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

Introduction

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 Fukushima prefecture, many tens of thousands of whom, five years after the start of the accident, remain living in 'temporary' accommodation.

The Fukushima nuclear disaster released large quantities of radioactive isotopes into the environment. The atmospheric release of major radioelements is estimated to be about 10% of the quantity released in the Chernobyl accident.[i] For xenon-133, it is the largest discharge in history, 2.5 times higher than the release at Chernobyl. About 80% of this release went towards the ocean, where it adds to the marine pollution[ii]. Although only 20% of the contamination was deposited on land, a large area of the Japanese territory will remain heavily contaminated for decades to come.[iii]

Radioactive fallout, in particular Iodine-131, Iodine-133, Caesium-134 and Caesium-137 were deposited and contaminated large areas of Fukushima prefecture. With radioactive decay, the principle radioactive material of concern as of today and into the future is radioactive caesium, in particular Caesium-137 with a half-life of 30 years, which will remain a hazard for centuries.[iv]

This briefing describes the results of Greenpeace's investigations into the current risks of radioactive contamination in certain areas around the Fukushima Daiichi nuclear plant. This investigation specifically looks into the effectiveness of the decontamination efforts by the government.

The failure of decontamination in Iitate, Fukushima prefecture

Iitate Village is a district of over 200 km^2 – much of it mountainous forest, with homes and agricultural fields spread throughout the wooded landscape.[v] Many of the homes in Iitate as well as many of the small farm fields are surrounded by and integrated into the forests and hillsides. The district of Iitate is located between 28km and 47km from the Fukushima Daiichi nuclear power plant.

In March 2011, Iitate was home to 6,200 people. 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 north-west from the nuclear power plant.[vi] According to the International Atomic Energy Agency (IAEA) Summary Fukushima Report, extremely high levels of radioactive caesium (caesium-137 or ^{137}Cs) were deposited in this region: deposition densities between 1000 kBq/m^2 and 10,000 kBq/m^2 were recorded.[vii] The average deposition density for ^{137}Cs throughout Fukushima prefecture is 100 kBq/m^2.[viii] These numbers far exceed IAEA's benchmark of 40 kBq/m^2 for contaminated land.

Along with other areas of Fukushima prefecture, Iitate was designated for radioactive

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decontamination in 2012.[ix] It is located in the Special Decontamination Area, where annual cumulative radiation dose today could exceed 20 mSv each year if people were to live there. This is significantly higher than the internationally accepted standard that radiation exposure to members of the public should not exceed 1mSv per year under non-accidental situations, which forms the basis for the government's long-term targets.

Figure 1 Bags with radioactive waste from decontamination close to people's houses.

In total, 'only' one quarter of the area of Iitate is to be decontaminated according to government plans: out of an area of 20,000 hectares (approximately 200 square kilometres), a total of 5,600 hectares are targeted for decontamination.[x] Even with 75% of the heavily contaminated land (mostly densely forested hillsides) being left in its current state, the decontamination work still is an enormous undertaking. Efforts to decontaminate the targeted 56 km^2 began on a significant scale in spring 2014, with a scheduled completion date of 2016. In reality the government is far from certain of reaching this deadline.

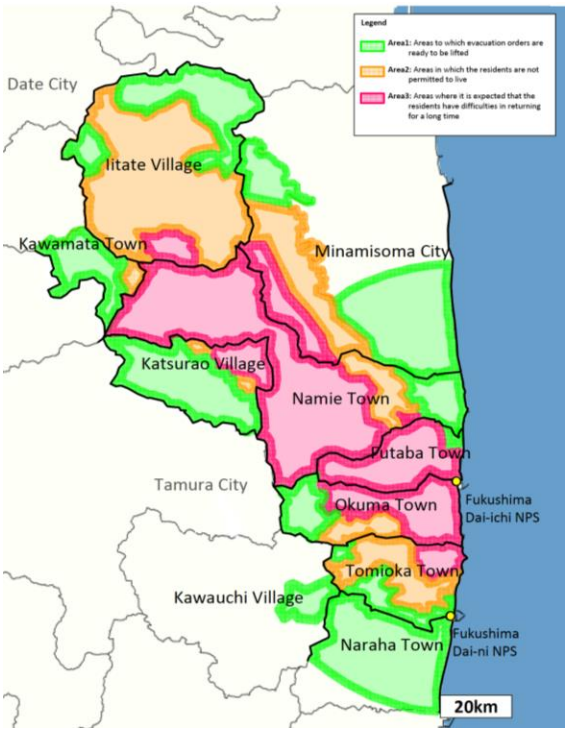


Figure 2 Areas to which evacuation orders have been issued (October 1, 2014), METI[xi]

