Nuclear scars:

The Lasting Legacies of Chernobyl and Fukushima

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Contaminated Landscape in Iitate Village
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This report is dedicated to the memory of Brian Blomme. Brian's contribution to Greenpeace and the fight for a better world won't end with his passing because we all learned so much from him.

Thanks Brian.

An abandoned house in Yonomori Town. Level of radiation is 2.72 microsieverts per hour. The normal rate before the Fukushima nuclear disaster was 0.08 microsievert an hour.

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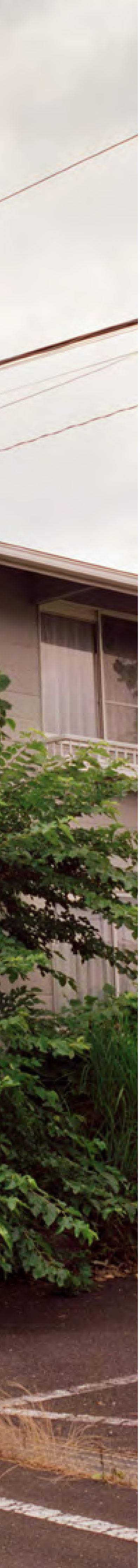

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Contaminated Streets in Namie Town

Namie town is completely abandoned and an officially closed off area. Only clean-up and nuclear workers from the plant are allowed into the zone with special permission. Level of radiation: 0.43 microsievert per hour.

1. Nuclear Scars: Introduction

It is 30 years since the beginning of the Chernobyl nuclear disaster. It is also five years since the Fukushima disaster began. To mark these anniversaries, Greenpeace has commissioned substantial reviews of scientific studies examining the continued radioactive contamination in the affected areas, and the health and social effects on the impacted populations. We have also carried out radiation field work to expose the unrelenting crises in Russia, Belarus, Ukraine and Japan that thousands of people still live with on a daily basis.

There is no simple or easy way to clean up an aftermath of a nuclear accident. Indeed, this report shows that there is no such thing in reality as a complete decontamination of radioactively contaminated areas. The disasters that began at Chernobyl Nuclear Power Plant (NPP) in 1986 and at Fukushima NPP in 2011 have demonstrated not only the terrible initial consequences of major nuclear accidents; they also left us with long-term consequences for human health and the environment. These scars are still with us today and will be with us long after tomorrow.

The nuclear industry likes to frame these accidents in terms of downplayed numbers of deaths, but the reality is far more complex and insidious. The impacts go far beyond the tens of thousands of fatalities and hundreds of thousands suffering health consequences. Following a nuclear disaster, people are put under overwhelming pressures. They must evacuate their communities to avoid radiation risks. They are displaced from their friends, families and communities for years. After 30 years, people have still not been able to return to communities in Ukraine; a major city in the impacted area, Pripyat, is still a ghost town. Communities in the Fukushima area are still abandoned, friends and neighbours in those communities are scattered and struggling to put their lives back together.

The world has over 400 nuclear reactors. And while some are more vulnerable than others, all of them might experience a meltdown. This means that millions of people are living at constant risk of another nuclear disaster. There is a continuing possibility of old reactors breaking down or suffering a major accident due to human error, acts of terrorists, loss of power to emergency systems, and natural disasters. Indeed, the world experiences a major nuclear accident about once a decade[1], in contrast to what the nuclear industry tells us.

Despite all the evidence to the contrary, the nuclear industry and its government supporters continue to hide the threats of nuclear power from the public. The real risk of nuclear power, however, is inescapable for hundreds of thousands of Chernobyl and Fukushima survivors. Despite the immense suffering that accompanies losing your home or living in a contaminated environment, the scale and seriousness of these effects continue to be played down or misrepresented.

Greenpeace commissioned a team of scientists led by Professor Omelianets, Principal Scientist for the Laboratory of Medical Demography at the National Research Centre for Radiation Medicine of National Academy of Medical Sciences of Ukraine (NRCRM), to review the published national and international scientific data and research on the health impacts from the Chernobyl and Fukushima disasters. Their report *Health Effects of Chernobyl and Fukushima: 30 and 5 years down the line* testifies to the broad impacts on the lives and health of many generations after a nuclear disaster.[2]

Professor Valerii Kashparov, the Director of the Ukrainian Institute of Agricultural Radiology (UIAR) of the National University of Life and Environmental Sciences of Ukraine (NUBiP of Ukraine), and his team reviewed the published scientific research on the extent of Chernobyl's contamination 30 years later. Their report, *Chernobyl: 30 Years of Radioactive Contamination Legacy* found Chernobyl's contamination to be still extensive.[3] More than 10,000 km^2 of land is still unusable for economic activity and about 5 million people live in zones officially considered contaminated.[4] David Boilley, a nuclear physicist and chairman of Association pour le Contrôle de la Radioactivité dans l'Ouest (ACRO), was commissioned to review current research into the contamination from the Fukushima disaster in order to gain an accurate picture of the current situation.[5]

Based on the extensive research listed above and Greenpeace investigations, this report seeks to clarify how governments, reactor operators and nuclear regulators were unprepared to deal with not only emergency evacuations immediately after the accidents, but with the long-term management of hundreds of thousands of displaced persons, as well as with the contaminated communities and agricultural lands.

Sadly, history repeats itself. This report documents the major consequences of the two nuclear disasters unprecedented in the history of the human race, at Chernobyl and Fukushima NPPs, which happened just 25 years apart. Both disasters have permanently changed their respective societies. Governments have been unable to provide the social support or compensation needed to address the scale of loss endured by survivors of Chernobyl and Fukushima.

The long-lived nature of radioactive contamination means the consequences of these disasters will be with us for decades and centuries to come. Justice demands that governments provide proper support for the survivors of Chernobyl and Fukushima. Compensation to survivors should be paid in full and expeditiously. We have an obligation to ourselves, our children and the planet to ensure we never see such destruction and misery ever again.

1.1 Chernobyl and Fukushima: Timing and Scale of Releases

In the event of a reactor accident, the consequences on the environment and human health will be determined by the magnitude, timing, duration and chemical properties of the radioactive elements released into the air or water. These radioactive releases are referred to as 'source term'.

The chemical properties of a radioisotope - an element with an unstable nucleus that emits radioactivity - impact how it travels or bio-accumulates in the environment. For example, iodine-131 (^{131}I) is quickly absorbed by the human thyroid and increases the risk of thyroid cancer. While it has a short half-life (8.3 days), iodine-131 can travel great distances by air in its gaseous form in the event of an accident.

Another key isotope in assessing the human health impacts and environmental contamination consequences of a nuclear accident is caesium-137 (^{137}Cs). It is a significant human health concern because it is stored in sediments and has a tendency

to bio-accumulate in plant tissue and enter the food chain. Caesium-137 has a long half-life (30 years) and can, therefore, cause long-term land contamination that can in turn prolong human and biota exposure to radiation.

Following Chernobyl, the International Atomic Energy Agency (IAEA) created the International Nuclear Event Scale (INES) as a common international metric for nuclear accidents. The INES's objective "is to facilitate communication and understanding between the technical community, the media and the public on the safety significance of events."[6]

There are seven levels to the INES scale. The highest-level accidents pose a significant risk to the environment and human health. INES accidents 4 – 7 are categorized based on the total radiological 'activity' of the releases to the environment expressed in Becquerel (Bq). Bq is defined as one nuclear decay per second in radioactive material. INES events between levels 1 and 4 are categorised by the number of people exposed to radiation and the doses they received. Due to the magnitude of radioactive releases for accidents on the INES scale, releases are often discussed in PetaBecquerels (PBq). One PBq is equivalent to 10^{15} = 1000,000,000,000,000 Bq.

A comparison between the Chernobyl and Fukushima accidents shows that the INES scale overlooks several important variables such as the timing and duration of releases as well as the possibility of simultaneous releases from several reactors at the same site. While Chernobyl and Fukushima are both categorized as INES 7 events, releases from Chernobyl were approximately 10 times greater than from Fukushima (see Table 1 for details).

Table 1: Comparison of select radionuclide releases* to the atmosphere from Fukushima and Chernobyl[7]

Chernobyl	Fukushima
April 26, 1986	March 11, 2011
^{131}I: 1760 PBq ^{137}Cs: 85 PBq	^{131}I: 153-160 PBq ^{137}Cs: 13 – 15 PBq
Total amount of radioactivity: 5300 PBq	Total amount of radioactivity: 520 PBq
INES 7	INES 7

*These values do not include the noble gases Krypton (Kr) and Xenon (Xe)

Fukushima I Nuclear Power Plant Damage

A satellite image shows damage at Fukushima I Nuclear Power Plant In Fukushima Prefecture. The damage was caused by the offshore earthquake that occurred on 11 March 2011.

1.1.1 The Chernobyl Accident

On April 26, 1986, reactor 4 at the Chernobyl nuclear power station underwent two quick and successive explosions that led to immediate large radioactive releases. The high temperatures in the reactor contributed to the melting of the remaining fuel and continuing radioactive emissions. Radioactive emissions continued on a smaller scale for approximately a month.

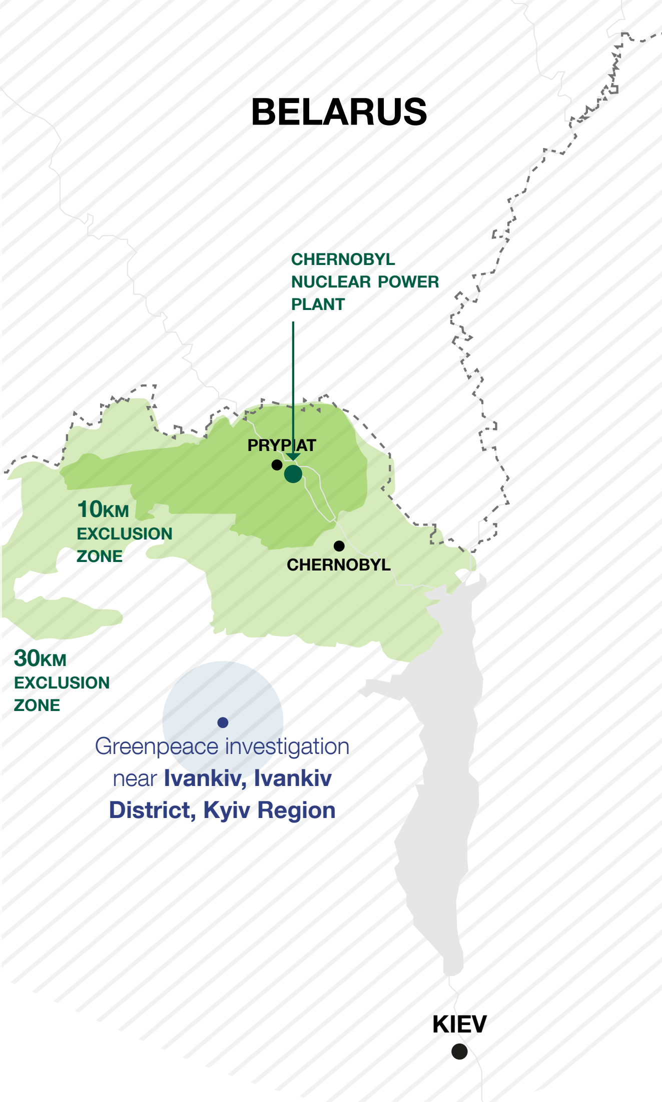
The Chernobyl accident was caused by a combination of human error and design flaws. During a scheduled test, operators lowered reactor power to prohibited levels before attempting to insert the shutdown rods into the reactor core. Instead of powering down, this led to a rapid explosive burst due to a flaw in the Chernobyl reactor design.

The resulting explosion released an estimated 450 PBq of radioactivity.[17] The radioisotopes rose to between 7 and 9 km into the atmosphere[18] and at these high altitudes were carried great distances and deposited across Europe and the whole northern hemisphere.

The World Health Organization (WHO) has observed that Chernobyl released 200 times the radioactivity in Becquerels than the Hiroshima and Nagasaki atomic bombs.[19] Approximately 85 PBq of caesium-137 was released into the environment.[20] Iodine-131 releases were estimated at 1760 PBq, the majority of which was released within the first three days of the accident.[21] The total amount of radioactivity released from Chernobyl was 5300 PBq.[22]

Ukraine, Belarus and Russia received the highest levels of contamination from radioactive fallout. But all of Europe was affected at lower levels with Scandinavian countries and the Alpine region being the most severely contaminated. Due to high radiation levels, a 30 km area was evacuated around the Chernobyl NPP.

Moreover, the fallout from the Chernobyl accident contained “hot particles” which were similar to the composition of irradiated nuclear fuel from Unit 4 during the accident. Fuel particles were found in the radioactive fallout both in close proximity to the reactor and at a considerable distance from it in several European countries.[23] Thus, areas close to Chernobyl NPP may be uninhabitable for tens of thousands of years.



