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Consequences of the Nuclear accident after the Great east Japan Earthquake

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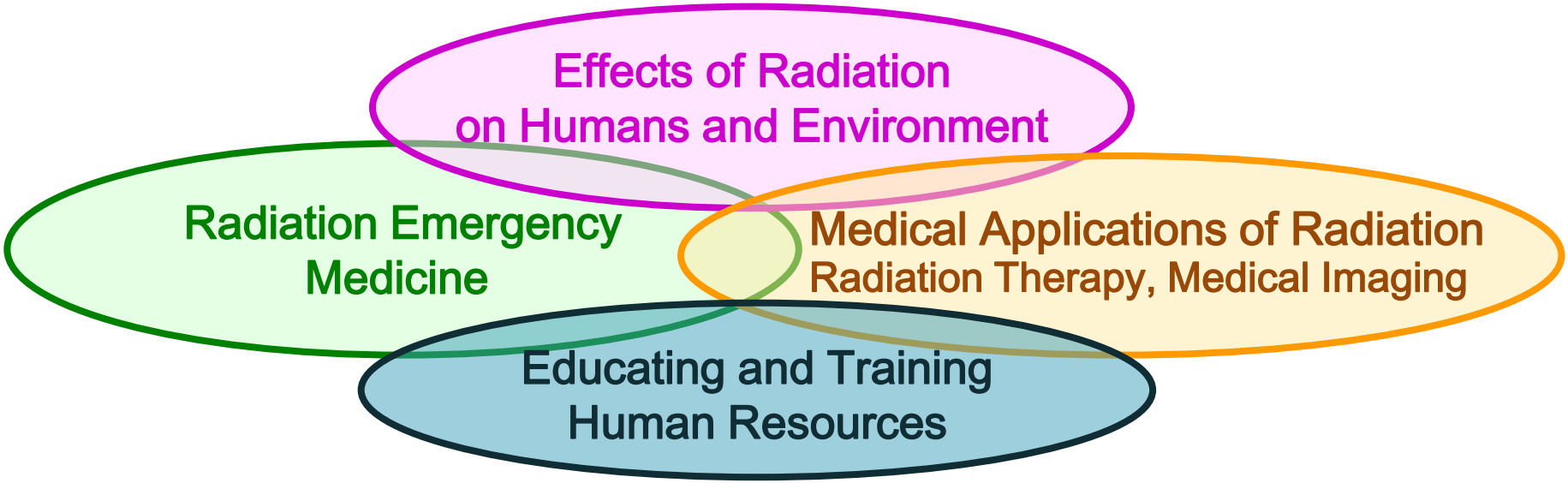
Brief History of NIRS

With a concern about nuclear weapon testing, the motivation was enhanced to establish an institute to study radiation effects on humans.

At that time, Japan was just going to use nuclear energy and radiation for peaceful purposes. The times required studies for medical use.

NIRS was established in 1957 as a unique institute in Japan dedicated to comprehensive research and development.



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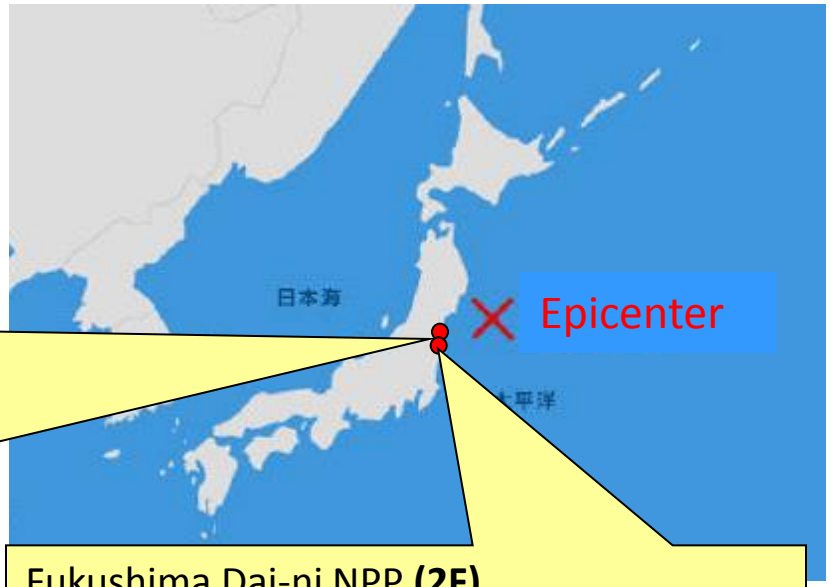
A. The accident and the release of radioactive material into the environment

On 11 March 2011, at 14:46 local time, a 9.0-magnitude earthquake occurred near Honshu (main island of Japan), creating a devastating tsunami that left a trail of death and destruction in its wake.

