Distribution of gamma-ray dose rate in Fukushima prefecture by a car-borne survey method

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The Tohoku Pacific Earthquake and Tsunami on March 11, 2011, caused severe damage to the TEPCO Fukushima Dai-ichi NPP. This was followed by a nuclear accident at an unprecedented scale, and huge amounts of radioactive material were released into the environment. The distributions of the gamma-ray dose rate in Fukushima prefecture were measured using a NaI(Tl) scintillation survey meter as part of a car-borne survey method on April 18–21, June 20–22, October 18–21, 2011, and on April 9–11 and July 30–August 1, 2012. The dose rate near TEPCO Fukushima Dai-ichi NPP and at iitate-mura, fukushima-city was high (1 to >30 μSv/h).

Key Words : *gamma-ray dose rate, car borne survey, NaI(Tl) detector, Fukushima Dai-ichi NPP*

1. Introduction

The Tohoku Pacific Earthquake and Tsunami caused by the earthquake that occurred on March 11, 2011, caused severe damage to the TEPCO Fukushima Dai-ichi Nuclear Power Plant(NPP), resulting in a nuclear accident at an unprecedented scale and the release of huge amounts of radioactive material into the environment. This distribution of radioactive material in Fukushima or on the global scale is now commonly known via the news or the homepage of Ministry of Education, Culture, Sports, Science and Technology(MEXT), among other sources. As part of the environmental radiation monitoring, we continuously measured the radioactivity distribution in Fukushima prefecture using an in-car NaI survey meter for one month after the accident.

The car-borne survey method for the radiation dose measurement after the Fukushima Dai-ichi NPP accident has already been carried out by MEXT and other research groups.[1)-3)] In addition, this method has been used to investigate the level of environmental radiation.[4)-7)] Through a continuous measurement of the radiation from an early stage after the accident, we observed a decontamination effect caused by the artificial or natural weathering.

The released radioactive material is not distributed uniformly, because it is greatly influenced by the wind direction, weather, or the topography. The measured values varied according to the conditions of the measurement points (e.g., the state of a road surface, the neighboring topography, and the usage situation). The shielding correction factor was calculated from the overall measurements to estimate the radiation dose outside of the car from measurement data in the car.

2. Experimental methods

The car-borne measurements were carried out on the same route in Fukushima on April 18–21, June 20–22, and October 19–21, 2011, and on April 9–11 and July 30–

August 1, 2012. The NaI(Tl) scintillation survey meter (TCS-171, Aloka Ltd.) was placed on the rear passenger seat of a car. The measured values were recorded in the memory at arbitrary points during the run. Simultaneously, the measurement locations were found from the GPS data (GPS-CS3, SONY) for those points. The shielding correction factor of the car was determined separately at various locations. Measurements were taken both inside and outside the car.

A radiation dose of 1 m above the ground was also measured using the NaI(Tl) scintillation survey meter at several locations.

3. Results and discussion

The dose rate (μSv/h) measured inside the car is shown in Figures 1-5. In these figures, the distance from Fukushima Dai-ichi NPP (denoted by ×) is depicted using concentric circles. The dose rate rises within the 20 km range, over Iitate-mura and Fukushima-city of the northwest direction. The measurements outside of the car indicated that the dose rate was low, 0.13μSv/h, in the Aizu district and was at its maximum, more than 30μSv/h (immeasurable by the NaI (Tl) survey meter), in Akougi, Namie-town, on April 2011. In the areas of high dose rate, the variation in measurements from one region to another was large. A detailed investigation of other regions along with the road surface is necessary to formulate a detailed distribution map.

From the measurements from inside and outside of the car, a shielding correction factor was calculated; the plot for the shielding correction factor values is shown in Fig. 6. The dose rate outside the car can be calculated by multiplying the measurement values shown in Figures 1-5 with this shielding correction factor. However, it should be noted that this calculated value is for the roads, and special attention is required for regions with different dose rates, such as residential areas, cultivated land, and forest areas.

The dose rates at several points are summarized in Table 1. The dose rate decreases with the decay of ^{131}I mainly from April to June, 2011. In approximately one year from June 2011 to July 2012 the dose rate decreased to 51-66%, and the rate of this decrease is larger than that calculated using only the half-life of ^{134}Cs (except for measurement point 4). Because artificial decontamination was not performed at these measurement points, the natural weathering can be considered to be greatly influential on the decreasing of the dose rate.

