ACRO

ASSOCIATION POUR LE CONTRÔLE
DE LA RADIOACTIVITÉ DANS L'OUEST

Fukushima five years later: back to normal?

Analysis by David Boilley (ACRO)
commissioned by Greenpeace Belgium

February 2016

The author thanks Reiko Hasegawa, Kazumasa Aoki, Kurumi Sugita and Greenpeace for valuable suggestions. This report, publications discussed, and conclusions made are solely the responsibility of the author and ACRO.

ACRO
138, rue de l'Eglise
14 200 Hérouville Saint Clair
France

Phone: +33 231 94 35 34

acro@acro.eu.org

ACRO.eu.org
Fukushima.eu.org

Summary

The nuclear disaster at the Fukushima daiichi nuclear power plant (FDNPP), ranked at Level 7 of the International Nuclear Event Scale (INES), which is the highest level, is widely recognized as man-made. It contaminated a vast territory in Japan and was responsible of the displacement of about 160 000 persons according to official statistics. Contaminated territories that were not evacuated are also strongly affected by the disaster.

The crippled reactors are still discharging radioelements into the environment. Anomalous discharges were hidden for several months, generating to a lot of confusion. Sloppy behaviours led to significant contamination by radioactive dust tens of kilometres away from the plant. TEPCo has difficulties to curb down the radioactive leaks into the ocean and tainted water piles up in tanks without any solution in sight.

TEPCo has yet to fully stabilize the power station and its priority is still to reduce the threat. Dismantling has not started yet. While communities around the station were evacuated due to the long-going contamination, and many fear radioactive emissions could resume in the event of another natural disaster. They wonder if it is safe to come back when the evacuation order is lifted. Actually, the crippled reactors at FDNPP are more fragile than usual reactors, and their containment vessels are leaking. They might not be able to sustain an earthquake or a tsunami, which would lead to a new massive release of radioelements.

Evacuees

Many people were forced to evacuate during emergency phase followed by others during the first months of the disaster due to the radioactive contamination. Many others evacuated on their own in order to protect their children or themselves. Five years later most of them remain evacuated and hardly imagine their future.

The total number of evacuees related to the nuclear disaster is not well known. Nevertheless, about 160 000 people fled from contaminated territories according to official statistics. Five years later, the number of nuclear displaced persons is still about 100 000 as evacuation orders have only been lifted in three places. Evacuees who resettled are not counted anymore although they might be still suffering.

Behind these figures, there are individuals whose life was disrupted. Major nuclear disasters are firstly human disasters leading to the displacement of many people who lose everything from dwellings, family life, social relationship and future. Displacement generates conditions of severe hardship and suffering for the affected populations, but it could be avoided. Non-evacuated people in contaminated territories worry for their health and future and their daily life is also severely affected.

To decide about the fate of evacuees, Japanese authorities have divided the evacuated territories into three zones depending on the airborne dose rate: Areas where the annual integral dose of radiation is expected to be 20 mSv or more within five years and the current integral dose of radiation per year is 50 mSv or more are classified as difficult-to-return zones. Evacuation orders will not be lifted before several years and residents' relocation is supported. Areas where it is confirmed that the annual integral dose of radiation will definitely be 20 mSv or less are classified as areas to which evacuation order is ready to be lifted. In between, with an annual external dose ranging from 20 to 50 mSv, the residents are not permitted to live, but decontamination is expected to reduce the annual dose below 20 mSv.

Radiation protection

Both evacuation and return policies are based on a lax interpretation of the international recommendations that not very binding. 20 mSv per year corresponds to the highest value of the International Commission on Radiological Protection (ICRP) reference interval in case of existing situation that includes post-accident. ICRP recommends lowering with time the reference level to 1 mSv per year. Consequently, Japanese authorities have adopted this value as a long-term target, without a precise agenda for compliance. At the moment authorities stick to the 20 mSv reference level that is considered as too high by many Japanese.

Regarding the food contamination, the strategy was completely different: maximum allowed concentrations were fixed below international standards to promote the recovery of consumers' confidence and food production in contaminated territories.

Contrast between the protection against external exposure and internal exposure through food intake is shocking. In the first case Japanese authorities refuse to lower the reference levels that are kept at the highest value of the international recommendations whereas in the second case maximum allowed values were divided by a factor 5 after a year.

Such a contrast shows that the primary concern of Japanese government is the economical consequences of the nuclear disaster. Contamination limits in food were lowered to regain the confidence of consumers who avoid products from Fukushima. On the contrary compensation of the evacuated people represents a heavy economical burden and authorities do not propose any other solution than the return of displaced persons.

To win the citizens' understanding, authorities keep claiming that radiation-induced cancer does not occur, or is undetectable even if it occurs, under the integrated exposure dose of 100 mSv although international recommendations on protection against radiations are based on the central assumption of a no-threshold linear dose–response relationship for the induction of cancer and heritable effects. And with a limit of 20mSv per year, 100 mSv might be quickly reached.

Consequently, Japanese authorities have changed their policy and introduced a new way of measuring the dose. Evacuation policy was based on the airborne dose rate that can be easily measured by various methods, including simple radiameters. Then, to estimate the annual dose, it is supposed that individuals spend 8 hours per day

outdoors and that indoors, exposure is reduced by 60%. For the return, authorities will provide an individual dosimeter or glass-badge to register each individual cumulative dose, without mentioning that this apparatus gives an overall value that is 30 to 40% lower from what can be deduced with an apparatus measuring airborne dose rate.

This new policy is also a change of paradigm: Individuals will be in charge of their own protection against radiations. On the contrary to nuclear workers who are supposed to be well controlled, nobody controls if the population wear such individual dosimeters. This is crucially problematic for children who are more sensitive to radiations. Continuously controlling one's life is a heavy burden that is hardly accepted, especially when there are children for which it is not a bright future to propose.

30 years after the Chernobyl disaster, international radiological protection rules and practices are not adapted for populations living in contaminated territories. They are extremely confusing and impossible to enforce, allowing authorities to adapt rules to their own advantage rather than the affected populations. Rule should be binding in terms of limits, temporal evolution and operational quantities.

Food contamination

Regarding the food issue, Japanese authorities initially failed to foresee the scale of problems with contaminated food and crops, and were repeatedly caught by surprise in the following months. As a consequence, many people's trust in the government was eroded and the population concerned about food safety reconsidered their relationship to the state and to the food.

But citizens, famers, producers, retailers and consumers have been monitoring food production forcing authorities to introduce systematic controls. Situation has quickly improved and except for wild plants and animals, including fishes and self-production, contamination of the food found on the market remains low. Internal contamination of children checked by whole body counting is also low enough to consider that external dose is the dominating problem for residents in contaminated territories. This success has a cost: many farmers cannot resume farming and some traditional productions might disappear.

The food issue shows the merit of an open process in which every one can check the contamination and adapt its diet to its own requirement. Nevertheless consumers are still reluctant to buy food produced in contaminated territories and producers, including farmers, fishermen and foresters are still suffering five years later.

Government's policy was focused on food safety (*anzen* in Japanese), but it did not address how to generate a climate of trustworthiness (*anshin* in Japanese) about food. Enforcing technical standards alone is not sufficient to overcome consumer mistrust. The challenge is to bring together food safety and the peace of mind that comes with it.

What future for evacuated territories?

Japanese government decided to withdraw evacuation orders by March 2017 and stop compensations by March 2018, except in the so-called difficult-to-return zones. Even J-Village, a former training centre for football, changed into a

base for the workers at the FDNPP will turn back to sports before the 2020 Olympic games.

As a matter of fact, Japanese authorities dream of a reversible disaster while international recommendations on post-accident management only focus on the return to normalcy. With a half-life of 30 years, caesium-137 decays too slowly. Japanese government has launched a huge decontamination programme in both non-evacuated and evacuated territories where the annual dose is higher than 1 mSv, except for the difficult-to-return areas. It consists on scrapping the soil, cutting the grass, trees, bushes and washing to roof of dwellings, roads, and sidewalks… in the vicinity of dwellings and other buildings, changing villages and towns into oasis in the middle of a vast contaminated land. In evacuated territories, decontamination plans covers about 24 800 ha and there are no such plans for the surrounding land, including forests and mountains that cover about 70% of Fukushima prefecture.

Decontamination is not very effective and generates huge amount of waste for which all proposed solutions failed because of the opposition of the populations. Actually, handling radioactive waste is a difficult issue in all countries that have accumulated significant amounts. But after a severe nuclear accident, it is even more difficult and volumes are enormous. 20 millions cubic meters are expected in Fukushima prefecture and the projected storage centre will cover 16 km^2. Projects are stalled in Fukushima and other prefectures, but authorities stick to their authoritative attitude that is a complete failure: Decide – Announce – Defend (DAD). In the mean time waste is piling up in bags that are quickly damaging.

Decontamination proved to be deceiving as dose rates have not significantly fallen compared to what can be observed in the forest. Nevertheless authorities keep encouraging inhabitants to come back.

Residents are reluctant to come back

So far, evacuation orders were lifted in parts of Tamura and Kawauchi in 2014, and in Naraha in 2015. All these areas lie within the less contaminated parts of the 20 km evacuation zone. Evacuation recommendations around scattered hot-spots are also completely lifted. But residents are reluctant to come back and contaminated areas are facing aging and depopulation problems.

The town of Hirono, which lies between 20 and 30 km from the FDNPP, was included in the emergency evacuation preparation zone. Residents are expected to return, but according to the latest census in 2015, large portion of the present population is involved in nuclear reactor decommissioning work: the male population is up 2.3% from 2010 whereas the female population, on the other hand, was down 42.3%. In Minami-Soma, the population declined to 66% of that prior to the accident and the average resident age increased by 14 years, a level that was expected in 2025.

Facts prove that return to normalcy is impossible after a large-scale nuclear disaster such as the ones that occurred at Chernobyl and Fukushima. United Nations' guidelines on internally displaced persons urge authorities to ensure the full participation of internally displaced persons in the planning and management of their return or resettlement and reintegration. But in Japan their participation is reduced to

"explanation meetings" (setsumeikai) usually organized behind closed doors without any presence of media, NGOs, legal or independent experts and thus leaving evacuees with little recourse.

Affected communities see no end to the severe hardship they are facing and are suffering. To stay or to flee, to come back or to relocate are difficult choices in a no-win situation. Number of people suffering from psychological disorders such as depression and post-traumatic stress disorder is larger than usual among both evacuated and non-evacuated people. The number of suicides related to the disasters is larger in Fukushima than in Miyagi or Iwate that were hit by the tsunami.

Conclusions

The impact of the accident still continues, and responses that can be accepted by the affected populations are urgently required. Residents in the affected areas are still struggling to recover from the effects of the accident. They continue to face grave concerns, including the health effects of radiation exposure, the dissolution of families, disruption of their lives, and the environmental contamination of vast areas of land. As nuclear disasters last for decades affected population see no end to the severe hardship they are facing.

After a nuclear disaster, many residents distrust authorities and official experts that failed to protect them. But recovery paths require a good coordination between authorities and the populations. Solutions cannot ignore the specific needs and demands of the affected populations, as well as their suggestions. This means new ways for deliberation and decision. Solutions might differ from families or communities. There is no good solution and each decision should be evaluated and then adapted. Beyond the pain of the affected persons, a nuclear disaster also shakes the ground of democracy.

Japanese citizens have proved to be resourceful about the measurement of radioactivity. Citizen mapping of the contamination was done all over and food monitoring prompted authorities, producers, and retailers to strengthen their controls and finally led to a decrease of intake of radioelements. Why such an open process that proved to be effective is not possible when deciding about the fate of contaminated territories and affected population?

Contents

Summary **3**
Evacuees 3
Radiation protection 4
Food contamination 5
What future for evacuated territories? 5
Residents are reluctant to come back 6
Conclusions 7

Contents **8**

Introduction **11**

Radioactive releases continue **13**
Source terms 13
Leaks persist 14
Impact to the sea 16
Sloppy behaviours led to significant contamination by radioactive dust 17
The FNPP is still threatening 18
Conclusions 18

Radioactive Contamination and Evacuation **20**
Unfolding of evacuation 20
Number of evacuees 23
Five years later 24
Conclusions 26

Overview of Protective Action Levels after the nuclear disasters **27**
Radiological protection principles 27
Evacuation policy 30
Protection versus operational quantities 31
Limits for food contamination 33
Conclusions 34

Food Contamination five years later **35**
Initial failures in food monitoring 35
Extended food monitoring 37
Internal exposure of the consumers 38
Restrictions on food production threatens many activities 39
Consumers are still cautious 40
Conclusions 41

Recovery of the contaminated the land **42**
Recovery policy 42
Limited effect of decontamination 43
Huge amounts of waste are produced 44
Waste is not well kept and secured 47
Conclusions 48

Return policy **49**
Governmental decisions 49

Residents are reluctant to come back 50
Ageing and depopulation problems in radiation-contaminated areas 51
Return policy 52
Human rights violations 53
Evacuees suffer 54
Conclusions 56

Conclusions 57

Abbreviations 59

Units 59

Bibliography 60

Fukushima five years later: back to normal?

Introduction

The nuclear disaster still unfolding at the Fukushima dai-ichi nuclear power plant (FDNPP) in Japan is not a "natural disaster" but clearly recognized as "man-made" [NAIIC2012]. Ranked at the level 7, the highest, of the International Nuclear Event Scale (INES), it led to the evacuation of about 160 000 persons in Fukushima prefecture in addition to the displacement of populations due to the earthquake and tsunami on the 11th of March 2011 [NAIIC2012, IOM2015]. Five years later, the number of nuclear refugees still tops 100 000 as most of the evacuated zones remain evacuated, but Japanese authorities decided to withdraw evacuation orders by March 2017 and stop compensations by March 2018 [Asahi19/5/2015]. After declaring on the 16th of December 2011 that the cold shutdown of the reactors was achieved at the FDNPP, consequences of the massive radioactive releases that felt down on a vast territory should officially vanish within few years. Even J-Village, the football training centre located near the FDNPP that is currently used by workers securing the crippled reactors, will turn back to sports in time for the 2020 Olympic games in Japan [FMinpo16/1/2015]. The FDNPP is presented as a training centre for decommissioning and become a show window for Japanese technology.

But facts prove that return to normalcy is impossible after a large-scale nuclear disaster such as the ones that occurred at Chernobyl and Fukushima and the affected populations are still suffering. Long-term social disruption, including the long-term displacement of people and communities, is a shared characteristic of Fukushima and Chernobyl. A nuclear disaster is primary a humanitarian disaster that is still unfolding. The FDNPP still discharge radioelements into the environment. Some anomalous releases were hidden for months and the crippled reactors are still threatening. Reducing the threat and then dismantling will take decades. The disaster has just started.

Japanese authorities have privileged the return of the populations to most of the evacuated zones. For that purpose, they have launched a huge decontamination programme in the contaminated territories that is deceiving. Airborne dose rates have not decreased as expected and authorities have difficulties to find solutions for the enormous volume of radioactive waste that is generated by these operations.

Regarding the evacuation and the return policy, authorities also have a lax interpretation of the international radiation protection recommendations. They have chosen the highest value of the International Commission on Radiological Protection (ICRP) reference dose for the so-called "existing situation" that ranges between 1 and 20 mSv/year. As a consequence, in the three municipalities where evacuation orders have already been lifted the return rate remains very low.

Solutions proposed by authorities cannot be accepted and affected populations have difficulties to imagine their own future. Both evacuated and non-evacuated populations are suffering. The gap between citizens and authorities is widening. The government

considers that populations are victim of “harmful rumours” and expect gaining citizens’ understanding of its policy by explaining it again and again. But it failed to convince them [Shirabe2015].

Population face grave concerns about the health effects of radiation exposure, the dissolution of families, disruption of their lives, and the environmental contamination of vast areas of land. For many, solutions proposed by the authorities cannot be accepted and where the evacuation order was lifted, the return rate remains low. The lack of foreseeable future adds to the suffering of the populations.

International guidelines regarding internally displaced persons are not respected: authorities should propose return and relocation without any discrimination and help the affected population to rebuild their life, whatever the chosen solution.

Radioactive releases continue

The March 2011 nuclear accident at FDNPP led to major discharges of radioelements into the atmosphere and the Pacific Ocean. Discharged quantities depend on the evaluation method. Atmospheric releases that lasted over ten days are estimated to be about 10% of the quantity released in the Chernobyl accident [Steinhauser2014]. They are responsible to the contamination of a vast territory for decades and triggered the displacement of about 160 000 people [NAIIC2012, IOM2015]. As for the discharge into the Ocean, it is the largest ever registered. Radioactive contaminants were quickly diluted into the vast Pacific Ocean thanks to the Kuroshio and Oyashio currents and traces of radioactive caesium coming from Japan have been detected in the seawater near the cost of North America [WHOI2015]. However, seabed sediments have accumulated large quantities of radioactive caesium near the Japanese coast and fishing is still forbidden for many species.

Discharges continue at a smaller scale and Tokyo Electric Power Company (TEPCo) tried to conceal related information. It took several months to acknowledge sloppy behaviours that led to several scandals.

In addition, TEPCo has accumulated a huge amount of contaminated water stored in tanks on the plant premises. It mainly contains tritium that is not filtered by the treatment facility. One of the proposed solutions is to discharge it into the ocean although this is not possible for the moment.

Five years after the Fukushima disaster began, TEPCo still tries to prevent ongoing radioactive releases. While communities around the station were evacuated during the first months of the accident when radioactive releases were highest, TEPCo has yet to fully stabilise the station and many fear radioactive emissions could resume in the event of another natural disaster. Is it safe to come back when evacuation orders are lifted?

Source terms

The Nuclear Accident Independent Investigation Commission of the National Diet in Japan (NAIIC) reports that, the source term, or radiation released into the atmosphere by the accident in March 2011, is estimated to be approximately 900 PBq, including 500 PBq of iodine-131 and 10 PBq of caesium-137, but excluding noble gases[1]. The former can affect the thyroid but quickly disappeared whereas the latter has long-term

[1] Units are defined in a specific section at the end of the report.

consequences, as its half-life is 30 years. In radiological equivalence to iodine-131, this is approximately one-sixth of the 5 200 PBq that was calculated to have been released by the Chernobyl accident [NAIIC2012]. The latest report of the United Nations Scientific Committee of the Effects of Atomic Radiations (UNSCEAR) confirms that estimates ranged generally from 100 to 500 PBq for iodine-131 and from 6 to 20 PBq for caesium-137. The averages of the published estimates were about 10% and 20%, respectively, of the corresponding releases into the atmosphere estimated for the Chernobyl accident [UNSCEAR2015]. Another review of the scientific literature suggests 150 PBq for iodine-131 and 12 PBq for caesium-137 as best estimates. The total source term excluding noble gases is then estimated to be 520 PBq. This is about one-tenth of the source term of Chernobyl accident [Steinhauser2014].

These estimations are based on the environmental measurements and dispersion modelling to quantify the source term that matches with what is observed. Near field codes for the Japanese territory and far field codes on a larger scale do not give the same result. Whatever the result, it corresponds to a level-7 accident on the INES scale although it took a month to Japanese authorities to acknowledge it.

All estimations agree that about 80% of atmospheric discharges went towards the Pacific Ocean and 20% fell down on the Japanese territory. Massive radioactive releases into the atmosphere last for more than ten days at the Fukushima dai-ichi NPP, which is far longer than what is usually forecasted in emergency planning.

According to the Ministry of the Environment of Japan, the contaminated land area in Fukushima Prefecture with a potential air dose rate of 5 mSv or more for the first year stretched over 1 778 km^2. Some 515 km^2 could have a potential annual air dose rate of more than 20 mSv [NAIIC2012]. As it will be explained later, the annual dose should not be higher than 1 mSv for planned exposure. 20 mSv corresponds to the highest value of the international recommendations in a post-accident situation.

