Fukushima disaster

Jan Willem Storm van Leeuwen
independent consultant

member of the Nuclear Consulting Group

July 2019
storm@ceedata

Note
In this document the references are coded by Q-numbers (e.g. Q6). Each reference has a unique number in this coding system, which is consistently used throughout all publications by the author. In the list at the back of the document the references are sorted by Q-number. The resulting sequence is not necessarily the same order in which the references appear in the text.

Contents

TABLES

FIGURES

1 Accident

The Fukushima Daiichi nuclear power plant in Japan, comprising six boiling-water reactors (BWRs), was struck by a powerful earthquake (magnitude 9.0), followed by a tsunami on March 11, 2011. All cooling systems broke down, causing the meltdown of the cores of reactors 1, 2 and 3 and the spent fuel cooling pool of reactor 4. The meltdowns in turn caused hydrogen explosions, destroying the reactor buildings. Fortunately western winds were blowing during the first four days after the explosions, so most of the released radioactive gases and particles were blown out to the sea. But then the wind turned towards the land.

Inconsistent information on the cause

Accident analysis by IPPNW Germany (Paulitz 2012 [Q559]) shows that the earthquake was the trigger event, in combination with deficient safety-related equipment, for the nuclear disaster. This analysis relies on official documents published by the Japanese government and recognised expert organisations used by the nuclear authorities.
According to the report of the Japanese government to the IAEA, the height of the tsunami's main wave on reaching the reactor was estimated to be only 8 metres, not 14 meters as the nuclear industry stated.
"There is no conclusive evidence that the damage was caused by the tsunami. The available information is based mainly on statements, sometimes merely conjectures, made by the plant operator Tepco."
"Basic reactor safety was wantonly neglected through inadequate spatial separation, redundancy and diversity."

From the analysis by Rosen 2012b [Q560]:
The WHO report states that "damage caused by the flooding of the site resulted in loss of cooling to the three reactor units", putting emphasis on the fact that it was the tsunami that caused the nuclear catastrophe and not the earthquake. As earthquakes occur relatively frequently and many nuclear power plants around the world (especially in Japan) were constructed near seismic fault lines, the nuclear industry has a great interest in diverting attention away from the earthquake as possible cause of the nuclear meltdowns and placing the blame on the much less frequent and more exotic "massive tsunami".
However, a comprehensive German study showed that the structural damage, which led to the nuclear catastrophe at Fukushima Dai-ichi, was caused by the earthquake and not by the ensuing tsunami. Atmospheric data collected by NILU also proved that radioactive emissions were first measured right after the earthquake had caused substantial damage to the reactors and before the tsunami struck the plant.

Brief description of events

Rosen 2012a [Q558] gives a brief description of the events following the earth quake and the tsunami: Some quotes:
"Since it became evident that a nuclear meltdown was possibly taking place in the reactor cores, a 20 km zone around the power plant (with an area of about 600 km²) was declared an evacuation zone and a total of 200,000 people were forced to leave their homes,"
"On March 25th, people living in the 30 km radius were asked to voluntarily evacuate their homes and leave the contaminated areas. On April 12th, the Fukushima nuclear meltdowns were categorized as a level 7 nuclear accident – …"

"Radioactive fallout occurred mainly above the Northern Pacific (79%), with about 19% of the fallout contaminating Eastern Honshu island, including the Tokyo Metropolitan area and leaving an area of more than 1000 km2 highly contaminated with radioactive isotopes."

Official investigation

A quote from Introduction of the report NAIIC 2012b [Q564] reads:

> The Commission recognizes that the fundamental cause of the Fukushima nuclear accident originated from "the collapse of nuclear safety monitoring and supervising functions stemming from the reversal of the relationship between the regulators and regulated" among the successive regulatory authorities and TEPCO. Considering that there had been many opportunities for both sides to undertake safety measures beforehand, we regard that this accident was not a "natural disaster" but clearly "man-made."

The report NAIIC 2012a [Q496] discusses exhaustively reforming of laws and regulations. The Commission concludes that it is necessary to realign existing laws and regulations concerning nuclear energy. Mechanisms must be established to ensure that the latest technological findings from international sources are reflected in all existing laws and regulations.

Laws and regulations related to nuclear energy have only been revised as stopgap measures, based on actual accidents. They have not been seriously and comprehensively reviewed in line with the accident response and safeguarding measures of an international standard. As a result, predictable risks have not been addressed. The existing regulations primarily are biased toward the promotion of a nuclear energy policy, and not to public safety, health and welfare. The unambiguous responsibility that operators should bear for a nuclear disaster was not specified. There was also no clear guidance about the responsibilities of the related parties in the case of an emergency. The defense-indepth concept used in other countries has still not been fully considered. We found an organization-driven mindset that prioritized benefits to the organization at the expense of the public.

Ccosmetic solutions. Replacing people or changing the names of institutions will not solve the problems. Unless these root causes are resolved, preventive measures against future similar accidents will never be complete.

Radiation exposures were disregarded by the expert panel.
"the central government was not only slow in informing municipal governments about the nuclear power plant accident, but also failed to convey the severity of the accident. (...) Specifically, only 20 percent of the residents of the town hosting the plant knew about the accident when evacuation from the 3 km zone was ordered at 21:23 on the evening of March 11. Most residents within 10 km of the plant learned about the accident when the evacuation order was issued at 5:44 on March 12, more than 12 hours after the Article 15 notification—but received no further explanation of the accident or evacuation directions. Many residents had to flee with only the barest necessities and were forced to move multiple times or to areas with high radiation levels. (...) Some people evacuated to areas with high levels of radiation and were then neglected, receiving no further evacuation orders until April."

2 Spatial extent of the Fukushima disaster

Dispersion of radionuclides

Only airborne radionuclides, i.e. iodine-131, xenon-133 and cesium-134/137 have been monitored over large areas by means of aerial surveys, These three radionuclides are fission products and are easily detectable due to their hard gamma radiation. As far as known no systematic investigations have been published of the contamination of soil, groundwater and vegetation with other radionuclides, alpha and beta emitters with no or weak gamma emission, for example tritium, carbon-14 and a number of actinides.
Both the international executive summary and the english version of the main report of the official report on

the Fukushima disaster for the National Diet of Japan (NAIIC 2012 [Q496]) do not mention the consequences of the contamination of large inhabited areas with radioactive substances, but only addresses the administrative and managerial issues raised by the accident. Apparently no official assessment of the health effects and societal disruption as a result of the nuclear disaster observed at present and to be expected in the future has been published up until October 2013.

