

Acta Facultatis Ecologiae



Journal of Faculty of Ecology and Environmental Sciences
Technical University in Zvolen

Volume 12
Supplement 2
2004

VI. Banskoštiavnické dni 2004



Environmentálne dopady energetiky na ŽP
Trendy v environmentalistike
a rádioenvironmentalistike

Edited by Peter Hybler

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**Periodikum Fakulty ekológie a environmentalistiky
Technická univerzita vo Zvolene**

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Recommended citation:

Hybler P. (Ed.) 2004: VI. Banskoštiavnické dni 2004: „Environmentálne dopady energetiky na ŽP. Trendy v environmentalistike a rádioenvironmentalistike“, Acta Facultatis Ecologiae, 12, Suppl. 2, ...pp. *Article author 2004: Article title.* In Hybler P. (Ed.), VI. Banskoštiavnické dni 2004: „Environmentálne dopady energetiky na ŽP. Trendy v environmentalistike a rádioenvironmentalistike“, Acta Facultatis Ecologiae, 12, Suppl. 2: 129 pages.

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ISSN 1336-300X

**Fakulta ekológie a environmentalistiky TU Zvolen
Slovenská nukleárna spoločnosť
Úrad pre normalizáciu, metrológiu a skúšobníctvo SR
Asociácia priemyselnej ekológie na Slovensku
Slovenské elektrárne a. s., AE Mochovce
Slovenské elektrárne a. s., AE Jaslovské Bohunice
Združenie pre reguláciu rizika z radónu
W-Ekoklub, Banská Štiavnica**

VI. Banskoštiavnické dni 2004



**Environmentálne dopady energetiky na ŽP
Trendy v environmentalistike a rádioenvironmentalistike**

v dňoch 6. – 8. 10. 2004
(areál FEE TU Zvolen, Banská Štiavnica, Kolpašská 9B)

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THE DETERMINATION OF ^{226}Ra IN WATER SAMPLES

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ABSTRACT

Kuruc J., Ceklovsky A., Rajec P.: **The Determination of ^{226}Ra in water samples**

The objective of this work was to develop a method for determination of ^{226}Ra volume activities of ^{226}Ra in drinking water, using of radon emanation technique. This specific method for ^{226}Ra is based on the emanation and scintillation counting of ^{222}Rn , a daughter product of ^{226}Ra . The ^{226}Ra from the water sample is separated by co-precipitation on barium sulphate. The precipitate is dissolved in EDTA reagent, placed in a sealed bubbler and stored for ingrowths of ^{222}Rn . After ingrowths, the gas is purged into a scintillation cell. When the short-lived ^{222}Rn daughters are in equilibrium with the parent (4h), the scintillation cell is counted for alpha activity. All results were in range from 0.017 Bq.dm⁻³ to 1.54 Bq.dm⁻³. This measurement proved that the separation technique and measurement method are fully applicable for determination of ^{226}Ra in drinking water samples.

Key words (INIS): radium 226; radon 222; radiation monitoring; drinking water; dose commitments; radioecology; site characterization

Introduction

Radium is a naturally occurring radioactive element formed by the decay of uranium in the environment. It occurs at low levels in virtually all rocks, soil and water. There are several methods to determinate radium in water, such as alpha-spectrometry, liquid scintillation counting, radon emanation technique and also modern extraction methods for fast radium analysis. The objective of this work was to develop a method for determination of ^{226}Ra volume activities of ^{226}Ra in drinking water using of radon emanation technique.

The method is based on emanation and consequential scintillation detection of ^{222}Ra and its daughter nuclides ^{218}Po and ^{214}Pb (activity of ^{214}Bi is neglected, because α -decay on the ^{210}Tl represents only 0.04%). Because half-life of all daughter nuclides of the ^{222}Rn is

shorter as half-life of the ^{222}Rn , a state of radioactive equilibrium exists among conterminously elements. In the state of radioactive equilibrium with the ^{222}Rn the other daughter nuclides have identical activity, therefore

$$A_{\text{tot}} = A_1 + A_2 + A_3,$$

where A_{tot} – total activity; A_1 , A_2 , A_3 – activities of ^{222}Rn , ^{218}Po and ^{214}Pb , respectively. Thus measured activity is 3-multiple of the ^{222}Rn activity, what is necessary to take into accounts in calculations. The state of radioactive equilibrium between ^{226}Ra and ^{222}Rn is consolidating during around 10 half-life of ^{222}Rn ($T_{1/2} = 3.82$ days). The radioactive equilibrium among these radionuclides is the main factor that allows determination of ^{226}Ra through ^{222}Rn .