In addition to this, Japan faced the highest radioactive leak into the ocean ever registered. TEPCo estimated that 520 m^3 of highly radioactive water was discharged into the ocean in April 2011, corresponding to a source term of 4.7 PBq consisting of 2.8 PBq of iodine-131 and 0.94 PBq of radioactive caesium. The Institute for Radioprotection and Nuclear Safety (IRSN), the French Technical Support Organisation, estimated it to be 20 times higher for caesium [IRSN2011b]. If estimates of leaks of radioactive material into the sea were judged according to the International Nuclear Event Scale, the severity of marine contamination would be rated level 5 or 6.

Leaks persist

TEPCo claimed to have plugged the leak in April 2011, nevertheless, the FDNPP is still leaking at a smaller scale, but at levels far higher than what is usually allowed for a nuclear power plant. Contaminated underground water continues to flow into the ocean.

Underground water near the crippled reactor is highly contaminated. TEPCo's monitoring shows levels reaching 670 000 Bq/L for the beta total contamination in December 2015 [TEPCo2015b]. The company put a lot of efforts to curb down these

leaks and the adopted measures are not so effective. On about 7 000 workers working each day at the plant, about half of them are designated to the management of contaminated water.

Continuous leaks were obvious according to data on the contamination of the seawater, as pointed out in the scientific literature. In March 2013, a study estimated that an average release rate of caesium-137 was estimated to be 93 GBq per day in summer 2011 and 8.1 GBq per day in summer 2012 [Kanda2013]. Values can be discussed, but not the fact that the plant was still leaking. However, TEPCo had persistently denied that contaminated water reached the sea, despite spikes in radiation levels in underground and seawater samples taken at the plant. The utility first acknowledged an abnormal increase in radioactive caesium levels in an observation well near the coast in May 2013. TEPCo officials finally acknowledged on the 22nd of July 2013 that a leak is possible because the underground water levels in suspected areas fluctuate in accordance with tide movements and rainfalls [AP22/7/2013].

In its communication [TEPCo2013], TEPCo mentions that the concentration of tritium in the seawater in the port has risen to 2 300 Bq/L. As tritium does not accumulate and cannot come from the contamination of the sediment of the seabed, it can only come from the crippled power plant. So far, several countermeasures were implemented to stop leaks from the highly contaminated water accumulated in trenches and the underground water. Sea monitoring in front of the plant shows an improvement but this is still a major issue for TEPCo.

What is the problem? TEPCo erased a part of the cliff to build the reactors of the FDNPP closer to the sea level. It was a fatal decision. Basement of the reactor and turbine buildings is on the path of the underground water flowing from a mountainside into the plant premises and then to the ocean. Before the disaster, TEPCo had to pump about 1 000 m^3 of underground water per day to avoid flooding of the basement. These pumps were stopped by the disaster and about 400 m^3 of groundwater was seeping into the reactor buildings every day and mixing with toxic water that has been used to cool the crippled reactors. Of course, part of this contaminated water also seeps into aquifers before reaching the ocean. During the summer 2013, TEPCo had to pump each day from the basement about 400 m^3 more than what it was pouring to cool the reactors to avoid new massive leaks to the ocean. The remaining 600 m^3 from the water flowing into the plant premises was still flowing into the ocean. TEPCo and authorities arbitrarily estimated that about half of it was contaminated. It was finally acknowledged that 300 m^3 is tainted with radioactive substances before leaking into the sea [ACRO2013, JT7/8/2013].

TEPCo and its subcontractors have been testing several methods to curb down this leak with limited effects so far. Among them, the company has being pumping underground water upstream of the reactor. Impact is deceiving. In September 2015, it has started to pump underground water near the reactors, partially decontaminate it and discharge it into the sea. Since then, the company estimates that 150 m^3 of underground has been penetrating everyday into the basement of the reactor and turbine buildings and that 400 m^3 per day flow into the ocean [ACRO2015d].

The latest measure to curb down leaks is an underground barrier all along the seashore. It has started to lean towards the ocean due to the water pressure [TEPCo2015a]. In January 2016, TEPCo recognized that it couldn't treat underground water pumped near the reactors anymore before discharging it into the ocean, because of its salinity and a too high contamination. It is instead poured back into the basement of reactors before being pumped into storage tanks. The current pumping of water into the turbine building has raised the combined average inflow to 600 m^3 daily, which is more than the amount of groundwater that was seeping into the basement in 2013 [TEPCo2016].

The company might have curbed down the leaks into the ocean but has increased the pile-up rate of contaminated water into tanks without any solution in sight. Another project is to freeze the ground all around the crippled reactors, but it is more difficult than expected, especially downstream where there are many trenches full of water that appeared impossible to freeze.

In the mean time TEPCo has being accumulating a huge amount of contaminated water in tanks on the plant premises. In May 2015, the company announced that almost all stored water has been treated to remove strontium (620 000 m^3), and for 440 000 m^3, 60 additional radioelements were removed. Tritium is not removed and TEPCo has no other solution for this stock of partially decontaminated water than discharging it into the ocean or evaporating it [ACRO2015b].

Taking into account tritium stored in the tanks (875 TBq) and still contained in the melted nuclear fuel (2 500 TBq), the total stock is evaluated at 3 400 TBq [TEPCo2014]. Considering that TEPCo was allowed to discharge a maximum of 22 TBq per year into the ocean before the accident, it would take more than 100 years to discharge it, unless the limit is raised.

Impact to the sea

In April 2011, when the leak into the ocean was at its maximum, the caesium-137 contamination of the seawater in front of the plant reached some 100 000 Bq/L [NRA2013a].

Because the FDNPP is facing a huge ocean, discharges are quickly diluted. Contamination of the seawater remains low, even at the proximity of the plant. Far away, traces of contamination coming from the early discharges could be detected near the North American West coast with the highest recorded value at 11 mBq/L for both radioactive caesiums [WHOI2015]. Impact would be more severe in case of similar leaks into the Mediterranean Sea, the North Sea or Great Lakes in North America.

On the contrary, sediments of the seabed near the crippled power plant and at the mouth of rivers are still contaminated from the early discharges and taint with radioactive elements the tropic chain starting from the benthic fauna. Consequently, some of the marine resources are still contaminated.

Sloppy behaviours led to significant contamination by radioactive dust

Similarly, atmospheric discharges are still larger than what is generally accepted for a NPP. In addition, sloppy dismantling of the upper part of the reactor 3 led to spread of radioactive dust that was detected kilometres away. 12 workers at the FDNPP were also contaminated during summer 2013. Once again it took more than one year to acknowledge the problem. One had to wait until December 2014 to learn that TEPCo diluted a dust suppressant that rendered it ineffective and allowed the spread of radioactive materials. It not only diluted the suppressant to levels well below the manufacturers' recommended standard, but it also did not use the suppressant on a daily basis when removing rubble. The sloppy practice continued for about a year [Asahi31/12/2014].

TEPCo finally acknowledged that on the 19th of August 2013, the quantity of radioactive materials released was 110 GBq. Some researchers evaluated this source term based on an atmospheric dispersion model and suggested that the estimated magnitude of the emission must have been greater at least by a factor of 3.61 for caesium-137. They also mention that one soil sample in the centre of the simulated plume exhibited a high strontium-90 contamination. Such a radioelement is more radiotoxic than radioactive caesium [Steinhauser2015].

These facts would have been kept secret without the independent monitoring done by researchers and NGOs. A team of researchers set up air sampling instruments at three points in residential areas of Fukushima Prefecture and have measured radioactive caesium concentrations every week since September 2012 to estimate residents' exposure to radiation. From samples collected between the 15th and the 22nd of August 2013, they found a reading of 1.28 mBq/m^3 at a location in Soma, 48 km northwest of the plant. That radioactivity level was more than six times higher than usual. Radioactivity levels were 20 to 30 times higher than normal in Minami-Soma, 27 km north-northwest of the Fukushima plant. And there were almost no changes in caesium concentrations in Kawauchi, 22 km west-southwest of the plant. Based on the wind's speed and direction at the time, as well as size of the collected particles, researchers concluded that the radioactive caesium came from the FDNPP. The team also found that caesium levels at the measuring point in Minami-Soma surged in May, June and August 2013. They presented their findings to the Environment Ministry in March 2014 [Asahi16/7/2014].

According to other university researchers, airborne radioactive materials released during debris-clearing work at the FDNPP were also found in Marumori in neighbouring Miyagi Prefecture, at 60 km away, on seven occasions since December 2011. The team determined that there were eight cases in which the amount of radioactive caesium in the samples were at least 10 times higher than usual levels and the material likely originated from the Fukushima plant because of wind direction and speed. The highest level of contamination was recorded in a sample collected between the 16th and the 20th of August 2013, reaching 50 to 100 times higher than usual levels. The research team reported the results of its findings to the farm ministry in May 2014 [Asahi31/7/2014].

However, Japanese had to wait until July 2014 to learn that the removal of rubble from the plant site in August 2013 spread radioactive substances to 14 rice paddies in Minami-Soma outside the evacuation zone and more than 20 kilometres from the plant. Caesium levels in the rice crops harvested autumn 2013 exceeded the safety standard of 100 Bq/kg. Radioactivity readings above the standard were also detected from rice grown at five locations inside the evacuation zone. Such high readings were not detected from rice crops in the area the previous year. Residents of Minami-Soma in Fukushima Prefecture expressed anger with the government and TEPCo for keeping them in the dark about this issue [Asahi14/7/2014, Asahi15/7/2014].

Japan's Nuclear Regulation Authority (NRA) now considers that it is highly unlikely that radioactive particles from the FDNPP contaminated rice fields some 20 km away. It estimated that 30 Bq/m^2 of radioactive caesium would have fallen on one location where the contaminated rice was harvested, and 12 Bq/m^2 on another. But the French IRSN calculated that the fallouts could have been at a level of 100 to 1 000 Bq/m^2 at Minami-Soma, contributing to the contamination of the rice crops [IRSN2014]. A more recent scientific publication also contradicts the findings of the NRA [Steinhauser2015].

Minami-Soma city council is not satisfied by official explanations and the city assembly unanimously decided to investigate how the NRA reached its conclusions in response to a petition submitted by a citizens group. The NRA did not specify the likely source of the contamination, and the government discontinued the investigation. *"The government should continue a scientific investigation so that farmers can be engaged in rice farming without anxieties, and accurate information can be conveyed to citizens in evacuation,"* the petition said [Asahi9/12/2015].

The FNPP is still threatening

The crippled reactors at the FDNPP are weaker than usual reactors and containment barriers are leaking. In case of natural disaster massive discharges might resume and threaten surrounding communities. Risk in No. 4 reactor was mitigated as last of nuclear fuel removed in December 2014 but TEPCo still faces the more challenging task of removing the fuel from the pools of the three reactors where meltdown occurred, as levels of radioactivity remain high. Access to the melted fuel in the containment vessels is even more challenging and is expected to take decades.

Nor is the contaminated water accumulated in tanks secured. As TEPCO faces insurmountable financial difficulties, it usually favours the cheapest options to the detriment of safety.

Conclusions

Sloppy behaviours have led to highly tainted discharges into the atmosphere adding a significant contribution to the previous fallouts. Contaminated water became TEPCo's nightmare at the plant's site. Efforts to curb down leaks into the ocean lead to accumulate huge amount of contaminated water in tanks without

any solution in sight. It took months to TEPCo and authorities to acknowledge problems that were first revealed by researchers doing measurements nearby the FDNPP.

TEPCo has yet to fully stabilize the station and its priority is still to reduce the threat. Dismantling has not started yet

While communities around the station were evacuated due to the long-going contamination, and many fear radioactive emissions could resume in the event of another natural disaster. They are reluctant to come back when the evacuation order is lifted. The crippled reactors at FDNPP are more fragile than usual reactors, and their containment vessels are leaking. They might not be able to sustain an earthquake or a tsunami, which would lead to a new massive release of radioelements.

Radioactive Contamination and Evacuation

Many people were forced to evacuate in a chaotic manner due to the radioactive fallouts. Many others evacuated on their own in order to protect their children or themselves. Five years later most of them remain evacuated and hardly imagine their future.

The total number of evacuees related to the nuclear disaster is not well known. Nevertheless, it is widely acknowledged that about 160 000 people fled from contaminated territories. Five years later, the number of nuclear displaced persons is still about 100 000 as evacuation orders have only been lifted in three places. Persons who resettled are not counted anymore.

Unfolding of evacuation

During the emergency phase of the disaster, population were forced to evacuate within a 20 km radius around the NPP, in successive stages. It is worth noticing that, as stressed by the NAIIC report, a 10 km radius zone was first chosen simply because it was the maximum area for an Emergency Planning Zone (EPZ). *"It was not decided on the basis of any kind of concrete calculations or rational grounds."* As for the next evacuation zone later decided due to the progression of the situation*, "a radius of 20 km was decided upon simply because of some people's subjective opinions. This can hardly be called a rational decision"* [NAIIC2012]. Residents had been forced to evacuate *"with little more than the clothes on their backs, and they had not known their evacuation was due to a nuclear accident"* [NAIIC2012].

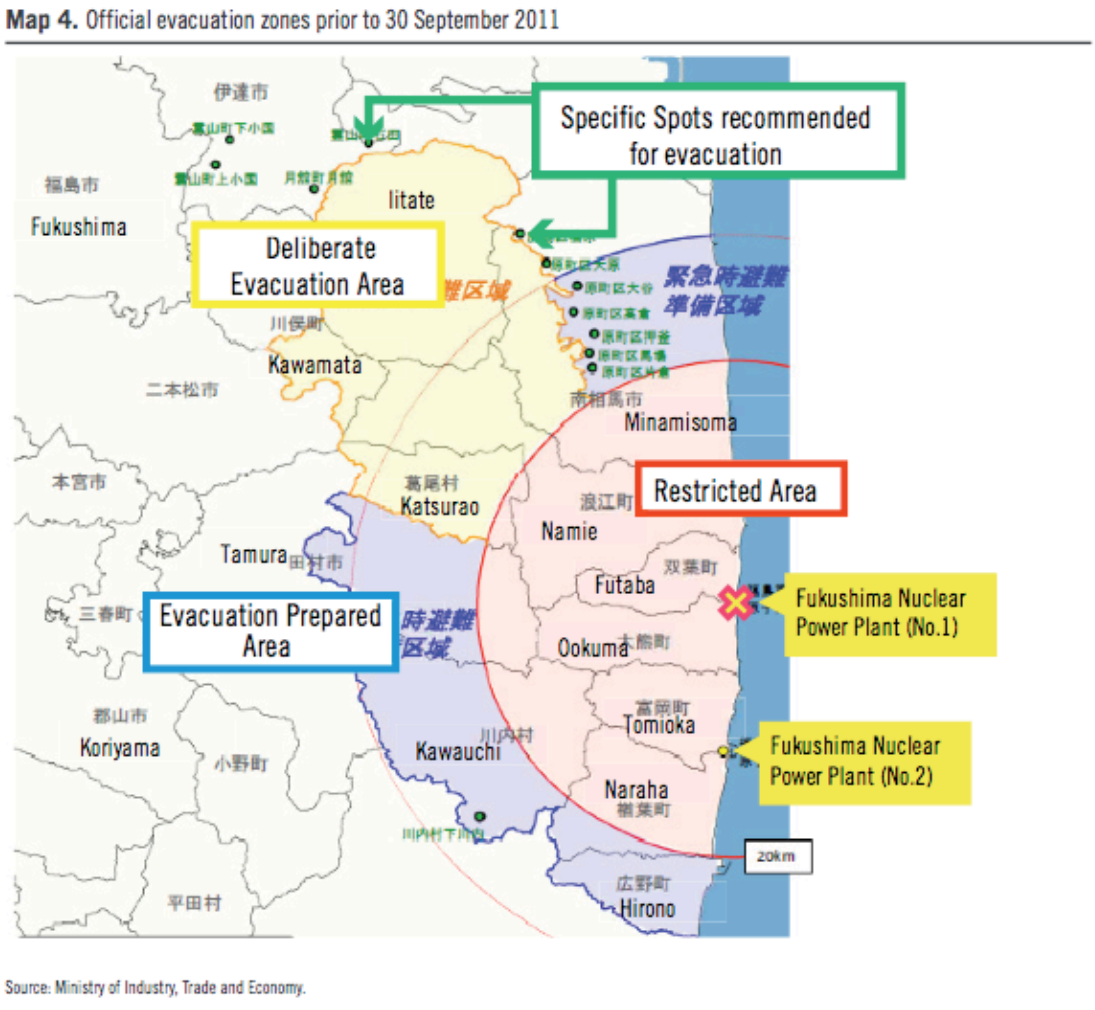
Later, on the 15th of March 2011, a shelter-in-place order was issued to residents living within a 20-to-30 km radius from the Fukushima dai-ichi plant. Those who did not evacuated voluntarily had to stay indoors continuously over a ten-day period until a new unofficial governmental instruction to voluntarily evacuate themselves was released on the 25th of March 2011. The residents who did not evacuate voluntarily at that time were forced to remain indoors for more than a month until the shelter-in-place orders were lifted on the 22nd of April.

The NAIIC report stresses that *"encouragement of residents to voluntarily evacuate, communicated via the municipal governments, means that the decision to evacuate was*

relegated to the residents themselves" [NAIIC2012]. It adds that the concept of *"voluntary evacuation"* created confusion among residents, as it was a new concept that had not been addressed in any emergency plan. The report stresses that "*it is the natural right of citizens to decide to evacuate from locations that are possibly contaminated with radioactive substances in order to safeguard their own health, so relegating the evacuation decision might seem like a decision that respects citizens' liberty. We must conclude, however, that relegating the evacuation decision to citizens was inappropriate. It is the endowed duty of democratic states to protect the lives and safety of citizens, as part of the social contract between citizens and the state"* [NAIIC2012]. The government abandoned its duty to protect the lives and safety of the citizens.

Radioactive fallouts contaminated territories at a significant level far beyond the 20 km evacuation zone. On the 22nd of April 2011, more than a month after the massive releases of radioelements, new evacuation orders were issued by the national government in the so-called Deliberate Evacuation Area which covers an area located northwest of the nuclear power plant where the contamination levels lead to cumulative air dose that might reach 20 mSv or more within a one-year period (see the map in Figure 1). It includes some parts of Katsurao and Namie, all area of Iitate, and some parts of Kawamata (Yamakiya district) and Minami-Soma.