Strikingly the report NAIIC 2012 [Q496] contains only one map of radioactive contamination with only one kind of radionuclide, Cs-137 (see Figure 1) and no cumulative deposition of any radionclide outside of the 80 km zone are presented. The map strongly suggests that radioactive contamination outside of the 80 km zone was or is negligible, for it has not been measured, or at least the surveys have not been published. Hot spots far into the country outside of the 80 km zone might be very well possible, judging from the map of the irregular deposition of Cs-137 after the Chernobyl explosion. Dispersion maps published in other publications also show very limited surveyed areas, often with sawtoothed boundaries, apparently resulting from aerial survey patterns.

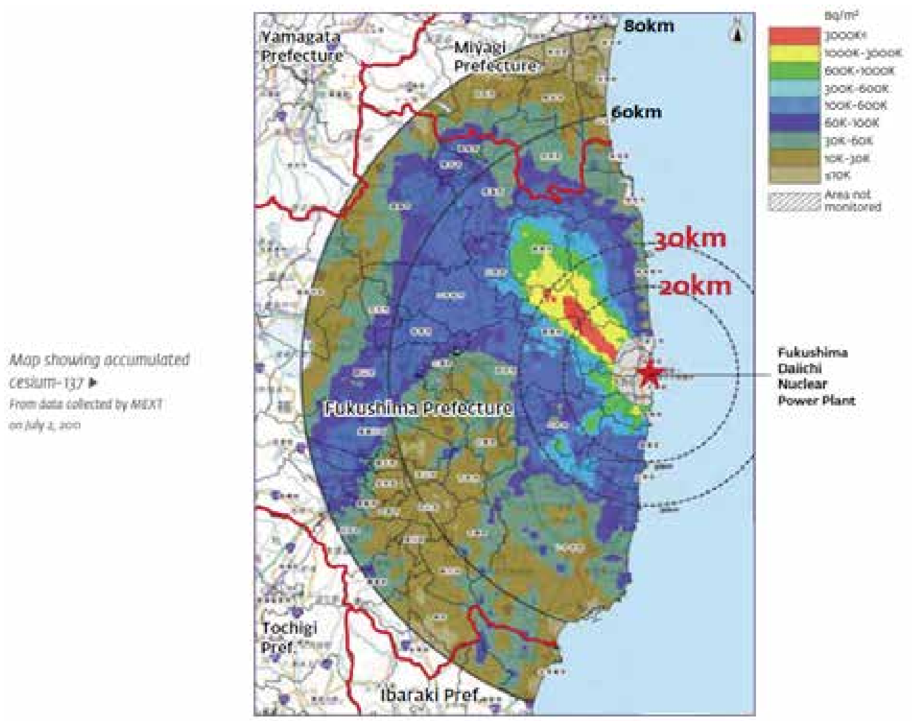

Figure 1

Dispersion of cesium-137 in the vicinity of the Fukushima Daiichi nuclear power plant on July 2, 2011. Source: NAIIC 2012 [Q496]. Only this map of dispersion of radioactive materials – and only Cs-137 – from the plant has been published in the Executive Summary of the official report of the Fukushima Nuclear Accident Investigation Commission of the National Diet of Japan, intended for the non-Japanese-reading global audience.

After the meltdowns the cripled reactors and spent fuel pools were cooled by flushing them with huge volumes of seawater and later of fresh water. During months the injected water was discharged into the sea and unknown amounts drained into the groundwater. A large but unknown fraction of the radioactive content of the reactors and spent fuel pools must have been washed out into the sea with the heavily contaminated waste water.

The extent of the contamination of the Pacific Ocean by radioactive materials washed into the sea during the Fukushima disaster is shown by Figure 2. As pointed out above the involved amounts of radioactive

materials are not known or not published, but include all kinds of radionuclides from spent fuel: fission products, actinides and activation products.
Noteworthy is the observation that at the time of writing of this report (September 2013), the map of Figure 2 could not be found on the websites of any of the institutions which contributed to the map of radioactive contamination of the pacific, mentioned in the caption of Figure 2.

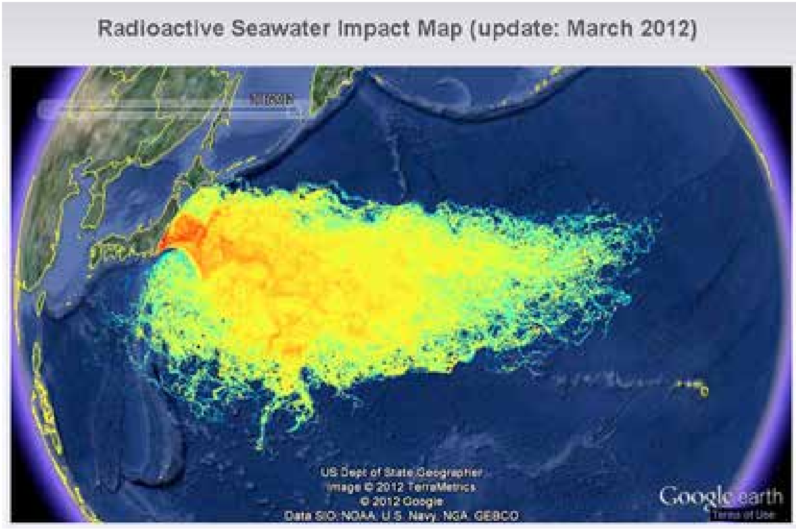

Figure 2
Radioactive seawater impact from Fukushima Daiichi. Image by TerraMetrics (2012) for US Department of State, Office of Geographer, using data from SIO (Scripps Institution of Oceanography), NOAA (National Oceanic and Atmosheric Administration), US Navy, NGA (National Geospatial-Intelligence Agency) and GEBCO (General Bathymetric Chart of the Oceans). The original publication could not be found on the web for free, but the image can be downloaded from various websites.

