Reference Materials

Basic Knowledge of Radioactive Substances

Differences between Radiation, Radioactivity, and Radioactive Substances

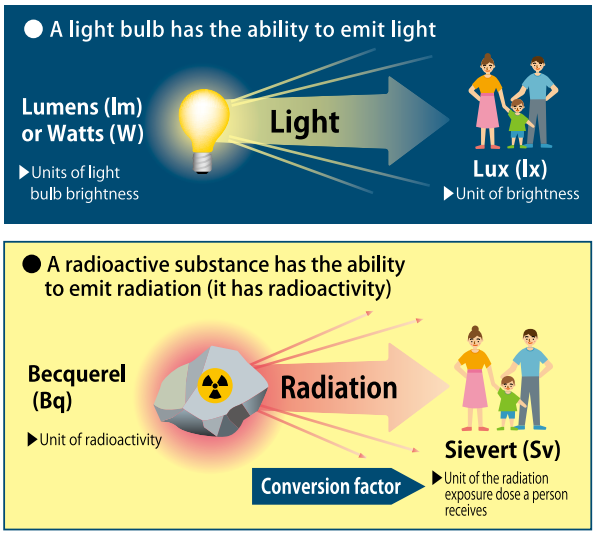
"Radiation" is like light that can pass through objects. The ability to emit radiation is called "radioactivity" (the unit for the amount of radioactivity is the Becquerel (Bq)), and substances which have that ability are called "radioactive substances".

The unit of Sievert (Sv) is used for the radiation exposure dose how much human body is affected by radiation.

If a radioactive substance is placed in a sealed container, radiation is emitted from the container, but the radioactive substance itself is not.

If we look at the example of a light bulb, the light is like radiation, the bulb is like the radioactive substance, and the ability to emit light is like radioactivity. The greater the radioactivity, the more radiation the radioactive substance emits.

The radiation exposure dose varies with distance between the radioactive substance and the exposed person. The strength of radiation increases with proximity to the source, and decreases with distance. That is like the way even a bright light bulb looks dim from a distance.



※Sieverts are related to the impact of radiation

[Figure] What Are Radiation, Radioactivity, and Radioactive Substances?

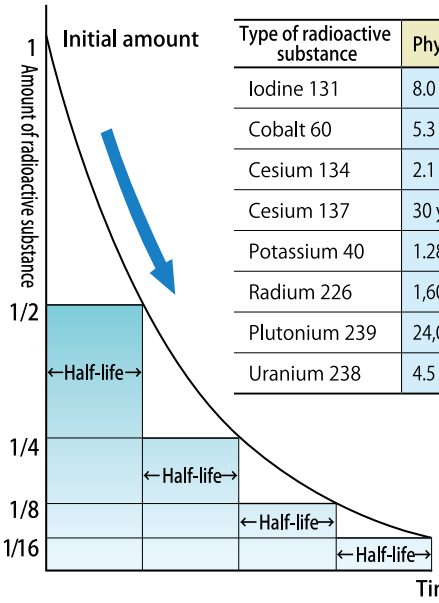
Reference : Ministry of the Environment "Unified Basic Reference on the Health Impacts of Radiation, FY2017 Edition";
Consumer Affairs Agency "Food and Radiation Q&A, 12th edition", March 8, 2018;
Ministry of the Environment "Unified Basic Reference on the Health Impacts of Radiation, FY2017 edition"

Half-life of Radioactive Substances

As radioactive substances emit radiation, they transform into stable substances which do not emit radiation. Therefore, the radioactive substances dispersed from a reactor accident do not remain in the natural environment eternally, because their quantity decreases over time. The time required for that radiation decay is determined for each type of radioactive substance, and the time it takes for the amount of radioactive substance to halve is called the physical half-life. For example, the half-life of iodine 131 is around 8 days, while that for cesium 134 is around two years, and for cesium 137 is around 30 years (Figure).