The earthquake and subsequent tsunami, which flooded over 500 square kilometres of land, resulted in the loss of more than 20,000 lives and destroyed property, infrastructure and natural resources.

2011 off Tohoku Pacific Earthquake

Fukushima Dai-ichi NPP **(1F)**



Fukushima Dai-ni NPP **(2F)**

- **Occurred 14:46 March 11, 2011**
- **Magnitude:9.0 Mw**
- **Epicenter location: 38° 6’’N and 142° 51’’E, and 24km in depth**
- **It is said that the height of tsunami attacked Fukushima Dai-ichi was more than 14m**

Tsunami after the earthquake

- East coast of northern area in the main island of Japan is seriously damaged
- As of 10th of April, 2015, 15,891 people are dead and 2,579 people are missing

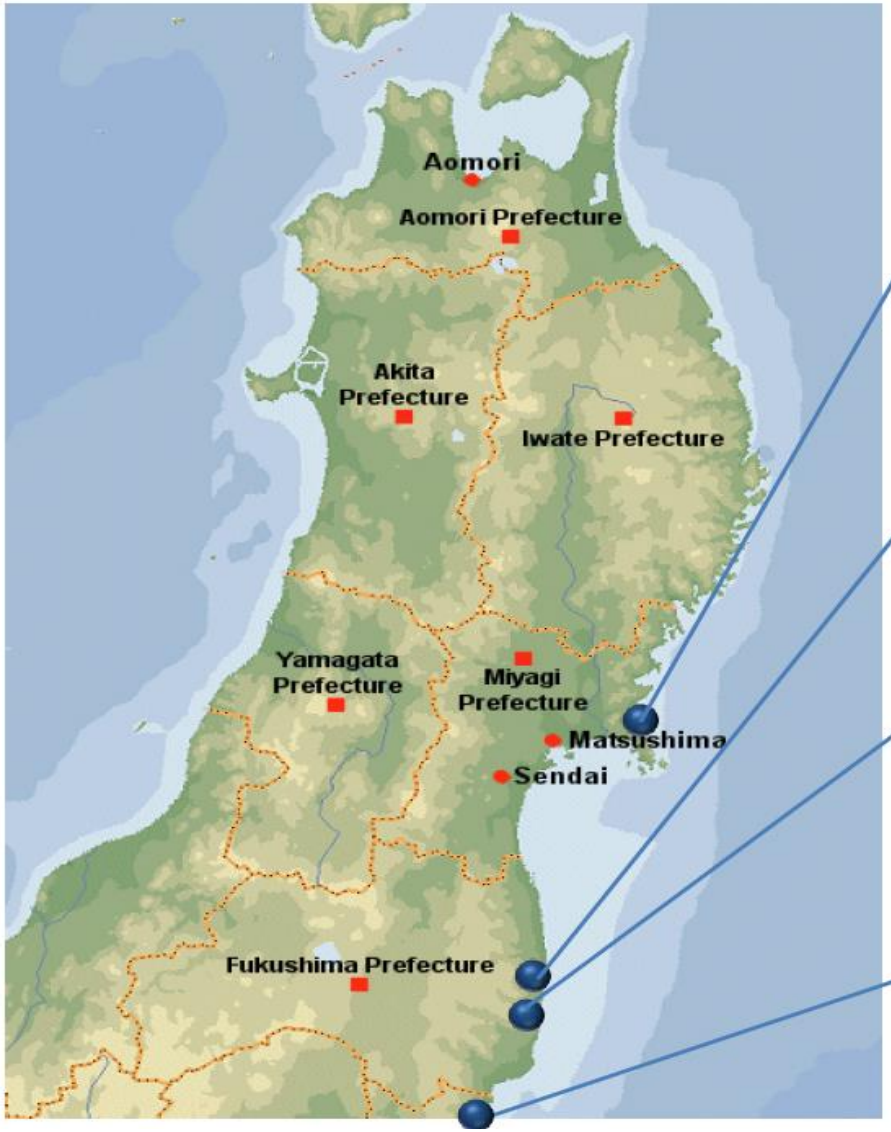
Source: Fire and Disaster Management Agency

The tsunami also led to the worst civil nuclear disaster since the one at Chernobyl in 1986.

The loss of off-site and on-site electrical power and compromised safety systems at the Fukushima Daiichi nuclear power station led to severe core damage to three of the six nuclear reactors on the site; this resulted in the release, over a prolonged period, of very large amounts of radioactive material into the environment.