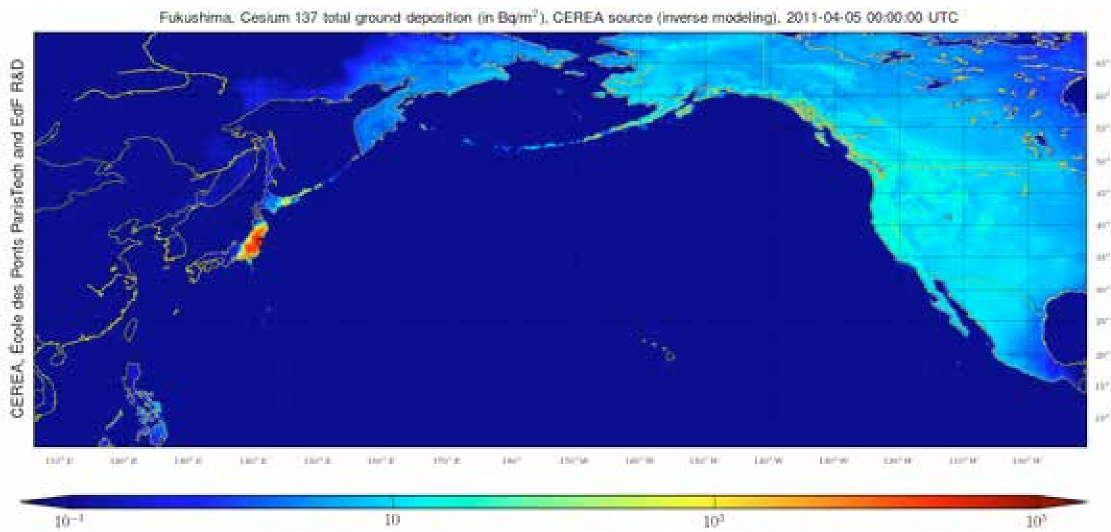

Figure 3
Map of the cumulative ground deposition of Cs-137)Bq/m^2) on April 6, 2011 after the Fukushima disaster. Note that the color scale at right gives the ^{10}log values of the surface activity; for example the numer 4.8 on the scale corresponds with a surface activity of $10^{4.8}$ = 63 kBq/m^2. Souce: CEREA 2013 [Q505].

Several international institutions have published maps presenting the dispersion of a small number of radionuclides into the atmoshere: ^{131}I, ^{133}Xe, ^{134}Cs + ^{137}Cs, but also ^{239}Pu and ^{239}Np. Please note that if the short- lived isotope ^{239}Np is present, the long-lived dangerous isotope ^{237}Np is also present. These maps are based on meteorological circulation models, starting from the published amounts of released radionuclides. Although these dispersion maps are not fully validated by measurements, the circulation models can be considered broadly reliable, as is shown by calculated dispersion maps of volcanic ash from eruptions in the recent past. Some ground measurements by an European network have been published (Masson et al. 2011 [Q555]) of four radionuclides: ^{131}I, ^{134}Cs + ^{137}Cs and ^{132}Te. In the USA the deposition of ^{131}I, ^{134}Cs and ^{137}Cs has been measured at some places (Gay et al. 2012 [Q557]). The importance of global precipitation data to assess wet deposition of radionuclides is addressed by Becker et al. 2011 [Q556].

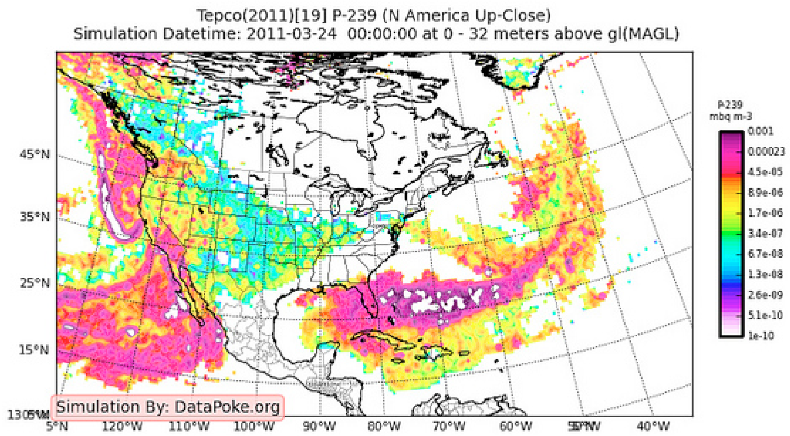

Figure 4

Dispersion of Pu-239 released during the first 100 hours of the Fukushima disaster. Modeling based on a leaked TEPCO document, suggesting the release of 1.2 TBq Pu (Pu-238, Pu-239, Pu-240 and Pu-241 collectively) and 76 TBq Np-239. Source: DataPoke 2011a [Q506a]. No validation of this map and other maps made by DataPoke took place due to the absence of any published physical measurements of the isotopes modeled, according to DataPoke.

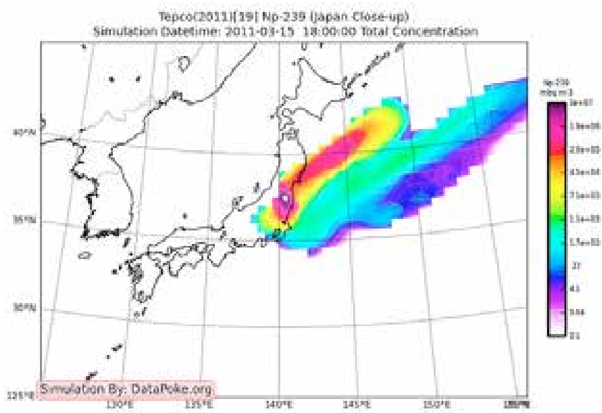

Figure 5

Dispersion of Np-239 released during the first 100 hours of the Fukushima disaster, on March 15, 2011. Source: Datapoke 2011d [Q506d]. See also caption of Figure 40. This modeling shows that a considerable part of Japan likely may have been contaminated with significant concentrations of neptunium-239. With a halflife of 2.5 days this nuclide transforms into plutonium-239

The maps of dispersion of radionuclides from Fukushima persuasively show how far-reaching the consequences are of a large nuclear accident can be. In addition to the contamination of the Pacific by the discharges of radioactive waste water, considerable parts of the Northern Hemisphere are contaminated by almost any kind of radionuclides. As the maps of DataPoke show, even non-volatile nuclides as plutonium and neptunium are dispersed worldwide via aerosols. Plutonium has been detected in the USA. In view of the chemical properties of Pu and Np, it may be expected that these radionuclides will end up in soil, groundwater and sea within a short period and so may enter the food chain.