Table 1 Dose rate of 1m above the ground (μSv/h)

No.	2011.4	2011.6	2011.10	2012.4	2012.7
1	12.7	9.88	7.8	8.03	6.48
2	39	30	25	20.2	15.6
3	1.42	1.25		0.8	0.8
4	0.63	0.43			0.34
5	0.7	0.55		0.38	0.29
6	1.48	1.26	1.06	1.09	0.65

1:Namie-town mizusakai, 2:Namie-town akougi, 3:Ryozen-town ishida,
4: Iwaki-city yotsukura-town yakuouji, 5:Tamura-city tokiwa-town yamane, 6:Iwaki-city ogawa-town kamiogawa

4. Conclusions

As part of the environmental radiation monitoring, radioactivity distribution in Fukushima prefecture was measured using an in-car NaI(Tl) survey meter. A high dose rate area was found on the Fukushima Dai-ichi NPP outskirts and in the northwest direction, as shown in the MEXT Report. The shielding correction factor was 1.71. In the first year, the effect of the natural weathering was prominent.

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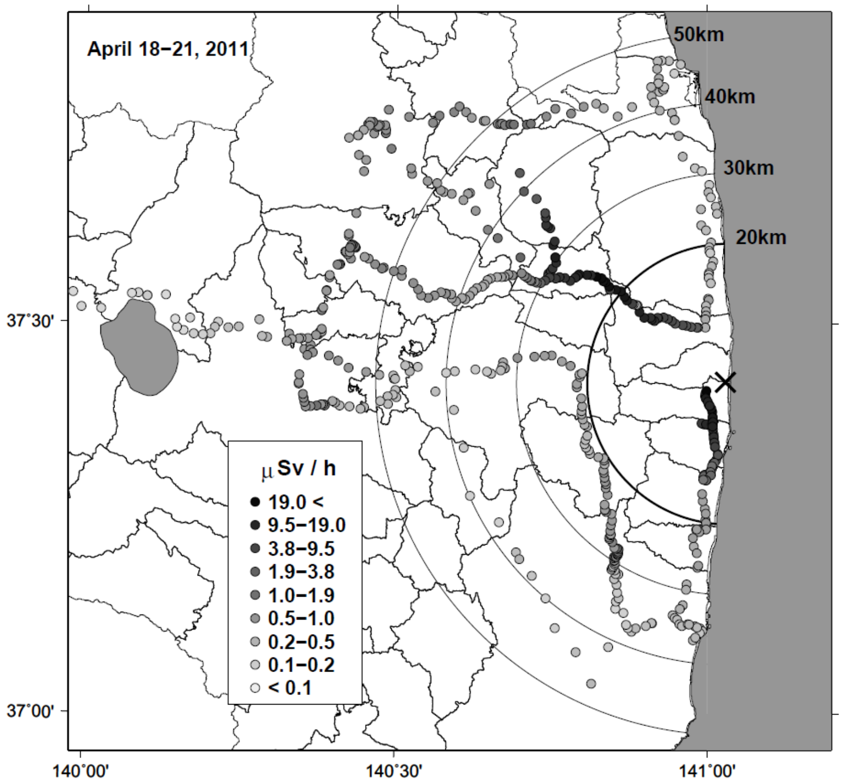

Fig. 1 Distribution of the dose rate measured inside the car on April 18-21, 2011

