Measurement of radiation dose inside a car across Fukushima from March 19 to 22, 2011

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Air dose rates were measured inside a car with an ion chamber detector across Fukushima Prefecture from March 19 to 22, 2011. The dose rate along the Tohoku Expressway basically ranged from 2 to 6 μSv/h. Relatively high values were obtained around Nihonmatsu City. The dose rate dipped to an exceptionally low value inside a tunnel to what was probably the normal background value before the Fukushima nuclear accident. The dose rate in Fukushima City ranged from 2 to 9 μSv/h. High values were obtained in the center of the city. The dose rates along the Banetsu Expressway and in Samegawa Village located in the Abukuma highlands were very low at 1.5 to 3 and 1 μSv/h, respectively. During our stay in Fukushima, external and internal exposure was evaluated at 0.1 and 0.0327 mSv, respectively. The masks used to avoid internal exposure showed six radionuclides, ^{131}I, ^{137}Cs, ^{134}Cs, ^{132}Te, and ^{136}Cs, in order of radioactivity, and the maximum total activity was 31 Bq.

Key Words: *mobile radiation survey, ion chamber detector, air dose rate*

1. Introduction

The Fukushima nuclear accident required radiation screening and medical support for refugees and residents from a very early stage. As one of these activities, we traveled to Fukushima Prefecture to perform radiation screening. The air dose rate inside a car was measured during the trip. The external and internal exposure during our stay in Fukushima for the screening activity was also measured. The measurement results are described in this report.

2. Materials and Methods

Our itinerary for the screening activity was as follows. On March 19, 2011, we left Kumatori Town, Osaka, in the morning and arrived at Iizaka Onsen in Fukushima City that night; on 20 March, we departed from Fukushima City and arrived at Nakoso High School in Iwaki City (southeast part of Fukushima Prefecture) for radiation screening, and then returned to Fukushima City that night; on 21 and 22 March, we departed from Fukushima City and traveled to Shirakawa City (southern part of Fukushima Prefecture) and Samegawa Village (only 21 March), and then returned to Fukushima City that night; finally, on 23 March we returned to Kumatori Town by bus, airplane, and train. Except for the last day, we travelled by the same delivery cargo van on all the other days.

The air dose rate inside the car was measured with an ion chamber detector (Aloka ICS-313) while travelling in Fukushima Prefecture. The ion chamber was calibrated with a Ra-226 standard source, whose radioactive strength provided 85 μSv/h at 1 m. The value of air dose rate was from one-time measurement at each location during car travel.

The resulting personal external and internal exposure was evaluated by a glass dosimeter (Chiyoda Technol Corporation) and by MONDAL with results from a NaI scintillation whole-body counter (detector size: 8"φ × 4"t),

respectively. In the whole body counting the measuring time was 10 min and the detection limit of I-131 and Cs-137 were 20 and 500 Bq, respectively.

During this activity, we wore new masks every morning to avoid internal exposure, and the radioactivity of masks was measured for 3600 s with two Ge semiconductor detectors (Princeton Gamma-Tech IGC3019 and Seiko EG&G 7600-0001). The radioactivity of masks was defined as the average value calculated from the two calibration equation for a thin membrane filter of 50-mm diameter and a charcoal filter of 60-mm diameter and 20-mm thick to take into account the effect of solid angle and then corrected for decay to the day when masks were used. The detection limit of Te-132, I-131, Cs-134, Cs-136, and Cs-137 were 0.3, 0.3, 0.4, 0.7, and 0.4, respectively.

3. Results and Discussion

(1) Air dose rate measurements

a) Along Tohoku Expressway

During this screening activity, we traveled on the Tohoku Expressway in Fukushima Prefecture five times. The change of air dose rates is shown in Fig. 1. The dose rates obtained on March 19 were low, and they increased with time. The degree of increment, however, was very fluctuant. It seemed that radioactive materials released still wafted over and not yet strongly adsorbed into the ground.

At the Adatara service area in Motomiya City around 7:00 pm on March 19, we observed the following dose rate change: the initial value was 2 μSv/h, it peaked at 4 μSv/h, and finally decreased to 2.7 μSv/h. This short-period change might have shown small radioactive plume that passed over. A radioactive peak seemed to have formed around Nihonmatsu where a high air dose rate on the expressway was reported in May 2011 by the Fukushima Prefecture government [1]. The dose rate dipped inside the Fukushima tunnel, about 900 m in length through Mt. Atago in Fukushima City. Although dose rates inside the long tunnel rapidly decreased due to the negligible direct radioactive deposition, these values gradually increased with time due to transit of contaminated traffic and air.

b) In Fukushima City

In Fukushima City as well as on the Tohoku Expressway, air dose rates measured several times on the same street between the Prefectural office (center of Fukushima City) and Iizaka Onsen (northern part of the city) are shown in Fig. 2. The dose rate in the center of the city was higher, and the highest values were obtained at the north end of the Shinobuyama tunnel through Mt. Shinobuyama (altitude 275 m).

