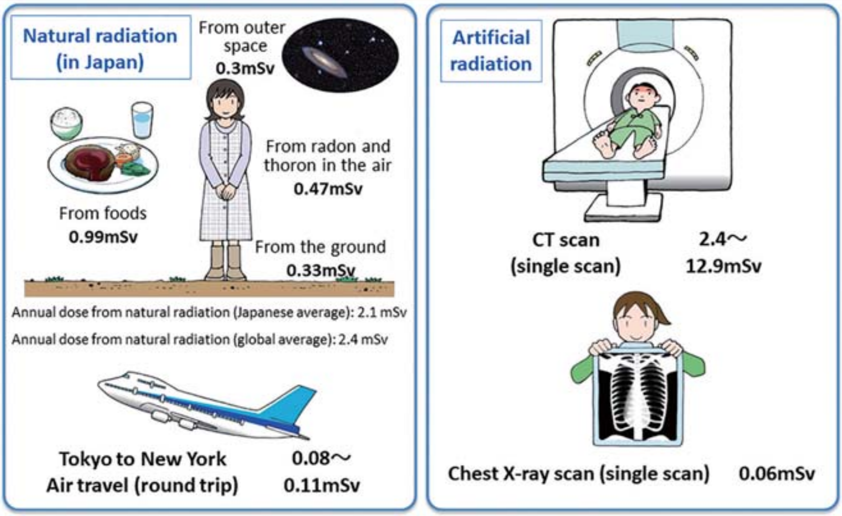
Radiation around Us

Exposure Dose from Natural and Artificial Radiation



mSv: millisieverts

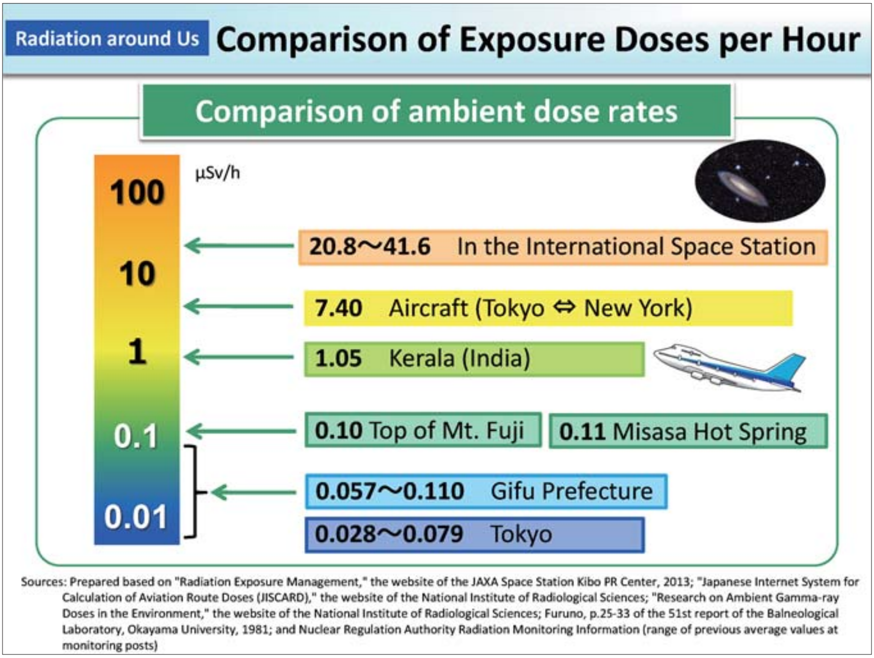
Sources: Prepared based on the 2008 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report; "Environmental Radiation in Daily Life (Calculation of National Doses), ver. 3" (2020), Nuclear Safety Research Association; and ICRP (International Commission on Radiological Protection) 103, etc.

Radiation exists around us and we are exposed to it in our daily lives without realizing. It is impossible to completely avoid radiation exposure in our daily lives.

External exposure to natural radiation from outer space and the ground, and internal exposure to naturally occurring radioactive materials, such as those in foods and radon in the air, amount to a global average of 2.4 mSv and a Japanese average of 2.1 mSv annually (p.65 of Vol. 1, “Comparison of Exposure Doses per Year”).

The percentage of medical exposure from radiological examinations is known to be high in Japan. The annual average medical exposure in Japan is estimated to be 2.6 mSv. This is considered due to the fact that an environment to ensure easy access to healthcare has been developed under the universal health insurance system and that CT scans, which involve high-dose exposure per examination, are quite common and upper gastro intestinal (UGI) examination is generally utilized for stomach cancer screening in Japan. In 2015, the diagnostic reference levels for medical exposure were established (revised in 2020), and efforts for optimizing medical exposure are now being made (p.76 of Vol. 1, “Radiation Doses from Medical Diagnosis”).

Included in this reference material on March 31, 2013
Updated on March 31, 2022



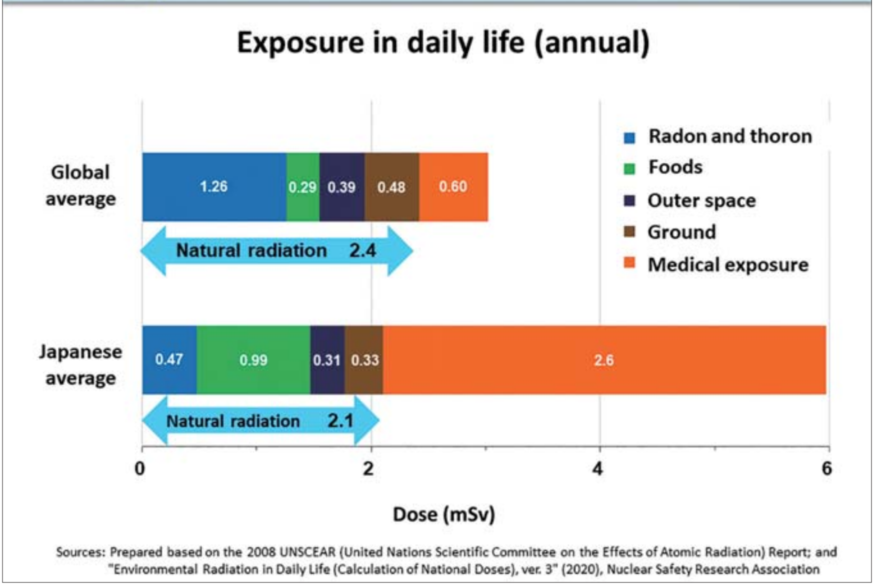
In outer space and aircraft, ambient dose rates are higher because of cosmic rays from galaxies and the Sun. Ambient dose rates are also high at high altitudes such as the top of Mt. Fuji, compared to low altitudes, because the influence of cosmic rays is stronger. At low altitudes, cosmic rays (radiation) interact with oxygen and nitrogen atoms in the atmosphere and thereby lose energy, resulting in reduced amounts of radiation reaching the ground. Accordingly, ambient dose rates become lower.