Nuclear reactors near epicenter of the earthquake

Location of the Nuclear Installations



Onagawa
- Unit1: 524 MW, 1984-
- Unit2: 825 MW, 1995-
- Unit3: 825 MW, 2002-

Fukushima Ⅰ
- Unit1: 460 MW, 1971-
- Unit2: 784 MW, 1974-
- Unit3: 784 MW, 1976-
- Unit4: 784 MW, 1978-
- Unit5: 784 MW, 1978-
- Unit6: 1,100 MW, 1979-

Fukushima Ⅱ
- Unit1: 1,100 MW, 1982-
- Unit2: 1,100 MW, 1984-
- Unit3: 1,100 MW, 1985-
- Unit4: 1,100 MW, 1987-

Tokai Ⅱ (1,100 MW, 1978-)

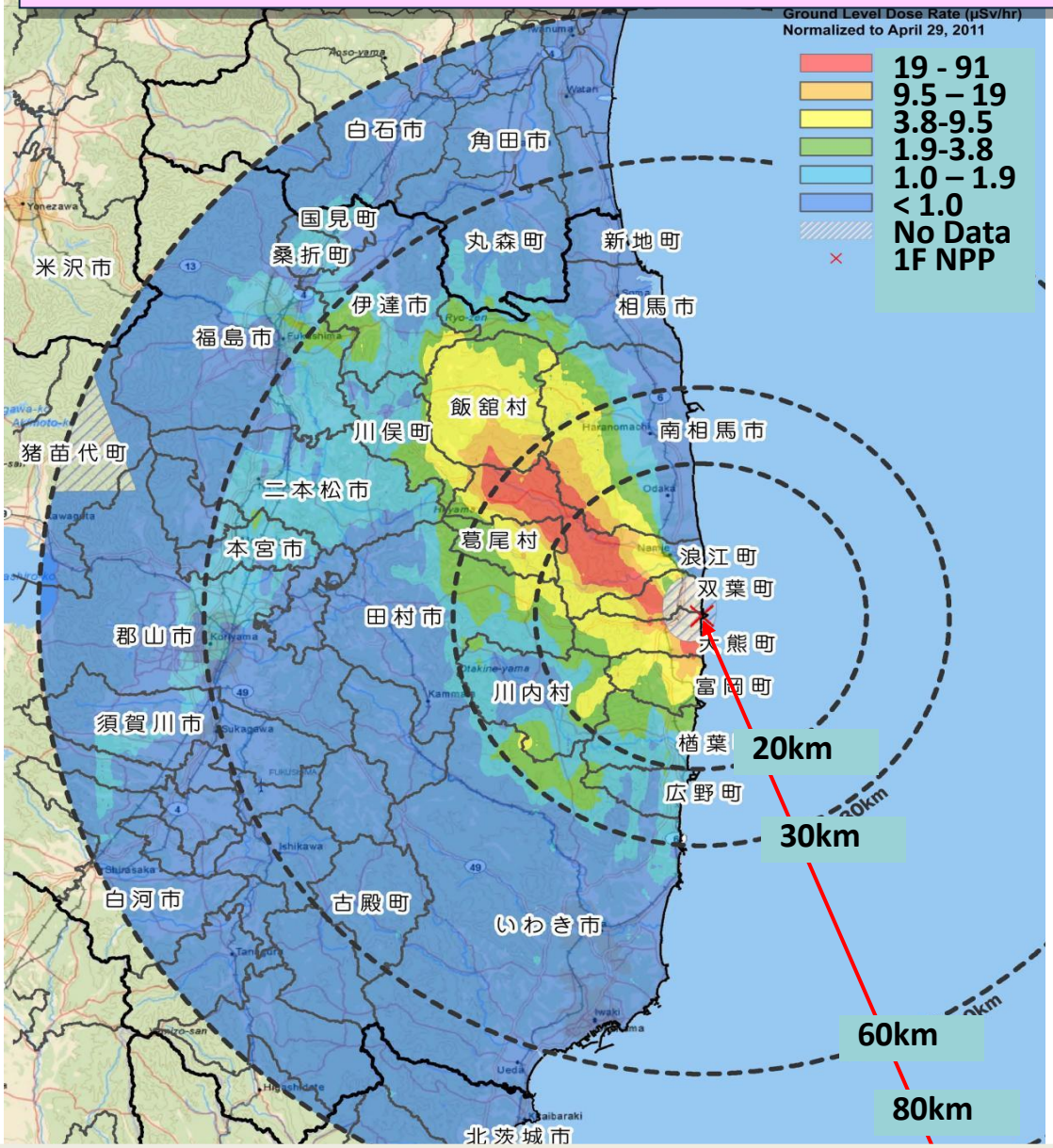
Chronology of Fuel Cooling

SF Pool | Reactor | Power Supply

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5-6	Common SF Pool
March 11, 14:46	**Earthquake**					
	11 Cooling by injecting fresh water				One D/G survived	
12th	12 Start injecting sea water		13 Start injecting sea water			
13th		14 Start injecting sea water				
14th			17 Start watering (sea water, fresh water)	20 Start watering (sea water, fresh water)	20 Reactor cooling shutdown	
17th		20 Start injecting sea water		22 Power Center (P/C) energized from Offsite Power	20～21 Switched from D/G to offsite power	21 Fresh water injection
20th			23 Recover Main Control Room lighting			
21th						
22th						24 Received electricity from offsite
23th	24 Recover Main Control Room lighting					
24th		26 Recover Main Control Room lighting	25 Switch from seawater to fresh water	29 Recover Main Control Room lighting		24 Start cooling by existing system
25th	25 Switch from sea water to fresh water					
26th		26 Switch from sea water to fresh water				
27th			29 Switch from seawater to fresh water	30 Switch from sea water to fresh water		
31st	31 Start watering fresh water	29 Switch from sea water to fresh water				

