Town of Miharu's Response to Fukushima: An Application of Dosimetry

UNIVERSITY *of* WASHINGTON

OUTLINE

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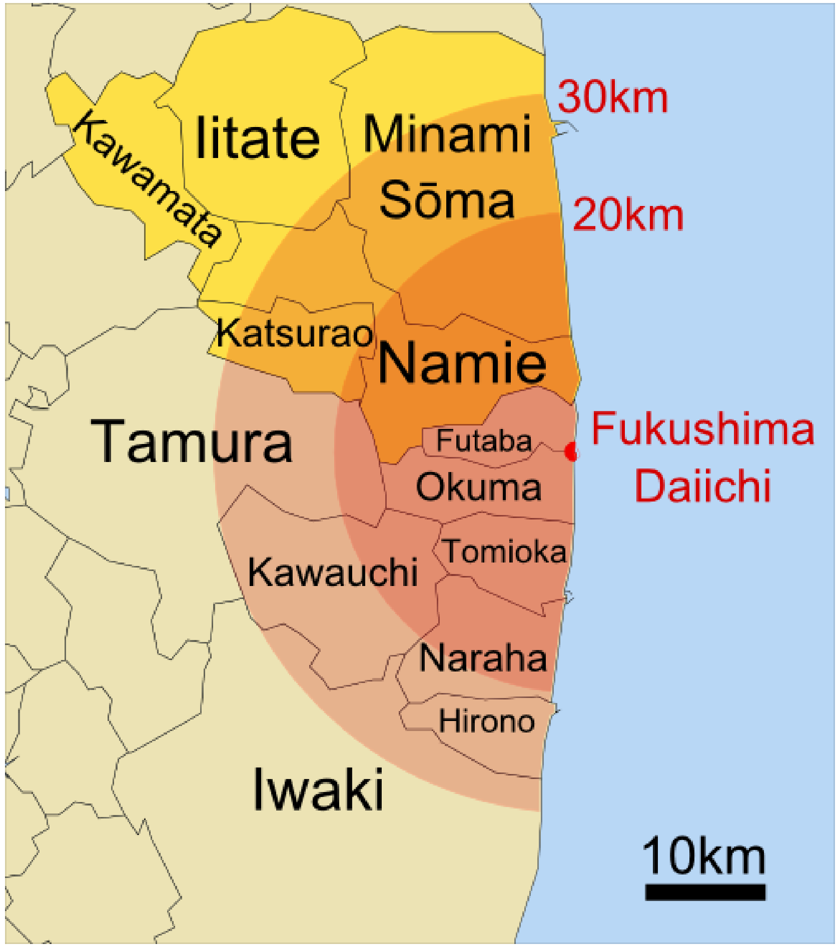
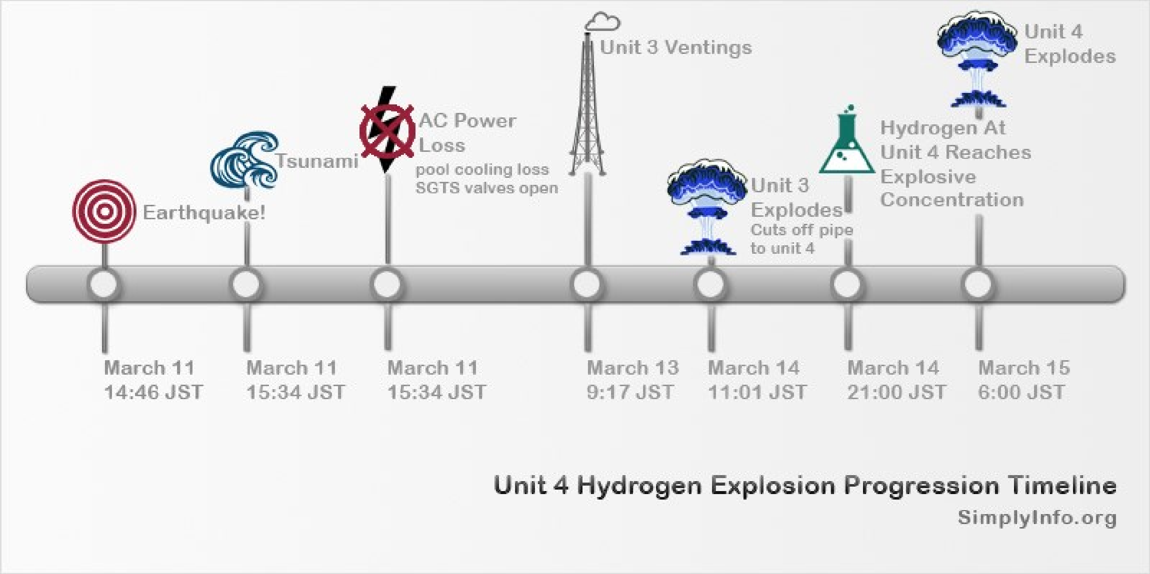
Fukushima Disaster