Areas to the north of Iitate were less contaminated by radioactive fallout from the Fukushima accident, in contrast to the central and southern Iitate parts. These highest contaminated areas make up only a small proportion of the overall targeted area for decontamination. The government has no intention to attempt to decontaminate these areas – not least for the simple reason that it is practically impossible.

During the last year, up to 7000 workers have been working in harsh and difficult conditions throughout Iitate. The decontamination efforts involve removing soil, leaf litter and small plants only from forests within the first 20 meters away from public roads and houses where people will return to live. The result is that decontaminated land is in close proximity to vast areas for which no decontamination will take place. The forests of Iitate act as a repository for the large amount of radioactive material deposited there. Migration of this radioactivity accumulated in forests to other areas, including decontaminated areas, poses a long-term risk to people who would decide to return. The close proximity and natural weathering are a risk of radiological migration and recontamination of decontaminated land.

Also, while the decontamination program is limited, it has generated vast quantities of nuclear waste, which remain stored in hundreds of thousands of bags scattered across the district.

Greenpeace radiological investigation

Since March 2011, Greenpeace has conducted 25 radiation surveys throughout Fukushima prefecture, including Iitate.[xii] Greenpeace found that authorities have consistently underestimated both the risks and extent of radioactive contamination. On March 27, 2011, Greenpeace revealed extremely high levels of radioactive contamination in Iitate village, and recommended the immediate evacuation of the more than 6000 residents.[xiii] [xiv] Until that date, the residents of Iitate had been told that evacuation was not required. The Japanese government did not begin evacuation until 22 April 2011. Still eight weeks after the start of the accident, in early June 2011, over 1200 people remained in Iitate.[xv] As a result, the people of Iitate were the most exposed to radiation of all citizens of Fukushima prefecture.[xvi]

The long-term target level by the Japanese government of 0.23 µSv/h in order to keep radiation exposure to the public under 1 milliSievert (mSv) per year, is based on the assumption that a person would spend on average 8 hours outside the house and 16 hours inside per day throughout the year.[xvii] The reality in an agricultural area like Iitate is that before the accident, people were mostly living an outdoor life. They would spend significantly more time outside their house than inside, particularly in spring, summer and autumn months.

In October 2014, Greenpeace monitoring results from Iitate (40km from Fukushima Daiichi), Fukushima city (60km), Miyakoji of Tamura city (20km) and Kawauchi village (20km) [xviii] showed that efforts at decontamination were still failing to reduce contamination in many areas to meet the Japanese government's long-term decontamination target level of 0.23 µSv/h.[xix] In Kawauchi, part of which had its evacuation order lifted in October 2014,[xx] Greenpeace monitoring found 59% of our radiation measurements were over the target level and, again, with higher levels found away from the roads.[xxi]

In June-July and October 2015, the longer-term radiation risks for Iitate village were investigated. The investigation included a survey of areas of Iitate, including forests. Furthermore, we concentrated our efforts on houses which were already decontaminated, to assess the remaining radiation levels people would have to live with if they would return.

Greenpeace systematically measured radiation on the roads of Iitate. Although radiation levels along the roads are significantly lower than off the road, in the forests or fields, they are a good indication for the overall radiation levels in the region. By taking a large number of measurements it is possible to compare different areas and to compare the evolution of radiation levels over

time. More than 11,000 (June 2015) and 16,000 (October 2015) measurements were recorded in Iitate.