Source: www.tepco.co.jp

Release of radioactive gas into the Atmosphere

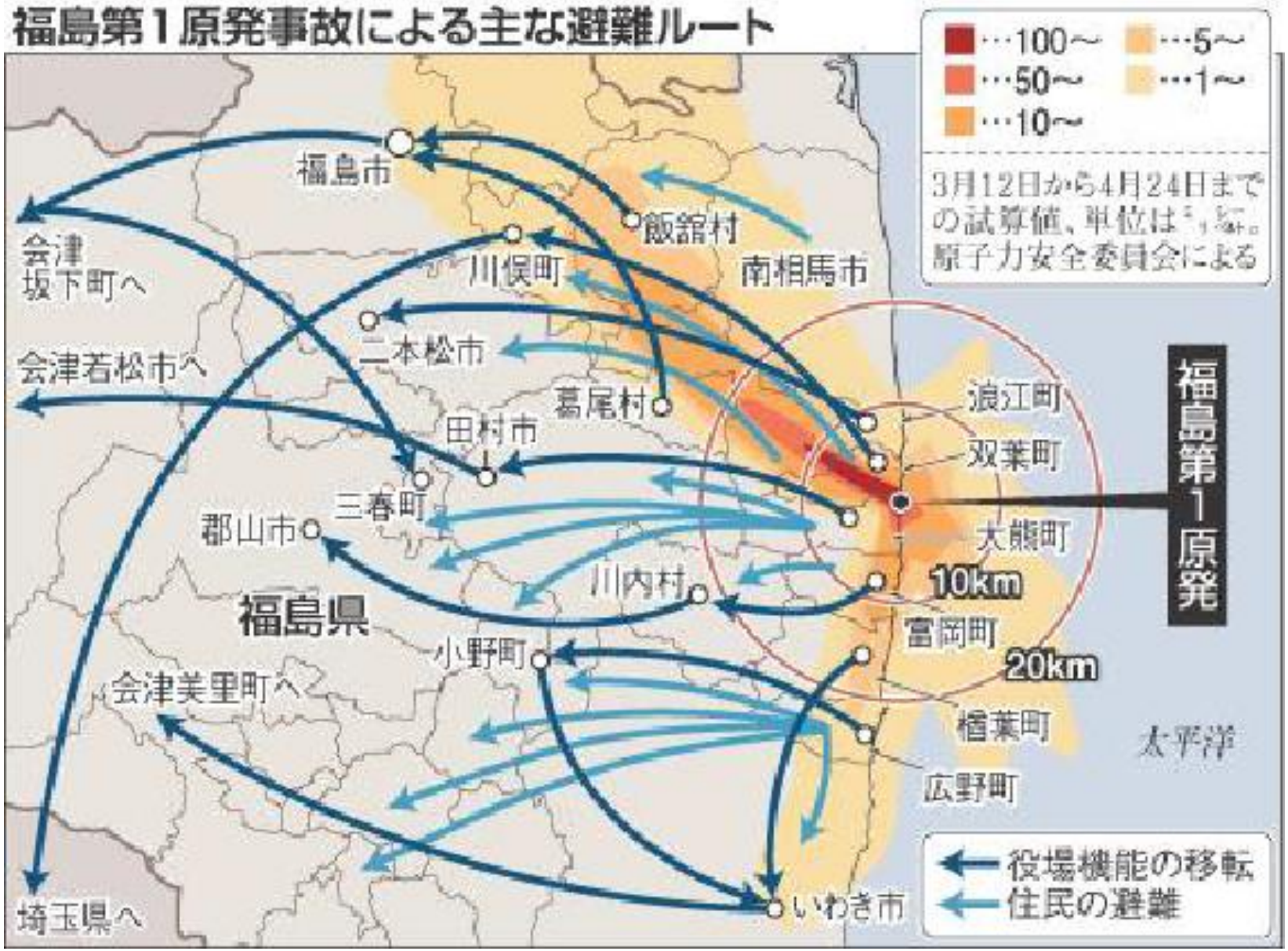


- MEXT and DOE assessed the <u>ambient dose rate on 1m from the ground surface</u> inside the zone of 80 km of 1F was carried out with a aerial monitoring system.
- The map was prepared based on results obtained from April 6th to 29th by a small airplane and two helicopters, in total 42 flights.
- Decay of radioactive substances was considered and actual readings were converted into values as of the last survey date of April 29^{th,} 2011.

Results of ambient dose rate inside the zone of 80km of 1F

Source: MEXT

As an immediate response, the Government of Japan recommended the evacuation of about 78,000 people living within a 20-km radius of the power plant and the sheltering in their own homes of about 62,000 other people living between 20 and 30 km from the plant. Later, in April 2011, the Government recommended the evacuation of about 10,000 more people living farther to the north-west of the plant (referred to as the deliberate evacuation area), because of the high levels of radioactive material on the ground.


福島第1原発事故による主な避難ルート
…100～
…50～
…10～
…5～
…1～
3月12日から4月24日までの試算値、単位はミリシーベルト。原子力安全委員会による
福島市
飯舘村
南相馬市
川俣町
会津坂下町へ
二本松市
会津若松市へ
葛尾村
浪江町
双葉町
田村市
三春町
大熊町
郡山市
10km
川内村
福島県
富岡町
小野町
20km
会津美里町へ
楢葉町
太平洋
広野町
福島第1原発
役場機能の移転
住民の避難
いわき市
埼玉県へ

The evacuations greatly reduced (by up to a factor of 10) the levels of exposure that would otherwise have been received by those living in those areas. However, the evacuations themselves also had repercussions for the people involved, including a number of evacuation-related deaths and the subsequent impact on mental and social well-being (for example, because evacuees were separated from their homes and familiar surroundings, and many lost their livelihoods).

The information reviewed by the UNSCEAR suggests that, as the interim values, the atmospheric releases of iodine-131 and caesium-137 (two of the more significant radionuclides from the perspective of exposures to people and the environment) in the ranges of 100 to 500 petabecquerels (PBq) and 6 to 20 PBq, respectively.

