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DOSE IN A RECREATIONAL WATER PARK WITH THERMAL WATER

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Introduction

This paper assesses the annual effective dose received by the public due to baths in thermal water of a recreational water park in Royat (France) with significant levels of natural radionuclides. After the context be precised and the measurements of radioactivity presented, an assessment of radiological consequences is performed, based on an hypothetical scenario for persons of the public.

Context

The french commune of Royat in the Massif Central (centre of France) intends to build a recreational water park, using thermal water from a local source, out of the public water supply network. With this aim in view, the operator builds up a technical file to get a prefectorial authorization. Considering that many waters and thermal waters in this area have significant levels of natural radionuclides (granitic subsoil) on the one hand, and that the operator of establishments receiving public is requested by L 1333-10 article of the Public Health Code to supervise the exposure if an impact on health is possible on the other hand, the operator asked IRSN to measure the level of radioactivity in the water. Considering the level of radioactivity measured, the competent authority then asks IRSN if this level is compatible with its use in a recreational water park.

Measurements

The measurements performed by IRSN [1] enable to identify several natural radionuclides - i.e. ^{210}Po , ^{222}Rn , ^{226}Ra , ^{228}Ra and ^{228}Th - with significant level¹ of activity, and to conclude to no significant level² of activity for other radionuclides - i.e. ^3H , ^{210}Pb , ^{230}Th , ^{232}Th , ^{234}U and ^{238}U . These measurements are presented in table 1.

Table 1 : Measurements of radioactivity in the thermal water of Royat

Radionuclide	Activity (Bq.L ⁻¹)
^3H	< 9*
^{210}Pb	< 0.066*
^{210}Po	0.011
^{222}Rn	22
^{226}Ra	0.59
^{228}Ra	0.18
^{228}Th	0.016
^{230}Th	< 0.002*
^{232}Th	< 0.002*
^{234}U	< 0.006*
^{238}U	< 0.006*

* : threshold of the equipment or technique used

Exposure

To determine if there is risk or not needs to imagine the behaviour of someone of the public frequenting the recreational water park so that its annual effective dose is reasonably maximum. With this aim in view, it is considered a person of the public who frequents the park 50 times a year, each visit during 4 hours. Such a person can be a child (except young baby) or an adult.

During its presence in the park, the person is exposed to the water of the pools and to the atmosphere above. So the ways of exposure to be considered are :

- immersion in the water of the pools,
- inadvertent ingestion of water of the pools,
- external exposure to the atmosphere of the park,
- inhalation of the atmosphere of the park.

0.2 L is adopted as a maximum value for inadvertent ingestion of water, per visit.

¹ above the threshold of the equipment or technique used for the measurement.

² under the threshold of the equipment or technique used for the measurement.

It is considered that the atmosphere of the park can contain 10^{-2} L.m⁻³ of water [2], with the same specific activity for each radionuclide as the one in the water of the pools. Due to the characteristics of rare gas of ²²²Rn, the determination of the level of activity of ²²²Rn in the atmosphere is based on the consideration that volumic activity of ²²²Rn per cubic metre of air is the same as volumic activity of ²²²Rn per litre of water [6]. This conservative approach is suggested by measurements performed in water and atmosphere of the Evaux les Bains hydropathic establishment [6].

The breath rates are from ICRP Publication 66 [5].

For external exposure, dose coefficients are from Federal Guidance [3].

For internal exposure, inhalation and ingestion dose coefficients are those of french legislation [4], themselves from ICRP Publication 68 and 72. For internal exposure by inhalation of ²²²Rn, a potential alpha energy exposure of $2.22 \cdot 10^{-9}$ J.h.m⁻³/Bq.h.m⁻³ [7] and a conversion coefficient of 1,1 Sv/J.h.m⁻³ [4] are adopted.

For exposure by immersion in the water and by ingestion, short lived progeny³ of ²²²Rn is considered at radioactive equilibrium with their parent. For exposure to the atmosphere of the park, short lived progeny of ²²²Rn is considered with an equilibrium factor of 0.4 [7] [6].

Results

Table 2 presents the annual effective dose according to the age of the person considered. For the total, the main figure is the annual effective dose due to radionuclides really measured, the figure in parenthesis is the annual effective dose taking also into account the other radionuclides with their threshold (see Table 1).

Table 2 : Annual effective dose (μSv)

Radionuclide	Age (y)				
	1 - 2	3 - 7	8 - 12	13 - 17	≥ 18
²¹⁰ Po	1.0	0.5	0.4	0.3	0.2
²²² Rn	14.7	14.5	14.5	14.4	14.4
²²⁶ Ra	8.5	6.7	8.4	13.3	5.5
²²⁸ Ra	11.1	7.0	8.1	10.9	2.1
²²⁸ Th	1.0	1.0	1.2	1.3	1.2
Total	36.3 (38.9)	29.7 (31.5)	32.5 (34.0)	40.1 (41.7)	23.3 (24.2)

³ ²¹⁸Po, ²¹⁴Pb, ²¹⁴Bi, ²¹⁴Po

As shown in Table 2, the most exposed group is the group of teenagers from 13 to 17 years old with an annual effective dose about 40 μ Sv. The main parts are those of ^{222}Rn (35%), ^{226}Ra (32%) and ^{228}Ra (26%); the contribution of radionuclides with levels below the detection limits is negligible.

It is interesting to have a look on the contributions of the different ways of exposure. The main parts are those of inadvertent ingestion of water (48%) and inhalation of the atmosphere of the park (44%); the contribution of the immersion in the water leads only to 7% of the annual effective dose.

The total annual effective dose is not very high, but it is directly related to the level of activity of ^{222}Rn and isotopes of radium. One should note, however, that other thermal French waters may have much higher ^{222}Rn concentration (up to $1,000 \text{ Bq.L}^{-1}$) [6]; their use in recreational water park could lead to annual effective doses much higher and then must be studied with attention.

Conclusion

In the particular case of the commune of Royat, the level of activity of natural radionuclides of the thermal water (22 Bq.L^{-1} for ^{222}Rn) is compatible with its use in a recreational water park, the annual effective dose being about $40 \mu\text{Sv}$ with a conservative approach. For other thermal waters in France which could have much higher levels of natural radioactivity, it is recommended to pay attention to their use in recreational water park.

References

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