Mechanism and Measures for Contaminated Rice

Production Environment Department, Environment / Crop Nutrition Department
Main radioactive material spread by the accident at TEPCO’s Fukushima Daiichi Nuclear Power Plant.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Emission volume (Bq)</th>
<th>Half-life</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Iodine 131 (I-131)</td>
<td>16,000 trillion</td>
<td>Approx. 8 days</td>
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<tr>
<td>Cesium 134 (Cs-134)</td>
<td>18,000 trillion*</td>
<td>Approx. 2 years</td>
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<tr>
<td>Cesium 137 (Cs-137)</td>
<td>15,000 trillion</td>
<td>Approx. 30 years</td>
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<tr>
<td>Strontium 89 (Sr-89)</td>
<td>2,000 trillion</td>
<td>Approx. 50.5 days</td>
<td></td>
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<tr>
<td>Strontium 90 (Sr-90)</td>
<td>140 trillion</td>
<td>Approx. 29 years</td>
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Source: Estimation of radioactive material released from TEPCO’s Fukushima Daiichi Nuclear Power Plant and the nuclear bomb dropped on Hiroshima (August 26, 2011)

*Emission of Cs-134 is according to the report from Nuclear and Industrial Agency.

A large amount of radioactive Cesium 134 and 137 was released. Since these have a longer half-life they will remain in agricultural land, and the risk of absorption by agricultural crops is a problem.
“Technological Development of Measures for the Removal and Reduction of Radioactive Material”

★Research consists of seven pillars set according to the advice of experts. A radiation countermeasures team was established, and research began.

1. Identification of the distribution status of radioactive material in farmland soil within the prefecture
2. Development of a simplified measurement method for radioactive materials (soil/animals)
3. Identification of the amount of absorption of radioactive materials in various crops
4. Development of technology for the removal/reduction of radioactive material
5. Development of technology for the control of absorption of radioactive material
6. Development of technology for the removal of radioactive material during processing of agricultural products
7. Development of technology for the reduction of radiation exposure in agricultural jobs
Distribution of radioactive cesium in Fukushima prefecture

Collected and analyzed from 2247 locations of farmland soil, published by the Ministry of Agriculture, Forestry and Fisheries
Effect of both pieces of construction equipment in the reduction of radioactive cesium in the soil was high, and the working time was short. Approx. 5cm of the surface soil was scraped off.
Scraping off decontamination work of surface soil in the “zones preparing for the lifting of the evacuation order” (Iitate village)
Processing of the soil removed during decontamination is an issue. Decontamination soil can be found throughout Fukushima prefecture.
There is a clear correlation between the amount of exchangeable potassium in soil and concentration in brown rice! In cases where the exchangeable potassium in soil was greater than 25 mg K2O/100g, the radioactive cesium concentration in brown rice was shown to be below the standard value.
Comparison of absorption control effect of potassium chloride and potassium silicate

The test results of a comparison of radioactive cesium concentration in brown rice where potassium fertilizer was not used, and where potassium fertilizer was used - in the form of potassium chloride, 8.3, 16.6, 33.3, 50.0kg (as K$_2$O, 5, 10, 20, 30kg), or potassium silicate 50, 100kg (as K$_2$O, 10, 20kg) per 10a.

- When the amount of exchangeable potassium in soil was significantly lower than the target value, fast-acting potassium chloride (which dissolves faster and has a higher reduction rate for radioactive cesium concentration in brown rice), rather than soluble potassium silicate (which dissolves potassium components in the soil more slowly), was used when applying potassium every year,
Comparison of absorption control effect of potassium chloride by fertilizing period

Radioactive cesium concentration in brown rice (Bq/kg)

- Potassium not applied
- Applied base fertilizer (May 7)
- Applied in midterm drying period (June 28)
- Applied in young formation period (July 19)
- Applied in meiosis period (July 30)

Description

- Test results of the absorption control effect of radioactive cesium concentration in brown rice, by changing the application period of potassium chloride (8kg/10a as K2O) in gley soil rice fields with 14.7mg K2O/100g of exchangeable potassium.

- Assuming the quantity of fertilizer is constant, early fertilizing as a base fertilizer was more effective than additional fertilization at later times.
Effect of zeolite application on the quantity of exchangeable potassium in soil and radioactive cesium concentration in brown rice

This confirmed the absorption control effect of zeolite.

The control effect of exchangeable potassium was shown to increase with use, according to the adsorption effect of radioactive cesium.
According to the results of continuous testing, long-term rice straw removal reduces exchangeable potassium.

Achievement of more than 20 years of steady research! “Endurance makes you stronger.”
Consideration of the influence of agricultural water

Description

・In addition to radioactive cesium contained in water as dissolved matter where cesium is dissolved in water by ions, etc., it is also present in the suspended state where it is absorbed and attached to suspended solids such as soil particles in suspension and organic matter.

・The fixed state and absorption state cesium (Cs) (suspended cesium) contained in irrigation water and suspended solids in rice field water is not directly absorbed by the rice stalk or roots, but the dissolved state of Cs in rice field water and water-soluble cesium in the plow layer migrate to through stalk and roots.
Absorption of dissolved radioactive cesium was easier in wet-land rice.

*Results from hydroponic culture in polluted water extracted from fallen leaves.

The dissolved state contained in actual river water and storage reservoir water are minuscule, so absorption to rice plants is small, and there is almost no effect from the radioactive material concentration.
Radiation in the soil in rice fields and dry fields
Change of cesium concentration over time (years)

* (results of radiation material measurement survey by a consigned project)
Survey method of radioactive cesium in soil and air dose rate

Survey period
Three years from 2012-2014
Radioactive material measurement survey consigned project (Ministry of Agriculture, Forestry and Fisheries)

Survey locations
Fields where crop cultivation was possible, excluding areas under evacuation orders 107 locations

- Rice field
  49 locations
- Farmland
  31 locations
- Orchards
  16 locations
- Grassland
  11 locations
2012-2014 Change in radioactive cesium in soil over three years

Decrease in radioactive cesium in the soil could be confirmed for all land categories

Fukushima Agricultural Technology Centre
Confirmation of concentration of radioactive cesium in soil in 2012, 2014

Radioactive Cs concentration in soil in 2012 (Bq/kg dry soil)

Radioactive Cs concentration in soil in 2014 (Bq/kg dry soil)

Physical attenuation estimation (y=0.765x)

Radioactive cesium concentration in soil in rice fields and farmland
→ Physical attenuation Normal - reduced below that
Main research on current radioactive material

   - Development of energy-saving farming technologies on decontaminated farmland
   - Development of technologies such as technology to prevent the flow of radioactive material into farmland
   - Clarification of the radioactive cesium absorption control mechanism

2. “Radioactive material measurement survey consigned project” (2012- )

3. “Experimental study on the resumption and revitalization of farmland in under the evacuation order” (2013- )
   *Handled by the Coastal Area Agricultural Recovery Research Center, Agricultural Technology Centre
Introduction and achievements of research results on the actual site

★ Main introduced technology
  ○ Appropriate amount of applied potassium fertilizer
  ○ Use of absorption control materials such as zeolite
  ○ Reverse tilling, deep tilling, and topsoil removal (+ soil addition)
  Farmland decontamination
  ○ Prevention of cross-contamination and secondary contamination of crops
  ○ Prevention of radioactive exposure in farming activities

Obtained achievements have been published on the website “Future From Fukushima,” providing agricultural technical information (nuclear power disaster countermeasures), and have been successfully utilized at actual sites.