- A tsunami as a result of a 9.0 earthquake disabled the power supply and cooling of three Fukushima Daiichi reactors,
- Accident on March 11, 2011; three cores largely melted in the first three days.
- After two weeks, the three reactors (units 1-3) were stable with water addition
- No deaths or cases of radiation sickness from the nuclear accident
- Over 100,000 people were evacuated with a resulting 1000 deaths from this activity

Timeline of Events



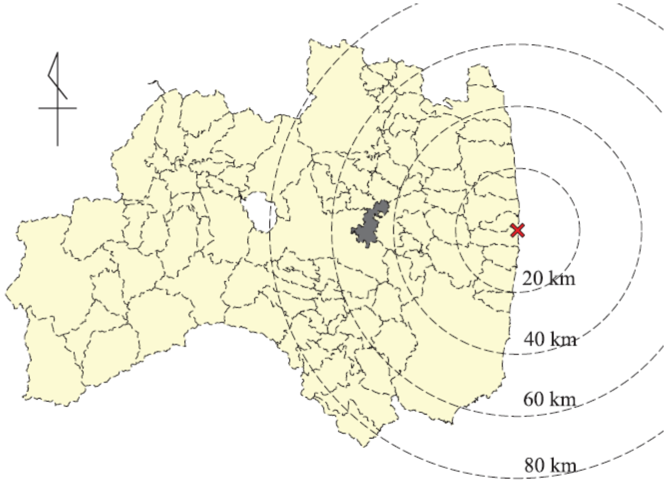
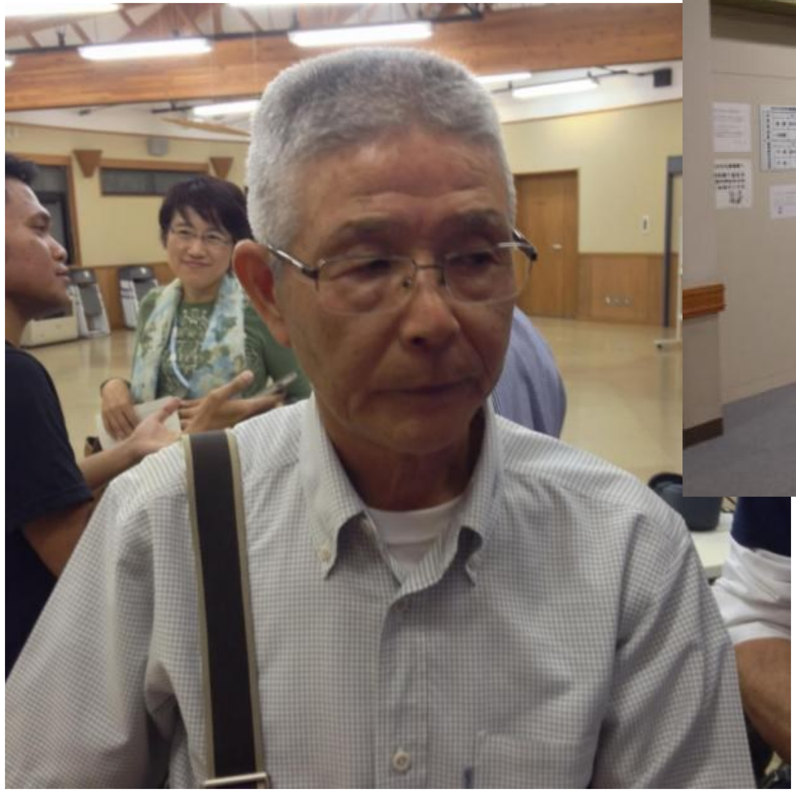
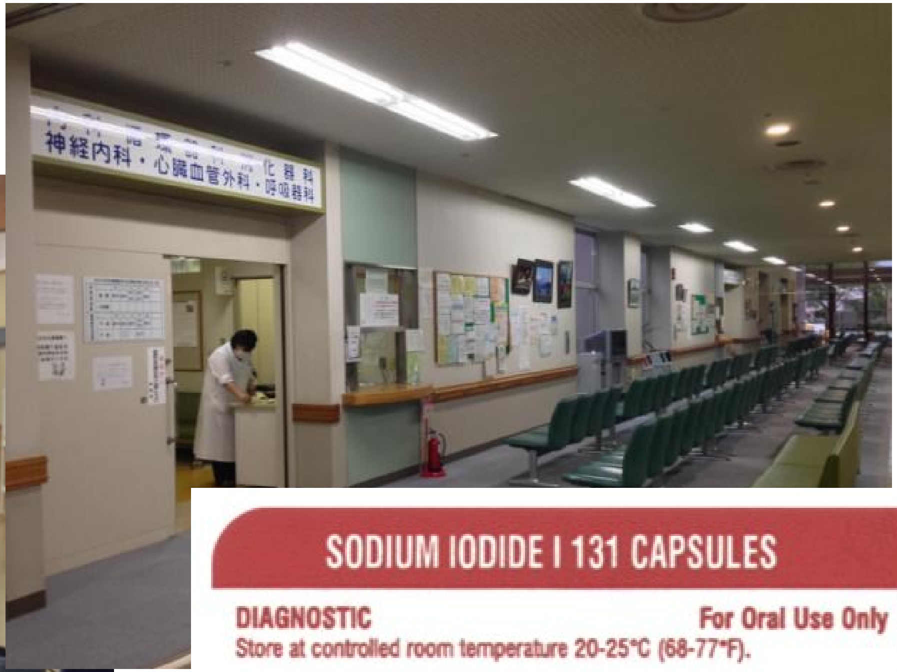


