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## Special Session on Accident of Fukushima Daiichi Nuclear Power Plant 4. Post Accident Radiation Monitoring in the Surrounding Environment

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After the accident, radiation survey has been done with the airplanes by DOE (Department of Energy), USA and MEXT (Ministry of Education, Culture, Science, Sports and Technology) in the area of about 100 km distance from the power plant. The car survey has also been done by MEXT and other groups, and Fukushima local government continues to monitor radiation levels at many local points. Radioactivities of soils and dusts were measured at various points by several organizations. It was found that the explosion of power plants on March 15 to 16 emitted a large amount of radioisotopes of I-131, Te-132, Cs-134 and Cs-137 etc. Iodine isotopes were predominant, about 100 times larger than cesium isotopes, but now after two months, Cs isotopes are dominant. Strontium isotopes were about 1/1000 to Cs isotopes. The radiation monitoring is going on by environmental monitoring institutes of many local governments and the data are reported every day. The analysis of radioactive effluents from the Fukushima power plant was also done using the SPEEDI (System for Prediction of Environmental Emergency Dose Information) code. The evaluated results agreed well with the radiation monitoring data and the distribution of radiation levels in the surrounding environment is clarified.

**KEYWORDS:** *Fukushima I power plant accident, environmental monitoring, radioactive effluent, time sequential trend, Iodine-131, Cs-134, Cs-137*

### I. Introduction

After the explosion of Fukushima Daiichi (First) nuclear power plants on March 14, 2011, radiation survey has been done with the airplanes by DOE (Department of Energy), USA and MEXT (Ministry of Education, Culture, Science, Sports and Technology) in the area of about 100 km distance from the power plants. The car survey has also been done by MEXT and other groups, and Fukushima local government continues to monitor radiation levels at many local points over 2000 points. Radio-activities of soils and dusts were measured at various points by several organizations, together with MAFF (Ministry of Agriculture, Forestry and Fisheries).

Nuclear and Industrial Safety Agency (NISA) and Nuclear Safety Commission (NSC) announced the total amount of radioactive materials discharged to the atmosphere to be  $1.5$  to  $1.6 \times 10^{17}$  Bq of  $^{131}\text{I}$  and  $1.2$  to  $1.5 \times 10^{16}$  Bq of  $^{137}\text{Cs}$ . These amounts are roughly 1/10 of radioactive materials emitted at Chernobyl accident. They also announced that highly contaminated water with radiation level of over 1000 mSv/h was discovered flowing into the seawater and the total amount of discharged radioactive materials was estimated  $4.7 \times 10^{15}$  Bq, and that low-level contaminated water was discharged into the seawater from April 4 to 10 in order to secure storage

capacity for contaminated water and the total amount of discharged radioactive materials was estimated  $1.5 \times 10^{11}$  Bq.

### II. Observed Radio-Nuclides Emitted from the Power Plants

Radio-nuclides emitted in the atmosphere from the explosion of power plants, especially on March 15 to 16, were observed by various groups with Ge detectors. Observed radio-nuclides were  $^{131}\text{I}$ ,  $^{132}\text{Te}$ ,  $^{133}\text{I}$ ,  $^{134}\text{Cs}$ ,  $^{136}\text{Cs}$ ,  $^{129\text{m}}\text{Te}$ ,  $^{137}\text{Cs}$ ,  $^{99}\text{Mo}$  and  $^{140}\text{Ba}$ . Iodine isotopes were predominant, about 100 times larger than cesium isotopes, but now after two months, Cs isotopes are dominant, since the longest half life of iodine isotopes is 8 days for  $^{131}\text{I}$ , while those of  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  are 2 years and 30 years, respectively. Strontium isotopes were about 1/1000 to Cs isotopes due to higher melting and boiling points.

