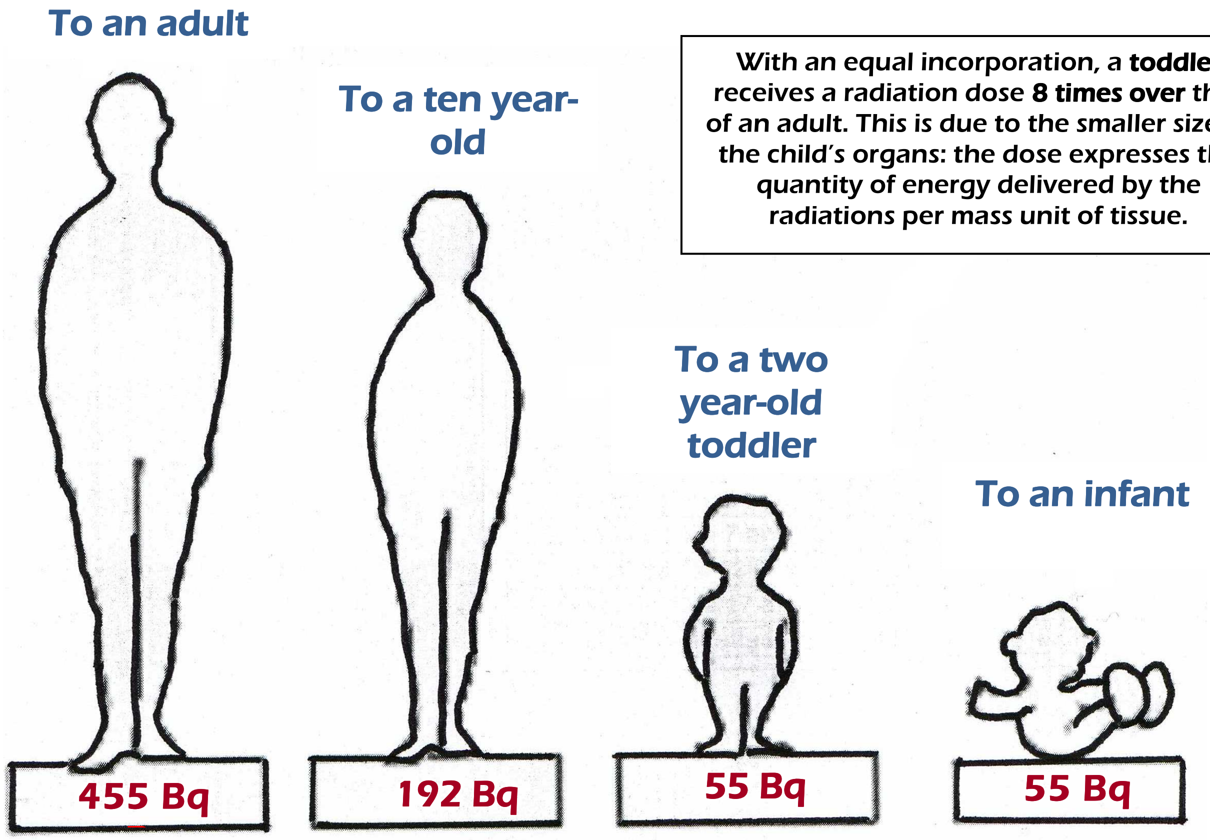
INCORPORATION of IODINE 131 by INGESTION

Quantity of iodine 131 delivering an effective dose of 10 µSv
(threshold under which authorities consider the risk as trivial)



With an equal incorporation, a **toddler** receives a radiation dose **8 times over** that of an adult. This is due to the smaller size of the child's organs: the dose expresses the quantity of energy delivered by the radiations per mass unit of tissue.

The becquerel (noted as Bq) is the legal unit to measure the activity (or radioactivity).
1 Bq = 1 disintegration per second

- **The dose is subject to the age and the quantity of ingested radioactive iodine**

For example, if the activity of water is **80 becquerels per liter** (Bq/l), it expresses that at each second in one liter of water, 80 atoms of iodine 131 disintegrate and emit ionizing radiations. (NB : this is a theoretical example with no tie to contamination generated by the Fukushima Daiichi releases in France or Europe).