Figure 1. Map of Fukushima Prefecture. Miharu town is coloured black. The location of FDNPP is marked X. Miharu is located ≈45 km west of FDNPP.

- Miharu is only 45KM from FDNPP
- By March 15 concerns about radiation reached town
- Government only commented on evacuation
- Mayor and Townspeople decided that “Civil Disobedience” was the choice

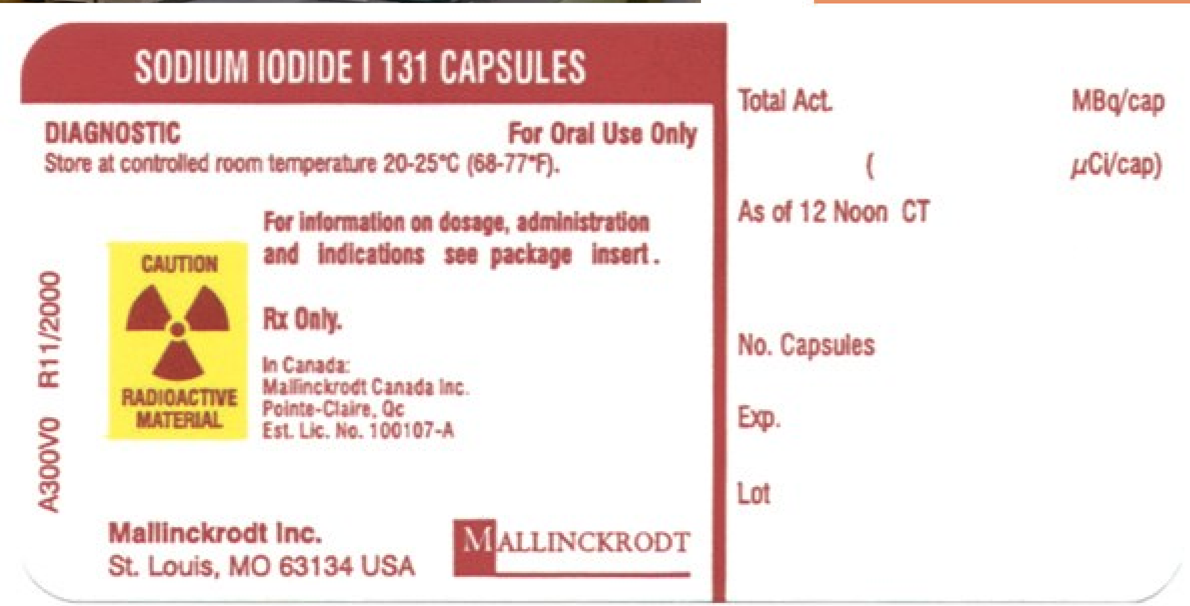
Town’s Response





SODIUM IODIDE

NaI



Radionuclide Impact on Human Biology

Key considerations is the difference between an accumulated dose vs. an ingested dose. An iodide prophylaxis is proven to be effective in blocking accumulation of radioactive iodine in the thyroid.