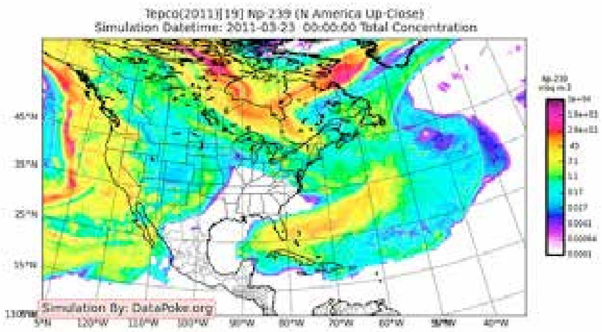

Figure 6

Dispersion of Np-239 released during the first 100 hours of the Fukushima disaster, on March 26, 2011. Source: Datapoke 2011d [Q506d]. See also caption of Figure 4. This modeling shows that even non-volatile radionuclides can be dispersed over large distances as aerosols.

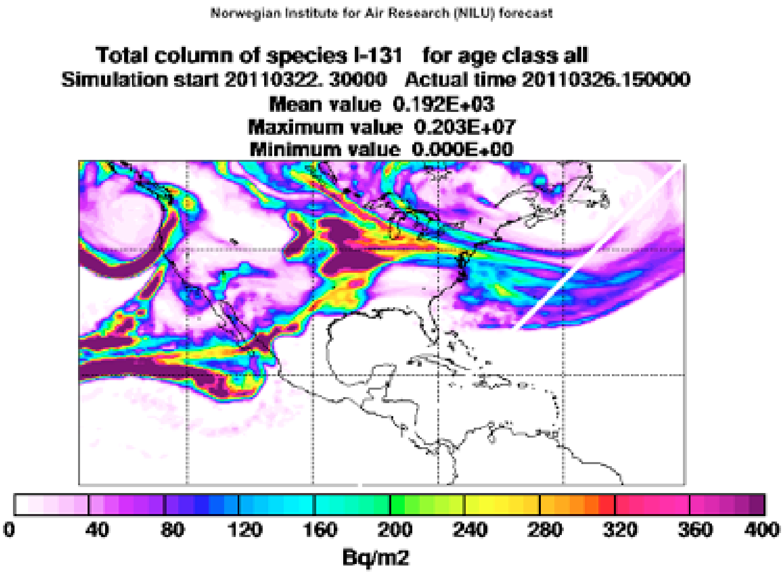

Figure 7

Map of the dispersion of iodine-131 on March 26, 2011, after the Fukushima metldowns. Source: Norsk institutt for luftforskning (NILU) [Q508],

“These products are highly uncertain based on limited information for the source terms. Please use with caution and understand that the values are likely to change once we obtain more information on the overall nature of the accident.”

On May 13 2011 NILU ended the forecasts with the statement:

> “Thank you for your interest in the FLEXPART products for Fukushima. The Forecast system is no longer running. We have discontinued our Flexpart forecast of the atmospheric dispersal of radionucleides from Fukushima. This due to

the fact that we do not have access to reliable release rates reflecting the current situation at the plant to be used as input to our simulations. It is likely that the release of radioactive material is significantly reduced compared to the initial period, and that levels no longer pose a health risk at distance from the plant." (http://transport.nilu.no/products/fukushima/, retrieved 2012-10-20).

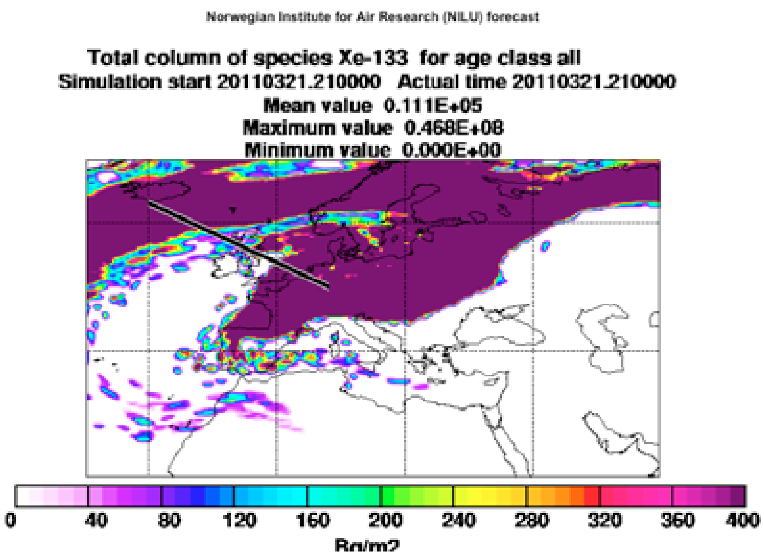

Figure 8

Map of the dispersion of xenon-133 on March 21, 2011, after the Fukushima metldowns. Source: Norsk institutt for luftforskning (NILU 2011 [Q508].