Ambient dose rates in most living spaces are in the range of 0.01 to 1 μSv/h, but there are areas where the level of natural radiation is high because soil there contains large amounts of radioactive materials, such as radium and thorium. Such areas are called high natural radiation areas (p.67 of Vol. 1, “Ground Radiation (World)”).

While there is no high natural radiation area in Japan, ambient dose rates are slightly higher in places where soil contains a lot of radium, such as Misasa Onsen Hot Springs, which is famous for radon hot springs (p.68 of Vol. 1, “Ground Radiation (Japan)”).

Included in this reference material on March 31, 2013
Updated on March 31, 2019

Comparison of Exposure Doses per Year



In November 2020, the Nuclear Safety Research Association of Japan published "Environmental Radiation in Daily Life (Calculation of the National Doses) ver. 3" and announced Japan's national doses therein. The survey shows that the annual average dose of Japanese people is 4.7mSv, of which 2.1 mSv are estimated to be caused by exposure to natural radiation.

Comparison with the global average shows that Japanese people's exposures to Radon-222 and Radon-220 (thoron) are relatively low while exposures from foods are relatively high. The Japanese people's exposure due to Lead-210 and Polonium-210 in foods amounts to 0.80 mSv, which is high compared to the global average, probably due to Japanese people's high consumption of fish and seafood (p.66 of Vol. 1, "Breakdown of Natural Exposure Doses (Japanese)"). Incidentally, analyses of Lead-210 and Polonium-210 in foods have rarely been conducted so often in foreign countries as in Japan and this is considered to be one of the factors of higher exposures to Lead-210 and Polonium-210 among Japanese compared with the global average.

The annual average medical exposure in Japan is estimated to be 2.6 mSv. As a result of the estimation based on the latest information, it was found that the annual average decreased significantly from 3.87 mSv stated in "Environmental Radiation in Daily Life (Calculation of the National Doses) ver. 2," which was published in 2011. While exposure doses from radiological examinations vary widely among individuals, Japanese people's exposure doses are known to be significantly high on average. In particular, the widespread use of CT scans is a major contributing factor. As criteria for determining the appropriateness of medical exposure, it is recommended to use the diagnostic reference levels. The diagnostic reference levels have also been published in Japan (p.76 of Vol. 1, "Radiation Doses from Medical Diagnosis").

Included in this reference material on March 31, 2013
Updated on March 31, 2022

Radiation around Us

Breakdown of Natural Exposure Doses (Japanese)

Type of exposure	Breakdown of radiation sources	Effective dose (mSv/year)
External exposure	Cosmic rays	0.3
	Ground radiation	0.33
Internal exposure (inhalation)	Radon-222 (indoors and outdoors)	0.37
	Radon-220 (thoron) (indoors and outdoors)	0.09
	Smoking (Lead-210, Polonium-210, etc.)	0.006*
	Others (uranium, etc.)	0.006
Internal exposure (ingestion)	Mainly Lead-210 and Polonium-210	0.80
	Tritium	0.0000049
	Carbon-14	0.014
	Potassium-40	0.18
Exposure under special environments	Exposure due to hot springs or other subsurface environments	0.005
	Exposure due to the use of aircraft	0.008
Total		2.1

(*) Per capita effective doses; The average exposure dose for smokers is 0.040 mSv/y.

Source: Prepared based on "Environmental Radiation in Daily Life (Calculation of National Doses), ver. 3" (2020), Nuclear Safety Research Association

This table shows that the intake of Lead-210 and Polonium-210 through ingestion accounts for a significant portion of Japanese people's internal exposures. Lead-210 and Polonium-210 are created when Radon-222 in the air goes through the following process. They are deposited on the ground or settled in rivers and oceans and are taken into the human body through foods.

Radon-222 (half-life of approx. 3.8 days) → Polonium-218 (half-life of approx. 3 minutes) → Lead-214 (half-life of approx. 27 minutes) → Bismuth-214 (half-life of approx. 20 minutes) → Polonium-214 (half-life of approx. 1.6×10^{-4} sec.) → Lead-210 (half-life of approx. 22 years) → Bismuth-210 (half-life of approx. 5 days) → Polonium-210 (half-life of approx. 138 days)

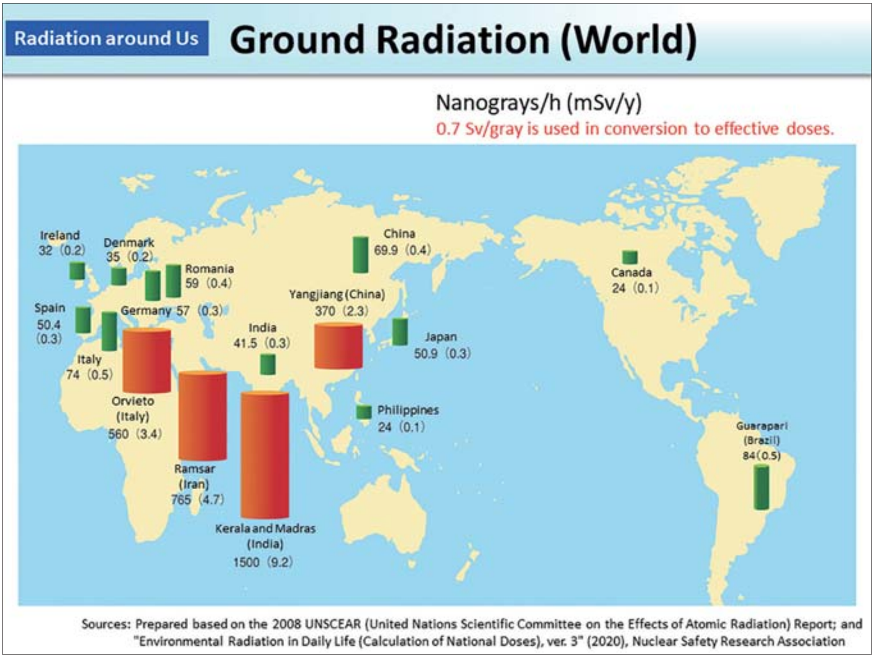
One reason why Japanese people's exposure doses from foods are higher compared to the rest of the world is that their diets contain lots of fish, which is rich in Polonium-210. This accounts for Japanese people's large effective doses. Incidentally, analyses of Lead-210 and Polonium-210 in foods have rarely been conducted so often in foreign countries as in Japan and this is considered to be one of the factors of higher exposures to Lead-210 and Polonium-210 among Japanese compared with the global average.

