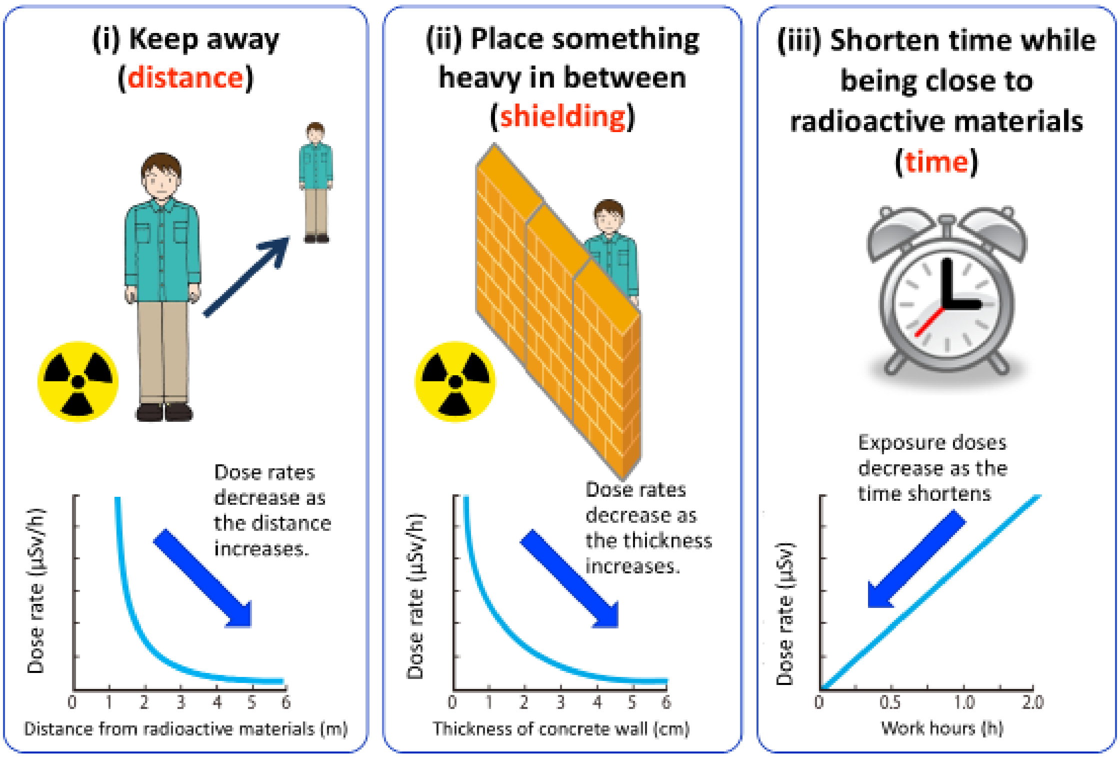
Dose Reduction

Three Principles of Reduction of External Exposure



There are three ways to reduce external exposure doses.

The first is to keep away from radioactive materials such as by removing soil contaminated with radioactive materials and isolate it from people's living environment.

The second is to shield radiation such as by staying indoors, replacing topsoil contaminated with radioactive materials with subsoil, and using uncontaminated soil as a shielding material.

The third is to shorten the time to stay at places with high ambient dose rates.

(Related to p.50 of Vol. 1, "Characteristics of External Exposure Doses")

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Dose Reduction

Reduction of Internal Exposure

- Be careful so that radioactive materials do not enter the body through the mouth, nose or wounds, in principle.
- Wash off soil immediately from the body, shoes and clothes.
- Exercise adequate care in eating wild mountain vegetables or mushrooms.
- Be aware of the information on the release and pollution of radioactive materials.
- Be careful not to lose nutritional balance, being excessively worried about a small amount of radioactive materials below the standard limit.

As causes of internal exposure, both intake through inhalation and oral intake through ingestion of foods and drinks need to be taken into consideration. After a nuclear disaster, radioactive materials remaining on the ground pose a problem, but little resuspended radioactive materials exist even immediately after the accident, and become further less over time.[1,2,3] Therefore, intake through inhalation of resuspended radioactive materials is scarce.[4] Proper daily hygienic control (such as washing hands and taking a bath, etc.) is also effective in reducing internal exposure.

In the meantime, attention needs to be paid to wild foods from which radioactive cesium is detected at high levels. In particular, special attention is required for wild mountain vegetables and mushrooms, which tend to contain cesium at high concentrations. In the aftermath of a nuclear disaster, radioactivity concentrations in foods are inspected by individual prefectures based on inspection plans they formulated in light of the inspection items and the system presented by the national government. Inspection results are released via the websites of the Ministry of Health, Labour and Welfare, the Ministry of Agriculture, Forestry and Fisheries, and individual local governments (p.54 of Vol. 2, "Publication of the Inspection Results Concerning Radioactive Materials in Foods").

Regarding internal exposure due to radioactive cesium, simple measurement services are available for residents to measure radioactive cesium concentrations in wild mountain vegetables and mushrooms and for home-grown vegetables. Residents can also measure internal exposures using a whole-body counter (WBC).

