Limits of decontamination of residential land in rural areas radioactively contaminated by Tokyo Electric Power Company Fukushima nuclear power plant accident

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Abstract

This is an empirical study on the actual condition of pollution and decontamination in Iitate Village, Fukushima Prefecture, in the affected area of radioactive contamination released by Tokyo Electric Power Fukushima Daiichi Nuclear Power Plant caused by the Great East Japan Great Earthquake of March 2011.We have clarified the secular change of the air dose rate in residential area and housing. Although there is a decline in spatial dose due to natural decay and decline due to decontamination, it is not an environment suitable for residence. We investigated the housing which was released from evacuation. According to the survey in 2017, although the dose in the housing tends to be high in the high space, it is less than 0.6 μSv/h. However, the room adjacent to the forest has a dose of about 1.4 times that of the central room. On the surface of the residential land is 0.65 μSv/h on average, exceeding the regulation standard value of the radiation control area. In the forest soil surrounding the residential land after decontamination, radioactive cesium is still 40,000 Bq/kg. Despite this contamination situation, the evacuation designation is canceled at the end of March 2017 under unreasonable circumstances. Villagers who went back home had no choice but to produce vegetables in farmland where pollution continues even though they were decontaminated. This absurdity continues to follow. Also, products of contaminated forests can't be eaten for the foreseeable future, and rich agricultural livelihoods have been lost.

Keywords: Fukushima nuclear power plant accident, Iitate village, Limit of decontamination of residential area, Air dose rate, Radioactive cesium up to five words;

1. Introduction

Iitate Village in Fukushima Prefecture was radioactively polluted in the long term due to the Tokyo Electric Power Fukushima Daiichi nuclear accident on March 11, 2011, and it became a catastrophic area. Nonetheless, evacuation was canceled by the national policy on 31 March 2017, except for the difficult-to-return area (Nagajima) in Iidate village. Since 1994, the authors have been carrying out support research on Iidate Village from a viewpoint of sustainable rural planning. After the nuclear accident, we have conducted resident consciousness survey, radiation dose rate measurement, measurement of the availability of radioactive cesium (Cs), dose rate measurement inside and outside the house. We also advanced development research on radiation reduction materials for houses. By our comprehensive research, decontamination limits have been presented. Forests accounting for about 80% of Iidate village cannot be decontaminated and return risk remains high.

In this state, evacuation was canceled in Iidate village. In an emergency, it can be said that "exceptional condition" is made by national policy and neglected.

In this study, we report the air dose rate in the house in Iidate village, the Cs measurement result in the soil in the summer of 2017 and predict future reduction. Moreover, we reveal contradictions that evacuation was lifted.

Fig.1. Mountain of decontamination soil on the paddy fieldT in Iitate village, 2018.

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2. Method and Object

Following 2014, from July 23 to 24, 2017, we measured nine in Iidate village, one in Namie Town, one in Kawamata Town Yamakiya district, in total of 11 houses. The measurement items are the air dose rate inside and outside the house and the adhesion amount of Cs to the soil depth of 30 cm in the residential area and the mountain in the back. Among the eleven houses, one of Namie-machi houses was dismantled. One case of Iitate village is soil measurement of only one place in the residential land. All housing lots have been decontaminated, and the effects and limitations of decontamination are also examined.

The space dosimeter used [ALOKA PDR - 111]. In-house measurements were taken at the center of each room, on the floor, 1 m above the floor, near the ceiling. The residential area was measured at a point about 1 m away from the building wall, on the ground, 1 m above the ground, about 2 m above the space. We drew a core of 30 cm in the soil with a pottery. The sample soil was divided into 5 cm units and measured with a germanium semiconductor wave height measuring instrument (manufactured by Canberra, RI room in Nihon University).

3. Space dose rate inside and outside at decontaminated housing

3.1 Space dose rate in housing

The characteristics of the average value of the measurement results are as follows. On the first floor of the room, the floor is the lowest, then 1 m above the floor, the ceiling in order, the upper part of the room tends to be higher(Fig.1.). The second floor also has the same tendency. In the 1 m above the floor which is the living space height, the average is 0.34 μSv/h. Without radioactive contamination due to a nuclear accident, the usual air dose rate is about 0.05 μSv/h, and now it is nearly 7 times its exposure dose. Assuming that people are constantly living in the room in this state, the pollution situation exceeds 1 m Sv per a year. According to Japanese law, the dose limit of the general public is 1 m Sv per a year.