EXPERIMENTAL

This method of separation and determination of ^{226}Ra is described in M.S. thesis of CEKLOVSKY (2004). The method uses co-precipitation of ^{226}Ra with barium sulphate in acidic solutions of HCl and H_2SO_4 . After decantation and centrifugation of precipitate the alkaline solution of EDTA is added and warmed on water bath up to dissolution. Sample is transferred into emanation container, which is bubbled during 20 min by nitrogen and it is waiting from 4 to 30 days for equilibrium between ^{226}Ra and ^{222}Rn .

Method of ^{222}Rn determination by emanation technique was developed by KOVACSOVA (2002) and optimised by ANDREJKOVICOVA (2003); ANDREJKOVICOVA et al. (2003). The volume activities of the ^{226}Ra in the samples were calculated by two methods:

the 1st method:

$$a_v = \frac{n_{ex} \cdot C}{3 \cdot A \cdot E \cdot V \cdot Y} \text{ [Bq} \cdot \text{dm}^{-3}\text{]};$$

the 2nd method:

$$a_v = \frac{n_{corr} \cdot C}{3 \cdot A \cdot B \cdot E \cdot V \cdot Y} \text{ [Bq} \cdot \text{dm}^{-3}\text{]}$$

where n_{ex} – value of impulses numerousness of the sample [s^{-1}], extrapolated from decay curve in the time t_0 (displace of radon into scintillation detector); n_{corr} - impulses numerousness of the sample, corrected to the background [s^{-1}]; A – correction factor of ^{222}Rn accumulation from closure of emanation container up to time of its transmission into scintillation detector; $A = 1 - e^{-\lambda t_1}$ where t_1 is time of accumulation of ^{222}Rn activity; B – correction factor of ^{222}Rn decay from end of de-emanation up to beginning of measurement, $B = e^{-\lambda t_2}$ where t_2 is time between the end of de-emanation and the beginning of measurement; C - correction factor of ^{222}Rn decay during measurement; $C = \lambda t_3 / (1 - e^{-\lambda t_3})$, where t_3 is measurement time

of sample; E - detection effectiveness [%]; V – water sample volume [dm^{-3}]; Y – chemical yield [%]; λ – decay constant of ^{222}Rn ($0,00755 \text{ h}^{-1}$ or $0,1813 \text{ d}^{-1}$). The values of minimal detection activities (MDA) were calculated according to the relation:

$$MDA = \frac{2,71 + 4,65 \cdot \sqrt{N_f}}{3 \cdot t_f \cdot E \cdot V} \cdot B \cdot C$$

where N_f - impulses numerousness of background; t_f – time of background measurement [s]. The chemical yield was determined to be 81 %, using gravimetric method.

The evaluation of committed effective dose from consumption of drinking water was realized by calculation of effective dose per 1 year by the consumption of 500 dm^3 of drinking water by adult man (300 dm^3 of natural mineral water) according to relation:

$$E = a_v \cdot V \cdot h_{ing}$$

where a_v – volume activity of ^{226}Ra in water sample [$\text{Bq} \cdot \text{dm}^{-3}$]; V – water receiving by ingestion [$\text{dm}^{-3} \cdot \text{y}^{-1}$]; h_{ing} - conversion factor for re-calculation of ^{226}Ra receiving by ingestion on committed effective dose for person from population.

RESULTS AND DISCUSSION

Six samples of drinking water from different sources (water from well, natural mineral water from spring and tap water) were analyzed (see Table 1).