### III. Environmental Radiation Monitoring around the Power Plants

Ambient dose equivalent rates both inside and outside of the 20 km zone of the power plants which is the evacuation area have been continuously measured after the accident at monitoring posts. **Figure 1** exemplifies the time-sequential trend of on-site radiation level in  $\mu\text{Sv/h}$  from March 12 to April 25. The highest data is registered to be about 12 mSv/h around the front gate of the power plant on March 15. The

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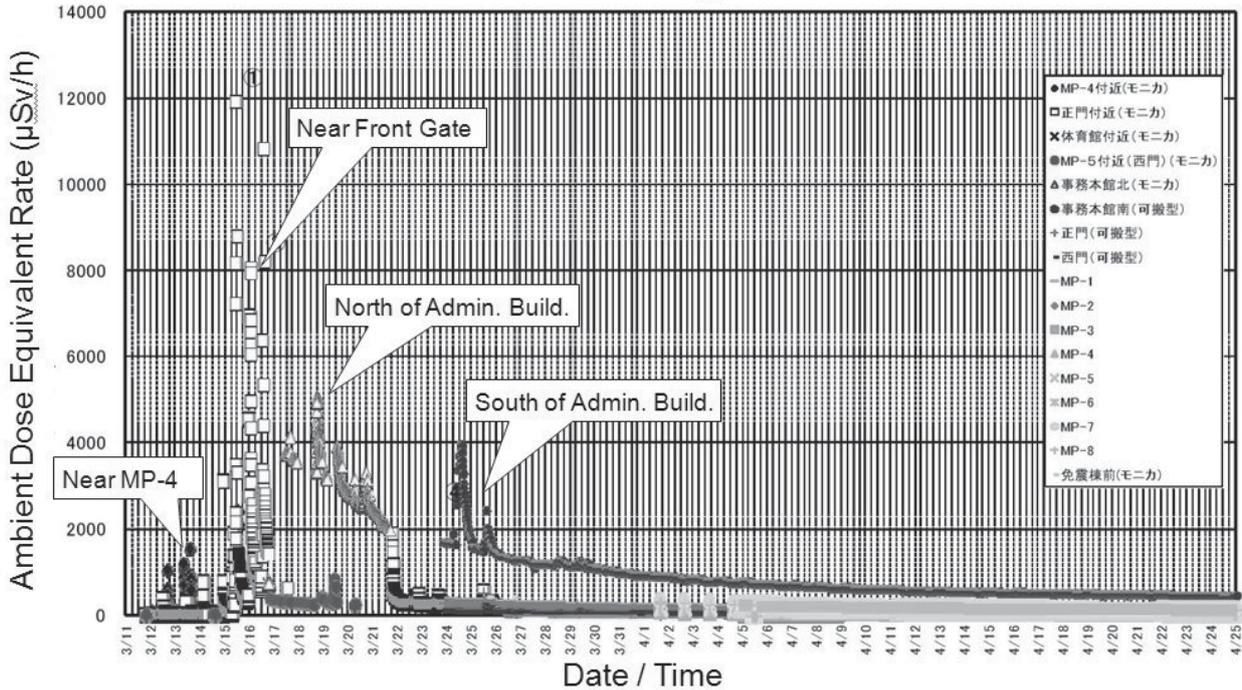


Fig. 1 Time-sequential trend of on-site radiation level from March 12 to April 25 cited from Ref. 1.

