Abstract of the Dissertation submitted by CUI LIMENG

Environmental Remediation of the difficult-to-return zone in Tomioka Town, Fukushima Prefecture

福島県富岡町の「帰還困難区域」における放射線量率の推移

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Scientific Reports・10,10165, 2020

〔Total Page Number: 8〕

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Introduction

The Great East Japan Earthquake and subsequent tsunami on March 11, 2011 caused an accident at the Fukushima Daiichi Nuclear Power Station (FDNPS) that resulted in various radionuclides being released into the atmosphere and eventually depositing on land and at sea in the surrounding areas.

Tomioka Town was rearranged into a residential zone and the difficult-to-return zone in response to the annual cumulative dose. We carried out a detailed and high-frequency radiation monitoring program using a car-borne survey to provide relatively high-density data. We also evaluated the effects of decontamination efforts, such as reductions in ambient dose rates, in three areas (“Decontaminated area”, “Radioactive waste storage area” and “Non-decontaminated area”) with markedly different characteristics in the difficult-to-return zone in Tomioka Town.

Materials and Methods

Tomioka Town is located 8.5 km south of the FDNPS. We measured ambient dose rates derived from the FDNPS accident in the difficult-to-return zone of Tomioka Town from July 2018 to July 2019.

The difficult-to-return zone of Tomioka Town was divided by the main road between Yonomori District and Oragahama District, both of which are located within 10 km of the FDNPS. Yonomori District was designated as a reconstruction and revitalization area and decontamination efforts started in July 2018. Part of Oragahama District was designated a radioactive waste storage area and was decontaminated in 2014; however, the forested area of this district has not been decontaminated since the FDNPS accident.

In the present study, Yonomori District is referred to as the Decontaminated area, the radioactive waste storage area in Oragahama District is referred to as the Radioactive waste storage area, and the forested area of Oragahama District is referred to as the Non-decontaminated area.

The difficult-to-return zone of Tomioka Town was surveyed using a car-borne survey system, Radi-probe® (Model: HDS-101GN, Mirion Technologies, Inc., Japan). The measurement points ranged from 748 to 1408, 510 to 849 and 127 to 189 in the Decontaminated area, Radioactive waste storage area and Non-decontaminated area, respectively.

Results

The median dose rates in the Decontaminated area in the difficult-to-return zone decreased rapidly from 1.0 μSv/h to 0.32 μSv/h; the median dose rates in the Non-decontaminated area and Radioactive waste storage area fluctuated between 1.1-1.4 μSv/h and 0.46-0.61 μSv/h, respectively.

On the basis of the slope of the regression line, ambient dose rates in the last surveys decreased to 28.1%, 78.9% and 72.1% of those in the first surveys in the Decontaminated area, Radioactive waste storage area and Non-decontaminated area, respectively.

Ambient dose rates were significantly higher in the Non-decontaminated area than in the other two areas ($p < 0.001$). In the surveys during 2018 and on January 24, 2019, the dose rates in the Decontaminated area were significantly higher than those in Radioactive waste storage area ($p < 0.001$). In the survey on January 12, 2019 and the four surveys after March 2019, the statistical results indicated the dose rates in the Decontaminated area fell below those of the Radioactive waste storage area ($p < 0.001$).

We calculated the annual external effective doses of decontamination workers and estimated that the median doses from July 2018 to July 2019 were 0.66 mSv/y for those working in the Decontaminated area and 0.55 mSv/y in the Radioactive waste storage area, respectively. Also, for residents who are going to return to the Decontaminated area, on the basis of the ambient rates in July 2019, we estimated that the median external effective dose of indoor workers was 0.69 mSv/y and that of outdoor workers was 0.87 mSv/y, respectively.

Discussion

A relatively stable downward trend was observed in the Decontaminated area. The dose rates in the Decontaminated area decreased faster than those in the Radioactive waste storage area and Non-decontaminated area from July 2018 to July 2019. The dose rates in the Decontaminated area dramatically decreased due to decontamination work aiming to help residents return home.

The results showed that the dose decreased by 71.9% within 1 year of decontamination efforts in areas where the initial dose rate was 1.0 μSv/h (median) in the Decontaminated area. The reduction rates during research period in the Radioactive waste storage area and Non-decontaminated area were 21.1% and 27.9%, respectively. Our results showed that the reduction rates of radiocesium in all three districts were noticeably faster than its physical decay.

In the present study, the estimated annual effective dose of decontamination workers, as well as the residents of decontaminated areas, was lower than the annual effective dose limits recommended by the Japanese government. Nevertheless, radiation safety education for workers is needed to appropriately protect them from radiation.

This case of Tomioka Town within the “difficult-to-return zone” may be the first reconstruction model for evaluating environmental contamination and radiation exposure dose rates due to artificial radionuclides derived from the nuclear disaster. The long-term follow-up monitoring in combination with various analytical apparatus and system such as car-borne survey and nuclides analysis of the environmental samples could be accurately evaluate the decontamination effects, external and internal radiation levels. These monitoring is extremely important for the reconstruction of affected areas around the FDNPS.