These estimates are lower, by a factor of about 10 and 5, respectively, than corresponding estimates of atmospheric releases resulting from the Chernobyl accident.

Winds transported a large portion of the atmospheric releases to the Pacific Ocean.

In addition, liquid releases were discharged directly into the surrounding sea. The direct discharges amounted to perhaps 10 and 50 per cent of the corresponding atmospheric discharges for iodine-131 and caesium-137, respectively; low-level releases into the ocean is still ongoing in April 2015.

B. Consequences of the accident

After the accident, several international organizations made struggle to draw up the report of the accident from their own perspectives. At the head, WHO had published the report on the preliminary dose estimation at May, 2012. This report was intended to provide the

consequences of the accident promptly to the

public of the member countries of the WHO.

In this report, doses of the public was estimated by the model calculation based on the expected exposure scenario because the sufficient information was not available at this time. Worker doses were not estimated because it wasn't the aim.

Further more, WHO published the report on the health risk assessment at Feb. 2013. In this report, doses of the TEPCO workers were estimated at the first time based on the exposure scenario. Then, in this report, the health risk of the public and the TEPCO workers were projected based on the estimated doses.

On April 2014, UNSCEAR published its 2013 Report of the Fukushima accident. In this report, the dose estimates for the public was conducted based on the exposure scenario. However, the exposure doses of the TEPCO workers had been discussed based on the data provided by the Japanese authority.

Following these reports, IAEA is now preparing its own report.

All these reports of the three international organizations are based on the scientific findings those slowly became more obvious after the accident.

B-1.
Overview of the Fukushima Health Management Survey

The Health Management Survey for the Residents in Fukushima Prefecture will be separated to "the Basic Survey" and "the Detailed Survey" to be implemented.