1.1.2 The Fukushima Daiichi Accident

On March 11, 2011 a magnitude 9 earthquake and subsequent tsunami caused a loss of power at Fukushima Daiichi nuclear power plant (hereafter referred to as Fukushima) in Japan. The three reactors in operation at the time of the earthquake underwent automatic shutdown. The loss of power, however, led to the failure of the station's cooling systems. This in turn led to increased temperatures and pressure on the containment of reactors 1, 2 and 3. At this point, the Nuclear and Industrial Safety Agency (NISA) announced a level 3 INES event at Fukushima.

Radioactive emissions began at approximately 5:00 JST (Japan Standard Time) on the morning of March 12.[8] To begin with, the radioactive releases were primarily noble gases, such as Xenon-133. Once radioactive releases began, NISA immediately upgraded Fukushima to a level 5 INES accident.[9]

Significant releases followed the hydrogen explosion at Unit 1 at 15:30 JST on the afternoon of March 12. At this time, releases of iodine-131 were estimated at a rate of 10^{15} Bq per hour. This coincided with the wind shifting to a north-westerly direction, pushing the radioactive plume over land instead of over the Pacific Ocean.

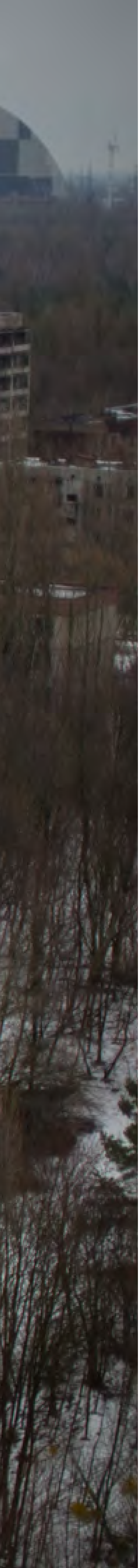
It is generally agreed that radioactive releases peaked between March 12 and 15 and then continued at lower levels until April. Indeed, the French Nuclear Safety Authority assessed Fukushima's releases as a level 6 INES accident on March 15.[10] As noted, wind direction during this period shifted from east to west, meaning a great deal of radioactivity was deposited on land to the north-west of the power plant. Nevertheless, prevailing westerly winds meant that the large majority of Fukushima's releases were deposited in the Pacific Ocean in March and April.

Based on the on-going emissions, Greenpeace assessed Fukushima as a level 7 INES accident on March 23.[11] NISA did not acknowledge it as an INES 7 event until a month after radioactive emissions began, on April 12.[12] The IAEA never contradicted NISA. The total amount of radioactivity released at Fukushima, excluding noble gases, was estimated at approximately 520 PBq, which is about 10% of that released during the Chernobyl accident.[13]

Aside from air emissions, the Fukushima accident also resulted in considerable releases into the Pacific Ocean in the form of radioactively contaminated water. The major releases to the ocean happened in March-April 2011. Estimates of iodine-131 releases to the ocean ranged from 10 to 20 PBq and releases of caesium-137 are estimated between 1 and 6 PBq.[14] Releases of contaminated water still continue five years later as TEPCO attempts to regain control of the plant.[15]

In 2012, the Independent Investigation Commission of the National Diet of Japan concluded that even though triggered by an earthquake and tsunami, the Fukushima disaster cannot be regarded as a natural disaster. "It was a profoundly manmade disaster – that could and should have been foreseen and prevented. And its effects could have been mitigated by a more effective human response," according to the report.[16]

Thirty years after the catastrophe Greenpeace revisited the site of the Chernobyl disaster – the 4th reactor block with a new confinement built nearby and the abandoned town of Pripyat.



2. Continued Contamination – an Overview

The initial hours, days and weeks of the nuclear accidents at Chernobyl and Fukushima, as described in the previous chapter, sent shock waves around the world as people watched events unfold via the news. However, despite the initial devastation, after a few months, the radioactive clouds and the fate of those evacuated fell out of the public's conscience. Unfortunately for the communities from the affected areas, there is still no reprieve from the continuing crisis either of living with long term radiation exposure, or being internally displaced.

The following chapter is divided into two sections: one focusing on Chernobyl 30 years later, the other on Fukushima 5 years later. They provide in-depth data on the current situation with regards to radiation levels and the effects on the communities living in radioactively contaminated zones.

2.1 Chernobyl 30 Years Later

The Chernobyl disaster caused irreversible damage to the environment that will last for thousands of years. Never in human history has such a large quantity of long-lived radioisotopes been released into the environment by a single event.

Chernobyl contaminated vast areas of land and affected millions of people. Variable weather conditions in the days following the accident led to contamination spreading over large parts of Scandinavia, Greece, Central and Eastern Europe, southern Germany, Switzerland, eastern France and the UK.

Closer to the exploded reactor, up to 150,000 km^2 of land in Belarus, Russia and Ukraine were contaminated to levels requiring the evacuation of people or the imposition of serious restrictions on land use and food production.[24] At the time of the accident, more than 8 million people (including 2 million children) were living in these areas.[25] About 350,000 of them were resettled or left the affected areas.[26]

Shortly after the accident, the population was exposed to radioactive iodine, iodine-131, resulting in increased risk of thyroid cancer, especially for those exposed as children. One of the greatest concerns in the medium to long term was the release, transport and subsequent deposition of caesium-137, a long-lived radionuclide, which is able to pass through the food chain and hence contaminate milk, fish and other food products. Given its half-life of 30 years, it will take several centuries for the radioactive pollution to decay. Despite this, many inhabitants over the years have continued to eat fruit and vegetables, fish, mushrooms and berries cultivated in areas that had become contaminated following the accident.

The Chernobyl accident has also had huge financial consequences on the region. Since independence, Ukraine has spent over USD 10 billion to mitigate the impacts of Chernobyl.[27] Between 1991 and 2010 Belarus spent USD 19 billion to mitigate the consequences of Chernobyl.[28] Ukraine no longer has or has no longer allocated sufficient funds to finance the programs needed to properly protect the public, putting people at risk.[29]

2.1.1 Current Situation

Thirty years after the Chernobyl disaster began, more than 10,000 km^2 of land is still unusable for economic activity,[30] and about 5 million people live in zones officially considered to be radioactively contaminated (1.1 million in Belarus; 1.6 million in Russia and 2.3 million in Ukraine).[31]

The 30 km exclusion zone around the Chernobyl reactor remains highly contaminated and unsuitable to live in. High levels of contamination within 10 km of the plant mean it is impossible for this area to be repopulated for tens of thousands of years.[32] More worryingly for the safety of the population are the areas with high levels of radioactive contamination, the so called 'hot spots', which have been discovered outside of the evacuated zones.[33] There are no restrictions on people entering these areas.

The radioactive contamination from key isotopes, such as caesium-137 and strontium-90, has declined by a factor of two since 1986.[34] While caesium-137 contamination has decreased in many agricultural products, it still persists in wild mushrooms, berries and meat, and has even increased in some instances.[35] In many rural areas it is the local produce that remains the main source of radiation exposure to the population.[36] Over time, the contribution of forest ecosystems, which account for about a third of the contaminated area, to the radionuclides intake to human organism has increased.[37]

Swampy areas are places known to accumulate radionuclides. When vegetation collected from these contaminated areas is turned into hay and given to cows on a regular basis, the radionuclides will also accumulate in the animal and be transported into their milk. If people drink this milk, the long-term accumulation of radioactivity in human bodies can lead to many severe illnesses.

Contamination of milk in many villages is higher than Ukrainian permissible limits, and this situation is not expected to improve in the near future because the use of counter measures has been exhausted.[38] Strontium-90 levels in grain have also increased significantly over the past 15 years due to this radionuclide being released from the fuel particles and its subsequent increased bioavailability.[39] Similarly, strontium-90 contamination of forest woods, used as a fuel in rural private households, is a growing problem.

It is the local produce that remains the main source of human radioactive exposure in the rural areas of Ukraine contaminated as a result of the Chernobyl accident.[40] To better understand how contamination affects the lives of Chernobyl survivors, Greenpeace carried out two small pilot investigations into the residual radionuclide contamination of locally produced food as well as forest products during the autumn of 2015. The first was carried out in two regions of Ukraine: the Rivne region and the Kyiv region. The second one was carried out in the Bryansk region in Russia, targeting selected areas around the cities of Novozybkov and Zlynka.

In the town of Novozybkov in the Bryansk region in Russia, residents sell local products outside the local bazaar. Here the food does not pass radiation control.

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2.1.2 Results of Greenpeace Investigation in Ukraine[41]

Analysis of milk, grain, mushroom, hay and wood samples collected from a number of villages located to the west and south-west of the Chernobyl NPP in August-September 2015 has reconfirmed that high levels of radionuclide contamination, both caesium-137 (^{137}Cs) and strontium-90 (^{90}Sr), still persist almost 30 years after the accident.

Table 2: The Ukrainian permissible levels (PL)[42,43] for ^{137}Cs and ^{90}Sr for food & wood products

Product	Caesium-137 Bq/kg	Strontium-90 Bq/kg
Milk and dairy products	100	20
Fresh wild berries and mushrooms	500	50
Dried wild berries and mushrooms	2500	250
Herbs	600	200
Fish	150	35
Wood and firewood	600	60
Grains	50	20

Greenpeace Findings:

- Of 50 milk samples collected from three villages in the Rivne region, located approximately 200 km from Chernobyl NPP, all but four contained ^{137}Cs at levels above the limit value set for consumption by adults in Ukraine, and all were substantially above the lower limit set for children.
- A sample of the hay fed to cattle, collected from a farm in one of the villages, contained levels of ^{137}Cs that could readily explain the high activity concentration found in the milk.
- Although mushrooms were scarce at the time of sampling due to dry weather, a single fresh sample had ^{137}Cs activity concentration more than twice the Ukrainian limit for human consumption. Six samples of dried mushrooms, stored by local families after collection in 2014, contained levels of ^{137}Cs between four and 16 times the higher limit for dried products.
- 42% of grain samples collected from fields in Ivankiv district, in the Kyiv region, situated approximately 50 km from Chernobyl NPP, had ^{90}Sr activity concentration above limit values for human consumption, and in two cases more than double this limit.
- Of 12 composite wood samples prepared from 60 single samples of wood collected in the forests of Ivankiv district, nine exceeded Ukrainian permissible limits for ^{90}Sr in firewood. In a single ash sample collected from a household oven using local brushwood as fuel, levels of ^{90}Sr were more than 20 times higher than in the most contaminated wood sample found in this study.

Case study from the Ivankiv District, Kyiv region, Ukraine

Anna and Vasyl Malashenko returned to their native Kyiv region in 2007, after years away following the accident. They now own a small farm near village Fedorivka, Ivankiv district, of 70 hectares. It consists of two plots, one field for wheat, and the other sunflowers. They have returned, even though they are still at risk from on-going radiation on the land.

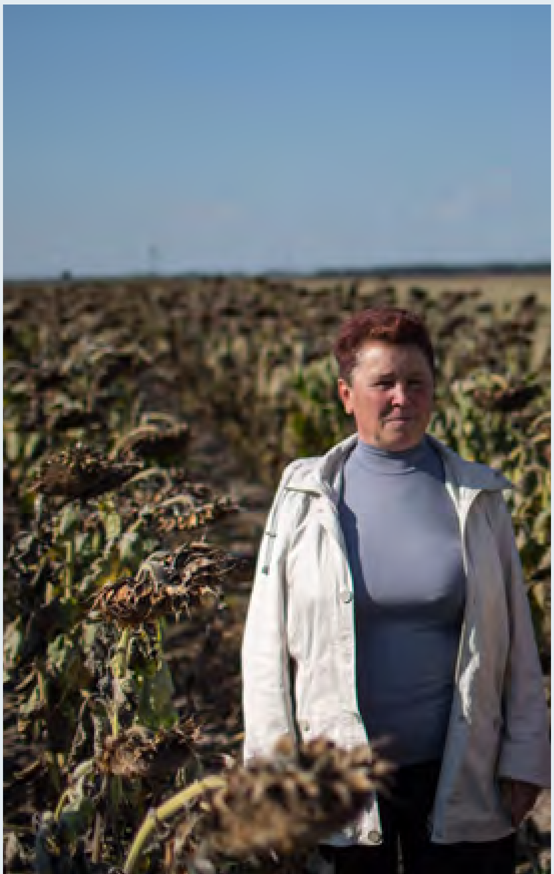
Vasyl explains: "When the accident happened we were sowing here in the field, I was working not far from here, I remember it as if it were today. And I felt it. When we were working during the first year, my wife's face turned red. And while we were reaping the harvest here, my throat was rasping. This is what I personally felt. And now I don't feel it. And the people around also don't complain about the radiation that exists now."

Anna adds: "During the first years they didn't test us. No medical tests. I don't know, maybe they had no suitable equipment for that. For several years they didn't do blood tests. In the first days the tests of the blood colour showed that something had gone wrong. Then they stopped it because they could not diagnose us judging from these tests. Then they go and say that people here were not affected."