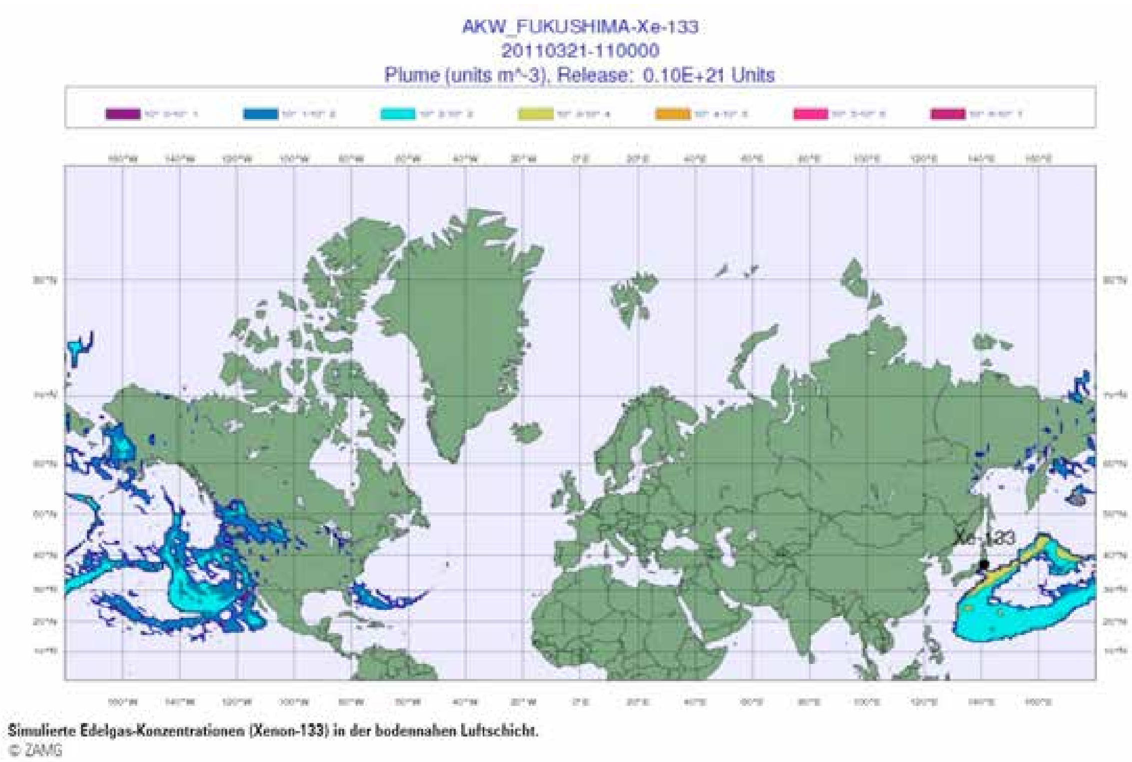

Figure 9

Map of dispersion of Xe-133 from Fukushima Daiichi on 23 March 2011. Source: ZAMG 2012 [Q504].

At large distances from Fukushime the deposition of the radionuclides generally will have low levels, but hot spots may be possible. A number of radionuclides tend to cumulate in the food chain, so a relatively high exposure may occur. In the contaminated areas many different kinds of radionuclides will be present in drinking water, food and fish for very long times. Actually the exposure to radionuclides will be chronic. The health effects of chronic exposure to even very low doses are poorly understood. The studies KiKK 2007 [Q392] and Geocap 2012 [Q494] prove that these health effects are very well observable by means of epidemiological investigations and that these effects cannot be explained by the radiological models employed by the nuclear institutions and nuclear industry.

Plutonium and neptunium

Plutonium and neptunium are actinides formed from uranium by absorption of neutrons released by fission of fissile nuclei in the reactor core. Plutonium-239 is formed from uranium-238 via neptunium-239 by neutron capture and beta emission. Plutonium-239 is converted into higher isotopes, mainly ^{240}Pu and ^{241}Pu, by capture of more neutrons, and from these heavy Pu-isotopes higher actinides are formed, such as americium and curium. Via complex nuclear reactions also ^{238}Pu comes into being in an operating reactor.

In addition to the short-lived neptunium isotope ^{239}Np (halflife 2.35 days) sizeable quantities of the long-lived isotope ^{237}Np (halflife 2.14 million years) are formed, mainly by neutron capture of ^{235}U and decay of americium-241.

In spent fuel the chemically reactive Np and Pu radionuclides are present as oxides, comparable with uranium oxide, and are non-volatile. During the first days of the Fukushima accident large amounts of neptunium and plutonium have been blown into the air as aerosols by the hydrogen explosions and steam eruptions. Massive, but unknown amounts of actinides have been washed, and are still being washed, into the sea by emergency cooling water.

From the maps of Datapoke (Figures 4, 5 and 6) follows that the aerosols with all isotopes of plutonium and neptunium can be dispersed over intercontinental distances. Likely a part of Japan has suffered from a large deposition of neptunium. The short-lived isotope ^{239}Np has been decayed to ^{239}Pu in a matter of weeks. The long-lived isotope ^{237}Np stays in the soil after deposition and decays slowly to hazardous decay products. Actinides like plutonium and neptunium are bone seekers after ingestion: they tend to accumulate in the bone marrow. Their alpha radiation is extremely damaging in living tissue.

3 Released radionuclides

This chapter has a somewhat patchy structure, for it comprises discussions of and quotes from a number of different reports.

Rosen 2012a [Q558] gives a table of released nuclides.
According to the IAEA the total amount of fission products 840 PBq.

According to Zheng et al. 2012 [Q577] the amount of ^{239}Pu + ^{240}Pu released during the Fukushima accident was 6.4 GBq.
From this statement follows that the total activity of released alpha emitters must be a multiple of this amount, for if ^{239}Pu + ^{240}Pu are released, other plutonium isotopes and other actinides are released too.

Report WHO 2012

Rosen 2012b [Q560] analysed the report "*Preliminary dose estimation from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami*" published by the World Health Organization (WHO 2012 [Q609]). Releases from four institutes are listed in Table 1.

Table 1

Radioactivity releases at Fukushima Daiichi

nuclide	reference	quantity (Pbq)	remarks
^{133}Xe	WHO	11300	during first 6 days
	NILU	16700	conservative calculation, 12 March-20 April
			largest release in history, more than 2x Chernobyl
	TEPCO	22300	12 March-15 March
^{131}I	WHO	1240-1590	between 12 March and 6 April
	ZAMG	3600-3900	12 - 14 March, roughly 20% of total release from Chernobyl
	TEPCO	3190	12-15 March
^{137}Cs	WHO	9.7-15.3 PBq	between 12 March and 6 April
	ZAMG	50	12 - 14 March
	NILU	35.8	12 March-20 April 40-60% of Chernobyl
	TEPCO	30.3	12-15 March

WHO: WHO 2012 [Q609]

NILU: Stohl et al. 2011 [Q507] NILU = Norwegian Institute for Air Research (Kjeller, Norway)

ZAMG: ZAMG 2011 [Q611]

TEPCO: TEPCO 2011 [Q612]

The WHO report bases its figures of the source term (Annex 4 of the WHO report) on Bannai 2011 [Q613] and Chino et al. 2011 [Q614]. The report gives no reason why their estimates of radionuclides emissions are much lower than the TEPCO, NILU and ZAMG estimates.