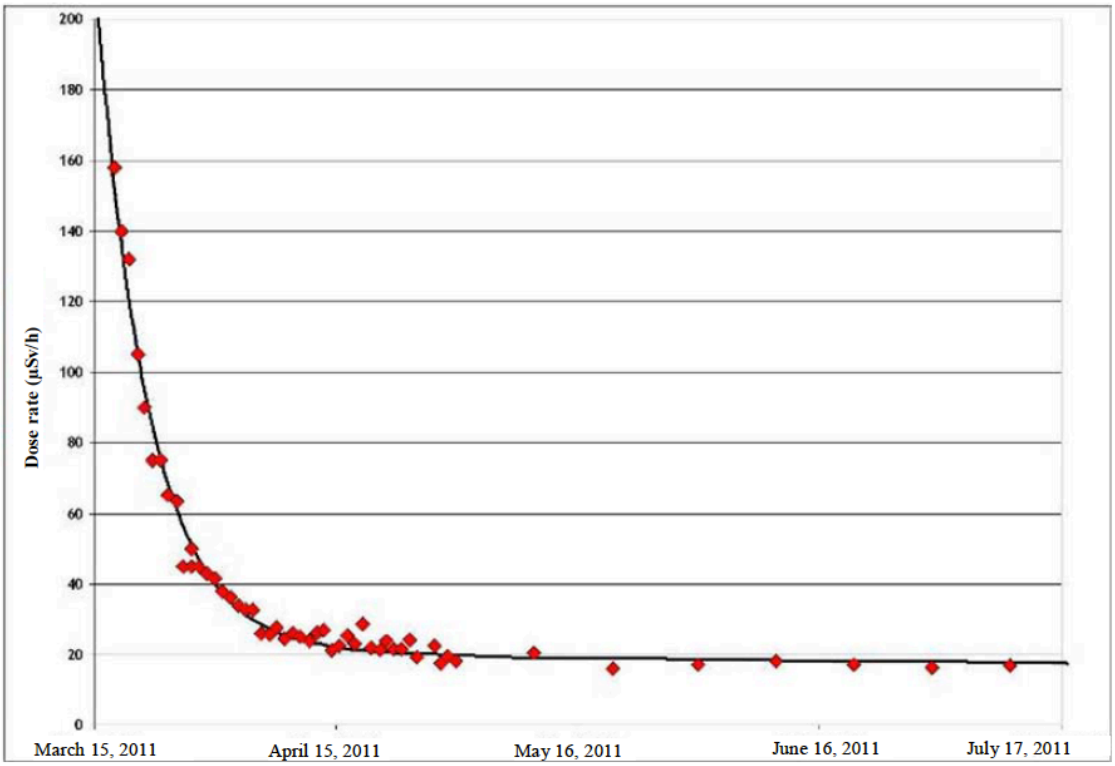
Figure 1: Map of evacuated territories in September 2011 (Extracted from [DEVAST2013])



The population of the planned evacuation zone numbers about 10 000. According to the five municipal governments, 6 000 residents was still remaining in the zone when the evacuation order was issued. Others already left on their own [Yomiuri23/4/2015].

Those forced to evacuate later in April spent more than a month in a zone where they should have been quickly evacuated. During the first month short-lived radioelements dominated the dose rate as shown by measurement done by ACRO on samples collected in Iitate in March 2011 [ACRO2011]. Consequently, lately evacuated population were exposed to undue doses. Figure 2 extracted from a report of the IRSN plots the evolution of the airborne dose rate as a function of time. It was up to 10 times larger than what was remaining when it was decided to evacuate residents [IRSN2012].

Figure 2: Evolution in the ambient dose rate due to radioactive fallout, measured in Namie (Akougi Teshichiro), 31 km northwest of the plant (extracted from [IRSN2012])



Consequently, many citizens felt abandoned by authorities that failed to protect them. This has generated distrust towards authorities that still remains.

The NAIIC reports that by the 29th of August 2011, the number of evacuees forced or recommended to leave their dwelling had reached a total of approximately 146 520 people. These included approximately 78 000 from the "Restricted Area" (within a 20 km radius from the Fukushima Daiichi Nuclear Power Plant), approximately 10 010 people from the "Deliberate Evacuation Area" (areas outside the 20 km radius from the power plant, where there was a concern that cumulative air dose might reach 20 mSv within a one-year period after the accident), and approximately 58 510 people from the areas 20-30 km from the power plant, excluding the Deliberate Evacuation Area and the zone where sheltering orders issued on 15th of March 2011 had been lifted [NAIIC2012].

In May 2011, IRSN explained that it would have recommended the evacuation of the population in territories contaminated at 600 000 Bq/m^2 or higher for radioactive caesium, which corresponds to an external dose of 10 mSv for the first year. Such a measure would have led to the evacuation of 70 000 additional persons beyond the restricted area, including residents of large cities like Fukushima [IRSN2011a].

Until September 2011, the authorities established *"specific spots recommended for evacuation,"* outside both the Restricted Area and the Deliberate Evacuation Area, where integral doses were predicted to exceed 20 mSv over one year after the accident. The recommendation was designated household by household. The designated residents had the choice to evacuate and become eligible to receive assistance (compensation from TEPCo, exemption for medical insurance, national health insurance, pension and public nursing care insurance, etc.).

Actually, more people left contaminated territories. International Organisation for Migration (IOM) explains that in addition to the mandatory evacuation under the government's order, residents living outside designated evacuation zones decided to flee on their own for fear of radiation effects despite the government's reassurances. *"These so-called "self-evacuees" (jishu-hinansha in Japanese) are not officially recognized as nuclear evacuees and thus not counted as such in official statistics. Dismissed as those having made a capricious decision based on their selfish views – the remark often insinuated by government officials during interviews – self-evacuees are accorded very little assistance from the authorities"* [IOM2015].

The DEVAST field research found that they were often regarded as cowards or evaders who abandoned their communities and troublemakers who made Fukushima appear as an unsafe place to live to the general public, thus jeopardizing the collective effort to reconstruct Fukushima. Although this negative perception has somewhat improved over the last few years, the trauma from such a divide still remains within these communities [DEVAST2013].

Number of evacuees

The total number of evacuees from the nuclear disaster is not well known, as it is difficult to establish. Official reports give various numbers that depend on the way of counting. The first comprehensive picture on the number of evacuees both from the tsunami and the nuclear accident was released on November 2011.

The total number of evacuees in shelters due to the earthquake, tsunami and nuclear accident peaked during the first few weeks to more than 450 000 in the whole country and reached 400 000 in Iwate, Miyagi and Fukushima, the most three affected prefectures [DMCO2012]. In Fukushima the number of refugees in shelters, hotels, relatives' home peaked in June 2012 to 163 404 [RA2012].

As already mentioned, the NAIIC reports that by the 29th of August 2011, the number of evacuees forced or recommended to leave their dwelling due to the nuclear accident had reached a total of approximately 146 520 people [NAIIC2012]. Not all of them left. Some

became self-evacuees when recommendation to evacuate the 20-30 km zone was lifted. The total number of so-called self-evacuees counted by authorities during the first six months reached approximately 50 000 in September 2011 [MEXT2011], more than half of them staying outside Fukushima prefecture.

Some of the self-evacuees came back; some others resettled in another place. There are no official statistics. Many cannot decide what would be the best solution for their future. Forced evacuees cannot come back to their home except in three zones where evacuation orders were lifted: parts of Tamura and Kawauchi in 2014, and the whole territory of Naraha in 2015. See the map in Figure 3. Few came back.

More than half of households that evacuated following nuclear disaster have been split up according to a survey by the Fukushima prefectural government. Of the 20 680 respondents, 16 965 households, or 82%, originally lived in the evacuation zone, while 3 683 households, or 18% are self-evacuees. Some 44.7% of the households still lived with all family members at their new homes. The figure included single-person households. But 48.9% of households said their family members now live at two or more locations, including 15.6% whose family members are scattered at three or more locations [Asahi29/4/2014].

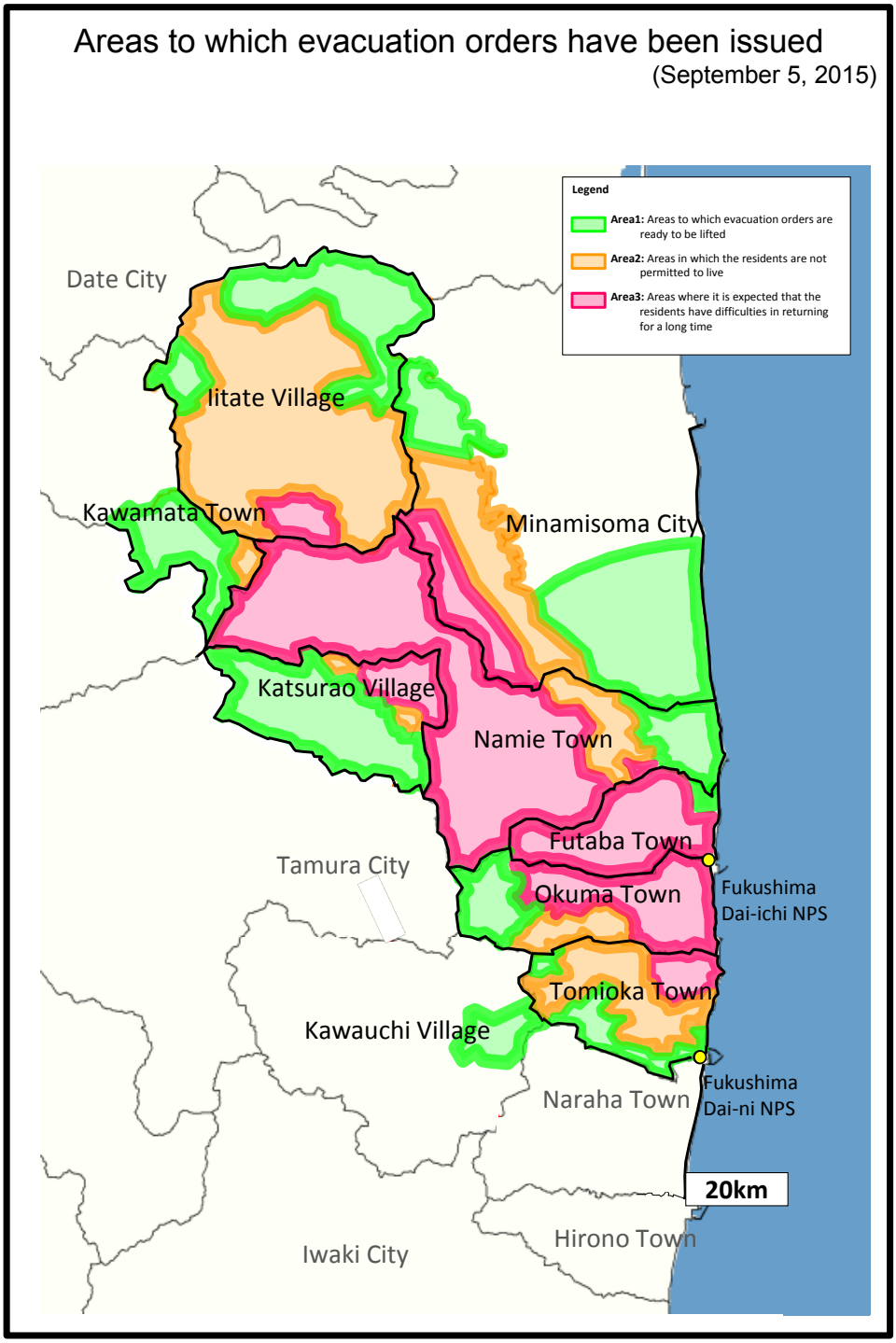
Five years later

Almost five years later, the population of Fukushima prefecture has decreases by 5.7% according to Japan latest census. There were around 1.9 million people living in the prefecture as of the 1st of October 2015. That's about 115 000 less than 5 years before. These population figures are based on the number of people living in the prefecture, irrespective of whether they are registered as local citizens or not. The population drop is mainly due to on-going evacuations following the nuclear disaster as can be seen from the gender gap: The prefecture lost 39 715 men and 75 743 women, a decrease of 4% and 7.3% from 2010, respectively. Workforce at FDNPP or around for reconstruction efforts is mainly male presence and many of the evacuees are female and children. The town of Hirono, where a large portion of the present population is involved in nuclear reactor work, tallied a male population of 2 746, up 2.3% from 2010. The female population, on the other hand, was about half that figure at 1 577, down 42.3%. Four towns where the entire population has left under evacuation orders recorded zero inhabitant: Okuma, Futaba, Tomioka and Namie. The village of Katsurao where evacuation order is supposed to be lifted in spring had 18 people [Asahi25/12/2015].

Five years later, the number of “nuclear refugees” is still about 100 000 according to a survey of Fukushima Prefecture: 56 463 evacuees were staying within Fukushima Prefecture as of the end of December, while 43 497 were outside the prefecture as of the 10th of December 2015. The whereabouts of 31 were unknown. The survey covered those staying in temporary housing facilities or taking shelter at relatives’ houses and other places. It excluded those who have bought houses in the areas they fled to or settled in public housing for disaster victims [JT9/1/2016]. This means that the type of housing determines the statistical category used to count the number of displaced persons.

Benefitting of a new lodging is a real improvement for displaced persons, but it does not mean that they should not be counted as evacuees anymore. They are still considering themselves as evacuees suffering from their status and mourning their previous life. When does a relocated person cease to be considered as an evacuee? This is a difficult question that should be answered together with affected populations.

Figure 3: Areas to which evacuation orders have been issued (Map extracted from [METI2015])



At the end of November 2015, there were still 30 293 prefabricated temporary housing units in Iwate, Miyagi and Fukushima prefectures, with 62 798 people living in them due to the triple disaster. At least 14 000 prefabricated temporary housing units are expected to remain occupied in as of April 2016. This is about one third of the peak figure of 48 628 units in April 2012. These temporary units have a lose durability and many of them are showing signs of deterioration, but the completion rate for public reconstruction housing units stood at 18% for those who fled as a result of the FDNPP accident [Yomiuri11/1/2016].

Conclusions

About 160 000 people fled from contaminated territories. Five years later, the number of nuclear displaced persons is still about 100 000 as evacuation orders have only been lifted in three places. Persons who resettled are not counted anymore.

Behind these figures, there are individuals whose life was disrupted. Major nuclear disasters are firstly human disasters leading to the displacement of many people who lose everything including dwellings, family life, social relationship and future. Displacement generates conditions of severe hardship and suffering for the affected populations. Non-evacuated people in contaminated territories worry for their health and future and their daily life is also severely affected.

It is primary the duty of the State to provide them a protection and trustworthy support to rebuilt their future.

Overview of Protective Action Levels after the nuclear disasters

Japanese authorities keep claiming that radiation-induced cancer does not occur, or is undetectable even if it occurs, under the cumulative exposure dose of 100 mSv although international recommendations on protection against radiations are based on the central assumption of a no-threshold linear dose–response relationship for the induction of cancer and heritable effects.

Both evacuation and return policies are based on a lax interpretation of the international recommendations that not very strict. The highest value of the ICRP reference interval was chosen. In addition, as radiological protection is based on a quantity that cannot be measured, authorities have changed the operational quantity to reduce the apparent dose without clearly explaining it to the affected population. This worsens distrust of authorities and the so-called "goyo-gakusha" in Japanese, i.e. experts specially appointed by authorities to convince populations that it is safe to live in contaminated territories [Shirabe2015].

Regarding the food contamination, the strategy was completely different: authorities set maximum allowed levels well below international standards to promote the recovery of consumers' confidence and then food production in contaminated territories.

Radiological protection principles

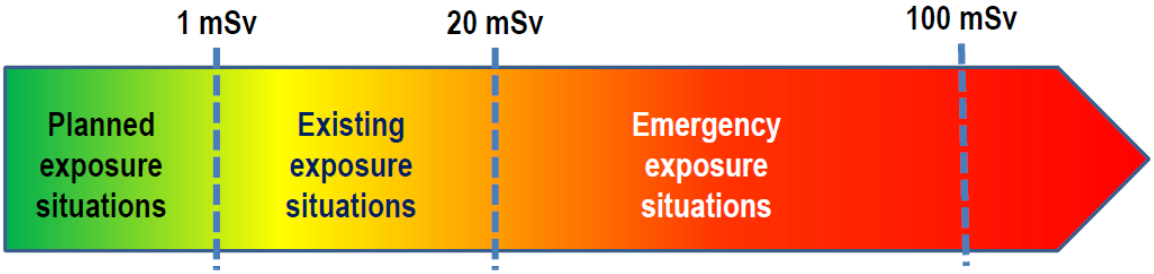
Radiological protection is based on three key principles that are the principles of justification and optimisation, which apply in all exposure situations whereas the principle of limitation only applies for doses expected to be incurred with certainty as a result of planned exposure situations. The International Commission on Radiological Protection (ICRP) defines these principles as follows [ICRP103]:

"The Principle of Justification: Any decision that alters the radiation exposure situation should do more good than harm.
The Principle of Optimisation of Protection: The likelihood of incurring exposure, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors.
The Principle of Application of Dose Limits: The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits specified by the Commission."

How to justify the life in contaminated territories? What are the benefits? The optimisation principle requires checking each action of daily life to reduce the dose. It is a heavy burden that is hardly accepted by many people.

Regarding benchmarking doses, ICRP publication 103 [ICRP103] introduced three kinds of situations. For planned exposure situations where radiological protection can be planned in advance, before exposures occur, and where the magnitude and extent of the exposures can be reasonably predicted, the limit for the public is fixed at 1 mSv per year. For specific exposures like planned discharges of long-lived radionuclides into the environment, lower limits are introduced.

ICRP also considers existing exposure situations that already exist when a decision on control has to be taken. They include post-accident management. Reference levels for existing exposure situations should be set typically in the 1 mSv to 20 mSv band of projected dose. Eventually, the last case corresponds to emergency exposure situations: Reference levels for the highest planned residual doses in emergency situations are typically in the 20 mSv to 100 mSv band of projected dose.

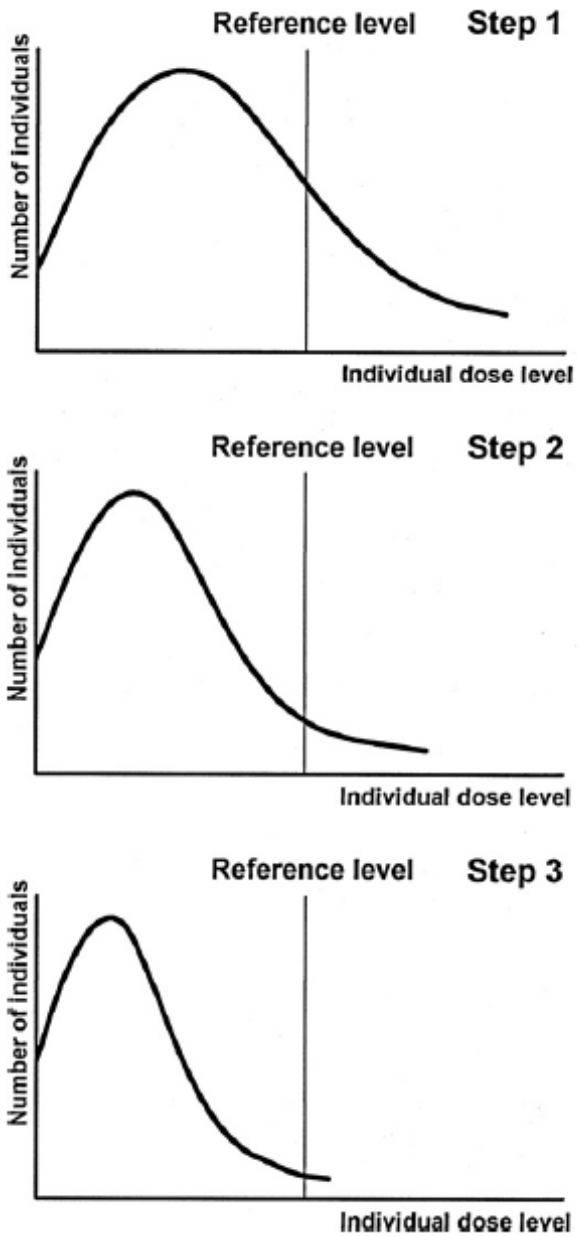


For existing situations like in Fukushima, ICRP introduced "reference levels" rather than limits and specifies their use. These levels are not strict limits and individual doses can be higher, but most of them should be lower than the reference level. As shown in Figure 4, the distribution of individual doses with time as a result of the optimisation process should evolve to lower values.

Such a point of view is not always accepted. Many Japanese expect that the Limitation principle is applied to existing situations to ensure that each individual is not exposed to doses higher than the limit. Anand Grover, Special Rapporteur to UN Human Rights Council, also notes: *"ICRP recommendations are based on the principle of optimisation and justification, according to which all actions of the Government should be based on maximizing good over harm. Such a risk-benefit analysis is not in consonance with the right to health framework, as it gives precedence to collective interests over individual rights. Under the right to health, the right of every individual has to be protected.*

Moreover, such decisions, which have a long-term impact on the physical and mental health of people, should be taken with their active, direct and effective participation" [HRC2013].

