Radiation around Us

Exposure Dose from Natural and Artificial Radiation

Natural radiation (in Japan)

From outer space
0.3mSv

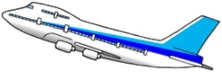
From foods
0.99mSv

From radon and thoron in the air
0.47mSv

From the ground
0.33mSv

Annual dose from natural radiation (Japanese average): 2.1 mSv

Annual dose from natural radiation (global average): 2.4 mSv



Tokyo to New York Air travel (round trip) **0.08〜0.11mSv**

Artificial radiation

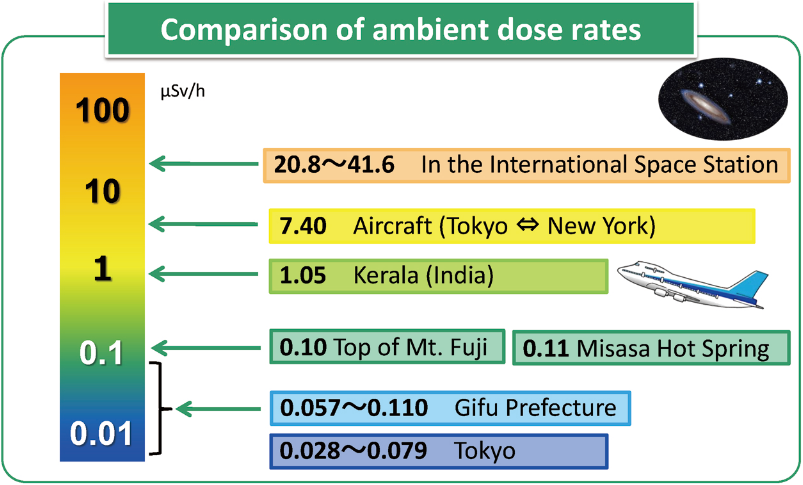
CT scan (single scan) **2.4〜12.9mSv**

Chest X-ray scan (single scan) **0.06mSv**

mSv: millisieverts

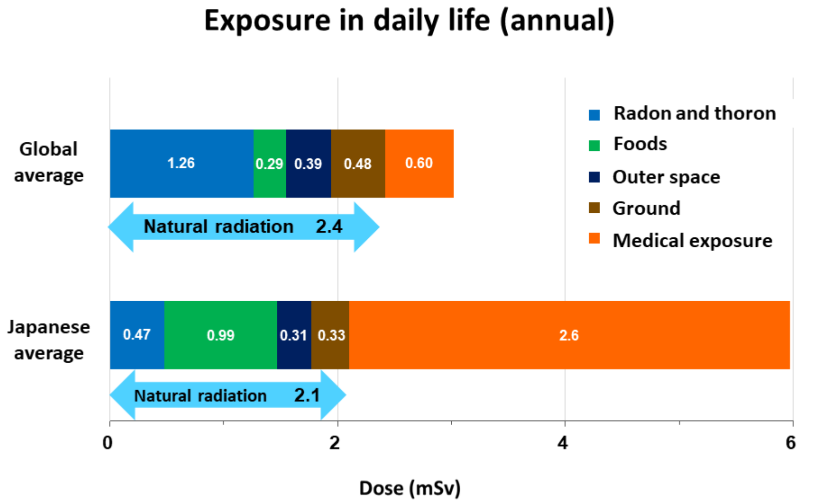
Sources: Prepared based on the 2008 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report; "Environmental Radiation in Daily Life (Calculation of National Doses), ver. 3" (2020), Nuclear Safety Research Association; and ICRP (International Commission on Radiological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

Comparison of Exposure Doses per Hour



Sources: Prepared based on "Radiation Exposure Management," the website of the JAXA Space Station Kibo PR Center, 2013; "Japanese Internet System for Calculation of Aviation Route Doses (JISCARD)," the website of the National Institute of Radiological Sciences; "Research on Ambient Gamma-ray Doses in the Environment," the website of the National Institute of Radiological Sciences; Furuno, p.25-33 of the 51st report of the Balneological Laboratory, Okayama University, 1981; and Nuclear Regulation Authority Radiation Monitoring Information (range of previous average values at monitoring posts)