If someone drinks **70 cl** of this water, an activity equal to **56 Bq** (80 Bq x 0,7 l) is ingested. But if the consumer is a **toddler** (70 cl of water used for the preparation of a baby bottle for instance), the ingestion of these 56 Bq will deliver in the space of one day a dose of **10 µSv**. Yet, the authorities consider that beyond a dose of 10 µSv per annum, the radiological risk is acceptable but is no longer inconsequential : from 10 µSv/yr to the threshold standard dose of 1 000 µSv/yr, expositions must be reduced insofar as "reasonably" possible to do so. Beyond 1 000 µSv/yr (hence 1 mSv/yr), the radiological risk (namely carcinogen) is considered as too high to be admitted [1].

1. At least in a normal operation. In a situation of accident, the authorities consider that risks and costs associated to protection measures (measures of safety needed to reduce expositions, such as evacuation, administration of natural iodine supplements, prohibition to sell contaminated foods, etc) must be taken into consideration and that the population can be subject to dose levels, and the risks superior to those admitted as tolerable in normal conditions.

If the contamination persists and that the child ingests, over a period of **3 weeks**, a daily activity of 56 Bq, the quantity ingested will equate to 56 x 21 = **1 176 Bq** hence a dose of **212 µSv** (thus, in 3 weeks time, the double limit of the annual standard dose for potable water : **100 µSv/an**).

If the same activity – 1 176 Bq – is ingested by an **adult**, the dose will only be of **26 µSv** ; If the adult drinks the same water but on a basis of **2 liter a day** (as opposed to 70 cl), the dose received will be of **74 µSv**, which remains inferior to the dose received by the 2 year-old child or younger, with an intake three times inferior to that of the child.

This demonstrates the necessity to establish specific protection measures for children. However, it is not so. The norms established for potable waters are designed for adults and do not protect them sufficiently.

See the CRIIRAD website/ News 2010 / Dossier CRIIRAD :
The radiological norms for potable water

• The activity of iodine 131 decreases with time (except in cases of new happenings)

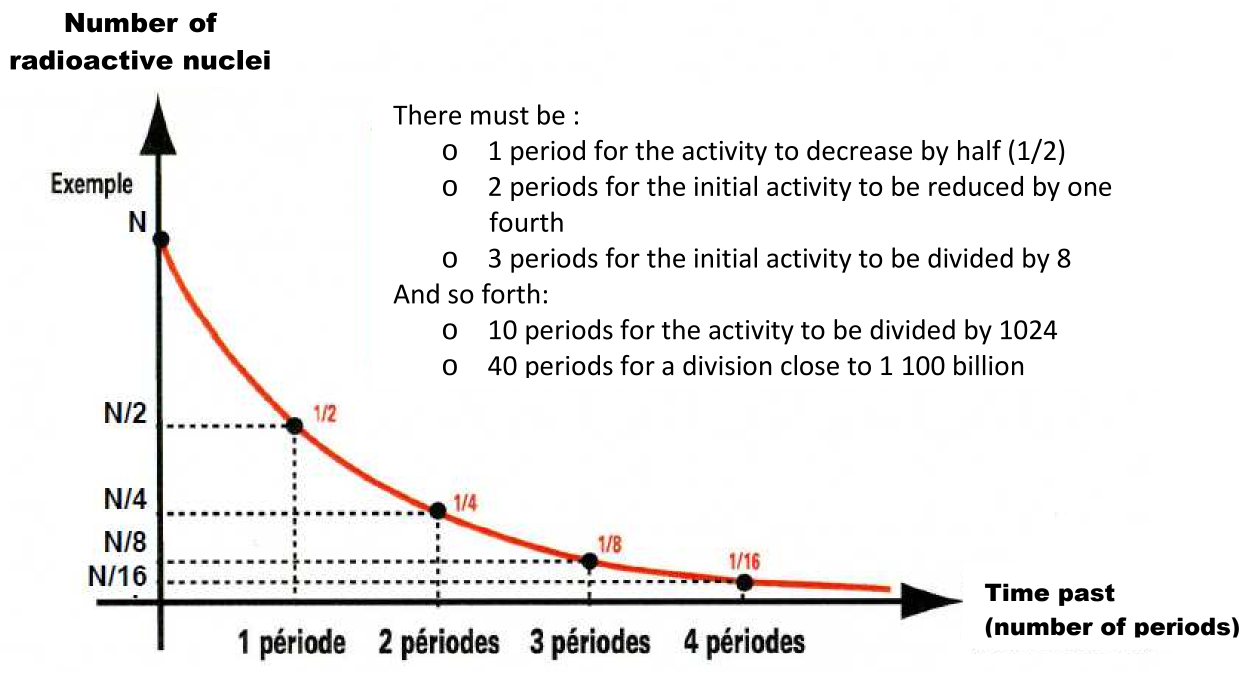
It must however be considered that, due to the fact that the **radioactive period** of iodine 131 is of **8 days** : this means that within 8 days (hence 1 period) its initial activity is divided by 2 (divided by 4 within 2 periods, i.e. 16 days ; divided by 8 within 3 periods, i.e. 24 days ; divided by 16 within 32 days, etc.)