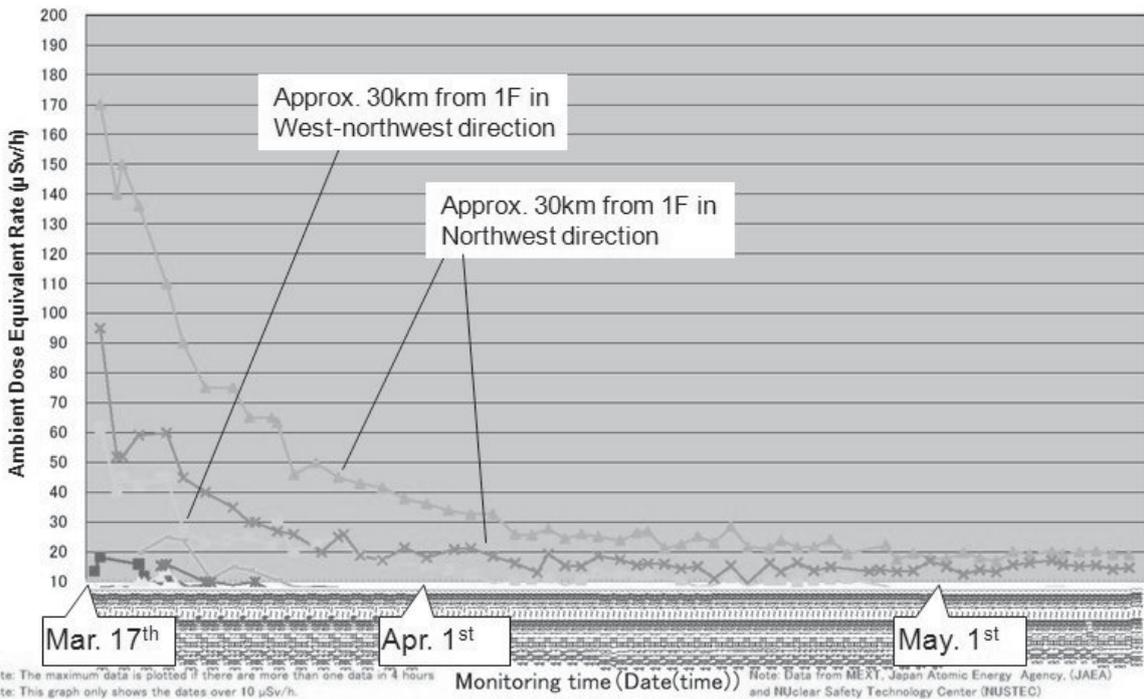


Fig. 2 Time-sequential trend of off-site (about 30 km from the power plants) radiation level in  $\mu\text{Sv/h}$  from March 17 to May 12 cited from Ref. 1.

data rapidly decreases with the 8-day half life of  $^{131}\text{I}$ , but now the decay becomes slow according to  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  isotopes. **Figure 2** exemplifies the time-sequential trend of off-site (about 30 km from the power plants) radiation level in  $\mu\text{Sv/h}$  from March 17 to May 12. The highest value is about 170  $\mu\text{Sv/h}$  and has been declining as well as in Fig. 1. Radioactive concentration in dust samples, soil samples and other environmental samples was also measured both inside

and outside the power plants. Air-borne monitoring within 100 km radius zone has been done with the airplanes by DOE (Department of Energy), USA and MEXT (Ministry of Education, Culture, Science, Sports and Technology). The car survey has also been done by MEXT and other groups, and Fukushima local government continues to monitor radiation levels at many local points over 2000 points. **Figures 3** and **4** give the results of ambient dose rates

in  $\mu\text{Sv/h}$  on 1 m from the ground and total deposition of  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  isotopes in  $\text{Bq/m}^2$  on April 29 inside the 80 km zone from the power plants, respectively. The map was prepared based on results obtained from April 6 to 29 by a small airplane and two helicopters in total 42 flights. Decay of radioactive materials was considered and actual readings were converted into values as of the last survey date of April 29. The deposition of  $^{134}\text{Cs}$  on the ground was calculated based on the results of air-borne monitoring and of measurements which the DOE took on the ground using a gamma-ray analysis. The deposition of  $^{137}\text{Cs}$  on the ground was calculated from the results of accumulated  $^{134}\text{Cs}$ . Both figures clarify the higher values of dose rates and deposition in the north-west area from the power plants. This spatial distribution showed good agreement with the estimation by the SPEEDI code. The highest integrated dose from March 23 to June 30 was observed to be 47 mSv at about 30 km northwest point away from the power plants. **Figure 5** shows the results of sea area monitoring measured during June 6 and 10. The concentrations of  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  isotopes in sea water along the coast near the power plants were measured at outer layer (1m depth from the sea surface), middle layer and lower layer (about 10 m from the bottom of the sea). All

measured data are under the detection limits in unit of Bq/L.

All data in these figures are cited from the MEXT homepage<sup>1)</sup>.

#### IV. Further Plan

MEXT is now strengthening monitoring by coordinating National Institute of Radiological Sciences, Japan Atomic Energy Agency, Japan Agency for Marine-Earth Science and Technology, Nuclear Safety Technology Center, Japan Chemical Analysis Center, Universities and US DOE etc. They are strengthening off-site monitoring, aerial monitoring, sea area monitoring to make a distribution map for ambient dose rate, deposition of  $^{131}\text{I}$ ,  $^{137}\text{Cs}$  and accumulated dose etc. Soil sampling and analysis started from the beginning of June by MAFF, JAEA and other relating organization. The first results will be given late July.