Methodology

A portable Georadis RT-30 gamma-spectrometer with a large NaI scintillation detector (103 cm3) was used to carry out radiation measurements. This instrument is designed as a highly sensitive radiation survey monitor, combined with fast radionuclide identification and built-in Bluetooth connectivity to allow for integrated GPS location data recording. Radiation mapping was done taking measurements with the Georadis RT30 every second outside the car at 1m height while driving at 20km/h or while walking a grid pattern on a specific area. The Georadis RT-30 was used in combination with a Qstarz 1000XT GPS. Data were logged every second in the Georadis RT-30 (counts per second and dose rate). For every 30 seconds, the GPS coordinates were recorded as well.

In order to assess the radiation levels around people's houses, we divided the area around the house into different areas (16 areas in this case). For each area 2 different methods were used:

- Systematic mapping: dose rate at 1m with the Georadis RT30 recording 1 measurement each second and the GPS location every 30 seconds. Measurements were recorded while walking in systematic way, e.g. grid patters or square. Specific areas were defined (e.g. field, path, around the house) which were measured separately, collecting statistics for each of these areas.
- Points of interest and hotspots: ambient dose was recorded at specific locations (GPS coordinates noted) at 10/50/100cm height with a NaI scintilator Radeye PRD-ER.

Results Iitate June/July 2015 and October 2015

The map in Figure 3 summarises the 11,757 measurements recorded in June 2015. It shows that radiation levels in the south of Iitate are higher than in the north of the district.[xxii] Of the 11,757 measuring points, 96% are higher than the Japanese government's long-term target of 0.23 µSv/h and 30% are above 1 µSv/h (see Figure 4). The highest dose rate measured along the road was 4.75 µSv/h, whereas off the road dose rates up to 30 µSv/h were measured in the south of Iitate.

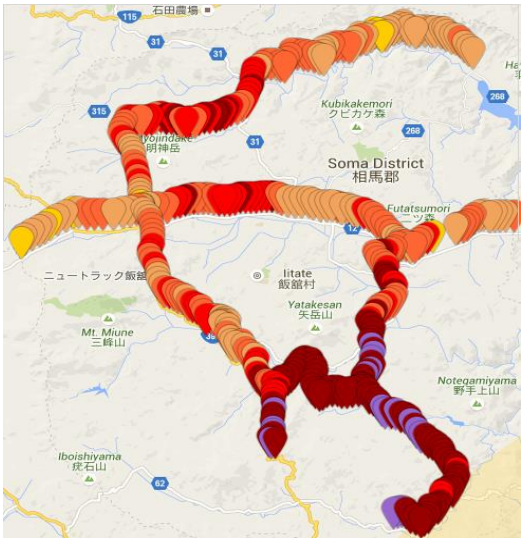
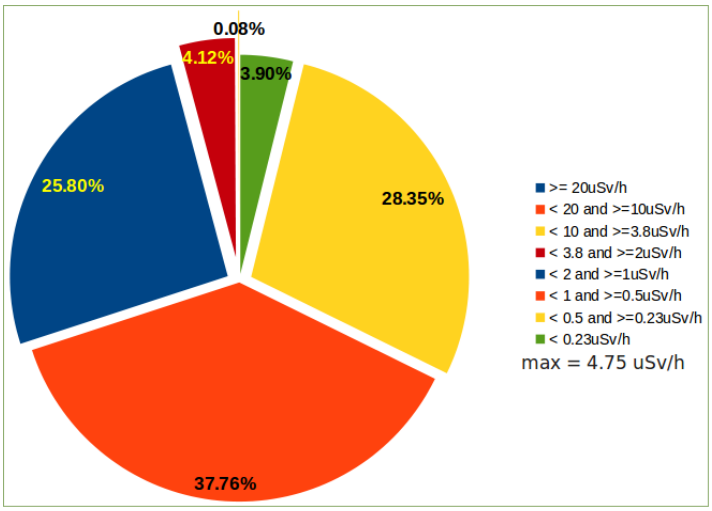


Figure 3 Radiation measurements recorded on the roads of Iitate village, June 2015. 11,757 measurements recorded. Colour coding: yellow ● = 0.1-0.23 microSv/h, beige ● = 0.23-0.5 microSv/h, light red ● = 0.5-0.75 microSv/h, red ● = 0.75-1 microSv/h, ● = 1-2 microSv/h, ● = 2-5 microSv/h

