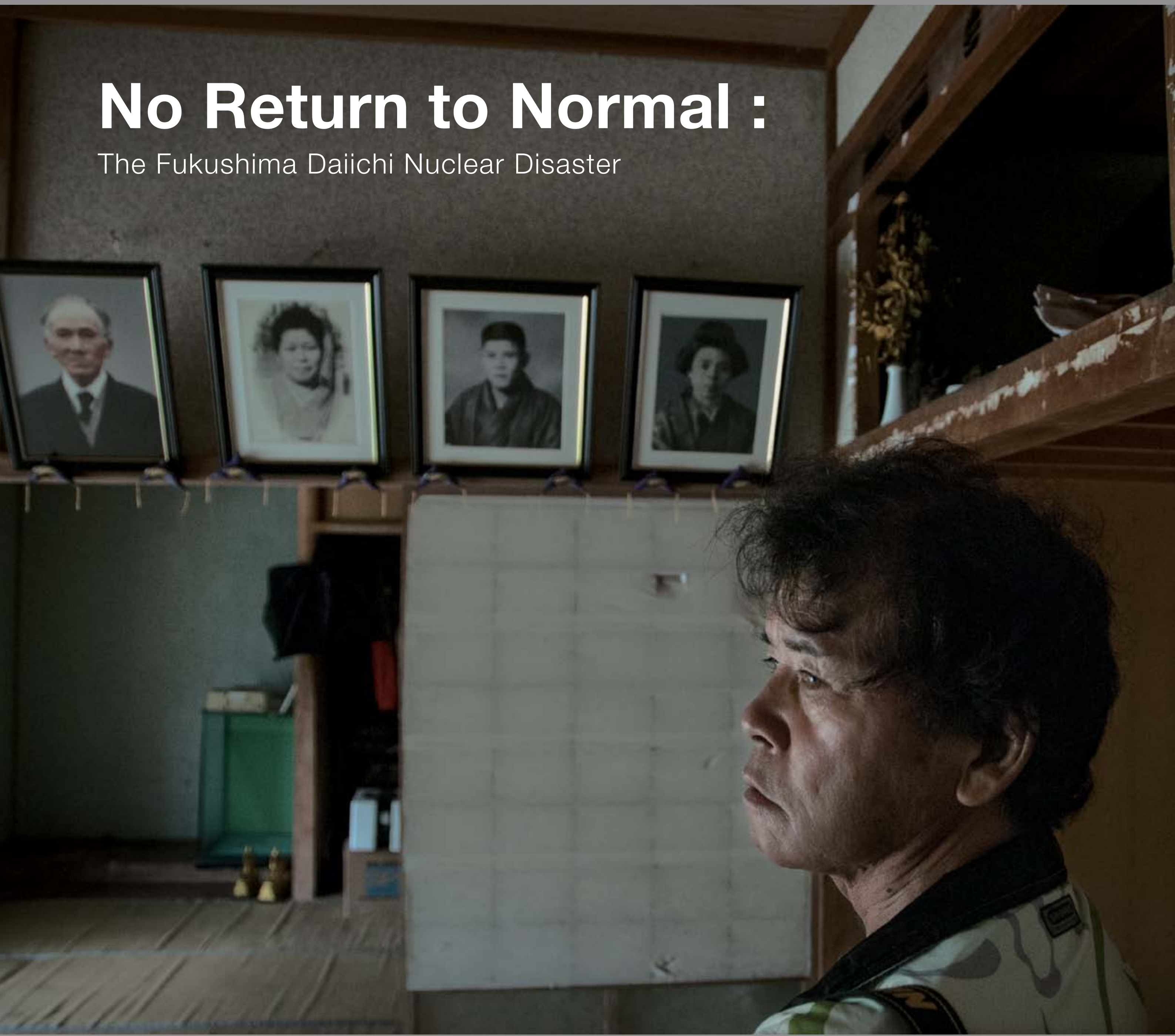
No Return to Normal :

The Fukushima Daiichi Nuclear Disaster



House Case Studies of the Current Situation and Potential Lifetime Radiation Exposure in Iitate, Fukushima Prefecture

GREENPEACE

February 2017

No Return to Normal : The Fukushima Daiichi Nuclear Disaster

House Case Studies of the Current Situation and Potential Lifetime Radiation Exposure in Iitate, Fukushima Prefecture

CONTENTS

February 2017

Data compiled and report written by
Jan Vande Putte, Greenpeace Belgium,
Heinz Smital, Greenpeace Germany,
Ai Kashiwagi, Greenpeace Japan,
Kazue Suzuki, Greenpeace Japan, Mai Suzuki,
Daul Jang, Greenpeace East Asia Seoul,
and Shaun Burnie, Greenpeace Germany;
the section 'Potential lifetime dose from
ground deposition for surveyed areas in Iitate'
was compiled under instruction from
Greenpeace Japan by Oda Becker[1].

Special thanks to house owners,
all the people who have supported
the Greenpeace radiation survey,
Dr. Rianne Teule,
Tetsuji Imanaka of Kyoto University
Research Reactor Institute,
and Oda Becker.

Cover photo : Mr. Toru Anzai in his house that he had to evacuate, a former resident of Iitate,
Fukushima Prefecture, November 2015
© Greenpeace

This page : Greenpeace soil sampling, Iitate, Fukushima Prefecture, November 2016
© Masaya Noda / Greenpeace

EXECUTIVE SUMMARY

The end of March 2017 marks the first time since 2011 when the people of Iitate in Fukushima prefecture will be able to return to their former homes. The Japanese government has set this date to lift evacuation orders, to be followed one year later by the termination of compensation payment. However, for the more than 6,000 citizens of Iitate, this is a time of uncertainty and anxiety. Iitate, which lies northwest of the destroyed reactors at Fukushima Daiichi power plant, was one of the most heavily contaminated by the 2011 nuclear disaster. The village of Iitate is over 200km^2, 75% of which is mountainous forest. Radiation levels in forests in Iitate, which were an integral part of the residents' lives prior to the nuclear accident, are comparable to the current levels within the Chernobyl 30km exclusion zone – an area that more than 30 years after the accident remains formally closed to habitation.[2]

Decontamination efforts have focussed in areas immediately around peoples homes, agricultural fields and in 20 meter strips along public roads. These efforts succeeded in generating millions of tons of nuclear waste which now lies at thousands of locations across the prefecture, but it has not reduced the level of radiation in Iitate to levels that are safe.

For people trying to make a decision on returning, a critical question that remains unanswered by the Japanese government is what radiation dose will they be subjected to, not in one year but over decades, in fact over a lifetime.

It was this question that a Greenpeace radiation survey team in 2016 sought to answer.

Greenpeace has been surveying Iitate since late March 2011, when it was the first to call for its evacuation. In our latest survey conducted in November 2016, the objective was to collect thousands of radiation measurements in designated zones at houses in Area 2 of Iitate. It is this area that will have its evacuation order lifted in March 2017 according to the Japanese government.

In addition to measurement data, which provided a weighted average for the zones, the survey work also included soil sampling with analysis in a Tokyo laboratory, measurement of radiation hot spots and recovery of dose badges that had been installed in two houses in February 2016.

The weighted average for the surveyed houses clearly indicate a higher risk for citizens if they were to return to Iitate. The dose range was between 39mSv and 183mSv over a 70 year lifetime from a period beginning in March 2017. This does not include natural radiation exposure dose rates expected over a lifetime, nor does it include the external and internal doses received during the days, weeks and in the case of Iitate several months, following the March 2011 Fukushima Daiichi nuclear accident. The International Commission on Radiological Protection (ICRP) recommendations for the public, sets the maximum recommended dose of 1mSv a year.[3,4] The Japanese government, International Atomic Energy Agency (IAEA) and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) have so far failed to provide data on estimated lifetime exposure for Fukushima citizens if they were to return to their former homes.

The dose badge data for Iitate citizen, Mr. Toru Anzai, suggest a possible overestimation of the shielding factor applied by the Japanese authorities for a wooden house, which reduces the inside radiation to 40% of the outside radiation. Whereas

© Masaya Noda / Greenpeace

Greenpeace radiation survey, Iitate, Fukushima Prefecture, November 2016.

the average measured level outside the house was 0.7 μSv/h which would equal 2.5 mSv/yr, based on government shielding estimates, the dose badges inside the house showed values in the range between 5.1 to 10.4 mSv/yr. The Japanese government's long-term decontamination target is 0.23 μSv/h which would give a dose of 1 mSv/yr.

Clearly the radiation dose rates at the surveyed houses in Iitate show that the government targets are far from being realized. The relatively high radiation values both inside and outside houses show a heightened radiation risk for citizens that were to return to Iitate. Risks that the Japanese government has chosen to ignore.

Our conclusion is that the highly complex radiological emergency situation in Iitate, and with a high degree of uncertainty and unknown risks, means that there is no return to normal in Iitate, Fukushima prefecture.

Recommendations:

- The government must not continue with its return policy which ignores Fukushima citizens and which ignores science based analysis, including potential lifetime exposure risks;
- The government should establish a fully transparent process to reflect and consider residents opinions on evacuation policy, including opening a forum of citizens including all evacuees;
- The government should provide full financial support to evacuees, and take measures to reduce radiation exposure based on the precautionary principle to protect public health and allow citizens to decide whether to return or relocate free from duress and financial coercion.

1. INTRODUCTION

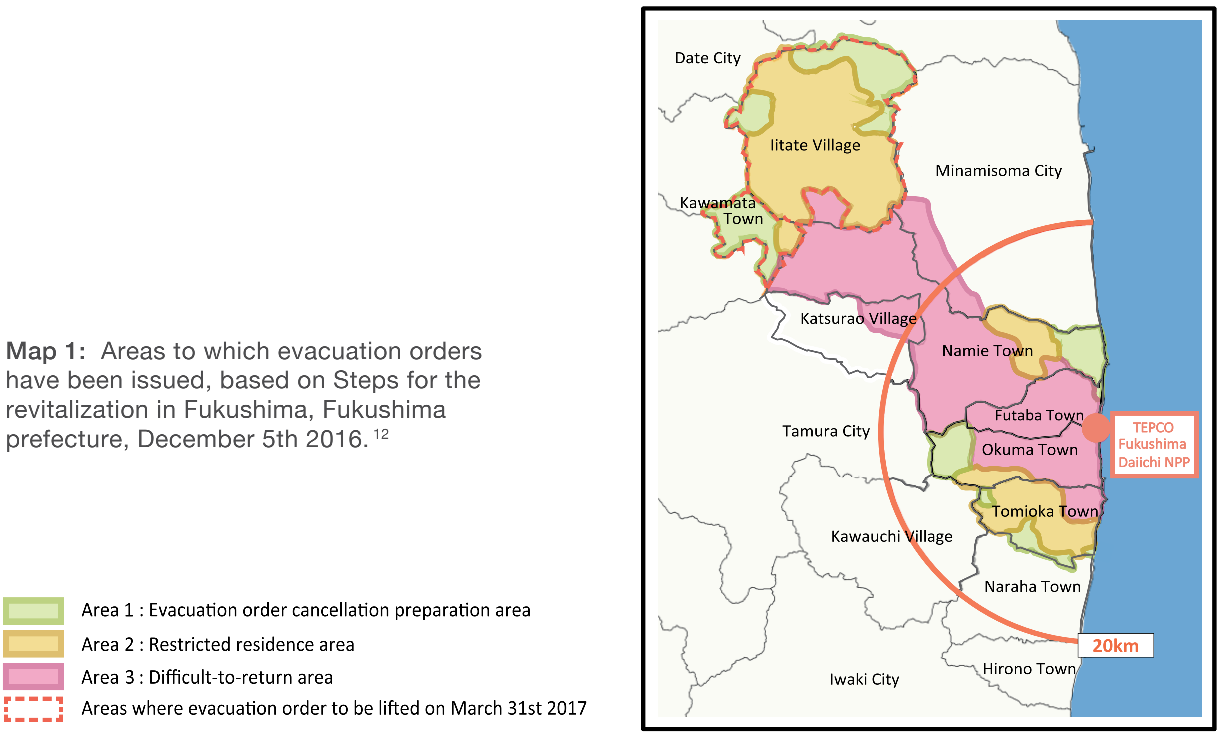
Greenpeace radiation survey of Mr. Toru Anzai's house, Iitate, Fukushima Prefecture, November 2016.