Comparison of Exposure Doses per Year



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

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

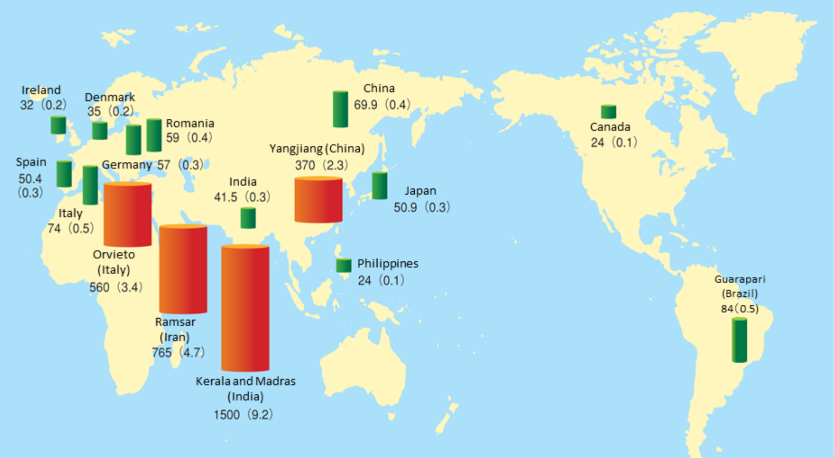
(*) Per capita effective doses; The average exposure dose for smokers is 0.040 mSv/y.

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

Ground Radiation (World)

Nanograys/h (mSv/y)

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

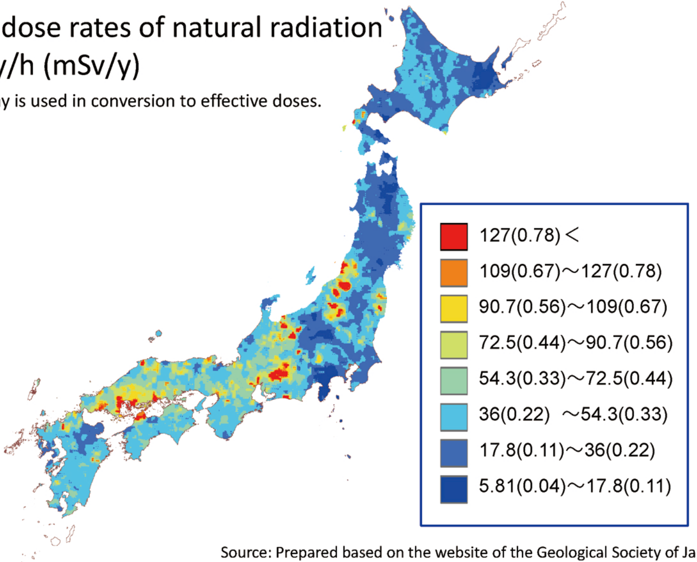


Sources: Prepared based on the 2008 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report; and "Environmental Radiation in Daily Life (Calculation of National Doses), ver. 3" (2020), Nuclear Safety Research Association

Ground Radiation (Japan)

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

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



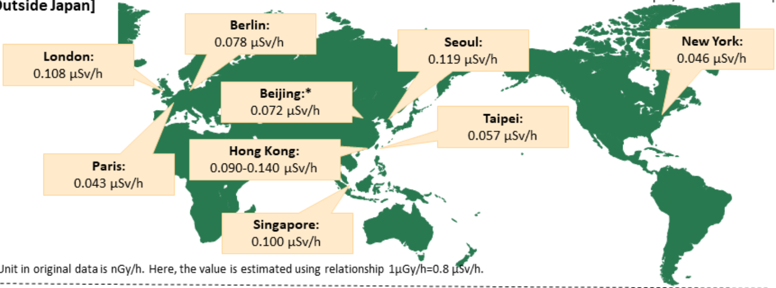
Source: Prepared based on the website of the Geological Society of Japan