This is substantially higher than the radiation dose rate measured along roads in Kawauchi (59% above 0.23 µSv/h) and Miyakoji (34% above 0.23 µSv/h),[xxiii] where the evacuation order was lifted in April and October 2014, respectively. Furthermore, no significant difference was observed between measurements recorded in Iitate in October 2014 (96% above 0.23 µSv/h) [xxiv] and June 2015 (96%), despite the large scale decontamination efforts.



uSv/h	no. of points	% of points	mSv/y (japan govt)
no. points >=0.23	11299	96%	>= 1 mSv/y
no. points >=0.5	7966	68%	>= 3 mSv/y
no. points >=1	3526	30%	>= 5 mSv/y
no. points >=2	493	4%	>= 10 mSv/y
no. points >=3.8	9	0%	>= 20 mSv/y
no. points >=10	0	0%	>= 52 mSv/y
no. points >=20	0	0%	>= 105 mSv/y

Figure 4 Radiation measurements recorded in Iitate (June 2015): 11,757 points outside car at 20km/h (1m high)

Case study 1: Radiation levels around Iitate farmhouse

As a case study, in June-July and October 2015 Greenpeace monitored the house of Mr. Toru Anzai in the south east of Iitate, and located 35km from the Fukushima Daiichi nuclear plant. At this time, workers had nearly completed decontamination of his farmland. The area around his house has been decontaminated by scraping away a layer of more than 5cm of topsoil which was removed as radioactive waste,and covering the surface with non-contaminated soil. This reduced radiation levels to 0.5-0.6 µSv/h in front of his house, still twice the 0.23 µSv/h target. To the rear of his house, close to a forest, radiation levels were much higher (around 1.5 µSv/h) even after the first 20m of the forest had been decontaminated. This was measurable inside the house, where radiation levels were at a similar level as outside (up to 1.6 µSv/h).

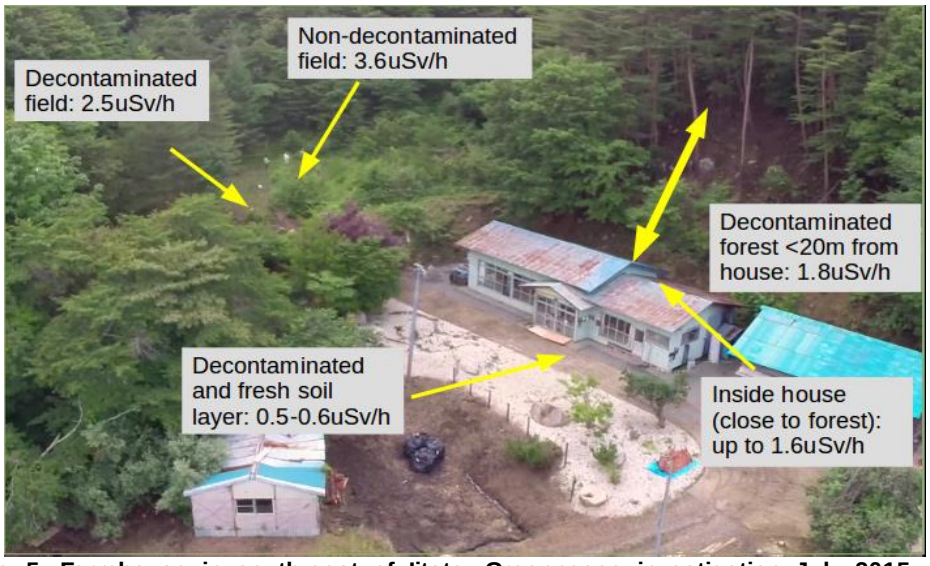


Figure 5. Farmhouse in south-east of Iitate. Greenpeace investigation July 2015 (c)Marco Kühne/Greenpeace

1. Results of systematic mapping at 1m (see figure 7):

- 5092 measurements were recorded outside the house, with an average of 1.2 µSv/h and a maximum of 2.6 µSv/h. All of the measurements are above 0.23 µSv/h and 72% of the recordings are above 1 µSv/h
- 817 measurements were recorded inside the house, with an average of 0.5 µSv/h and a maximum of 0.9 µSv/h. All measured radiation levels inside the house were above 0.23 µSv/h.

