Implementing optimisation in post-accident situation: Some lessons from Fukushima

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Introduction

- **Optimisation** is one of the fundamental principles of radiological protection system by the ICRP.
- The concepts of **reference level** are used in the process of optimisation of protection to assist in ensuring that all exposures are kept as low as reasonably achievable, societal and economic factors being taken into account.
- The Fukushima Daiichi Nuclear Power Plant accident is the first experience using those for decision-making on protective actions after a nuclear accident.

➡ To get insights on **the choice and update of the reference level** in post accident situation;

- Reviewing of the evolution of numerical criteria which were used for making decisions on protective actions after the Fukushima accident.
- Analyzing the data on confusions which were caused by the use of the reference level and other numerical criteria.

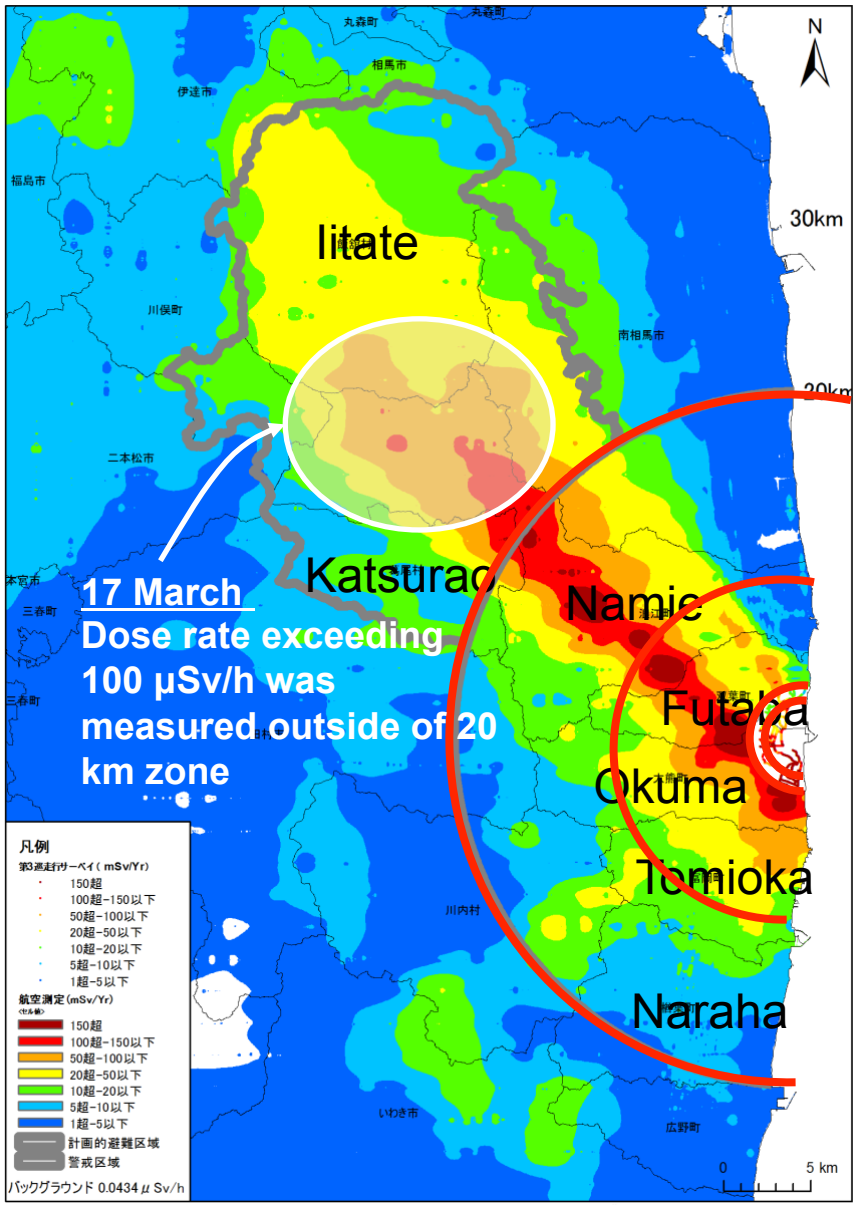
Off-site protective actions in the Fukushima accident

