Don't Panic
The simple guide to the health consequences of drinking contaminated water or milk in the USA and Europe

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Data from Fukushima releases are now appearing on the internet.
How can non-scientists assess the risk associated with the various levels of contamination being reported?
I will address this question here.

Contamination reports from various bodies focus on several radionuclides and until now, results have become available for contamination of milk, drinking water, rainwater and some farm produce. There are also measurements of concentrations in air. The current radiation risk model, that of the ICRP, gives dose conversion coefficients, numbers that can be used to convert internal ingestion or inhalation of any specific radionuclide into a whole body or "effective" dose. These numbers are wildly wrong for certain radionuclides but roughly correct for others. The degree to which they are wrong depends on number of things, basically how the DNA is affected, and so the ECRR has developed and published weighting factors which modify (multiply) the ICRP coefficients. These are based on theoretical considerations of molecular interactions and physical decay sequences and qualities but also based on epidemiology of internal exposures.

Pico Curies and Becquerels

For some reason, the USA agencies still employ the picoCurie (pCi) as a measure of activity. 1 pCi is 0.037Bq. We will work in Bq.

Dose, dose rate and contamination

Dose, or absorbed equivalent dose is given in Sieverts. It is this quantity that is used to predict radiation risk. It is a lump of radiation that has been delivered to your body. Although for some radionuclide internal exposures, absorbed dose is a meaningless concept, because it is an average to all tissue rather than the energy delivered to the DNA, we can use weighting factors to convert the absorbed dose into the energy delivered to the DNA. This is what the ECRR has done. A microSievert (μSv) is one millionth of a Sievert.

Dose rate, or microSieverts per hour (μSv/h or μSvh^{-1}) enables you to obtain the dose. If you are exposed for a day at 2 μSv/h your dose is 24 x 2 = 48 μSv.

Activity, measured in Becquerels or pico Curies is a quantity of radioactivity. One Becquerel is one disintegration per second. If you have an apple in your hand and the activity of Cs-137 in the apple is 50Bq then the apple will be emitting 50 radioactive emissions per second. If you are standing on a 1 square metre table with a surface activity of 100Bq/sq metre Cs-137 then the contamination will be emitting 100 radiation rays or photons per second in all directions. About $1/6^{th}$ of these will go upwards and through your body. This will result in a dose due to the absorption by your body of some of this energy. There are ways of calculating what this dose will be but they are quite complicated and don't concern us here.

Ingestion

The latest ECRR coefficients for the main exposure radionuclides reported and for Uranium are tabulated in ECRR2010 which the committee has put on the website www.euradcom.org as a free download. The ICRP cancer risk coefficient is about 0.05 per Sievert and that of the ECRR is 0.1 per Sievert.

Table 1 The ECRR adult ingestion dose coefficients for Caesium-137, Iodine -131 and uranium-238 particulates are given below.

Radionuclide	**ICRP dose coefficient Sv/Bq**	**ECRR dose coefficient Sv/Bq**
Cs-137	1.3 E-8	6.5 E-8
I-131	2.2 E-8	1.1 E-7
Uranium particulate	4.5 E-8	2.5E-6

We can now assess the risk from internal exposures in the USA and Europe.

Example 1
The measured activity of I-131 in drinking water is 500mBq/l. The effective dose is 5.5×10^{-8} or 0.055 microSieverts. The cancer risk to an adult who drinks 1 litre is then $0.5 \times 1.1 \times 10^{-7} \times 0.1 = 5.5 \times 10^{-9}$. That is 5.5 cancers in 1 billion people in 50 years who have all consumed 1 litre. Drinking 1 litre for a month would obviously increase this risk by 30-fold.

Example 2
The measured activity of I-131 in milk in California is 120Bq/l. The cancer risk to a person who drinks 1 litre is $120 \times 1.1 \times 10^{-7} \times 0.1 = 1.32 \times 10^{-6}$. We would expect 1.32 extra cancers in 1 million individuals in 50 years.

These calculations show that there is a very low level of risk from adult exposures to the quantities of these radionuclides being reported in Europe and the USA.

Children, infants and the foetus.

There is plenty of evidence that risks to the foetus, infants and children are greater. But this is not due to Iodine or Caesium exposures. The dose coefficient is perhaps as much as 5 times greater for children. Infant leukemia increased after Chernobyl at levels where the ICRP foetal doses from Caesium-137 were about 50microSieverts and the ECRR coefficients for Cs-137 would not have predicted these increases (Busby 2009). At levels of 100Bq/l of Caesium-137 1 litre would commit a ICRP dose of $100 \times 1.3 \times 10^{-8}$ = 1.3 microSieverts and drinking 30 litres would provide a dose of 39 microSieverts ICRP. Therefore the effects on infant leukemia are believed to be due to other radionuclides and particulates present with the Caesium-137. Such particulates were measured after Chernobyl in many countries. Similar increases in child leukaemia and cancer are found near nuclear sites at ICRP doses of perhaps 50 microSieverts. Again, this is probably due to inhalation of particles released by these plants by the mothers and fathers.

Inhalation

The inhalation doses are likely to be significant for particulates, especially uranium particulates. Where there are levels of I-131 or Cs-137 in the air, there may also be particulates. These are sub micron diameter particles of reactor fuel or recombined condensed reactor fuel and will contain Uranium nuclides and plutonium also. They can travel vast distances and were found in filters in the UK after the 2003 Gulf war. It was probably the exposure to these particulates that was the driver of the Chernobyl effects even though the exposures were modelled as Cs-137. The modelling using Cs-137 occurs because, like I-131, it is an easy radionuclide to measure using dispersive gamma spectrometry. For this reason, and various theoretical ones, uranium particulates have an ECRR 2010 inhalation dose coefficient of 8.4×10^{-3} for adults and 1.2×10^{-2} for children aged 1-14.
However, no measurements of uranium or plutonium have been reported.
It is recommended that the levels of atmospheric particulates from Fukushima be assessed as a matter of extreme urgency as this could be a global issue.

Other significant radionuclides

Other significant radionuclides for which no measurements have been made, and which will have been emitted from Fukushima are given in Table 2 with their ECRR dose coefficients.

Table 2 Unreported radionuclides with significant potential for health effects

Radionuclide	**ECRR dose coefficient (adult)**	**Note**
H-3 Tritium (HTO)	2.0 E-10	Tritiated water
H-3 Tritium (CHT)	1.0 E-9	Organically bound
Pu-239 particle	7.5 E-5	
Am-241	2.0 E-7	

Measurements of Tritium in drinking water and in the atmosphere near Fukushima are likely to be significant health issues but have not been reported.

For further information please consult ECRR2010.

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Busby, C.C. Very Low Dose Fetal Exposure to Chernobyl Contamination Resulted in Increases in Infant Leukemia in Europe and Raises Questions about Current Radiation Risk Models. *Int. J. Environ. Res. Public Health* **2009**, *6*, 3105-3114.