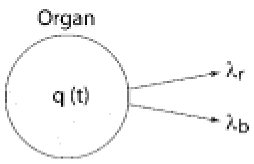


Fig. 9-1 Radionuclide consisting of N atoms with activity $q(t) = \lambda N$ is assumed to be distributed uniformly in an organ mass from which radioactive atoms are cleared by both radioactive transformation (λ_r) and biological removal (λ_b).

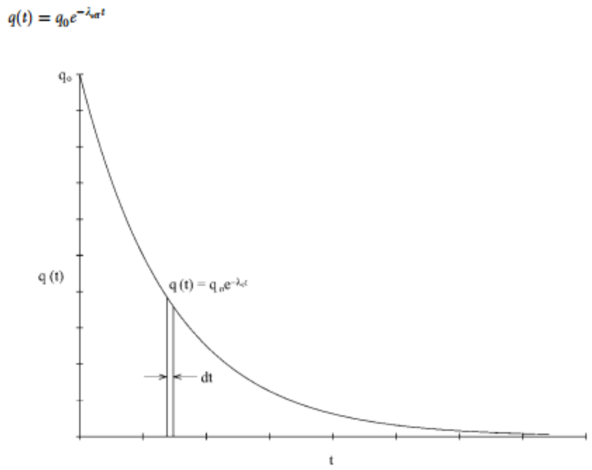


Fig. 9-2 Variation of the instantaneous dose rate with time after deposition in a tissue from which it is removed by radioactive transformation and biological processes, or with an effective removal constant $\lambda_{eff} = \lambda_r + \lambda_b$.

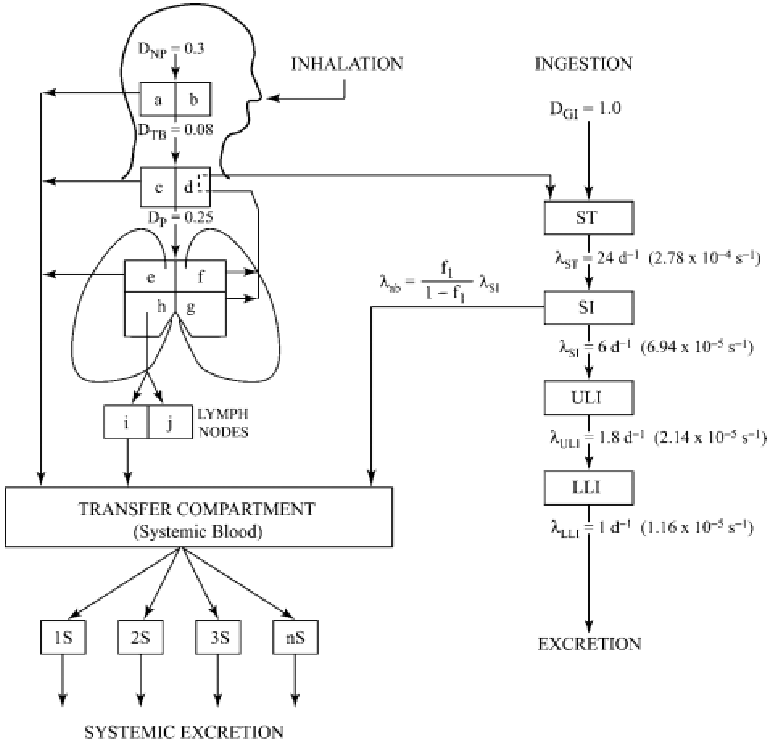


Fig. 9-4 Deposition and clearance routes of inhaled and ingested materials according to ICRP 30 schema.

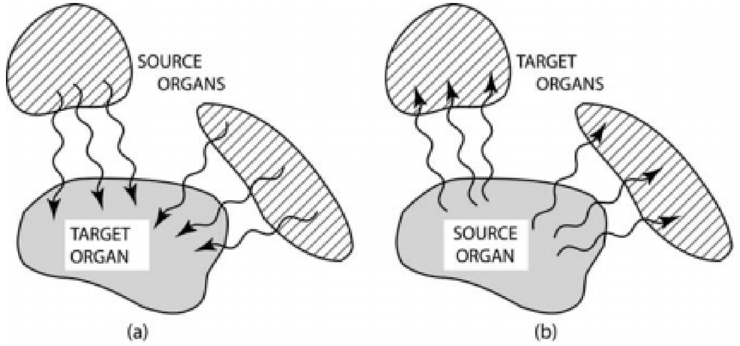


Fig. 9-3 A radionuclide may be deposited such that (a) more than one source organ produces absorption of energy in a target tissue, or (b) a source organ can produce energy absorption in more than one target tissue.

Radionuclide as the Solution

The side effects from the Na-I or lower than the effect of radiation in people under 40.

