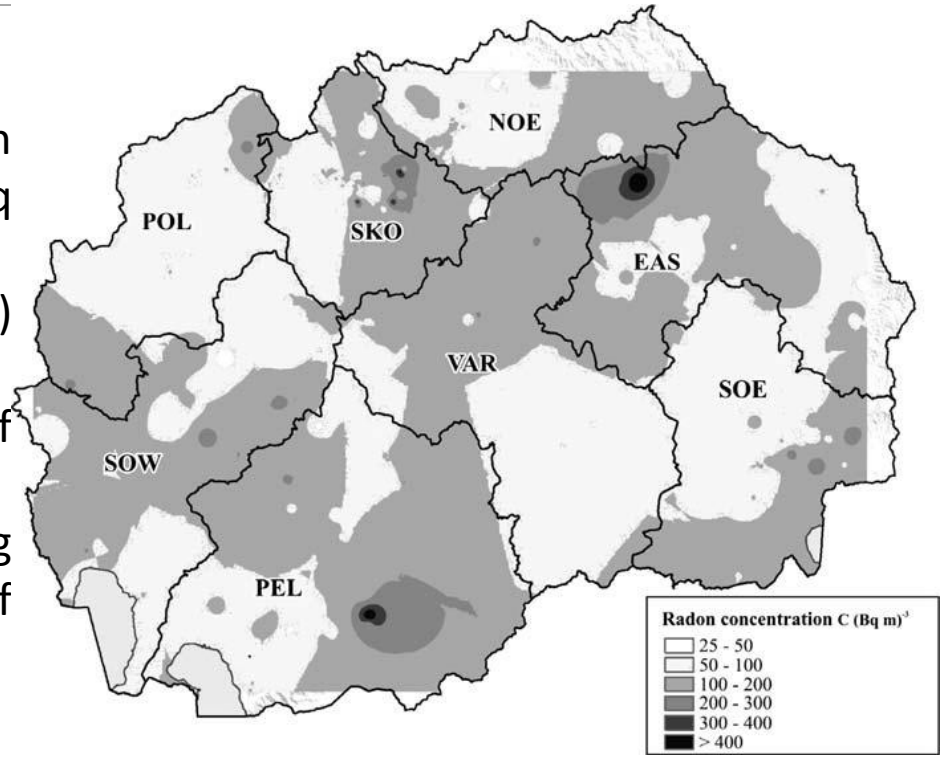
- Specific activity of ^{137}Cs (Bq/m^3) in mushrooms collected in Western and Eastern-Central part of country

		Western	Eastern & Central
Sample		71	68
Average Value		3.02	2.47
95% Certainty	Lower Limit	2.42	2.02
	Upper Limit	3.62	2.93
Variation		6.41	3.52
Standard Deviation		2.53	1.88
Minimum		0.21	0.12
Maximum		9.92	9.31
Standard Error		0.30	0.23

A. Todorovic, P. Sekulovski,Z. Hajrulai-Musliu,E. Dimitrievska Stojkovic,B. Stojanovska Dimzoska (2012). **Differences in activity levels of ^{137}Cs in mushrooms in Eastern and Western Macedonia.** The First International Conference on Radiation and Dosimetry in Various Fields of Research. Proceedings 333-335.

Indoor radon(^{222}Rn) concentration

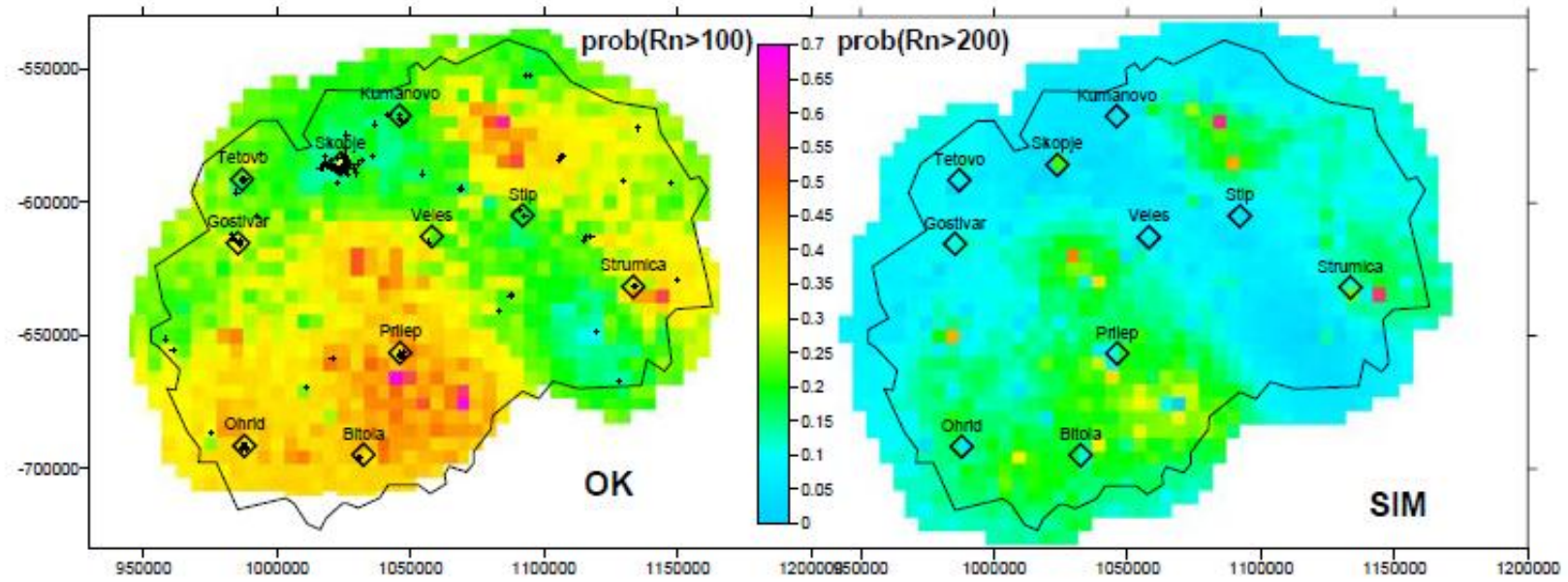
- 430 dwellings (2008-2009)
- Geometric mean value of radon concentration: 84 Bq/m^3 (3 - 720) Bq m^3
- Estimated dose: 2.1 mSv y^{-1} (0.5-18) mSv y^{-1}
- Regional and seasonal variability of results
- Correlation with geology and building characteristic (floor, presence of basement, building materials)