On the other hand, exposure to Radon-222 and Radon-220 (thoron) is smaller among Japanese people, and this is considered to be due to the fact that traditional Japanese houses are well ventilated and Radon-222 and Radon-220 (thoron) that seep indoors from the ground are quickly diffused outside.

Internal exposure to Radon-222 and Radon-220 (thoron) through inhalation will be explained in "Internal Exposure to Radon and Thoron through Inhalation" on p.71 of Vol. 1.

Tritium has smaller effects on the human body compared with other nuclides and exposure doses due to natural tritium are relatively small (p.57 of Vol. 1, "Conversion Factors to Effective Doses").

Included in this reference material on March 31, 2013
Updated on March 31, 2022



There are regions around the world where natural radiation is 7 to 30 times higher than in Japan, such as Yangjiang in China, Kerala in India, and Ramsar in Iran. The high levels of natural radiation in these regions are due to the fact that soil there is rich in radioactive materials such as radium, thorium and uranium.

It has been reported that in Guarapari in Brazil, which was previously well-known as a high natural radiation area, ambient dose rates have reduced as a result of asphalt paving for urbanization.

Based on epidemiological studies in China and India, no significant increases in cancer deaths and incidence rates have been reported so far in these regions (p.124 of Vol. 1, “Effects of Long-Term Low-Dose Exposure”). In Ramsar, analysis on cancer risks is underway.

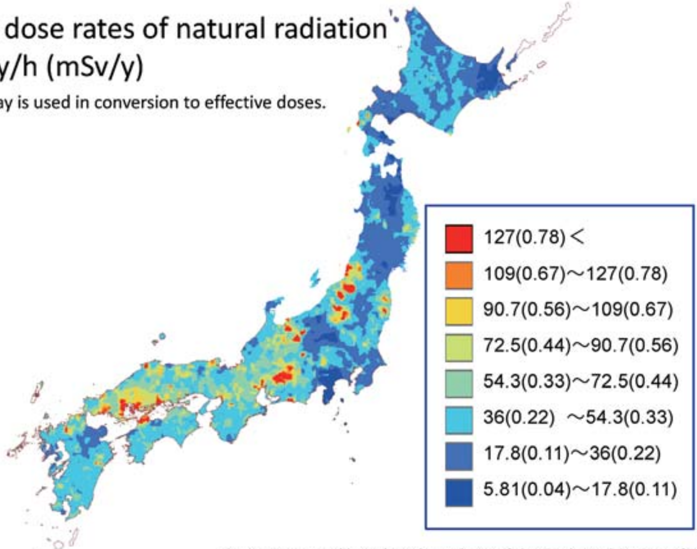
Included in this reference material on March 31, 2013
Updated on March 31, 2022

Radiation around Us

Ground Radiation (Japan)

Ambient dose rates of natural radiation
Nanogray/h (mSv/y)

- 0.7 Sv/gray is used in conversion to effective doses.



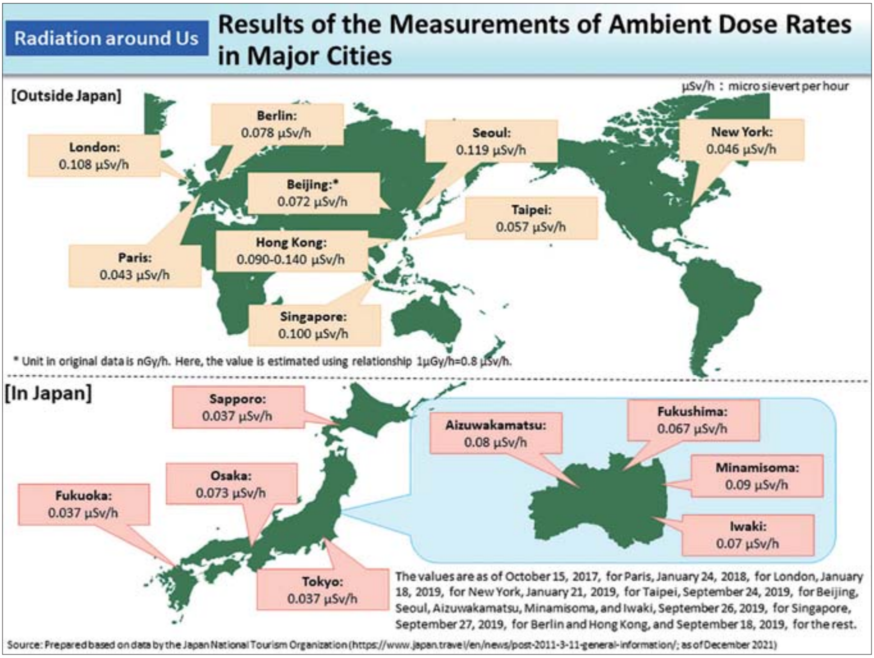
Source: Prepared based on the website of the Geological Society of Japan

In Japan, like everywhere else, the amount of ground radiation varies from area to area. Comparison of ambient dose rates among different prefectures shows that there is a difference of 0.4 mSv per year between Gifu, where the ambient dose rates are highest, and Kanagawa, where the values are lowest.

In the Kanto Plain, where a fewer types of radionuclides are contained in the ground, the amount of radiation from the ground is generally less. In western Japan, where granite is directly exposed to the ground in many places, the amount of radiation from the ground tends to be about 1.5 times higher than in eastern Japan because granite is relatively rich in radionuclides such as uranium, thorium and potassium.