Table 1. Reference levels for different population groups for consideration in planning stable iodine prophylaxis[a]

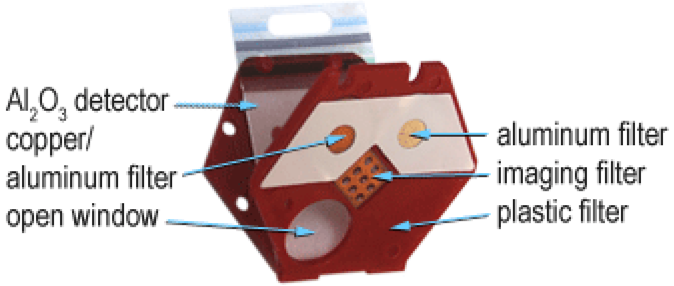
Population group	Exposure pathways to be considered	Reference levels
Neonates, infants, children, adolescents to 18 years and pregnant and lactating women	Inhalation (and ingestion[b])	10 mGy[c] avertable dose to the thyroid
Adults under 40	Inhalation	100 mGy[c] avertable dose to the thyroid
Adults over 40 years	Inhalation	5 Gy[d] projected dose to the thyroid

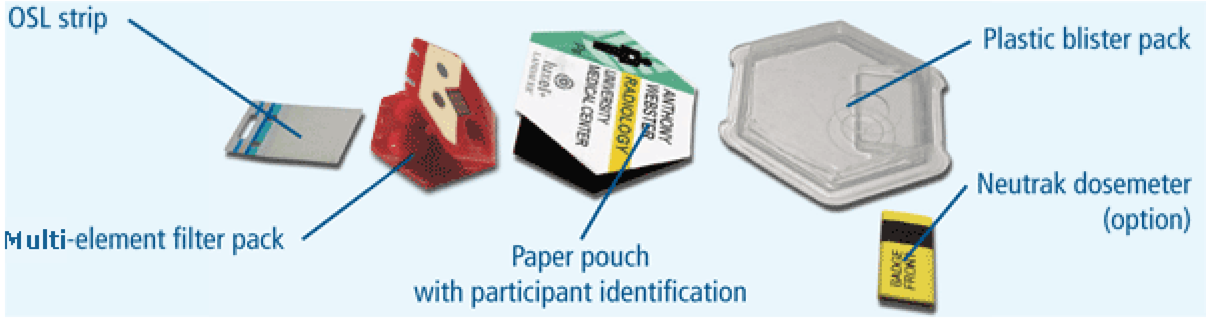
Notes
[a]These idealized levels do not take into account the practicalities involved in planning to respond to an accident involving many radionuclides in unknown quantities in real time. For this reason, a generic intervention level of 100 mGy has been specified in the Basic Safety Standards. Nevertheless, this does not preclude the need to consider the practicality of planning to implement iodine prophylaxis for specific age groups.
[b]Ingestion of milk by infants where alternative supplies cannot be made available.
[c]Adherence to these values would ensure that doses for all age groups would be well below the threshold for deterministic effects.
[d]Intervention for this group is undertaken to ensure prevention of deterministic effects in the thyroid. 5Gy is the recommended limit for deterministic effects given in the Basic Safety Standards.

Table 2. Recommended single dosage of stable iodine according to age group

Age group	Mass of iodine mg	Mass of KI mg	Mass of KIO_3 mg	Fraction of 100 mg tablet
Adults and adolescents (over 12 years)	100	130	170	1
Children (3–12 years)	50	65	85	1/2
Infants (1 month to 3 years)	25	32	42	1/4
Neonates (birth to 1 month)	12.5	16	21	1/8

