PHYSICAL CHEMISTRY 2014

12th International Conference
on Fundamental and Applied Aspects of
Physical Chemistry

The Conference is dedicated to the
25. Anniversary of the Society of Physical Chemists of Serbia

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September 22-26, 2014
Belgrade, Serbia

ISBN 978-86-82475-30-9

Title: PHYSICAL CHEMISTRY 2014 (Proceedings)
Editors: Ž. Čupić and S. Anić
Published by: Society of Physical Chemists of Serbia, Studenski trg 12-16, 11158, Belgrade, Serbia
Publisher: Society of Physical Chemists of Serbia
For Publisher: S. Anić, President of Society of Physical Chemists of Serbia
Printed by: "Jovan" Priting and Publishing Company; 200 Copies;
Number of pages: 6+ 441; **Format**: B5; Printing finished in September 2014.

Text an Layout: "Jovan"

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12th International Conference on
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Organized by
The Society of Physical Chemists of
Serbia

in co-operation
with

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Boreskov Institute of Catalysis of Siberian Branch of the Russian Academy of Sciences

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NATURAL RADIOACTIVITY IN THE SOIL SAMPLES OF SUBOTICA, SERBIA

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ABSTRACT
The activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th from 23 locations of the territory of Subotica were determined by gamma ray spectrometry. Based on the results obtained the value of absorbed gamma dose rate in air was calculated. Mean values of activity concentrations were found to be 277 Bq kg^{-1} for ^{40}K, 18 Bq kg^{-1} for ^{226}Ra and 18 Bq kg^{-1} for ^{232}Th. The total absorbed gamma dose rate varied between 20 and 44 nGy h^{-1}. The mean value 31 nGy h^{-1} is lower than the world average value.

INTRODUCTION
Around 90 % of human radiation exposure arises from natural sources such as cosmic radiations, exposure to radon gas, and terrestrial radiations. The naturally occurring radionuclides present in soil include ^{40}K, ^{226}Ra and ^{232}Th [1]. The knowledge of activity concentrations and distributions of the radionuclides in soil are of interest since it provides useful information in the monitoring of environment radioactivity.
The aim of this work to determine the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in soil samples collected across the city of Subotica, using gamma ray spectrometry and use the results to calculate absorbed gamma dose rate in air.

EXPERIMENTAL
Subotica is the most northern city in Republic of Serbia. It is located on latitude $46^0$5'55" North and longitude $19^0$39'47" East. By cencus from 2002 it has 99,471 inhabitants and it is the second largest city in Autonomous Province of Vojvodina and sixth in Republic of Serbia. Subotica with its surroundings has continental climate and average annual temperature of 11.4°C. City is located in the Pannonian plane on 1,008 km^2 [2].
The samples of undisturbed soils (n=23) were collected from 23 locations of Subotica during 2013-2014. From each location, 3-4 subsamples were collected by template method [3], up to depth of 10 cm, and they were mixed (put together) into one composite sample. Samples were dried at

105°C to a constant weight and then homogenized. The homogenized samples were placed in 0.5 L Marinelli beakers. The beakers were sealed hermetically and kept a side for about a month to ensure equilibrium between ^{226}Ra and its daughters before being taken for gamma spectrometric analysis.

The measurements were performed using HPGe gamma-ray spectrometer ORTEC-AMETEK (49% relative efficiency and 1.85 keV FWHM for ^{60}Co at 1.33 MeV, 8192 channels) shielded with 10 cm lead internally lined with 2 mm copper foil. The activity of each sample was measured for 60 000 s. The activity of ^{226}Ra was evaluated from the gamma ray of 609.3 keV of ^{214}Bi peak and 351.9 keV of ^{214}Pb, while 911.2 and 969.1 keV gamma-ray lines emitted by ^{228}Ac and 238.6 keV emitted by ^{212}Pb was used to determine ^{232}Th. The activity of ^{40}K was determined using its 1460.8 keV gamma-ray line. Gamma Vision 32 was used to process the spectra obtained.

The external gamma dose rate in the air at 1 m above ground level was calculated from the measured activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in soil assuming that other radionuclides, such as ^{137}Cs, ^{90}Sr and the ^{235}U series can be neglected as they contribute very little to the total dose from environmental background [4]. The calculation were performed according to the following equation:

$$D = 0.462A_{Ra} + 0.604A_{Th} + 0.042A_K \qquad (1)$$

where $A_{Ra,}$ $A_{Th,}$ and A_K are activity concentrations (Bq kg^{-1}) of ^{226}Ra, ^{232}Th and ^{40}K, respectively.