(Related to p.8 of Vol. 1, “Naturally Occurring or Artificial”)

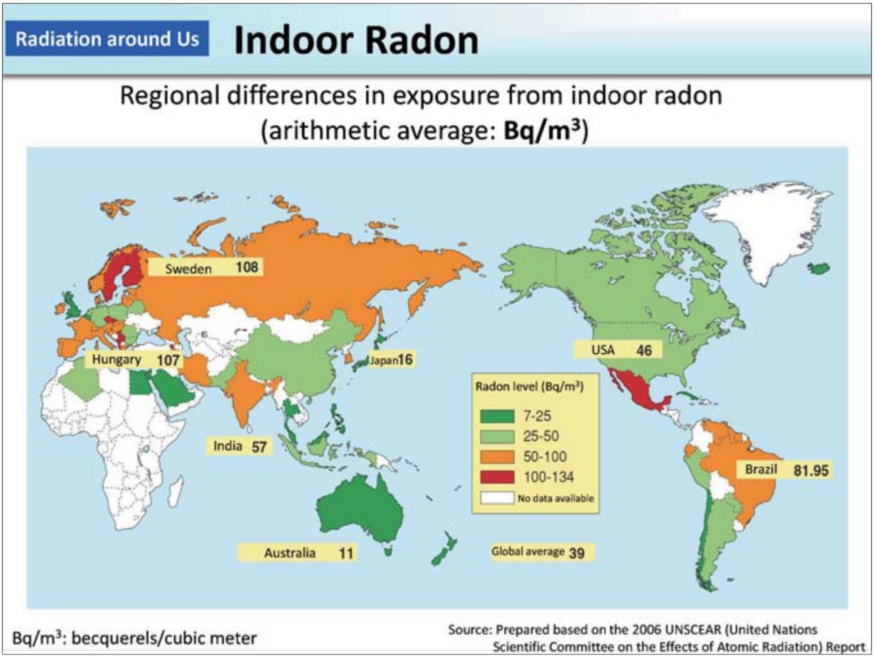
Included in this reference material on March 31, 2013
Updated on March 31, 2022



These figures show the results of the measurements of ambient dose rates at major cities in and outside Japan. Radiation doses shown in the figures are mostly from 0.03 μSv/h to 0.14 μSv/h, which reveals that radiation doses vary by region. This is mainly because radiation doses from the earth differ due to differences in soil and rocks in respective regions.

Ambient dose rates in four cities in Fukushima Prefecture decreased significantly over time after Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS Accident and have become almost the same as those in other major cities in and outside Japan.

Included in this reference material on March 31, 2019
Updated on March 31, 2022



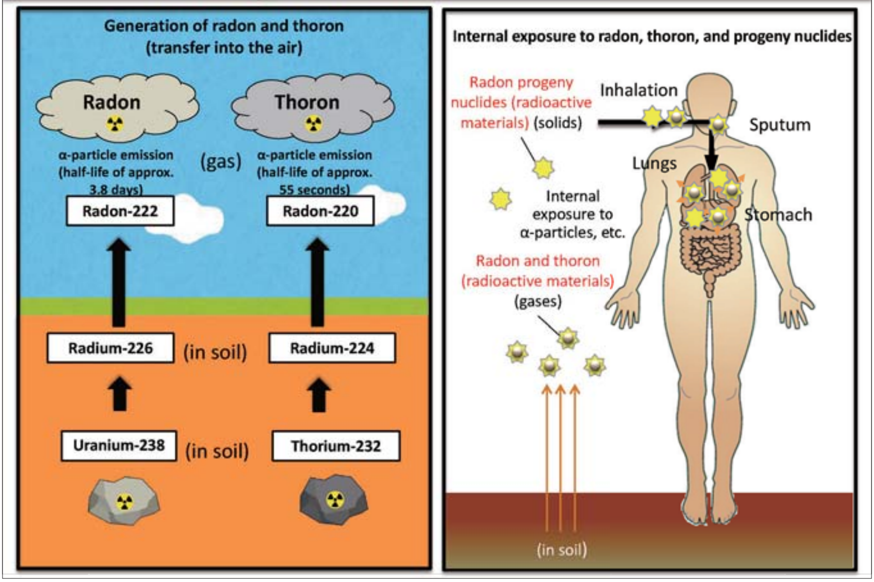
Radon is a radioactive noble gas produced by the alpha-decay of radium, which is universally present under the ground. Since radon is a gas, it is emitted from the ground and seeps into houses (p.71 of Vol. 1, "Internal Exposure to Radon and Thoron through Inhalation").

In areas where people live in masonry houses, such as Europe, indoor radon concentrations are high and exposure doses tend to be high as a result.

The global average of indoor radon concentrations is 39 Bq/m^3, while Japan has an average value of 16 Bq/m^3. There are also large regional differences in internal exposure doses from indoor radon.

Included in this reference material on March 31, 2013
Updated on March 31, 2015

Radiation around Us — Internal Exposure to Radon and Thoron through Inhalation



Radon (Radon-222) and thoron (Radon-220) are gaseous radioactive materials produced through radioactive decay of a radium ore. They enter the human body through inhalation. Radon results from decay of Radium-226 produced in a decay chain (uranium series) that starts from uranium, and thoron results from decay of Radium-224 produced in a decay chain (thorium series) that starts from Thorium-232. Radon has a half-life of approx. 3.8 days and thoron has a half-life of approx. 55 seconds.

Radon and its progeny nuclides are the largest contributors of natural radiation exposure.

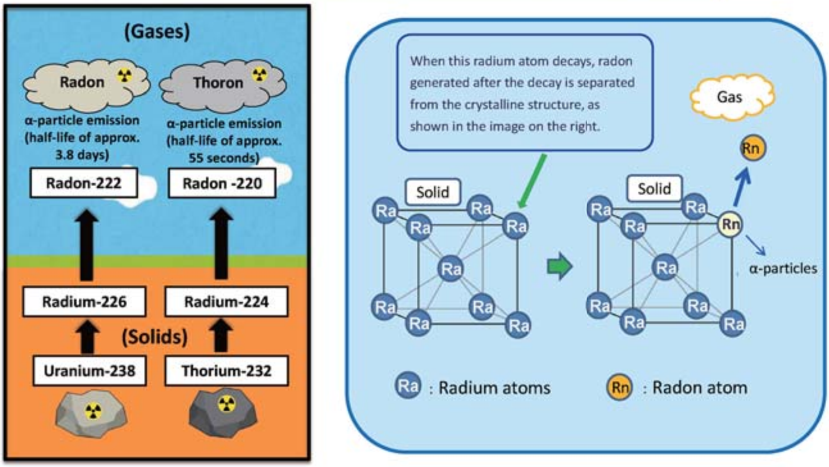
Because radon and thoron diffuse into the air from the ground, building materials, etc. (p.72 of Vol. 1, “Generation of Radon Gas from Solid Radium”), people inhale radon and thoron in their lives on a daily basis. Inhaled radon reaches the lungs and emits α-particles, causing internal exposure of the lungs. Radon inhaled into the body further decays into progeny nuclides, which then migrate from the lungs and the esophagus to the digestive organs together with sputum, causing further internal exposure.

Radon contributes less to internal exposure than its progeny nuclides. This is because radon, being a gas, is easily exhaled, while radon daughter nuclides, i.e., radioactive Polonium-218 and Lead-214 that is created through decay of the former, are solids and therefore not easily expelled out of the body once inhaled as they adhere to the alveoli and the bronchial wall surface.