The couple moved away for a while to take their family to a non-radioactive part of the country. "We left this place. In 1990 we went to Kovel, in Volyn. We spent 17 years there, until 2007, and then we came back to our native place. Our children studied in Kyiv and now they work there," says Vasyl.

"It was because of our personal circumstances that we returned. We didn't want to come back, because we were settled there, had friends, I was a farmer and had a plot of land. It was very hard to leave. And when I came back to my native place, everything was strange – the language, customs."

"But we had lived here before, so it was quite easy for us to settle down here. You see, now we have taken some land to cultivate. Because people left their plots they gave it to us and in return we give them grain."



Local farmers Anna and Vasyl Malashenko grow wheat and sunflowers in the Ivankiv District, the Kiev region, Ukraine.

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Case study from Vezhytsia village, Rokytne District, Rivne Region, Ukraine

Halina Chmulevych is a single mother of two children living in the rural Rokytne District, located about 200 km to the west from Chernobyl NPP, with limited possibilities for cleaner foodstuffs.

© Denis Sinyakov / Greenpeace

"I've got two kids. One goes to school. They get meals at school, the state provides it. However, in the previous year they stopped it. Then from the last year they started it again. I don't know. For us it's better when they get food at school," says Halina.

"But if they stop giving food to kids at school, I'd do it at home, will give them cow's milk, potatoes. We have milk and bake bread ourselves – that yes, is with radiation. Everything here is with radiation. I myself was born here when it exploded at the station. But I'm alive. I eat, live and so they will eat what we have. Of course, it worries me but what can I do? We grow potatoes, the cow grazes on the pasture."

Halina concludes: "I don't know, it's scary. You are not sure what they sell in the shops either. (…) So I give my children my own food – cottage cheese, sour cream. I think the most important thing is health. It's scary. My mother got cancer immediately after the Chernobyl [disaster] and she died."

2.1.3 Results of Greenpeace Investigation in Russia[44]

In October 2015, a Greenpeace research team visited several places in the Bryansk region, Russia, to map general radiation levels, and collect samples of food and forest products from those areas which comprise a significant component of the local diet. This pilot study shows that high levels of caesium-137 still remain in a range of food and forest products in the Bryansk region.

Table 3: The Russian permissible levels (PL)[45] for ^{137}Cs for food & wood products

Product	Caesium-137 Bq/kg
Milk	50
Fish	130
Grains	80
Berries	40
Fresh and pickled mushrooms	500
Dried mushrooms	2500
Construction timber wood	370
Firewood	1400
Wood for carpentry	2200

Greenpeace Findings:

- 13 samples of wild mushrooms were analysed including nine freshly harvested, three dried mushrooms and one sample of pickled mushrooms. Also one sample of red berries (lingonberry) and one sample of grapes were analysed, both fresh. All the mushroom samples analysed as well as the lingonberries contained ^{137}Cs above the permissible levels.[46] Only the sample of grapes contains ^{137}Cs within the allowed range.
- The milk samples analysed contain detectable levels of ^{137}Cs, but all far below the permissible levels of 50 Bq/kg.
- Five of the six fish analysed contain ^{137}Cs above permissible levels, with a maximum level of 300 Bq/kg. This is remarkable, as the fish were caught

at a location in an area with relatively low ground contamination. However, it has been reported that radioactive caesium can accumulate in sediment of water basins.[47]

- Radionuclides levels detected in wood samples were compared to permissible levels for construction wood, firewood and wood for carpentry, taking into account different possible uses of the wood. All four wood samples contained ^{137}Cs above the permissible level for construction wood. The timber wood sample from a saw mill in Novozybkov showed more than 6000 Bq/kg of radioactive caesium, more than the permissible level of any use of the wood.
- Radiation mapping by Greenpeace clearly illustrated that forests continue to act as storage place for radioactive contamination.
- In villages radiation risks can be around the corner: a children's playground in the city park of Zlynka city showed radiation dose rates of 0.84 microsievert per hour (μSv/h) at 1 m and 1.6 μSv/h at 10 cm height. Also, in a school garden in Stariy Bobovichi, radiation levels as high as 0.6 μSv/h at 1 m and 1.1 μSv/h at 10 cm were found.
- Soil samples analysis identified an average caesium-137 contamination density of 269 kBq/m^2 on a field in Polyana village.[48] Hence, based on these ^{137}Cs levels, this area would fall under the Zone 3 category of territories (with the right for resettlement) according to the Russian law. Polyana village is currently categorised as zone 4 with Preferential Socioeconomic Status, for which contamination levels should be below 185 kBq/m^2.

Most settlements in the Bryansk areas categorised as 'Evacuation Zone' were never evacuated, and the population is at constant risk of exposure to harmful radionuclides. Many of the people in the contaminated areas continue to rely on locally produced food products, and food control is limited. The analysis of wood samples shows that there is a serious risk of contaminated wood entering the market and being transported out of the Bryansk area to other parts of Russia or even abroad.

More extensive environmental and food monitoring programmes are needed to reduce the radiation exposure of impacted local communities. Also highly contaminated areas should be fenced off and clearly marked to prevent wood and mushroom harvesting and spread of contamination to populated areas. Contaminated areas in places with high population density, such as city parks and school gardens should be decontaminated in order to reduce population exposure.

2.1.4 Risks of Recontamination – Forest Fire

Another long-term risk after a nuclear disaster is the redistribution of radioactive matter via forest fires. During the period 1993-2013 more than 1100 wildfires of different sizes were officially registered in the Chernobyl exclusion zone, including in the most contaminated 10 km zone. The largest fires occurred on August 1992 in a total area of 17,000 hectares of meadows and forests.[49]

Unfortunately, due to the lack of forest management in the Chernobyl exclusion zone, and bad fire prevention infrastructure, there is a high risk of large-scale forest fires. Given that the Chernobyl exclusion zone is not highly populated, "special attention should be focused on the fire fighting capacity in the Chernobyl Exclusion zone and also on the creation of modern systems of fire detection and fire fighting".[50]

During a forest fire, a fine radioactive aerosol forms due to radionuclides evaporation followed by their adsorption to various carriers including ash. This results in a rise of above-ground radionuclide concentration in the air, up to hundreds and thousands of times higher than the normal background levels.[51]

During a forest fire some 3-4% of caesium-137 and strontium-90, as well as up to 1% of the plutonium isotopes can be released from the forest litter. The amount of radionuclides released can be even bigger in case of large-scale fires of high intensity.[52]

At the same time, a sharp decrease of the airborne radionuclide concentration can be observed with the increase of the distance from the source of radionuclides release in case of forest fires, therefore, the contribution to the terrestrial contamination through the radionuclides re-suspension during forest fires is not significant. Research shows that inhalation of radionuclides (as well as the external irradiation from radionuclides in air) does not contribute significantly to radiation exposure for the population outside of the exclusion zone.[53]

Despite this, providing information on fires in the Chernobyl zone is important for the population of both Ukraine and other countries. More attention should be focused on the firefighting capacity in the

Case study from the Bryansk region in Russia

Victor A. Khanayev from Novozybkov, is a surgeon at the central hospital of Novozybkov district in the Bryansk region. He is also a member of the local municipal council, and formerly member of the regional Bryansk parliament.

"I remember the May Day demonstration in 1986, five days after the reactor exploded, which we were happy to attend with our small daughter. We were not warned about anything. The weather was beautiful, only the wind was possibly too strong. Now, my friends and I remember this with some horror."

"The first year after the explosion brought a lot of stress to health. I am myself a strong guy, but that winter, after the explosion, four times I got ill with severe angina. Normal incidences of illnesses increased dramatically, as immunity was under stress."

Over the years, contamination levels decreased to some extent, but the invisible danger to people remains. Hunters, fishermen, mushroom pickers, the producers of agricultural products, and those who buy local products are particularly at risk.

"If we talk about what is sold on the streets, in front of the market, then there is no control at all."

"In the early days after the accident we followed recommendations of doctors and authorities. However, after a long time it is impossible for rural people and even the district town's residents to refuse local produce from the land and their garden, especially with the official monetary compensation being so small."

"People again went into the forest to pick mushrooms and berries. They began keeping livestock and are less willing to cooperate with local radiologists, less willing to give the products to testing. Even more serious is the situation with the wild hunted mammals and birds. I saw the data collected in the regional Duma: once a wild pig boar was caught, and contamination of its meat exceeded the norm 300 times. Fish in the lakes is contaminated too. "

A lot of the problems are caused by selling contaminated berries, mushrooms and fish.

"Theoretically, sellers must have health certificates, as all products must be tested. There is a special inspection, and still you can encounter dirty milk, meat, mushrooms. If we talk about what is sold on the streets, in front of the market, then there is no control at all."

Another serious problem, threatening the people for tens or hundreds of kilometres around, is radiation contamination of vast forest and swamp areas.

"In case of fire, radioactive substances rise into the air and may be transported over long distances. For example, the old district of Vyshkov in the last three years has been facing serious problem with peat fires in the contaminated territories. The fire fighters come from the whole Bryansk region and even from other regions. They're poorly protected against radiation, and delve into the scorching heat. As far as I know, there has been no control of the doses that people receive."

Victor A. Khanayev concludes: "Regional authorities are trying to do something to solve the problem of Chernobyl contamination, but little can be done without money. The budget is like a short blanket, being pulled to one side or another - some parts always remain naked. The state is obliged to provide people with a decent life and protect them from exposure to radiation, give them adequate monetary compensations and full quality medical service, and resettlement."

The challenges arising from the lack of funding of the monitoring programs are described in chapter 4 of this report.

In the town of Novozybkov in the Bryansk region in Russia, residents sell local products outside the local bazaar. Here the food does not pass radiation control.

© Denis Sinyakov / Greenpeace

exclusion zone, and other contaminated lands, as well as the creation of modern systems of fire detection and firefighting.[54]

2.1.5 Conclusions

Greenpeace's independent field research and the review of the scientific findings both clearly show that radiation from Chernobyl is still very present in the contaminated regions of Ukraine, Belarus and Russia. This contamination touches every aspect of the lives of the people who must live in these places. It is in what they eat and what they drink. It is in the wood they use for construction and burn to keep warm as well as in the ashes they use as fertiliser on their fields and orchards. And just as this contamination will be with them for decades to come so will the related impacts on their health (see chapter 3 for details on this).

This ever-present contamination of food and wood raises very serious concerns about the pervasive, long-term exposure of the local people to harmful radiation, including children born decades after the accident. Simple and practical measures that could help reduce the presence of contamination in food - such as sourcing hay and other forage from outside the contaminated areas, and radical improvement of fields and treatment of cattle with ferrocyn to reduce the transfer of radionuclides to milk – could and should be put in place.

The current lack of routine and comprehensive environmental and food monitoring programs is another major concern, and one that continues to place severe limits on the assessment of radiological risk and on the design and implementation of measures that could otherwise help limit people's exposures to caesium-137 and strontium-90.

It is vital that scientific monitoring programs are reinstated, and properly financed into the future, to reduce the exposure to radiation these communities experience. The affected population should be involved in the monitoring programme. Highly contaminated areas should also be closed off and clearly marked to prevent the harvesting of wood, berries and mushroom which then spreads further contamination to populated areas. Contamination in areas with high population density, such as city parks and school gardens, should be urgently decontaminated in order to reduce risks to people's health.

2.2 Fukushima 5 Years Later

2.2.1 Current Situation

As stated in section 2.1, the full impact of the Chernobyl disaster is still not known after 30 years. Only five years since the Fukushima disaster began, the picture in Japan is, as one might expect, even less clear. Greenpeace commissioned David Boilley, nuclear physicist and chairman of Association pour le Contrôle de la Radioactivité dans l'Ouest (ACRO) to evaluate published research into the contamination from the Fukushima disaster in order to gain an accurate picture of the current situation.

The report *Fukushima five years later: back to normal?* tells us that five years since March 11, 2011, Fukushima Daiichi's operator "has yet to fully stabilize the station and many fear radioactive emissions could resume in the event of another natural disaster."[55] Of the 100,000 people still displaced by the disaster, 62,798 were living in temporary accommodation as of November 2015[56]. The population of Fukushima prefecture has fallen 5.7% (115,000) according to Japan's latest census[57]. Those affected by the disaster face an uncertain future and many may never return to their homes, lands and livelihoods. Most of the highly contaminated areas are expected to remain uninhabitable for decades. Generations of families that once lived together were separated by the evacuation and may never be reunited.

According to the IAEA Summary Fukushima Report, extremely high levels of radioactive caesium were deposited north west of the Fukushima Daiichi NPP. It states that contamination densities between 1000 kBq/m^2 and 10,000 kBq/m^2 were recorded.[58]

Contaminated Landscapes in Motooka Shimizu

On the border of the closed zone. Level of radiation is 2.9 microsieverts per hour. The normal rate before the Fukushima nuclear disaster was 0.08 microsieverts an hour.