Radioactive substances taken into the bodies of organisms are expelled from the body through metabolism and the excretory effects of defecation, urination, perspiration, respiration, etc. The time required for those processes to halve the amount of radioactive substance is called the biological half-life. The biological half-life of cesium 137 in humans is around 9 days in people aged up to one year, around 38 days in those aged up to nine, around 70 days in those aged up to 30, and around 90 days in those aged up to 50. Biological half-life is shorter in children because of their faster metabolism. For example, if cesium 137, which has a long physical half-life of 30 years, enters the body of a person aged 50, half of the cesium has been expelled from the body after around three months.

(Reference) Physical half-life



Type of radioactive substance	Physical half-life
Iodine 131	8.0 days
Cobalt 60	5.3 years
Cesium 134	2.1 years
Cesium 137	30 years
Potassium 40	1.28 billion years
Radium 226	1,600 years
Plutonium 239	24,000 years
Uranium 238	4.5 billion years

[Figure] Physical Half-life

Reference : Ministry of Agriculture Forestry and Fisheries (2012) "Basics of Radioactive Substances";
Consumer Affairs Agency "Food and Radiation Q&A, 12th edition", March 8, 2018;
Ministry of the Environment "Unified Basic Reference on the Health Impacts of Radiation, FY2017 edition"

Radiation around Us

Radioactive substances are originally present in the natural world, and we receive some amount of radiation all the time (the average in Japan is 2.1mSv per person per year). We also receive radiation from medical procedures such as CT scans and X-ray imaging. The effect of radiation on the human body occurs when part of the DNA that forms the body of genes within cells is damaged, but most cells either return to normal or are replaced by healthy cells. Therefore, we do not need to think about radiation during our daily lives. However, if we are exposed to more than a certain amount of radiation in a short time, health impacts occur, in acute forms such as hair loss and bleeding, and there may be a marked increase in cancer risk.

The increase in risk of carcinogenesis due to radiation is so small at low doses of 100mSv or less that it is obscured by the carcinogenesis risks of smoking and other factors, and it is considered difficult to prove a clear increase in cancer risk due to radiation (Figure, Table).

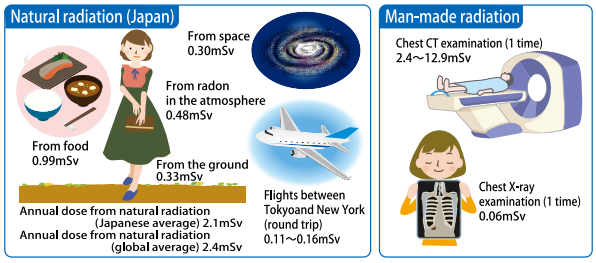
Smoking	Equivalent to 1,000 – 2,000 mSv
Obesity ※1	Equivalent to 200 – 500 mSv
Passive smoking ※2	Equivalent to 100 – 200 mSv
Lack of vegetables ※3	Equivalent to 100 – 200 mSv

※1 : The risk for a group with BMI (Body Mass Index, an indicator of obesity calculated from height and weight) ≧30, compared to the risk of the group with BMI 23.0 - 24.9.
※2 : The group risk of women whose husbands do smoke, compared to the group of women whose husbands do not smoke.
※3 : The risk (median) for a group which consumes 420g of vegetables per day, compared to the risk (median) of the group which consumes 110g per day.

[Table] Comparison of Radiation with Other Carcinogenesis Factors

Reference : Reconstruction Agency "FAQ Concerning Radiation Risks Often Mentioned at Evacuee Briefings etc.", December 25, 2012

Radiation around Us **Exposure dose from natural and man-made radiation**



[Figure] Radiation around Us

Reference : Ministry of the Environment "Unified Basic Reference on the Health Impacts of Radiation, 2017 Edition";
Consumer Affairs Agency "Food and Radiation Q&A, 12th edition", March 8, 2018;
Reconstruction Agency "FAQ Concerning Radiation Risks Often Mentioned at Evacuee Briefings etc.", December 25, 2012;
Cabinet Office, Ministry of Agriculture, Forestry and Fisheries, and others "The Basics of Radiation Risks", revised February 2, 2016