The Fukushima Daiichi nuclear catastrophe, which began in March 2011, has had enormous consequences for the people of Japan. Over 160,000 people were evacuated and displaced from their own homes, many tens of thousands of whom, six years after the start of the accident, remain living in 'temporary' accommodation. However, the Abe government is determined to try to normalize a nuclear disaster, creating the myth that just years after the widespread radioactive contamination caused by the nuclear accident of 11 March 2011, people's lives and communities can be restored and reclaimed. By doing so, it hopes, over time, to overcome public resistance to nuclear power.

The Abe government's attempt at normalization of areas of Fukushima that remain radiologically contaminated was crystallized into policy in June 2015, when a new plan was approved that will determine the future of tens of thousands of Japanese citizens from Fukushima prefecture.[5] The Abe government decided to lift restrictions on areas of Fukushima where today the radiation levels remain well above the government's long-term decontamination target of 0.23 μSv/h.[6] One area of particular concern is Iitate village, which is over 200km^2 – approximately 75% of which is mountainous forest, with homes and agricultural fields interspersed throughout the wooded landscape. The population of Iitate in March 2011 was 6,200. Located between 28km and 47km from the Fukushima Daiichi nuclear power plant, Iitate was particularly affected by radioactive releases from the disaster on the nights of March 15 and 16, 2011 due to weather patterns that carried radioactivity northwest from the nuclear power plant.[7] With radioactive decay of shorter-lived radionuclides, the principle radioactive material of concern as of today and into the future is radioceasium, particularly Cs-137 which has a half-life of 30 years. It takes ten half-lives (300 years) to reach a level of 1:1000 of the original contamination.[8] Along with other areas of Fukushima prefecture, Iitate was designated for radioactive decontamination in 2012. In Iitate, there are Areas 2 and 3 are within the so called Special Decontamination Area (SDA).[9] The target area for the lifting of evacuation in March 2017 is Area 2 where annual radiation dose today could exceed 20mSv each year if people were to live there. This is significantly higher than the internationally accepted standard that maximum public exposure should not exceed 1mSv per year, and which forms the basis for the government's long-term targets. Iitate also has higher contaminated land in designated Area 3, which remains closed to habitation, though the government aims of lifting evacuation orders by 2022 for part of such areas.[10]

The government will also terminate compensation payments for the citizens of these areas one year after orders are lifted. As a result, more than 6,000 Iitate citizens are confronted with having to make a decision as to whether to return to their houses. A critical factor for the people of Iitate, and the wider population of Fukushima, is the level of radiation they would be exposed to not just over the coming few years, but over the coming decades. Until now the Japanese government has exclusively focussed on annual radiation exposure and not the potential radiation dose rates returning citizens could potentially face over their entire lifetime.

Over the past six years, Greenpeace radiation survey teams have investigated the level of radioactive contamination resulting from the accident. This report focusses on homes in the village of Iitate, and where our first investigation was conducted in late March 2011, and subsequently a total of 5 surveys have been conducted between 2011-2016.[11]



Map 1: Areas to which evacuation orders have been issued, based on Steps for the revitalization in Fukushima, Fukushima prefecture, December 5th 2016.[12]

2. SURVEY METHODOLOGY

Following on from our survey work in Iitate in 2015, in November 2016, a Greenpeace radiation survey team conducted research in seven houses within Area 2 in Iitate. These were randomly selected based upon personnel exchange with the owners.

The Greenpeace team used two different methods for survey work at each house:

Scanning: systematic measurements:

- Ambient dose rate at 1m with a high-efficient and calibrated NaI scintillator (Georadis RT30: 2000cps / μSv.h-1 (Cs-137) with 1 measurement each second.
- High-precision GPS (GNSS Trimble R1) with external antenna and <1m precision, with 1 set of gps-coordinates / second.
- Walking in systematic way, without searching for hotspots, where possible in a grid pattern.
- The area around the house is divided into zones (typically: a field, path, and around the house) and each measured separately. We defined 10 - 15 zones around each house, with a minimum of 100 measurement points per zone, and a median range of 200 - 300 points per zone. The overall total of points for each house ranged between 3,000 - 5,000 points.
- Statistics are collected for each of these zones (average, minimum and maximum for each zone). The average of all the zones of one house is calculated as a weighted average, with the same weight for each zone. This also allows a comparison between different years (as the number of measurement points for each year is not identical).

In addition, hotspots and points of interest were identified and measured as follows:

- Ambient dose rate at 10 / 50 / 100cm using a NaI scintillator (Radeye PRD-ER) and GPS position from handheld Garmin Montana 650 were used;
- These points were collected for each of the defined zones.

In addition to radiation scanning, soil samples were collected. These samples were then analyzed in the independent Japanese laboratory 'Chikurin'[13] and used to verify the Cs-137 and Cs-134 ratio.

Ai Kashiwagi, Greenpeace radiation survey House A, Iitate, Fukushima Prefecture, November 2016.

3. 2016 IITATE SURVEY RESULTS

© Masaya Noda / Greenpeace

Mai Suzuki, Greenpeace radiation survey, Iitate, Fukushima Prefecture, November 2016.

In November 2016, Greenpeace surveyed seven houses in Iitate. In this report, we include details of the farmhouse of Mr. Toru Anzai located in Area 2 in the south east of Iitate, 35km from the Fukushima Daiichi nuclear power plant. Mr. Anzai evacuated from his home on 24 June 2011. Greenpeace first surveyed Mr. Anzai's house in July 2015[14] with the survey methodology explained above. Summary results of surveys of six other houses are included below, though these owners' names are not included due to their wish to remain anonymous.

Image 1: Aerial image of Mr. Anzai's house, Iitate, Fukushima prefecture, July 2015.

© Marco Kuhne / Greenpeace

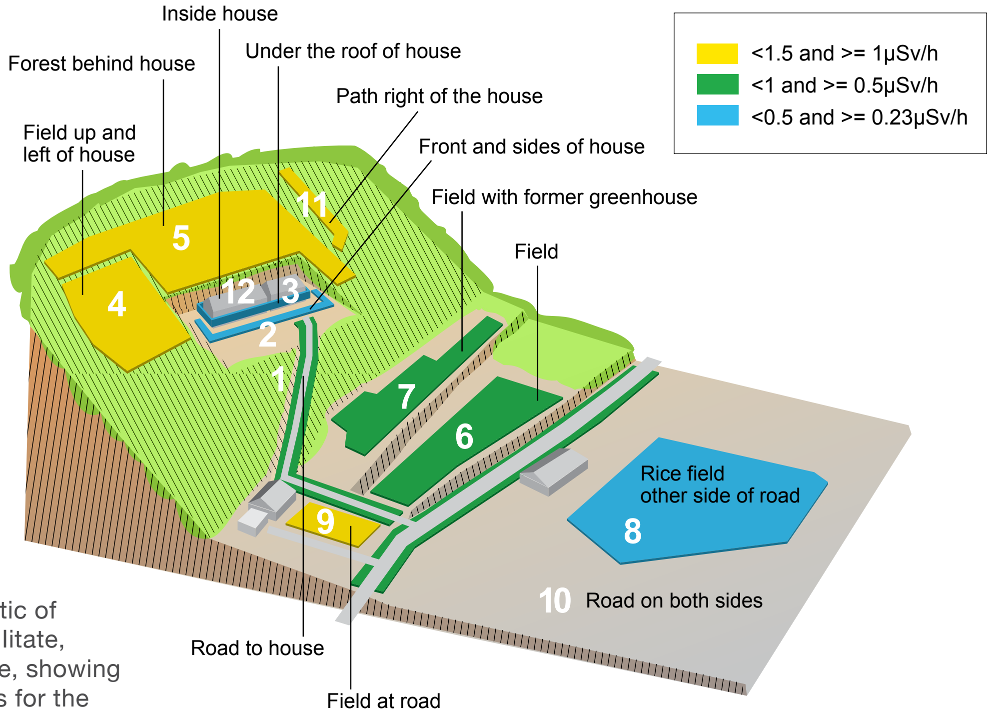


Diagram 1: Schematic of Mr. Anzai's house in Iitate, Fukushima prefecture, showing the designated zones for the Greenpeace radiation survey team.

Mr. Anzai's house, and the surrounding area, was decontaminated by the authorities during the period 2014 - 2015. This involved scraping away a layer of more than 5cm of topsoil, which was then removed from the site and stored as radioactive waste. In some cases, the surface was recovered with uncontaminated soil.

Survey result at Mr. Anzai's house in 2016 and 2015 is shown at Table 1. Additional data from the house survey is contained in Appendix 1.

Diagram 1 shows the location and boundaries of the 11 survey zones around Mr. Anzai's house. A total of 3,061 measuring points were taken. At the time of the 2016 survey, the decontamination work had been finished for all zones except for Zone 5. When conducting the survey in October 2015 decontamination work was still in progress, which means that the measured decrease is a combined effect of further decontamination, decay and erosion.

Zone name		2016						2015				
		Max (μSv/h)	Average (μSv/h)	Average % of 2015	# points	Above 0.23 μSv/h	Above 1 μSv/h	Max (μSv/h)	Average (μSv/h)	# points	Above 0.23 μSv/h	Above 1 μSv/h
Zone 1	Road to house	0.8	0.6	58%	264	100%	0%	1.4	1.1	481	100%	78%
Zone 2	Front and sides of house	0.7	0.3	60%	301	87%	0%	1.3	0.6	234	100%	4%
Zone 3	Under the roof of house	0.7	0.4	57%	169	98%	0%	1.2	0.7	573	100%	11%
Zone 4	Field up and left of house	1.5	1.1	61%	283	100%	88%	2.3	1.9	524	100%	100%
Zone 5	Forest behind house	1.5	1.0	75%	358	100%	53%	2.2	1.4	814	100%	71%
Zone 6	Field	1.1	0.8	69%	327	100%	2%	2.0	1.2	1,126	100%	73%
Zone 7	Field with former greenhouses	1.6	0.8	n/a	578	100%	18%	n/a	n/a	n/a	n/a	n/a
Zone 8	Rice field other side of road	0.6	0.3	23%	239	98%	0%	1.7	1.4	332	100%	100%
Zone 9	Field at road	1.5	1.0	n/a	103	100%	30%	n/a	n/a	n/a	n/a	n/a
Zone 10	Road on both sides	1.0	0.6	48%	194	100%	1%	2.6	1.3	592	100%	95%
Zone 11	Path right of the house	1.5	1.0	n/a	245	100%	50%	n/a	n/a	n/a	n/a	n/a
Zone 12	Inside house	n/a	n/a	n/a	n/a	n/a	n/a	0.9	0.5	817	100%	0%
Total=weighted average		1.6	0.7	67%	3,061	98%	23%	2.6	1.1	5,493	100%	58%

Table 1: Radiation measurement data from Mr. Anzai's house, comparing results in 2016 and 2015. The maximum μSv/h cited are those taken during the systematic measurements, not hot spot areas. (see below)

Overall, for all the zones outside Mr. Anzai's house, the weighted average from November 2016 is 0.7 microsievert per hour (μSv/h), which is 67% of the 2015 weighted average of 1.1μSv/h. The most significant decrease of radiation is measured in Zone 8, which has been decontaminated (5cm of topsoil removed) subsequently covered with a layer of uncontaminated soil. The new soil layer shields quite effectively the residual radiation underneath. This gives a decrease of radiation from an average of 1.4μSv/h in October 2015 to 0.3μSv/h in November 2016.