The average deposition density for caesium-137 throughout the Fukushima prefecture is 100 kBq/m^2, according to the IAEA.[59] These numbers far exceed the IAEA's benchmark of 40 kBq/m^2 for contaminated land.

The overall radioactive contamination of the region has decreased during the five years since the disaster began. This is largely due to the natural decay of caesium-134 (^{134}Cs) which formed about half of the contamination in the environment and has a two-year half-life. In addition, washout by rain or snow can contribute to the natural decrease of contamination, while at the same time it can cause an increase of contamination in other places due to accumulation. Although run-off from forests to river systems in cases of normal precipitation events is very low, heavy rains and typhoons can increase the rate of radioactive caesium discharge significantly.[60] Measurements of radiation levels in forest areas, where no decontamination works had been done, found the decrease in levels of contamination to be around 57% in June 2015.[61] The residual contamination is largely caused by long-lived caesium-137, which means the overall levels of contamination are now falling more slowly.[62]

Caesium-137 is expected to persist in the complex forest ecosystems for decades, as it is incorporated in for example fungi, higher plants and trees due to uptake from the soil through the root systems, as well as directly from the atmosphere through bark and leaves.[63] [64] Caesium migrates within the forest system by complex patterns influenced by water circulation and biological factors such as fungi and animals (herbivory).[65] Leaf loss is an important route for caesium migration,[66] as it returns the caesium to the top soil layers where it is most bioavailable to plants and animals.[67]

Unfortunately, the government's decontamination efforts seldom result in larger reduction of radioactivity levels than processes occurring naturally. As Boilley observes, decontamination in non-evacuated zones between August 2011 and August 2013 has shown a decrease in exposure to external radiation of about 60% for the public. In evacuated residential zones, the radiation levels (airborne dose rate) decreased 54% in areas with dose rates higher than 1 μSv/h, and only 23% for lower dose rates.[68]

Decontamination efforts do not 'get rid' of the radioactive contamination – they simply move it to another location. The amount of hazardous radioactive waste produced in the aftermath of the disaster is staggering. Around the Fukushima plant alone, radioactive waste covers an area of 16km^2.[69] In September 2015, 9.16 million 1m^3 bags of waste were stored at 114,700 sites across Fukushima prefecture. The durability of these bags of waste is only guaranteed for three years and some are already damaged or deteriorating.[70]

These huge amounts of waste are often stored insecurely. Storage sites were flooded by rains from the Etau typhoon in September 2015.[71] More than 400 bags were swept away by a river in Iitate village[72] while others are stored close to seafronts not protected from tsunamis. There were reports of children playing on bags of waste at a park in Shirakawa – radiation readings taken at the site by a reporter revealed levels of 2.23 μSv/h.[73]

Where much of this waste will finally be stored remains open to a question. Complicated politics involving 12 prefectures outside Fukushima prefecture that are holding radioactive waste, along with resistance from the public and local officials, means the process to identify and build final storage sites is extremely slow.

2.2.2 Impacts on the Village of Iitate

Iitate village is a district of over 200 km^2 – much of it mountainous forest, with homes and agricultural fields spread throughout the wooded landscape. Many of the homes in Iitate as well as many of the small farm fields are surrounded by and integrated into the forests and hillsides. The district is located between 28 km and 47 km from Fukushima Daiichi.[74]

The forests of Iitate now act as a repository for a large amount of radioactive material released during the early stages of the Fukushima Daiichi accident. Iitate was particularly affected by radioactive releases from the disaster on the nights of March 15 and 16, 2011 due to weather patterns that carried radioactivity north-west from the nuclear power plant.[75] In March 2011, Iitate was home to 6,200 people who remain displaced after having been evacuated in April 2011.

Along with other areas of Fukushima prefecture, Iitate was designated for radioactive decontamination in 2012.[76] It is located in the Special Decontamination Area, where the annual cumulative radiation dose today could exceed 20 milliSievert (mSv) if people were to live there. This is significantly higher than the internationally accepted standard stating that radiation exposure to members of the public should not exceed 1mSv per year under non-accidental situations, which forms the basis for the government's long-term targets. There is however no clear timeline for the government to reach this target.[77]

In total, only one quarter of the area of Iitate is to be decontaminated according to government plans: out of an area of 20,000 hectares, a total of 5,600 hectares (56 km^2) are targeted for decontamination.[78] Even with 75% of the heavily contaminated land (most dense forest) being left in its current state, the decontamination work still is an enormous undertaking. Efforts to decontaminate the targeted 56 km^2 began on a significant scale in spring 2014, with a scheduled completion date of 2016. In reality, the government is far from certain of reaching this deadline.

The dense forest of Iitate will not be decontaminated, apart from very small parts along roads and houses. Nevertheless, the Ministry of Environment's decontamination website can be understood as saying that 86% of the forest in Iitate has already been decontaminated.[79] However, reality is different. Only 1,100 hectares area of forest has been decontaminated, while the entire Iitate forest area is 17,316 hectares.[80] This means that only 6% of the whole forest has been decontaminated.

Soil, leaf litter and small plants will be removed only from forest within the first 20 m away from roads and houses where people will return to live. Houses in Iitate whose surroundings have been decontaminated are easily spotted: the soil, grass and plants surrounding a house are removed and new soil brought in as replacement. There is no plan to decontaminate beyond this first 20m, now or in the future. An official from the Ministry of Environment told Greenpeace that "the forest decontamination is still in the process of study and experiment."[81] Migration of radionuclides from the forest to other areas, including decontaminated areas poses a long-term risk to people who would decide to return.

2.2.3 Results of Greenpeace Investigation in Iitate, Fukushima

Since March 2011, Greenpeace experts have undertaken 25 radiation surveys of areas in Fukushima prefecture, including Iitate[82]. In June-July and October 2015, Greenpeace conducted radiation monitoring trips to Iitate village to investigate the current situation and the longer-term radiation risks in the places where people are expected to return in the near future.[83] Greenpeace concentrated its monitoring efforts on houses which were already decontaminated, and their surrounding forests, to assess the residual radiation levels people would have to live with if they would return.

The Greenpeace measurements confirm that forests, which cannot be decontaminated, are a massive store of radioactivity. They will pose a risk to the population for decades or even centuries to come. Even areas that have been decontaminated, such as narrow forest strips along roads and around people's houses, remain heavily contaminated. A proportion of radioactive caesium is slowly migrating downstream from the forests. It is still largely unknown how and where this contamination will re-accumulate, but it will likely continue to pose a risk to the population in the coming decades.

Radiation levels measured along the roads in Iitate are significantly higher compared to other contaminated areas where the evacuation order was lifted in 2014 (Miyakoji and Kawauchi). In Iitate, 96% of more than 10,000 measurement points were found to be above the government target level of 1 mSv per year or 0.23 μSv/h[84], compared to 59% in Kawauchi and 34% in Miyakoji.

Case study investigation:

Mr. Anzai´s house[85]

Mr. Toru Anzai, who owns a farmhouse in the south-east of Iitate, has been assisting Greenpeace radiation monitoring work since 2011. He left his home in the aftermath of the disaster, and must now wear radiation protection when entering his house. In the years during Mr. Anzai's absence, the house's interior has deteriorated, allowing animals to enter and dust to accumulate.

In June-July and October 2015 Greenpeace investigated Mr. Anzai's house, where workers had nearly completed decontamination. The area around his house has been decontaminated by scraping away a layer of more than 5 cm of topsoil and covering the surface with non-contaminated soil. This reduced radiation levels to 0.5-0.6 μSv/h at 1 m height in front of his house, still twice the 0.23μSv/h government target. To the rear of his house, close to a forest, radiation levels were much higher (around 1.5 μSv/h at 1 m) even after the first 20 m of the forest had been decontaminated. This caused increased radiation levels inside the house, similar to outside levels (up to 1.6 μSv/h), which means people living in the house would be exposed to 10-15 mSv per year.

However, even though radiation doses inside houses were higher than outside, according to the decontamination plan for the area, the inside of a house is not eligible to be decontaminated. Systematic mapping of radiation levels around Mr. Anzai's house shows that measurements at all points are above the government target level of 0.23μSv/h, with hotspots up to 2.3 μSv/h at 1 m and 13.7 μSv/h at 10 cm on a decontaminated greenhouse and 2.76 μSv/h at 1 m, 9.9 μSv/h at 10 cm height along the road.[86]

Fukushima Victim Toru Anzai

Toru Anzai at his house in Iitate inside the evacuation zone. He lived in Iitate when the nuclear accident happened in Fukushima on March 11,2011. He has been evacuated, but has to move back to his house inside the evacuation zone even though it is still highly contaminated with radioactivity.

© Daniel Mueller / Greenpeace

Risks of Recontamination

What is clear from Greenpeace´s investigations is that despite the effort of thousands of workers and the expenses incurred, decontamination of Iitate is likely to be a never-ending process with limited impact on the reduction of radiation dose levels to the population.

After the clean-up efforts, decontaminated land is still in the vicinity of vast areas which will not be decontaminated. This close proximity and natural weathering creates a real risk of radionuclide migration and leading to recontamination. As a result of the heavy contamination of the hills, mountains, and forests of Fukushima Prefecture, radioactive material may be transferred down into reservoirs and lower river basins,[89] and to formerly decontaminated areas. This radiological recontamination of areas declared 'decontaminated' will likely continue for the foreseeable future.

The example of the area around Mr Anzai's house demonstrates this. Radiation levels are expected to remain stable over the next years or even increase, especially at the back of the house which is just 2 m from a steep slope with forest. Given the steep slope, radioactive materials could be washed down with the rain, re-contaminating the back of the house and increasing the radiation exposure risks inside and around the house significantly.

Case study investigation:
House in the Yamabesawa, the flower farmer[87]

A flower farmer of Iitate and her family lived in the Yamabesawa area of the village. When the Fukushima Daiichi nuclear disaster struck, they were preparing flowers to meet orders from all over Japan for Mother's Day presents. The orders were cancelled.

Now, the mother of the family has been separated from her children and grandchildren, who have bought houses outside Iitate. They have no plans to return even after the evacuation order is lifted.

Greenpeace monitoring found radiation levels as high as 23 μSv/h at a height of 10 cm, just in front of greenhouse where the flower farmer grew her flowers. In the area around the house, which is supposed to be de-contaminated, the radiation levels were 1-3 μSv/h at 1 m height, which is up to 10 times higher than the level that the Ministry of Environment is targeting as its final goal.[88]

2.2.4 Back to Normal?

The Japanese government, led by Shinzo Abe, is determined to overcome the political and economic impacts of the disaster. However, the health and well-being of tens of thousands of evacuees are not its priority. Instead, the Abe government is creating the myth that people's lives and communities can be restored and reclaimed just five years after widespread radioactive contamination. By doing so, it hopes to overcome public resistance to nuclear power.

This attempt at normalization became policy in June 2015, with the approval of the plan to lift restrictions on people living in the areas of Fukushima where today the radiation levels are still too high to permit return.[90] The plan involves continued decontamination efforts, which as the Greenpeace investigation shows, are proving largely inadequate and ineffective, with the aim of lifting evacuation orders in March 2017. Then, in 2018, TEPCO's much-criticized monthly compensation scheme for evacuees will end.[91] This decision has major implications for the health and well-being of 54,800 people, or 70% of those evacuated in the aftermath of the disaster.

The Abe government is particularly determined to push the more than 6,000 people evacuated from the district of Iitate to return to their former homes. The radioactively contaminated landscape of Iitate is a constant reminder that the impacts of a severe nuclear accident are not limited to a 10-20 km perimeter around reactor sites. The levels of radiation in the forests, which before the accident were an integral part of the residents' lives and livelihoods, are similar to radiation levels within the Chernobyl 30 km exclusion zone. As only one quarter of Iitate's land is now officially being 'decontaminated', small islands with lower radiation levels are being created. Even these small 'cleaned up' islands largely fail to meet the government's long-term decontamination targets.

Five years since the disaster began, many of Iitate's former residents are still living in temporary accommodation and are faced with an impossible choice: to return to their contaminated homes surrounded by contaminated forests, or to abandon their houses to try to establish life elsewhere without adequate compensation. Many will be forced to return home due to lack of financial resources. This amounts to economic coercion of those individuals and families that are victims of a nuclear disaster they had no part in creating.

The compensation process for evacuees has many problems. The processing of claims has been slow and the monthly payments are not enough to allow people a living, let alone to set up new lives. Also, not all are eligible for compensation, and those who are, receive only a fraction of the value of their lost homes. According to many polls, most have abandoned hope of picking up their old lives and would prefer sufficient money to start again.[92]

Evacuation Orders Lifted

In some parts of Fukushima's 20 km evacuation zone, the government has already partially lifted the evacuation order in April 2013. The Fukushima Prefecture town Namie was realigned into three evacuation zones according to estimated annual radiation doses, with parts expected to be opened up in 2016.[93] However, a survey by Namie town office in 2013 found that 37.5% of residents had given up on reclaiming their previous lives, and the same percentage remained 'unsure'.[94] Only about 19% of the original Namie residents were confident they would return.