If we consider a tanker in which rainwater in collected, the decay of the iodine 131 activity becomes effective only if surges of radioactive material no further occur. So long as airborne contaminated masses continue to bring iodine 131 and that the rainfall running off the roof continues to be collected, contamination does not necessarily decrease, at least not at the radioactive period rate.

On the contrary, in the first stage, the radioactivity level increases. Schematically, when the flows of radioactive atoms and their fading by disintegration break-even, the levels of contamination stabilize. It is only in the absence of any new surge that the water tanker activity of iodine 131 will be divided by half every 8 days.

See pages below : precisions on the notion of radioactive period

Precisions on the notion of « radioactive period »



There must be :

- 1 period for the activity to decrease by half (1/2)
- 2 periods for the initial activity to be reduced by one fourth
- 3 periods for the initial activity to be divided by 8

And so forth:

- 10 periods for the activity to be divided by 1024
- 40 periods for a division close to 1 100 billion

The radioactive period corresponds to the decrease of a factor 2. At the end of 2 periods, the decrease reaches a factor 4 (half of the half) ; at the end of 3 periods, the activity is divided by 8 (half of the half of half) ; etc.

The table on the right indicates for an increasing number of radioactive periods, the corresponding reduction factor.

It is often stated, wrongly so, **the 10 period rule** at the end of which a radioactive source would be no longer dangerous.

In fact, this value corresponds to a division by 1000 (precisely by 1024) of the initial activity. Whether the character of this reduction level is satisfactory or unsatisfactory rests, in fact, on the initial activity of the source.

If it is very high, 30 periods may be necessary ; hence a division by just over a billion ; 40 periods, hence a division by over 1 000 billions ; 50 periods, hence a division of the initial activity by over a million billion or perhaps even longer.

Nombre de périodes	Facteur de réduction
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1 024
11	2 048
12	4 096
13	8 192
14	16 384
15	32 768
16	65 536
17	131 072
18	262 144
19	524 288
20	1 048 576
21	2 097 152
22	4 194 304
23	8 388 608
24	16 777 216
25	33 554 432
26	67 108 864
27	134 217 728
28	268 435 456
29	536 870 912
30	1 073 741 824
40	1 099 511 627 776
50	1 125 899 906 842 620

The radioactive periods are characteristic to each radionuclide and extremely variable: from less than one billionth of microsecond to hundreds of billions years. Some examples are presented in the periodic table below.

Radionucléide	Période radioactive		Radionucléide	Période radioactive
rubidium 99	0,06 seconde		strontium 90	28,5 ans
calcium 51	10 secondes		césium 137	30 ans
césium 126	1,64 minutes		nickel 63	100,1 ans
technétium 99m	6 heures		américium 241	432,7 ans
iode 123	12,2 heures		radium 226	1 600 ans
iode 131	8 jours		carbone 14	5 730 ans
béryllium 7	53,29 jours		américium 243	7 380 ans
iode 125	60,14 jours		plutonium 239	24 000 ans
cobalt 58	70,92 jours		thorium 230	75 400 ans
césium 134	2 ans		iode 129	15 700 000 ans
cobalt 60	5,27 ans		uranium 235	703 700 000 ans
tritium	12,33 ans		potassium 40	1 277 000 000 ans
plutonium 241	14,4 ans		uranium 238	4 468 000 000 ans
			thorium 232	14 050 000 000 ans

For the activity to be **divided by 4** it will be necessary to wait until 2 periods have passed, which corresponds to :

- 12 hours for the technetium 99m (T= 6 hours)
- 16 days for iodine 131 (T = 8 days)
- 60 years for cesium 137 (T = 30 years)
- 3 200 years for radium 226 (T = 1600 years)
- Close to 9 billion years for Uranium 238 (T = 4,47 billion years)

For the activity to be divided by **one million** a delay of 30 periods will be necessary, in other words :

- 30 x 6 hours or 7,5 days for Technetium 99m
- 30 x 8 days or 240 days for iodine 131
- 30 x 5,27 years or 158 years for cobalt 60
- 30 x 30 years or 900 years for cesium 137
- 30 x 1 600 years or 48 000 years for radium 226