Report IRSN 2012

Radioactive releases according to IRSN 2012 [Q563]:

- Radioactive noble gases, mainly ^{131}Xe, 6550 PBq same order of magnitude as Chernobyl
- Radioiodine: 408 Pbq (about 10% of Chernobyl): 197 PBq ^{131}I + 168 PBq ^{132}I
  [remark SvL: 197 + 168 = 365, difference Δ = 43 PBq, does this amount refer to ^{129}I ?]
- Radioactive tellurium: 145 PBq, including 108 PBq ^{132}Te with its decay product ^{132}I, and 12 PBq ^{129m}Te with its decay product ^{129}Te (initial release ^{129}Te estimated at 8 PBq)
  [remark Svl: 108 + 12 = 120, difference Δ = 25 PBq, what about ^{129}I ?]
- Radioactive cesium: 58 PBq (about 1/3 of Chernobyl), including 21 PBq of ^{137}Cs, 28 PBq of ^{134}Cs and 9,8 PBq of ^{136}Cs

The other radionuclides released (38) were estimated to represent a total activity of 29 PBq, less than 0.5% of all radioactive substances released. Only some of these radionuclides have actually been detected, in a low quantity, in the Japanese environment. In particular, plutonium released during the accident (attested by its isotopic composition) was measured in the deposits formed in the northwest of the Fukushima Daiichi plant, but at very low levels, difficult to distinguish from the plutonium from fallout in the atmosphere produced by nuclear weapons testing.

The main releases occurred from 12 to 25 March 2011, in about fifteen events, with the most important releases taking place before 17 March.
IRSN modelled the atmoapheric dispersion of the releases of radioactivity during these events. During the first events the radioactivity was mainly dispersed over the Pacific. During later events the meteorological conditions had changed and large plumes were blown over land.

Based on the analysis of a soil sample taken from Iitate Maeta, located approximately thirty kilometres northwest of the Fukushima Daiichi plant (samples provided by ACRO), IRSN was able to reconstruct the isotopic composition of the deposition in this area, for its presumed date of formation (15 March 2011).

Dry deposits of aerosols are formed on all surfaces, wet deposits are formed were precipitstion (rain or snow) was produced during the dispersion of the radioactive plume.
These deposits have had two main consequences:

- a permanent increase in the ambient dose rate due to gamma radiation emitted by the radionuclides contained in the deposits, which progressively decreases over time as a function of the radioactive decay of the radionuclides making up the initial deposit;
- contamination of agricultural products, more or less immediate and more or less longlasting.

Within the first two months the short-lived radionuclides decay to near the detection limit. From 20 May 2011 on, ^{134}Cs + ^{137} Cs were contributing more than 80% of the activity of the residual deposits in Japan (whereas these two only accounted for 9% of initial activity), which explains why the maps of deposits published in Japan only addressed these two radionuclides.

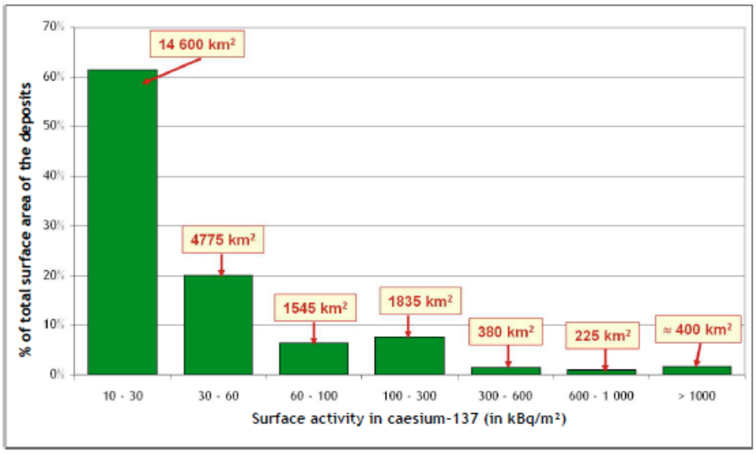

Figure 10
Proportion of surface area affected by the caesium-137 deposits as a function of the amount of these deposits (with the assumption that the deposits in the 9-km zone are the highest). Source: IRSN 2012 [Q563].

The contaminated surface areas in Japan are smaller than those of the contaminated land around Chernobyl, due to the fact that a large portion of the releases from the Fukushima accident dispersed over the Pacific. It is estimated that there are approximately 600 km² of land with a ^{137} Cs deposit greater than 600 kBq/m² in Japan (including the part within the 20-km zone), compared to 13,000 km² around Chernobyl, representing 20 times less surface area. However, in addition to the 80,000 people emergency evacuated from the 20-km zone, the population living in these areas is estimated at approximately 70,000, which together represents more than half of the population in the most contaminated areas around Chernobyl (270,000 people in the areas with ^{137} Cs deposits of greater than 555 kBq/m²).

The deposition in the contaminated areas is highly heterogenous regarding both the activity level (which may vary by a factor of 10 locally) and the isotopic composition.

IRSN mentions a number of analyses of foodstuffs done at different moments after the disaster. From the report does not follow a picture of coordinated actions and no mention is made of systematic long-term monitoring programmes.

Evidently, radioactive pollution in the sea caused by the Fukushima Daiichi has also an impact on marine species. Even if the cesium contamination in the sea water has fallen sharply in the vicinity of the Fukushima Daiichi power plant, there is justification for continuing to monitor the marine species fished from the coastal waters of northeast Japan. Much radionuclides have accumulated in the sediments and in marine organisms.

Information on ^{129}I is missing completely from IRSN 2012 Q563 report even in context with ^{129}Te.

