Radiation Risk by Consumption of Contaminated Food after the Catastrophe at Fukushima Dai-ichi Nuclear Power Plant

The German Federal Minister for Nutrition, Agriculture and Consumer Protection has announced that the European Commission and the EU member states have agreed on April 8 to adopt the valid Japanese allowable limits for maximum contamination by radionuclides as new limits for food and animal feed from Japan imported into the European Union.

The respective contamination limits are as follows, in Becquerel per kilogram (Bq/kg):

Food for Human Consumption				
	Food for infants and children	Milk and dairy products	Other foodstuffs except beverages	Beverages
Strontium isotopes, especially Strontium-90*	75	125	750	125
Iodine isotopes, especially Iodine-131	100	300	2000	300
Plutonium isotopes, especially Plutonium-239	1	1	10	1
Cesium-134 and Cesium-137	200	200	500	200
Feed for Animals				
Cesium-134 and Cesium-137	500			
Iodine isotopes	2000			

*Note: Regulations in Japan do not give an allowable limit for Strontium

Calculation of Risk

The following calculations are based on the prescripts of the valid German Radiation Protection Ordinance[1]

Nutrition contaminated with radionuclides at the limits given above for Iodine 131 and the average yearly consumption rates as given in Annex VII, Table 1 of the German radiation protection ordinance of 2001 will entail the following yearly doses to the thyroid gland:

760 milliSievert thyroid gland dose per year for an infant (up to one year of age)[2]
1 390 milliSievert thyroid gland dose per year for a small child (1 to 2 years of age)[3]
1340 milliSievert thyroid gland dose per year for a child of 2 to 7 years of age[4]

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[1] Amount consumed in kg x radioactivity concentration in Bq/kg x dose coefficient (as decreed by the German Ministry for the Environment on 23. July 2001) in Sv/Bq = dose in Sv; 1 Sv = 1000 milliSievert.
E-6, for example, is a bureaucratic way of writing the correct mathematical term of 10^{-6} = 0.000 001 which is used in the German ordinance. Because the allowable limits for milk and dairy products on one hand and beverages on the other are the same, I summarized the two positions by adding the mean consumption quantities. The new position is: milk and beverages.

[2] (145 kg/year x 100 Bq/kg + 45 kg x 300 Bq/kg + 80.5 kg x 2000 Bq/kg + 55 kg x 300/Bq/kg) x 3.7E-6 Sv/Bq = 0.76 Sv = 760 mSv/year.

[3] (160 kg/year x 300 Bq/kg + 154 kg/year x 2000 Bq/kg + 100 kg/year x 300 Bq/kg) x 3.6E-6 Sv/Bq = 1.39 Sv/year = 1390 mSv/year

750 milliSievert thyroid gland dose per year for a child of 7 to 12 years of age[5]
560 milliSievert thyroid gland dose per year for an adolescent of 12 to 17 years of age[6]
360 milliSievert thyroid gland dose per year for a grown up older than 17 years of age[7]

According to § 47 of the German radiation protection ordinance of 2001, under normal operating conditions of nuclear facilities the allowable limit for the organ dose to the thyroid gland is 0.9 milliSievert per year. In a nuclear accident, § 49 of the ordinance allows a dose limit of 150 milliSievert to the thyroid gland. This corresponds to a so called effective dose of 7.5 milliSievert.[8] To consume food and beverages at the allowable limits of radio-Iodine contamination given above thus means to transgress these dose limits by a multiple in all the cases.

Iodine-131 has a half-life of 8.06 days. After the Fukushima reactors have burnt themselves out and stopped emitting radioactivity into the environment, Iodine-131 will be reduced to less than 1% of the original amount after 7 half-lives or in a little less than 2 months. For example, of 2000 Becquerel Iodine-131 after just less than two months there will remain about 16 Becquerels and only after 11 half-lives or 88 days the original amount will have dwindled to less than 1 Bq.

Effective Doses

Of special interest in the long run are the longer-lived radionuclides like Cesium-134 with a half life of 2.06 years, Cesium-137 with a half-life of 30.2 years, Strontium-90 with a half-life of 28.9 years and Plutonium-239 with a half-life of 24 400 years.
From measurements of food published so far in Japan, we gather that the concentrations of Cesium-134 and Cesium-137 are roughly the same at present. Taking this and the allowable limits given in the table above into account, the following effective doses per year can be calculated:

for an infant (up to 1 year of age) – 63 milliSievert effective dose per year[9]
for a small child (1 to 2 years of age) – 83 milliSievert effective dose per year[10]
for a child of 2 to 7 years of age –78 milliSievert effective dose per year[11]