The decontamination was, however, much less effective in Zone 5. As can be seen in Diagram 1, the farmhouse is located with a steep forested slope behind. This is similar to many houses in Iitate, which are also located in close proximity to hillside forests. It is not possible to decontaminate these forests.

As is standard practice throughout the contaminated regions, up to 20 meters from Mr. Anzai's house into the forest has been 'de-contaminated'. In Zone 5 including non-decontaminated area, we measured a decrease from an average of 1.4μSv/h in 2015 to 1.0μSv/h in 2016, which is explained by both decay and erosion, and a maximum of 1.5μSv/h. The radiation levels on the steep slope close to the house is quite important as it has a direct impact on the radiation levels inside the house. Also, we could expect that contamination from the non-decontaminated forest might re-contaminate the already decontaminated area below closer to the house.

All measuring data was collated, together with the results of soil sample analysis, and formed the basis of calculations on the potential range of lifetime doses that Mr. Anzai and his family members would potentially be exposed to if they were to return permanently.

Greenpeace will conduct a follow-up survey in the coming years, which will further clarify to what extent radiation levels are still decreasing due to erosion and decay. It might also be possible that in some zones, radiation levels will not decrease but increase due to re-contamination through migration of radionuclides from the nearby forested mountain slopes.

Greenpeace radiation survey team discuss with Mr. Toru Anzai, Iitate, Fukushima Prefecture, November 2016.

House A

Zone name		2016						2015				
		Max (µSv/h)	Average (µSv/h)	Average % of 2015	# points	Above 0.23 µSv/h	Above 1 µSv/h	Max (µSv/h)	Average (µSv/h)	# points	Above 0.23 µSv/h	Above 1 µSv/h
Zone 1	Under roof house	0.4	0.2	86%	272	26%	0%	0.5	0.2	104	52%	0%
Zone 2	Front house and car park	0.5	0.2	96%	280	41%	0%	0.4	0.2	77	45%	0%
Zone 3	Under roof car park	0.7	0.3	75%	132	54%	0%	1.3	0.4	48	71%	6%
Zone 4	Right of car park	0.6	0.4	96%	245	100%	0%	0.6	0.4	143	100%	0%
Zone 5	Field right of house	0.6	0.3	91%	321	90%	0%	0.5	0.3	151	97%	0%
Zone 6	Road to shrine	1.1	0.4	70%	1,440	93%	0%	1.5	0.6	466	100%	7%
Zone 7	Inside house	0.2	0.1	94%	382	0%	0%	0.2	0.1	105	0%	0%
All points around house		1.1	0.3	86%	2,690	79%	0%	1.5	0.4	989	89%	4%

Table 2: Radiation measurement data from House A, comparing results in 2016 and 2015.

Greenpeace conducted surveys of this central Iitate house and property in October 2015 and November 2016. Prior to the Greenpeace survey in October 2015, all areas measured, including the house itself, had already been designated as decontaminated. Radiation levels outside the house (including a public road to a shrine) are 14% lower in 2016 compared to 2015 (weighted averages).

As Table 2 shows, the highest contamination is still found around the covered car park (Zone 3), where radiation had accumulated on the ground under the perimeter of the roof as a result of rain runoff. The maximum dose rate at 1m high decreased from 1.3 to 0.7µSv/h between 2015 and 2016. Overall, there was an average decrease of 25%. Although no further decontamination was reported to Greenpeace between 2015 and 2016, this decline perhaps suggests otherwise, or is as a result of dispersal through weathering, including heavy rains.

Along the road from the house to the shrine (Zone 6), a decrease of approximately 30% was measured. It is likely that this is a result of further decontamination along this public road, which passes a school.

As the house is located in a flat area in the central village, the risk for re-contamination from non-decontaminated areas is low. We could expect radiation levels to further decrease, but only very slightly over the next year. Around the house itself (excluding the public road), we would expect a decrease of only a few percent.

House B

Zone name		2016						2015				
		Max (µSv/h)	Average (µSv/h)	Average % of 2015	# points	Above 0.23 µSv/h	Above 1 µSv/h	Max (µSv/h)	Average (µSv/h)	# points	Above 0.23 µSv/h	Above 1 µSv/h
Zone 1	Along road	0.8	0.5	39%	199	100%	0%	2.7	1.3	254	100%	78%
Zone 2	Path to house	0.6	0.5	n/a	68	100%	0%	n/a	n/a	n/a	n/a	n/a
Zone 3	Front and side of house	1.0	0.6	n/a	96	100%	1%	n/a	n/a	n/a	n/a	n/a
Zone 4	Under roof	1.6	0.7	67%	215	100%	26%	2.2	1.1	240	100%	56%
Zone 5	Back of house	1.0	0.8	53%	68	100%	1%	2.3	1.5	415	100%	90%
Zone 6	Field left of house	2.2	1.1	n/a	433	100%	76%	n/a	n/a	n/a	n/a	n/a
Zone 7	Field greenhouse	1.2	0.8	68%	279	100%	5%	2.0	1.1	404	100%	77%
Zone 8	Field with trees	1.6	1.2	n/a	183	100%	81%	n/a	n/a	n/a	n/a	n/a
Zone 9-10	Rice field and field	1.5	0.8	54%	804	100%	29%	1.8	1.5	560	100%	100%
Zone 11	Forest left	1.3	0.7	n/a	155	99%	14%	n/a	n/a	n/a	n/a	n/a
Zone 12	Forest behind house	n/a	n/a	n/a	n/a	n/a	n/a	2.7	2.0	404	100%	100%
All points		2.2	0.8	54%	2,500	100%	32%	2.7	1.4	2,277	100%	80%

Table 3: Radiation measurement data from House B, comparing results in 2016 and 2015.

For this house, the 2016 measurements were made in more detail and more extensively than in 2015, which explains the larger number of zones. The weighted overall average has declined from 1.4 to 0.8μSv/h as seen in Table 3, which is explained partially by ongoing decontamination work which was finalized before November 2016.

House C

Zone name		2016				
		Max (μSv/h)	Average (μSv/h)	# points	Above 0.23 μSv/h	Above 1 μSv/h
Zone 1	Road	0.6	0.3	309	88%	0%
Zone 2	Under roof	0.4	0.2	181	49%	0%
Zone 3	Around house	0.8	0.3	543	73%	0%
Zone 4	Field left	0.8	0.4	232	100%	0%
Zone 5	Field back	0.7	0.5	478	100%	0%
Zone 6	Field right	0.6	0.4	169	100%	0%
Zone 7	Around office and path	0.7	0.4	533	92%	0%
Zone 8	Factory field	1.1	0.4	1,242	78%	0%
Zone 9	Field near factory	1.6	0.9	1,329	100%	33%
Zone 10	Forest path left house	1.1	0.8	189	100%	6%
Zone 11	Forest around house	1.1	0.7	911	99%	3%
All points		1.6	0.5	6,116	90%	8%

Table 4: Radiation measurement data from House C.

This house is located in the northern (and generally less contaminated) part of Iitate. There were no measurements done in 2015. The decontamination for designated area had been finalized before our measurements in November 2016. Table 4 shows the fields had been decontaminated and covered with a layer of non-contaminated soil. The forest is an area uphill (Zone 11), above the house and was mostly not decontaminated, we measured an average of 0.7μSv/h in this area. The area around the factory (Zone 9) is a downhill area below the house. There is no conclusive explanation for the relatively high radiation levels of this area which had been decontaminated. Possibly, radioactive contamination has been washed down in the years since 2011 with snow melt and rainfall.

House D

Zone name		2016				
		Max (μSv/h)	Average (μSv/h)	# points	Above 0.23 μSv/h	Above 1 μSv/h
Zone 1	Road both sides	1.7	0.9	720	100%	35%
Zone 2	Rice field	1.8	1.3	501	100%	100%
Zone 3	Roof front	2.6	1.3	111	100%	67%
Zone 4	Around house	2.2	1.4	148	100%	95%
Zone 5	Path and front of the house	2.3	1.2	407	100%	74%
Zone 6	Inside garage	1.4	0.9	132	100%	27%
Zone 7	Field in front garage	1.7	1.3	189	100%	100%
Zone 8	Forest	2.0	1.5	520	100%	100%
Zone 9	Mushroom area	2.0	1.4	562	100%	98%
All points		2.6	1.2	3,290	100%	78%

Table 5: Radiation measurement data from House D.

This house is located in the southern (and generally higher contaminated) part of Iitate. There were no Greenpeace measurements conducted in 2015. This house has not been decontaminated and will not be in the future. As been seen in Table 5, the highest average contamination is found in the non-decontaminated forest (Zone 8) (1.5μSv/h).

House E

Table 6: Radiation measurement data from House E.

Zone name		2016 Max (µSv/h)	Average (µSv/h)	# points	Above 0.23 µSv/h	Above 1 µSv/h
Zone 1	Road	1.1	0.6	297	100%	1%
Zone 2	Field right	1.4	0.6	500	100%	4%
Zone 3	Front of house	0.7	0.5	106	100%	0%
Zone 4	Behind and side house	3.0	1.4	447	100%	65%
Zone 6	Path to left house	2.3	1.2	191	100%	62%
Zone 7	Greenhouse close to House	2.7	1.2	390	100%	66%
Zone 8	Far greenhouse	2.0	1.2	370	100%	91%
Zone 11	Farmland for cow	3.0	1.4	848	100%	70%
All points		3.0	1.0	3,149	100%	52%

This house is located in the southern part of Iitate. Decontamination had been finalized before the measurements in November 2016. It was quite surprising to find that some of the highest contamination was very close to the house (Zone 4), with dose levels up to 3µSv/h. As is shown in Table 6, the highest average was 1.4µSv/h. Although no measurements were done inside the house, it is expected that this has a significant impact on the radiation levels inside the house, due to our findings revealed by the placement of dose badges inside Mr. Anzai's house and House A.

House F

Table 7: Radiation measurement data from House F.

Zone name		2016 Max (µSv/h)	Average (µSv/h)	# points	Above 0.23 µSv/h	Above 1 µSv/h
Zone 1	Forest mushrooms	2.0	1.6	536	100%	100%
Zone 2	Field decontaminated	1.6	0.7	407	100%	11%
Zone 3	Greenhouse	1.0	0.6	100	100%	2%
Zone 4	Back of house	1.4	0.9	165	100%	42%
Zone 5	Front of house	1.1	0.6	303	100%	3%
Zone 6	Under roof	0.7	0.5	133	98%	0%
Zone 7	Pond and greenhouse	1.2	0.8	221	100%	14%
Zone 8	Field decontaminated	0.9	0.5	409	100%	0%
All points		2.0	0.8	2,274	100%	32%

This house is located in the southern part of the Iitate. The decontamination had been finalized before the measurements in November 2016. Zone 1 had an average dose rate of 1.6µSv/h. As can been seen in Table 7, some of the highest contamination was also found very close to the house, similar to our findings at House E. Zone 4 (back of the house) averaged a dose rate of 0.9µSv/h. Although no measurements were done inside the house, it is expected that this has a significant impact on the radiation levels inside the house.