The distance between the Prefectural office and Iizaka Onsen is about 9 km, and they are located 60 and 64 km from the Fukushima Daiichi NPP, respectively. In spite of similar distances from the Fukushima Daiichi, a large variation in the air dose rate at these locations was observed.

Further, a dip in the air dose rates inside the Shinobuyama tunnel was observed. The rates were 6 to 8 μSv/h at both the ends and they decreased to 1.5 to 2 μSv/h at the center of the tunnel.

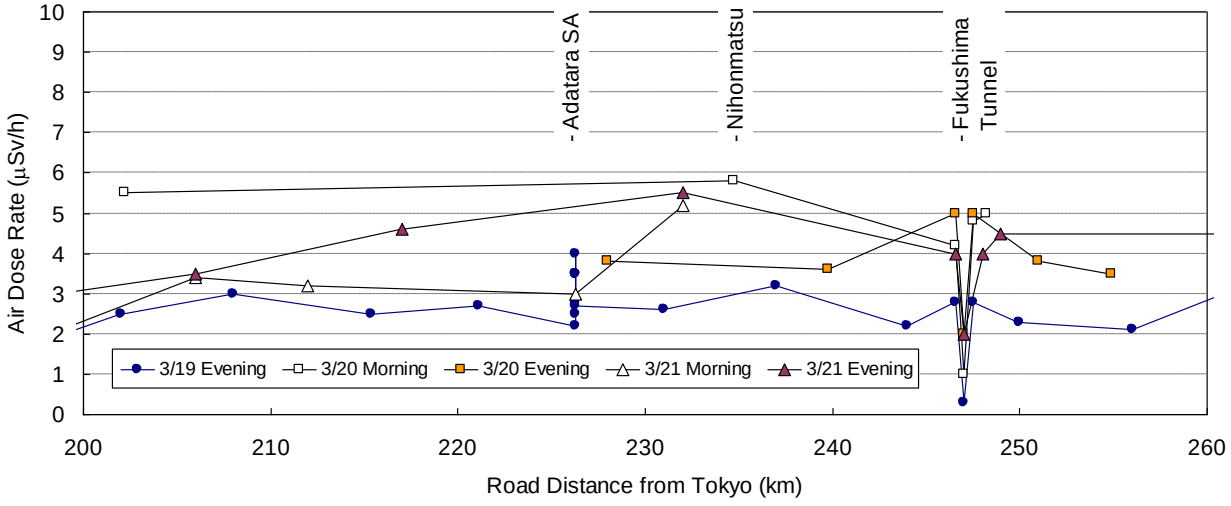
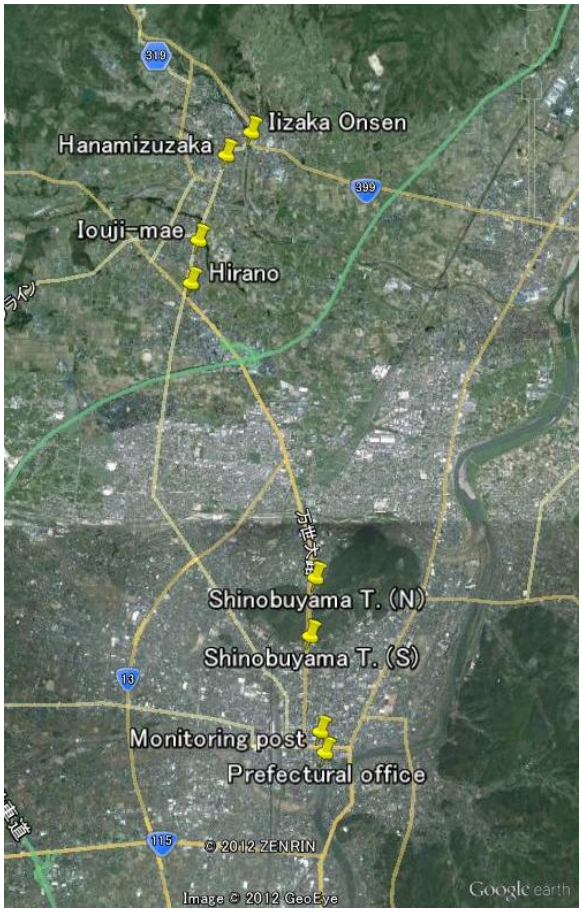