Radiation around Us

Results of the Measurements of Ambient Dose Rates in Major Cities

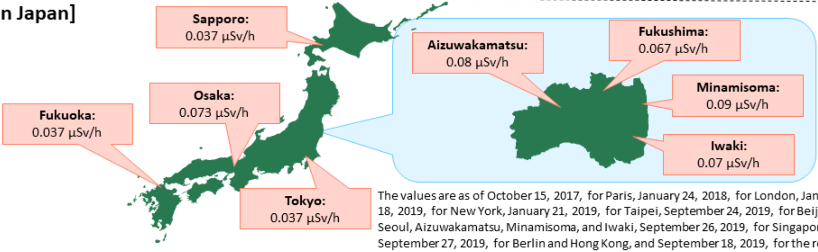
μSv/h : micro sievert per hour

[Outside Japan]



* Unit in original data is nGy/h. Here, the value is estimated using relationship 1μGy/h=0.8 μSv/h.

[In Japan]

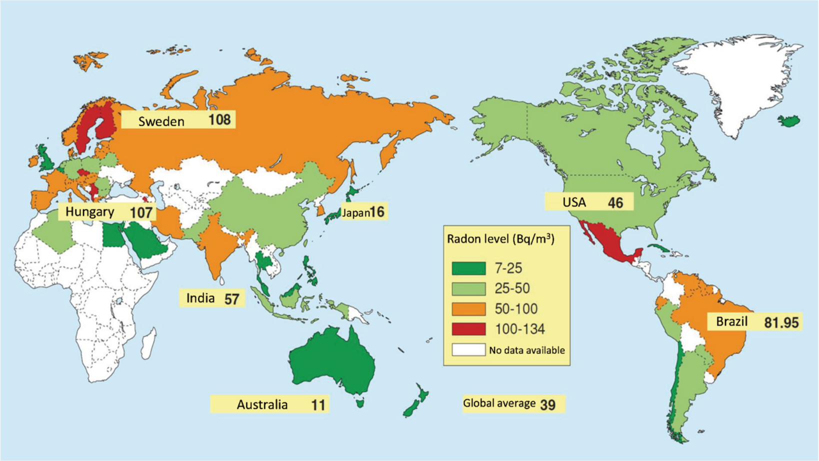


The values are as of October 15, 2017, for Paris, January 24, 2018, for London, January 18, 2019, for New York, January 21, 2019, for Taipei, September 24, 2019, for Beijing, Seoul, Aizuwakamatsu, Minamisoma, and Iwaki, September 26, 2019, for Singapore, September 27, 2019, for Berlin and Hong Kong, and September 18, 2019, for the rest.

Source: Prepared based on data by the Japan National Tourism Organization (https://www.japan.travel/en/news/post-2011-3-11-general-information/; as of December 2021)

Indoor Radon

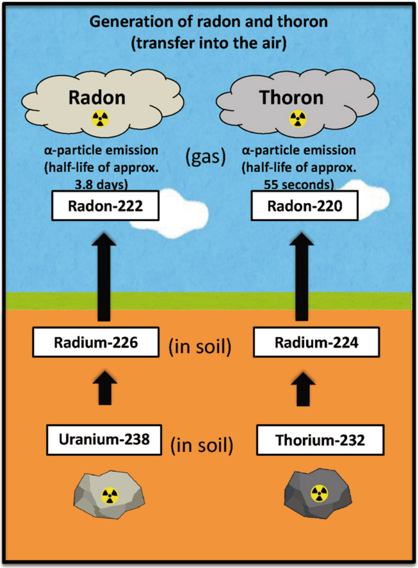
Regional differences in exposure from indoor radon (arithmetic average: **Bq/m³**)