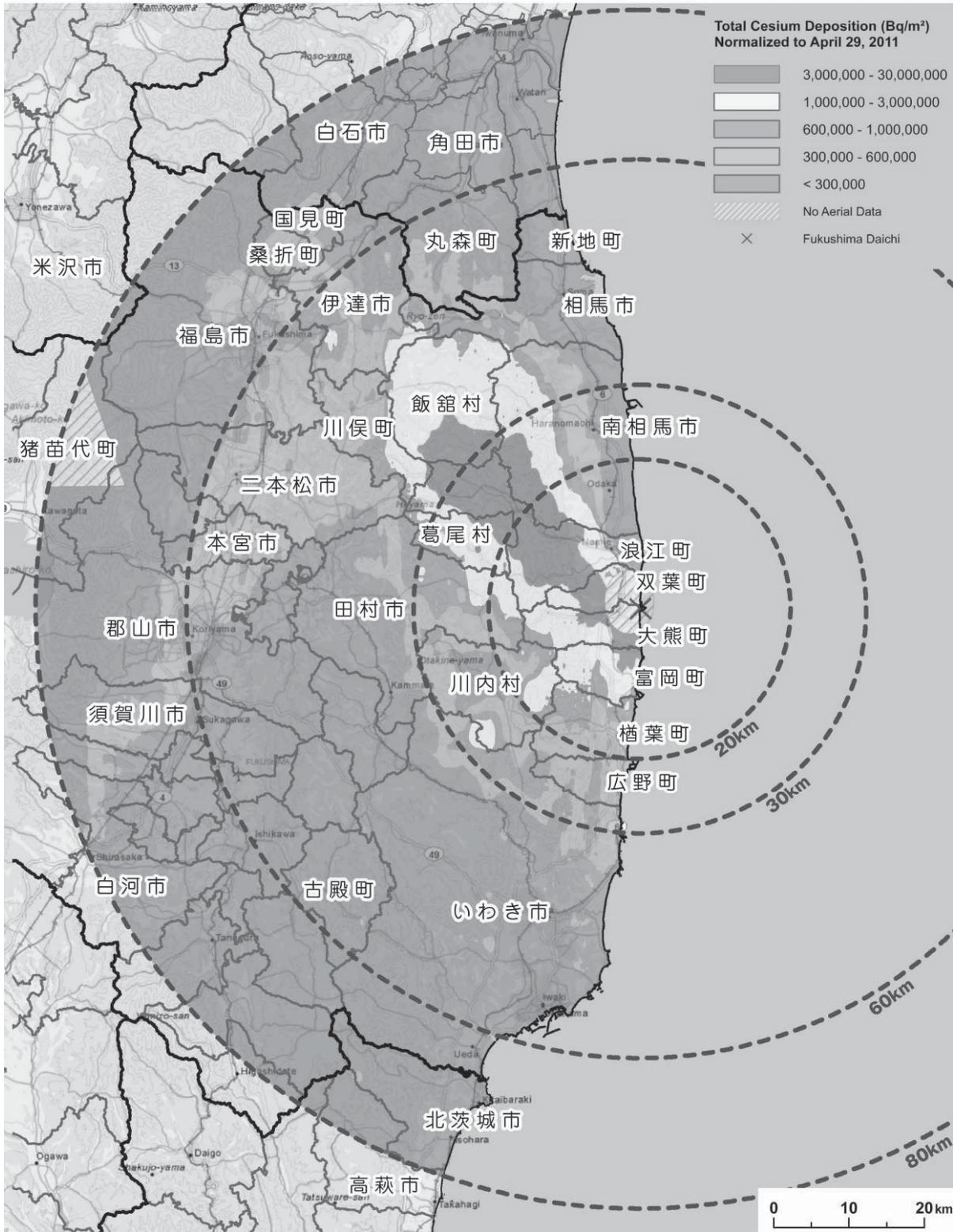
#### References

- 1) Website of Ministry of Education, Culture, Science, Sports and Technology <<http://www.mext.go.jp>>



# Aerial Measuring Results

Joint US / Japan Survey Data



**Fig. 4** Distribution map of total deposition of <sup>134</sup>Cs and <sup>137</sup>Cs isotopes in Bq/m<sup>2</sup> on April 29 inside the 80 km zone from the power plants cited from Ref. 1.