Time	Evacuation	Other actions (Sheltering, ITB, Restriction on foods, etc.)
11 March	20:50 **2 km** radius of the NPP 21:23 **3 km** radius	Sheltering: within 3–10 km radius of the NPP
12 March	05:44 **10 km** radius of the NPP 18:25 **20 km** radius of the NPP	Monitoring: 13000 cpm was used for evacuees
14 March		Monitoring: Criterion changed from 13000 cpm to 100000 cpm
16 March		Advice on implementing ITB
19 March		Food restriction: Activity in leafy vegetables and milk exceeding criteria to restrict food
21 March		Restrictions on certain foods
25 March	Voluntary evacuation within 20–30 km radius recommended (by whom?)	
11 April	**20 mSv/y** criterion established to determine areas beyond 20 km evacuation area that will relocate	
19 April		Re-opening of schools: **20 mSv/y** criterion established to determined which schools will re-open (subsequently became lower to 1mSv/y)

This table was made based on following references:

NAIIC, 2012 The official report of the Fukushima Nuclear Accident Independent Investigations Commission (NAIIC, 2012);
Callen and Homma, 2017, Health Phys. 112(6): 550–559;2017.

Evacuation



Earthquake (11 March 14:46)

11 March 20:50 **2km** radius from **the past experience** of emergency preparedness drill

11 March 21:23 **3km** radius from **the past experience** and **International Standards** (PAZ).

Delay of vent

12 March 05:44 **10km** radius from **Emergency Planning Zone** (EPZ).

Hydrogen explosion in the Unit 1

12 March 18:25 **20km** radius from **some people's subjective opinions**.

A lot of times spent for:
- coordinating contradictory opinions between related organization.
- discussing the criteria to determine the new evacuation zone

19 April 20 mSv/y was applied for judging whether use of school grounds

22 April Deliberate Evacuation Area was designated based on **20 mSv/y**.

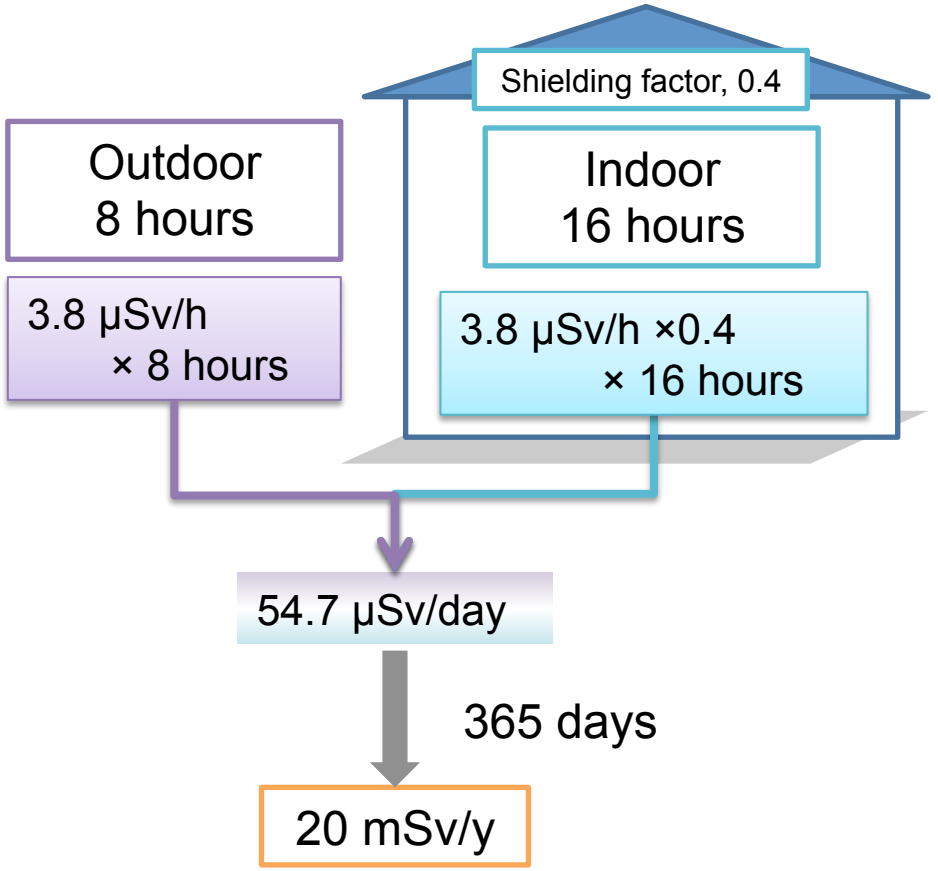
Consideration on the deliberate evacuation zone