On the other hand, decontamination is effective. Places where the air dose rate in the room exceeds the radiation control area standard (0.6 μSv / h) are limited to the vicinity of the ceiling.

At the floor, 1 m above the floor, near the ceiling, the air dose rate in the room facing the mountain around the residential land tends to be higher and the value of the room in the middle of the house tends to be lower(Table 1.). On the floor 1 m, the central room is reduced to 70% of the room facing the forest. Please note that these houses are houses that are not renovated at the measurement stage. The situation of indoor pollution at new housing will be the next question to be investigated.

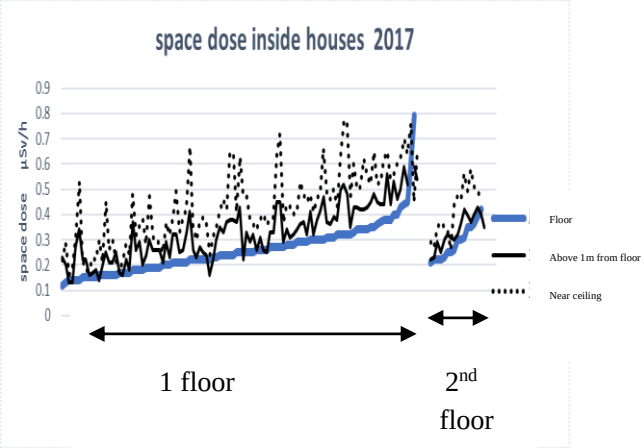

Fig.1. Spatial dose in the house after decontamination (by height from the floor) 2017

Table 1. Comparison of special dose rate by room μ Sv/h

Room location	on the floor	1 m above the floor	Near the ceiling
room facing the forest	**0.28**	**0.37**	**0.49**
central room	**0.21**	**0.26**	**0.32**
other rooms	**0.25**	**0.32**	**0.41**
average	**0.26**	**0.33**	**0.43**

3.2 Spatial dose rate of residential land

Contamination continues even after decontamination of peeling off 5 cm of the topsoil of the residential land and then placing the soil. Despite decontamination, the dose on the ground surface is the highest. The average value of the air dose rate on the ground surface is 0.65 μSv / h, exceeding the standard value of the legally required radiation control area. Later, I will explain in the situation of Cs remaining in the soil, the reason is considered the residual influence of polluted fallen leaves and residual Cs in the soil.

1 m above the ground, 2 m above the ground average 0.54 μSv / h, 0.59 μSv / h. The reason that the air dose rate of 2 m above the ground is higher than 1 m above the ground can be presumed to be the influence of radiation from surrounding forests. The ground facing the forest is about 1.5 times the air dose rate compared to the unfaced ground.

3.3 Correlation of Space Dose Rate in and outside the House

Dose rate at outdoor and at home is highly correlated with a correlation coefficient of 0.8(Fig.2). In the same housing investigation result in 2014, the correlation coefficient is 0.85 and so on. Residential housing in 2014 included houses before decontamination. At that time, the air dose rate in

decontaminated houses tended to be low. Reduction due to decontamination and natural decay is clear. We see the shielding effect by height for both inside and outside the house. The reduction rate on the floor surface is high and the reduction rate on the ceiling surface is low. We estimate that the dose from surrounding forests is affecting.