Data not published

It is not known if the deposition in Japan of radionuclides other than ^{137}Cs has been measured and is being monitored and if so, if results are published.

- Why no reports on iodine-129, ^{129}I ?

If the short-lived isotope ^{131}I is prresent, the long-lived isotope ^{129}I is also present.
If tellurium-132 ^{132}Te is present, the isotope ^{129m}Te is also present and consequently also ^{129}I.
Does the nuclear world consider iodine-129 harmless because of its long half-life and consequently low specific acitiviy?

- Are the models used to assess the health hazards of released radionuclides based only on externally measurable radiation, so gamma radiation? Is that the reason why ^{129}I, ^{3}H and ^{14}C and other alpha and beta emitters are not included in the assessments? Apparently the models do not include the biological behaviour of radionuclides

- What is known on the biological behaviour of the radioisotopes of selenium (^{79}Se), tellurium, Te, and technetium, Tc ? Selenium-79 accumulates in kidneys and pancreas.

Are the depositions of these radionuclides being investigated and monitored?

- If the radionuclides ^{137}Cs, ^{131}I, ^{133}Xe, ^{239}Np and ^{239}Pu can be dispersed worldwide, other radionuclides can be as well. A considerable number of biologically dangerous radionuclides escaping from the destroyed reactors and fuel pool at Fukushima cannot be detected by commonly used radiation counters. Massive amounts of these radionuclides must have been released into the environment and they rapidly enter the food chain.

How large is the deposition of these nuclides? And how are they monitored?
How long will the exposure of the local people to these radionucides last?

- What is known about the deposition of still other radionuclides from the reactors? What are the pathways along which they can enter the human body. What are the consequences?

- What is known about the bioaccumulation of all radionuclides dispersed into the atmosphere and into the sea, including the hardly detectable, but nevertheless hazardous radionuclides?

4 Health effects of the Fukushima catastrophe

Note The numbers in the quotes in the following text refer to references in the original texts.

As with Chernobyl, the published reports give a fragmentary picture of the effects of the disaster,, not only the health effects, but social and economic effects as well.
There exist large uncertainties:
one of them the amount of radioactive material dispersed: widely different figures in published reports,
secondly the dispersion patterns of the radionuclides are
thirdly only a few radionuclides are actually measured.

Obviously the health effects of the radioactive contamination resulting from the Fukushima disaster have also long incubation times, like any exposure to radioactivity as pointed out in Chapter 1. In case of acute radiation syndrome (ARS), caused by extremely high radiation doses, the effects become noticeable within hours to days. The impact of the disaster on the health of the people living in the contaminated regions, exposed chronically to 'low' doses, has yet to become observable.

A major part of the radionuclides released during the accident are washed into the sea, so for many years to come the consumption of seafood might pose significant health hazards.

There are uncertainties with regard to the contamination of land areas: where, how much and which radionuclides. How complete were and are the surveys? In addition the pathways of ingestion of radionuclides are not well understood. What are the effects of bioaccumulation?
In view of the massive amounts of radioactivity released during the accident and thereafter, some fear the consequences of Fukushima may become as severe as Chernobyl, or even worse. Health consequences are becoming observable and should be monitored and documented over the next decades.

Report Rosen 2012a

Rosen 2012a [Q558]: "200,000 people were forced to leave their homes as a 20 km2 zone around the plant was evacuated indefinitely. 70,000 people remained in more than 870 km² of highly contaminated land outside of the evacuation zone, where they were exposed to an external radioactivity 100 times higher than the normal background radiation in the first year after the catastrophe."
"Not taken intoconsideration at all are the effects of internal radiation through ingestion or inhalation of radioisotopes, which may cause diseases similar to those occurring in the liquidators of the Chernobyl accident."
"As no estimates exist regarding the total amount of internal radiation exposure through ingestion or inhalation and as the amount of radiation discharged from the Fukushima plant continues to rise (according to TEPCO, atmospheric emissions of radioactive caesium still occurred at 1,440 MBq/h on January 27th, 2012), calculations of expected cancer cases or deaths are not possible at this stage."
"Large-scale epidemiological studies are needed in order to better understand the effects of internal low-level radiation and to estimate the extent of health effects in the coming decades and possibly even for future generations. It is important that these studies are undertaken by independent researchers and not by organizations with the aim to promote nuclear energy, such as the IAEA.**
It is too early and too little data exists in order to estimate the extent of health effects caused by the nuclear disaster. Large-scale epidemiological studies are required in order to determine the effect and the extent of health consequences for the population. It is important that this research is performed by independent groups not associated with the nuclear industry, such as TEPCO, JAEA, the IAEA or affiliated organizations."

"Considering the victims of this disaster, the claim by several government advisers in Fukushima that the nuclear catastrophe will have little to no effect on people's health is not only unscientific but also deeply immoral."

Soil contamination

The nuclear fallout included different types of radioactive particles, each with its own characteristics. The Japanese Ministry of Science and Technology (MEXT) conducted soil surveys in 100 locations within 80 km of the Fukushima power plant in June and July of 2011. In the entire prefecture, they found contamination with various radioactive substances. While the list of radioactive isotopes released during the meltdowns included more than 30 (see previous chapter), the most well-known for causing damage to human tissue are the following:

Strontium-90: Strontium-90 with a physical half-life of 28 years is a beta-emitting radioactive particle. Upon ingestion, it is metabolized similar to calcium. This means that it is incorporated
into the bone, where it can remain for many decades (biological half-life of 50 years). In the bone, strontium irradiates the sensible blood-producing bone-marrow and can cause leukemia and other malignant diseases of the blood.23

Iodine-131: This radioisotope has a relatively short half-life of 8 days. If ingested, it behaves like normal iodine and is incorporated into the thyroid gland. Here, it damages surrounding tissue with beta- and gamma-radiation until its full decay, causing thyroid cancer, especially in
children.25

Caesium-137: This radioisotope has a half live of 30 years. Upon ingestion, it is metabolized similar to potassium. This means that it is fairly evenly distributed in the body. Caesium is mainly a beta-emitter, but its decay product barium-137m also produces gamma-radiation. It can cause solid tumors in virtually all organs. Caesium-137 has a biological half-life of 70 days and is secreted through urine similar to potassium. It therefore accumulates in the bladder, where it can cause irradiation of the adjacent uterus and fetus in pregnant women.29