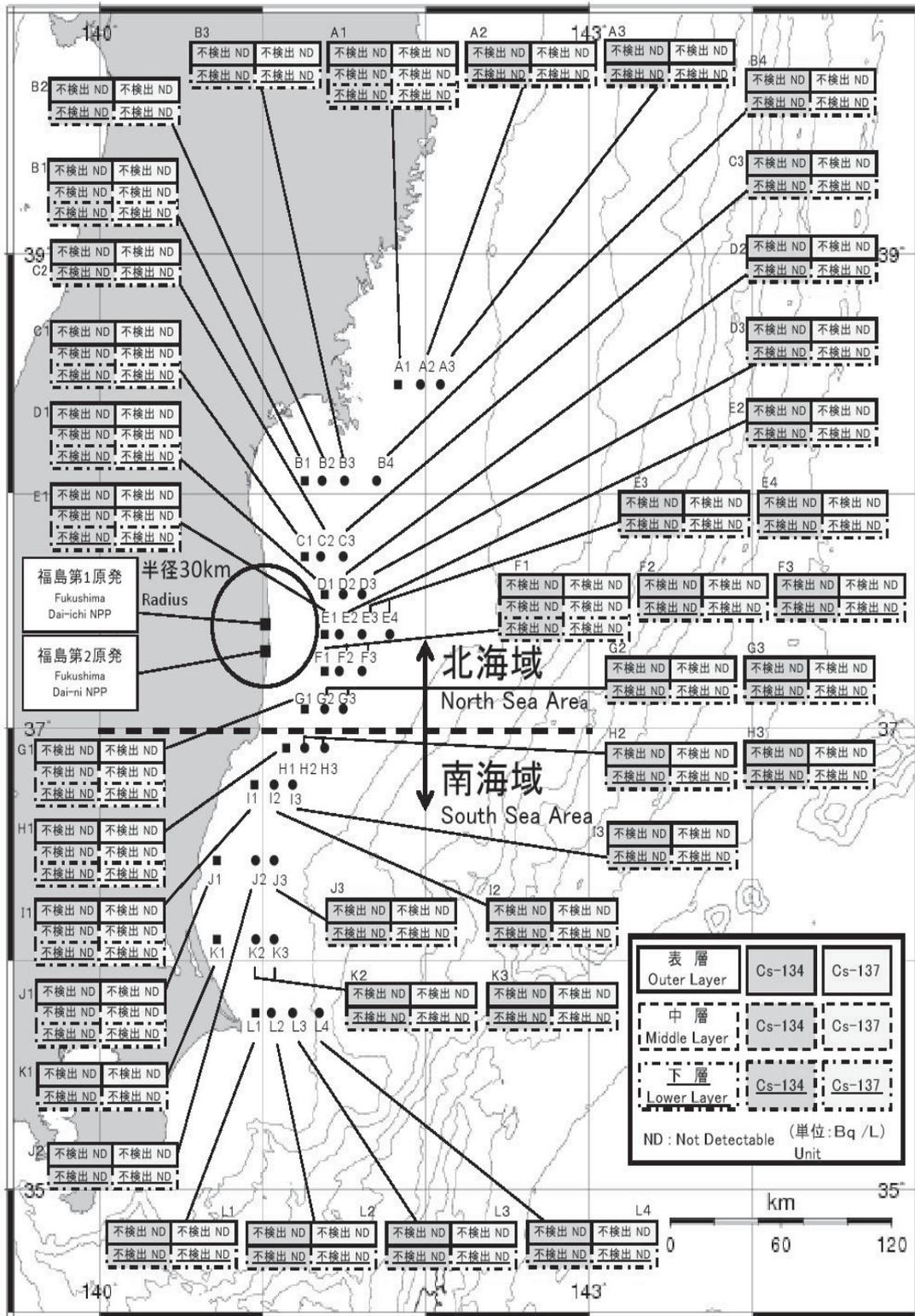


Fig. 5 Sea area monitoring data measured during June 6 and 10 around the coast near the power plants at outer layer (1 m depth from the sea surface), middle layer and lower layer (about 10 m from the bottom of the sea cited from Ref. 1).