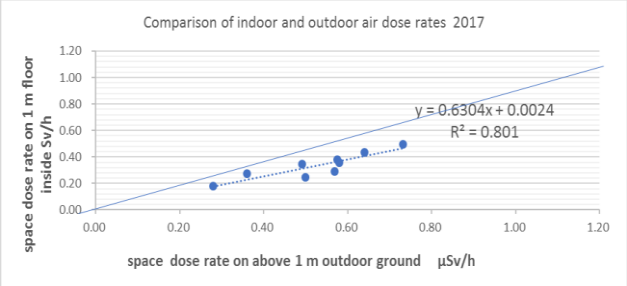

Fig. 2. Comparison of indoor and outdoor air dose rates 2017

3.4 Estimated annual exposure in indoor living space

Based on the average air dose rate of 1 m above the floor of the room and the average air dose rate over 1 m of the residential land, the annual exposure dose was estimated. We estimated at 9 houses as 16 hours indoor and 8 hours outdoor stay. The result was from 2.25 mSv per a year to 6.73 per a year. The average value is 4.58 mSv per a year, which is more than four times the general public exposure limit of 1 mSv per a year. In addition, assuming only gamma ray exposure from Cs, simply estimate the damping change of the annual exposure dose with natural half-life of 2 years for Cs 134 and 30 years for Cs 137. It can be estimated that 4.58 mSv per a year in 2017 will decay to 1 mSv per a year after about 50 years.

4. Content of radioactive cesium in soil of decontamination residential lot and mountain of the back

4.1 Residual amount of Cs of surface soil

As the cause of the high air dose rate even after decontamination, there is residual Cs in the mountain near the residential land and residential land. Within 20 meters of the mountain adjacent to the residential area, fallen leaves etc. of the surface layer are decontaminated. However, the topsoil of the mountain is not decontaminated. We measured the amount of Cs (Cs 134 + Cs 137) in the soil of 5 cm of the surface layer of the decontaminated residential area and the mountain. The ratio of Cs 134 to 137 is 1: 1 at the beginning of the disaster, roughly 1: 8 at the time of 2017 as six years later, the influence of Cs 137 is great in the future.

The depth of 5 cm of soil in the residential area ranges from 89 to 6844 Bq/kg, which is a recontamination of the surface layer of the residential land. The mountain was continually contaminated, and the maximum value of the surface layer of 5 cm was 41394 Bq / kg under the cedar tree. The average of Cs of the surface layer of the residential land is 2919 Bq / kg, and the average of the mountain is 17736 Bq / kg(Fig.3).

The surface soil of the mountain is contamination situation of Cs six times that of the residential land. After nuclear accident, the government formulated the law and set the radiation contamination countermeasure standard value at 8000 Bq / kg (its value is 80 times the value before the accident). Radioactive contaminated soil more than twice as much remains in the surface soil of the mountain near the residential land.

It is very unreasonable that evacuation has been lifted, which permits living reconstruction at such places.

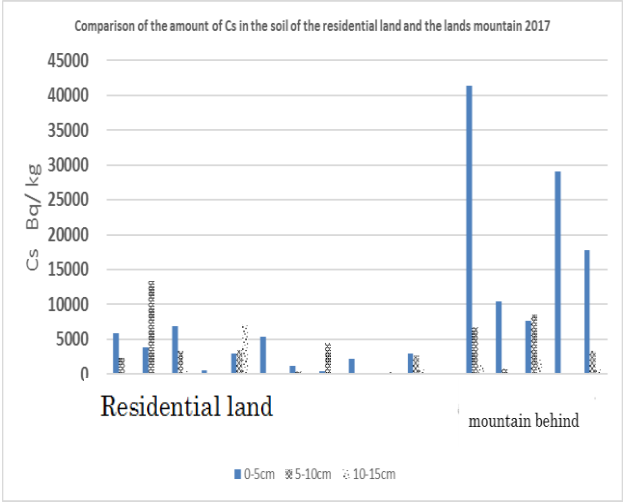

Fig.3. Comparison of the amount of Cs in the soil of the residential land and the lands mountain 2017

4.2 Characteristics of residual radioactive cesium by depth

We analyze the remaining situation of Cs by depth. 39% in the surface layer 5 cm and 37% in the 5 to 10 cm layer in the residential land. In 2014, about 90% of Cs adhered to the surface layer of 5 cm, but in 2017 after decontamination, it is about 40% in the surface layer of 5 cm. It can be inferred that the permeation and fixing of Cs into the soil are getting deeper.

The reason for this can be inferred as follows.

① Penetrate according to the nature of the soil.

② Cs penetrated into the layer of 5 cm or less by the decontamination operation. Prior to the decontamination work, the wild boar had soil disturbance to predispose earthworms, etc. As a result, Cs of the surface layer had entered the deep soil. After that, when decontaminating, the agitated soil was leveled. Then only 5 cm of the surface

layer was removed, and it can be inferred that Cs remained at a depth of 5 cm or less.