Included in this reference material on March 31, 2015
Updated on March 31, 2021

Radiation around Us **Generation of Radon Gas from Solid Radium**

It may seem strange that solid radium directly turns into radon gas.
This is caused by radioactive decay that causes atoms to change.

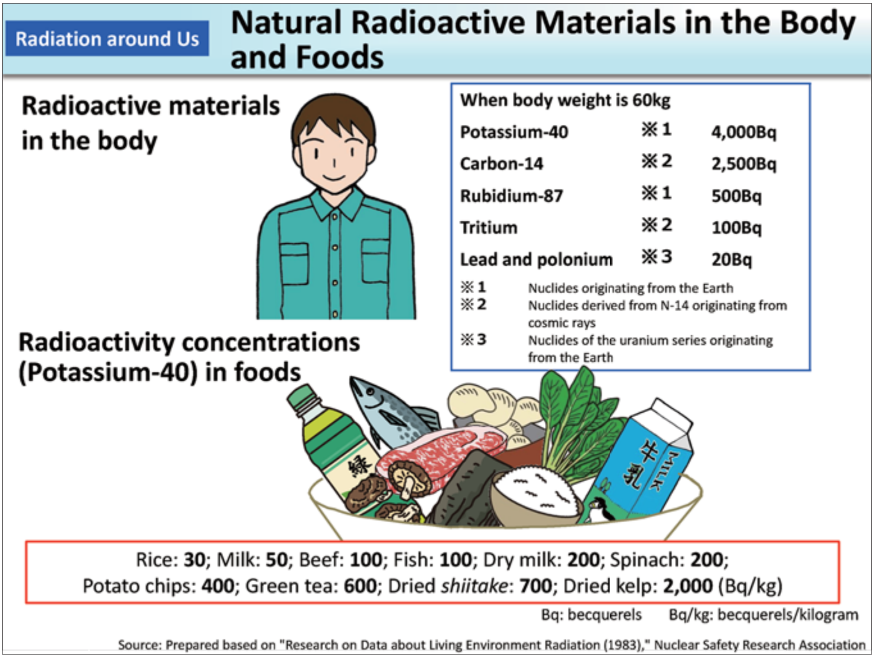


Radium, a radioactive material, is present in a crystal structure called body-centered cubic at room temperature and normal pressure, as shown in the right image.

When radium decays, it emits α-particles and turns into radon.

Radon is a chemically stable element, like helium and neon. Being chemically stable or being an inert element means that it stably exists as radon without reacting with other elements to form compounds. Radon has a melting point of approx. -71°C and a boiling point of approx. -62°C and is therefore in a gas form under normal conditions. When radium atoms making up the crystal structure decay into radon atoms, they leave the crystal structure (because the force binding them as a crystal is lost) and come to exist in a gas form. Since radon is an inert gas, it emanates from the ground into the air without reacting with any underground substances.

Included in this reference material on March 31, 2016



Potassium is an element necessary for life and is contained in most foods. Because 0.01% of potassium is radioactive, most foods contain radioactive potassium. Radioactive potassium emits β-particles and γ-rays, causing internal exposure from food intake (p.74 of Vol. 1, "Visualized Radiation"). The internal potassium concentration is held constant, so exposure doses from potassium in foods depend on individuals' physiques and are considered unaffected by diet (p.8 of Vol. 1, "Naturally Occurring or Artificial").

The values for dry foods in the list are those analyzed in their product states, which include the effects of concentration increases due to drying. For example, if the weight decreases to one-tenth through drying, concentration increases by ten times.

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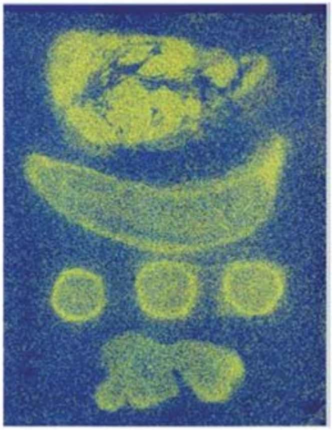
Updated on February 28, 2018

Radiation around Us

Visualized Radiation



Radiographs of pork meat, banana (cut vertically and horizontally), and ginger

Radiation from foods

- Mostly β-particles from Potassium-40
- The natural abundance ratio of Potassium-40* is **0.012%.**
- Potassium-40 has a half-life of **1.26 × 10^9** years.

*Percentage of Potassium-40 relative to the total amount of potassium found in nature

Source: Applied Physics Vol.67, No.6, 1998

Potassium-40 contained in foods emits β-particles and γ-rays.

The distribution of potassium can be found by using an imaging plate*1 and detecting β-particles from Potassium-40.

The above image was obtained by placing pieces of pork meat, banana and ginger on an imaging plate and exposing for 25 days while blocking shielding external radiation. The protein part of the pork meat, the peel of the banana, and the buds of the ginger contain relatively large amounts of potassium. It can be seen that the fat portion of the pork meat contains little potassium.

*1: An imaging plate is a support medium, such as a plastic sheet, coated with a fluorescent substance that reacts to radiation. By placing a sample containing radioactive materials on a plate for a defined period of time, two-dimensional distribution of radioactivity in the sample can be examined.

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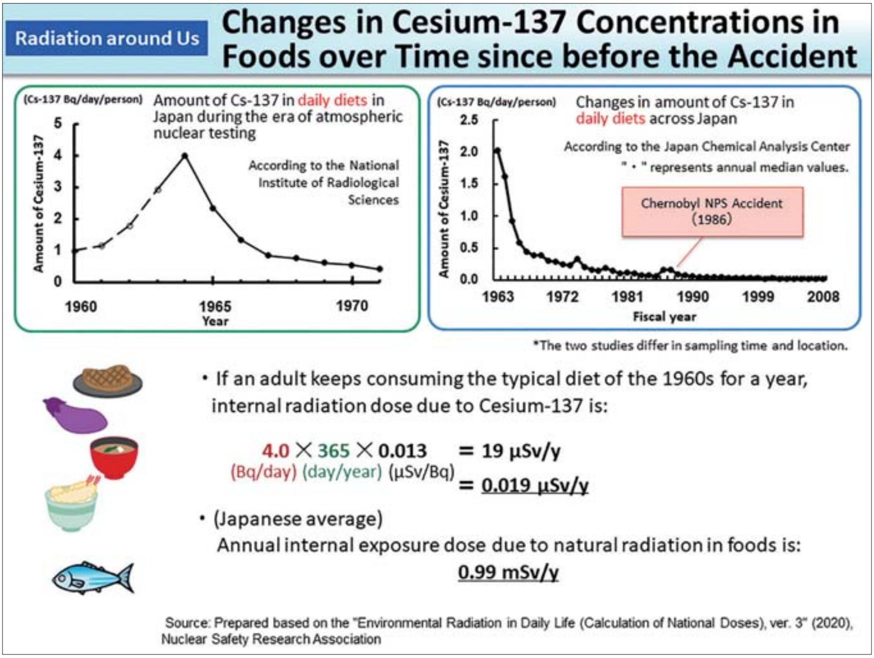
Updated on March 31, 2019