Figure 6 Specific areas 1-16 as defined for systematic mapping around Mr. Anzai's house.

2. Results of the specific measurements and hotspots

- The highest hotspots were recorded on a decontaminated greenhouse (2.3 µSv/h at 1m, 13.7 µSv/h at 10cm) and along the road (2.76 µSv/h at 1m, 9.86 µSv/h at 10cm).

Area 13 is an area with dismantled greenhouses which has been decontaminated. The mapping of area 13 shows that all measurements are above 0.23 µSv/h and 73% are above 1 µSv/h, with an average of 1.2 µSv/h (see figure 8).

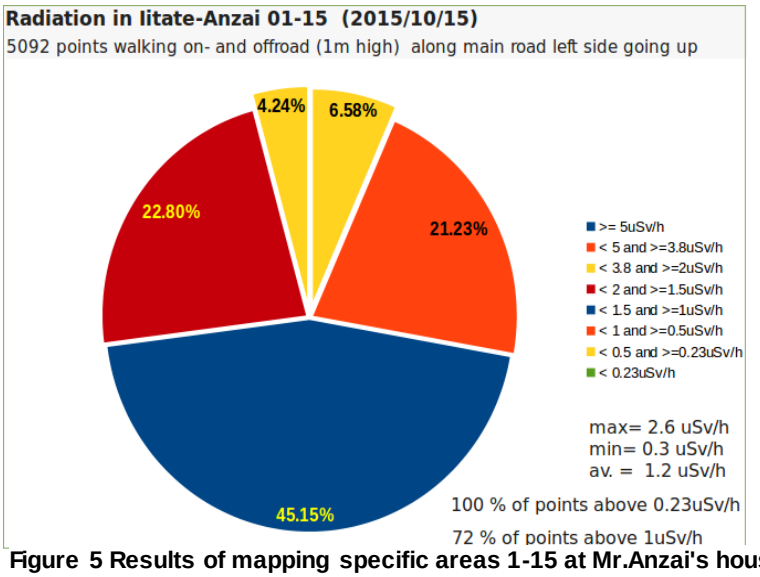


Figure 5 Results of mapping specific areas 1-15 at Mr.Anzai's house

3. Result of decontamination

In many areas around Mr. Anzai's house, especially along the road, paths and on the fields, decontamination has not succeeded in lowering the radiation levels below an average of 1µSv/h. Only around the main house and in front of the main hose, radiation levels are significantly lower. In this area, new sand and gravel has been put on top of the soil after decontaminating the soil.