Figure 4: The use of a reference level in an existing exposure situation and the evolution of the distribution of individual doses with time as a result of the optimisation process (figure extracted from [ICRP103])



These international recommendations on protection against radiations were never discussed with stakeholders and populations. Affected populations discovered them after the disaster and they don't know how these benchmarking levels were fixed. They expect strict limits to protect each individual, in agreement with the right to health.

Evacuation policy

Japanese authorities have focused their policy and communication on the external dose for the evacuation. Above an estimated external dose of 20 mSv for the first year, people had to evacuate. Protection measures such as long-term evacuation are also terrible for the affected population who lose everything, but in the case of the Fukushima accident, they were fully justified as the estimated projected doses reached values above 200 mSv, which are no longer in the range of "low doses" according to UNSCEAR definition.

Japanese officials explained that 20 mSv corresponds to the lower range of the ICRP recommendations in case of emergency. But when the limit was introduced on the 22nd of April 2011 for the communities beyond the 20 km zone, the emergency phase was over. This limit is presently used for the return of the population to the evacuated territories, although it corresponds to the higher value of the proposed range by the ICRP for the so-called existing exposure situations. Japanese officials generally omit to mention this point. As already mentioned, French IRSN would have recommended to evacuate all population in areas where external exposure could be higher than 10 mSv per year [IRSN2011a].

It is worth recalling that, in “peaceful times”, the maximum allowed exposure of the public is limited to 1 mSv per year. The new value of 20 mSv per year corresponds to the maximum annual exposure allowed in average for nuclear workers. It is now applied to any citizens of the affected zones, including babies, toddlers, children who are more sensitive to radiations. Many Japanese do not accept it.

As a comparison, according to Japanese insurance standards for nuclear industry workers introduced in 1976, the government pays compensation to workers who are exposed to 5 mSv or higher levels of radiation annually and develop leukaemia more than a year after they first engaged in work that could expose them to radiation, if other factors can be excluded. In October 2015, the Japanese government recognised, for the first time, a cancer case among workers of the crippled FDNPP, as linked to his clean-up work. A 41-year old man was diagnosed with leukaemia in January 2014 after having worked 15 months at the plant and been exposed to a total of 20 mSv of radiation [JT20/10/2015]. In 1976, 5 mSv was corresponding to the maximum permissible yearly level for the public. It is 1 mSv per year nowadays. Such a standard contradicts the official stance that radiations are safe below 100 mSv and many inhabitants wonder if they will benefit from the same compensation in similar circumstances.

Note that the ICRP recommends lowering with time the reference level for existing exposure situations. Consequently, Japanese authorities have adopted the 1 mSv standard as a long-term target, without a precise agenda for compliance. *“In most existing exposure situations, there is a desire from the exposed individual, as well as from the authorities, to reduce exposures to levels that are close to or similar to situations considered as ‘normal’”* [ICRP103]. On the contrary, return policy to the evacuated zones has a well-defined calendar as Japanese government announced to withdraw evacuation orders by March 2017 and stop compensations by March 2018. It keeps the 20 mSv annual limit over this period.

ICRP does not fix any predetermined temporal or geographical boundaries that delineate the transition from an emergency exposure situation to an existing exposure situation. *"In general, a reference level of the magnitude used in emergency exposure situations will not be acceptable as a long-term benchmark, as these exposure levels are generally unsustainable from social and political standpoints. As such, governments and/or regulatory authorities will, at some point, identify a new reference level for managing the existing exposure situation, typically at the lower end of the range recommended by the Commission of 1–20 mSv/year"* [ICRP109].

In contrast, U.S. guidelines require relocation when people may be exposed to 20 mSv or more of radiation in the first year and 5 mSv or below from the second year. The long-term objectives are to keep cumulative doses at or below 50 mSv in 50 years. The relocation protective action guide addresses post-plume external exposure to deposited radioactive materials and inhalation of re-suspended radioactive materials that were initially deposited on the ground or other surfaces [FEMA2013].

ICRP also stresses that exposures below the reference level should not be ignored; these exposure circumstances should also be assessed to ascertain whether protection is optimised, or whether further protective measures are needed. The individuals concerned should receive general information on the exposure situation and the means of reducing their doses. In situations where individual life-styles are key drivers of the exposures, individual monitoring or assessment as well as education and training may be important requirements [ICRP103].

In conclusion, Japanese authorities have chosen the less stringent value from international recommendations to decide their evacuation policy. This value is kept for the return policy because non-evacuated population would not understand why they were not protected at the same level.

Protection versus operational quantities

Beyond references levels or limits that are highly controversial, implementation is also difficult. As a matter of fact, two types of quantities are specially defined for use in radiological protection: *protection quantities* that are defined by ICRP, and *operational quantities* that are defined by the International Commission on Radiation Units and Measurements (ICRU) for area and individual monitoring. The latter are designed to provide an estimate of the former. The relation between the two sets of quantities is extremely complicated and is the object of a more than 100-page international standard that is not openly available on line [IRCU1998].

In other words, dose limit and reference values are expressed in terms of protection quantities that cannot be directly measured and compliance with these values is demonstrated by a determination of the appropriate operational quantity.

In Japan, evacuation policy was based on the airborne dose rate that can be easily measured by various methods, including simple radiameters. Then, to estimate the annual dose, it is supposed that individuals spend 8 hours per day outdoors and that indoors, exposure is reduced by 60%. Consequently, an airborne dose rate of 0.23 μSv/h

leads to an annual exposure of 1 mSv per year after subtracting the background estimated to be 0.04 μSv/h. This is a gross estimation that is supposed to over-estimate the annual dose because very few people stay 8 hours outdoors everyday. On the contrary, indoor dose rate is sometimes found to be higher than what is assumed by this model. In addition, some individuals might have some penalizing behaviours that are not taken into account in such a scenario, such as going to the forest, staying near a hot-spot without knowing it, and so on. This is a general practice in protection against radiations to keep a margin in order to be sure to protect everyone.

Determination of the airborne dose rate also depends on the measurement methods and tools with large discrepancies observed on the field. There can be up to a factor 3 between values given by static apparatus, and by ones transported by a vehicle or a helicopter. This is not yet understood.

Instead of decreasing the evacuation limit, authorities required studies to have a more realistic evaluation of the doses of populations living in contaminated territories and requested radiation estimates by job type. In July 2013, National Institute of Radiological Sciences (NIRS) and the Japan Atomic Energy Agency (JAEA) were asked to measure air dose rates and estimate individual radiation doses at 43 locations, covering seven types of living spaces, including private residences, farmland and schools, in Tamura, Kawauchi and Iitate. Measurements were taken in September 2013 and the new results were significantly higher than expected. Consequently, authorities requested the JAEA and NIRS to recalculate the results by ditching the assumption that people would be outside eight hours a day, using instead 2010 statistics on how people spent their time. Under these new assumptions, a farmer was expected to spend an average of six hours a day outdoors. The new, lower radiation exposure results were resubmitted in March 2014. The government kept these data under wraps for six months [Mainichi25/3/2014].

The study was finally published on line on the 18th of April 2014, after evacuation order for the Miyakoji district in Tamura city was lifted [METI2014]. Those working in the forest industry in this district are calculated to be exposed to 2.3 mSv of radiation per year, according to the survey results. The report also estimates that farmers and teachers in the district will annually receive radiation doses of 0.9 to 1.2 mSv and 0.7 mSv, respectively. In a district of Kawauchi the estimated radiation dose for each farmer stood at 3 mSv a year. Even in unrestricted areas, the estimated dose exceeds 1 mSv a year in a case covering elderly people living in wooden houses. Of the 43 explored sites, 27 points were also found to be above 1 mSv per year. None of the cases, however, exceeds 20 mSv per year. Only adults were subject to the survey. The study also showed that the radiation measured by individual dosimeters tends to be about 70% that of levels estimated from air doses.

Consequently, Japanese authorities want to shift from this gross evaluation method, as it was the case for evacuation, to a new one based on individual dosimeters [NRA2013b]. This so-called glass-badge has already been adopted in zones where people were not evacuated. In Date, for example, the local authorities also adopted a reference level of 5 mSv per year for the integrated dose measured by the individual apparatus.

However, the glass-badge gives an overall value that is 30 to 40% lower from what can be deduced with an apparatus measuring airborne dose rate because they don't measure the same operational quantity. The deployment of the glass-badge was done without explaining this important fact to the population. Although international specialists advise the mayor of Date on this issue they never explained such a difference. The city council discovered the facts during a meeting with an NGO. The president of the company producing the individual dosimeter was attending the meeting and had to apology for not mentioning it [ShukanAsahi28/1/2015, ACRO2015a]. This point is presently acknowledged on the homepage of the company. However, it is explained that the value given by the glass-badge provides a better estimate of the protection quantity and airborne apparatus over-estimates the dose [Chiyoda2015].

Radiological protection rules and standards are very confusing for the populations. Authorities changed the operational quantity to get lower results than with the one used as a reference to evacuate the population. This should have been clearly explained. This new policy is also a change of paradigm for the protection of the citizens. The sovereign duty of the State to protect the population is transferred to individuals.

On the contrary to nuclear workers who are supposed to be well controlled, nobody controls if the population wear such individual dosimeters. This is crucially problematic for children who are more sensitive to radiations. Radiological protection rules and practises were developed for workers who are exposed to radiation during a limited time in a restricted area. It is then possible to evaluate the dose prior to the work and control it afterwards. Protection measures are controlled by an external regulation or safety authority and employers are responsible for the protection of their employees. This is not possible after a nuclear disaster. A NRA official told a researcher that under the current law, nuclear operators are responsible for the radiation protection of citizens who are living around their installations [Hasegawa2015]. Currently, Ministry of Environment is responsible for the radiation protection of the populations affected by the Fukushima nuclear accident.

30 years after the Chernobyl disaster, radiological protection rules and practices are not adapted for populations living in contaminated territories. They are extremely confusing and impossible to enforce.

Limits for food contamination

Regarding the food contamination, maximum contamination limits adopted by the Japanese government during the first year of the disaster were lower than the international recommendations of the Codex alimentarius [CODEX2009]. They were reduced by a factor 5 after about a year to recover the confidence of consumers. Table 1 summarises the food limits adopted in Japan for radioactive caesium in comparison with other standards.

The first limits were fixed assigning 1mSv per year to each food category: 1) drinking water, 2) milk and dairy products, 3) vegetables, 4) grains and 5) Meat, eggs, fish, etc.

Considering the diet and susceptibility of adults, children and infants, some maximum contamination levels were derived, keeping the most stringent value for each category. Japanese authorities considered that food safety was basically secured. However, to recover consumer confidence, Japan reduced the maximum permissible dose from 5 mSv/year to 1 mSv/year for the food intake, dividing by 5 all maximum contamination limits [MHLW2011b]. New limits were implemented from the 1st of April 2012. Note that they are lower than the limits adopted in Europe after the Chernobyl accident [EC2008].

Table 1: Comparison between various maximum allowed levels in food for radioactive caesium (References: [CODEX2009], [MHLW2011b], [EC2008])

Radioactive caesium	Baby food	Milk and dairy products	Other food products
Codex Alimentarius		1 000 Bq/kg	
Japan, 17/3/2011 – 31/3/2012	200 Bq/kg	200 Bq/kg	500 Bq/kg
Japan, from 1/4/2012	50 Bq/kg	50 Bq/kg (only milk)	100 Bq/kg
EU, from 15/07/2008	370 Bq/kg		600 Bq/kg

Conclusions

Contrast between the protection against external exposure and internal exposure through food intake is shocking. In the first case Japanese authorities refuse to lower the reference levels that are kept at the highest value of the international recommendations whereas in the second case maximum allowed values were divided by a factor 5 after a year. They are also lower than what has been adopted in Europe in the post Chernobyl context [EC2008].

Such a contrast shows that the primary concern of Japanese government is the economical consequences of the nuclear disaster. Contamination limits in food were lowered to regain the confidence of consumers that avoid products from Fukushima. On the contrary compensation of the evacuated people represents a heavy economical burden and authorities do not propose any other solution than the return of displaced persons.

International recommendations are confusing, allowing authorities to adapt rules to their own advantage rather than the affected populations. Rule should be binding in terms of limits, temporal evolution and operational quantities.

Food Contamination five years later

As we stressed in the Greenpeace 2012 report on the lessons of the Fukushima accident [GPI2012], Japanese authorities failed to foresee the scale of problems with contaminated food and crops, and were repeatedly caught by surprise in the following months as well as not being able to deal with them. They had a flawed programme for monitoring and screening, leading to scandals that further undermined public confidence and caused unnecessary additional economic damages to farmers and fishermen. As a consequence, many consumers' trust in the government was eroded and the population concerned about food safety reconsidered their relationship to the state and to the food [Sternsdorff-Cisterna2015].

But citizens, famers, producers, retailers and consumers have been monitoring food production forcing authorities to introduce systematic controls. Situation has quickly improved and except for wild plants and animals, including fishes and self-production, contamination of the food found on the market remains low. Internal contamination of children checked by whole body counting is also low enough to consider that external dose is the dominating problem for residents in contaminated territories. This success has a cost: many farmers cannot resume farming and some traditional productions might disappear.

Initial failures in food monitoring

Initially, Japanese authorities decided to allow the production of food in the contaminated areas except for those products that exhibited contamination levels above the limit. Such a policy has major weaknesses, as it is impossible to test all foods and led to great confusion. Institutions were unable to predict and avoid many problems, such as beef contamination due to feeding cattle on contaminated rice straw. Nor did they expect the tealeaves to exceed the limit as far away as Shizuoka, located at about 300 km from the FDNPP. An alternative adopted in several countries is to prohibit all food products of an extended zone, except those that are tested and meet safety standards [GPI2012].

Of course, the lack of measurement instruments hampers such a programme during the first months of the disaster. On top of this lack of infrastructure, the NAIIC report notes that in Japan there were also local governments that were unenthusiastic about performing the tests because of their concerns about the harm to their reputations, so the level of the tests varied depending on the local government. "*Considering this in light of the intent to develop uniform testing systems for wide areas in order to ensure the safety*

of the residents, we conclude that there is a problem with these variations among the local governments" [NAIIC2012].

Many people's trust in the government expertise was eroded due to these weaknesses in the food control led during the first months of the disaster [Sternsdorff-Cisterna2015].

Japanese authorities fixed food contamination limits on the 17th March 2011 at a level that was lower than the international recommendations of the Codex Alimentarius, as already mentioned. These limits were hastily extended on the 5th of April to also include seafood in response to the concern about the contamination of the sea. Later, to recover the confidence of the consumers, Japanese authorities decided to decrease the concentration limit in the food by a factor 5 from the 1st of April 2012. As a consequence, the maximum concentration of radioactive caesium in the food dropped from 500 to 100 Bq/kg. Local authorities sometimes apply stricter standards for school lunches. Fishermen's cooperatives adopted more stringent limits for their own catches: 50 Bq/kg. Some individuals use these references to fix their own standards, generally to have a contamination as low as possible, especially when there are young children in the family.

But this is not enough. Government's policy was focused on food safety (*anzen* in Japanese), and it did not address how to generate a climate of trustworthiness (*anshin* in Japanese) about food from Fukushima. Enforcing technical standards alone is not sufficient to overcome consumer mistrust. The challenge is to bring together food safety and the peace of mind that comes with it [Sternsdorff-Cisterna2015].

A survey by the Food Safety Research Institute at Tokyo University found that suspicion of Fukushima-grown food has increased over time. In 2011, just over 10% of respondents would not eat Fukushima products even if they were free, and this figure increased to a little over 20% in 2012. In addition, prices for some Fukushima products continue to be approximately 20% lower than comparable products from other Japanese prefectures [Sternsdorff-Cisterna2015].

Tap water that is generally captured on the surface in Japan was mainly affected by iodine-131 at the beginning of the disaster with concentration values exceeding the provisional limits in several prefectures over Japan. Due to the short half-life, this problem quickly vanished [MLHW2011a]. Because of this contamination, the government requested that drinking water not be given to infants for a brief time period, leading to great confusion among citizens.

The latest data published by the nuclear regulation authority show trace of radioactive caesium in tap water of several cities in Japan. The highest value is 0.004 4 Bq/L in Utsunomiya, Tochigi prefecture [NRA2015]. Ministry of Health, Labour and Welfare reports that none of the tap water samples collected within Fukushima prefecture in 2015 exceeded the management target level fixed at 10 Bq/kg for the sum of both radioactive caesium. Consequently, there is no restriction on water intake implemented by water supply utilities [MLHW2015c].

Extended food monitoring

As a matter of fact, situation has quickly improved in Japan regarding the food issue. Samples with a contamination higher than the limit are rare and the internal contamination of most of the population is small or cannot be detected. There are various reasons for that. First, the transfer of radioelements to the plants through leaves is high, whereas the transfer through roots is lower. As a consequence, leafy vegetables and milk were the first contaminated food at the beginning of the crisis because the leaves were directly exposed to the fallouts. This problem disappears in following years. In addition, a better control of the food leads to a stabilised context.

During fiscal year 2014, according to the Ministry of Health, Labour and Welfare, 565 items among 314 216 tests had a radioactive caesium concentration above the limit. These excesses were mainly in wild animal meat (349 items), wild plants and fungi (104 items) and fishes (100 items). Its reports show that excesses in the food contamination mainly concern wild plants and animals [MHLW2015b].

The lack of confidence in the official monitoring led citizens to build alternative channels to ensure the health of future generations through the development of a citizen monitoring: Consumers, producers, retailers, schools, municipalities invested into simple detectors and everybody can access to a measurement station. This open process turned out to be very efficient [ACRO2012, Sternsdorff-Cisterna2015].

Such a private monitoring was not welcome by authorities. The NAIIC report explains that in response to the voluntary tests performed by the private sector and to the lower standards fixed by some retail stores, the Ministry of Agriculture, Forestry and Fisheries released a document on the 20th of April 2012 to the heads of food industry associations, to notify them that they should comply with the standard values stipulated by law, in order to avoid excessive regulations and confusion at the consumption stage. NAIIC considers that *"in Japan, which is a free country, there is no reason for state organs to restrict private sector groups that are setting voluntary standards which are stricter than the standards stipulated by law and exercising voluntary restraint, so this response from the Ministry of Agriculture, Forestry and Fisheries is a fundamental problem. However, this notification was released to reflect the interests of the producers and the possible harm to their reputation, which shows the complexity of this problem"* [NAIIC2012].

This private monitoring triggered the development of official monitoring. Fukushima prefecture has about 190 measurement stations specially dedicated to the rice that allows radiation scanning of all bags of rice before shipping. If the scanning result is under the national limit of 100 Bq/kg, the bag receives a seal confirming that it has been scanned. In 2014, more than 10 millions bags were scanned and only two of them had a contamination higher than the limit. All cleared radiation tests for the first time in 2015 [FMinpo9/1/2015,FMinpo8/1/2016]. Fukushima prefecture also performed 5 850 tests on food products in 2014, and none of them had a contamination higher than the limit. This official monitoring programme does not cover private production.

There is also a will to scan the whole ampo-gaki production, a delicacy made of dried persimmon. Shipment resumed in Date in 2014.

There are also about 530 conventional radiation detectors at 59 municipalities in Fukushima. There are even more detectors operated by NGOs, producers, consumers, but non-official measurement stations are not recognised by central authorities, nor counted. Their results are mostly ignored although some local governments recognise such monitoring when they are alerted on specific problems. Consequently, measurement results are widespread on many websites[2] and no effort is done to collect and analyse the data. Beyond single results, there is a need to analyse the trends of the contamination.