The Japanese Government, in part, justifies the decision to lift the evacuation restrictions on the basis that their decontamination goals are consistent with the recommendations of the International

Commission in Radiological Protection (ICRP) and the Nuclear Regulation Authority (NRA of Japan).

However, the Abe government is selectively choosing how to interpret the ICRP's figures. Japan's central government refined its policy in April 2011, defining evacuation zones as "areas where cumulative dose levels might reach 20 mSv per year".[95] This is 20 times higher than the limit recommended by the ICRP for non-accidental situations, and also 20 times higher than the maximum annual effective dose of 1 mSv per year set in Ukraine, Belarus and Russia after the Chernobyl accident.[96]

The risk of the higher radiation dose limit of up to 20 mSv each year - which the people of Iitate could be exposed to as a result of the government's decision - is unacceptable from a public health perspective. And as described above, even reducing dose limits to less than 20 mSv seems out of reach in certain areas.

Local governments are spending millions of dollars to persuade refugees to return, and the nuclear clean-up costs are shared with the central government, which handles the most toxic areas. The cost for the decontamination effort is estimated at USD 50 billion,[97] and even that figure is widely considered an underestimate.

2.2.5 Conclusion

It is five years since the Fukushima disaster began and, as at Chernobyl, it is difficult to foresee its end. Huge areas remain heavily contaminated with radioactive caesium and will for tens or even hundreds of years. The comparisons between Fukushima and Chernobyl are stark.

Greenpeace investigations have confirmed that the Japanese government's decontamination efforts have been piecemeal, inadequate and leave the door open to recontamination of supposedly decontaminated areas. In fact, in some areas this recontamination is inevitable. In combination with the ineffective process of decontamination, it is clear that people will continue to be exposed to radiation when evacuation orders are lifted and people return to their homes.

It is clear from the situation in Japan that the contamination with long-lived radioactive materials cannot be solved by decontamination efforts – this is simply moving the substances and creating new problems elsewhere. Temporary storage of radioactive waste will continue to pose hazards to communities and the environment.

The human impact of the radioactive contamination of vast areas of land cannot be underestimated. Tens of thousands of people have lost their homes, lands and livelihoods. Generations of families who once lived together are now separated and many will never be reunited. They have been poorly compensated (if at all) and many still live in deteriorating temporary accommodation. All because of a nuclear disaster they played no part in creating.

President Abe's drive to rehabilitate nuclear power in the eyes of a sceptical public and so restart Japan's idle nuclear reactors has led to the downplaying of the dangers of the nuclear contamination from the Fukushima disaster. His rush to convince evacuees to return to their homes, whether they wish to or not, speaks to his government's economic and political priorities rather than considerations of the health and wellbeing of the disaster's victims. As our findings show, under current government plans, many returning evacuees will be forced to live in or close to highly contaminated areas.

Valery Kuzmich, a local resident, has founded and runs the Rokitnovshchina House of Charity, a private shelter for the aged and people with disabilities in the village of Vezhytsia, the Rokytne District of the Rivne Region, Ukraine.

3. Health Consequences of Chernobyl and Fukushima

The health consequences of the Chernobyl and Fukushima catastrophes are extensive. Thirty years after Chernobyl, mortality is higher, birth rates are lower, cancer incidence has increased and mental health disorders are widespread among Chernobyl survivors. Just five years after Fukushima, incidence of mental health disorders, such as depression, anxiety and Post Traumatic Stress Disorder (PTSD) is already elevated, and a discernible increase of thyroid cancer has already been detected.

The causes of these health effects could be separated into three categories: radiation-induced effects, effects caused by both radiation and confounding factors, and effects triggered by the psychological and social impacts of the disasters.[98] The dramatic social changes, inadequate governmental information, psychosocial impact and stress-related disorders following nuclear disasters can cause a significant deterioration of health among exposed populations.[99]

That said, the true extent of Chernobyl and Fukushima's health effects will probably never be known. Comprehensive data gathering and internationally recognised publications of Chernobyl's consequences have not taken place. This means that the relationship between radioactive contamination and certain observed health effects may never have conclusive evidentiary support.

Notwithstanding the difficulties in obtaining reliable dose estimates, the Belarussian scientist Malko has published estimates of the total excess cancer deaths based on calculations of individual and collective exposure doses for the population in all countries polluted by the Chernobyl accident. He predicts more than 90,000 excess cancer deaths in his study in 2006, and more than 115,000 in a more recent study.[100] This is in stark contrast to the WHO prediction of 9,000 additional fatalities attributable to Chernobyl.[101]

3.1 Recognized Health Consequences

Thirty years after Chernobyl, studies show there is an undeniable decline in the health and well-being of Chernobyl survivors. In particular, there is increased mortality among irradiated populations, increased thyroid cancer, breast cancer and leukaemia incidence, increased cataracts, and widespread mental health effects.

Most notably, mortality – deaths rates – is higher among residences of contaminated areas.[102] Diseases of the cardiovascular system (DCS) are the leading contributor to this increased incidence of mortality. DCS is generally associated with radiation exposure and seen in Chernobyl clean-up workers, evacuated adults, and residents of radioactively contaminated territories.[103]

Research shows that birth rates fell in the first two years in the areas of Ukraine most contaminated by the Chernobyl disaster. Significant changes in Ukrainian birth rates can also be seen between 1991 and 2012. They fell from 12.1 births per 1000 in 1991 to 7.7 per 1000 in 2001. The years 2000, 2001 and 2002 saw the lowest birth rates since the country's records began.[104]

There has been a significant increase in thyroid cancer, particularly in youth, since Chernobyl. After

20 years, analysis of data among children in Ukraine aged 10-14 (at the moment of the disaster) found that incidences of thyroid cancer in radioactively exposed children were 9.7 times higher than in those who were unexposed. Similarly, the thyroid cancer incidence rate was 3.4 times higher in exposed young people aged 15-19.[105] According to the WHO Guidelines (1999) for iodine prophylaxis following nuclear accidents, the yearly incidence of thyroid cancer in children in the most affected area in Belarus had risen close to 100 per million children, which was more than 100-fold compared to the situation before the accident.[106] It is accepted that this excess has resulted from exposure to the radioactive iodine released in the Chernobyl accident.

Moreover, what is most notable about the incidence of thyroid cancer is its occurrence among population residing in areas far from Chernobyl. The WHO found that: "The Chernobyl accident has thus demonstrated that significant doses from radioactive iodine can occur hundreds of kilometres from the site, beyond emergency planning zones."[107] This should have ramifications for nuclear emergency planning everywhere.

Though results of studies made in Ukraine and Belarus show a low probability of childhood leukaemia in those experiencing low exposure to radiation, there has been an observed increase incidence of leukaemia in Chernobyl clean-up workers from Belarus, the Russian Federation, Ukraine and Baltic countries.[108]

Female clean-up workers have also seen a significant increase in breast cancer – 1.6 times more cases. Studies on the Belarusian and Ukrainian populations found a two-fold increase in breast cancer incidence among women living in the most heavily contaminated areas. As Prof. Omelianets observes, these results "confirm the necessity of profound investigation of the possible role of radiation in breast cancer incidence rate in the entire population and in separate population groups most affected after the Chernobyl catastrophe." [109]

Studies conducted after Chernobyl show that radiation-related cataracts can be caused by significantly lower exposures to radiation than previous research has shown. The time between exposure and cataracts becoming apparent can be more than 24 years. Prof. Omelianets' review concludes that radiation cataracts have been "observed to a higher extent than expected."[110]

Due to the prevalence of thyroid cancer in children observed in areas affected by the Chernobyl accident, more than 280,000 children have been screened for thyroid impacts in Fukushima prefecture. Up until the end of 2015, 90 Fukushima children have been diagnosed with thyroid cancer – an incidence much higher than that found in the regions surrounding Chernobyl despite radiation levels from Fukushima being lower. This rise in thyroid cancer incidence can be partly put down to the screening programme – more children are being screened in Fukushima than in Chernobyl, hence more cases are being found. However, a 2015 study states that the observed increase is unlikely to be fully explained by widespread screening alone.[111]

Mental Health Consequences

Until very recently, mental health disorders such as anxiety, depression and Post Traumatic Stress Disorder (PTSD) were not taken as seriously as physical illnesses by the medical establishment and the public. Thankfully, the recognition and acceptance of these diseases has increased significantly over the past several decades. This allows for a more comprehensive discussion of the health effects of Chernobyl and Fukushima.

Nuclear accidents may have the most prolonged and complex mental effects, including PTSD, alcoholism, smoking and anxiety leading to unexplained physical symptoms.[112] These psycho-pathological responses occur due to concern for the future, such as risk of cancer, genetic impacts on descendants, living in contaminated areas, the inability to return home and unfair compensation losses.[113]

Suicide was found to be the leading cause of death in Estonian clean-up workers in a 2006 study and a 1997 study found suicide rates in Lithuanian clean-up workers to be above that of the population level. The United Nation's Chernobyl Forum recognises suicides among clean-up workers to be one of the most important issues in the disaster's aftermath. Clean-up workers have also experienced sleep disorders, alcohol abuse, agoraphobia and other physical manifestations of mental health problems. Several studies have used the term 'radiation anxiety' to describe these conditions.

These conditions are often caused or exacerbated by low levels of public awareness about the situation in contaminated areas. This is made worse by "concerns about the quality of medical care, use of non-evidence-based diagnostics and treatments, and lack of knowledge in the population about the signs of both physical and mental disorders"[114] as well as a lack of research on how to deal with these issues. Much further study is necessary in conjunction with the development and improvement of care procedures for the victims of nuclear accidents.

Early studies around Fukushima have found "disaster emergency workers, children, internally displaced people, patients with psychiatric disorders, and the bereaved persons" [115] are particularly susceptible to depression, anxiety, psychosomatic conditions and PTSD. Studies show that a significant number of people affected by the disaster have severe depression. Of the mothers having babies in the region closest to the Fukushima plant, 28% were found to have symptoms of depression. These figures were significantly lower in areas of lower radioactive contamination. [116]

These effects stem from fears over possible radioactive contamination, the shortage of mental health care and the issue of social stigma where people regarded as contaminated may be shunned or discriminated by wider society. It is feared that the disaster may create social isolation in evacuees, leading to mental health problems and alcohol abuse. There are parallels with Chernobyl in the Fukushima disaster where public stress and anxiety had increased due to inadequate governmental information and non-transparency.[117]

The lesson here is that psychological care and support for the disaster's survivors should be urgently improved. Regular physical and mental health checks are required as well as earlier diagnoses and intervention. Systems of long term care should also be implemented as well as further studies into the mental wellbeing of clean-up workers and survivors.

The mental health crises that have followed Fukushima and Chernobyl all suggest a need to upgrade nuclear emergency preparedness. Aside from protocols and measures planned to shield the public from radiation in the event of an accident, governments need to prepare measures to manage the mental health crisis likely to accompany a major radiological emergency.[118]

Notably, a 2015 study found a higher incidence of death has also been detected in people evacuated from areas contaminated by Fukushima's radiation. The authors attribute the higher levels of mortality (compared to people evacuated due to the tsunami) to the stresses unique to radiological emergencies, such as prolonged displacement and an uncertain future.[119]

Case study:
Viktor Petrovich Slesarev

Patient at the Central District Hospital, Rokytne District, Rivne Region, Ukraine

"I have cancer, I'm a disabled person of group II, Chernobyl. In the present situation in Ukraine the healthcare system has forgotten about us."

"For example, I take medication like this, it is very expensive. Leukeran. It's very hard to get it in Ukraine and 25 tablets cost more than 2000 hryvnias [about EUR 77] now. They found that I have blood cancer." Personally, he is sure: "Of course this disease is because of Chernobyl."

"We're lucky that we have doctors here, who take care of us. I don't know what it will be like in the future. There are rumours that they may close the hospital. And you just go to the cemetery, dig a hole, lie down and die."

"Before that I was a driver, at an open-pit mine not far from here, I've been working there for 26 years. I was here when the accident happened, I've been living here all the time, here in the zone, in the contaminated zone. I live in a village, I've got a cow, pigs, you see what I mean? I must work, must help my children too. And what's that? I don't know. And there are thousands, thousands like me in Ukraine."

Case study:
Nataliya Brychka, Ukraine

Head of Outpatient Clinic, Central District Hospital, Rokytne District, Rivne Region, Ukraine

"Of course, the morbidity rate grows. And the impact of the Chernobyl disaster on that is an ascertained fact."

"If we look at the course of the morbidity over time, we can say, that in the first years after the accident, when there was external exposure, there was a substantial growth of thyroid diseases – hyperplasia, diffuse goitre. To compare the figures, at the start, the rate was 87.1 per 100,000 and literally in the first years it grew up to 507.2. Recently, we have seen the growth of the morbidity rate of the endocrine system diseases, of hypothyreosis, diabetes, of the cardio- and cerebrovascular diseases and those of the digestive and respiratory apparatus. If previously they were caused by external exposure, now, as we think, and it is medically proven, they are caused by internal exposure to radiation from the food, drinking water, the milk that our kids drink."