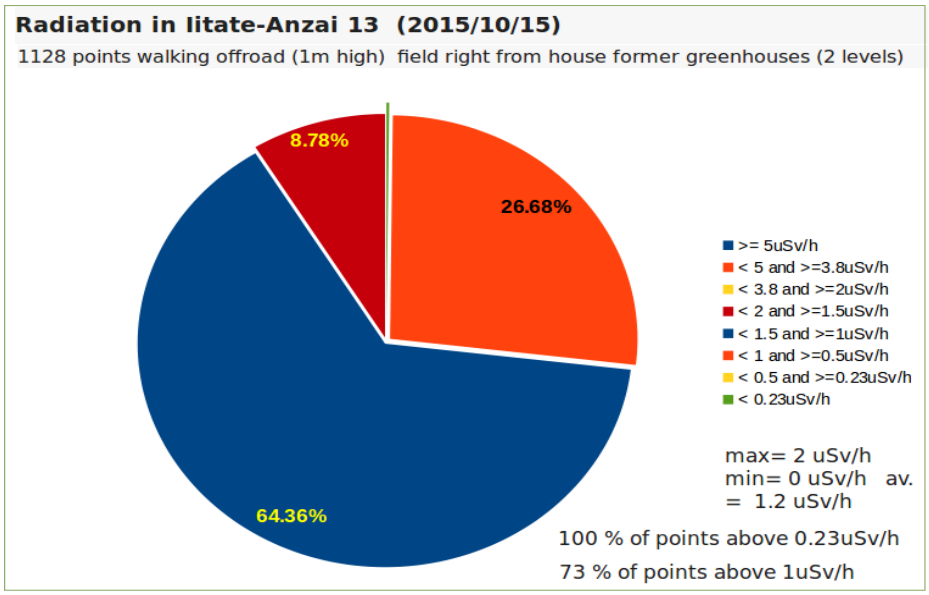


Figure 6 Results of mapping specific area 13 at Mr.Anzai's house

4. Estimation of annual dose

The annual effective dose for the population in Fukushima contaminated areas is highly dependent on their lifestyle. Before the nuclear disaster, people in Iitate district had an outdoor lifestyle, either working on the field or in the forests. The methodology applied by the Japanese government to calculate effective dose on the basis of a life 8h per day outside and 16h per day inside the house is therefore not realistic in this rural area. It would only be applicable if people would change their lifestyle, restricting the people's freedom of movement.

Alternatively, calculation the annual effective dose on the basis of 12h inside and 12h outside the house, and utilising the actual radiation inside the house of Mr. Anzai instead of using the shielding factor that the government uses, would result in an additional radiation dose from the Fukushima contamination of around 7mSv per year in 2015, based on a pre-March-2011 lifestyle.

5. Risk of recontamination near the house

The decontamination works in the area around Mr. Anzai's house has been almost completely finalised. Radiation levels are expected remain stable over the next years or even increase, especially at the back of the house which is just 2m from a steep, forested slope. This forest will not be decontaminated, apart from the first metres near the house. Given the steep slope, radioactive materials could be washed down with the rain, recontaminating the back of the house and increasing the radiation levels inside the house.

Case study 2: Contamination of forests

As noted earlier, 75% of Iitate is covered by dense forest. Greenpeace measured radiation levels in the forest along a small river heading to the Ganbe lake in Iitate. Radiation was measured to be in the range of 1-3 µSv/h at 1m height. Soil samples of the forest soil show contamination levels in the range of 6,200-33,500 Bq/kg at one location (see Figure 9) and between 24,800 and 83,000 Bq/kg at a different location alongside a small river close to Ganbe lake.

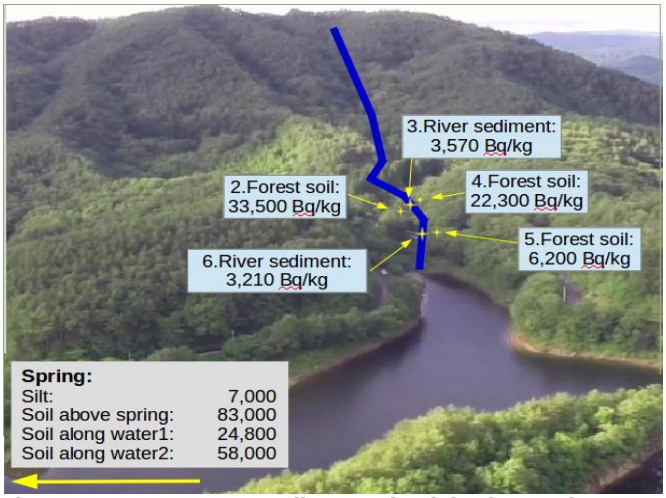


Figure 7 Forest surrounding Ganbe lake in southwest Iitate, Greenpeace investigation July 2015 (c) Marco Kühne / Greenpeace

These levels are about a factor 10 higher than the contamination levels measured in sediment samples from the riverbed. This indicates that radioactive materials are slowly migrating from the forest ground to the river, and is washed down by the river towards Ganbe lake. Research financed by the Japanese government (F-Trace project) also shows such slow migration[xxv].