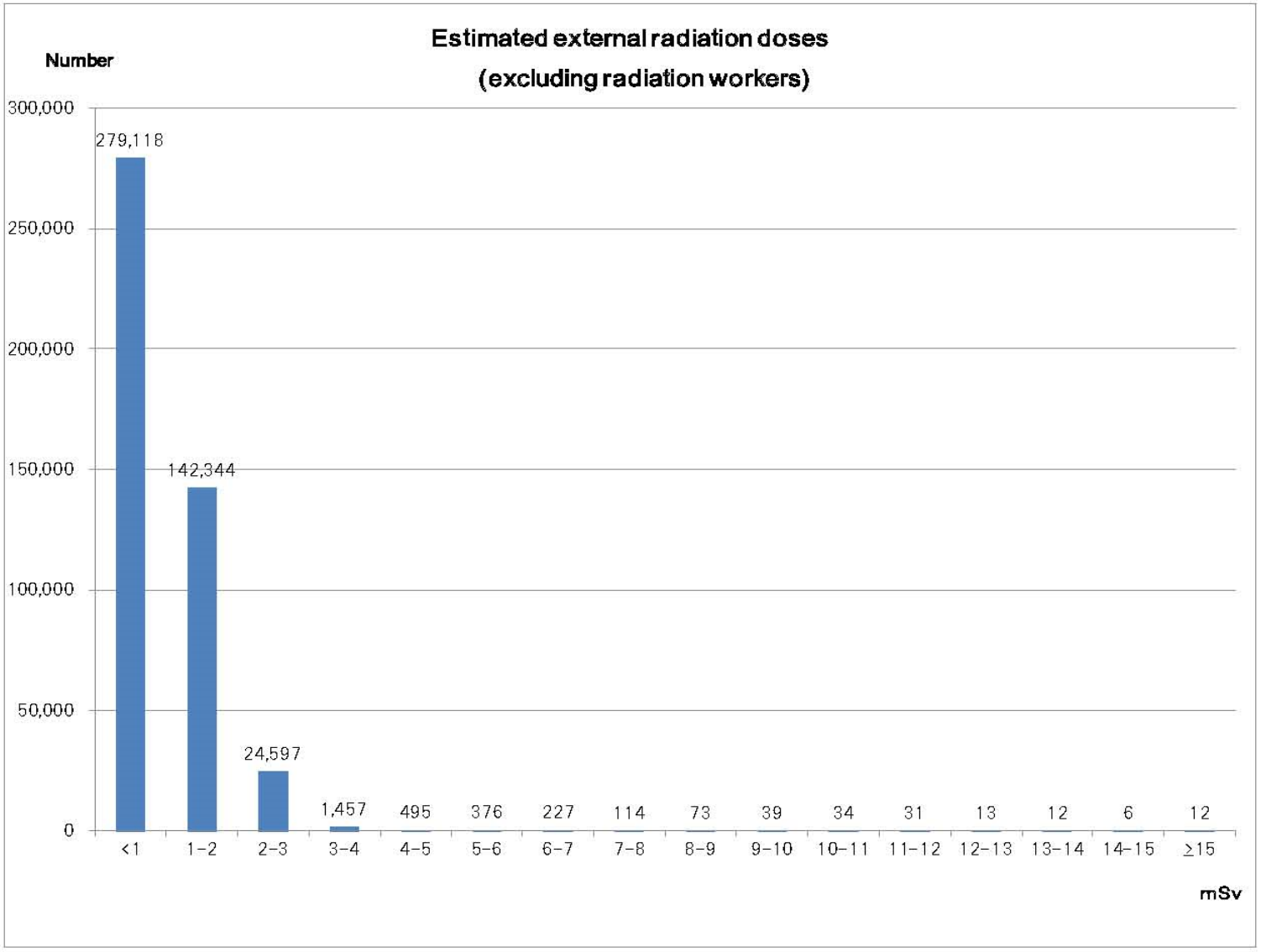
"The Basic Survey" is to estimate exposure dose through filling in action recorded by the residents after 11 March, and "the Detailed Survey" is to examine the health conditions of the residents in the prefecture and to manage their health into the future.

Basic Survey

The Basic Survey is a questionnaire targeting roughly 2,050,000 residents and visitors to Fukushima Prefecture as of 11 March 2011.

Estimated external radiation doses were calculated based on recorded movements of respondents in the four months following the nuclear accident.

Basic Survey, Fukushima Health Management Survey
(External doses from accident to July 2011)



Result of the Basic Survey as of Dec.31 2014.

Cumulative Effective External dose of persons in Fukushima prefecture from accident to July 2011, for 4 months were caluculated from evacuation movement patterns.