Internal exposure of the consumers

30 years after the Chernobyl disaster people living on the contaminated land still ingest radioactive elements daily, and some of these people are affected by a significant on-going internal contamination. The situation is very different in Japan. Urine tests [Chikurin2015] show that internal contamination of Japanese children remains low or undetectable. Whole body scans performed on over 2 700 babies and small children in and around Fukushima Prefecture 33 to 49 months after the Fukushima dai-ichi accident show that none had detectable levels of radioactive caesium. The minimum detectable activities for caesium-137 were 3.5 Bq/kg for ages 0 – 1 and down to 2 Bq/kg for ages 10 – 11. Including the caesium-134 contribution, these translate to a maximum committed effective dose of 16 µSv/y according to the authors. This is generally lower than the external exposure, which is the main concern in contaminated territories [Hayano2015]. This study is interesting because it is not limited to concerned parents who take a special care of the diet but also include a systematic screening of the Daigo and Miharu school children. Analysis of the questionnaire filled out by the parents of the scanned children regarding their families' food and water consumption revealed that the majority of children residing in the town of Miharu regularly consume local or home-grown rice and vegetables.

Of course, there are exceptions due to a diet based on self-grown products and wild plants that escape to any monitoring. It is difficult to evaluate the extend of such exposure. Nevertheless, voluntary radiation contamination screenings and counselling program in Minami-Soma Municipal General Hospital and Hirata Central Hospital shows that from a total of 30 622 study participants internal caesium-137 contamination ranges from 2 130 to 15 918 Bq/body. Cs-134 should be added. 9 residents displayed internal caesium-137 levels of more than 50 Bq/kg because they consumed home-grown produces without radiation inspection, and often collected mushrooms in the wild or cultivated them on bed-logs in their homes. After being advised to refrain from consuming potentially contaminated foods, re-examination of caesium levels revealed remarkable reduction of internal contamination a few months later. The study notes that the current screening program had a possible selection bias arising from the voluntary nature of the internal contamination monitoring. Since the individuals who care most for their level of internal radiation exposure are more likely to participate in the screening

[2] For example, Fukushima prefecture's results are here:
http://www.new-fukushima.jp/monitoring/en/
A network of 28 NGOs developed its own quality assurance procedures, cross-checks and database:
http://en.minnanods.net/

program, the number of residents who had relatively high contamination levels might be underestimated [Tsubokura2014].

Many fear that vigilance is relaxed with time and the impact of food contamination increases with the years.

Restrictions on food production threatens many activities

The counterpart of this policy is that agriculture is still forbidden in many places and some farmers have decided to stop their activities. At the end of 2015, there are still 54 restrictive requirements on food production [MLHW2015d]. Twenty-nine kinds of marine fish are currently restricted from distribution, but the ban is expected to be lifted for them step by step. Local fishermen operate on a trial basis in waters outside the 20-km zone from the plant, catching 64 varieties of fish.

In 2011, rice production was forbidden in 12 municipalities of Fukushima. Fukushima Prefecture's rice harvest, at around 450 000 tons, was the fourth largest in the nation pre-disaster, but in 2012 its harvest was down to 370 000 tons, making it the seventh largest producer. Rice production has just resumed as a test in a limited number of paddies in evacuated territories.

Wild plants and animals could still be highly contaminated and with values higher than the limit in areas as far as Nagano or Shizuoka prefectures [MHLW2015a]. Shipment bans and voluntary shipment restrictions continue to affect wild plants and mushrooms in 15 prefectures. This is threatening some traditional activities, like in the mountainous community of the southernmost end of Iwate Prefecture. Mushrooms, Japanese angelica, bracken, royal fern, bamboo shoots… came under shipment bans and voluntarily shipment restraints after radioactive substances were detected in them. Only few products are not covered by shipment restrictions, such as butterbur, wasabi leaves and *shidoke* plants. Iwate Prefecture formerly was a major producer of log-grown shiitake. It boasted an output of 201 tons in dried shiitake and 385 tons in raw shiitake in 2010, but both figures plummeted to less than half in 2012, partly because most of the mushrooms used to be grown outdoors under natural environments and partly because radioactive contamination rendered substrate tree logs unusable, for which the limit was fixed at 50 Bq/kg, because caesium levels in shiitake mushrooms rise to double the levels in their substrates [Asahi24/7/2014].

Growing shiitake mushrooms on tree logs is laborious and recovery will take years. Harvest comes only at the end of two summers after the logs are inoculated with spawn in winter. More than 70% of log-grown shiitake mushroom producers told a survey by the Ichinoseki city government that they did not want to restart their cultures. The number of log-grown shiitake mushroom producers has plummeted to less than one-fifth and less than one-third the pre-disaster levels, respectively, in Fukushima and Miyagi prefectures. Fukushima Prefecture, a major producer of *konara* oak trees, has provided mushroom substrate logs to all parts of Japan. But the nuclear disaster rendered many of the logs unsuited. The output of substrate tree logs now stands at only

6% of pre-disaster levels. A culture, which people have long preserved, is on the brink of collapsing as it takes 20-30 years for new shoots to grow large enough to serve as mushroom substrates. Authorities want to scan all substrate logs produced in Fukushima to ease forestry recovery [Asahi24/7/2014].

Many farmers test new production methods to lower the caesium contamination in the crops. The Fukushima Agricultural Technology Centre was among groups whose research showed that, when given large amounts of potassium fertiliser, rice plants would take up less caesium, which has similar chemical properties with potassium. The research also found that adding zeolite to soil would absorb caesium, reducing the amount that rice plants take up. Another finding was that caesium levels fall when rice plant straw from harvested plants is left in rice field paddies [Mainichi17/11/2013].

Organic farmers who are used to experiment new practices were pioneers. Solidarity and cooperation is fundamental to succeed because a producer can only perform one test per year. These farmers usually have close relationships with consumers that helped to keep their confidence [GC2013].

Consumers are still cautious

Many citizens are still reluctant to buy food products from Fukushima and neighbouring prefectures. Some consider that food should be free of caesium contamination because there is no threshold for the impact of low doses. Moreover, distrust towards authorities remains deeply rooted among consumers. Distress of farmers seems to have no end and government seems helpless. When farmers talk about dignity and future, authorities' response is limited to money and fighting against "harmful rumours".

According to the estimates of the Agriculture, Forestry and Fisheries Ministry, 44 countries and territories either banned the import of food items produced in Japan in 2011, or demanded that they be inspected when imported, even though they are regarded safe and marketed domestically. It was 41 in 2014. Japanese authorities are lobbying foreign countries banning the import of food produced in several prefectures of Japan to have the ban lifted.

Europe has eased importation on some Japanese food in January 2016, but maintains requirements to sample and analyse food items from 13 prefectures. There are mainly mushrooms, certain edible wild plants and fish products. Agriculture products from 7 prefectures are also included [EU2016].

Food safety requires more than laboratory tests; it is also a social relationship. Food safety can only exist insofar as people trust that the products they are selling, producing, and eating are indeed safe [Sternsdorff-Cisterna2015]. Actually, Japanese citizens can be sorted into three categories. Some have not changed their food habits. Two other groups have changed them. One group, a minority, has been buying more products from the affected territories to support recovery. Another group, on the contrary, avoids such food to protect itself in a defiance context [GC2013].

As already mentioned, Japanese government's policy was focused on food safety (*anzen* in Japanese), but it failed to generate a climate of trustworthiness (*anshin* in Japanese) about food from Fukushima. *"Anshin refers to the positive emotional reactions people have about food. It is a subjective and personal way of understanding food safety that emphasizes the peace of mind one feels about the products"* [Sternsdorff-Cisterna2015].

Populations facing uncertainties and doubts prefer the most protective option especially with exposure to radiations, as the health impact has no threshold. Food habits and culture are more complex than few uniform standards. Some people avoid some items for religious reasons, others for allergies. Some prefer organic food while others don't care much. Culture and taste also play an important role. Japanese agribusiness already faced several scandals in the past and many citizens already turned themselves to cooperatives they trust more. Recovery requires a direct link between producers and consumers to restore confidence. Such short links should be supported even if it is challenging big agribusiness corporations.

Conclusions

The food issue shows the merit of an open process in which every one can check the contamination and adapt the diet to its own requirement. Internal contamination of consumers remains low except for people eating their own production and wild plants or animals. Nevertheless consumers are still reluctant to buy food produced in contaminated territories. To restore the confidence of consumers Japanese authorities have adopted maximum allowed levels in food that are lower than what was adopted in Europe after the Chernobyl disaster. Farmers, fishermen and foresters are still suffering five years later. It is not a matter of "harmful rumours" but rather the results of the initial failures.

Recovery requires trust, controls and new ways of producing, selling and consuming food that has to be defined with all stakeholders.

Recovery of the contaminated the land

Japanese authorities dream of a reversible disaster while international recommendations on post-accident management only focus on the return to normalcy. With a half-life of 30 years, caesium-137 decays too slowly. Japanese government has launched a huge decontamination programme both in non-evacuated and evacuated territories. It consists on scrapping the soil, cutting the grass, trees, bushes and washing to roof of dwellings, roads, and sidewalks... Although NAIIC reports recommended implementing "measures that correspond to residents' needs" [NAIIC2012], the huge decontamination programme was implemented without consultation.

Decontamination is not very effective and generates huge amount of radioactive waste for which all proposed solutions failed because of the opposition of the populations. Authorities keep their approach: Decide – Announce – Defend and expect that risk communication will help to convince neighbours of forecast storage centres.

Recovery policy

Japanese authorities have divided the evacuated territories into three zones depending on the airborne dose rate. See the map in Figure 3. Areas where the current integral dose of radiation per year is 50 mSv or more and may remain over 20 mSv per year within five years are classified as difficult-to-return zones. Areas where it is confirmed that the annual integral dose of radiation will definitely be 20 mSv or less are classified as areas to which evacuation order is ready to be lifted. In between, where the annual external dose ranges from 20 to 50 mSv, the residents are not permitted to live.

The government launched a vast decontamination programme in the last two areas in order to reduce the external annual dose well below 20 mSv. In evacuated territories, decontamination plans covers about 24 800 ha, but it should be noted that they are limited to the immediate surroundings of the zones where authorities prepare the return of the inhabitants. The government is responsible for the work in evacuated territories and the methods for decontamination vary greatly, depending on the characteristics of the area being decontaminated.

At the end of 2014 decontamination is said to be finished in Tamura, Naraha, Kawauchi and Okuma. But, when Japanese authorities mention that decontamination is achieved, it should be understood that only the zones included in these plans were decontaminated. There are no such plans for the surrounding land, including forests and mountains that cover about 70% of Fukushima prefecture. In December 2015, the central government decided not to decontaminate the forests.

As of the end of December 2015, decontamination plan in target areas is supposed to be completed in Tamura, Naraha, Kawauchi, Okuma, Katsurao and Kawamata. In Okuma for example, where most of the municipality is classified as difficult-to-return zone, this target area is limited to 400 ha where some economical activities are expected to resume. Decontamination of the Joban expressway is also completed [ME2016].

In non-evacuated zones, 104 municipalities in 8 Prefectures that have areas whose average air dose rates exceed 0.23 µSv/hour (corresponding to an annual exposure dose of 1 mSv/year) had to implement a decontamination plan. The designation was lifted in five municipalities because of the natural decrease of the radiation dose rate. 94 municipalities out of 99 had a decontamination plan at the end of 2015. It was completed or almost completed in 49 of them [ME2016].

Limited effect of decontamination

The NAIIC report already stressed in 2012 that the decontamination operations do actually reduce the radiation dose rate, but the effect is limited [NAIIC2012].

The overall contamination level has naturally decreased during the first five years of the disaster. A large part is due to the decay of caesium-134, which was representing about half of the contamination few months after the accident and has half-life of two years. Washout by the rain or snow also contributed to the decrease of the contamination in large areas but also to its increase in some accumulation zones. In non-decontaminated forests, a 57% decrease of the average dose rate was observed in June 2015. Now, as caesium-137, which has a half-life of 30 years, dominates, contamination is very slowly decreasing.

Comparatively, decontamination shows low performances. A reduction of more than 70% of the initial activity is rarely observed. In non-evacuated zones, first results on external doses show a 61% decrease in average for the public and 64% for children between August 2011 and August 2013. In evacuated residential zones, a decrease of 54% of the airborne dose rate is observed when dose rates are higher than 1 µSv/h. It is only 23% when dose rates are lower. Regarding dwellings, IRSN explains that roof decontamination is inefficient (decrease lower than 35%) [IRSN2015].

Decontamination is also very expensive and requires a lot of manpower. In evacuated territories major companies are in charge but subcontractors do the work. Workers have to wear an individual dosimeter and the registered dose should not be higher than 50 mSv over a year and 100 mSv over 5 years, like nuclear workers. Official statistics on 26 000 workers show that such limits were respected. Mean effective dose is 0.5 mSv per year and 14% of the workers had a registered value higher than 1 mSv per year. 34

received more than 10 mSv in a year and the highest dose is 13.9 mSv in a year [REA2015].

It is worth noticing that above statistics compiled by the Radiation Effect Association give a total number of workers that is lower than in Ministry of Environment's statistics. Some of the workers might not be registered. Presently, there are 12 000 workers per day involved in decontamination work. Some press scandals revealed that homeless people were exploited in such works [ACRO2015c].

Violations of labour regulations are still frequent. Between January and June 2015, the Fukushima Prefectural Labour Bureau supervised 342 employers and found 233 violations of laws and regulations related to labour standards (violation rate: 68.1%). On 364 violation cases, 134 were related to working conditions (payments, working hours…) and 230 related to safety and health (preliminary survey, dosimetry, use of protective gear, etc…) [FPLB2015].

Note that at least 30 000 volunteer workers have been involved in decontamination in evacuated zones without any support by the national government for the management of their radiation levels. For workers engaged in decontamination work, measurement and record-keeping of radiation levels are required by law, but not for the work by the volunteer group who are not subject to the nuclear workers' radiation limits. Furthermore, volunteer work insurance does not cover radiation exposure [Mainichi9/3/2015].

Huge amounts of waste are produced

Authorities have difficulties to manage the huge amount of radioactive waste generated by the nuclear disaster. During the early phase, straw at several farms was directly exposed to the fallouts. Contaminated manure also piled up, as it cannot be used as fertilizer anymore. In cities, the rainwater washed out soils and contaminated mud from sewage plants. Ashes from incineration plants might also be contaminated to levels that require a proper management. Eventually, the vast decontamination programme launched by the Japanese authorities generates larger amounts of radioactive waste for which the government is still looking for solutions.

Note that some municipal authorities have avoided submitting applications to the central government for more than 3 600 tons of radioactive waste in order to avoid shouldering the responsibility of storing it [Yomiuri2/4/2015]. The targeted waste is mainly rice straw and pasture grass from farms being kept in special plastic greenhouses or agreements have been made directly with individual farms to safeguard it.

Post-accident waste is sorted into three categories depending on the level of contamination. Below a caesium concentration of 8 000 Bq/kg it is managed as usual waste. Such a level is higher than international standards on activity concentration values for exemption or clearance of material. In Europe such values are fixed at 100 Bq/kg for each caesium [EURATOM2013]. The 8 000 Bq/kg threshold was derived from the 1 mSv limit for a worker staying one year nearby the storage centre.

Japan has to find locations to isolate the waste from the environment in specific storage centres for waste having a caesium contamination larger than 8 000 Bq/kg and than 100 000 Bq/kg. The former will be stored in so-called "controlled landfill sites" and the latter in "isolated landfill site" with a technology close to what is planned for nuclear waste.

At the end of 2015, 12 prefectures, including Fukushima, hold a total of 170 000 tons of designated waste. See Table 2 for details [Yomiuri4/2/2016]. The basic rule is to have each prefectural government to find a final disposal site for radioactive waste produced within its jurisdiction through garbage incineration or sewage treatment. Moreover, the central government plans to move other material from existing temporary storage sites in the 12 prefectures where it was collected to final disposal facilities in five prefectures where: Miyagi, Ibaraki, Tochigi, Gunma and Chiba [JT5/1/2015].

Table 2: Amount of designated waste in tons by prefecture as of the 31st December 2015 [Yomiuri4/2/2016]

Fukushima	Tochigi	Chiba	Ibaraki	Miyagi	Gunma
142 139	13 533	3 690	3 533	3 409	1 187
Niigata	**Tokyo**	**Iwate**	**Shizuoka**	**Kanagawa**	**Yamagata**
1 018	982	476	8.6	2.9	2.7

The government has already selected potential sites for final disposal facilities in Tochigi and Miyagi, but the projects remain stalled amid strong opposition from local officials and residents. In many places, the access to the site was blocked to prevent geological investigations and petitions were addressed to the government. Japanese authorities organised public meetings that were rather information meetings to win the consent of local residents, as usual. The government sticks to its so-called DAD policy: Decide – Announce – Defend. It is a failure for this issue.

On the 13th of December 2015, three municipalities in Miyagi Prefecture that have been selected as candidates told the Environment Ministry that they would relinquish their candidacies as for the second straight year authorities were unable to carry out land surveys. They consider that all the three candidate sites are inappropriate. The ministry refused municipalities' decision and is rather seeking renewed permission to survey the sites in detail [Mainichi14/12/2015].

In Tochigi prefecture, the government eyes 3 hectares of state-owned land in Shioya to construct the storage site. Just 4 km from the proposed site is the source for Shojinzawa Yusui spring water, one of the "best 100" mineral waters as designated by the government in 1985 and the core of local economic revitalisation efforts.

In Chiba, mud from sewage plants and incinerators ashes are waiting on lands belonging to the prefecture. The central government is looking at the possibility of using private land for a disposal facility due to a shortage of suitable state-owned land in the area. When the Environment Ministry designated TEPCo's compound in Chiba City as a candidate site, a local group immediately opposed the project, as there are schools and residential areas within 3 km around.

Gunma and Ibaraki prefectures are so far behind as they have not even decided how to select candidate sites. In Iwate Prefecture, a citizen campaign is underway against the construction of a dedicated incinerator.

Fukushima prefecture has the largest amount of waste. The government plans to have an intermediate storage in Futaba and Okuma, where most areas are designated difficult-to-return zones, to store the waste, including the highly contaminated soil, ashes and other wastes with radioactive concentration of over 100 000 Bq/kg. Covering an area of 16 km^2 around the FDNPP, the waste is supposed to be definitively stored outside the Fukushima prefecture before 30 years. Japan Environmental Safety Corporation (JESCO) is in charge of the project. See the map in Figure 5.

The Ministry of Environment estimates that generated soil from decontamination will be approximately 16 to 22 millions cubic metres after volume reduction by incineration [ME2015a]. Consequently, more than one million transports by truck will be necessary to bring the waste. As authorities plan to achieve the transfer in three years, more than 1 000 batches per day will be necessary. Who can believe that this waste will be taken away after 30 years? In addition, authorities do not have the faintest idea on the way to find and secure other sites outside Fukushima prefecture. Ensuring such a promise by a law does not solve the problem.

In June 2014, government completed a series of briefings for residents from the two designated towns. A total of 2 605 people have participated in the 16 meetings. The Asahi newspaper reports that many residents expressed concern that the site for the final disposal has not been chosen although the waste is to be removed from Fukushima Prefecture within 30 years after storage begins. Price of the land was the most difficult issue. Few residents or local officials came away satisfied from the series of briefings. Despite residents' repeated calls for an explanation about concrete steps to be taken, government officials failed to provide specifics of the plan [Asahi16/6/2014]. Government officials repeatedly stressed they will determine the purchase price of lands and buildings on a case-by-case basis. Even many municipal officials and residents who believe that intermediate storage facilities are necessary for decontamination and reconstruction of the entire prefecture, said the government's explanation was insufficient.