Optically Stimulated Luminescence

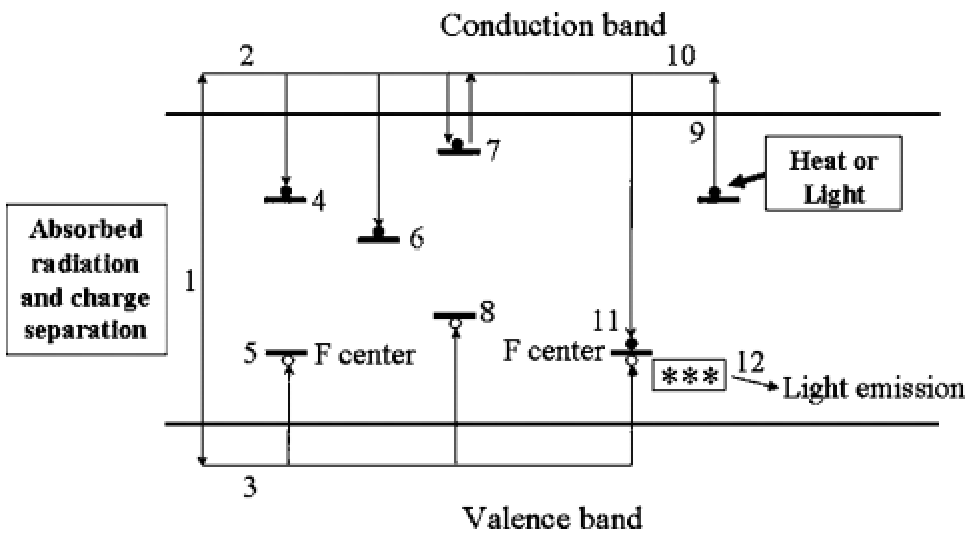


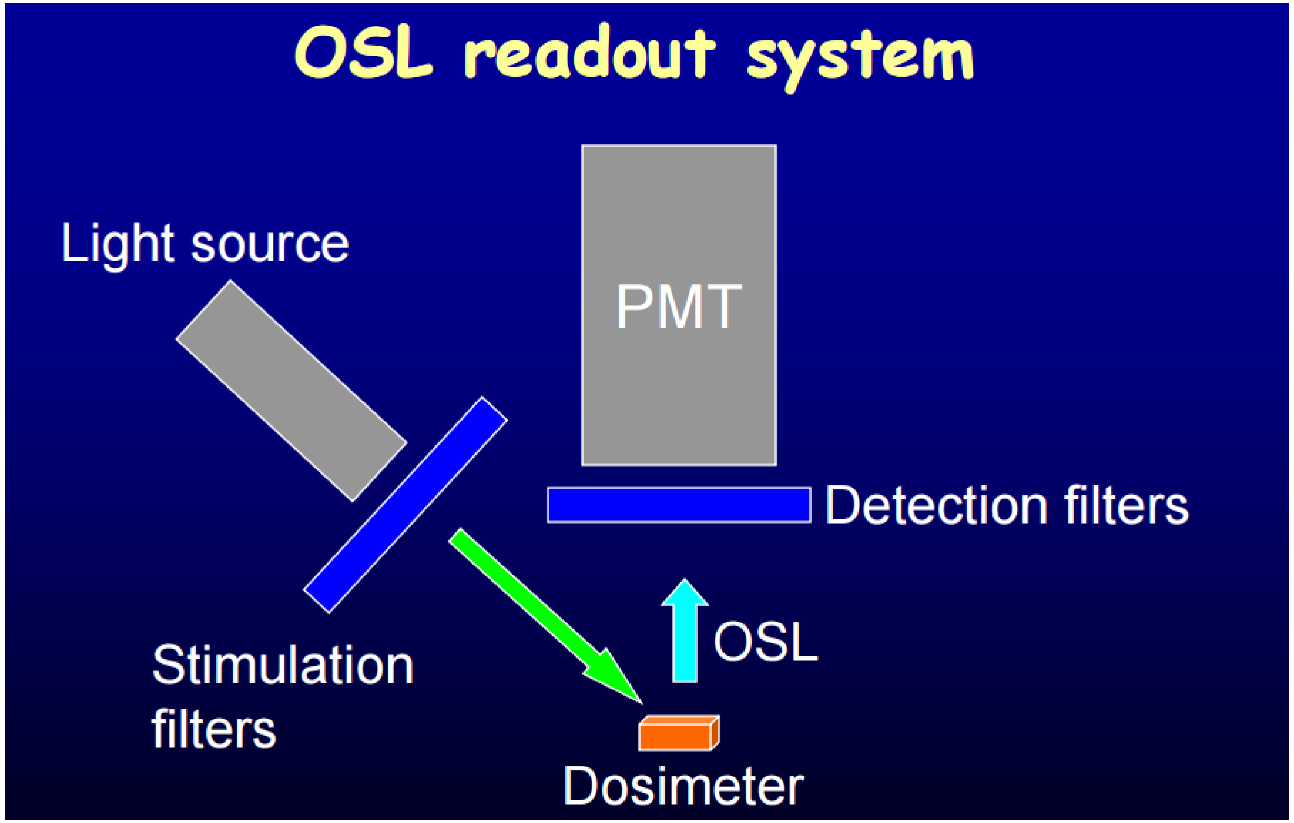


- To determine impact of the radiation, school children were provided OSL badges
- Regular readings were taken to determine exposure
- Cross checking was done via controls at a series of schools
- Unique because in Japan civilians are not allowed this type equipment!

