Detection of ^{222}Rn and ^{226}Ra in environmental samples by scintillation method

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Rn-222 Ra-226 by LSC

Introduction

Natural radionuclides generally represent the main source of radiation exposure to the public. In the environment, they arise either from the direct radon release from the ground into ambient air or through dissolution natural U and Th-series into water. Radon exists at low concentration in surface waters, whereas its concentration in ground waters can be many orders magnitude greater. ^{222}Rn is the radon isotope sufficiently abundant and long-lived to be a health concern with its decay products. Doses caused by ^{222}Rn in the human body from drinking water has been estimated and compared with other models. Most of the water samples are surface water.

Methods

^{222}Rn measurements

Water samples are analyzed on site using a portable liquid scintillation counter Triathler™ (Figure 1). For calibration, a liquid scintillation spectrometer Berthold Betaszint 5000/300 is used. Counting efficiency for the Berthold counter is nearly 100% for each radionuclide α-emitter and 90% per β-emitter in equilibrium conditions into account (480% total in equilibrium). . The ^{222}Rn concentrations found are given in Table [1].

Figure 1

Detection of ^{226}Ra in water

Determination of ^{226}Ra by the ingrowth of ^{222}Rn and its progenies into organic cocktail 12 mL of a ^{226}Ra containing water sample are pipetted under 8 mL of Beta Plate Scint™ or any other water immiscible organic cocktail in a 20 mL glass vial. The vial is closed and refrigerated with the cap downwards in order to avoid ^{222}Rn losses through the plastic cap. After equilibrium between ^{226}Ra and ^{222}Rn has been established (2 to 3 weeks) the vial is shaken vigorously and stored for further 3 h. The measurement is then done in a wide energy channel usually with about 480% counting efficiency (100% counting efficiency for each ^{222}Rn, ^{218}Po, ^{214}Po as α-emitter, for β-emitting daughters ^{214}Pb and ^{214}Bi about 90% counting efficiency each).
The ingrowth of ^{222}Rn may be estimated nearly 50 % after four days storage which corresponds approximately to 50% of ^{226}Ra concentration in water sample (Figure 2).

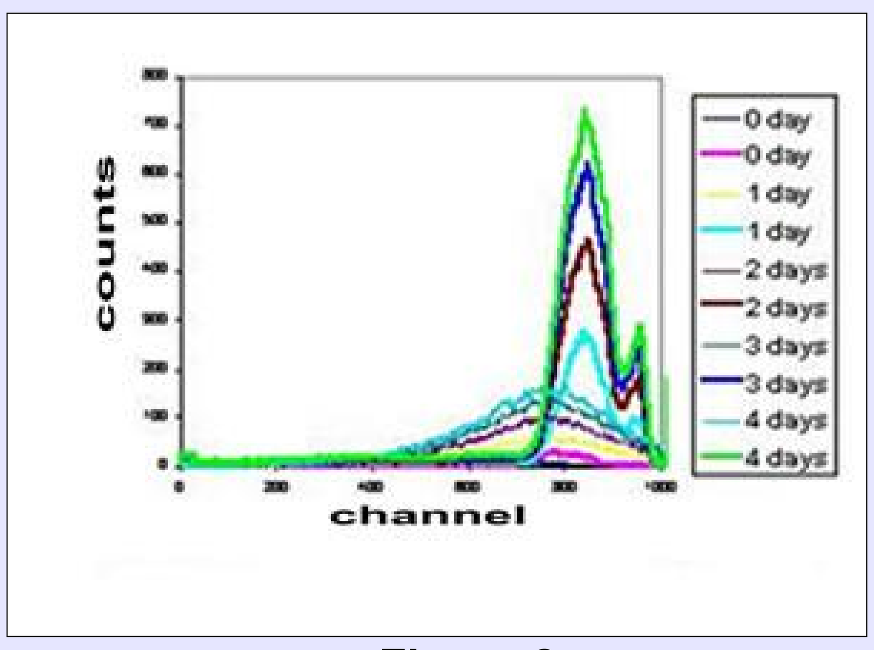

Figure 2

Results and Discussion

Table [1]. ^{222}Rn concentrations in Water samples from Vinaninkarena-Vatovory-Ambohitraivo

Sample	Activity of ^{222}Rn [mBq.L^{-1}]	Sample	Activity of ^{222}Rn [mBq.L^{-1}]
MNG01	10 ± 3.37	VJV01	46.75 ± 3.37
MNG02	107.93 ± 3.37	VJV02	2.70 ± 3.37
MNG03	174.60 ± 3.37	VNK01	91.57 ± 0.9
MNG04	70.74 ± 3.37	VNK02	111.88 ± 1.8
MNG05	104.82 ± 3.37	VNK03	30.68 ± 1.8
VTV01	703.60 ± 3.37	VNK04	17.50 ± 1.8
VTV02	170.24 ± 3.37	VNK05	12.64 ± 1.8
AMS01	251.90 ± 1.8	VNK06	155.17 ± 1.8
AMS02	55.25 ±0.9	VNK07	32.74 ± 1.8

For the 18 water samples collected, a lognormal ^{222}Rn concentrations distribution is observed. ^{222}Rn concentrations range from 10 Bq.L^{-1} to 703.60 Bq.L^{-1}. The arithmetic mean is 119.40 Bq.L^{-1}, the median value is 55 Bq.L^{-1} and the geometric mean is 4.10 Bq.L^{-1}.

Of the ^{222}Rn concentrations acquired, 99 % of results are above 5.9 Bq.L^{-1} the mean ^{222}Rn concentrations value in drinking water fixed by German regulation and 11 Bq.L^{-1} the limit set by Environmental Protection Agency (EPA) while 70% are above 50 Bq.L^{-1}, 60 % are above 100 Bq.L^{-1} and 13.33 % are above 200 Bq.L^{-1}.

Table [2]. ^{226}Ra concentrations in Water samples measured by ingrowth of ^{222}Rn

Sample	Activity of ^{226}Ra [mBq.L^{-1}]	Sample	Activity of ^{226}Ra [mBq.L^{-1}]
MNG01	< MDC*	VJV01	100 ± 70
MNG02	230 ± 20	VJV02	100 ± 80
MNG03	380 ± 32	VNK01	340 ± 28
MNG04	180 ±15	VNK02	240 ± 20
MNG05	200 ± 17	VNK03	190 ± 16
VTV01	250 ± 21	VNK04	150 ± 12
VTV02	100 ± 80	VNK05	160 ± 13
AMS01	130 ± 11	VNK06	220 ± 18
AMS02	120 ±10	VNK07	130 ± 10

** Minimal Detectable Concentration*

Extraction of the ^{222}Rn from the water in the organic scintillator leads to the determination of the ^{226}Ra in water. The method is not fast but simple and sensitive. It requires at least two weeks of storage before counting so that equilibrium between the ^{226}Ra and the ^{222}Rn is established.

Conclusion

Considerable concentrations of ^{222}Rn were found in water samples from Vinaninkarena – Antsirabe, Madagascar. The maximum ^{222}Rn concentration measured is 703.60 Bq.L^{-1}, which corresponds to an annual effective dose of 163.14 µSv. This was evaluated starting from the water consumption of 2 liters per day. Radiation dose estimated for the same radon concentrations through Bayesian analysis (Crawford-Brown 1987) are relatively higher because using the geometric mean ^{222}Rn concentration of 4.10 Bq L^{-1}, it is estimated that an additional tracheobronchial lung dose of 6.10^{-2} mSv.y^{-1} is delivered from the same water to home pathway.

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