Nobuteru Ishihara, ministry of environment at that time, suggested that payments to residents in Fukushima Prefecture would resolve the problem of selecting a site: *"In the end, it will come down to money"* [Asahi16/6/2014]. Facts prove that it is far more complicated than this arrogant point of view. Landowners are still suffering for the loss of their land and they have not received clear explanations about the future. Mourning is not possible in such conditions.

The government has to convince about 2 365 landowners to sell or rent their land for the storage centre but negotiations have made little headway. Ministry officials have been unable to contact about 990 individuals, or about 40% of the total. Only 44 landowners signed a contract by the end of January 2016. Those contracts only covered about 0.15 km^2, which does not even reach 1% of the total land that needs to be acquired [Asahi14/2/2016]. The first bags of waste were transferred to two small

locations in spring 2015 in front of mass medias. But the two sites secured by authorities are limited to a storage capacity of 20 000 m^3.

As citizens do not want storage centres, the latest idea of the authorities is to "recycle" the radioactive soil as construction materials for public work projects. Activity concentration values for exemption or clearance are not fixed yet, but they will be higher than international standards. Official documents mention 3 000 or 8 000 Bq/kg [ME2015b]. This solution might also be rejected, as the impact of the treatment facilities to reduce the activity concentration in the soil is not known. Residents in the neighbourhood of the public works where such waste is to be used will also oppose the plans. But they will probably not be informed, as the radioactive soil will not be classified as waste anymore.

Nevertheless, Ministry of environment expects to *"develop national public understanding through dissemination of information concerning the reuse of low radioactive materials and the final disposal outside Fukushima Prefecture"* [ME2016].

Waste is not well kept and secured

In the mean time, bags of radioactive waste are piling in many places without any guaranty related to their safety. In autumn 2013, the Mainichi daily news reports that a Shirakawa resident called the Fukushima government when she saw children playing on a pile of bags, in which radioactive waste was stored, at a park in a public apartment complex. According to her, the prefectural government did not take any action about the matter. When the reporter put a radiameter near bags that were placed close to a street, the device showed radiation levels of 2.23 µSv/h. In another place, there were two junior high school students talking right next to a pile of waste bags [Mainichi16/12/2013]. In some schools waste is simply buried in the yard, reducing the area where children can play.

Radioactive waste bags are scattered on 54 000 sites in the non-evacuated part of Fukushima. Municipal governments are responsible for storing the waste until its disposal, including deploying sandbags to block radioactivity and installing sheets to prevent rainwater from coming into contact with the waste. The leasing contract for the temporary storage has been signed for three years. Contracts expired without any schedule on the relocation of the waste. Local governments don't know how long they should extend the contract.

The number of bags of waste from decontamination efforts around the FDNPP reached 9.16 million as of the end of September 2015. The 1m^3 bags are found at some 114 700 interim storage or decontamination sites across the prefecture [Mainichi10/12/2015].

Plastic bags are guarantied for 3 years only, without taking into account damages from radiations and the content is not always well known and recorded. Some are already damaged. Grass is growing in some others. This is well known from the local population and many pictures circulate in social medias. In June 2015, a survey by the Environment Ministry has found that bags are damaged at dozens of initial storage sites located in non-evacuated zones [NHK17/6/2015]. Ministry officials say bags and water-proof

sheets were found to be damaged at 78 sites. At 113 sites, part of the ground where bags had been placed had crumbled due to rain or other causes.

In September 2015, torrential rains from the Etau typhoon flooded seven storage sites with radioactive waste from the decontamination. At Iitate in Fukushima prefecture, more than 400 bags were taken away by the river. It was more than 300 in Tochigi prefecture. Some others located near the seashore are not protected in case of tsunami.

It is therefore urgent to find solutions to secure such waste.

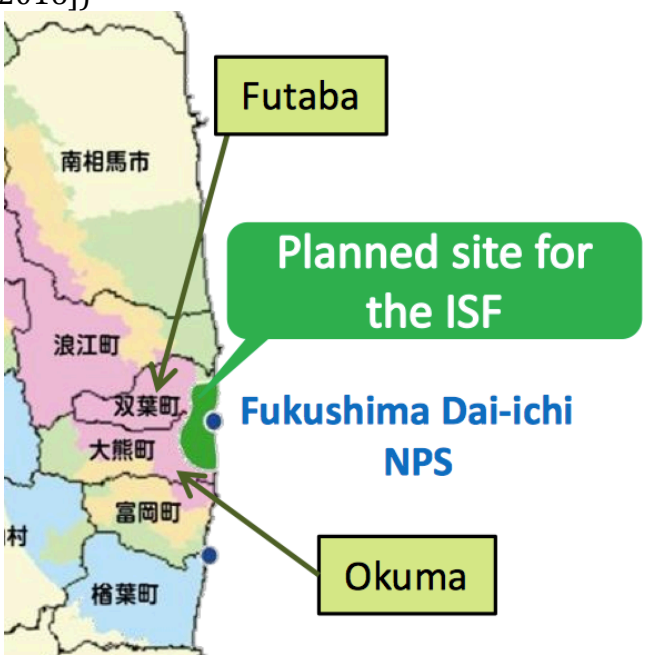
Conclusions

Handling radioactive waste is a difficult issue in all countries that have accumulated significant amounts. After a severe nuclear accident, it is even more difficult and volumes are enormous. Projects are stalled in Japan and authorities stick to their authoritative attitude that is a complete failure: Decide – Announce – Defend. In the mean time waste is piling up in bags that are quickly damaging.

The vast decontamination programme that generates most of this waste has not been well justified to the population. Is it necessary to decontaminate zones where residents don't want to come back? In evacuated territories decontamination is limited to areas surrounding dwellings and other buildings, changing villages and towns into oasis in the middle of a contaminated land. Even there, decontamination proved to be deceiving as dose rates have not significantly fallen compared to what can be observed in the forest.

Nevertheless authorities keep pushing inhabitants to come back.

Figure 5: Map of the projected intermediate storage facility in Futaba and Okuma (extracted from [ME2016])



Return policy

Whatever the performances of decontamination and the fate of radioactive waste, Japanese government policy consists in the return of the population to the evacuation zones except the ones classified as "difficult-to-return zone" where the external dose may be higher than 50 mSv per year. Its approach to convince the populations is the same as for the waste centres: Decide – Announce – Defend. Contact with residents is limited to "information meetings". To achieve its goal, the government plans to stop financial compensation by March 2018. Such a policy violates United Nations Guiding Principles on Internal Displacement that guaranty the right to chose between return and relocation.

Evacuated people face severe hardship and are suffering from their conditions. Non-evacuated people are worrying about their future and their children's health. Most of them cannot accept the government's decision. Communities where evacuation orders or recommendations were lifted are facing depopulation and aging problems. How to rebuilt a community in such conditions? Consequently populations suffer from their conditions and from the lack of acceptable future.

Governmental decisions

The return calendar is fixed: evacuation order should be lifted before March 2017, affecting 55 000 evacuees, some 23 000 from the so-called "residency restriction zones" and 32 000 for the "areas preparing for the lifting of evacuation orders." Financial support will cease one year later [Asahi19/5/2015].

It is not clear whether radiation levels will drop as expected by March 2018. Even if evacuation orders remain in place because of delays in decontamination work, the compensation payments should still end in 2018 for the two zones.

Regarding the "self-evacuees", 25 000 of them benefit of a free lodging, including 20 000 outside of the Fukushima prefecture, but this support will cease in March 2017. Other self-evacuees who do not benefit from any support are just ignored by authorities and not accounted.

So far, evacuation orders were lifted in parts of Tamura and Kawauchi in 2014, and in Naraha in 2015. All these areas lie within the less contaminated part of the 20 km evacuation zone. Evacuation recommendations around scattered hotspots are also completely lifted.

Residents are reluctant to come back

The lift of the evacuation order was preceded by a trial period that always leads to the government plan despite oppositions from evacuees. In Tamura, the government simply prolonged the trial period, after which it unilaterally announced that it would lift the evacuation order in April 2014. At that time, only 6.7% of the Tamura evacuees expressed willingness to return and 34.5% were in favour of return if certain conditions were met [IOM2015].

Such a trend is general in Fukushima. Surveys in a joint study conducted by the Reconstruction Agency, the Fukushima prefectural government and the two municipal governments of Tomioka and Okuma show that less than 15% of the households want to come back. This number is decreasing. On the contrary, 50.8% of the households of Tomioka and 63.5% of Okuma declare that they don't want to come back. These numbers are increasing [Asahi28/10/2015].

On the 5th of September 2015, evacuation order was lifted in Naraha, situated within the 20-km radius from the FDNPP. Naraha is one of the 11 municipalities where the entire or a part of the territory has been placed under evacuation orders since 2011. As pointed out by the International Organisation for Migration's Policy Brief Series, an opinion survey on the question of return was conducted among these evacuees in January 2014. With a participation rate of almost 60%, the result was that only 8% of the evacuees wish to return as soon as possible, and around 60% of them were either undecided or did not wish to return. In the questionnaire, there were no questions about local integration and resettlement options [IOM2015].

Once the evacuation order was lifted, less than 200 persons among more than 7 000 came back home during the first weeks. However, some 1 100 people working on decontamination and decommissioning work live in the approximately 10 prefab accommodations that have been set up in Naraha replacing the former residents.

Recent census of the Fukushima population based on the number of people living in the prefecture as of the 1st of October 2015, irrespective of whether they are registered as local citizens or not, shows that 976 people were living in Naraha. There are 6 724 people, or 87.3% less from 2010, two months after evacuation order was lifted [Asahi25/12/2015].

The town of Hirono, which lies between 20 and 30 km from the FDNPP, had its coastal portion inundated by the devastating tsunami. The town was included in the emergency evacuation preparation zone, as it was just outside the 20 km exclusion zone. However, the town government recommended that all residents evacuate and all civic services were shut down. Although the central government advised that it was safe to return in September 2011, the town government maintained its evacuation recommendation until April 2012. The town hall reopened on 1st of March 2012 in preparation for the return of residents and the radioactive decontamination of schools. According to the census, large portion of the present population is involved in nuclear reactor decommissioning work: the male population of 2 746, is up 2.3% from 2010 whereas the female population, on the other hand, was about half that figure at 1 577, down 42.3% [Asahi25/12/2015].

The population of Kawauchi, where the evacuation order was lifted in some areas in October 2014, plummeted 28.3% from 2 820 to 2 021. In contrast, municipalities in the prefecture that host many evacuees and workers engaged in disaster recovery work saw their populations increase from the pre-disaster period. The populations of Iwaki and Soma rose 2.1% and 2%, respectively. This is the first time in 20 years that these cities have seen increases in their populations [Mainichi25/12/2015].

These figures underline the huge gap between the Japanese policy and the wishes of the affected populations. Why are they reluctant to go back home when they suffer as evacuees? Basic infrastructures like easy access to medical or shopping centres are not yet restored. In Naraha, the school has not reopened yet and the new anti-tsunami wall not yet built. In some towns, the number of nuclear or decontamination workers exceeds the number of residents, making them less attractive. Trucks regularly cross other towns.

Besides these problems, there is a real fear about the consequences on health of the radiations. As already mentioned, the external dose is considered as too high for many evacuated people, especially when there are children.

Ageing and depopulation problems in radiation-contaminated areas

In an interview to the Asahi Shimbun, the mayor of Kawauchi believes that it is no longer possible to restore the village to what it was. The village of Kawauchi, is located 20 to 30 km of the FDNPP. Of the 3 000 or so people who lived in there before the nuclear disaster, some 1 600 have returned. Kawauchi's current population of 1 600 had initially been projected for some time around 2030. But the nuclear disaster has abruptly turned that projection into a reality. Only 20% of those aged 40 or under are back. Families are no longer the same as before. As they had to be separated to live in evacuation the number of households has increased from the pre-disaster figures of 1 100 to 1 500. Young villagers have landed jobs in urban areas, where they took shelter. Children have also gotten used to schools to which they were transferred. Those people are building new lives for themselves, although they are called "evacuees." They have come to think of returning to their own homes as something like a "resettlement" because a return to Kawauchi would require them to once again drastically alter their living environment. The mayor considers that how to cope with an on going depopulation is, in fact, presenting an extremely crucial issue showing the serious nature of the nuclear disaster. He believes that it is not cash but human resources that have the potential to change a local community. Rebuilding Kawauchi also requires assisting those who have left the village, as they do need a home community to which they could return whenever they wish to [Asahi19/03/2015].

As also pointed out by a scientific study, *"the emigration of residents following the Fukushima nuclear accident has resulted in aging and depopulation problems in radiation-contaminated areas. The recovery of affected areas, and even those areas with low radioactive pollution levels, is still heavily affected by this problem"* [Zhang2014]. A quickly shrinking and aging population has far-reaching impacts on all aspects of

society. The authors studied Minami-Soma where the population declined to 66% of that prior to the accident and the average resident age increased by 14 years, a level that was expected in 2025. The number of seniors who need nursing care increased by approximately 29% between February 2011 and May 2013 when about half of clinics and hospitals were forced to close and the number of doctors and nurse on duty declined by 15% and 19% respectively. More generally, the working-age population decreased by 33% in Minami-Soma when reconstruction requires a lot of manpower.

Authors identify three causes of emigration: (1) The health risks of living in a low radiation zone are still unknown; (2) The post-disaster psychological disturbance and distrust of government information promotes the emigration of evacuees; (3) an absence of economic vitality and of a leading industry renders the area less attractive to individuals residing outside of the city [Zhang2014].

Return policy

As already mentioned, Japanese government will allow the return of the population in zones where the external dose is lower than 20 mSv per year, considering that the residents spend 8 hours per day outdoor. This is the same limit that was fixed for evacuation. This means that over the years residents might be exposed to cumulative doses higher than 100 mSv, from which Japanese authorities consider that *"the incidence of cancer and death rate have a tendency to increase in proportion with the exposure dose"* [NRA2013b].

In such a context, the Nuclear Regulation Authority (NRA) of Japan with other governmental organisations formulated practical measures of radiation protection for the evacuees [NRA2013b]. They recall that *"additional exposure dose which an individual person is exposed after returning home should be 1 mSv/year or less (a long-term goal)."* But, no agenda is given nor recommended. The recommended policy focuses on the individual dose measured by a glass-badge *"for the purpose of addressing anxieties about radiation exposure and reducing individual exposure dose after returning homes"*.

Japanese government has adopted this policy in order to reassure evacuees and win their consent. Authorities expect that the recorded external doses by the glass-badge are far lower than the gross estimation based on airborne radiation rate. They also expect that returning population will learn how to reduce doses in contaminated territories. Besides the change of paradigm, there is also a change of measured quantity that reduces the final result as we already explained. NRA document never mentions it.

This new policy was never discussed nor debated with the affected populations. Many families consider that controlling their daily life is not a future to propose to their children and they prefer relocation. They are also worried that children do not always wear the glass-badge, especially if they decide to play in forbidden places like the forest. On the contrary, some elder persons definitively want to go back to their hometown and this is an acceptable burden.

NRA also stresses that *"the Japanese Government has been placing full respect on decision-making by individual evacuee regardless of whether they return to their homes or not"* [NRA2013b], but fact shows that the Japanese government rather encourage the return.

For example, evacuees who are expected to come back in evacuated zones are ineligible for long-term "post-disaster recovery public housing". Evacuees whose homes are located in areas that have been deemed difficult-to-return zones are the only ones eligible for this public housing currently under construction. But because many of these eligible evacuees have been able to receive sufficient compensation from TEPCo to buy new homes, the number of applications is much lower than predicted. Meanwhile, those who are not eligible to apply face some difficult decisions when they are forced out of their temporary homes. They are at a loss about what to do when their time is up in the emergency temporary housing facilities [Mainichi2/12/2015].

The Dispute Reconciliation Committee for Nuclear Damage Compensation produced the 4th Supplement to compensation guidelines on the 26th of December 2013, which recommends TEPCO to compensate the house reconstruction or purchase of the evacuees from all evacuation zones without discrimination, close to the real cost, regardless of the choice between return and relocation [DRC2013]. This made the choice of relocation easier for many evacuees. But the problem remains for those who have not yet made up their minds. Fukushima Prefecture also said that temporary housing will be extended depending on the situation of long-term post-disaster recovery public housing construction for the evacuees from three evacuation zones, concerning 7 towns: Naraha, Tomioka, Okuma, Futaba, Namie, Katsurao and Iitate [FP2015].

Human rights violations

Japanese policy was criticised by Anand Grover, Special Rapporteur to UN Human Rights Council, who notes: *"As the possibility of adverse health effects exists in low-dose radiation, evacuees should be recommended to return only when the radiation dose has been reduced as far as possible and to levels below 1 mSv/year. In the meantime, the Government should continue providing financial support and subsidies to all evacuees so that they can make a voluntary decision to return to their homes or remain evacuated"* [HRC2013].

United Nations state that internally displaced persons (IDP) are persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, as a result of various causes including *"natural or human-made disasters, and who have not crossed an internationally recognized State border"*. Evacuated persons from the contaminated places by the nuclear accident enter into this category and should benefit from the rights guaranteed by the Guiding Principles on Internal Displacement [UNESC1998].

Recalling that *"displacement nearly always generates conditions of severe hardship and suffering for the affected populations",* these Guiding Principles on Internal Displacement provide them guaranties. In particular, *"competent authorities have the primary duty and responsibility to establish conditions, as well as provide the means, which allow internally displaced persons to return voluntarily, in safety and with dignity, to their homes or places*

of habitual residence, or to resettle voluntarily in another part of the country. Such authorities shall endeavour to facilitate the reintegration of returned or resettled internally displaced persons." They add that *"internally displaced persons have the right to be protected against forcible return to or resettlement in any place where their life, safety, liberty and/or health would be at risk"* and that *"special efforts should be made to ensure the full participation of internally displaced persons in the planning and management of their return or resettlement and reintegration"* [UNESC1998]. This is definitively not the case in Japan.

International Organisation for Migration's Policy Brief Series notes that there is lack of recognition as IDPs in official discourses. Existing international normative framework and a set of human rights instruments were not referred to, and as a result scarcely applied in dealing with the issues of nuclear evacuees. Instead, the matter was handled differently from other cases of displacement, notably those displaced by Japan's 2011 earthquake and tsunami. "*Field researches by DEVAST and SHINRAI found, for example, that matters related to the evacuees from the earthquake and tsunami are managed by the Reconstruction Agency, while those of nuclear evacuees are mainly handled by the Ministry of Economy, Trade and Industry (METI) or the Reconstruction Agency officials seconded by METI"* [IOM2015].

Many important decisions concerning the future, such as the schedule of return, are often predetermined by METI and only communicated to nuclear evacuees at the last minute, leaving them often with no choice but to accept such decisions. *"Moreover, these "explanation meetings" (setsumeikai in Japanese) are usually organized behind closed doors without any presence of media, NGOs, legal or independent experts, producing often no record of what has been exactly discussed and thus leaving evacuees with little recourse"* [IOM2015].

Many citizens consider that instead of spending a lot of money in decontamination, waste management and recovery of evacuated territories, it would be more effective to use these funds to support relocation. Some even propose to build new town to keep the communities bounded. They are simply ignored by the central government.