Atmospheric nuclear tests were carried out around the world from 1945 to 1980. As a result, large amounts of artificial radionuclides were released into the air and fell to Japan as well (p.78 of Vol. 1, "Effects of Radioactive Fallout due to Atmospheric Nuclear Testing"). Radioactivity in daily diets has been measured across Japan in order to find out what effects the artificial radionuclides would have on health.

Meals people actually consume are used as samples to measure radioactivity in daily diets, and this practice is useful in estimating and evaluating internal exposure doses from meals.

The amount of Cesium-137 in daily diets was highest around 1963, the year when nuclear testing, particularly in the atmosphere, was banned. It dropped sharply afterwards, and in 1975, it reduced to about a tenth of the peak amount. While there was a slight increase in 1986 because of the Chernobyl NPS Accident, the amount went down slowly until the 2000s.

If an adult were to keep consuming a typical diet of the 1960s, which had the highest level of Cesium-137, Japanese people's internal exposure dose due to Cesium-137 would be as follows:

$$4.0\ (\text{Bq/day}) \times 365\ (\text{day/year}) \times 0.013\ (\mu\text{Sv/Bq}) = 19\ \mu\text{Sv/y} = 0.019\ \text{mSv/y}$$

This value is about 2% of Japanese people's internal exposure dose (0.99 mSv/y) due to natural radiation in foods.

Because the above two studies differ in the location where samples (daily diets) were taken and the number of samples, there is a difference in their numerical values.

(The black dots in the graph (right) showing changes in amount of Cesium-137 in daily diets over time across Japan represent annual median values.)

Included in this reference material on March 31, 2017
Updated on March 31, 2022

Radiation Doses from Medical Diagnosis

Type of examination	Diagnostic reference levels*1	Actual exposure dose*2	
		Dose	Type of dose
General imaging: Front chest	0.4 mGy (less than 100 kV)	0.06 mSv	Effective dose
Mammography (mean glandular dose)	2.4 mGy	Around 2 mGy	Equivalent dose (Mean glandular dose)
Fluoroscopy	IVR (InterVentional Radiology): Equipment reference fluoroscopic dose rate 17 mGy/min	Gastric fluoroscopy: 10 mSv/min (25 to 190 sec, varies depending on operators and subjects)*3	Effective dose
Dental imaging (Intraoral radiography)	From 1.0 mGy at the frontal teeth of the mandible to 2.0 mGy at the molar teeth of the maxilla (In either case, incident air kerma (Ka,i) [mGy] is measured)	Around 2 - 10 μSv	Effective dose
X-ray CT scan	Adult head simple routine: 77 mGy (CTDIvol)	Around 5 - 30 mSv	Effective dose
	Child (age 5 - 9), head: 55 mGy (CTDIvol)		
Nuclear scanning	Value for each radioactive medicine	Around 0.5 - 15 mSv	Effective dose
PET scan	Value for each radioactive medicine	Around 2 - 20 mSv	Effective dose

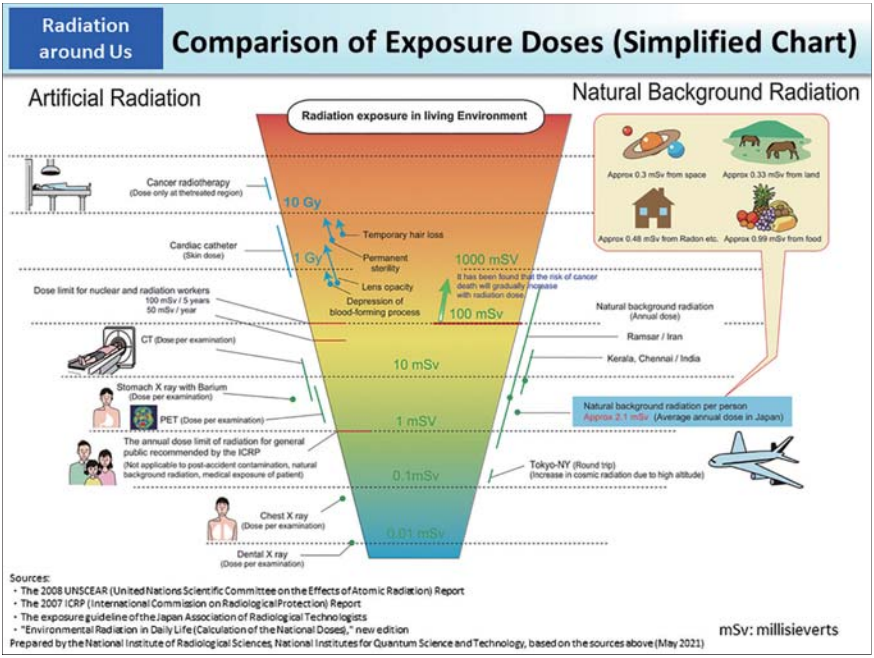
*1: "National Diagnostic Reference Levels in Japan (2020) (Japan DRLs 2020)," J-RIME, July 3, 2020 (partially updated on August 31, 2020) (http://www.radher.jp/J-RIME/)
*2: "Q&A on Medical Exposure Risks and Protection Regarding Medical Exposure from CT Scans, etc.," National Institutes for Quantum and Radiological Science and Technology (https://www.qst.go.jp/site/qms/1889.html)
*3: "Gastric Fluoroscopy" in "X-ray Medical Checkup" in "Basic Knowledge on Medical Radiation," Kitasato University Hospital, Radiology Department
Prepared based on materials *1, *2 and *3 above

Exposure doses from radiological examinations vary by the types of examinations. Some examinations, such as dental imaging, only involve very slight, local exposure, while some other examinations, such as X-ray CT scans and nuclear scanning, involve relatively high exposure doses. Even with the same type of examination, doses could vary widely depending on the medical institution. It is therefore recommended to use the diagnostic reference levels as criteria for determining whether radiation doses from medical diagnosis are appropriate or not. If the average radiation dose of a medical institution greatly deviates from the diagnostic reference levels, the International Commission on Radiological Protection (ICRP) recommends that irradiation conditions for the examination be reconsidered.