Radiation doses for a total of 457,859 residents have been estimated to Dec. 31, 2014. The results for 448,948 respondents (excluding radiation workers) suggest that the doses for 94% of the respondents were less than 2 mSv.

Individual Dosimeter Survey, Fukushima City
(External doses from November 2012 to January 2013)

個人線量計（ガラスバッジ）測定結果

Dose (mSv)	Person	割合（%）
0.1未満	2,888	17.802
0.1以上0.5未満	13,127	80.916
0.5以上1.0未満	203	1.251
1.0以上1.5未満	2	0.012
1.5以上2.0未満	2	0.012
2.0以上2.5未満	1	0.006
合計（3ヶ月間測定者数）	16,223	100.000

More than 99% of the residents were less than 2 mSv/year

Detailed Surveys

- Thyroid Ultrasound Examination
- Comprehensive Health Check
- Mental Health and Lifestyle Survey
- Pregnancy and Birth Survey

Thyroid Ultrasound Examination

The examination covers roughly 360,000 residents aged 0 to 18 years at the time of the nuclear accident.

The initial screening is to be performed within the first three years after the accident, followed by complete thyroid examinations from 2014 onwards, and the residents will be monitored regularly thereafter.

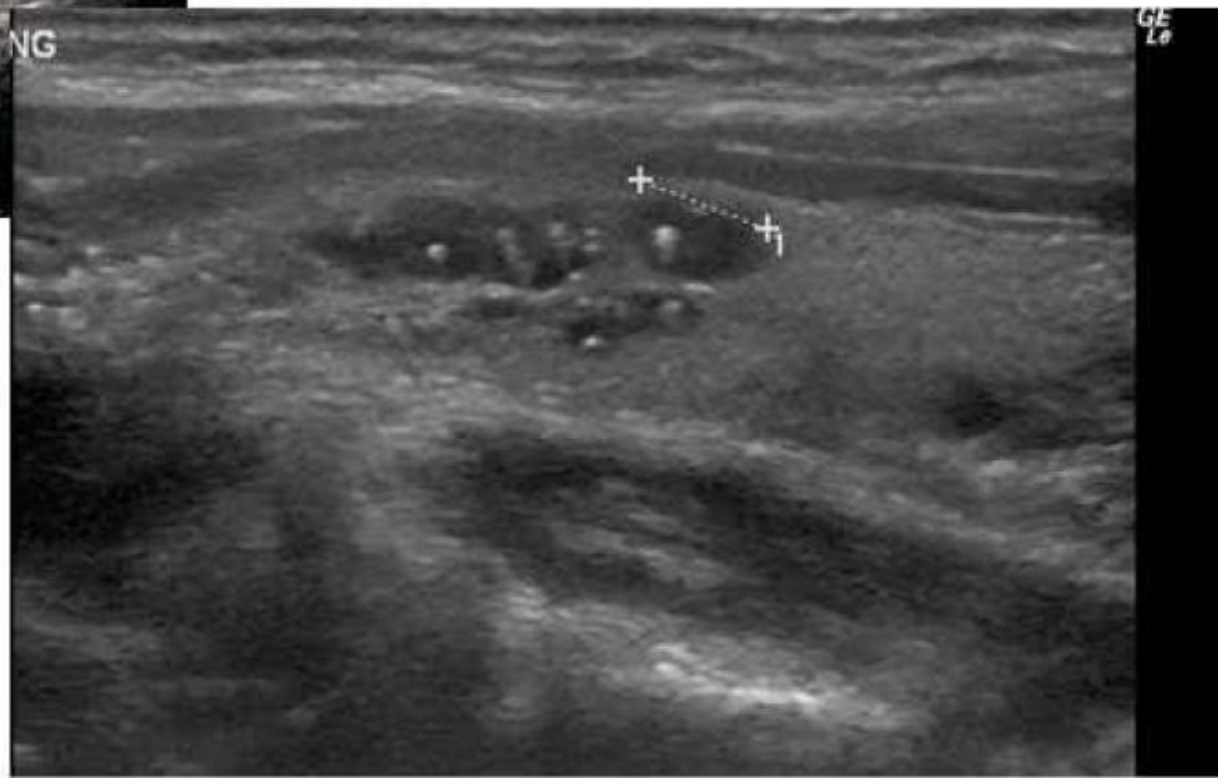
Thyroid Ultrasound Examination for Children
Basic Survey, Fukushima Health Management Survey

Start on October 9, 2011

Nodule and Cyst in Thyroid Gland

Nodule

Cysts



Result of Thyroid Ultrasound

The screening has detected asymptomatic 87 thyroid abnormalities that would have gone undetected if asymptomatic children had been screened using standard equipment. However, similar results were obtained when the same screening was carried out on children living in the non-areas affected by the accident in Japan. the thyroid abnormalities detected in the survey are unlikely to be associated with radiation exposure due to the accident.