Evacuees suffer

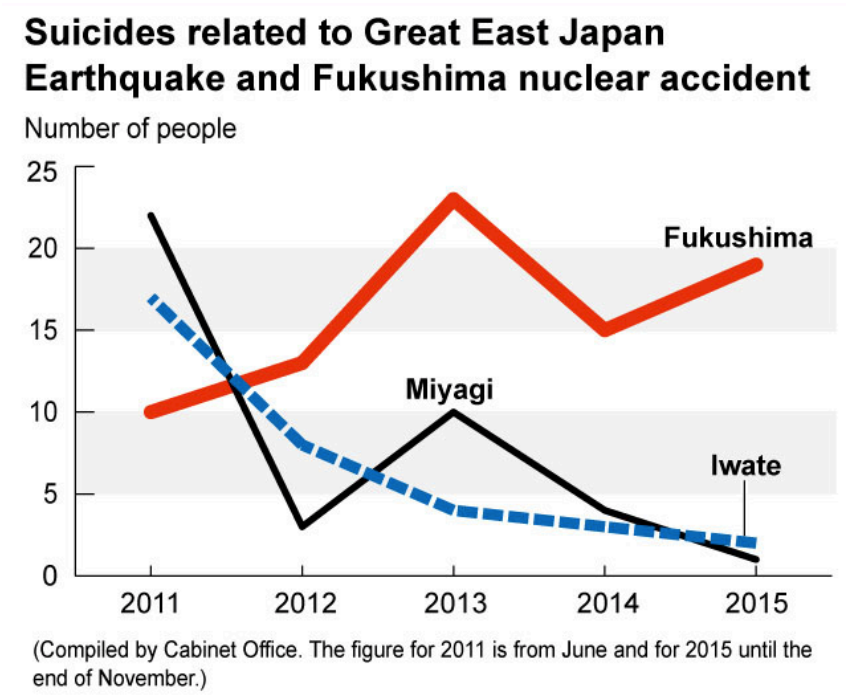
Japanese policy leads to a lot of suffering of the communities affected by the nuclear accident. The Japan Times reports the dilemmas faced by mothers living in contaminated territories of all affected prefectures: *"To stay or to flee. […] Those who remain there live in constant fear for their children's health. But choosing to flee opened them to accusations of being bad wives who abandoned their relatives, community and husbands tied to jobs. It is a no-win situation."* Whether to move back or not is another difficult question [JT29/9/2015].

Number of people suffering from psychological disorders such as depression and post-traumatic stress disorder is larger than usual among both evacuated and non-evacuated people. Statistics compiled by the Centre for Psychological Studies of Disaster at Fukushima University shows that psychological stress from the accident at the FDNPP has remained around the same level as in 2014 among mothers and children living in

Fukushima city. The stress levels had been dropping since 2011, the year the nuclear disaster started, but apparently bottomed out in 2014. The respondents were asked a number of questions and the researchers quantified the levels of the respondents' stress on a scale ranging from zero to 3. The average stress level for mothers in Fukushima city was 1.36, the same as that of 2014. It was 1.63 in 2011. Mothers who left areas where evacuation orders have been issued showed the highest stress level, at 1.85. In Soma, the level was 1.48, while it was 1.29 in Iwaki. In Hyogo and Kagoshima prefectures, which are not affected by the nuclear disaster, the average stress level was 1.06 [Asahi2/10/2015, Mainichi2/10/2015].

There is also a significant difference between the situation of populations affected by the nuclear disaster and of those affected by the tsunami. The number of suicides related to the disasters is larger in Fukushima than in Miyagi or Iwate, as shown in Figure 6. To determine if a suicide was related to the disaster and subsequent evacuation, local police talks to bereaved family members. To compare, as of November 2015, about 24 000 people in Iwate and about 55 000 in Miyagi were living in temporary housing away from their homes. In Fukushima, the number was about 103 000. Disaster victims in Fukushima were also found to be more likely to suffer from depression or post-traumatic stress disorders than people in Miyagi and Iwate prefectures [Asahi28/12/2015].

Figure 6: Suicides related to Great East Japan Earthquake and Fukushima nuclear accident (extracted from [Asahi28/12/2015]).



Disaster-related death is defined generally as death caused by illness or deterioration of a chronic disease arising from disaster-induced fatigue or psychological trauma, including suicide. Elder people are especially vulnerable after major disasters. As of December 2015, the deaths of 2 007 people in Fukushima Prefecture had been recognized as related to the earthquake, tsunami and nuclear crisis. Among the three

hardest hit prefectures, Fukushima has a particularly high number of disaster-related casualties. Iwate had 455 related deaths and Miyagi 918 [Mainichi28/12/2015]. A death is recognized as disaster-related if it is deemed by a panel of doctors, lawyers and other experts to have a causal relationship with the quake, tsunami or nuclear disaster. There are also objections from relatives of dead people who are not recognized as disaster victims by the panel.

A scientific study shows that the ineffectiveness of the countermeasures for disaster-related deaths can mainly be attributed to the complicating factors of the nuclear accident that followed the earthquake and tsunami [Tanaka2015]. The author explains that compared with a typical natural disaster, displaced persons of the nuclear accident have experienced a longer period of evacuation with an uncertain future. The seriousness of the combined earthquake, tsunami, and nuclear accident limited the effectiveness of countermeasures that had been implemented based on previous disaster experiences, particularly with respect to older refugees. The author concludes that *"there is an urgent need to recognize refugees' stressful situations, which could even cause death, and to provide them with high-quality medical treatment, including care for their long-term mental health."*

Conclusions

After any disaster, displaced persons are suffering. Nevertheless, in the case of the Fukushima nuclear accident many are reluctant to come back home once the evacuation order is lifted. Such an attitude is due to the fact that they face the same dilemma as non-evacuated people living in contaminated territories who wonder whether they should stay or leave and worry about the health of the children.

Whatever the opinion of affected populations, Japanese authorities have focused their response on their return: evacuation orders should be lifted before March 2017, except in the so-called difficult-to-return zones. Returning persons will find a depopulated town with an aging population. Hesitating persons feel abandoned by authorities. This uncertain future generates additional stress to the post-traumatic stress common to any disaster.

Japanese government should rather base its policy on the Guiding Principles on Internal Displacement that require special efforts to ensure the full participation of internally displaced persons in the planning and management of their return or resettlement and reintegration.

Conclusions

In 2012, the NAIIC warned that *"the impact of the accident still continues, and that responses are urgently required, to the vulnerability of the building and equipment at the Fukushima Daiichi Nuclear Power Plant after the accident and also to the residents' damages"* [NAIIC2012]. This is still true in 2016.

It also warned that *"the residents in the affected area are still struggling to recover from the effects of the accident. They continue to face grave concerns, including the health effects of radiation exposure, the dissolution of families, disruption of their lives, and the environmental contamination of vast areas of land"* [NAIIC2012]. This is again still true in 2016. As nuclear disasters last for decades affected population see no end to the severe hardship they are facing. In the case of Fukushima reactors, it is widely acknowledged that decommissioning and dismantling will take over 40 years. Reactors will be threatening for many years, as nobody knows how to access to the melted fuel.

But Japanese government rushes to turn the page and claims that disaster is almost over. Population are still suffering and in Fukushima disaster-related deaths are already exceeding the number of direct casualties by the quake and tsunami [Tanaka2015, Mainichi28/12/2015]. Sustainable solutions that can be accepted affected communities and individuals should be quickly found. Life in contaminated territories can also lead to a lot of stress. Many children do not play outside any more. Families also need answers to their specific problems and support. A nuclear disaster is primary a humanitarian disaster.

However, response by Japanese authorities only focuses on the return of the population in evacuated areas, except the most contaminated ones. International recommendations suggest conditions to restore a 'normal' life in the contaminated area, which is impossible. Whatever the solution, it will be very different from the pre-disaster situation. It has to be acknowledged that a return to normal life is not possible after a severe nuclear accident with large radioactive emissions. Authorities should also clearly explain that in the most contaminated places return is simply impossible.

After a nuclear disaster, many residents distrust authorities and official experts that failed to protect them. Distrust is enhanced by scandals when TEPCo and authorities fail to acknowledge the additional radioactive discharge into the environment. However, recovery paths require a good coordination between authorities and the populations. Solutions cannot ignore the specific demands of the affected populations and their suggestions. This means new ways for deliberation and decision. At the end, solutions might differ from families or communities. There is no good solution and each decision should be evaluated and then adapted.

Nevertheless, Japanese authorities push their unique solution ignoring the demand of the affected populations. Regarding decontamination, waste management and return policies, their method is limited to "Decide, Announce and Defend". Families and communities that do not accept such a solution are left in a painful situation. Beyond the pain of the affected persons, a nuclear disaster also shakes the ground of democracy.

Convinced that such public distrust derived from their lack of scientific knowledge, the authorities undertook a strategy to enhance their communication on radiological risk and its health effects [NRA2013b]. But, on the contrary, risks cannot be properly defined without understanding the real concern of the population nor taking into account existing scientific controversies and uncertainties. In such a context, one rather needs participatory processes where risks and solutions are debated by multiple stakeholders and actors including independent experts and third parties such as NPOs, and are defined collectively rather than decided single-handedly by policymakers – the authorities and their affiliated experts [Shirabe2015].

Japanese citizens proved that they were resourceful about the measurement of radioactivity [ACRO2012]. Citizen mapping of the contamination was done all over and food monitoring prompted authorities, producers, retailers to strengthen their controls and finally led to a decrease of intake of radioelements. There are also many initiatives for the recovery of territories. Some farmers decided to change their productions. Others invest in renewable energy production. Why such an open process that proved to be effective is not possible when deciding about the fate of contaminated territories and affected population?

Abbreviations

FDNPP	Fukushima Daiichi Nuclear Power Plant
ICRP	International Commission on Radiological Protection
IDP	Internally displaced persons
IOM	International Organization for Migration
IRCU	International Commission on Radiation Units and Measurements
IRSN	Institut de Radioprotection et de Sûreté Nucléaire
NAIIC	Nuclear Accident Independent Investigation Commission of the National Diet of Japan
NRA	Nuclear Regulation Authority
TEPCo	Tokyo Electric Power Company

Units

1 Bq	One becquerel or one disintegration per second
1 GBq = 10^9 Bq	One billion becquerels
1 TBq = 10^{12} Bq	One thousand billions becquerels
1 PBq = 10^{15} Bq	One million billions becquerels
1 Sv	One sievert, the unit for the effective dose
1 mSv = 10^{-3} Sv	One thousandth of a sievert
1 µSv = 10^{-6} Sv	One millionth of a sievert

Bibliography

[ACRO2011] ACRO 2011, *Results of measurement in Japan*, April 2011, accessed in December 2015
http://www.acro.eu.org/results-of-acros-monitoring-in-japan/

[ACRO2012] ACRO 2012, *Initiatives citoyennes au Japon suite à la catastrophe de Fukushima*, étude réalisée à la demande de l'Autorité de Sûreté Nucléaire, Février 2012
http://www.acro.eu.org/Rap_initiatives_fukushima2012_1.pdf

[ACRO2013] ACRO 2013, *Point sur la situation de l'eau contaminée à Fukushima*, ACROnique de Fukushima, 11 septembre 2013
http://fukushima.eu.org/point-sur-la-situation-de-leau-contaminee-a-fukushima/

[ACRO2015a] ACRO 2015, *Les dosimètres sous-estiment la dose enregistrée*, ACROnique de Fukushima 2015, 24 janvier 2015
http://fukushima.eu.org/les-dosimetres-sous-estiment-la-dose-enregistree/

[ACRO2015b] ACRO 2015, *Toute l'eau contaminée des cuves a été « traitée »,* ACROnique de Fukushima, 27 mai 2015
http://fukushima.eu.org/toute-leau-contaminee-des-cuves-traitee-avant-la-fin-du-mois/

[ACRO2015c] ACRO 2015, *L'impact sanitaire de la catastrophe de Fukushima,* ACROnique de Fukushima, 9 juin 2015
http://fukushima.eu.org/limpact-sanitaire-de-la-catastrophe-de-fukushima/

[ACRO2015d] ACRO 2015, *TEPCo annonce avoir fermé le mur le long du littoral*, ACROnique de Fukushima, 27 octobre 2015
http://fukushima.eu.org/tepco-annonce-avoir-ferme-le-mur-le-long-du-littoral/

[AP22/7/2013] Associated Press, *Tepco: Fukushima likely leaking radioactive water into sea*, 22nd July 2013

[Asahi29/4/2014] Asahi, *Survey: Half of Fukushima evacuee households split up; distress rife in families*, The Asahi Shimbun on line, 29th April 2014
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201404290046

[Asahi16/6/2014] Asahi, *State fails to convince Fukushima residents to accept intermediate storage facilities,* The Asahi Shimbun on line, 16th June 2014
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201406160028

[Asahi14/7/2014] Miki Aoki 2014, *TEPCO's rubble removal at Fukushima plant likely spread caesium to rice paddies*, The Asahi Shimbun on line, 14th July 2014
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201407140051

[Asahi15/7/2014] Asahi, *Minami-Soma lambastes government, TEPCO for remaining mum on rice contamination*, The Asahi Shimbun on line, 15th July 2014
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201407150040

[Asahi16/7/2014] Miki Aoki 2014, *Study: Caesium from Fukushima debris removal likely spread 50 km*, The Asahi Shimbun on line, 16th July 2014
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201407160064

[Asahi24/7/2014] Toshihide Ueda 2014, *COMMENTARY: Radioactive pollution endangers cultures of Tohoku mountain communities*, The Asahi Shimbun on line, 24th July 2014
http://ajw.asahi.com/article/views/column/AJ201407240005

[Asahi31/7/2014] Miki Aoki 2014, *Radioactive dust released during Fukushima cleanup reaches as far as Miyagi Prefecture*, The Asahi Shimbun on line, 31st July 2014
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201407310044

[Asahi31/12/2014] Miki Aoki 2014, *TEPCO's sloppy handling of suppressant led to spread of radioactive dust in 2013*, The Asahi Shimbun on line, 31st December 2014
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201412310025

[Asahi19/3/2015] Yuko Endo 2015, POINT OF VIEW/ *Yuko Endo: 4 years from nuclear disaster, Fukushima needs to reverse depopulation,* based on an interview by Susumu Okamoto, The Asahi Shimbun on line, 19th March 2015
http://ajw.asahi.com/article/views/opinion/AJ201503190009

[Asahi19/5/2015] Asahi, *Ministry plans to end TEPCO compensation to 55,000 Fukushima evacuees in 2018,* The Asahi Shimbun on line, 19th May 2015
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201505190055

[Asahi2/10/2015] Asahi, *Study: Radiation-related stress not easing among Fukushima mothers*, 2nd October 2015
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201510020006

[Asahi28/10/2015] The Asahi Shimbun, *Less than 15 percent of evacuees want to return to Fukushima homes,* The Asahi Shimbun on line, 28th October 2015
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201510280056

[Asahi9/12/2015] Masakazu Honda, *City to investigate NRA's conclusion that radioactive rice unrelated to Fukushima plant work*, The Asahi Shimbun on line, 9th December 2015

[Asahi25/12/2015] Kenji Izawa, *Fukushima's record decreasing rate of population causing gender gap, census shows*, The Asahi Shimbun on line, 25th December 2015
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201512250067

[Asahi28/12/2015] Mana Nagano, *Suicides rise among Fukushima nuclear disaster evacuees,* The Asahi Shimbun on line, 28th December 2015
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201512280026

[Asahi14/2/2016] The Asahi Shimbun, Little progress made in securing land for interim storage facilities for radioactive soil, The Asahi Shimbun on line, 14th February 2016
http://ajw.asahi.com/article/0311disaster/fukushima/AJ201602140022

[Chikurin2015] NPO 法人市民放射能監視センター (Chikurin citizen radioactivity monitoring station) 2015, database. Accessed in November 2015.
http://chikurin.org/?page_id=10

[Chiyoda2015] 千代田テクノル 2015 (Chiyoda Technol Corporation), 個人線量当量と周辺線量当量について, press release, 28th January 2015
http://www.c-technol.co.jp/archives/1038

[CODEX2009] Codex alimentarius: Food and Agriculture Organization of the United Nations and World Health Organization, *Codex General Standard for Contaminants and Toxins in Food and Feed*, Codex Standard 193-1995, revised in 2009, amended in 2013
http://www.codexalimentarius.org/download/standards/17/CXS_193e.pdf

[DEVAST2013] Reiko Hasegawa 2013, *Disaster Evacuation from Japan's 2011 Tsunami Disaster and the Fukushima Nuclear Accident*, DEVAST Project, May 2013.
http://www.devast-project.org/img/research/STUDY0513_RH_DEVAST_report.pdf

[DMCO2012] Disaster Management, Cabinet Office, Government of Japan 2012, 東日本大震災の避難所生活者数の推移について
http://www.bousai.go.jp/taisaku/hinanjo/h24_kentoukai/1/pdf/8.pdf

[DRC2013] Dispute Reconciliation Committee for Nuclear Damage Compensation 2013, *Outline of "Fourth Supplement to Interim Guidelines (Concerning Damages Associated with the Prolongation of Evacuation Orders, etc.)"*, 26th December 2013, in Nuclear Law Bulletin No. 94, Volume 2014/2, OECD/NEA
https://www.oecd-nea.org/law/nlb/nlb94.pdf#page=158

[EC2008] COUNCIL REGULATION (EC) No 733/2008 of 15 July 2008 on the conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station, Official Journal of the European Union L201/1, 30th July 2008
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:201:0001:0007:EN:PDF

[EU2016] European Union 2016, *Commission Implementing Regulation 2016/6 of 5 January 2016 imposing special conditions governing the import of feed and food originating in or consigned from Japan following the accident at the Fukushima nuclear power station and repealing Implementing Regulation No 322/2014*, Official Journal of the European Union L 3/5, 6th January 2016
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0006

[EURATOM2013] European Union 2013, 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, Official Journal of the European Union, L13/1, 17th January 2014
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013L0059&from=FR

[FEMA2013] Federal Emergency Management Agency 2013, *Program Manual - Radiological Emergency Preparedness,* June 2013
http://www.fema.gov/media-library-data/20130726-1917-25045-9774/2013_rep_program_manual__final2_.pdf

[FMinpo9/1/2015] Fukushima Minpo 2015, *All 2014 Fukushima rice cleared radiation tests,* Fukushima Minpo on line, 9th January 2015. Published in the Japan Times of the 18th January 2015
http://www.japantimes.co.jp/news/2015/01/18/national/all-2014-fukushima-rice-cleared-radiation-tests-thanks-to-fertilizer/

[FMinpo16/1/2015] Fukushima Minpo 2015, *J-Village eyed as Japan soccer team's training camp site for 2020 Olympics*, Fukushima Minpo on line, 16th January 2015
http://www.fukushimaminponews.com/news.html?id=457

[FMinpo8/1/2016] Fukushima Minpo 2015, *All 2015 Fukushima rice clears radiation tests, 1st since nuke disaster*, Fukushima Minpo on line, 8th January 2016
http://www.fukushimaminponews.com/news.html?id=613

[FP2015] Fukushima Prefecture 2015, 東日本大震災に係る応急仮設住宅の供与期間の延長について, press release of the 15th June 2015
http://www.pref.fukushima.lg.jp/sec/16055b/260528-kasetukyouyoencyou.html

[FPLB2015] Fukushima Prefectural Labour Bureau 2015, Labour Standards Department, Inspection Division, Ministry of Health, Labour and Welfare, *Results of supervision and instruction activities for employers of decontamination workers*, 9th October 2015
http://www.mhlw.go.jp/english/topics/2011eq/workers/dr/dr/dr_151009.pdf
Promotion of General Measures toward Improvement of Level of Compliance with Laws and Ordinances for Decontamination Works, etc., 30th October 2015
http://www.mhlw.go.jp/english/topics/2011eq/workers/dr/dr/dr_151030.pdf

[GC2013a] Louis Augustin-Jean et Nicolas Baumert 2013, *Les réactions des consommateurs japonais suite à la contamination nucléaire de mars 2011 et leurs conséquences sur le rapport au territoire* (Eating behavior in Japan after March 2011: consumers' attitudes and geographical consequences), Géographie et Culture 86 (2013) 49-64
http://gc.revues.org/2881
Keiichi Ishii et Shantala Morlans 2013, *La reprise des activités agricoles dans les régions contaminées après l'accident de Fukushima - Un défi lancé aux agriculteurs* (The resumption of agricultural activities in contaminated areas after the Fukushima accident: a challenge to farmers), Géographie et Culture 86 (2013) 65-82
http://gc.revues.org/2891

Etona Orito 2013, Traduction de Sylvie Guichard-Anguis et Nicolas Baumert, *Les teikei – les précurseurs au Japon de l'agriculture biologique – face à la catastrophe nucléaire de mars 2011* (The teikei system – The precursors of Japanese organic farming – facing the nuclear disaster of March 2011), Géographie et Culture 86 (2013) 83-99
http://gc.revues.org/2900

[GPI2012] David Boilley 2012, *Emergency Planning and Evacuation*, in, *Lessons from Fukushima*, Greenpeace International 2012
http://www.greenpeace.org/international/Global/international/publications/nuclear/2012/Fukushima/Lessons-from-Fukushima.pdf

[Hasegawa2015] Reiko Hasegawa 2015, private communication

[Hayano2015] S. Hayano et al 2015, *Whole-body counter surveys of over 2700 babies and small children in and around Fukushima Prefecture 33 to 49 months after the Fukushima Daiichi NPP accident*, Proc. Jpn. Acad., Ser. B 91 (2015) 440
https://www.jstage.jst.go.jp/article/pjab/91/8/91_PJA9108B-06/_article

[HRC2013] Anand Grover, Human Rights Council 2013, *Report of the Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of physical and mental health*, Mission to Japan (15 - 26 November 2012), 2nd May 2013 (A/HRC/23/41/Add.3)
http://www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session23/A-HRC-23-41-Add3_en.pdf

[ICANPS2012] Investigation Committee on the Accident at Fukushima Nuclear Power Stations of Tokyo Electric Power Company 2012, *Final report*, 23rd July 2012
http://www.cas.go.jp/jp/seisaku/icanps/eng/final-report.html

[ICRP103] International Commission on Radiological Protection 2007, Publication 103: *The 2007 Recommendations of the International Commission on Radiological Protection*, Approved by the Commission in March 2007.