4. PROJECTIONS ON DOSE RATE AND LIFETIME EXPOSURE BADGES

Imanaka of Kyoto University Research Reactor Institute et al. have assessed the potential long-term radiation exposures for former Iitate residents, if they were to return. An analysis published in October 2016 projects the dose rate (μSv/h) over 50 years.[15] This takes the decay of both Cs-134 (half-life: 2y) and Cs-137 (half-life: 30y) into account. In an area with a dose rate of 1μSv/h in 2016, the level would be roughly 0.2μSv/h in 2066.

Inspired by this approach, Greenpeace commissioned research from nuclear physicist Oda Becker to further calculate what the total dose would be over a period of either 50 or 70 years.

The results of that are summarized Chapter 5.

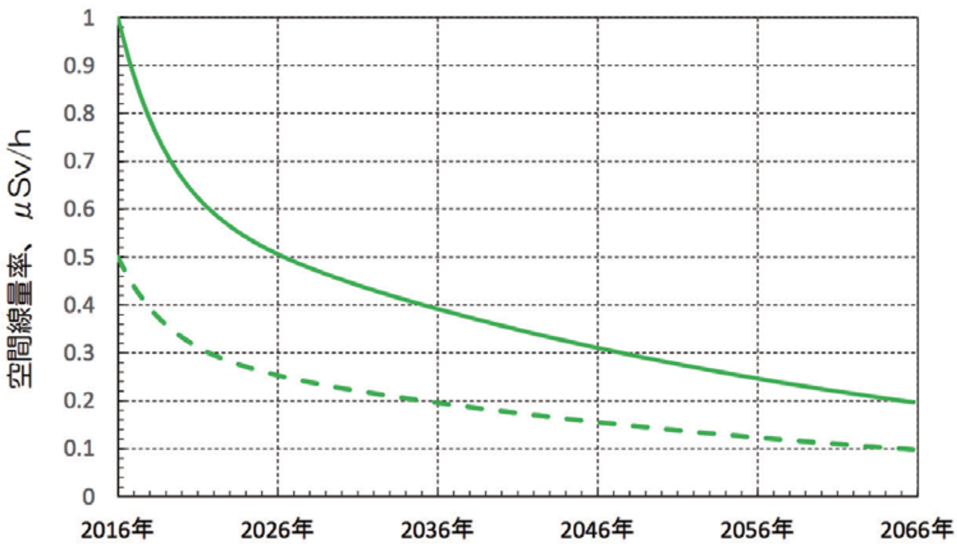


Chart 1: Prediction of air dose rate transition in the cases, 1 μSv/h and 0.5 μSv/h on 1st January 2016.

The Original chart title is 放射線量率の推移予想：2016年1月1日に1μSv/h の場合と0.5μSv/h の場合, from the report titled 飯舘村上飯樋地区の空間放射線の現状調査報告 on 29th October 2016.
http://www.rri.kyoto-u.ac.jp/NSRG/Fksm/kamiiitoi2016-10-9.pdf

5. POTENTIAL LIFETIME DOSE FROM GROUND DEPOSITION FOR SURVEYED AREAS IN IITATE

According to Imanaka,[16] radiocesiums (Cs-137 and Cs-134) contributed to almost all (98%) of the long-term cumulative exposure. During the Fukushima nuclear disaster, equal amounts of Cs-137 and of Cs-134 were released. Thus, the ratio of ground-deposition of Cs-137 and Cs-134 was 1 on March 15, 2011.

As a result of the different decay constants, this ratio had changed to 6.41 on December 4, 2016 (see Table 8). On behalf of Greenpeace, the laboratory Chikurin in Japan conducted soil tests, and the results showed a ratio of Cs-137 / Cs-134 of 6.55 ±0.12. This ratio corresponds to the expected ratio that would result from the decay time differential, and it is therefore appropriate to use the measured ratio to calculate possible long-term and lifetime doses. Due to the long half-life of Cs-137 (30y), the decline of the dose rates will take several decades (see Table 11).

For a dose rate of 1µS/h on the date of measurement (November 25, 2016), the possible dose for people after resettlement on March 31, 2017 has been calculated using the specific decay constants and dose factors. Integrating the dose[17] rates over long periods (70 years) results in potential lifetime doses (see Table 9).

Nuclide	Decay constant λ (s^{-1})	Dose factor ground radiation (Sv/s)/(Bq/m²)	15-Mar-11		4-Dec-16	
			Ground deposition (kBq/m²)	Ratio Cs-137/Cs-134	Ground deposition (kBq/m²)	Ratio Cs-137/Cs-134
Cs-134	1.10E-08	1.50E-15	100	1	14	6.41
Cs-137	7.30E-10	5.30E-16	100		88	

Table 8: Calculation of the theoretical ratio of Cs-137/Cs-134 on the 4-December 2016.

Action			**Release**		**Measure-ments**	**Soil samples**			**Resettlement**		**Lifetime Dose**
Date			15-Mar-11		25-Nov-16	4-Dec-16			31-Mar-17		30-Mar-87
Nuclide	Decay constant λ (s^{-1})	Dose factor ground radiation (Sv/s)/(Bq/m²)	Ground deposition (kBq/m²)	Dose rate (µSv/h)	Dose rate (µSv/h)	Ground deposition (kBq/m²)	Dose rate (µSv/h)	Ratio Cs-137/Cs-134	Ground deposition (kBq/m²)	Dose rate (µSv/h)	Dose 70 years (mSv)
Cs-134	1.10E-08	1.50E-15	414.94	2.24	0.30	55.87	0.30	6.55	50.04	0.27	6.82
Cs-137	7.30E-10	5.30E-16	414.94	0.79	0.70	365.97	0.70		363.31	0.69	211.18
Total					**1.00**		**1.00**			**0.96**	**218.01**

Table 9: Calculation of lifetime doses assuming a dose rate of 1 µSv/h on the 4th December 2016.

When calculating the external irradiation from deposited radionuclides it is necessary to consider a reduction in exposures from being indoors and the shielding effects of the building materials. Wooden houses are the most common type of houses in Fukushima. According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)[18] wooden houses provide a shielding which reduces the inside gamma radiation to 40 % of the outside radiation. As such, this was applied to our calculation, however, there is a question over the shielding factor as it applies to Mr. Anzai and House A, as a result of our dose badge results that require further investigation (see Chapter 7).

For this analysis, we calculated two separate scenarios to account for lifestyle differences. The first scenario assumed that an individual spent an average of 8 hours per day outside, as is the standard Japanese government calculation assumption. The second scenario assumed a person spent 12 hours a day outside (see Table 10).

It should be noted that for people living in this rural area, the standard used by the Japanese authorities of spending only 8h / day outside is for many people an underestimation. Residents in this agriculture and forestry-dependent region mostly worked and lived outside prior to the Fukushima nuclear disaster, particularly during the spring, summer, and autumn seasons. Even during the winter period, work is conducted outside, for example in the forest.

	Lifetime dose (70 years)		
Dose rate (μSv/h)	24 h outside (mSv)	12 h outside (mSv)	8 h outside (mSv)
0.1	22	15	13
0.2	44	31	26
0.3	65	46	39
0.4	87	61	52
0.5	109	76	65
0.6	131	92	78
0.7	153	107	92
0.8	174	122	105
0.9	196	137	118
1.0	218	153	131
1.1	240	168	144
1.2	262	183	157
1.3	283	198	170
1.4	305	214	183
1.5	327	229	196
1.6	349	244	209
1.7	371	259	222
1.8	392	275	235
1.9	414	290	249
2.0	436	305	262
2.1	458	320	275
2.2	480	336	288
2.3	501	351	301
2.4	523	366	314
2.5	545	382	327
2.6	567	397	340
2.7	589	412	353
2.8	610	427	366
2.9	632	443	379
3.0	654	458	392

Table 10: Lifetime dose (70 years) corresponding to different dose rates and durations of stay outside.

	Dose rate (μSv/h)								
Nuclide	1-Jan-16	1-Jan-26	1-Jan-36	1-Jan-46	1-Jan-56	1-Jan-66	1-Jan-76	1-Jan-86	1-Jan-96
Cs-134	0.37	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cs-137	0.63	0.50	0.40	0.31	0.25	0.20	0.16	0.12	0.10
Total	**1.00**	**0.51**	**0.40**	**0.31**	**0.25**	**0.20**	**0.16**	**0.12**	**0.10**

Table 11: Changing of the dose rates for the next 80 years starting with 1 μSv/h on the 1st January 2016.

© Masaya Noda / Greenpeace

6. LIFETIME EXPOSURE IITATE HOUSE SURVEY RESULTS

Jan Vande Putte, Greenpeace radiation specialist inside House A, Iitate, Fukushima Prefecture, November 2016.

Based upon both the results of our radiation survey case studies and Oda Becker's calculations (Table 12), the potential lifetime exposure dose for the houses in Iitate included in our research is considerable. These would range between 39mSv and 183mSv over 70 years, over and above the expected lifetime exposure due to natural sources.

In the case of Mr. Anzai's house, the measuring data showed a weighted average of 0.7μSv/h, which would result in a 70-year lifetime dose between 92 and 107mSv (8 hours and 12 hours per day outside, respectively).[19]

House	Weighted Average dose rate (μSv/h)	8 hours outside (mSv)	12 hours outside (mSv)
Mr. Anzai	0.7	92	107
A	0.3	39	46
B	0.8	105	122
C	0.5	65	76
D	1.2	157	183
E	1.0	131	153
F	0.8	105	122

Table 12: Potential lifetime exposure over 70 years for surveyed houses in Iitate, Fukushima Prefecture.

7. DOSE BADGES

In addition to the survey measurement and soil sampling, Greenpeace installed four dose badges inside and around Mr. Anzai's house and House A in February 2016.[20] These were left in place for 281 and 282 days, respectively, and recovered in November 2016. These flat glass environmental dose badges are used for the measurement of environment equivalent dose H.[21] This was done in order to provide additional information about the potential doses that could be received at these specific locations over an extended period of time.

In Mr. Anzai's house, the badges were installed in the kitchen, the living room, the bathroom toilet, and in a tool cabinet. During the measurement period, the kitchen was rebuilt. While it is no longer a kitchen, the dose badge was not moved during this period.

In House A, one badge was placed in the storage areas on the ground floor and first floor, and two outside in a shed.

The relatively high radiation values both inside and outside these two houses show quite clearly that these areas are far from normal from a radiation protection point of view, despite the fact that they have both been officially declared decontaminated.

One important observation that requires further investigation: the dose badges inside the rooms of Mr. Anzai´s house show higher cumulative doses than would be expected if the government's estimation of a reduction to 40% due to shielding were correct.