- **Contradictory opinions between related organizations**
  - Fukushima Prefecture (21 March)
    - ✓ “establishing evacuation zones would make **residents anxious**”
    - ✓ “changing the zones of evacuation orders was assumed to cause **confusion among residents**”
  - Iitate village (27 March)
    - ✓ Mayor of Iitate village also commented that expanding the evacuation zones would make residents wary, which would not be favorable.

- **Discussion on the criteria to determine the new evacuation zone**
  - The National authority considered the reference levels should be adopted as criteria for the new evacuation zone.
    - ✓ How to choice the criteria from the dose band between 20 mSv/y and 100 mSv/y.
    - ✓ Decision makers considered on the premise that the previous dose criteria for evacution is 50 mSv and this level is equivalent to 25 mSv/y.

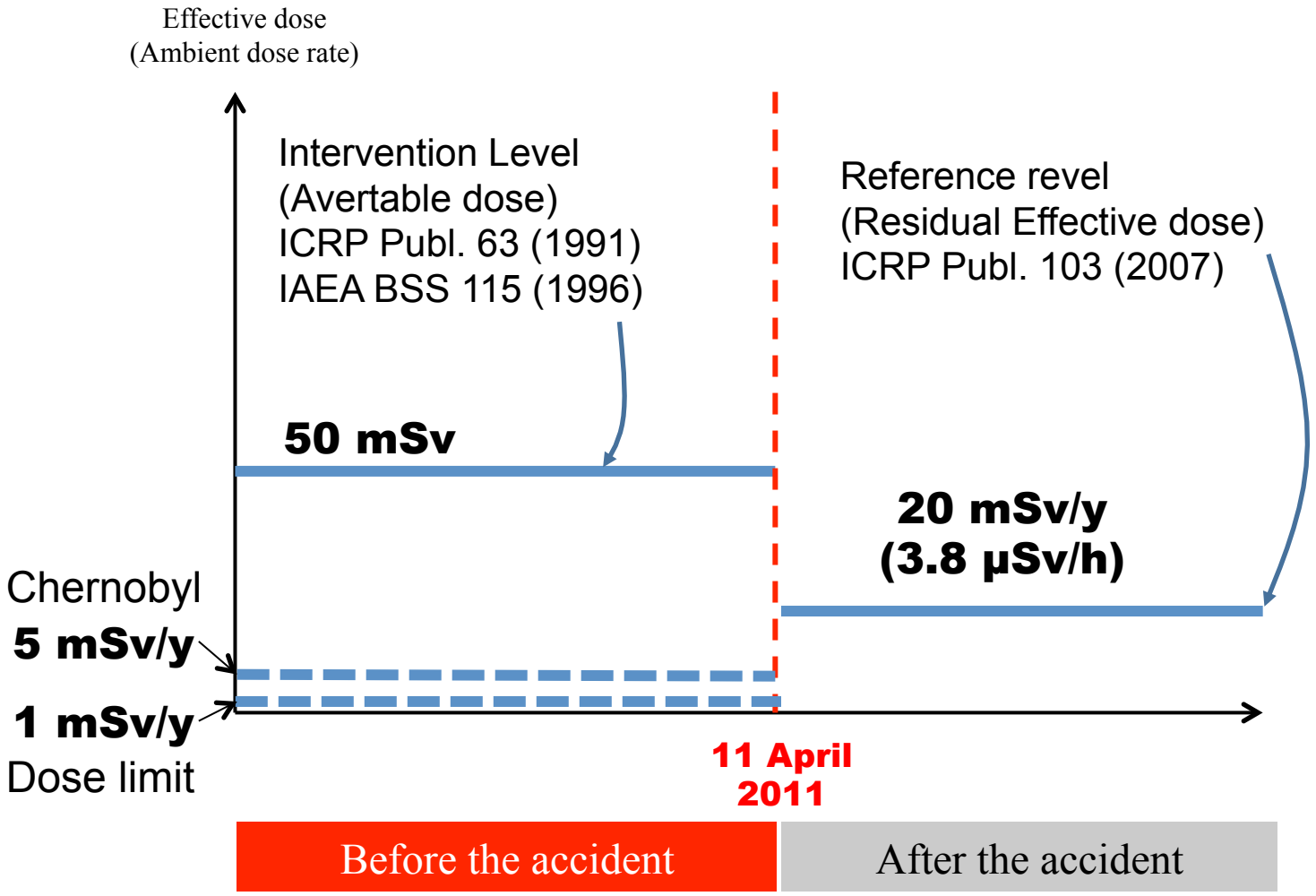
Calculation scheme of 3.8 μSv/h

- Effective dose cannot be measured directly.
- This scheme has some problems:
  - (1) Dose conversion (effective dose or ambient equivalent dose)
  - (2) Exposure pathway (only external exposure)
  - (3) Time-dependence of dose did not take into account (physical decay, weathering)
  - (4) Differences due to inter-individual variability.



The ambient dose rate of 3.8 μSv/h measured at outdoor is equivalent to 20 mSv/y

Dose criteria for evacuation in Japan



Reopening of schools

Ministry of Education, Culture, Sports, Science and Technology (MEXT)

6–8 April

■ **Schools should be reopened?**

- Haw about the safety of reopening schools?
- How to determine the contaminated area

9 April

■ **School buildings and ground can be used?**

- How about the use of **20 mSv/y** for judging availability of school buildings and ground?

14 April

- Internal exposure can be negligible.

19 April

- Finally, MEXT decided to use **3.8 μSv/h**, which is equivalent to **20 mSv/y**, for restricting the outdoor activities at the schools.