Physics of the OSL Badges

Stored energy from the badge material is stimulated via light, and energy is released as luminescence. This can be used even years after exposure to check radiation levels/quality.





Measuring the Impact of the Radiation

Collecting data with the OSL badges, as well as measurements with a Geiger counter, researchers showed a negligible impact of the radiation.

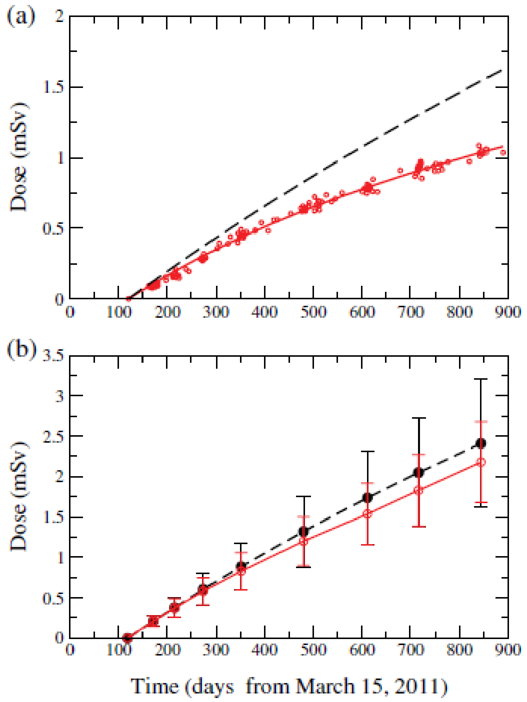


Figure 11. (*a*) Cumulative dose reading as a function of days of a reference OSL badge placed in the Miharu building office. Open circles are read values with a solid fitting curve with a weathering factor as one of the parameters. The dashed curve without weathering is also shown for comparison. (*b*) Similar to (*a*) for the 522 students who made all eight measurements over more than two years. The red curve represents the measured trend, while the dashed one is a prediction based on the first read-out values without the weathering factor. Error bars represent one standard deviation (σ).

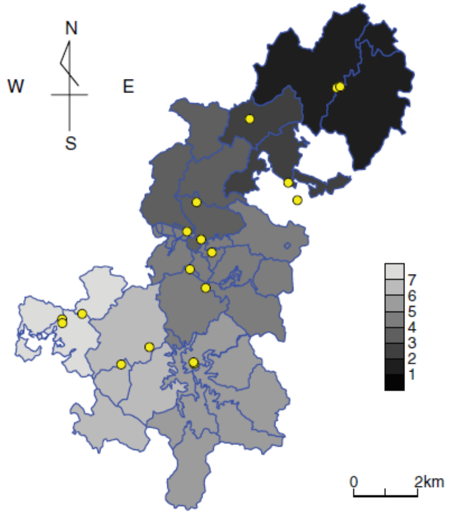


Figure 7. Map of Miharu town. Yellow circles are locations of the schools surveyed.