1. IAEA-TECDOC-1162 "Generic procedures for assessment and response during a radiological emergency" (2000)
2. K. Akimoto: Jpn. J. Health Phys., 49(1): 17-28, 2014.
3. K. Akimoto: Health Phys., 108(1): 32-38, 2015.
4. UNSCEAR 2020/2021 Report

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Dose Reduction | **Reduction of Exposure Indoors due to Radioactive Materials Released into the Environment**

- Studies on reduction of external exposure indoors
  - ✓ From the results of measurements of ambient doses inside and outside of buildings, the reduction coefficient*1 in wooden and light-gauge steel houses is evaluated as 0.38 on the first floor and 0.49 on the second floor.

    (Source: N. Matsuda et al.: *J Environ Radioact* 166: 427-435, 2017.)
  - ✓ From the results of measurements of ambient doses inside and outside of buildings, the median value of the reduction coefficient for wooden houses is evaluated as 0.43.

    (Source: H. Yoshida et al.: *SCIENTIFIC REPORTS* 4: 7541, 2014.)

- Studies on reduction of internal exposure indoors
  - ✓ From the results of measurements of radioactivity concentrations inside and outside of buildings, the decontamination factor*2 for radioactive materials in the air is evaluated as 0.64 for particulate I-131 and 0.58 for Cs-137.

    (Source: T. Ishikawa et al.: Environ Sci Technol 48:2430-2435, 2014.)
  - ✓ As factors for internal exposure indoors, the natural ventilation rate, temperature differences between inside and outside of rooms, wind speed, and the total coverage and ages of buildings, etc. were set as parameters and were examined experimentally, thereby evaluating the coefficient of reduction of internal exposure (varying within the range of 0.1 to 1).

    (Source: J. Hirouchi et al.: *ASRAM2018-010*, 2018.)

*1: Ratio of a dose within a building when assuming the dose outdoors as 1
*2: Ratio of the concentration within a building when assuming the concentration outdoors as 1

When being indoors, radiation from radioactive materials released into the environment that are suspended in outdoor air or deposited on the ground surface, etc. is shielded by the building and the external exposure dose decreases. Additionally, the concentration of radioactive materials suspended in indoor air is lower than that outdoors thanks to the airtightness of the building, and the internal exposure dose through inhalation also decreases.

The value, 0.4, which is used as the coefficient of reduction of external exposure for typical Japanese wooden houses when considering radiological protection, is said to be based on the IAEA-TECDOC-225 (1979) (p.53 of Vol. 1, “Shielding and Reduction Coefficient”). As recent studies on the reduction of exposure indoors, the outcomes of studies concerning the coefficient of reduction of external exposure[1,2] are reported.

Additionally, as the effects of reducing internal exposure indoors, not only external exposure, the outcomes of studies concerning the effects of reducing radioactivity concentrations[3] and the coefficient of reduction of internal exposure[4] are also reported. It is reported that the effects of reducing internal exposure indoors vary by individual buildings' ages, wind speed, temperature differences between inside and outside of rooms, and other factors.

1. N. Matsuda et al.: J Environ Radioact 166: 427-435, 2017.
2. H. Yoshida et al.: SCIENTIFIC REPORTS 4: 7541, 2014.
3. T. Ishikawa et al.: Environ Sci Technol 48:2430-2435, 2014.
4. J. Hirouchi et al.: ASRAM2018-010, 2018.

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Dose Reduction

Removal of Radioactive Cesium through Cooking and Processing of Foods

Radioactive materials can be reduced through cooking.

Item	Cooking/Processing methods	Removal rate (%)
Leaf vegetables (spinach, etc.)	Washing - Boiling	7～78
Bamboo shoots	Boiling	26～36
Japanese radish	Peeling	24～46
Nameko mushrooms (raw)	Boiling	26～45
Fruits (grape, persimmon, etc.)	Peeling	11～60
Marron	Boiling - Peeling astringent skin	11～34
Japanese plum	Salting	34～43
Cherry leaves	Salting	78～87
Fish	Cooked lake smelt soaked in Japanese sweet and peppery vegetable sauce	22～32

● Avoid eating wild foods too much.

$$\text{Removal rate (\%)} = \left(1 - \frac{\text{Total amount of radioactivity in cooked or processed foods (Bq)}}{\text{Total amount of radioactivity in raw materials (Bq)}}\right) \times 100$$

Source: Prepared based on the "Environmental Parameters Series Expanded Edition (2013): Radionuclide Removal Rates through Cooking and Processing of Foods - Centered on Data on Radioactive Cs Removal Rates in Japan -" (September 2013), Radioactive Waste Management Funding and Research Center

Immediately after the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi NPS, radioactive materials detected from vegetables were only attached to the surface thereof, and such radioactive materials could be washed off to some extent.

At present, radioactive materials are seldom attached to the surface of vegetables, but some radioactive materials in soil may be taken into vegetables through their roots. However, radioactive cesium absorbed into vegetables from the roots can be removed through cooking or processing with some ingenuity.

The table above shows removal rates of radioactive cesium in foods.

When boiling vegetables, the longer the boiling time is, the larger the removal rate is. This is considered to be because radioactive cesium in vegetable cells comes out into the boiling water as vegetable cells break. Also in the case of salted vegetables, the longer the salting time is, the larger the removal rate is. This is considered to be because radioactive cesium in vegetables is replaced with sodium in salt.

When cooking meat or fish, the amount of radioactive materials can be halved by discarding the cooking liquid. It is known that the removal rate is higher when boiling or cooking than grilling them.

Refer to the webpage (https://www.rwmc.or.jp/library/kankyo/, in Japanese) for the details of the related data.

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