③ Even after being covered with new soil by decontamination, polluted leaves and contaminated rainwater from the surrounding forests have flowed to the new topsoil.

At the part facing the mountain at the decontaminated residential land, decontamination of about 10 cm is desired.

Cs in the mountain soil adjacent to the residential area remains about 80% at the surface layer of 5 cm and 15% even under the 5 to 10 cm layer thereunder. There is a strong tendency to remain in the surface layer 5 cm as compared with the residential land. Also, Cs of about 3000 Bq/kg remains even in the 5 to 10 cm layer, so some decontamination measures are required.

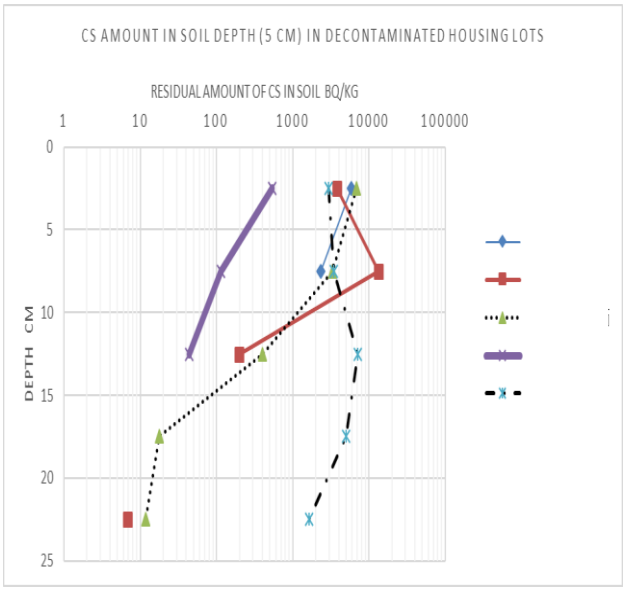

Fig.4. Cs amount in soil depth (5 cm) in decontaminated housing lot

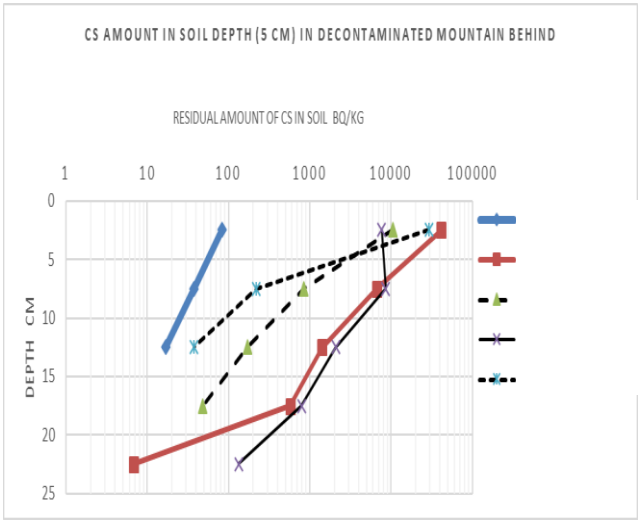

Fig.5. Cs amount in soil depth (5 cm) in mountain behind

5. Conclusions

In Iitate village where radioactive contamination by nuclear power plant accident occurred, evacuation was lifted, but people are not in a situation where people can live with peace of mind. There is still a 4 to 5 times exposure risk of 1 m per year for the general public's dose limit. It is irrational to release evacuation in a kind of "exceptional condition", the standard of radiation control areas, which is the standard for avoiding radiation before the accident. Radioactive contamination at decontamination residential land continues, indicating the limit of decontamination. Especially, the continuation of living held in the mountain adjacent to the residential land where terrible pollution continues is severe.

The villagers have been deprived of symbiotic living with mountains peculiar to rural villages, or "the right to reside in harmony with nature". Even if it is calculated from the half life of radioactive cesium, it is a future of more than 50 years that it can return to the state before the nuclear accident. It takes more than 100 years to safely live with forestry. The regeneration and resurrection of traditional rural life culture will be the future for more than 100 years.

This situation should be strongly recognized by the state, prefecture, village authorities and citizens. Measures and relief for victims of radioactive contamination (pollution victims of radioactive contamination) that are receiving the sorrow are increasingly needed.

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