Measurement location	Height of badge (m)	Dose (mSv) 281 days	Calculated dose (mSv) 365 day (year)
Hamburg Greenpeace office	0.5	0.63	0.82
Tokyo Greenpeace office	1.0	0.74	0.96
Mr. Anzai's house kitchen	1.0	3.94	5.12
Mr. Anzai's house bathroom	1.2	8.03	10.43
Mr. Anzai's house living room	1.8	4.65	6.04
Mr. Anzai's house shed tool cabinet	0.2	5.74	7.46

Table 13: Dose badge measurement – Mr. Anzai's house.
MPA NRW report: 161222_UG1_30469 – Measurement uncertainty about 30%

Measurement location	Height of badge (m)	Dose (mSv) 282 days	Calculated dose (mSv) 365 day (year)
Hamburg Greenpeace office	0.5	0.63	0.82
Tokyo Greenpeace office	1.0	0.74	0.96
House A shed roof trench street side	0.1	51.77	67.01
House A ground floor storage room	1.0	1.95	2.52
House A room 1st floor living room	1.0	1.89	2.45
House A shed roof trench back side	0.1	82.7	107.04

Table 14: Dose badge measurement – House A.
MPA NRW report: 161222_UG5_30469 – Measurement uncertainty about 30%

The average dose rate outside his house was 0.7 μSv/h which would equal 6.1 mSv/yr. With a reduction of the inside radiation to 40% of the outside radiation, the dose inside the house should be 2.5 mSv/yr. However, the dose badges inside the house showed values in the range between 5.1 to 10.4 mSv/yr (see Table 13). House A also showed similar indications of a possible underestimation of indoor radiation dose rates (see Table 14).

This could have significant implications. Even if people stayed inside for longer periods of time than assumed in the 8 hour /12 hour outside scenarios, the lifetime exposures could be underestimated as a result of doses inside houses being potentially higher than expected.

© Masaya Noda / Greenpeace

Heinz Smital, Greenpeace radiation specialist surveying inside Mr. Anzai's house, Iitate, Fukushima Prefecture, November 2016.

8. RADIATION HOT SPOTS

Soil sample collected in Iitate, Fukushima Prefecture, November 2016.

Apart of the systematic scanning of the radiation levels in each zone, at 1m in a grid pattern with 1 measurement / second, as described in the methodology, the Greenpeace radiation survey team also took measurements of hotspots in each house zone in November 2016. As an illustration, we summarize the highest hotspots found at four houses in Iitate (see Table 15) :

Clearly, hot spots are not representative of the weighted average radiation levels at the surveyed house zones. However, these hot spots highlight that, in addition to the generally elevated levels of radiation throughout the area, there are places where levels are many tens of times higher than the government's long-term decontamination target of 0.23μSv/h, even after decontamination has been completed.

House	Location	Dose rate (μSv/h)		
		1m	0.5m	0.1m
Mr. Anzai	Zone 6 Field	1.7	4.8	16.1
A	Zone 5 Farm land	0.7	1.2	15.3
B	Zone 4/5 Under roof and back of house	3.3	6.1	13.9
E	Zone 7 Greenhouse field	2.7	6.1	18.3

Table 15: Highest hotspots found at four houses in Iitate.

9. CONCLUSION AND RECOMMENDATIONS

Six years after the start of the Fukushima Daiichi nuclear disaster, the radiation levels in Iitate remain too high for the safe return of its citizens. The results of our latest radiation survey in November 2016 reveal levels of radiation in both decontaminated and non-decontaminated areas that could result in increased health and safety risks for former inhabitants of Iitate returning, and therefore this is not recommended from a public health and safety perspective. In 2017, there clearly remains a radiological emergency within Iitate.

To clarify the use of the word emergency: if these radiation levels were measured in a nuclear facility, not Iitate, prompt action would be required by the authorities to mitigate serious adverse consequences for human health and safety, property or the environment.[22] In contrast, the government has formally declared that the decontamination of the surveyed area is completed. As a result of this, evacuation orders will be lifted as of March 2017. Thousands of citizens will then be faced with having to make the choice of return or not – a decision significantly complicated by the loss of compensation one year later.

These case studies demonstrate that there is clearly a risk that returning citizens could be exposed to a lifetime effective radiation dose in excess of 100mSv. This is far higher than the International Commission on Radiological Protection (ICRP) recommendations[23] for the public, which sets a maximum dose of 1mSv/year in normal situations.

Neither the International Atomic Energy Agency (IAEA) nor the UNSCEAR have so far provided an analysis of potential lifetime exposures for evacuees returning to Iitate or the other areas scheduled for reopening.[24]

The results of our survey work illustrate a highly complex radiological situation, and very far from normal. The wide variation in doses, measured both in the survey and with the dose badges, show the high degree of uncertainty and unknown risks.

Risking such exposures for the citizens of Iitate, including the vulnerable populations of women and children, when such great uncertainties remain is unjustifiable. Potential exposures for children are of particular concern, as they are both more vulnerable to the impacts of ionizing radiation exposure and are much greater risk of coming into contact with ground level radiation through play. Further, should residents return, the complex radiation situation in Iitate would require very different day to day behavior to minimize exposure, compared with pre-March 2011.

It is worth emphasizing that only a small percentage of Iitate's land area is officially being "decontaminated" – small islands of lower radiation levels, but which still largely fail to meet the government's long-term decontamination targets of 0.23μSv/h. Radiation levels in forests in Iitate, which were an integral part of the residents' lives prior to the nuclear accident, are comparable to the current levels within the Chernobyl 30km exclusion zone – an area that more than 30 years after the accident remains formally closed to habitation.[25]

The Japanese government has deliberately decided to create an open-air prison of confinement to "cleaned" houses and roads –

where radiation levels are still largely unsafe – and where the vast and untouched radioactive forests continue to pose a significant risk of recontamination of these "decontaminated" areas.

Greenpeace investigations and analysis have confirmed that the radiation exposure over a lifetime for citizens that return to the area could be high and well beyond the level acceptable from a public health safety perspective. Epidemiological studies monitoring the health effects of long-term exposure to low-ionizing radiation conclude that there is no low-threshold limit for excess radiation risk to non-solid cancers such as leukemia.[26] The additive radiation risk for solid cancers continues to increase throughout life with a linear dose-response relationship, which is the international basis for radio-protection standards set by the ICRP.[27]

Women, young people, and children are known to be more vulnerable to the impacts of radiation and would be exposed to radiation over many decades should they return to these contaminated areas. It is shocking to consider that nuclear plant workers worldwide, working in hazardous and controlled environments have, under regulation, more protection from radiation than will the citizens of Iitate if they choose to return to their homes.[28]

Four years ago, the United Nations Human Rights Council (UNHRC) Special Rapporteur called on the government of Japan to protect citizens' right to health and base its post-Fukushima policies upon the substantial body of evidence showing adverse health effects resulting from low-dose radiation exposures, including below 100mSv. He urged that "evacuees should be recommended to return only when the radiation dose has been reduced as far as possible and to levels below 1mSv/year."[29]

The conclusion of our survey work in Iitate is that the Japanese government has chosen to defy the recommendations of the UNHRC, and cynically and deliberately disregard the interests of tens of thousands of Fukushima citizens.

Recommendations:

- The government must not continue with its return policy which ignores Fukushima citizens and which ignores science based analysis, including potential lifetime exposure risks;
- The government should establish a fully transparent process to reflect and consider residents opinions on evacuation policy, including opening a forum of citizens including all evacuees;
- The government should provide full financial support to evacuees, and take measures to reduce radiation exposure based on the precautionary principle to protect public health and allow citizens to decide whether to return or relocate free from duress and financial coercion.

ENDNOTE

1. Dipl. Phys., Expert on the Risks of Nuclear Facilities Scientific Consulting for Energy and the Environment, Hanover (Germany)
2. See Distribution Map for Radiation Dose “Establishment of the Base for Taking Measures for Environmental Impact of Radioactive Substances-Study of the Distribution of Radioactive Substances”; the 2011 Radioactivity Measurement and Investigation Project commissioned by MEXT entitled “Investigation and Study of the Secondary Distribution of Radioactive Substances due to the Accident at the Fukushima Daiichi Nuclear Power Plant” updated 5 December 2016, see http://ramap.jmc.or.jp/map/eng/, accessed 29 January 2017.
3. The ICRP sets a recommended public dose limit of 1mSv in a year, with a higher value being allowed in special circumstances as in the case of the Fukushima Daiichi nuclear accident, provided the average over five years does not exceed 1mSv per year, see ICRP 111: Protection of People Living in Long-term Contaminated Areas after a Nuclear Accident or a Radiation Emergency, available at http://www.icrp.org/ accessed 3 February 2017.
4. OECD, Nuclear Energy Agency: Evolution of ICRP Recommendations 1977, 1990 and 2007. Changes in Underlying Science and Protection Policy and their Impact on European and UK Domestic Regulation, ISBN 978-92-64-99153-8, 2011, see https://www.oecd-nea.org/rp/reports/2011/nea6920-ICRP-recommendations.pdf, accessed 25th January 2017.
5. The Prime Minister in Action: Nuclear Emergency Response Headquarters June 12, 2015. http://japan.kantei.go.jp/97_abe/actions/201506/12article1.html, accessed 20 January 2017.
6. Japan Times: Cabinet OKs plan to lift Fukushima evacuation orders by end of fiscal 2016 Kyodo June 12, 2015, see http://www.japantimes.co.jp/news/2015/06/12/national/cabinet-oks-plan-lift-fukushima-evacuation-orders-end-fiscal-2016/#.VaWUSSiyT6h, accessed 20 January 2017.
7. IRSN, “Summary of the Fukushima accident’s impact on the environment in Japan, one year after the accident”, February 28 2012, see http://www.irsn.fr/EN/publications/thematic/fukushima/Documents/IRSN_Fukushima-Environment-consequences_28022012.pdf, accessed January 25 2017.
8. The total Cs-134 inventory was almost equivalent to Cs-137 at the time of initial deposition (year 0) but will become less than 10% of the total initial inventory after 5 years due to the fact that Cs-134 has a half life of 2.1 years. The total Cs-137 and Cs-134 combined inventory will decrease to approximately half of the initial fallout after approximately 10 years, primarily because of the radioactive decay of Cs-134. However, the rate at which the total radiocesium inventory decreases will slow after 10 years, when Cs-137 remains as the dominant nuclide, see “Predicted spatiotemporal dynamics of radio-cesium deposited onto forests following the Fukushima nuclear accident”, Shoji Hashimoto, Toshiya Matsuura, Kazuki Nanko, Igor Linkov, George Shaw & Shinji Kaneko, http://www.nature.com/srep/2013/130902/srep02564/full/srep02564.html, accessed January 25 2017.
9. The legal policy framework for ongoing decontamination efforts in Iitate and the other districts in the Special Decontamination Areas is the Act on Special Measures Concerning the Handling of Radioactive Pollution (“the Act on Special Measures”) enacted in August 2011 and which took full effect from January 2012: the Ministry of the Environment is responsible for off-site remediation and waste management; the Ministry of Agriculture, Forestry and Fishery is involved in countermeasures related to forest and agricultural areas; the Ministry of Health, Labour and Welfare is responsible for radiation protection of remediation workers; the Cabinet Office for the designation and rearrangement of evacuated areas, and, the Nuclear Regulation Authority supports all activities by the coordination of monitoring and the provision of scientific and technical advice.
10. According to Ministry of Economy, Trade and Industry, “The Policy on how to handle difficult-to-return areas: Based on the actual circumstances of each municipality, the “recovery base” will be set. The base aims to make it possible to lift the evacuation order and live in. In that case, decrease in the does should be considered. The will be completed by 5 years from now, see http://www.meti.go.jp/earthquake/nuclear/kinkyu/pdf/2016/0831_01.pdf Aug.31, 2016, accessed 23 January 2017.
11. Fukushima Disaster: Risks to the Population Returning to Decontaminated Areas Results of the Greenpeace monitoring project in Iitate village, February 2016. Field investigation: led by Jan van de Putte, June-October 2015, see http://www.greenpeace.org/international/Global/international/briefings/nuclear/2016/Greenpeace_Iitate%20Investigations_2015.pdf, accessed 23 January 2017.
12. http://www.pref.fukushima.lg.jp/uploaded/attachment/195697.pdf
13. See http://chikurin.org/wp/?page_id=1941
14. Greenpeace Japan: Fukushima disaster: Ongoing nuclear crisis - The Failure of radioactive decontamination in Iitate, Greenpeace Briefing July 2015; Updated September 2015, see http://www.greenpeace.org/japan/Global/japan/pdf/Iitate_Brief_Jul2015_EN.pdf, accessed 2 February 2017.
15. See http://www.rri.kyoto-u.ac.jp/NSRG/Fksm/kamiiitoi2016-10-9.pdf, (in Japanese), accessed 23 January 2017.
16. Imanaka 2015: Comparison of the accident process, radioactivity release and ground contamination between Chernobyl and Fukushima-1; Tetsuji Imanaka, Gohei Hayashi and Satoru Endo; Journal of Radiation Research, 2015.
17. Formula - H: dose in mSv, B: ground deposition in Bq/m^2, gb: dose rate factor for ground radiation in $mSv{*}m^2/s{*}Bq$; λ: decay constant in 1/s, t: time period in s
18. UNSCEAR: SOURCES, EFFECTS AND RISKS OF IONIZING RADIATION: United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR 2013, Report to the General Assembly with Scientific Annexes, VOLUME