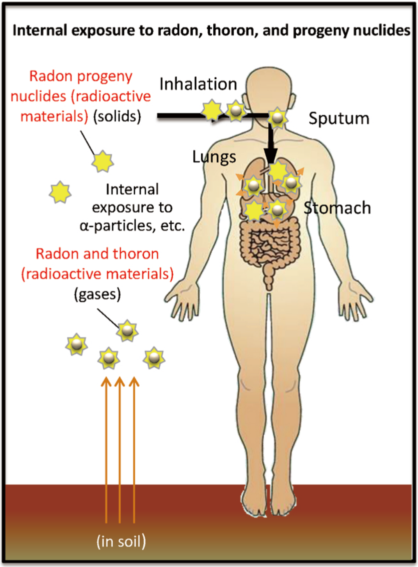


Bq/m³: becquerels/cubic meter

Source: Prepared based on the 2006 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report

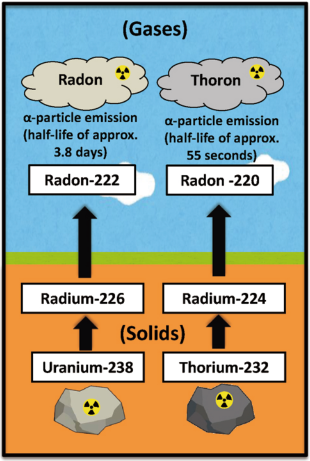
Internal Exposure to Radon and Thoron through Inhalation

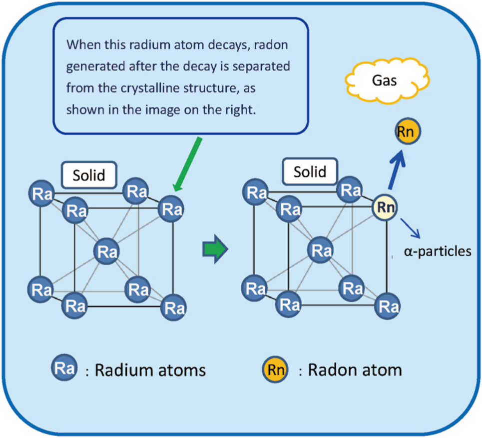




Generation of Radon Gas from Solid Radium

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





Natural Radioactive Materials in the Body and Foods

Radioactive materials in the body

When body weight is 60kg		
Potassium-40	※1	4,000Bq
Carbon-14	※2	2,500Bq
Rubidium-87	※1	500Bq
Tritium	※2	100Bq
Lead and polonium	※3	20Bq

※1 Nuclides originating from the Earth
※2 Nuclides derived from N-14 originating from cosmic rays
※3 Nuclides of the uranium series originating from the Earth

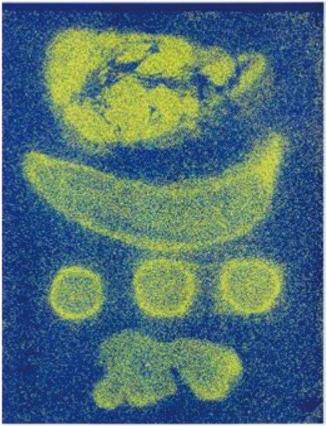
Radioactivity concentrations (Potassium-40) in foods

Rice: **30**; Milk: **50**; Beef: **100**; Fish: **100**; Dry milk: **200**; Spinach: **200**;
Potato chips: **400**; Green tea: **600**; Dried *shiitake*: **700**; Dried kelp: **2,000** (Bq/kg)

Bq: becquerels Bq/kg: becquerels/kilogram

Source: Prepared based on "Research on Data about Living Environment Radiation (1983)," Nuclear Safety Research Association

Visualized Radiation



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

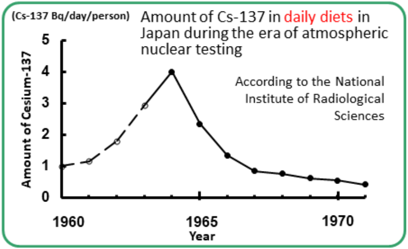
Radiation from foods

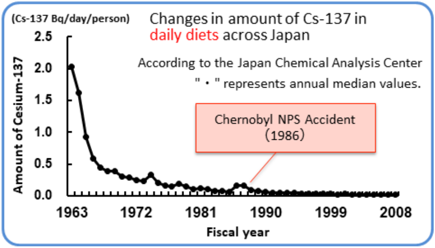
- Mostly β-particles from Potassium-40
- The natural abundance ratio of Potassium-40* is **0.012%**.
- Potassium-40 has a half-life of **1.26×10^9** years.

