Appendix 4

INFORMATION ON DECAY CHAINS

NATURALLY OCCURRING RADIONUCLIDES

Tables A4.1, A4.2 and A4.3 list the radionuclides in each of the three radioactive decay chains of relevance to this study. Every radionuclide, when ingested, gives rise to a radiation dose to the individual. The amount of dose varies by orders of magnitude from one radionuclide to another, as illustrated by the tabulated values of annual dose per unit activity concentration in water. Details of the calculations involved are given in Appendix 8.

Notes on Tables A4.1, A4.2 and A4.3

1. The annual dose per unit activity in water is defined for the purposes of this study as the radiation dose, in millisieverts, received annually by an individual from the sole continuous use of drinking water at two litres per person per day containing 1 becquerel of activity of the radionuclide concerned per litre of water, averaged over a lifetime of 70 years.

2. (1 becquerel = 1 nuclear disintegration per second).

3. Radionuclides in ***bold italics*** are those measured in all or part of this study.

4. Radionuclides marked with an asterisk* are the radon isotopes and their short half-life daughters.

5. Dose conversion factors not given by the IAEA are left blank and are taken as negligible.

6. Uranium-238 and uranium-235 occur naturally in the approximate activity ratio 21 : 1.

7. Gross alpha activity, as measured in this study, is taken to be the sum of the activities (in becquerel) of all the alpha emitters (excluding radon and radon daughters), per litre of water.

8. Gross beta activity, as measured in this study, is taken to be the sum of the activities (in becquerel) of all the beta emitters (excluding radon daughters), per litre of water. The list of beta emitters includes potassium-40, a naturally occurring radionuclide which is found in water, but which does not form part of the uranium-238, uranium-235 or thorium-232 decay series. It is not of interest in dose calculations because its concentration in the body is essentially independent of intake.

Table A4.1: Uranium-238 series radionuclides

Radionuclide	Type of radiation emitted	Annual dose per unit activity concentration in water (mSv/a) per (Bq/ℓ)
Uranium-238	Alpha	0,33
Thorium-234	Beta	0,0027
Protactinium-234m	Beta	
Uranium-234	Alpha	0,036
Thorium-230	Alpha	0,15
Radium-226	Alpha	0,27
Radon-222*	Alpha	
Polonium-218*	Alpha	
Lead-214*	Beta	0,00012
Bismuth-214*	Beta	0,000087
Polonium-214*	Alpha	
Lead-210	Beta	0,59
Bismuth-210	Beta	0,0010
Polonium-210	Alpha	1,0

Table A4.2: Uranium-235 series radionuclides

Radionuclide	Type of radiation emitted	Annual dose per unit activity concentration in water (mSv/a) per (Bq/ℓ)
Uranium-235	Alpha	0,034
Thorium-231	Beta	0,00027
Protactinium-231	Alpha	0,52
Actinium-227	Beta	0,85
Thorium-227	Alpha	0,0080
Radium-223	Alpha	0,11
Radon-219*	Alpha	
Polonium-215*	Alpha	
Lead-211*	Beta	0,00015
Bismuth-211*	Alpha	
Thallium-207*	Beta	

Table A4.3: Thorium-232 series radionuclides

Radionuclide	Type of radiation emitted	Annual dose per unit activity concentration in water (mSv/a) per (Bq/ℓ)
Thorium-232	Alpha	0,167
Radium-228	Beta	0,886
Actinium-228	Beta	0,00034
Thorium-228	Alpha	0,064
Radium-224	Alpha	0,069
Radon-220*	Alpha	
Polonium-216*	Alpha	
Lead-212*	Beta	0,0057
Bismuth-212*	Alpha 36% Beta 64%	0,00021
Thallium-208*	Beta	
Polonium-212*	Alpha	