I, Scientific Annex A; 2014. http://www.unscear.org/docs/reports/2013/13-85418_Report_2013_Annex_A.pdf, accessed 23 January 2017.

19. For the weighted average, we used an identical weight for each zone.
20. For reference, dose badges were also placed in the Greenpeace Japan office in Tokyo and in the Greenpeace Germany office in Hamburg over the same period.
21. H represents the stochastic health effects of low levels of ionizing radiation on the human body. It is derived from the physical quantity absorbed dose, but also takes into account the biological effectiveness of the radiation, which is dependent on the radiation type and energy. The company providing the equipment and service is an official radiation protection service company in Germany MPA NRW. http://www.mpanrw.de/en/services/radiation-protection/. In the field of personal dosimetry the MPA NRW is competent as an official measuring point for approximately 12,000 companies and more than 110,000 personal dose values are determined every month. The dose badges are described in detail here (in German only): http://www.mpanrw.de/fileadmin/user_upload/pdf/Strahlenschutz/Downloads/Datenblaetter/Flachglas-Umgebungsdosimeter.pdf, accessed 20 January 2017.
22. For example, the European Union defines an "emergency" as a non-routine situation or event involving a radiation source that necessitates prompt action to mitigate serious adverse consequences for human health and safety, quality of life, property or the environment, or a hazard that could give rise to such serious adverse consequences – see COUNCIL DIRECTIVE 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom; In terms of radiation dose levels, "Member States should ensure that these workplaces are notified and that, in cases where the exposure of workers is liable to exceed an effective dose of 6mSv per year or a corresponding time-integrated radon exposure value, they are managed as a planned exposure situation and that dose limits apply, and determine which operational protection requirements need be applied. The EC directive classifies exposed workers as those receiving an effective dose of 6 mSv per year." see https://ec.europa.eu/energy/sites/ener/files/documents/CELEX-32013L0059-EN-TXT.pdf, accessed 26 January 2017.
23. The ICRP sets a recommended public dose limit of 1mSv in a year, with a higher value being allowed in special circumstances as in the case of the Fukushima Daiichi nuclear accident, provided the average over five years does not exceed 1mSv per year, see ICRP 111: Protection of People Living in Long-term Contaminated Areas after a Nuclear Accident or a Radiation Emergency, available at http://www.icrp.org/ accessed 3 February 2017.
24. UNSCEAR, Development Since the 2013 UNSCEAR Report on the Levels and Effects of Radiation Exposure Due to the Nuclear Accident following the Great East-Japan Earthquake and Tsunami: A 2016 white paper to guide the Scientific Committee's future program of workhttp://www.unscear.org/docs/publications/2016/UNSCEAR_WP_2016.pdf, accessed 25 January 2017.
25. See Distribution Map for Radiation Dose "Establishment of the Base for Taking Measures for Environmental Impact of Radioactive Substances-Study of the Distribution of Radioactive Substances"; the 2011 Radioactivity Measurement and Investigation Project commissioned by MEXT entitled "Investigation and Study of the Secondary Distribution of Radioactive Substances due to the Accident at the Fukushima Daiichi Nuclear Power Plant" updated 5 December 2016, see http://ramap.jmc.or.jp/map/eng/, accessed 29 January 2017.
26. David Richardson et al, Ionizing Radiation and Leukemia Mortality among Japanese Atomic Bomb Survivors, 1950-2000, Radiation Research (September 2009), vol.172, no.3, pp.368-82. as cited in Human Rights Council, Twenty-third session Agenda item 3, Promotion and protection of all human rights, civil, political, economic, social and cultural rights, including the right to development A/HRC/23/41/Add.3 Distr.: General 2 May 2013 Report of the Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of physical and mental health, Anand Grover Addendum Mission to Japan (15 - 26 November 2012).
27. National Research Council, Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2 (Washington DC, The National Academies Press, 2006), p.30; Kotaro Ozasa et al, Studies on the Mortality of Atomic Bomb Survivors, Report 14, 1950-2003: An Overview of Cancer and Non-cancer Diseases, Radiation Research (March 2012), vol.177, no.3, pp.229-243,pp. 229,236.; David J. Brenner et al, Cancer Risks Attributable to Low Doses of Ionizing Radiation: Assessing what we really know, PNAS (November 2003), vol.100, no.24, pp.13761-13766; Pierce and Preston, Radiation-Related Cancer Risks at Low Doses among Atomic Bomb Survivors, Radiation Research (2000),vol.154,pp.178-186,p.185. As cited in Report of the Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of physical and mental health, Anand Grover Addendum Mission to Japan (15 - 26 November 2012).
28. See for example German worker protection § 55 (StrlSchV) where in the case of occupational radiation exposure (3) For persons under 18 years of age, the effective dose limit is 1mSv in a calendar year, see Verordnung über den Schutz vor Schäden durch ionisierende Strahlen (Strahlenschutzverordnung - StrlSchV) StrlSchV Ausfertigungsdatum: 20.07.2001, http://www.gesetze-im-internet.de/bundesrecht/strlschv_2001/gesamt.pdf, accessed 31 January 2017.
29. Human Rights Council, Twenty-third session Agenda item 3, Promotion and protection of all human rights, civil, political, economic, social and cultural rights, including the right to development A/HRC/23/41/Add.3 Distr.: General 2 May 2013 Report of the Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of physical and mental health, Anand Grover Addendum Mission to Japan (15 - 26 November 2012).

APPENDIX 1

Chart 1: Dose rate average by Scanning (systematic measurements) and a comparison between 2016 and 2015 – Mr. Anzai's house

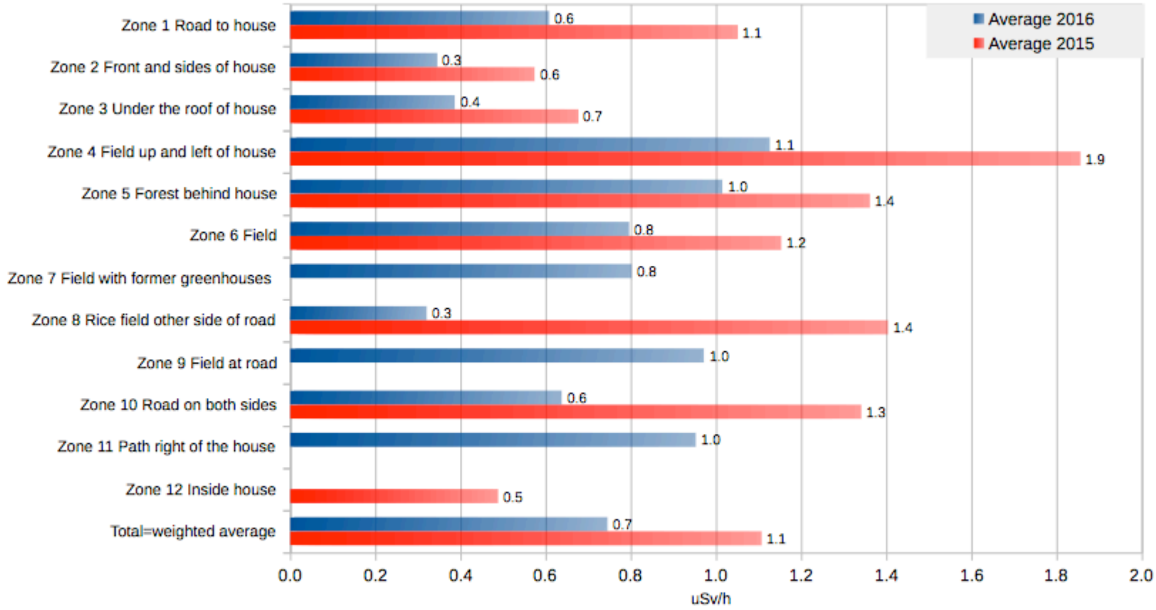
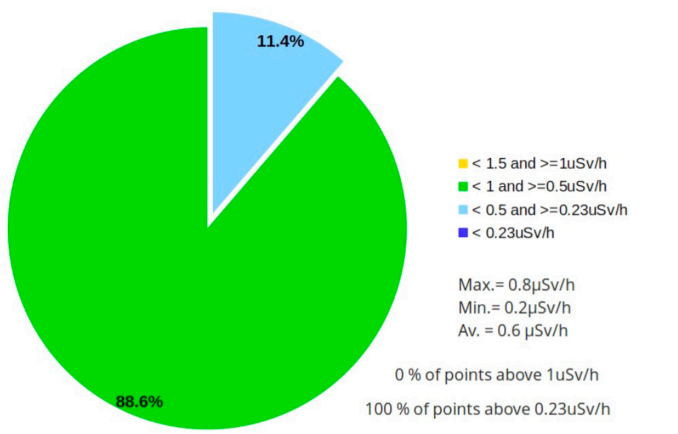


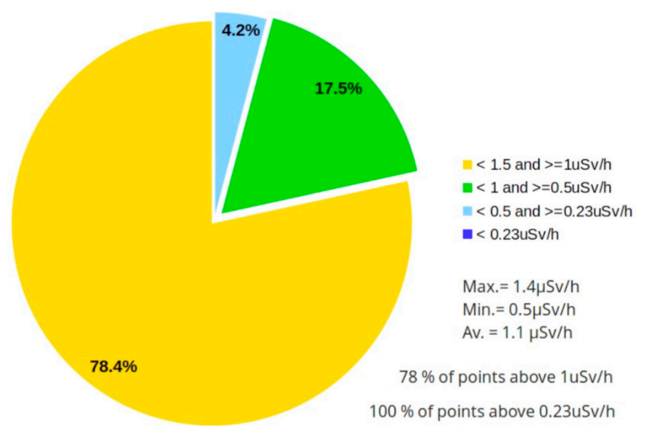
Chart 2: Proportion of dose rate in 12 zones measured by Scanning (systematic measurements) and a comparison between 2016 and 2015 – Mr. Anzai's house