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[4] (160 kg/year x 300 Bq/kg + 280 kg/year x 2000/Bq/kg + 100 kg /year x 300 Bq/kg) x 2.1E-6 Sv/Bq = 1.34 Sv/year = 1 340 mSv/year

[5] (170 kg/year x 300 Bq/year + 328,5 kg/year x 2000 Bq/year + 150 kg/year x 300 Bq/kg) x 1.0 E-6 Sv/Bq = 0.75 Sv/year = 750 milliSievert/year

[6] (170 kg/year x 300 Bq/year + 356 kg/year x 2000 Bq/kg + 200 kg/year x 300 Bq/kg) x 6.8 E-7 Sv/Bq = 0.56 Sv/year = 560 milliSievert/year

[7] (130 kg/year x 300 Bq/kg + 350.5 kg/year x 2000 Bq/kg + 350 kg/year x 300 Bq/kg) x 4.3 E-7 Sv/Bq = 0.36 Sv/year = 360 milliSievert/year

[8] *Effective dose* means the contribution of the dose received by an organ or organ system to the 100% of total dose. In the German radiation protection ordinance, Annex VI, Part C 2, the thyroid gland is weighted by 5% (the factor 0.05) only. The reasoning given for this low weighting is that cancer of the thyroid gland is easily operable.

[9] 145 kg baby food/year x [100 Bq/kg x (2.1 E-8 Sv/Bq Cs-137 + 2.6E-8 Sv/Bq Cs-134) + 75 Bq/kg x 2.3E-7 Sv/Bq Sr-90 + 1 Bq/kg x 4.2 E-6 Sv/Bq Pu-239 + 100 Bq/kg x 1.8 E-7 Sv/Bq I-131] + 100 kg milk and other beverages/year x [100 Bq/kg x (2.1 E-8 Sv/Bq Cs-137 + 2.6 E-8 Sv/Bq Cs-134) + 125 Bq/kg x 2.3 E-7 Sv/Bq Sr-90 + 1 Bq/kg x 4.2 E-6 Sv/Bq Pu-239 + 300 Bq/kg x 1.8 E-7 Sv/Bq I-131] + 80.5 kg other foods/year x [250 Bq/kg x (2.1 E-8 Sv/Bq Cs-137 + 2.6 E-8 Sv/Bq Cs-134) + 750 Bq/kg x 2.3 E-7 Sv/Bq Sr-90 + 10 Bq/kg x 4.2 E-6 Sv/Bq Pu-239 + 2000 Bq/kg x 1.8 E-7 Sv/Bq I-131] = 62.8 mSv/year.

[10] 260 kg milk and other beverages/year x [100 Bq/kg x (1.2 E-8 Sv/Bq Cs-137 + 1.6E-8 Sv/Bq Cs-134) + 125 Bq/kg x 7.3E-8 Sv/Bq Sr-90 + 1 Bq/kg x 4.2 E-7 Sv/Bq Pu-239 + 300 Bq/kg x 1.8 E-7 Sv/Bq I-131] + 154 other foods kg/year x [250 Bq/kg x 1.2E-8 Sv/Bq Cs-137 + 1.6E-8 Sv/Bq Cs-134) + 750 Bq/kg x 7.3 E-8 Sv/Bq Sr-90 + 10 Bq/kg x 4.2 E-7 Sv/Bq Pu-239 + 2000 Bq/kg x 1.8 E-7 Sv/Bq I-131] = 82.8 mSv/year

[11] 260 kg milk and other beverages/year x [100 Bq/kg x (9.6 E-9 Sv/Bq Cs-137 + 1.3 E-8 Sv/Bq Cs-134) + 125 Bq/kg x 4.7E-8 Sv/Bq Sr-90 + 1 Bq/kg x 3.3 E-7 Sv/Bq Pu-239 + 300 Bq/kg x 1.0 E-7 Sv/Bq I-131] + 280 other

for a child of 7 to 12 years of age – 60 milliSievert effective dose per year[12]
for an adolescent of 12 to 17 years of age – 58 milliSievert effective dose per year[13]
for a grown-up (older than 17 years of age) – 33 milliSievert effective dose per year[14]

According to § 47 of the valid German radiation protection ordinance under normal operating conditions of nuclear facilities a yearly dose limit of 0.3 milliSievert per individual of the population "due to emissions of radioactive substances into the air or into the water" is considered allowable. This limit is transgressed by more than a hundredfold if you consume food and beverages contaminated by radionuclides at the maximal level permitted by the EU and Japan for a year. The yearly permissible dose limit of 0.3 mSv/person would only be complied with, if for example grown-ups would not consume more than 0.9% of foods contaminated at permissible levels with their yearly intake of food and beverages.