The mechanisms for the movement of radioactivity both in and out the forests is complex. There is evidence that radioactivity on the forest floor remains high, but also that it is entering the soil, with most retained in the top soil layer to a depth of 5cm. Radioactivity that deposited on the forest in the initial days of the accident washed down to the forest floor as well as into small streams, with a portion washing downstream into rivers and lakes.[xxvi] Over the longer term, radiocaesium in the surface organic layers on the forest floor has moved into the mineral soil, while some of the radiocaesium in organic and mineral soil layers is absorbed by plant roots and transferred into above ground plant structures: trunks, stems, and leaves. A portion of the deposited radiocaesium will migrate from forests via stream flow, but the forests of Iitate, as

elsewhere in Fukushima are acting as a long lasting reservoir for radiocaesium and as a large source for future recontamination the environment beyond the forest. Understanding what portion of this will then migrate into the wider area, including into farmland and around people's homes, and how much will be retained in the long-term is one of the major questions urgently needed to be answered.

Case study 3: Kawauchi

Both in October 2014 and in October 2015, Greenpeace investigated the radiation levels in the municipality of Kawauchi, which is located SW of the Fukushima-Daiichi nuclear power plant. In October 2014, the evacuation order was lifted of one part of the evacuated area of Kawauchi, which is within the 20km zone. Another part of Kawauchi still remains evacuated.

Greenpeace mapping of radiation levels measured outside a car along the main roads of Kawauchi in both area's showed in 2014 that 59% of all measurements recorded were above 0.23 µSv/h and 2.5% above 1µSv/h. In October 2015, the same area showed a decrease of radiation levels to 41% above 0.23 µSv/h and only 0.16% above 1 µSv/h (see figure 10).

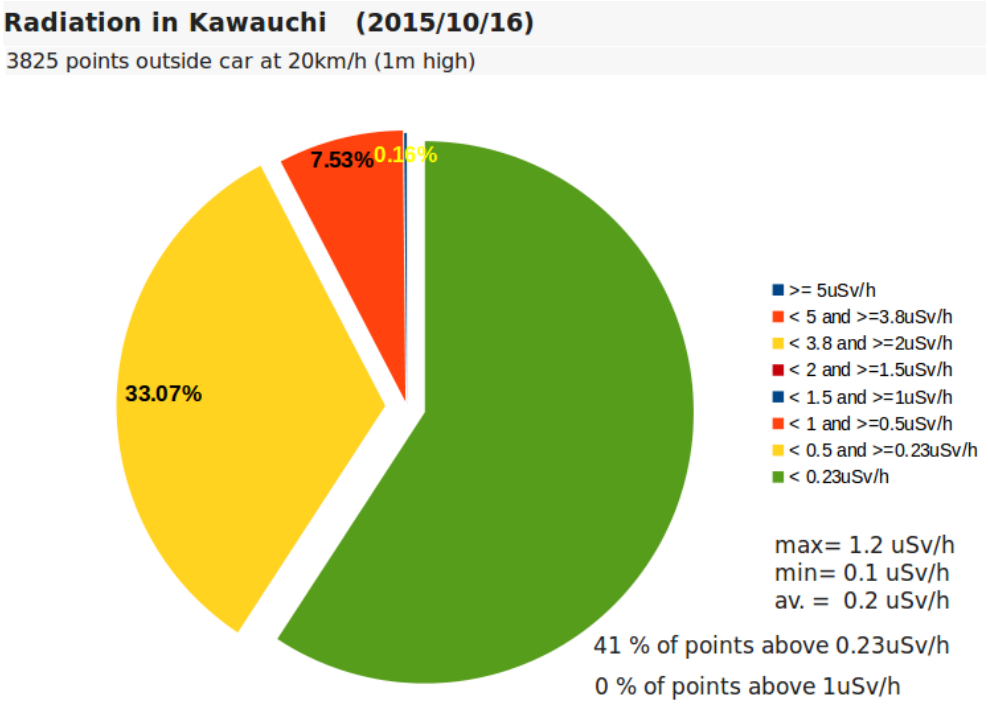


Figure 8 Mapping of radiation levels in Kawauchi, October 2015

Conclusions and recommendations

Greenpeace investigation as shown that the radiation levels in the contaminated areas around Fukushima Daiichi nuclear power plant do not significantly decline more than 4 years after the accident. This is caused by the fact that the short-lived radioisotopes have decayed and Cs-134 with a half-life of only 2 years has been reduced with more than 75%. The main remaining radionuclide, Cs-137, with a half-life of 30 years is now strongly bound to soil and its contamination levels are not expected to decrease significantly over the coming years, posing a long-term risk.´

Areas that have been decontaminated, in narrow forest strips along roads, and around people's houses, remain heavily contaminated despite decontamination efforts. The forests, which cannot be decontaminated, are a massive stock of radioactivity which will pose a risk to the population for the coming decades. A proportion of caesium is slowly migrating from the forests downstream.