Designation Status of Areas under Evacuation Orders

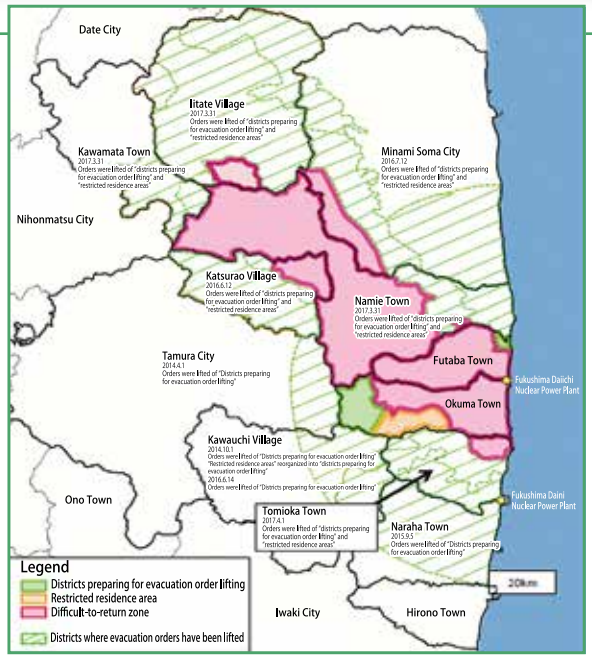
The accident at the Fukushima Daiichi Nuclear Power Plant, caused by the Great East Japan Earthquake, led the national government to issue evacuation orders immediately after the accident, to keep local residents from danger to lives and health due to damage to the reactor and the release and dispersion of radioactive materials. As the severity of the accident deepened, areas under evacuation orders were gradually specified.

When it became clear that the reactors are in a state of cold shutdown, area status was reviewed into the three types, of districts preparing for evacuation order lifting, restricted residence area, and difficult-to-return zones, according to the average annual dose (April 1, 2012). That was a step for making environmental improvements and advancing the recovery and regeneration, towards residents' return. After that, evacuation orders were lifted for the urban parts of Tamura City, Kawauchi Village, Naraha Town (with the exception of some areas), Katsurao Village (with the exception of some areas), Minami Soma City (with the exception of some areas), the Yamakiya district of Kawamata Town, Iitate Village (with the exception of some areas), Namie Town (with the exception of some areas), and Tomioka Town (with the exception of some areas). The districts which residents are allowed to return to have been increasing gradually.

The map shows the current status of areas under evacuation orders.

[District Classifications]

- **Districts preparing for evacuation order lifting**
  Districts where rapid support measures for restoration and recovery are conducted, aiming for environmental improvements that will allow residents to return home.
- **Restricted residence area**
  Districts where planned decontaminations are conducted, aiming for the future return of residents and the rebuilding of communities, and districts intended for the restoration of infrastructure facilities which are essential for early recovery.
- **Difficult-to-return zone**
  Zones where radiation levels are extremely high, so barricades and other physical protection measures have been erected and residents are asked to evacuate.



[Figure] Status of Areas under Evacuation Orders in Fukushima Prefecture (As of April 1, 2017)

Reference: Fukushima Prefecture website "Fukushima Revitalization Station - Status of Areas under Evacuation Orders";
Fukushima Prefecture website "Fukushima Revitalization Station - Status of Areas under Evacuation Orders" , "Fukushima Revitalization Station - Commentary on Changes in Evacuation Zones", updated February 28, 2018

<Specfic Rebirth and Regeneration Base Districts>

The Amendment to the Act on Special Measure for the Rebirth of Fukushima (May 2017) made it possible to set "Specific Rebirth and Regeneration Base Districts", lifting evacuation orders and allowing residence, within difficult-to-return zones where residence had been restricted over the future.

Mayors of municipalities can set Special Recovery and Regeneration Center Districts, and formulate plans for environmental improvements (such as decontamination and development of infrastructure etc.) in those districts. Such plans are subject to approval by the Prime Minister.

As of August 2018, districts had been approved in six municipalities (the towns of Futaba, Okuma, Namie, and Tomioka, and the villages of Iitate and Katsurao).