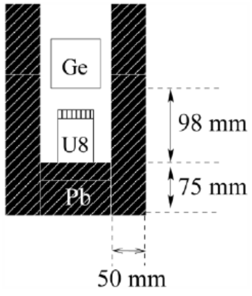
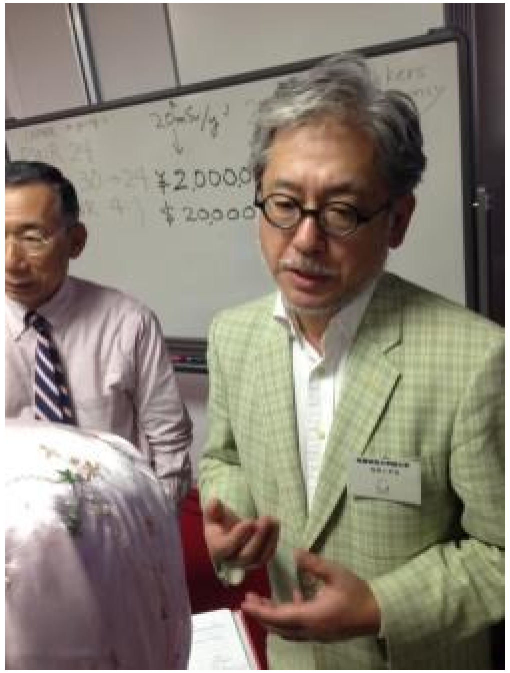
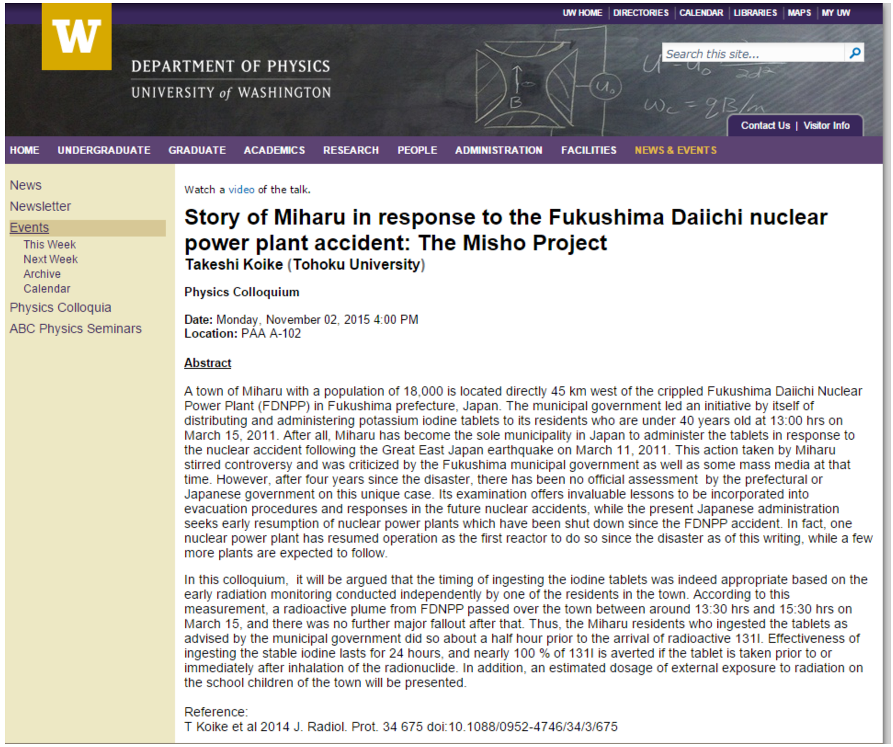


Figure 8. Schematic diagram of measurement setup. A germanium crystal of diameter 70 mm × 70 mm and a U8 polystyrene container of diameter 50 mm × 65 mm were placed inside a lead-brick chamber. The distance between the lead surface and the end cap of the Ge detector was 98 mm.

Legacy of the Misho Project

Proactive treatment and ability for civilian response in conjunction with a low cost radiation monitoring method makes this a future model for other potential areas of exposure.





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Story of Miharu in response to the Fukushima Daiichi nuclear power plant accident: The Misho Project

Takeshi Koike (Tohoku University)

Physics Colloquium

Date: Monday, November 02, 2015 4:00 PM
Location: PAA A-102

Abstract

A town of Miharu with a population of 18,000 is located directly 45 km west of the crippled Fukushima Daiichi Nuclear Power Plant (FDNPP) in Fukushima prefecture, Japan. The municipal government led an initiative by itself of distributing and administering potassium iodine tablets to its residents who are under 40 years old at 13:00 hrs on March 15, 2011. After all, Miharu has become the sole municipality in Japan to administer the tablets in response to the nuclear accident following the Great East Japan earthquake on March 11, 2011. This action taken by Miharu stirred controversy and was criticized by the Fukushima municipal government as well as some mass media at that time. However, after four years since the disaster, there has been no official assessment by the prefectural or Japanese government on this unique case. Its examination offers invaluable lessons to be incorporated into evacuation procedures and responses in the future nuclear accidents, while the present Japanese administration seeks early resumption of nuclear power plants which have been shut down since the FDNPP accident. In fact, one nuclear power plant has resumed operation as the first reactor to do so since the disaster as of this writing, while a few more plants are expected to follow.

In this colloquium, it will be argued that the timing of ingesting the iodine tablets was indeed appropriate based on the early radiation monitoring conducted independently by one of the residents in the town. According to this measurement, a radioactive plume from FDNPP passed over the town between around 13:30 hrs and 15:30 hrs on March 15, and there was no further major fallout after that. Thus, the Miharu residents who ingested the tablets as advised by the municipal government did so about a half hour prior to the arrival of radioactive 131I. Effectiveness of ingesting the stable iodine lasts for 24 hours, and nearly 100 % of 131I is averted if the tablet is taken prior to or immediately after inhalation of the radionuclide. In addition, an estimated dosage of external exposure to radiation on the school children of the town will be presented.

Reference:
T Koike et al 2014 J. Radiol. Prot. 34 675 doi:10.1088/0952-4746/34/3/675

QUESTIONS