"The point is that if the people were using clean food that would make the difference. But they live, they eat, raise their children and give them the milk to drink where they live. And for the moment this remains a serious problem."

"There is another problem. Those who give birth to children now were either born at the time of the accident or were at the puberty age. Now they are having their own kids. Because of that the probability rate of cardiac defects is much higher, there are more chromosome diseases. And we must take into account the impact of the radioactive contamination. Kids' immunity is weaker, they fall ill more frequently, they are more exposed to viral and bacterial infections, are weaker and recover slower."

3.2 Controversial Health Consequences

Radiation-induced health effects are often controversial and evoke significant scientific debate. This is because our understanding of the health effects of radiation is by and large limited to lessons learned from the survivors of the nuclear bombings of Hiroshima and Nagasaki. Nagasaki and Hiroshima, however, have mostly increased understanding of a punctual external exposure to radiation.

The health effects from Chernobyl and Fukushima are controversial because radiation exposure has occurred and continues to occur primarily through chronic low-level external and in some areas internal exposure. This means that dose consequences models confirmed through studies of Hiroshima and Nagasaki survivors aren't necessarily transferable to the survivors of Fukushima and Chernobyl.

Confirming the impacts of Chernobyl has become difficult due to the lack of comprehensive and trustworthy data. While 1,800,000 people have been designated as Chernobyl survivors, only 131,450 survivors have had their dose exposure estimated in long-term study.[120] Dose reconstruction has not taken place for 44,000 clean-up workers who received an acute radiation dose and then went on to live in radioactively contaminated areas.[121] The analysis of peer-reviewed literature shows there has been no update on Chernobyl survivor dose estimates since 2005.[122] As a result, this lack of comprehensive dose estimates makes it extremely difficult to assess the carcinogenic and other impacts of Chernobyl.[123] This is mirrored in the situation in Fukushima, where there is a similar lack of reliable dose estimates. Indeed, in Prof. Omelianets' view it is now "almost impossible" to comprehensively assess the effects of Chernobyl because of the reduced funding and the resulting end of data collection and publication.[124]

The issue of disabilities being caused by the radioactive contamination released by Chernobyl is one that has not been given the attention it deserves and has been addressed in research only relatively recently. Published data suggests that, in Ukraine, the number of disabled people has risen from 9,040 in 1992 to over 100,000 today. The proportion of disabled people who are survivors of Chernobyl continues to rise. This has resulted in a decrease in the number of employable people in the population. The pattern of disabilities in children exposed to radiation is different from that in Ukraine as a whole. Despite these figures, the impacts of radiation doses and health effects of long-term exposure on disabilities have not been studied in depth.[125]

Prof. Omelianets and his team describe the need for further studies into the effects of Chernobyl radiation on brain function (including that of children exposed in the womb) and the central nervous system as 'urgent'. They also call for the improvement of neuropsychiatric care for Chernobyl survivors. In their analysis they identify the neuropsychiatric effects of the disaster as:

"1) psychological and psychosomatic disorders; 2) long-term disturbance in mental health including the alcohol abuse; 3) cerebrovascular and other organic diseases of the central nervous system, 4) cognitive disorders; 5) effects on the developing brain; 6) potential radiocerebral effects, 7) Chronic Fatigue Syndrome, 8) suicides." [126]

Studies on children born to families exposed to radiation from the Chernobyl disaster have shown evidence of genetic mutations. One study found mutations in children residing in highly contaminated areas of Belarus to be twice the norm. Another study reported DNA mutation in children born to families of clean-up workers to be 5.6 times that of siblings born before the disaster. However, despite extensive research, the ability to predict the impact of radiation on human genetics is not yet possible. [127]

Additionally, genetic and ecological research in wildlife around Fukushima and Chernobyl has observed significant radiation induced genetic, physiological, developmental, and fitness effects. Studies around Chernobyl have found elevated incidence of genetic damage and mutation rates in major taxonomic groups investigated.[128] The evidence of mutation and genetic damage in animals and plants in response to low-dose radiation around Chernobyl, which so far has not been proven in humans, highlights our limited understanding of radiation and the necessity of further investigation on its effects on biota. In light of our limited knowledge and the significant uncertainties, a precautionary approach to radiation exposure should be maintained.

3.3 Conclusions

The data show that the Chernobyl catastrophe has caused a significant deterioration in the state of health of the affected population of Ukraine. Both cancer and non-cancer diseases have been associated with Chernobyl-induced exposure to radioactive contamination. Most notably, higher mortality rates among population residing in contaminated areas, lower birth rates, higher incidence of thyroid cancer in youth, and of breast cancer and leukaemia among clean-up workers have been reported. Depression, PTSD and anxiety, especially among mothers and clean-up workers, are undisputable consequences of Chernobyl.

The long latency periods between exposure to radiation due to the Chernobyl disaster and health effects emerging show that continued monitoring of victims of nuclear accidents is vital. Extensive radiation monitoring and estimation of doses to workers and the public are essential to establish a link between exposure and potential health impacts.

Given it is only five years after Fukushima, scientific evidence on specific cancer and disease effects are not expected yet. Nevertheless, higher mortality rates have already been observed among Fukushima evacuees. Many mental health effects have also been observed in response to the Fukushima disaster and this major aspect of nuclear accidents is very much neglected. It is vitally important that monitoring of non-cancer diseases is in place for both Fukushima and Chernobyl survivors.

Abandoned Stores in Namie, Fukushima

Vending machine and sake bottles outside a store in the district of Namie, located between 5-15 km north of the Fukushima Daiichi Nuclear Power Plant. Namie had a population of nearly 20,000 people who were evacuated on March 12, 2011.

4. Nuclear Accidents: Once Evacuated You May Never Go Home

The survivors of Fukushima and Chernobyl have been consistently excluded from decisions regarding their personal safety. Hundreds of thousands have been forced to evacuate and never return home. Others have been forced to live in contaminated areas and to live with the reality of chronic exposure to low levels of radiation. It goes without saying that Chernobyl and Fukushima's survivors never consented to having their lives forever changed. Millions have been done a great injustice by these nuclear accidents.

Decisions on what constitutes a 'safe' level of radiation for survivors after their communities have been irrevocably contaminated have been haphazard, inconsistent, badly communicated and motivated. The main motivation behind these decisions appears to be reducing costs to government and industry. This, of course, has increased distrust in authorities among public.

The scientific controversies around chronic low-dose radiation exposure risks and the decisions based upon them continue. This chapter details the current situation in countries the most effected by Fukushima (Japan) and Chernobyl (Ukraine, Belarus and Russia) catastrophes with regards to the zoning of contaminated areas as well as the social effects this is having on the local populations.

What is common between Chernobyl and Fukushima is the lack of respect for victim rights and involvement of survivors in decisions on the conditions they wish to live in and the risks they are willing to accept.

4.1 Chernobyl: Contaminated Zones, Survivors and Financial Support

The impacts of the Chernobyl disaster were so versatile and broad-scale for Ukrainian society that the rights of survivors and obligations of the government were codified in law and even in Ukraine's Constitution once it became independent following the fall of the Soviet Union. Thirty-years after the disaster began, however, the state has yet to fully respect its obligations to Chernobyl survivors. Moreover, in recent years the government has been reducing funds for measures of social support for the population affected by Chernobyl accident.

The legal framework for the continuing issue of the affected territories of Belarus, Russia and Ukraine including the social protection of its citizens, was adopted in the beginning of 1991 before the collapse of the USSR. It is based on a uniform 'Concept for habitation' of the population within the territories of higher radioactive contamination.

The basic principle of the Concept is that human radiation exposure connected with the Chernobyl catastrophe should not exceed 1 mSv per year (and 70.0 mSv per all life for the critical group of the population, i.e. children born in 1986).[129] In Ukraine, Belarus and Russia the average annual effective dose of 1 mSv is accepted as the dose limit. At the exceeding of this limit protective measures (countermeasures) are considered justified.[130]

Based on this principle, Radioactively Contaminated Territories were divided into four zones. These zones were defined by radiation dose levels and land contamination density: [131]

1	Exclusion Zone or Zone of Primary Evacuation: people were evacuated in 1986 and 1987
2	Zone of Evacuation or Obligatory Resettlement Zone: ^{137}Cs contamination levels >555 kBq/m^2, ^{90}Sr >111 kBq/m^2, annual effective dose >5mSv
3	Zone of Guaranteed Voluntary Resettlement or Living Zone with the Right to Resettle: ^{137}Cs contamination 185-555 kBq/m^2, annual effective dose 1-5mSv
4	Zone of Strict Radiological Control or Zone with Preferential Socioeconomic Status: ^{137}Cs contamination 37-185 kBq/m^2, annual effective dose <1mSv.

The exclusion zone in Ukraine is approximately 1,210 km2 and was home to about 91,600 people before the accident. No one is allowed to live in this zone due to the contamination.[132] The obligatory resettlement zone in Ukraine is approximately 6,490 km^2. About 50,000 people were required to leave this area due to radiation levels in 1991 and 1992. The 'guaranteed voluntary resettlement zone' in Ukraine is approximately 23,620 km^2, with about 600,000 residents. In this zone, dose may exceed 1 mSv per year and in such cases may require additional protective measures to reduce it.

The Ukrainian Strict Radiological Control Zone 4 is approximately 22,480 km^2 and has 1,600,000 residents. In this zone, doses may exceed 0.5 mSv annually. On December 28, 2014, this zone was eliminated, which effectively means that residents are no longer considered to be at risk of radiation by Ukrainian authorities.[133] At the same time, more than 10 settlements, which were previously among those assigned as Zone 4, are still located in areas with strontium-90 contamination density higher than 5.5 kBq/m^2, and, therefore, should be assigned as Zone 3 (Zone of Guaranteed Voluntary Resettlement or Living Zone with the Right to Resettle).[134]

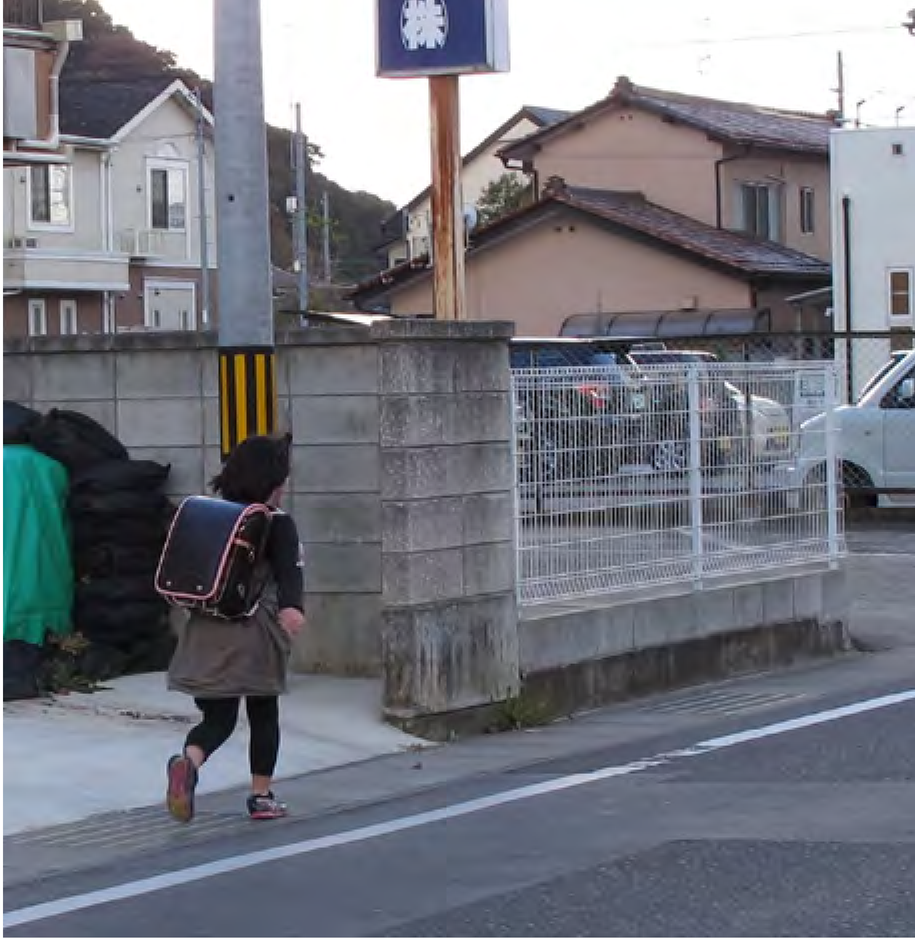
As Kashparov and co-authors stated in their research, the decisions for the officially approved methods of assessment of the radiation effective dose to the population are different in the three countries. Therefore, state-to-state comparison of such data for the countries of concern is difficult.[135]

4.1.1 Financial Support

Protective measures provided by these laws (resettlement, providing free residence, special health service, various privileges and compensations such as early retirement, free transport and food, reduced cost of utility bills, etc.) had to be financed by funds of the general union budget of the USSR. After the collapse of the Soviet Union in the end of 1991, this had to be financed out of the budgets of the independent states. However, tough economic times mean that the protective measures have not been properly financed.[136]

The continuing responsibility of the state after the Chernobyl catastrophe is reflected in the Constitution of the Ukraine in Article 16: "overcoming of the consequences of the Chernobyl catastrophe – a catastrophe of global scale, and preservation of the gene pool of the Ukrainian people, is the duty of the State".[137] From 1992-1998 a special fund was created - also part of the Ukrainian budget - focused on mitigating the consequences of the Chernobyl accident and on protecting the population (Fund for Measures on Mitigating Chernobyl Accident Consequences and Social Protection of Population). At the beginning of 1999, the financial contribution to the Fund became solely the State´s responsibility, while enterprises and economic organisations did not have to pay into the Fund anymore, when they previously had.