RESULTS AND DISCUSSION

Activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th in soil samples collected in Subotica area are presented in Table 1.

It can be seen that activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th ranged from 160 to 390 Bq kg^{-1}, from 12 to 29 Bq kg^{-1} and from 13 to 23 Bq kg^{-1}, respectively. Mean values of activity concentrations were found to be 277 Bq kg^{-1} for ^{40}K, 18 Bq kg^{-1} for ^{226}Ra and 18 Bq kg^{-1} ^{232}Th. These values are lower than the averages in Serbia (^{40}K 607 Bq/kg, ^{226}Ra 34 Bq/kg, ^{232}Th 42 Bq/kg) because of the different geological structures [5], but are similar to those obtained for Palic (^{40}K 310 Bq/kg, ^{226}Ra 19.9 Bq/kg and ^{232}Th 23.5 Bq/kg) [6].

Activity concentrations of analyzed radionuclides in soil are lower than those reported for neighboring Hungary (^{40}K (79-570) Bq/kg, ^{226}Ra (14-76) Bq/kg and ^{232}Th (12-45) Bq/kg) [7]. However, they are similar to the range

of activity concentrations in soil of Csongrad, the city in Southeast Hungary about (130 km far from Subotica) with similar geological substrate (^{40}K (276-453) Bq/kg, ^{226}Ra (14-44) Bq/kg, ^{232}Th (14-35) Bq/kg) [8].
The values of total gamma dose rates varied between 20 and 44 nGy h^{-1}, with the mean value 31 nGy h^{-1} (52% lower than the world average value of 58 nGy h^{-1}) [9]. The contribution to the total absorbed gamma dose rate by ^{40}K, ^{226}Ra and ^{232}Th was 38%, 27% and 35%, respectively.

Table 1. Activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th in soil samples collected in Subotica (Bq kg^{-1})

Location	^{40}K	^{226}Ra	^{232}Th
Su-1	310±20	19±3	20±3
Su-2	320±20	18 ±3	19±3
Su-3	280±20	18±2	18±3
Su-4	360±30	20±4	21±2
Su-5	250±20	13±2	15±2
Su-6	390±30	22±3	23±3
Su-7	300±20	21±3	20±2
Su-8	270±20	16±3	18±4
Su-9	200±20	13±2	19±3
Su-10	260±30	17±3	16±3
Su-11	270±20	19±4	17±3
Su-12	230±30	21±3	15±2
Su-13	350±30	22±3	23±4
Su-14	240±20	12±3	13±3
Su-15	280±30	16±2	19±4
Su-16	160±10	29±3	15±3
Su-17	350±20	22±4	22±4
Su-18	220±20	15±3	14±3
Su-19	310±30	20±4	21±3
Su-20	300±30	18±4	20±4
Su-21	240±20	14±3	15±2
Su-22	200±30	12±3	14±3
Su-23	290±20	18±3	20±4

CONCLUSION

The activity concentrations of natural radionuclides ^{40}K, ^{226}Ra and ^{232}Th in 23 soil samples collected from the territory of Subotica were measured by gamma ray spectrometry. Based on these concentrations, the value of absorbed gamma dose rate in air was calculated. The obtained activity

concentrations and total gamma dose rates are lower than the world average values.

The results obtained in this study may be used for preliminary estimation of population exposure due to natural radionuclides. Further investigation is needed before definite conclusions on this issue are drawn.

ACKNOWLEDGEMENT

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Project NoIII43009).

REFERENCES

[1] Rani, S. Singh, Atmos. Environ, 2005, 39, 6306 - 6314.
[2] Republički zavod za statistiku, Stanovništvo, pol i starost, podaci po naseljima, Beograd, 2003.
[3] International Atomic Energy Agency, Soil sampling for environmental contaminants, IAEA-TECDOC-1415, 2004.
[4] K.C. Leung, S.Y. Lau, C.B. Poon, J. Environ. Radioact., 1990, 11, 279-290.
[5] S. Dragović, Lj. Janković, A. Onjia, G. Bačić. Radiat. Meas., 2006, 41, 611-616
[6] I. Bikit, J. Slivka, Lj. Čonkić, M. Krmar, M. Vesković, N. Žikić-Todorović, E. Varga, S. Ćurčić, D. Mrđa J. Environ. Radioact., 1990, 11, 11-19.
[7] UNSCEAR, Sources and effects of ionizing radiation. Report to General Assembly, with Scientific Annexes, United Nations, 2000.
[8] Z. Papp, Rad. Prot. Dos., 2010, 141, 56-63.
[9] UNSCEAR, Sources and effects of ionizing radiation. Report to General Assembly, United Nations, New York, 2008.