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

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

Changes in Cesium-137 Concentrations in Foods over Time since before the Accident





*The two studies differ in sampling time and location.

- If an adult keeps consuming the typical diet of the 1960s for a year, internal radiation dose due to Cesium-137 is:

$$4.0 \times 365 \times 0.013 = 19\ \mu Sv/y$$

(Bq/day) (day/year) (μSv/Bq)

= **0.019 mSv/y**

- (Japanese average)
  Annual internal exposure dose due to natural radiation in foods is:
  0.99 mSv/y

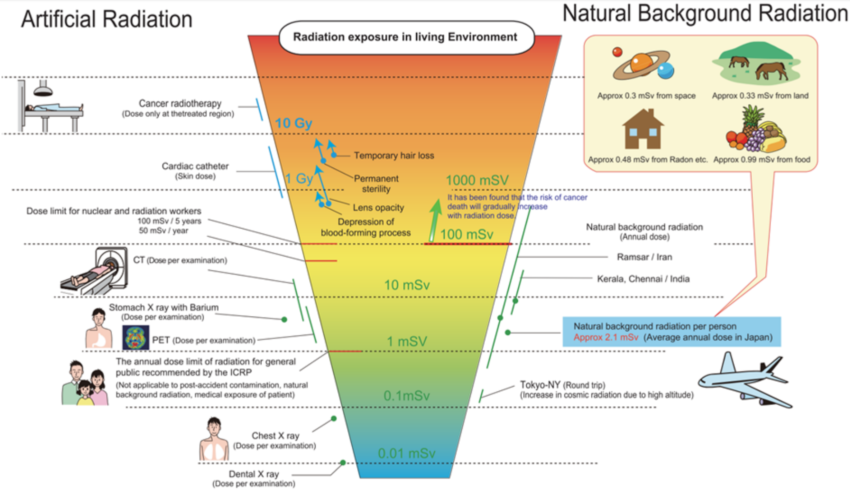
Source: Prepared based on the "Environmental Radiation in Daily Life (Calculation of National Doses), ver. 3" (2020), Nuclear Safety Research Association

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

Comparison of Exposure Doses (Simplified Chart)



Sources:
- The 2008 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) Report
- The 2007 ICRP (International Commission on Radiological Protection) Report
- The exposure guideline of the Japan Association of Radiological Technologists
- "Environmental Radiation in Daily Life (Calculation of the National Doses)," new edition

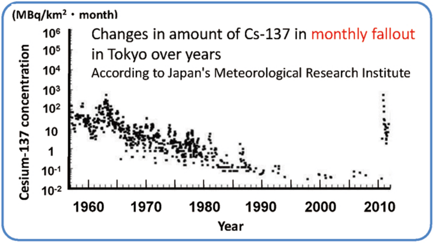
Prepared by the National Institute of Radiological Sciences, National Institutes for Quantum Science and Technology, based on the sources above (May 2021)

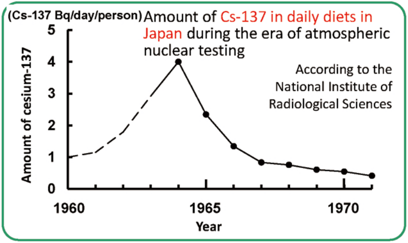
mSv: millisieverts

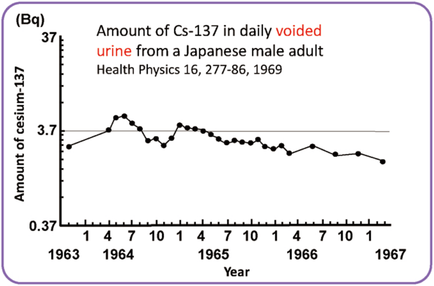
Radiation around Us

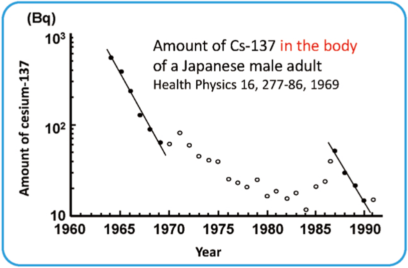
Effects of Radioactive Fallout due to Atmospheric Nuclear Testing