Unfortunately, due to the lack of financing for the social protection of the affected population, some communities that continue to suffer from the consequences from the Chernobyl accident are not fully supported.[138] For instance, no agricultural countermeasures, which could potentially decrease the average annual effective dose to population to acceptable levels (below 1 mSv), have been implemented in Ukraine since 2009. However, social payments for the populations (compensations and privileges) are considered more important than the expenses for the radiation protection and have continued.[139]



Nuclear Waste in Fukushima City

Nuclear waste storage beside houses in Fukushima city. Plastic bags with contaminated soil are stored on the street.

© Shaun Burnie / Greenpeace

Belarus also established major funds for the financing of programmes to deal with the consequences of the accident. In recent years, priority was given to individual payments for the social protection and medical care of the population, followed by the social and economic recovery or development of the affected regions, then for the radiation protection and implementation of countermeasures and a bit more than 1% for scientific and information support.[140]

Due to the reduced financial support to deal with the aftermath of the Chernobyl disaster, control of contaminated foodstuffs is reduced (as we have seen in chapter 2), less money is available to implement protective measures, and less scientific monitoring data are available. This means that the radiation exposure of people still living in the contaminated areas is likely increasing, even though this continuing impact of the disaster goes largely unnoticed. Thousands of children, even those born 30 years after Chernobyl, still have to drink radioactively contaminated milk on a daily basis.

4.1.2 Living in Contamination

Settlements in the Zone of Evacuation in Russia were only partly evacuated after the disaster in 1986. This has caused relatively large radiation dose exposures to the local population in contaminated areas compared to Belarus and Ukraine.

In certain areas radiation exposure has declined because of the decay of radionuclides and auto-rehabilitation processes as well as due to application of countermeasures. As a result, in Belarus the number of settlements officially attributed to the different zones of radioactive contamination has decreased to date by a factor of 1.5 and the number of people who live there decreased by a factor of 1.9 (the status of the zones is reconsidered by the Government of Belarus every 5 years).[141]

Nevertheless, Prof. Kashparov's review found hundreds of settlements in Russia, Ukraine and Belarus still exceed the annual dose limit of 1 mSv and about 1 million people continue to live in these settlements. Table 4 below summarizes the number of settlements with exposure above dose limits by country.

Table 4: The amount of settlements in Ukraine, Belarus, and Russia where the effective doses are greater than the established dose limits[142]

Country	Year	Number of settlements		
		Total in zone	1-5 mSv/y	>5 mSv/y
Belarus	2015	2396	82	0
Russia	2014	4413	276	8
Ukraine	2012	2293	26	0

In 2015 the average annual effective dose of the population exposure in Belarus was equal or higher than 1 millisievert per year (mSv/y) in 82 settlements out of 2396 located in the areas of radioactive contamination. In nine settlements the dose was higher than 2 mSv/y but less than 5 mSv/y.[143] In 2012, the average annual effective dose to population in Ukraine was equal or higher than 1 mSv in 26 settlements out of 2293. In six settlements, the dose was higher than 2 mSv but less than 5 mSv.[144] Recent research in Russia's radioactively contaminated zones found that 276 of the 4413 settlements (about 6%) had an average annual dose greater than or equal to 1 mSv, and in eight settlements it was higher than 5 mSv/y.[145]

The new Russian governmental decree in October 2015 meant a change in categorisation for hundreds of settlements in the Bryansk region (see Table 5).[146] There is a push for the reduction of the official list of contaminated areas for the sake of returning territories into agricultural use.[147] However, the change of status can have significant impact on people's lives, as benefits and protection measures, including free medical and prophylactic programmes, are reduced.[148] Furthermore, measurements in the Greenpeace investigation (see chapter 2) have shown that the classification of settlements does not always seem to be consistent with the observed radioactive contamination.

Table 5: Number of settlements in the different contaminated zones in Bryansk, Russia[149]

	2005	2015
Exclusion Zone	4	4
Zone of Evacuation	202	26
Living Zone with Right to Resettle	237	191
Zone with Preferential Socioeconomic Status	535	528
Total number of settlements	978	749

4.2 Fukushima: Contaminated Zones, Survivors and Financial Support

During the emergency phase of the Fukushima disaster, about 80,000 people were evacuated within a 20 km radius around the NPP, in successive stages. Residents were 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".[150]

However, much like with the Chernobyl accident, radioactive fallout contaminated territories far beyond the 20 km evacuation zone. On April 22, 2011, 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 with contamination levels leading to cumulative air dose that might reach 20 mSv or more within a one-year period. It included parts of Katsurao and Namie, all of Iitate, and some parts of Kawamata (Yamakiya district) and Minami-Soma.[151]

The population of the newly assigned evacuation zone numbered about 10,000. According to the five municipal governments, 6,000 residents were still in the highly contaminated zone when the late evacuation order was issued; others left on their own beforehand.[152]

By August 29, 2011, the number of evacuees forced or recommended to leave their dwelling had reached a total of approximately 145,000 people. These included approximately 58,000 people from the areas 20-30 km from the NPP.[153]

Invisible to official statistics are the so-called 'self-evacuees', people outside of the designated evacuation zones who decided to leave out of fear for radiation effects or simply because they did not want their children to grow up not being able to play outside. These self-evacuees receive very little support from the government. Though 25,000 of them are currently receiving free lodging, this support will also cease in March 2017.

4.2.1 Living in Contamination

Five years after Fukushima, the Japanese government has set a goal to have the majority of evacuees return to their contaminated homes in 2017. The government's return policy was established without the involvement of affected citizens or the option to resettle in a non-contaminated community.

In normal circumstances, the maximum allowed radiation exposure of the public is limited to 1 mSv per year. However, following the Fukushima accident, the new value of 20 mSv per year was set, corresponding to the normal maximum annual exposure previously set up for workers of nuclear establishments only. This industrial standard is now being applied to all citizens of the affected zones including children who are more sensitive to radiation.[154] As noted, it is also 20 times higher than the limit used for communities contaminated by Chernobyl.

The policy outlines the return of the population to all evacuation zones, except those that are classified as 'difficult-to-return zone' where the external dose may be higher than 50 mSv per year.[155] The return calendar is fixed: the evacuation order will 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.[156]

In contrast, the Special Rapporteur to the United Nations Human Rights Council, Anand Grover said a forced return policy at these higher radiation levels was not "in consonance" with the human right to health and that 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." He went on to state that the return of evacuees should only be "when the radiation dose has been reduced as far as possible and to levels below 1 mSv/year."[157]

The Japanese government, much unlike the former Soviet Union, launched a huge decontamination programme both in non-evacuated and evacuated territories.[158] As described in chapter 2, despite extensive but ineffective decontamination efforts, evacuees are being forced to return to contaminated areas and accept exposure to elevated radiation levels in their daily lives.

Local governments are spending millions of dollars to persuade refugees to come back. The Japanese Government's attempt at normalisation of the contaminated situation was crystallised into policy in June 2015, when a new plan was approved that will determine the future of tens of thousands of Japanese citizens from Fukushima Prefecture, and their return to the contaminated lands.

So far, evacuation orders were lifted in parts of Tamura and Kawauchi in 2014, and in Naraha city in 2015. All these areas lay within the less contaminated part of the 20 km evacuation zone. Evacuation recommendations around scattered hot-spots are also completely lifted.[159]

The Abe government is particularly determined to push the people of the district of Iitate in Fukushima prefecture to return to their former homes. The 6,000 people from Iitate were the most exposed population in Japan before they were finally evacuated between April and July 2011. Today they remain displaced, most of them still living in temporary accommodation – many still fighting for enough compensation to allow them to establish a life somewhere else. According to many polls, most have abandoned hope of picking up their old lives and want enough money to set up new ones.[160]

4.2.2 Financial Support

The 'normalisation' policy of the Japanese government means financial support to 55,000 evacuees will cease in 2018, effectively forcing victims to return to their original homes in contaminated areas.

Despite the lifting of the evacuation orders, 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.[161] These figures underline the huge gap between the Japanese policy and the wishes of the affected populations. Basic infrastructure like easy access to medical or shopping centres is not yet restored. In Naraha, the school has not reopened yet and the new anti-tsunami wall has not yet been built.[162]

In order to force the return, evacuees who are expected to come back to previously evacuated zones are not eligible for long-term "post-disaster recovery public housing". Evacuees, whose homes are located in areas that have been deemed as difficult-to-return zones, are the only ones eligible for the public housing that is currently under construction. However many of these eligible evacuees chose to buy new homes with the compensation they received from TEPCO. This means 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.[163] In order to reassure evacuees and win their consent, Japanese authorities will provide an individual dosimeter to each person to register the external dose of radiation.[164]

Citizens living outside designated evacuation zones who decided to leave were often stigmatized and seen as undermining the nation's effort to reconstruct Fukushima. Those so-called 'self-evacuees' are officially not recognized as nuclear evacuees anymore, they are not counted in official statistics and can rely hardly on any support from the authorities.[165]

By 2018, the monthly compensation payments TEPCO paid to evacuees will also be terminated.[166] The process of compensation payments has been subject to public criticism in the past due to the non-transparency and complexity of the process being mainly driven by TEPCO´s interests and not the interests of the victims themselves, whose already disrupted lives were made even more difficult.[167] At the beginning of the disaster, TEPCO's compensation application form was 60 pages long and accompanied by a 156-page instruction manual[168]. Not only that but some of the sums paid in compensation were derisory. Among many examples, Masumi Kowata, from Okuma, a town in Fukushima Prefecture, just 5 km from the crippled plant, was been offered just Yen 700,000 (USD6,000)[169] for her 180-year-old house[170].

Japan's Act on Compensation for Nuclear Damage (1961) obliges TEPCO and other nuclear utilities to arrange private insurance of roughly Yen 120 billion (USD 1 billion) per site. This has been shown to be woefully inadequate by the events at Fukushima. In 2013, TEPCO officials estimated the costs of compensation and decontamination at Yen 10 trillion (USD 80 billion)[171].

Due to existing liability schemes, the nuclear industry pays little to none of the full costs required to help victims recover from a nuclear disaster. TEPCO was nationalised in 2012 meaning it is the Japanese tax-payer who ultimately picks up the bill. Companies, such as GE, Hitachi, and Toshiba, that got large contracts by building, supplying and servicing the Fukushima NPP, have simply continued their business as if nothing happened. They have made absolutely no meaningful contribution to improving the lives destroyed by their technologies. Not only that, but by taking roles in the decommissioning of the destroyed reactors and the decontamination process, these companies are actually profiting from the disaster.[172]

4.3 Scepticism, Distrust and Empowerment: The Social Impacts of Nuclear Disasters

The huge social upheaval caused by Chernobyl and Fukushima has never been honestly or sympathetically acknowledged or addressed by government authorities, the nuclear industry nor the IAEA. To the contrary, authorities have consistently minimized and dismissed the social impact and stress of long-term displacement, or chronic and non-consensual radiation exposure.

As documented in this report, the continued suffering of Fukushima and Chernobyl victims shows that the risk created by nuclear facilities is socially unacceptable. The reality of this risk was masked before these disasters occurred.

Millions of lives changed after Fukushima and Chernobyl. Everyday people in contaminated communities must make decisions on how to reduce or limit their exposure to radiation. Shopping, cooking, eating, working outside or inside, and heating your home are all daily choices that can put you and your family at risk. It is no wonder that stress and anxiety are associated with nuclear accidents.

This is the reality of thousands of mothers, fathers and grandparents in Japan, Ukraine, Russia and Belarus. Chernobyl and Fukushima have profoundly changed their day-to-day experience as well as their relationships with government authorities and experts. These communities, of course, never consented to this on-going, chronic radiation exposure. Their refusal to simply accept the additional risks imposed on them is the crux of the conflict between industry experts and public opposition.

