IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

# Assessment of the environmental and dosimetric consequences in Japan due to the radioactive releases since March 12, 2011 by the nuclear power plant of Fukushima Daiichi

*Updated March 23, 2011*

## 1 – What is known about the radioactive releases emitted since 12 March 2011?

IRSN does not have any direct information regarding the composition and scale of the radioactive releases. But has the following information at its diposal:

- technical information on the damaged installations which makes it possible to assess their state of degradation;
- measurement results of the ambient dose rate carried out on the site, which give information on the release periods;
- results of measurement in the environment, allowing to identify the main radioactive elements released.

The interpretation of the information made it possible for IRSN to work out possible degradation scenarios for the 3 reactors since March 12. According to the new information received by the IRSN, the estimate of the radioactive releases is periodically updated. The most recent estimate of these releases is provided on the IRSN website.

**> More information:**
Assessment of radioactivity released by the Fukushima Daiichi Nuclear Power Plant (Fukushima I) through 22 March 2011

According to IRSN estimates, the main radioactive elements released during various radioactive release periods between the 12 and 23 March would be:

- The noble gases are radioactive elements with a very low chemical reactivity, and they remain in the air without ground deposits. In particular xenon 133 which has a radioactive half-life of 5,3 days;
- Volatile elements, mainly of the radioactive isotopes of iodine, radioactive caesium, radioactive tellurium. These elements form fine suspended particles in the air (aerosols), which due to their weight will gradually end up falling on the ground when released in the air.

The available measurement results in the environment, coming from Japan, confirm the presence of mainly:

- Iodine 131 (8 days of radioactive half-life), iodine 132 (2,3 hours of radioactive half-life) and of iodine 133 (20,8 hours of radioactive half-life);
- Tellurium 132 (3,2 days of radioactive half-life) the radioactive decrease produces iodine 132, as well as tellurium 129m (33,6 days of radioactive half-life) combined with tellurium 129 of a shorter period (1,16 hours);
- Caesium 137 (30 years of radioactive half-life) and of caesium 134 (2,1 years period).

## 2 – Dispersion of radioactive releases in the atmosphere on a regional scale

According to the meteorological observations available and forecasts provided by Meteo France, the IRSN re-assesses periodically, using its numerical models, dispersion in the air of released radioactive elements since March 12 by the nuclear power plants of Fukushima. These evaluations relate to the area close to the site (50 km around the site) as well as a broader area covering all of Japan and the area close to Japan.

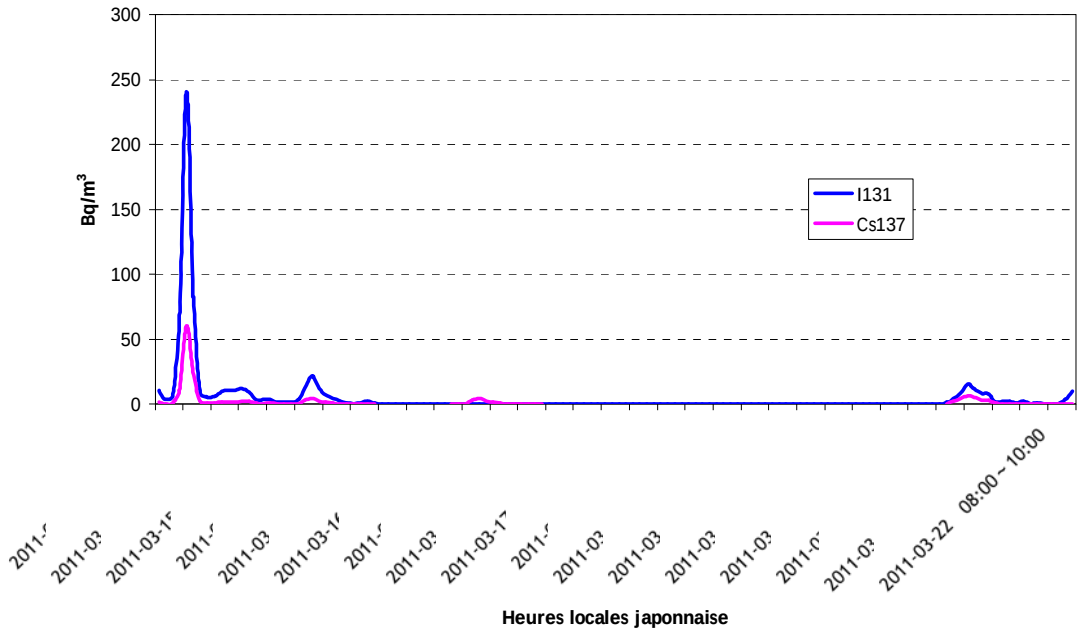
The map below shows the result of the most recent simulation carried out by IRSN, for the radioactive releases estimated between the 12 and March 23. This simulation was applied to caesium 137, selected as a representative element of the radioactive plume dispersion. The results of this modelling are expressed in becquerels of cesium 137 per cubic meter of air (Bq/m3).