The International Commission of Radiological Protection (ICRP) calculates that of 100 000 children irradiated by a dose of about 80 milliSievert per year, about 400 per year will die of cancer later on due to this irradiation only, in addition to those dying of cancer from other causes. Independent evaluations of the data of Hiroshima and Nagasaki[15] have shown, that the figure may well be 10 times higher, i. e. 4000 cancer deaths per year later on among children irradiated with 80 milliSievert per year.
For grown-ups irradiated by nutrition at the maximum levels allowed by EU and Japan with a dose of 33 milliSievert per year, the figure would be 165 to 1 650 persons per year to die of cancer exclusively due to this irradiation. By allowing such limits for food and drink the Japanese and EU governments demand human sacrifice in that order. Note, that the concept of the so-called 'effective dose' considers only deaths by cancer later on, but not cancer illnesses, the figure of which is higher. After the catastrophe at the Chernobyl nuclear power plant in 1986 besides various cancers an increase in other somatic illnesses was observed: weakening of the immune system, premature ageing, cardio-vascular diseases in younger years, chronic diseases of the stomach, the thyroid gland and the pancreas as well as neurological-psychiatric diseases as a direct somatic effect of low dose radiation.

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foods kg/year x [250 Bq/kg x 9.6 E-9 Sv/Bq Cs-137 + 1.3E-8 Sv/Bq Cs-134) + 750 Bq/kg x 4.7E-8 Sv/Bq Sr-90 + 10 Bq/kg x 3.3 E-7 Sv/Bq Pu-239 + 2000 Bq/kg x 1.0 E-7 Sv/Bq I-131] = 78.4 mSv/year

[12] 320 kg milk and other beverages per year[100 Bq/kg x (1.0 E-8 Sv/Bq Cs-137 + 1.4E-8 Sv/Bq Cs-134) + 125 Bq/kg x 6.0E-8 Sv/Bq Sr-90 + 1 Bq/kg x 2.7 E-7 Sv/Bq Pu-239 + 300 Bq/kg x 5.2 E-8 Sv/Bq I-131] +328.5 other foods kg/year x[250 Bq/kg x 1.0 E-8 Sv/Bq Cs-137 + 1.4E-8 Sv/Bq Cs-134) + 750 Bq/kg x 6.0E-8 Sv/Bq Sr-90 + 10 Bq/kg x 2.7 E-7 Pu-239 + 2000 Bq/kg x 5.2 E-8 Sv/Bq I-131] = 60,1 mSv/year

[13] 370 kg milk and other beverages/year x [100 Bq/kg x (1.3E-8 Sv/Bq Cs-137 + 1.9E-8 Sv/Bq Cs-134) + 125 Bq/kg x 8.0E-8 Sv/Bq Sr-90 + 1 Bq/kg x 2.4 E-7 Sv/Bq Pu-239 + 300 Bq/kg x 3.4 E-8 Sv/Bq I-131] + 356 kg other foods/year x[250 Bq/kg x 1.3E-8 Sv/Bq Cs-137 + 1.9E-8 Sv/Bq Cs-134) + 750 Bq/kg x 8.0E-8 Sv/Bq Sr-90 + 10 Bq/kg x 2.4 E-7 Pu-239 + 2000 Bq/kg x 3.4 E-8 Sv/Bq I-131] = 58.0 mSv/year

[14] 480 kg milk and other beverages/year x[100 Bq/kg x (1,3E-8 Sv/Bq Cs-137 + 1.9E-8 Sv/Bq Cs-134) + 125 Bq/kg x 2.8E-8 Sv/Bq Sr-90 + 1 Bq/kg x 2.5E-7 Sv/Bq Pu-239 + 300 Bq/kg x 1.8 E-7 Sv/Bq I-131] + 350.5 kg other foods/year x[250 Bq/kg x 1.3E-8 Sv/Bq Cs-137 + 1.9E-8 Sv/Bq Cs-134) + 750 Bq/kg x 2.8 E-8 Sv/Bq Sr-90 + 10 Bq/kg x 2.5 E-7 Sv/Bq Pu-239 + 2000 Bq/kg x 2.2 E-8 Sv/Bq I-131] = 33.0 mSv/year

[15] Nussbaum RH, Belsey E, Köhnlein W: Recent Mortality Statistics for Distally Exposed A-Bomb Survivors: The Lifetime Cancer Risk for Exposure under 50 cGy (rad). Medicina Nuclearis 1990. 2,151-162.