[ICRP109] International Commission on Radiological Protection 2008, Publication 109: *Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations*, Approved by the Commission in October 2008.

[ICRP111] International Commission on Radiological Protection 2011, Publication 111: *Application of the Commission's Recommendations to the Protection of People Living in Long-term Contaminated Areas after a Nuclear Accident or a Radiation Emergency*, Approved by the Commission in October 2008, published in April 2011.

[IOM2015] Reiko Hasegawa 2015, *Returning home after Fukushima: Displacement from a nuclear disaster and international guidelines for internally displaced persons*, Migration, Environment and Climate Change: Policy Brief Series, Issue 4 | Vol. 1 | September 2015, International Organization for Migration (IOM)
http://publications.iom.int/bookstore/index.php?main_page=product_info&cPath=59&products_id=1529

[IRCU1998] International Commission on Radiation Units and Measurements, IRCU report 57, *Conversion Coefficients for use in Radiological Protection Against External Radiation*, 1st August 1998.

[IRSN2011a] Institut de Radioprotection et de Sûreté Nucléaire 2011, *Gestion radiologique des territoires contaminés à la suite de l'accident de Fukushima : l'IRSN rend public son rapport d'analyse de la situation*, press release of the 23rd May 2011
http://www.irsn.fr/FR/Actualites_presse/Actualites/Pages/20110523_Gestion_radiologique_territoires_contamines_Fukushima-Rapport_IRSN.aspx
See also the report that could be downloaded from this page.

[IRSN2011b] Institut de Radioprotection et de Sûreté Nucléaire 2011, *Synthèse actualisée des connaissances relatives à l'impact sur le milieu marin des rejets radioactifs du site nucléaire accidenté de Fukushima Dai-ichi*, 26 octobre 2011
http://www.irsn.fr/FR/Actualites_presse/Actualites/Documents/IRSN-NI-Impact_accident_Fukushima_sur_milieu_marin_26102011.pdf

[IRSN2012] Institut de Radioprotection et de Sûreté Nucléaire 2012, *Fukushima, one year later - Initial analyses of the accident and its consequences*, Report IRSN/DG/2012-003 of the 12th March 2012
http://www.irsn.fr/EN/publications/technical-publications/Documents/IRSN_Fukushima-1-year-later_2012-003.pdf

[IRSN2014] Institut de Radioprotection et de Sûreté Nucléaire 2014, *Site nucléaire de Fukushima Daiichi : Rejets aériens survenus lors de travaux sur la tranche 3 en août 2013*, Juillet 2014
http://www.irsn.fr/FR/Actualites_presse/Actualites/Documents/IRSN_Fukushima_NI-rejets-2013-reacteur-3_20140731.pdf

[IRSN2015] Institut de Radioprotection et de Sûreté Nucléaire 2015, *Stratégie de décontamination et de gestion des déchets à Fukushima,* RT/PRP-DGE/2015-00015. Unpublished.

[JT7/8/2013] Kyodo, *Tepco needs public cash to dig deep wall - Radioactive flow to sea 300 tons daily; Suga says utility can't halt it*, The Japan Times on line, 7th August 2013
http://www.japantimes.co.jp/news/2013/08/07/national/tepco-needs-public-cash-to-dig-deep-wall/

[JT5/1/2015] The Japan Times 2015, *Permanent radioactive waste disposal facing significant hurdles*, 5th January 2015
http://www.japantimes.co.jp/news/2015/01/05/national/permanent-radioactive-waste-disposal-facing-significant-hurdles/

[JT29/9/2015] Megan Green, *Reluctant to speak, Fukushima moms admit fear of radiation, pressure from families*, The Japan Times, 29th September 2015
http://www.japantimes.co.jp/news/2015/09/29/national/social-issues/reluctant-speak-fukushima-moms-admit-fear-radiation-pressure-families/

[JT20/10/2015] Kyodo 2015, *Fukushima No. 1 worker's leukemia officially deemed a work accident*, The Japan Times on line, 10th October 2015
http://www.japantimes.co.jp/news/2015/10/20/national/science-health/nhk-says-health-ministry-confirms-link-workers-leukemia-fukushima-blast/

[JT9/1/2016] Jiji 2016, *Fukushima nuclear evacuees fall below 100,000*, The Japan Times online, 9th January 2016
http://www.japantimes.co.jp/news/2016/01/09/national/fukushima-nuclear-evacuees-fall-100000

[Kanda2013] Kanda, J. 2013, *Continuing ^{137}Cs release to the sea from the Fukushima Dai-ichi Nuclear Power Plant through 2012*, Biogeosciences Discuss., 10, 3577–3595, 2013
http://www.biogeosciences-discuss.net/10/3577/2013/bgd-10-3577-2013.pdf

[Mainichi17/11/2013] Mainichi 2013, *Fukushima rice farmers try to ease consumer fears with thorough scanning*, Mainichi Japan on line, 17th November 2013

[Mainichi16/12/2013] Mainichi 2013, *Contaminated waste at public apartments shocks Fukushima residents*, Mainichi Japan on line, 16th December 2013

[Mainichi24/3/2014] Mainichi 2014, *Gov't team withholds high radiation data on three Fukushima sites*, The Mainichi on line, 25th March 2014

[Mainichi9/03/2015] Mainichi 2015, *Radiation decontamination volunteers not supported by national gov't*, The Mainichi on line, 9th March 2015
http://mainichi.jp/english/articles/20151002/p2a/00m/0na/006000c

[Mainichi2/10/2015] Mainichi 2015, *Moms, children from Fukushima no-go zones feel more stress*, The Mainichi on line, 2nd October 2015

[Mainichi2/12/2015] Mainichi 2015, *Post-disaster recovery public housing' not meeting real needs,* The Mainichi on line, 2nd December 2015
http://mainichi.jp/english/articles/20151202/p2a/00m/0na/017000c

[Mainichi10/12/2015] Mainichi 2015, *Over 9 million bags of nuclear cleanup waste piled up across Fukushima Pref.*, 10th December 2015
http://mainichi.jp/english/articles/20151210/p2a/00m/0na/020000c

[Mainichi13/12/2015] Mainichi 2015, *3 Miyagi municipalities against hosting disposal sites for contaminated waste,* The Mainichi on line, 14th December 2015
http://mainichi.jp/english/articles/20151214/p2a/00m/0na/007000c

[Mainichi25/12/2015] Mainichi 2015, *Population in Fukushima Pref. decreased by 110,000 in aftermath of nuke disaster*, The Mainichi on line, 25th December 2015
http://mainichi.jp/english/articles/20151225/p2a/00m/0na/011000c

[Mainichi28/12/2015] Mainichi 2015, 「震災関連死」２０００人超える　原発避難長期化, The Mainichi on line, 28th December 2015
http://mainichi.jp/articles/20151229/k00/00m/040/043000c

[ME2015a] Ministry of the Environment 2015, *Progress on Off-site Cleanup and Interim Storage in Japan*, September 2015
http://josen.env.go.jp/en/pdf/progressseet_progress_on_cleanup_efforts.pdf?150601

[ME2015b] Ministry of the Environment 2015, 中間貯蔵除去土壌等の減容・再生利用技術開発戦略検討会、21st December 2015
http://josen.env.go.jp/chukanchozou/facility/effort/investigative_commission/proceedings_151221.html

[ME2016] Ministry of the Environment 2016, *Progress on Off-site Cleanup and Interim Storage in Japan*, January 2016
http://josen.env.go.jp/en/pdf/progressseet_progress_on_cleanup_efforts.pdf

[METI2014] Ministry of Economy, Trade and Industry 2014, 東京電力(株)福島第一原子力発電所事故に係る個人線量の特性に関する調査 (*Researches on the characteristics of personal doses after the accident of TEPCO Fukushima Dai-ichi nuclear power plant*), NIRS and JAEA, 18th April 2014
http://www.meti.go.jp/earthquake/nuclear/radioactivity/pdf/20140418_02.pdf

[METI2015] Ministry of Economy, *Trade and Industry 2015, Areas to which evacuation orders have been issued*, 5th September 2015
http://www.meti.go.jp/english/earthquake/nuclear/roadmap/pdf/150905MapOfAreas.pdf

[MEXT2011] Ministry of Education, Culture, Sports, Sciences and Technology 2011, 自主的避難関連データ, published on the 11th November 2011
http://www.mext.go.jp/b_menu/shingi/chousa/kaihatu/016/shiryo/__icsFiles/afieldfile/2011/11/11/1313180_2_2.pdf

[MHLW2011a] Ministry of Health Labour and Welfare 2011, Health Sciences Council, *The Survey Results of Radioactive Materials in Tap Water*, 19th April 2011
http://www.mhlw.go.jp/english/topics/2011eq/dl/Document2.pdf

[MHLW2011b] Department of Food Safety Pharmaceutical & Food Safety Bureau, Ministry of Health Labour and Welfare 2011, *New Standard limits for Radionuclides in Foods*
http://www.mhlw.go.jp/english/topics/2011eq/dl/new_standard.pdf

[MHLW2015a] Ministry of Health, Labour and Welfare 2015, *Sum up of radionuclide test results reported in FY 2015*, Up-to-date Report as of 13th October 2015
http://www.mhlw.go.jp/english/topics/2011eq/dl/13_October_2015Sum_up_of_radionuclide_test_results.pdf

[MHLW2015b] Ministry of Health, Labour and Welfare 2015, Radioactive materials in foods – current situation and protective measures, not dated, accessed in December 2015
http://www.mhlw.go.jp/english/topics/2011eq/dl/food-130926_1.pdf

Sum up of radionuclide test results reported in FY2015 (Up-to-date Report as of 30th November 2015)
http://www.mhlw.go.jp/english/topics/2011eq/dl/30_November_2015Sum_up_of_radionuclide_test_results.pdf

[MHLW2015c] Ministry of Health, Labour and Welfare 2015, *Information on the Great East Japan Earthquake, Water Supply*. Accessed in December 2015.
http://www.mhlw.go.jp/english/topics/2011eq/watersupply.html

[MHLW2015d] Ministry of Health, Labour and Welfare 2015, Cancellation of Instruction to restrict distribution based on the Action Special Measures Concerning Nuclear Emergency Preparedness, press release of the 3rd December 2015
http://www.mhlw.go.jp/english/topics/2011eq/dl/food_press_December3_2015.pdf

[NAIIC2012] The National Diet of Japan 2012, *The official report of The Fukushima Nuclear Accident Independent Investigation Commission*
http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/report/

[NHK17/6/2015] NHK, *Bags of contaminated soil damaged at storage sites*, 17th June 2015

[NRA2013a] Nuclear Regulation Authority 2013, 福島第一原発近傍ポイントにおける放射能濃度の推移. Accessed in January 2016.
https://www.nsr.go.jp/data/000048858.pdf

[NRA2013b] Nuclear Regulation Authority 2013, *Practical Measures for Evacuees to Return Their Homes*, 20th November 2013 (English translation was posted in February 2014)
https://www.nsr.go.jp/data/000067234.pdf

[NRA2015] Nuclear Regulation Authority 2015, *Readings of radioactivity level in drinking water by prefecture, July-September, 2015*, published on the 30th of October 2015
http://radioactivity.nsr.go.jp/en/contents/11000/10416/24/194_20151030.pdf

[RA2012] Reconstruction Agency 2012, 全国の避難者等の数, 13th June 2012
http://www.reconstruction.go.jp/topics/120613hinansya.pdf

[REA2015] Radiation Effect Association 2015, 除染作業者等の被ばく線量等の集計結果を公表します, press release, 15th April 2015
http://www.rea.or.jp/chutou/koukai_jyosen/honbun-press.pdf
Attached document: 除染作業者等の被ばく線量等の集計結果について
http://www.rea.or.jp/chutou/koukai_jyosen/toukai-press.pdf

[Shirabe2015] Masashi Shirabe, Christine Fassert and Reiko Hasegawa 2015, *From Risk communication to Participatory Radiation Risk Assessment*, Fukushima Global Communication Programme, Working Paper Series Number 21, December 2015
http://i.unu.edu/media/ias.unu.edu-en/news/12850/FGC-WP-21-FINAL.pdf

[ShukanAsahi28/1/2015] 週刊朝日 2015 (Weekly Asahi), スクープ「個人線量計が最大 4 割低く表示」福島県内の子供が危ない！ 28th January 2015
http://dot.asahi.com/wa/2015012700082.html

[Steinhauser2014] Georg Steinhauser, Alexander Brandl and Thomas E. Johnson 2015, *Comparison of the Chernobyl and Fukushima nuclear accidents: A review of the environmental impacts*, Science of the Total Environment 470–471 (2014) 800–817
http://www.sciencedirect.com.gate4.inist.fr/science/article/pii/S004896971301173X
Erratum, Science of the Total Environment 487 (2014) 575
http://www.sciencedirect.com/science/article/pii/S004896971400480X

[Steinhauser2015] Georg Steinhauser, Tamon Niisoe, Kouji H. Harada, Katsumi Shozugawa, Stephanie Schneider, Hans-Arno Synal, Clemens Walther, Marcus Christl, Kenji Nanba, Hirohiko Ishikawa, and Akio Koizumi 2015, *Post-Accident Sporadic Releases of Airborne Radionuclides from the Fukushima Daiichi Nuclear Power Plant Site*, Environ. Sci. Technol. 49 (2015) 14028−14035
http://pubs.acs.org/doi/10.1021/acs.est.5b03155

[Sternsdorff-Cisterna2015] Nicolas Sternsdorff-Cisterna 2015, Food after Fukushima: Risk and Scientific Citizenship in Japan, American Anthropologist 117 (2015) 455–467
http://onlinelibrary.wiley.com/doi/10.1111/aman.12294/full

[Tanaka2015] Reiichiro Tanaka 2015, *Prolonged Living as a Refugee from the Area Around a Stricken Nuclear Power Plant Increases the Risk of Death*, Prehospital and Disaster Medicine 30, August 2015, pp 425-430
http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=9909736&fileId=S1049023X15004926

[TEPCo2013] Tokyo Electric Power Company 2013, Reference Materials, *Increases in the Concentration of Radioactive Materials in Seawater and Groundwater on the Ocean Side of the Site: Current Situation and Countermeasures*, 22nd July 2013
http://www.tepco.co.jp/en/nu/fukushima-np/handouts/2013/images/handouts_130722_07-e.pdf

[TEPCo2014] Tokyo Electric Power Company 2015, 福島第一原子力発電所におけるトリチウム量 - 及び多核種除去設備処理水化学的水質について, 24th April 2014
http://www.meti.go.jp/earthquake/nuclear/pdf/140424/140424_02_003.pdf

[TEPCo2015a] Tokyo Electric Power Company 2015, 福島第一原子力発電所-海側遮水壁閉合後の埋立地舗装面等の状況について, handouts for the press, 26th November 2015
http://www.tepco.co.jp/nu/fukushima-np/handouts/2015/images/handouts_151126_06-j.pdf

[TEPCo2015b] Tokyo Electric Power Company 2015, *Monitoring by sampling, Results of Radioactive Analysis around Fukushima Daiichi Nuclear Power Station*, accessed in December 2015.
http://www.tepco.co.jp/en/nu/fukushima-np/f1/smp/index-e.html

Regarding data mentioned in the text see: 福島第一港湾内、放水口付近、護岸の詳細分析結果, 9th of December 2015
http://www.tepco.co.jp/nu/fukushima-np/f1/smp/2015/images/2tb-east_15120901-j.pdf

[TEPCo2016] Tokyo Electric Power Company 2016, *TEPCo stores rather than discharges from groundwater drain after monitoring detects higher contamination levels*, Fukushima Daiichi NPS Prompt Report, 8th January 2016
http://www.tepco.co.jp/en/press/corp-com/release/2016/1265513_7763.html

[Tsubokura2014] M. Tsubokura et al. 2014, *Reduction of High Levels of Internal Radio-Contamination by Dietary Intervention in Residents of Areas Affected by the Fukushima Daiichi Nuclear Plant Disaster: A Case Series*, Plos One 9 (2014) e100302
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0100302

[UNESC1998] United Nations, Economic and Social Council, Commission on Human Rights 1998, *Guiding Principles on Internal Displacement*, E/CN.4/1998/53/Add.2, 11th February 1998
http://www.ohchr.org/EN/Issues/IDPersons/Pages/Standards.aspx

[UNSCEAR2015] United Nations Scientific Committee on the Effects of Atomic Radiation 2015, *Developments 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 2015 white paper to guide the Scientific Committee's future programme of work*
http://www.unscear.org/unscear/en/publications/Fukushima_WP2015.html

[WHOI2015] Woods Hole Oceanographic Institution, Results of the citizen monitoring of the radioactivity in the ocean: http://www.ourradioactiveocean.org/ (Accessed in October 2015)

[Yomiuri23/4/2011] The Yomiuri Shimbun 2011, *Govt officially sets new evacuation zone*, Yomiuri on line, 23rd April 2015

[Yomiuri2/4/2015] The Yomiuri Shimbun 2015, *Radioactive waste left in limbo / Local authorities avoid filing paperwork for 3,600 tons*, Yomiuri on line, 2nd April 2015

[Yomiuri11/1/2016] Takeshi Ishikawa and Erina Suzuki 2016, *14,000 temporary units still occupied*, Yomiuri on line, 11th January 2016
http://the-japan-news.com/news/article/0002675068

[Yomiuri4/2/2016] The Yomiuri Shimbun 2015, *Govt to ease radioactive waste rules*, Yomiuri on line, 4th February 2016
http://the-japan-news.com/news/article/0002727876

[Zhang2014] Hui Zhang, Wanglin Yan, Akihiro Oba and Wei Zhang 2014, *Radiation-Driven Migration: The Case of Minamisoma City, Fukushima, Japan, after the Fukushima Nuclear Accident*, Int. J. Environ. Res. Public Health 11 (2014) 9286-9305
http://www.mdpi.com/1660-4601/11/9/9286