… Zdenka Stojanovska, Jovan Januseski, Peter Bossew, Zora S. Zunic, Tore Tollefsen, Mimoza Ristova, 2011. **Seasonal indoor radon concentration in FYR of Macedonia**. Radiation measurement 46, 602-610.

… Zdenka Stojanovska, Jovan Januseski, Blazo Boev, Mimoza Ristova (2012) **Indoor exposure of population to radon in the FYR of Macedonia**. Radiation Protection Dosimetry:148(2):162-7.

Expected radon risk- estimated from distribution of ^{226}Ra in soil



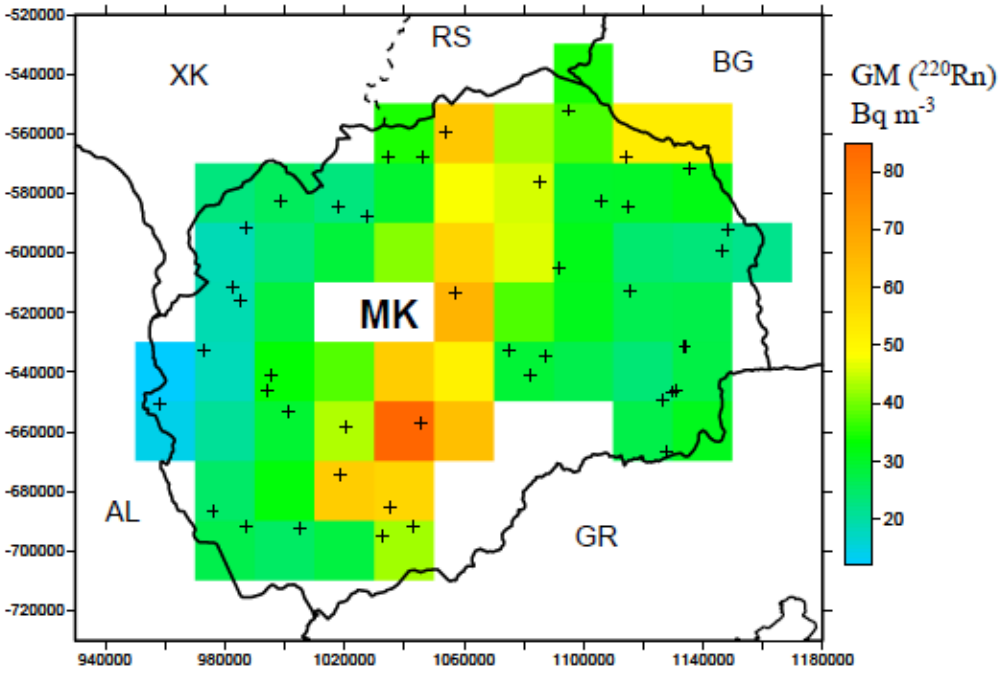
– Probability that the ^{222}Rn concentration is ground floor rooms of houses with basement exceeds 100 Bq/m³ (left) or 200 Bq/m³ (right), estimated from ^{226}Ra concentration in soil. Crosses:

… Peter Bossew, Zdenka Stojanovska, Zora S Zunic, Mimoza Ristova 2013. **Prediction of indoor radon risk from radium concentration in soil: Republic of Macedonia case study**. Romanian Journal of Physics 58:29-43..

Indoor thoron(^{220}Rn) concentration

- 300 dwellings (2008-2009)
- Geometric mean value of thoron concentration: 28 Bq/m3
- ranged (3 - 272) Bq m3
- Estimated dose: future goal

- Regional and seasonal variability of results
- Correlation with geology and building materials



Stojanovska Z, Bossew P, Tokonami S, Zunic ZS, Bochicchio F, Boev B,Ristova M, Januseski J. (2013). **National survey of indoor thoron concentration in FYR of Macedonia (continental Europe e Balkan region).** Radiation Measurements, 49, 57-66.

Ongoing and future activities

- Radon, thoron and its progeny concentrations in schools
  - Effective dose
  - Teachers and children
- Radioactivity in building materials
- Map of the radon in soil gas