Some countries are already using the diagnostic reference levels. In Japan, the Japan Association of Radiological Technologists issued a medical exposure guideline (reduction targets) in 2000, in which they compiled values equivalent to the diagnostic reference levels. It was updated in 2006 as the 2006 medical exposure guideline. The Japan Network for Research and Information on Medical Exposures (J-RIME)*1 established Japan's first diagnostic reference levels based on the results of surveys conducted by participating organizations. For the latest diagnostic reference levels, the "National Diagnostic Reference Levels in Japan (2020) (Japan DRLs 2020)" was published on July 3, 2020 (partially updated on August 31, 2020).

*1: The Japan Network for Research and Information on Medical Exposures (J-RIME) started in 2010 as a base for establishing a medical exposure protection system that matches Japan's circumstances, by gathering expert opinions through cooperation from academic societies and associations, and collecting and sharing domestic and international research information on medical exposures. J-RIME's activities include collecting data on medical exposure, such as exposure doses from radiation therapy and risk assessment, to get a picture of medical exposures in Japan, and building an appropriate protection system for medical exposure in Japan while taking international trends into account (source: prepared based on http://www.radher.jp/J-RIME/index.html).

Included in this reference material on March 31, 2013
Updated on March 31, 2022



Comparison of radiation doses in daily life shows that doses from one single event and annual doses are mostly on the order of millisieverts, except for special cases such as radiation therapy (p.76 of Vol. 1, "Radiation Doses from Medical Diagnosis").

Exposure doses found to have health effects on people are considered to be at levels exceeding 100 millisieverts.

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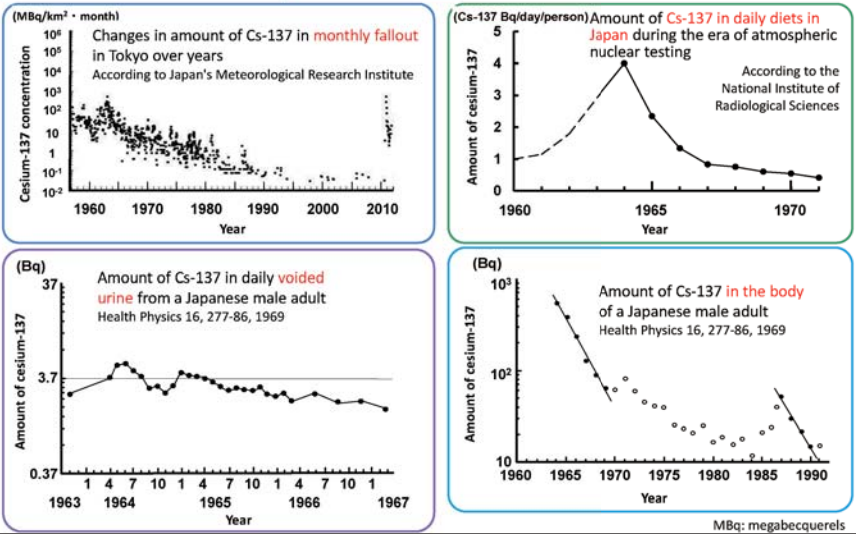
Radiation around Us

Effects of Radioactive Fallout due to Atmospheric Nuclear Testing

Internal radioactivity: Body weight: 60 kg | Potassium-40: 4,000 Bq; Carbon-14: 2,500 Bq; Rubidium-87: 520 Bq; Tritium: 100 Bq



Large amounts of artificial radionuclides were released into the environment in the era during which atmospheric nuclear testing was frequently conducted. These artificial radionuclides were spread all around the world as they were carried by air currents, and gradually fell onto the surface of the Earth from the atmosphere. Such radioactive falling matter is called fallout. The amount of fallout was highest in 1963, just before the ban of atmospheric nuclear testing, and has been decreasing since then.

Because there is a time lag between contamination of foods with cesium and their consumption, the amount of radioactive cesium in daily diets was highest in 1964, then dropped sharply by 1967, and has been decreasing relatively slowly since then.

Like the amount of cesium in daily diets, the amounts of Cesium-137 in urine and the body were also highest in 1964. An increase in the amount of cesium in the body was also found among Japanese people as a result of the influence of the Chernobyl NPS Accident.

As a result of atmospheric nuclear testing during the aforementioned era, plutonium and Strontium-90, etc. were released into the environment, in addition to radioactive cesium. These radionuclides still exist in soil, albeit only slightly.

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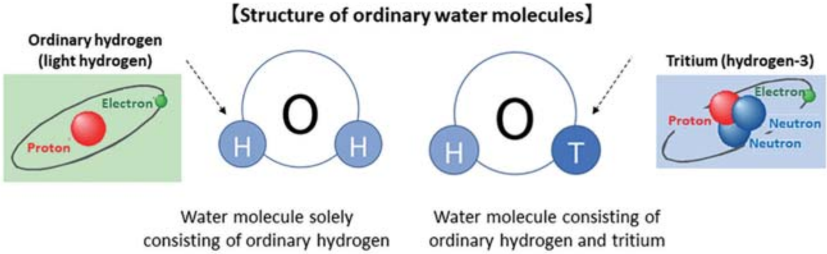
Radiation around Us

Characteristics of Tritium

Tritium is a radioisotope of hydrogen, called "hydrogen-3," and exists around us mostly being contained in water molecules. β-particles emitted from tritium only have low energy (18.6 keV at the largest) and can be shielded with a sheet of paper.



Source: Prepared based on the "Important Stories on Decommissioning 2018" by the Agency for Natural Resources and Energy, METI, the "Tritiated Water Task Force Report" by the Tritiated Water Task Force (2016), and the "Scientific Characteristics of Tritium (draft)" by the Subcommittee on Handling of the ALPS Treated Water

The water processed with the multi-nuclide removal equipment, also called the Advanced Liquid Processing System (ALPS), or other equipment, at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, still contains tritium, which is a radioactive material.

Tritium is a radioisotope of hydrogen, called "hydrogen-3." As tritium combines with oxygen to form water molecules just as ordinary hydrogen does, it exists around us contained in water molecules, and is also found in water vapor in the air, rainwater, seawater, and tap water. It is difficult to remove tritium by ALPS as it exists as part of water molecules. Tritium is generated in nature by cosmic rays in addition to being artificially generated through operations of nuclear power plants.