Zone 1 Road to house

2016

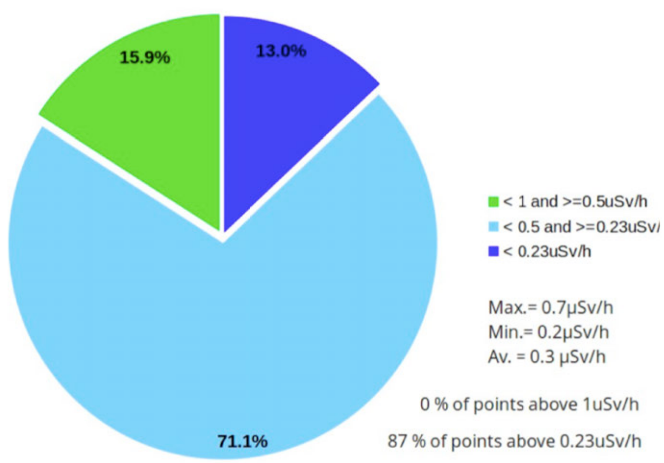


2015

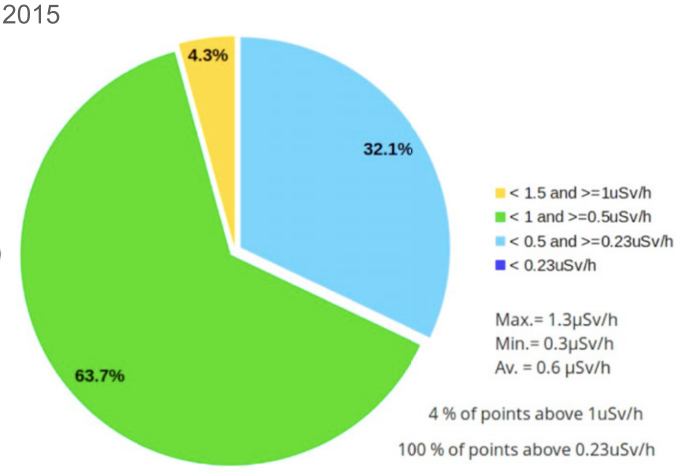


Zone 2 Front and sides of house

2016

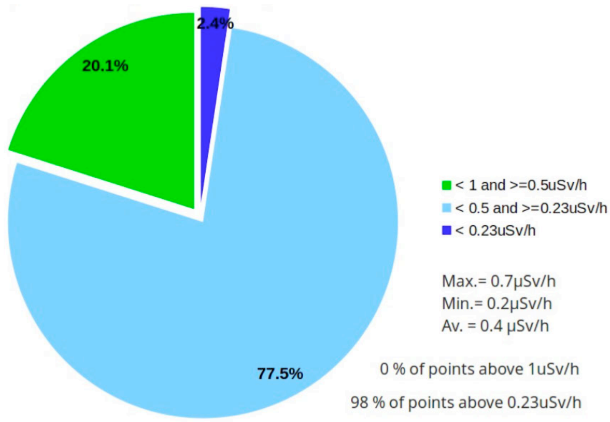


2015

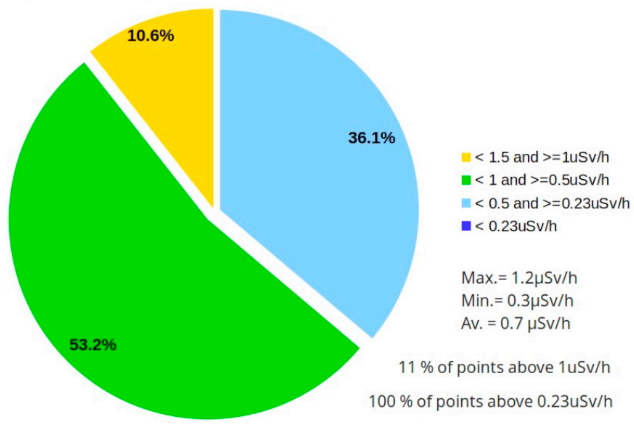


Zone 3 Under the roof of house

2016

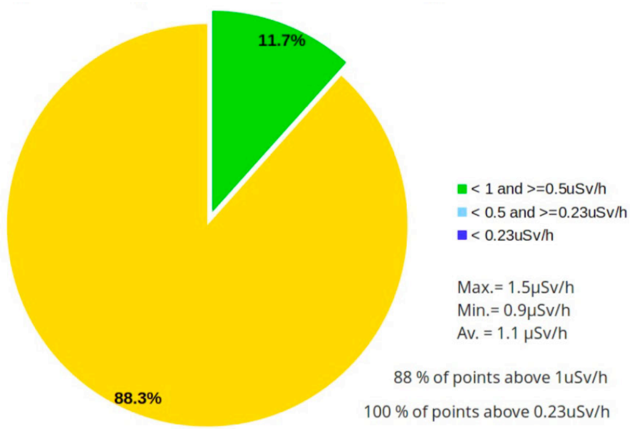


2015

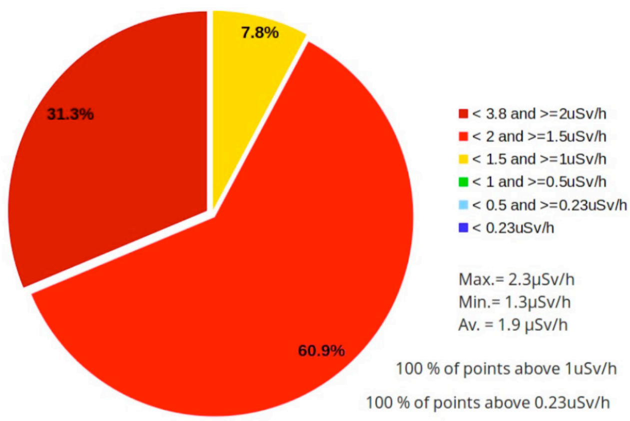


Zone 4 Field up and left of house

2016

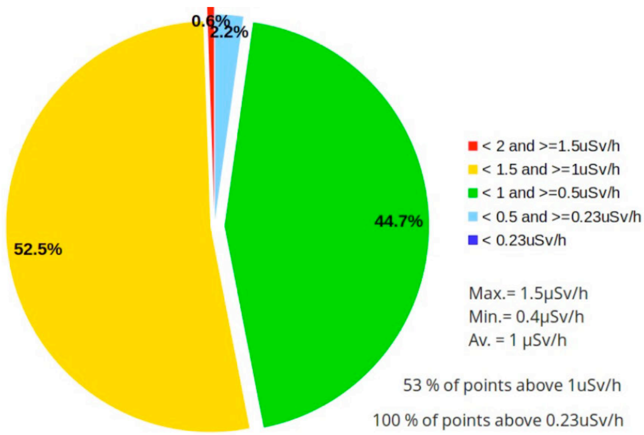


2015

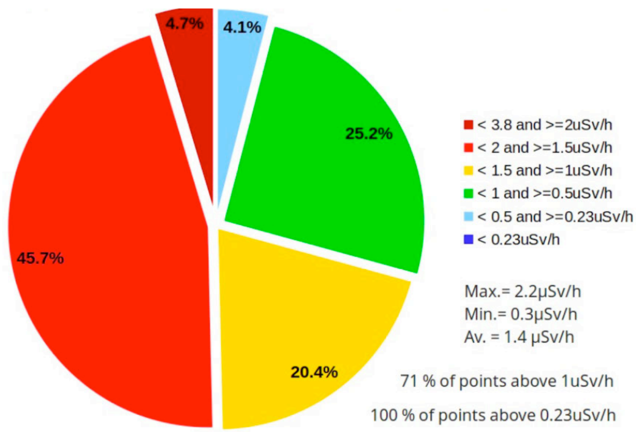


Zone 5 Forest behind house

2016

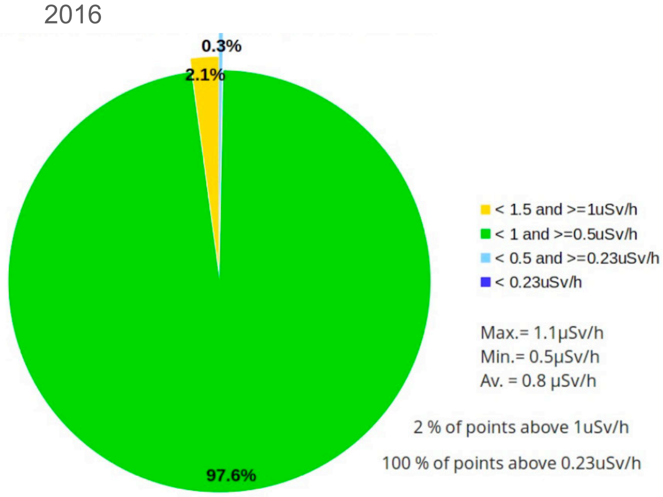


2015

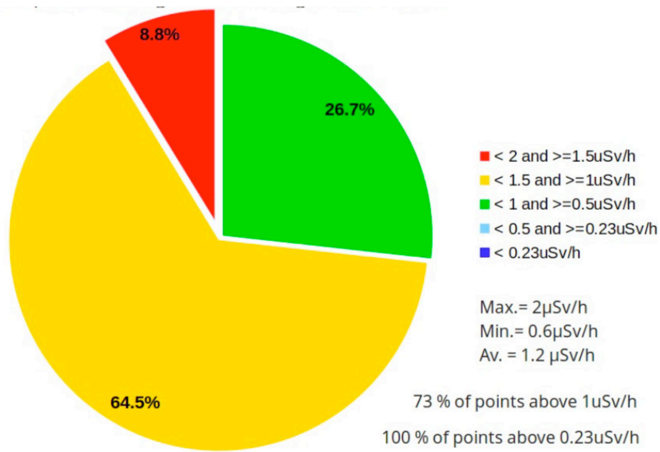


Zone 6 Field

2016

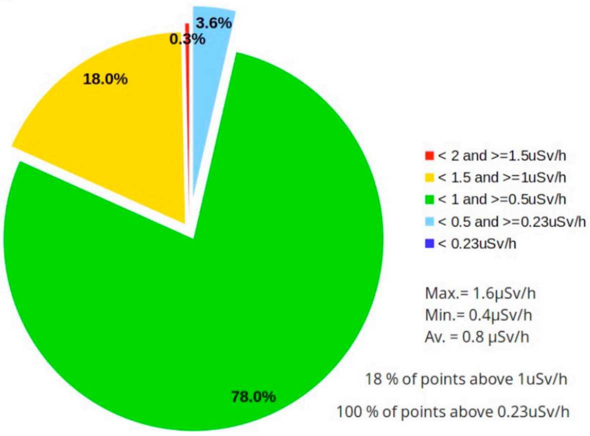


2015



Zone 7 Field with former greenhouses

2016

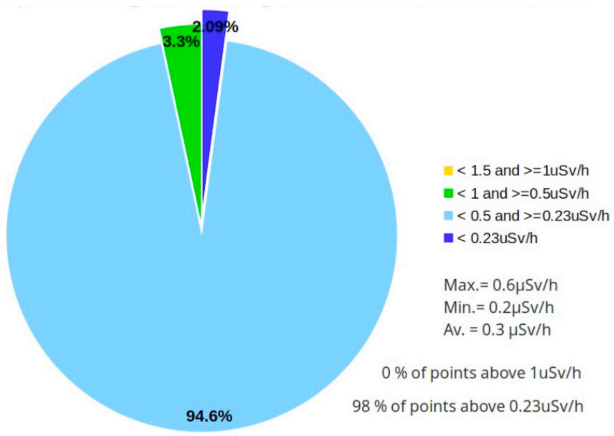


2015

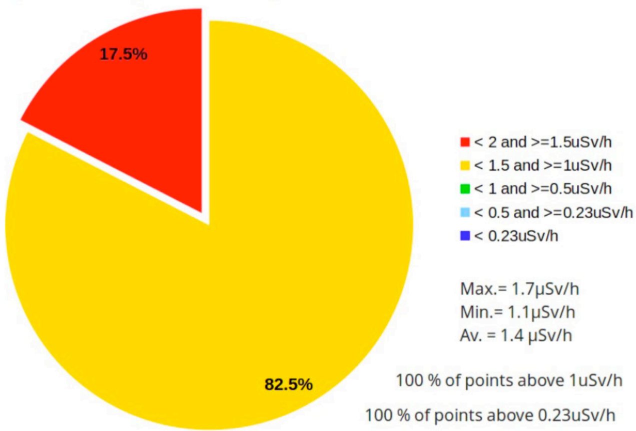
No measurements

Zone 8 Rice field other side of road

2016

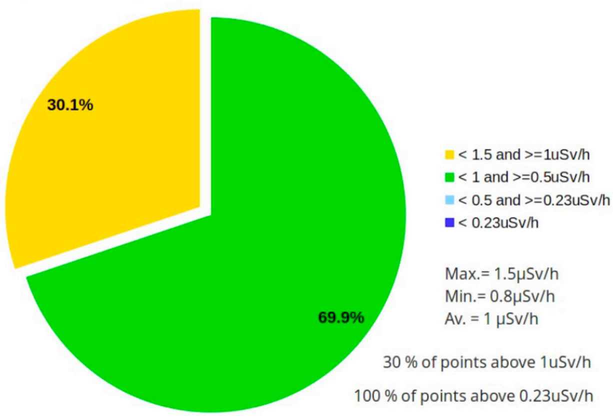


2015

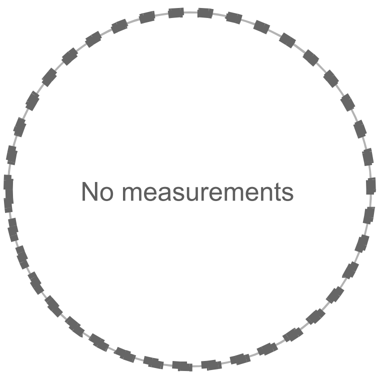


Zone 9 Field at road

2016

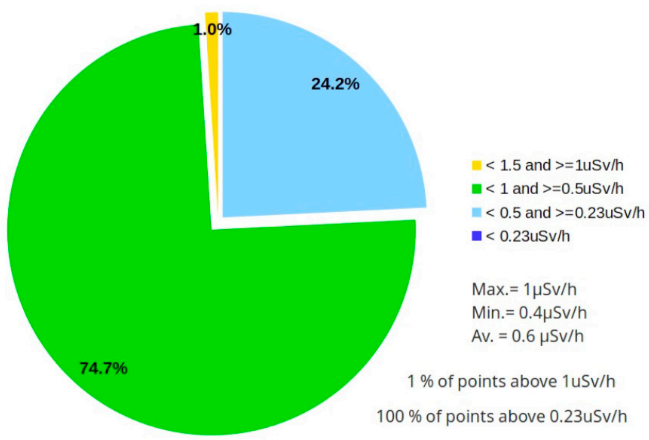


2015

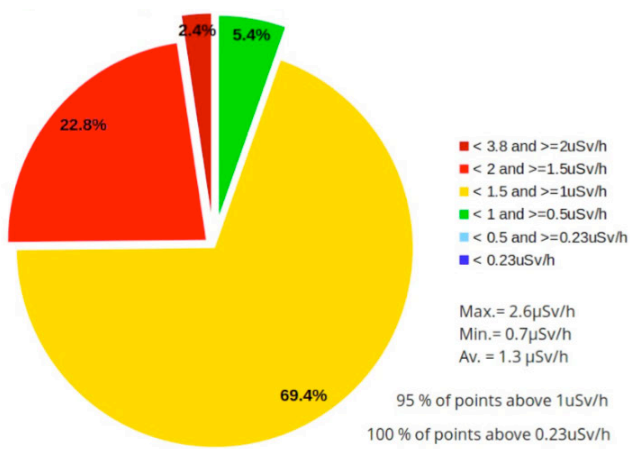


Zone 10 Road on both sides

2016

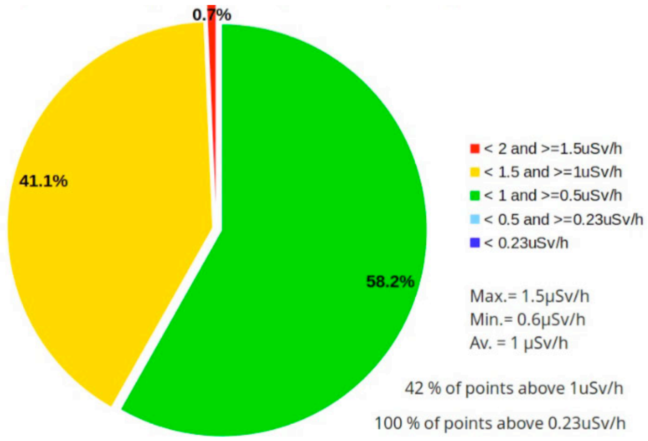


2015

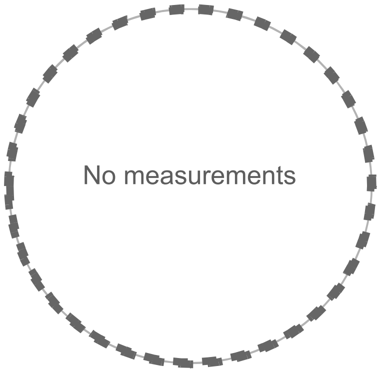


Zone 11 Path right of the house

2016

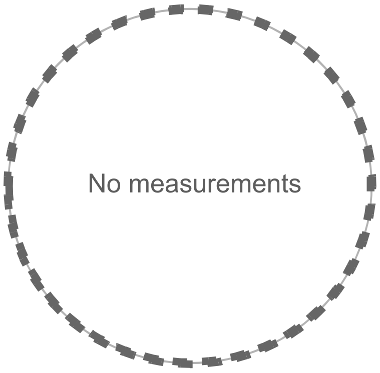


2015



Zone 12 Inside house

2016



2015

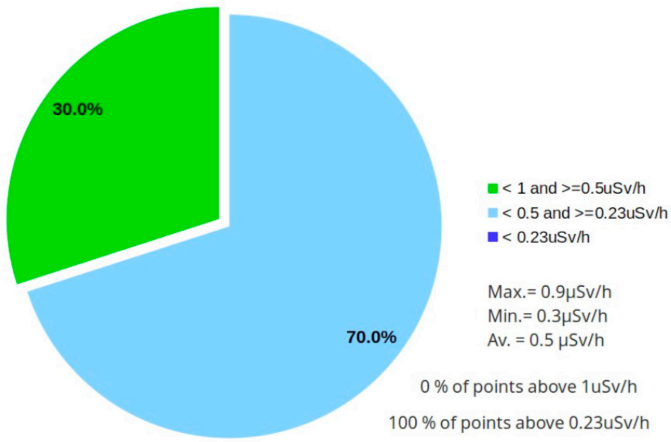


Chart 3: Activity of dried soil samples – Mr. Anzai's house

No.	Cs-134 (Bq/kg)	Cs-137 (Bq/kg)	Cs Total (Bq/kg)	Dose rate (μSv/h)		
				1m	0.5m	10cm
1	1,400 ± 200	9,000 ± 1,300	10,400	1.2	1.4	1.5
2	3,300 ± 470	22,000 ± 3,100	25,300	1.5	1.6	1.8

The samples were taken in Zone 4 Field up and left of house

The analysis were performed by gamma spectrometry with high-purity germanium detector at Chikurin (RMCC,Radioactivity Monitoring Center for Citizen), Tokyo.

Chart 4: Highest hotspots – Mr. Anzai's house

Zone name	Dose rate (μSv/h)		
	1m	0.5m	0.1m
House zone 1 Road to house	1.3	1.5	2.5
House zone 2 Front and sides of house	1.5	2.2	5.2
House zone 3 Under the roof of house	1.3	1.5	3.3
House zone 4 Field up and left of house	1.8	2.7	4
House zone 5 forest behind house	2.2	2.5	3.2