Fig. 1 Change in air dose rate along Tohoku Expressway



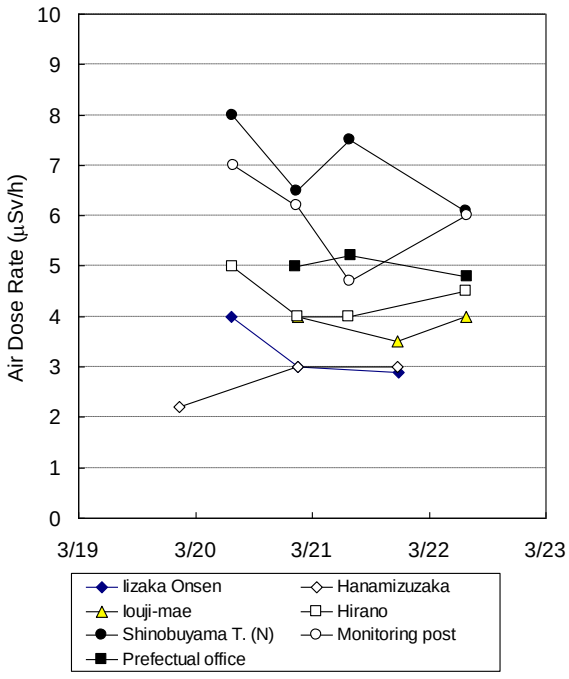


Fig. 2 Measurement locations (upper) and temporal variation of radiation dose rate (bottom) in Fukushima City

c) Across Fukushima Prefecture

We made a round trip to Iwaki City on 20 March. The temporal change in the air dose rate is shown in Fig. 3. The rates along the Banetsu Expressway and in Iwaki City were considerably lower than those along Tohoku Expressway and in Fukushima City described above. This trend across Fukushima Prefecture was agreed with the results from airborne monitoring in April 2011 [2], which would suggest the distribution of contamination (mainly radioactive cesium) was roughly stabilized since March 20 at the latest.

Screening activity was conducted in Samegawa Village and Shirakawa City on 21 and 22 March, and their dose rates were approximately 1 and 2 μSv/h, respectively.

Low air dose rates were obtained on both Banetsu Expressway and in Samegawa Village in the Abukuma highlands. The Abukuma highlands served as a barrier to the diffusion of the radioactive plume released from Fukushima Daiichi NPP [3]. Consequently, the plume streamed along the basin at the foot of the highland where Fukushima City and Tohoku Expressway are located and high radioactive contamination was detected.

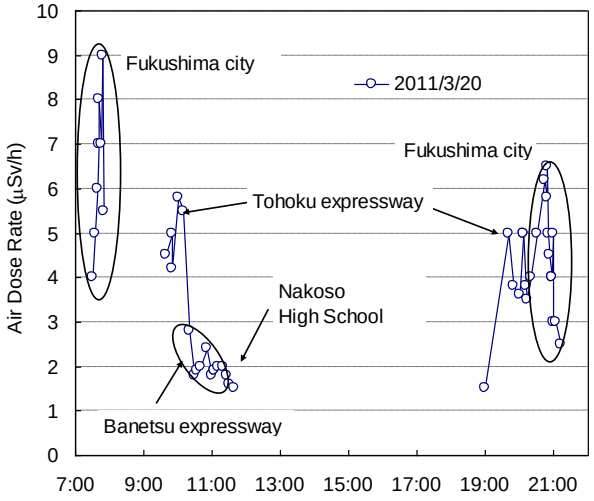


Fig. 3 Change in air dose rate on one day of screening activity

(2) Radiation exposure

The radioactivity of the masks used on each day is shown in Fig. 4. Among detected nuclides, only ^{136}Cs was found in masks used on 20 March with ^{131}I showing a slightly different trend, and the radioactivity decreased faster than their own physical half-lives, which was caused by the difference in location of screening activity and time spent outdoors. During this screening activity, the effective dose (external exposure) was 0.1 mSv, and the committed effective dose (internal exposure) was 0.0327 mSv.

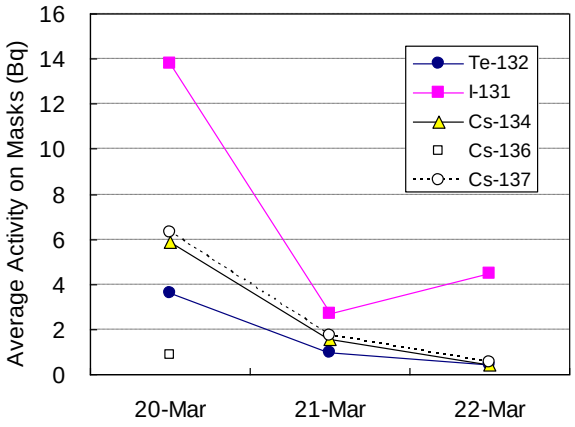


Fig. 4 Average activity on masks used during screening activity

4. Conclusion

Air dose rates were measured in Fukushima City, Iwaki City, Shirakawa City, and Samegawa Village and along Tohoku and Banetsu Expressway during our screening activity in Fukushima Prefecture from March 19 to 22, 2011. Those in Fukushima City were highest, followed by along Tohoku Expressway. While those in Samegawa Village and along Banetsu Expressway (both located in Abukuma highlands) were relatively low. This radioactive distribution was agreed with the MEXT reports consisted of airborne monitoring in April 2011. The radioactivity on masks used and the external and the internal exposure were substantially low.

Acknowledgments

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