Despite industry and government authorities' assurances of safety, public distrust, scepticism and opposition is well founded. After both Chernobyl and Fukushima, there are ample examples of the authorities in Japan and Ukraine providing broad and over-confident reassurances of safety to the public. These confident declarations are a total contrast to the reality of affected communities and societies. The combination of the lack of information, contradictory government communications, concern about future health effects, official secrecy, and unfair compensation for losses, dramatically increased stress, fear, anxiety and mental health effects such as PTSD and depression.[173] Inconsistent and contradictory information related to the safety of food in case of radioactive contamination caused an increased distrust of experts and government authorities following both Fukushima and Chernobyl.[174]

This has triggered many Japanese citizens to rethink their once deferential relationship with state and expert authorities. Fukushima has, in effect, changed the social relationships of Japanese society. This new distrust in authorities has spurred ‘bottom-up' responses, including citizen-led science challenging government policies and protesting against government policies.[175]

When citizens lose faith in government expertise, they develop other means to protect their lives and health. Following Fukushima, Japanese citizens developed their own technical capacity to assess government safety reassurance, including learning to monitor, share and understand the risk of radiation levels in food and communities. This 'scientific citizenship' is a direct response to the Fukushima disaster.[176] Simply put, due to distrust in government, citizens have come together to develop tools and community networks to protect their health and avoid radiation exposure.

The other obvious citizen's response to the Fukushima disaster is the advent of renewable energy. Before Fukushima, Japan was planning to build new nuclear reactors and keep its existing reactors operational. Five years after Fukushima, while operators are pushing to restart their reactors, public anti-nuclear opposition is growing stronger and stronger in favour of alternative energy sources. Meanwhile, Japan has commissioned 85,550 megawatts of renewable energy since the Fukushima accident.[177]

The social upheaval from Chernobyl manifested itself very differently. In 2006, Mikhail Gorbachev acknowledged that Chernobyl was a principal cause of the Soviet Union's dissolution. He said, “even more than my launch of perestroika, [Chernobyl] was perhaps the real cause of the collapse of the Soviet Union five years later. Indeed, the Chernobyl catastrophe was an historic turning point: there was the era before the disaster, and there is the very different era that has followed.”[178]

Following Fukushima, the former Chairman of the Nuclear Regulatory Commission (NRC), Gregory Jaczko, acknowledged that the disaster was clearly socially “unacceptable”, however it was not considered unacceptable under international safety norms. As Jaczko stated: “While Fukushima was certainly a very significant event, it was not a very significant event from the risk metrics that we currently use in terms of those health effects.”[179]

No immediate radiation-induced deaths occurred due to Fukushima, so the disaster is deemed ‘technically acceptable' under international safety requirements. Indeed, this gap between the nuclear industry's concept of safety and the obvious social unacceptability of Fukushima and Chernobyl is sufficient for some academic observers to argue that a focus “on the number of nuclear refugees could be a better measure of the severity of the radiological consequences than the number of fatalities”.[180]

Fukushima and Chernobyl revealed the full risk of nuclear power. Beyond their impact on the environment and human health, nuclear accidents are undeniably unacceptable social disasters.

Measuring Radiation in Fukushima

Greenpeace radiation expert Rianne Teule monitors contamination levels on the outskirts of Fukushima City, 60 km from the stricken Fukushima Daiichi nuclear plant.

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Contaminated Landscapes in Yonomori

Yonomori Railway Station. Level of radiation is 1.31 microsievert per hour. The normal rate before the Fukushima nuclear disaster was 0.08 microsievert an hour.

5. Conclusions

This report has endeavoured to illustrate how nuclear disasters leave scars for decades and will no doubt continue to do so for centuries. Thus, the 5th and 30th anniversaries of the Fukushima and Chernobyl nuclear accidents mark only the beginning of the aftermath. Their full consequences won't be known for centuries.

The nuclear industry once claimed that such disasters were near impossible. However, with major accidents happening about once a decade,[181] the nuclear lobby has changed its position and is trying to portray nuclear disasters like any other industrial accident.

But nuclear accidents are unique in their ability to put populations at both physical and mental harm, permanently displace large populations, tear apart community relationships, and leave survivors burdened with stress caused by their chronic exposure to radiation. The social upheaval experienced by Fukushima and Chernobyl victims is unprecedented.

Hundreds of thousands of people have been permanently displaced by the Fukushima and Chernobyl disasters. Millions more live in radioactively contaminated areas. Their right to determine their own personal safety and protect their families from radiation risks has been forever taken away.

Indeed, "We want our lives back" is a sentiment heard from many of the survivors of nuclear disasters. By their lives, they mean their right to live, work, play in a safe community and a healthy environment. Beyond the environmental and human effects, which will be debated for decades to come, Chernobyl and Fukushima were gross violations of human rights.

In spite of industry attempts to minimize and deny the consequences of these disasters, the social, health and environmental effects seen at the 5th and 30th anniversaries of Fukushima and Chernobyl are striking.

5.1 Contamination

Fukushima and Chernobyl caused the dispersal of long-lived radioisotopes. In areas where the concentration is too high, people can't return home. Millions of people still live in radioactively contaminated areas around both Chernobyl and Fukushima. This contamination causes chronic, low level radiation exposure, increasing the risk of both physical and mental health effects.

Thirty years after the Chernobyl disaster began, over 10,000 km^2 of land is unusable for economic activity, more than 150,000 km^2 in Belarus, Russian and Ukraine are designated contaminated areas, and 5 million people live in areas officially considered contaminated by Chernobyl's radioactivity. Due to high levels of plutonium contamination within 10 km of the plant mean it is impossible for this area to be repopulated for the next 10,000 years.

While caesium-137 contamination has decreased by tens of times in many agricultural products, it decreased only several times in wild mushrooms and berries. At the same time, levels in milk, cattle meat and non-wood forest products continue to exceed the permissible content for caesium-137. Fieldwork carried out by Greenpeace in the Rivne region of Ukraine in 2015 found that milk contained levels of caesium-137 above consumption limits.

The Japanese government's decontamination efforts have been piecemeal, inadequate and there is a serious risk of recontamination of supposedly decontaminated areas. In spite of the massive effort and expenses incurred, decontamination is likely to be a never-ending process. Also, decontamination efforts do not 'get rid' of the radioactive contamination – they simply move it to other locations where temporary storage sites continue to pose hazards to communities and the environment.

The human impact of the radioactive contamination of vast areas of land should not be underestimated. It is clear that people will continue to be exposed to radiation risks when evacuation orders are lifted and people return to their homes. In addition, tens of thousands of people have lost their homes, lands and livelihoods. Generations of families who once lived together are now separated and many will never be reunited. They have been poorly compensated (if at all) and many still live in deteriorating temporary accommodation. All because of a nuclear disaster they played no part in creating.

Thirty years after the catastrophe Greenpeace revisited the site of the Chernobyl disaster – the 4th reactor block with a new confinement built nearby and the abandoned town of Pripyat.

5.2 Health Effects

The public debate on the health effects of Chernobyl and Fukushima is mostly focused on the radiation-induced human health consequences. These effects are often controversial in large part due to our limited understanding of the impacts of low-level radiation and lack of comprehensive data on the radiation doses received by large populations.

The scale of the consequences, however, is best understood by the overall decline in human health and well-being that has occurred in populations displaced by and exposed to Chernobyl and Fukushima's radioactive fallout.

Chernobyl has caused a significant decline in the health and well-being of large populations of Ukraine, Belarus and Russia. Indicators of this decline include higher mortality rates in the radioactively contaminated areas of Ukraine and lower birth-rates. Notably, the mortality rate among children with irradiated parents is also higher. A key cause of the increased mortality in contaminated areas is diseases of the Cardiovascular System (DCS). In addition, tens of thousands excess cancer deaths are expected.

As mentioned, radiation-induced health effects are often controversial and evoke significant scientific debate. This is because our understanding of the health effects of radiation is by and large limited to lessons learned from the survivors of Hiroshima and Nagasaki. This, however, has mainly increased the medical world's understanding of a punctual external exposure to radiation. Exposure to radiation from Chernobyl and Fukushima is primarily received via chronic low-level and internal exposure.

Nevertheless, the following health consequences have been observed and can be attributed to radiation exposure:

- significant increases in thyroid cancer in both children and clean-up workers
- leukaemia and breast cancer in Chernobyl clean-up workers
- a decrease in the cognitive function of clean-up workers
- an increase in cataracts among clean-up workers
- an increase of mortality of the clean-up workers and of the population resulting from diseases of the Cardiovascular System (DCS)
- disability of the clean-up workers and of the population of the contaminated territories

Given the latency period for cancer, no discernible increase in cancer incidence is expected at this moment in populations exposed to radiation after the Fukushima accident. That said, a rise in thyroid cancer incidence has been observed in Japan that cannot be fully explained by the widespread screening.

It is increasingly understood that mental health has an impact on physical health. The mental health effects of Chernobyl and Fukushima are caused by the combined stress of displacement, the inability to return home, social stigmatisation, and worry of chronic radiation exposure. This in turn contributes to the decline in physical health.

Mental health effects caused by these disasters include PTSD, depression, anxiety, somatoform, alcohol abuse and psychometric disorders. Until recently, mental health disorders were treated less sympathetically than physical ailments. It is imperative that moving forward these adverse health effects be acknowledged and addressed in nuclear emergency plans as well as programmes to support the survivors of Fukushima and Chernobyl.

Children in Fukushima

The city of Fukushima has been contaminated by radioactive fallout from the ongoing crisis at the Fukushima Daiichi nuclear plant.

5.3 Social Effects

The huge social upheaval caused by the Chernobyl and Fukushima disasters has never been honestly and sympathetically acknowledged or addressed by government authorities, the nuclear industry or the IAEA.

Fukushima and Chernobyl have forced hundreds of thousands from their homes – never to return. Millions are forced to live in contaminated areas. This changes the daily decisions hundreds of thousands of people in Japan, Ukraine, Russia and Belarus face. This clearly increases stress, worry and distrust in government authorities. The symptoms of this social upheaval manifest themselves in a number of ways.

Increased rates of suicide have been observed in the aftermath of both accidents. Significant depopulation has occurred and continues in contaminated areas of Ukraine. Similar depopulation trends are also being observed in contaminated areas of Japan.

Since Fukushima, Japan has seen an upsurge in citizen protest and what is known as 'citizen science'. Citizens have started to monitor radiation and set up networks to share their knowledge, rather than relying on governmental classifications of regions as safe for return. Both public protest and citizen science are an expression of their distrust in expert authorities and an increased willingness to challenge official wisdom.

In the village of Vezhytsia, the Rokitne District of the Rivne Region, a family has just brought a wagonful of locally grown potatoes.

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5.4 Demands

In light of the scale of the social, human health and environmental impacts caused by the Fukushima and Chernobyl accidents, an obvious and reasonable response is to phase out nuclear power entirely in favour of clean energy solutions. Various countries did in fact decide to shut down or phase out their nuclear reactors following the accidents in Fukushima and Chernobyl.

In countries that decide to maintain nuclear power, authorities must design nuclear emergency plans to protect citizens in the event of radioactive releases on par with Fukushima and Chernobyl. Such plans should be ready to manage the long-term displacement of large populations and, in addition to radiation protection measures, provide long-term physical, psychological and psychiatric care, to mitigate the mental and other health impacts associated with nuclear disasters.

Justice demands that governments provide proper support for the survivors of Chernobyl and Fukushima. In light of health impacts, ongoing radiation hazards and unfair government policies, Greenpeace recommends the following actions be taken to fully support the Chernobyl and Fukushima survivors:

- Survivor rights should be respected. Authorities have a responsibility to involve impacted people in decisions related to their personal safety.
- Survivors should have the right to choose and not be forced to return to any place they see as risky to their personal safety or health.
- People should receive full support from authorities whatever their decision.
- Regardless of an individual's choice they should be fully compensated for losses to their livelihood and property as well as any mental distress or health risks incurred.
- The long-term study of the effects of Chernobyl and Fukushima should be supported. Important areas of study include non-cancer diseases, such as cognitive dysfunction, the impacts of low-level radiation on animals, insects and plants, the long-term mental health impacts suffered as the result of radiation disasters,[182] low-dose effects on cerebral function, cognitive impairments and psychotic symptoms among Chernobyl survivors,[183] and the collection of more objective data on radiation exposure and physical health.
- The measures to decrease the radiation exposure of the population should be continued to reduce the overall radiation doses to which people are exposed.
- Radiation (environmental and food) monitoring programs around Chernobyl should be re-instated with participation from affected communities.
- Introduction of restrictions on people entering areas with high levels of radioactive contamination, the so called 'hot spots'.

Chernobyl and Fukushima environmental and social scars will continue to remind us for decades and centuries to come, that nuclear power is simply not worth the risk. There is only one sure way to avoid nuclear catastrophes in the future and that is to rid the planet of nuclear energy.

The Chernobyl and Fukushima disasters destroyed the myth that this energy source is safe, cheap and reliable. The time, money and resources being squandered in developing new generations of nuclear reactors should be used to build a future based on clean and sustainable renewables and energy efficiency. We have an obligation to ourselves, our children and the planet to learn these lessons and ensure we never see such destruction and misery ever again.

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