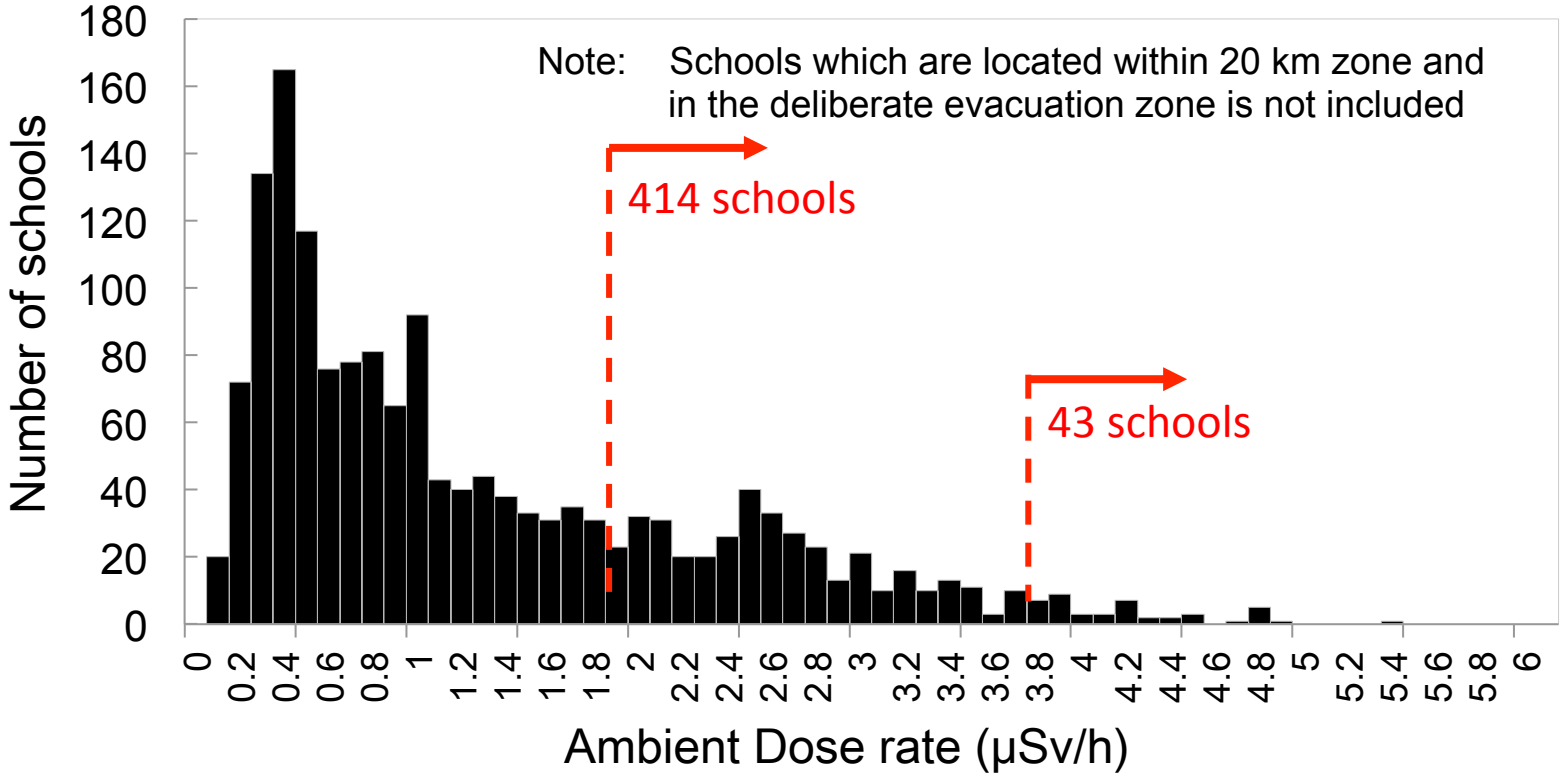
Nuclear Safety Commission (NSC)

- MEXT have to establish benchmark for judgment by themselves.
- As reference, the dose limit for the public was **1mSv/y.**

- The 20mSv/year benchmark should be used on a limited basis;
- Even if this value is adopted, the doses from **external and internal exposures should be considered**.

Radiation situation and MEXT's attitude

- MEXT confirmed the number of schools whose dose rate are exceeding 3.8 μSv/h (as of 8 April, 2011).
- MEXT thought that if the selected dose criteria is below 20 mS/y, many schools are not respecting this criteria (COGJ, 2011).



COGJ, 2011: Hearing record on Investigation Committee on the Accident the Fukushima Nuclear Power Stations of Tokyo Electric Power Company (http://www.cas.go.jp/jp/seisaku/icanps/eng/)

Criticism against the dose criteria of Reopening of schools

- Parents in Fukushima
- Japan Federation of Bar Associations
- Japan Medical Association

- Comparison with the other standards
  - 1 mSv/y is used for dose limit
- Doubts remain about the extent to which MEXT considered the health and safety of children.
- Schooling provided under prohibits and restricts can ensure children a proper learning experience.
- Scientific and other basis for this dose criteria was not clear.

- MEXT aimed to keep the dose that children and students receive at schools **1mSv/y**
- MEXT decided
  (i) To distribute dosimeters to all schools in Fukushima Prefecture
  (ii) To offer financial support for schools whose the dose rate was more than 1μSv/h, in order to help the costs of decontamination.

Lessons learned

- **Reasonableness of dose criteria**
  - Reference level vs Operational quantity
  - Comparison with the past experience and other standards
  - Comparison with the criteria for other protective actions
- **To Clarify the scientific and other basis for dose criteria, and the aim of dose criteria**
  - How to derive the numerical criteria and the validity of the data which used for the calculations.
  - What is the target to achieve using the selected criteria.
- **To clarify the role and responsibility for the choice and update of dose criteria**

Thank you for your attention!

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