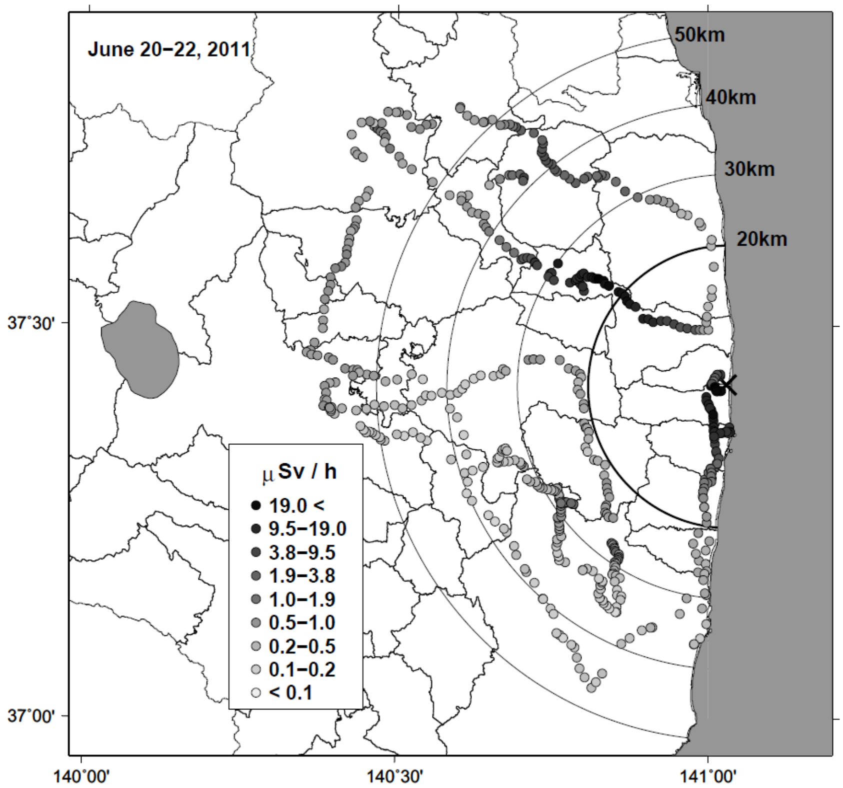

Fig. 2 Distribution of the dose rate measured inside the car on June 20-22, 2011

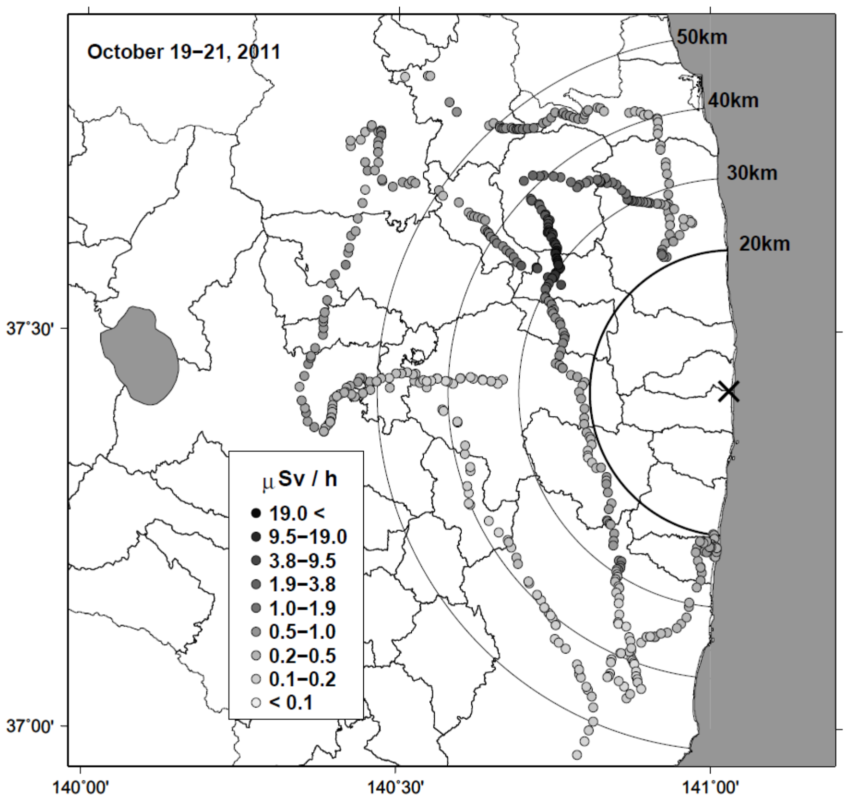

Fig. 3 Distribution of the dose rate measured inside the car on October 19-21, 2011