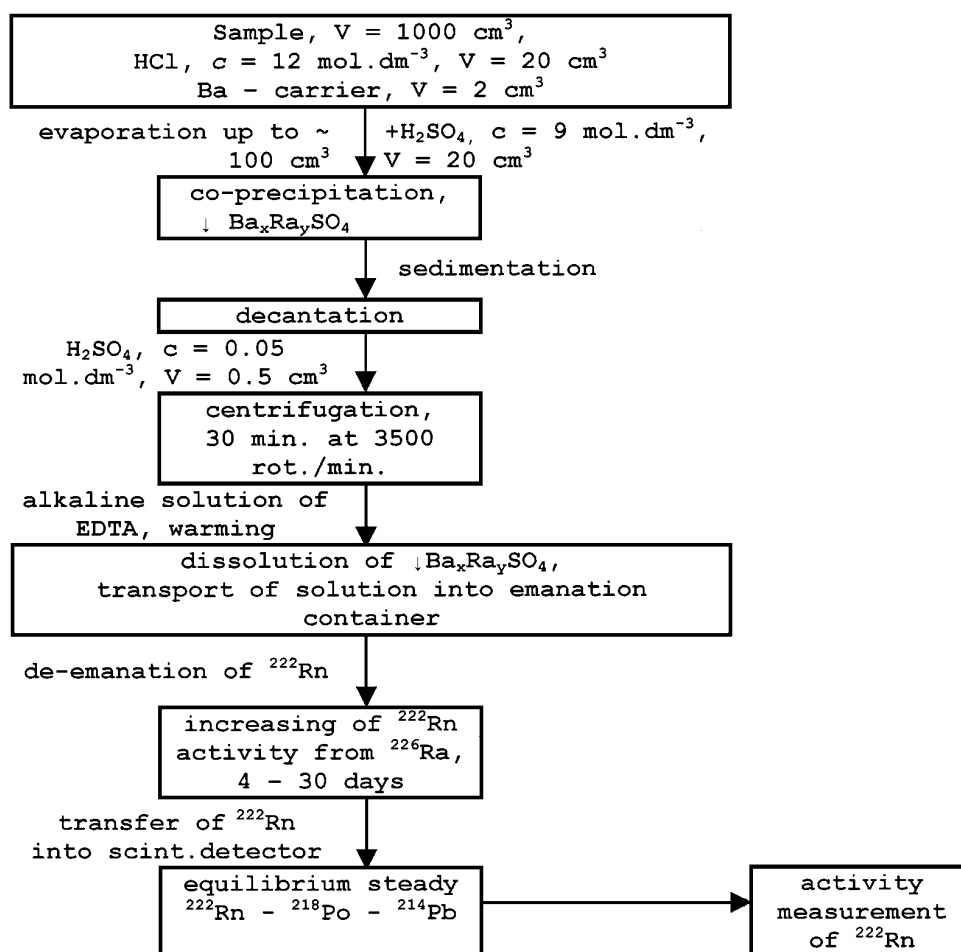
Samples No.3 and No.4 were not dissolved in the solution of EDTA. These samples were unusable for α -activity measurement by radon emanation technique. Calculated value of chemical yield of Ba is 81%. The procedure was verified by using of standard solution of ^{226}Ra . On the basis of our experiments the following scheme (Figure 1) of the method was used and can be recommended.

Table 1 Analysed samples of drinking water and volume activities of the ^{226}Ra

No.	Locality	Source of water	* $a_{v1} \pm u(a_{v1})$ [mBq.dm ⁻³]	MDA [mBq.dm ⁻³]	E(τ) [mSv.rok ⁻¹]
			** $a_{v2} \pm u(a_{v2})$ [mBq.dm ⁻³]		
1	Pezinok	well	74 ± 5	2.66	0.01
			75 ± 1.3		
2	Povazska Bystrica	mineral water	1540 ± 23	2.85	0.098
			1165 ± 4.7		
3	Povazska Bystrica	tap water	-	-	-
			-		
4	Bratislava	tap water	-	-	-
			-		
5	Bratislava	tap water	70 ± 6.2	2.33	0.0097
			69 ± 1.9		
6	Spisska Nova Ves	tap water	21 ± 3.8	2.6	0.0024
			17 ± 0.9		

* value a_v calculated by extrapolation from decay curve;

** value a_v calculated from measured values of impulses numerousness

Figure 1 Scheme of ^{226}Ra determination by radon emanation technique

CONCLUSIONS

The volume activities of ^{226}Ra in analysed samples were low. Although the volume activities of ^{226}Ra were determined to be low, the possible health risk from ingestion was calculated. We found out that neither effective dose nor volume activity was higher as the allowed limits.

Acknowledgement

Acknowledgements are due to Dr. M. Vicinova, Institute of Preventive and Clinical Medicine, Bratislava for her help with radon standards.

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