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







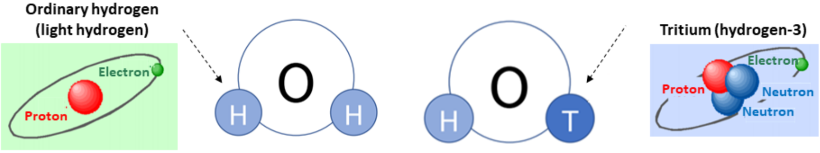


MBq: megabecquerels

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.

【Structure of ordinary water molecules】

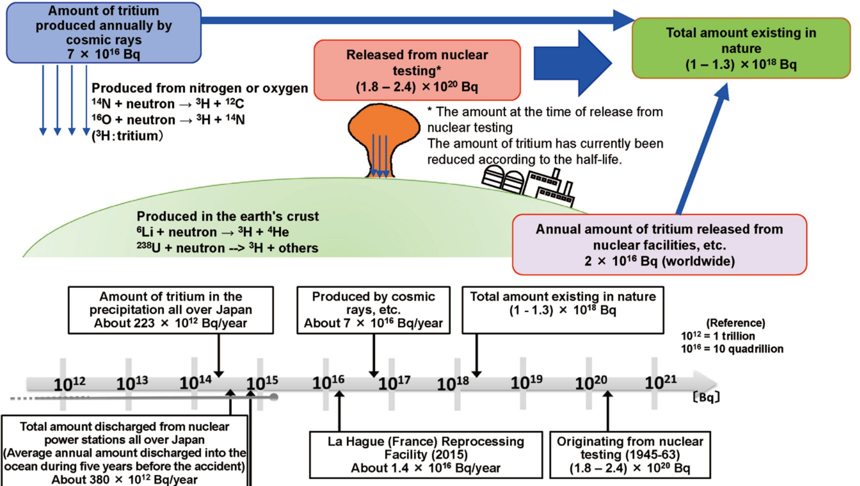


Water molecule solely consisting of ordinary hydrogen

Water molecule consisting of ordinary hydrogen and tritium

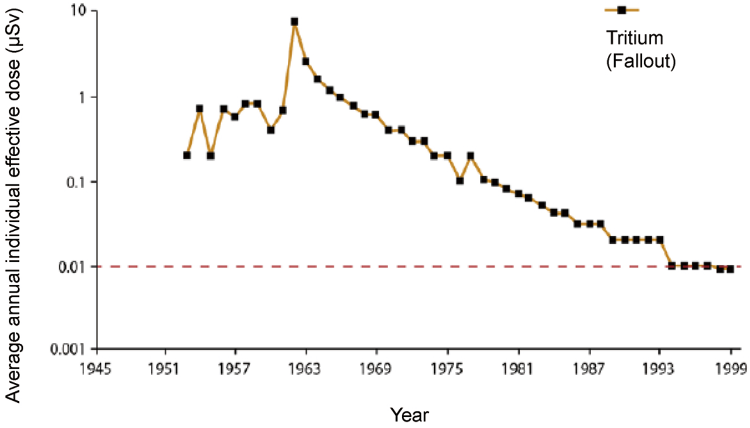
Source: Prepared based on the "Important Stories on Decommissioning 2018" by the Agency for Natural Resources and Energy, METI, the "Tritiated Water Task Force Report" by the Tritiated Water Task Force (2016), and the "Scientific Characteristics of Tritium (draft)" by the Subcommittee on Handling of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

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)

Changes in Tritium in Radioactive Fallout over Time



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