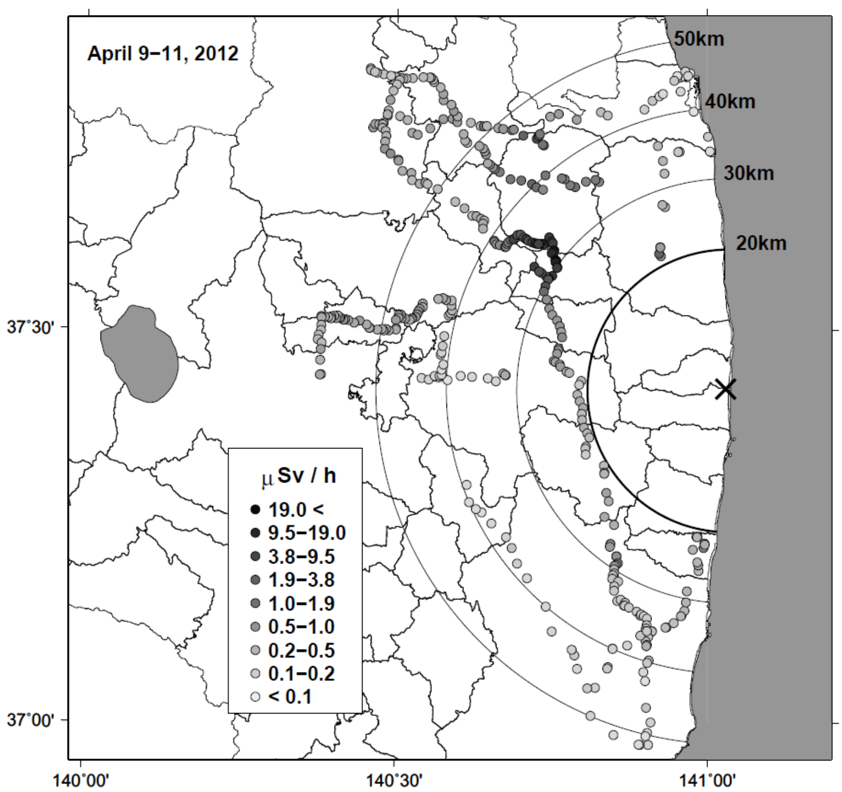

Fig. 4 Distribution of the dose rate measured inside the car on April 9-11, 2012

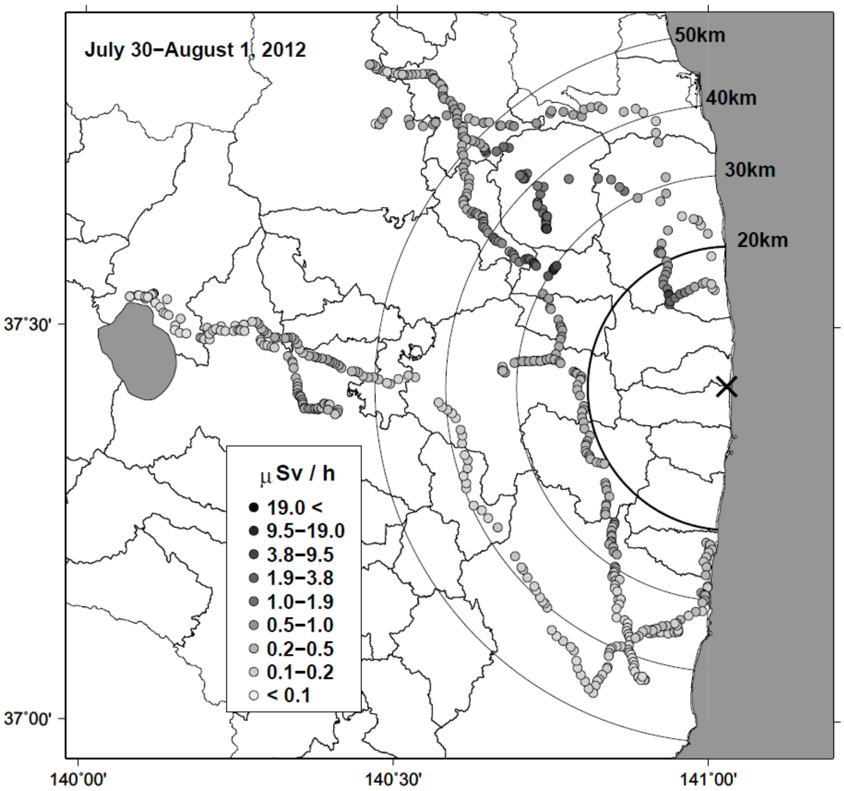

Fig. 5 Distribution of the dose rate measured inside the car on July 30-August 1, 2012

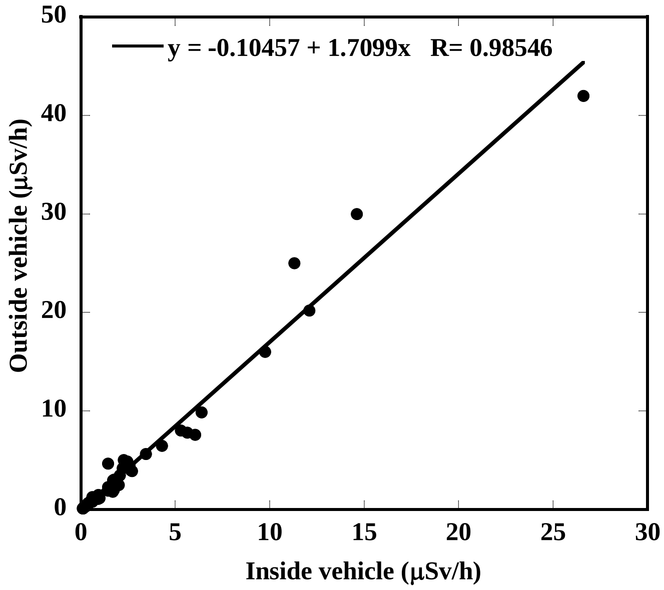

Fig. 6 Shielding correction factor for vehicle using TCS-171