**> View the simulation updated on March 22, 2011**

The modelling carried out on a Japan scale shows that the plume moved in directions which varied in the course of time: initially towards the North-East until March 14, then towards the south and south-west, for Tokyo, March 15, then towards the east, in direction of the Pacific Ocean. From March 20 and during the following days, the radioactive plume tends to move inland in a changing way, in particular towards Tokyo (especially on March 23) but also North-West. The plume should again move towards the east as from March 25.

The IRSN compared the results of this simulation with the measurement results of the air contamination carried out in Tokyo presented in the graph below for cesium 137 and iodine 131. They are of the same order of magnitude as the values measured in this city.

**Evolution de l'activité volumique du césium 137 et de l'iode 131 (en Bq/m$^3$) mesurée dans l'air à Tokyo du 15 au 22 mars 2011 (Heure locale)**




## 3 -Radioactive release consequences for the environment in Japan

According to the weather conditions, the radioactive elements released into the air at the time of the accident disperse on the ground and in the oceans by forming a radioactive plume. The radioactive elements in the form of particles settle gradually on various surfaces on the ground, in particular on the leaves of crop plants, grass of the grazing grounds, stagnant water outside or the water of the rivers, in the urban environments...

Vegetables with leaves (spinach, salads, leeks...) are particularly sensitive to this radioactive fallout and are quickly contaminated after the accident. The results of the measurements taken in Japan, at more than 100 km away from the nuclear power plant of Fukushima, on this product category confirm this:

| Sampling date | Area / type of vegetable | Iodine 131 | Caesium 137 et 134 |
|---|---|---|---|
| 18 mars 2011 | Tochigi Prefecture<br>- Spinach | 2100 to 54100 Bq/kg | 121 to 1931 Bq/kg |
| 19 mars 2011 | Tochigi Prefecture<br>- Spinach<br>- Leeks | 3200 to 5700 Bq/kg<br>270 Bq/kg | 460 to 790 Bq/kg<br>27 Bq/kg |
| | Ibaragi Prefecture<br>- Spinach<br>- Leeks | 1900 and 11000 Bq/kg<br>440 Bq/kg | 71 to 586 Bq/kg<br>7 Bq/kg |
| | Gunma Prefecture<br>- Spinach<br>- Leeks | 2080 and 2630 Bq/kg<br>40 and 81,1 Bq/kg | 268 to 310 Bq/kg<br>11,15 and 11,18 Bq/kg |

These results indicate that for iodine 131 in spinach, the acceptable maximum level in Japan for marketing and the consumption of food products (2000 Bq/kg) are systematically exceeded in these territories. It is the same for radioactive caesium, but to a lesser extent (acceptable maximum level in Japan of 500 Bq/kg). The leeks, which offer a smaller leaf area in contact with the ambient air, seem less contaminated.

The contamination of vegetables with leaves is certainly more important while approaching the site of Fukushima, according to the importance of the radioactive fallout.

Generally, the contamination of these vegetables will remain important in the next days. During weeks to come, if new important releases do not occur, a clear reduction in the contamination of vegetables with leaves should be observed, because of the radioactive decrease of the radionuclides with a short life (iodine 131) and of the effect of the vegetable growth which dilutes the initial contamination in the mass of the plant.

## 4 – Estimating the doses likely to have been received by people exposed to the radioactive plume

IRSN has estimated the doses likely to have been received by a person exposed to the radioactive plume, assuming that this person remained in the same place and with no protection (i.e. outside) throughout the entire release period (from 12 to 20 March). For these dose calculations, IRSN studied the case of a one-year old infant, the most sensitive to iodine-131 (dose to the thyroid). In other words, these are the most cautious hypotheses.

The simulations below show how the doses evolve over time, throughout the simulation period. If there are further releases in the future, these doses may increase further if the most exposed people are unprotected.

Whole body doses likely to be received by a one-year old infant with no protection during the releases

**> View the simulation updated on March 22, 2011**

In the event of an accident, the recommended minimum dose values used to launch protective actions are 10 mSv for taking shelter and 50 mSv for evacuation. Below 10 mSv, the health risk is deemed to be sufficiently low and therefore such protective actions are considered unnecessary. To compare, the average annual dose received in France due to natural radioactivity and medical exposure is 3.7 mSv.

Doses to the thyroid likely to be received by a one-year old infant with no protection during the releases

**> View the simulation updated on March 22, 2011**

In the event of an accident, the recommended minimum dose values for prescribing the ingestion of stable iodine are 100 mSv in Japan