House zone 6 Field	1.7	4.8	16.1
House zone 7 Field former greenhouses	1.9	3.3	8.6
House zone 8 Rice field and other side of road	1.8	2	2.4
House zone 9 Field at road	2.9	3.1	3.8
House zone 10 Road on both sides	2.1	2.5	7.1
House zone 11 Path right of the house	1.5	2	2.9
House zone 12 in the house	0.9	0.8	0.8

APPENDIX 2

Chart 5: Long-term dose (50 years and 80 years) corresponding to different dose rates and durations of stay outside

	Long-term dose (50 years)		
Dose rate (μSv/h)	24 h outside (mSv)	12 h outside (mSv)	8 h outside (mSv)
0.1	19	13	11
0.2	37	26	22
0.3	56	39	34
0.4	75	52	45
0.5	94	66	56
0.6	112	79	67
0.7	131	92	79
0.8	150	105	90
0.9	169	118	101
1.0	187	131	112
1.1	206	144	124
1.2	225	157	135
1.3	243	170	146
1.4	262	183	157
1.5	281	197	169
1.6	300	210	180
1.7	318	223	191
1.8	337	236	202
1.9	356	249	213
2.0	374	262	225
2.1	393	275	236
2.2	412	288	247
2.3	431	301	258
2.4	449	315	270
2.5	468	328	281
2.6	487	341	292
2.7	506	354	303
2.8	524	367	315
2.9	543	380	326
3.0	562	393	337

	Long-term dose (80 years)		
Dose rate (μSv/h)	24 h outside (mSv)	12 h outside (mSv)	8 h outside (mSv)
0.1	23	16	14
0.2	46	32	27
0.3	69	48	41
0.4	92	64	55
0.5	114	80	69
0.6	137	96	82
0.7	160	112	96
0.8	183	128	110
0.9	206	144	124
1.0	229	160	137
1.1	252	176	151
1.2	275	192	165
1.3	297	208	178
1.4	320	224	192
1.5	343	240	206
1.6	366	256	220
1.7	389	272	233
1.8	412	288	247
1.9	435	304	261
2.0	458	320	275
2.1	481	336	288
2.2	503	352	302
2.3	526	368	316
2.4	549	384	330
2.5	572	400	343
2.6	595	416	357
2.7	618	432	371
2.8	641	449	384
2.9	664	465	398
3.0	686	481	412

Greenpeace radiation survey at nuclear waste storage area, Iitate, Fukushima Prefecture, November 2016.


遮

Greenpeace is an independent campaigning organisation. Founded in 1971, it acts to change attitudes and behavior, to protect and conserve the environment, and promote peace and sustainability.

Greenpeace Japan

8-13-11 NF Bldg. 2F, Nishi-Shinjuku,
Shinjuku, Tokyo 160-0023

For further information:

Jan Vande Putte
jan.vande.putte@greenpeace.org

Heinz Smital
heinz.smital@greenpeace.org

Shaun Burnie
shaun.burnie@greenpeace.org

Ai Kashiwagi
ai.kashiwagi@greenpeace.org

www.greenpeace.org/japan/ERJ