Tritium emits β-particles, a type of radiation, but β-particles emitted from tritium have low energy and can be shielded with a sheet of paper. Therefore, external exposure to tritium is unlikely to exert any influence on the human body. A biological half-life for water containing tritium is ten days, and even if it is ingested, it will be eliminated from the body promptly and will not accumulate in any specific organs (p.31 of Vol. 1, "Radioactive Materials Derived from Nuclear Accidents"). The committed effective dose coefficient when orally ingesting tritium is 0.000018 µSv/Bq, a smaller value compared with other radionuclides (p.57 of Vol. 1, "Conversion Factors to Effective Doses").

In April 2021, the Government of Japan announced the Basic Policy on the handling of the ALPS treated water purified by the Advanced Liquid Processing System (ALPS), etc. to be discharged into the sea after a preparation period of about two years, on the premise that safety will be ensured, and that the government will take all necessary measures to prevent adverse impacts on reputation.

[Reference materials]
Basic knowledge on tritium:
- Contaminated water management in Fukushima: Top priority on safety and security; Measure (ii) What is "tritium"?
  https://www.enecho.meti.go.jp/about/special/johoteikyo/osensuitaisaku02.html (in Japanese)
- Top priority on safety and security; Measure (iii) Explanation of tritium and radiation exposure
  https://www.enecho.meti.go.jp/about/special/johoteikyo/osensuitaisaku03.html (in Japanese)
  Portal Site for Decommissioning and Countermeasures for Contaminated Water and Treated water:
- ALPS Treated Water
  https://www.meti.go.jp/english/earthquake/nuclear/decommissioning/atw.html

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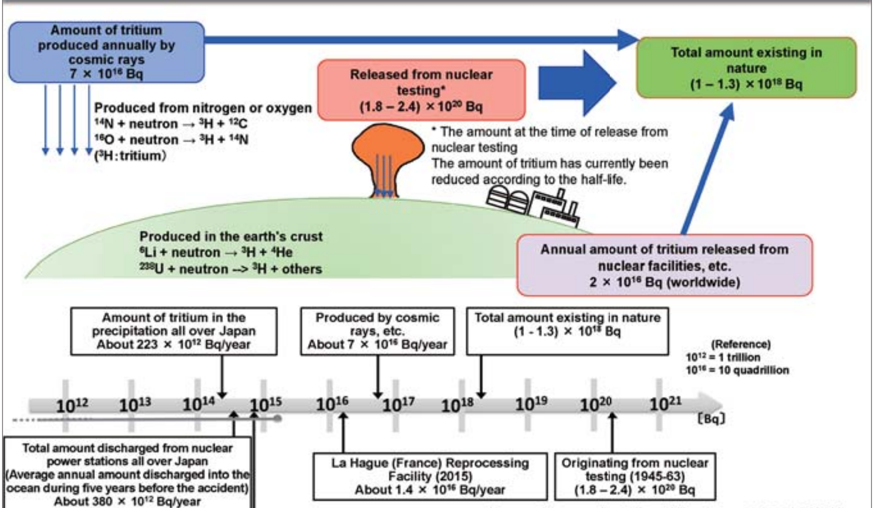
Updated on March 31, 2022

Radiation around Us

Amount of Tritium Existing in Nature



(Source of the upper illustration: "Tritium Research Society" 2014 by Atomic Energy Society of Japan. Sources of the lower illustration: Explanatory materials for the explanation meeting/public hearing by the sub-committee on handling of Advanced Liquid Processing System (ALPS) treated water, and the UNSCEAR 2016 Report)

Tritium (^{3}H) is a radioisotope of hydrogen (with a half-life of about 12.3 years) and emits weak radiation (β-particles) (p.79 of Vol. 1, "Characteristics of Tritium"). In nature, about seventy quadrillion (7×10^{16}) Bq of tritium is produced annually by cosmic rays, etc. on earth. In the past nuclear testing (1945 to 1963), tritium of 1.8 to 2.4×10^{20} Bq was released. In addition, tritium is discharged daily from facilities such as nuclear power stations around the world and the annual amount of tritium released from nuclear power stations around the world is 2×10^{16} Bq. Before the Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS Accident, the annual amount of tritium released from nuclear power stations all over Japan was 380×10^{12} Bq (which is the average annual amount discharged into the ocean during the five years before the accident). The total amount of tritium existing in nature is estimated to be 1 to 1.3×10^{18} Bq. The released tritium exists mostly as hydrogen that makes up water molecules and it is also contained in water vapor in the atmosphere, rainwater, sea water and tap water. The annual amount of tritium contained in the precipitation in Japan is estimated to be about 223×10^{12} Bq.

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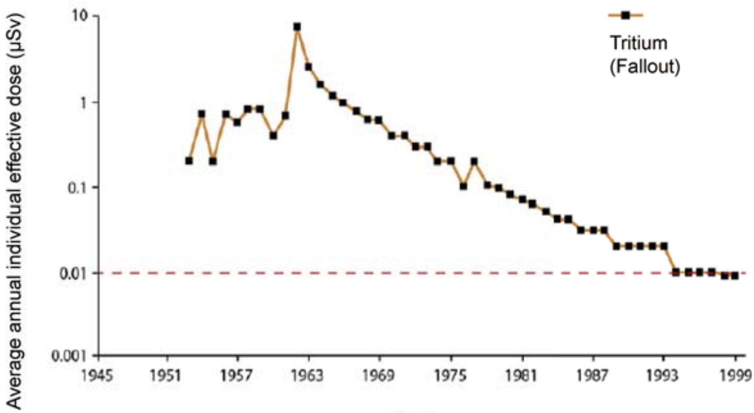
Changes in Tritium in Radioactive Fallout over Time



Source: UNSCEAR 2016 Report, Annex C-Biological effects of selected internal emitters-Tritium

During the period from 1950 to 1963, nuclear weapon tests were conducted and caused a large amount of radioactive fallout across the globe. As a result, the average annual individual doses from tritium increased with the peak value of 7.2 μSv in 1962. After that, the amount of tritium decreased with the half-life, which resulted in little effect on the individual dose. In 1999, it became 0.01 μSv, which was about one-seven hundredth of the peak value.

In the nuclear testing, not only tritium but also cesium, plutonium and strontium were released into the environment.

According to the 2016 report by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the epidemiological studies conducted so far have not confirmed any tritium-specific risk about the effects of public exposure to tritium. Additionally, from the fact that the incidence of childhood leukemia has not increased since the early 1960s when nuclear tests were frequently conducted, it is considered that there is a low possibility that the health risk by exposure to tritium is underestimated.

(Related page: p.78 of Vol. 1, “Effects of Radioactive Fallout due to Atmospheric Nuclear Testing”)

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