It is still largely unknown how and where this contamination can re-accumulate downstream and pose a risk to the population in the coming decades.

What is clear from our investigations is that in spite of the effort of thousands of workers, decontamination of Iitate is likely to be a never ending process and with limited impact on reducing radiation dose levels. Due to the scale of contamination of the hills, mountains and forests of Iitate, radiological recontamination of areas declared decontaminated will likely continue to the foreseeable future. The decontamination efforts also do not "get rid" of the contamination – they simply move it. The process is generating vast amounts of radioactive waste, which is being piled up at temporary sites throughout the district and the prefecture.

Additionally, when considering the impact of the forest contamination on human life in the region, we must also consider the quality of life. Life in Iitate was largely lived outdoors. Many people were employed as farmers or in forestry. Residents gathered wood, mushrooms, and wild fruits and vegetables from the mountain forests. Children played outside in the forests and streams.
The damage of radiological contamination of the Iitate forests extends far beyond the immediate threat to health, and includes the destruction of livelihoods and an entire way of life. Even if the 20m around people's houses were to be successfully decontaminated – which is largely not the case – the damage to former resident's lives is irreversible.

Recommendations:

- The evacuation order in Iitate should not be lifted, as the area is too contaminated for people to return safely, even in those areas that have been decontaminated; it should be formally recognised that the heavy contamination of the forests poses a significant and ongoing risk of recontamination and further exposure; and that the quality of life of former residents have been irreparably destroyed;
- Former residents should be allowed to make the highly personal decision as to whether to return to their homes in evacuation zone based upon accurate, scientific data regarding the contamination levels in the area and in their houses being provided to them; should be neither harassed nor pressured in either direction; should receive full support of the Government and TEPCO whatever their decision; should not require any other person who does not want to live in the evacuation zone to do so;
- Regardless of the individual's choice, whether that person has decided to incur the risks of living within the evacuation zone or chooses to establish a life elsewhere, they must be fully compensated for their loss of livelihood, property, community, mental distress, and health risks incurred, so that they may fully support themselves to move forward to pursue whatever life they so choose.

The damage done to the people and communities of Fukushima Prefecture, and especially the already heavily exposed people of Iitate, can never be repaired. These communities, even those where citizens are able to return, will never be the same – particularly as many young families do not want to return to areas that may put the health of their children at risk.

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[iii] Ibid.
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[viii] Ibid.

[ix] 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, 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.

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[xviii] Jan Vande Putte, 31 October 2014. Learning the tragic lesson of Fukushima: No nuclear restart at Sendai. http://m.greenpeace.org/international/en/mid/news/Blogs/nuclear-reaction/No-nuclear-restart-at-Sendai/blog/51158/ accessed February 11th 2015.

[xix] The Japanese government set a long-term target level of 0.23 µSv/h to remain under 1mSv/year, based on the assumption that a person in that region would spend on average 8 hours outside the house and 16 hours inside each day throughout the year (http://ramap.jmc.or.jp/map/eng/map.html). The reality in this agricultural area is however very different. Before the accident, people spend significantly more time outside their house, particularly in spring, summer and autumn months.

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[xxii] All data can be consulted on the interactive map: http://gp.naturalserver.co.uk/map/45/language=en

[xxiii] Jan Vande Putte, 31 October 2014. Learning the tragic lesson of Fukushima: No nuclear restart at Sendai. http://m.greenpeace.org/international/en/mid/news/Blogs/nuclear-reaction/No-nuclear-restart-at-Sendai/blog/51158/ accessed February 11th 2015.

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