Comprehensive Health Check

The program aims at early detection and treatment of diseases as well as prevention of lifestyle-related diseases. Its main target includes 210,000 former residents of evacuation zones whose lifestyle changed drastically after the accident.

Additional tests such as differential leukocyte count are performed apart from the routine tests included in the general medical check-up at the workplace or by the local government.

Results of Comprehensive Health Check

Comparing the FY 2013 survey with 2011, most children of target municipalities including nationally designated evacuation zones tend to be taller and weigh less possibly due to better lifestyle.

Compared it with the national median, most children were taller and weigh more, and the older children are, greater gap especially in weight. (Girls aged 15 years were taller and weighed less).

B-2.
Emergency workers

According to the records provided by TEPCO, the average effective dose of the 25,000 workers over the first 19 months after the accident was about 12 mSv. About 35 per cent of the workforce received total doses of more than 10 mSv over that period, while 0.7 per cent of the workforce received doses of more than 100 mSv.

The UNSCEAR examined the data on internal exposure for 12 of the most exposed workers and confirmed that they had received absorbed doses to the thyroid in the range of 2 to 12 Gy, mostly from inhalation of iodine-131. The Committee also found reasonable agreement between its independent assessments of effective dose from internal exposure and those reported by TEPCO for those workers for whom there were measurable levels of iodine-131 in the body.

However, there are many other problems.

1) No account was taken of the potential contribution from intakes of shorter-lived isotopes of iodine, in particular iodine-133; as a result, the assessed doses from internal exposure could have been underestimated by about 20 percent. For many workers, because of the long delay before monitoring, iodine-131 was not detected in their thyroids; for those workers the internal doses estimated by TEPCO and its contractors are uncertain. UNSCEAR 2013 Report is using this estimates.

2) Still the estimated doses are not concrete.

a) The results of the preliminary dose estimation by TEPCO was provided to UNSCEAR on early 2012.

b) However, first re-estimation was conducted in July 2013 to reflect the information of Whole body counting which the contractor company carried out at the early satge of the accident for their worker but TEPCO did n't know about.

c) Second re-estimation was conducted in March 2014.

Long-term Health Care for Emergency Workers at the TEPCO Daiichi NPP

References

① Because the radiation exposure dose limit has been tentatively raised to 250mSv, long-term health care for emergency workers (approximately 20,000 workers) will be provided according to the guidelines (11 October 2011)

1 Development of a database

- Personal identification (name, affiliation, address, etc.)
- Exposure dose, job descriptions
- Results of medical examinations, etc.
- Health consultation/guidance, etc.
- Others (lifestyle, etc.)

Submission (Managed by the database)

MHLW

- Operation/management of the database
- Administration of health consultation/guidance
- Response to data inquiry

2 Health care control items

Medical examinations commensurate to the levels of radiation exposure dose will be provided with the development of a database *1

Specific medical examination items

- **For all emergency workers**
  - Statutory medical examinations (general and ionizing radiation medical examinations)
  - Health consultation/guidance including mental health.
- **For emergency workers with doses exceeding** 50mSv (*2)
  - Examinations for cataract, in addition to the aforementioned examinations.
- **For emergency workers with doses exceeding** 100mSv (*2)
  - Thyroid examinations, cancer screenings (stomach, lung, colon) in addition to the aforementioned examinations.

Issue a passbook upon application (radiation exposure dose, certificate for medical examination, etc.)

Issue a database registration card (Certificate for the inquiry of the data)

*1 In principle, the medical examination cost shall be paid by employees. However, the national government shall cover the cost if the workers whose doses exceed 50mSv are (a) not engaged in radiation work after changing their job, (b) engaged in non-radiation work though still employed by the same employer (small and medium sized employer only) as that when they had been engaged in the emergency work, (c)currently unemployed.

*2 Effective radiation doses received while engaged in the emergency work.

② Workers excluding emergency workers (The most are engaged in work after 16 December 2011)

- Medical examinations pursuant to the Act and the Ordinances (general and ionizing radiation medical examination, etc.)
- Health consultation and health guidance pursuant to the Act and the Ordinances

Emergency to Recovery & Beyond

- More and more issues, one after another-

- Decontamination
- Radioactive waste
- Radioactivity control in food
- Returning home
- Revitalizing communities
- ・・・・・

Thank you for your attention.

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