Notes 23, 25 and 29 = "Toxicological Profile Information", Agency for Toxic Substances & Disease Registry www.atsdr.cdc.gov

Table 2
Effective half-lives of three radioactive isotopes [34]

isotope	physical halflife	biological halflife	effective halflife
I-131	8 days	80 days	7.3 days
Cs-137	30 years	70 days	70 days
Sr-90	28 years	50 years	18 years

Note 34 = "Table D-2 – Half-Lives of Some Radionuclides in Adult Body Organs" in "Toxicological Profile Information Appendix D. Overview of basic radioation physics, chemistry, and biology", Agency for Toxic Substances & Disease Registry. www.atsdr.cdc.gov/toxprofiles/tp159-a.pdf

Contamination of the marine environment

Massive amounts of water were used in a desperate attempt to cool the reactors and the burning spent fuel ponds. This led to equally large amounts of radioactive waste water, which was continually discharged into the sea, seeped into soil and ground-water deposits or evaporated into the atmosphere.

The waters north-east of the Fukushima plant are amongst the busiest fishing zones in the world. Half of

Japan's sea-food comes from this area. Fish and other marine animals in Ibaraki prefecture showed elevated levels of radioactive isotopes and had to be treated as radioactive waste.
Due to the spread of radioactive contamination in the Pacific Ocean, more people are potentially affected, as there is no safe minimum threshold for radioactivity.50 Secondly, the trophic cascade leads to an accumulation of radioactivity in fish higher up the food chain, which are then eaten by humans.

Effects on food and drinking water
As stated above, there is no safe level of radioactivity in food and drinking water. Potentially, even the slightest amount of radioactivity can cause genetic mutation and cancer.52 According to the German Society for Radiation Protection, it is estimated that a person is normally exposed to about 0.3 mSv per year through ingestion of food and drink. This should be considered the permissible level of ingested radioactivity in order to prevent excessive health risks. In order not to surpass this level, the amount of radioactive caesium-137 should not exceed 8 Bq/kg in milk and baby formula and 16 Bq/kg in all other foodstuff. Radioactive iodine with its short half-life should not be permitted in food at all.53 In Japan however, the permissible level of radioactive caesium in milk and baby formula was set at 200 Bq/kg and 500 Bq/kg for all other foodstuff. For radioactive iodine, the permissible level was set at 300 Bq/kg for milk and drinking water and 2,000 Bq/kg for vegetables.54, 55 The Fukushima nuclear meltdowns caused a major contamination of food and drink in Japan. According to the IAEA, nearly all vegetable and milk samples taken in Ibaraki and Fukushima prefectures one week after the earthquake revealed levels of iodine-131 and caesium-137 exceeding the radioactivity limits set for food and drink in Japan.56 In the months after the catastrophe, contamination was found to be even higher in certain foods:

Japanese government samples found vegetables from Iitate highly contaminated with more than 2,500,000 Bq/kg of iodine-131 and more than 2,600,000 Bq/kg of caesium-137.75 Drinking water was found to contain 965 Bq/l.76 No epidemiological data has yet been published on the observed health effects of the Iitate population (birth statistics, morbidity, etc.).

Inhabitants of contaminated areas: Following the nuclear meltdowns, the government ordered 200,000 people to evacuate their homes as an area of about 600 km² around the plant was deemed to be uninhabitable due to radioactive fallout.82 About 70,000 people, including 9,500 children were still living in highly contaminated areas outside of this evacuation zone two months after the Fukushima meltdowns.83

Radiation levels between 16-115 µSv/h were measured outside of the 20 km evacuation zone by the IAEA radiation monitoring team.84 The IAEA's conservative extrapolations from these soil samples calculate the total dose of beta-radiation in the area of 30-32 km from the plant to be 3,800,000-4,900,000 Bq/m².85

The IRSN projected the external exposure of the 70,000 people living in the highly contaminated areas outside of the 20 km evacuation zone can reach up to 200 mSv in the first year and up to 4 Sv over the course of a lifetime, not including additional radioactive exposure through ingestion of contaminated food, air or water.
… an adult eating 500g of food contaminated with 100,000 Bq/kg of iodine-131 and 900,000 Bq/kg of caesium-137 would be exposed to about 34,8 mSv. As stated above, the normal exposure to internal radioactivity through food per year is 0.3 mSv.97 Eating just 500g of this contaminated food would cause an internal radiation exposure of more than 100 times the normal exposure per year. For a child of 1-14 years, the internal radiation exposure would be double that of an adult and for toddlers and fetuses, the impact of radioactively contaminated food is even more harmful …

As stated before, the greatest health effects of radiation are seen in children. They have a higher surface area, a more permeable skin, their immune systems are not yet fully developed, they breathe in more air per minute than adults, the metabolism of their tissues is higher and their habits like playing on or eating from the ground lead to a higher exposure to radiation. In the womb, the unborn child receives radioactive isotopes through the umbilical vein and is irradiated by gamma-radiation from isotopes collected in the bladder. Radioactive isotopes like iodine-131 are also transmitted through breast-milk.

Not a single epidemiological study on the health effects of the Fukushima nuclear catastrophe has yet been published in a peer-reviewed journal. Except for the unpublished small studies cited above, there is no scientific data to ascertain the extent to which the people of the affected regions will be affected.

As no estimates exist regarding the total amount of internal radiation exposure through ingestion or inhalation and as the amount of radiation discharged from the Fukushima plant continues to rise (according to TEPCO, atmospheric emissions of radioactive caesium still occurred at 1,440 MBq/h on January 27th, 2012)112, calculations of expected cancer cases or deaths are not possible at this stage.

Ultimately, no proper estimates can be made on the basis of the existing data. Large-scale epidemiological studies are needed in order to better understand the effects of internal low-level radiation and to estimate the extent of health effects in the coming decades and possibly even for future generations. It is important that these studies are undertaken by independent researchers and not by organizations with the aim to promote nuclear energy, such as the IAEA.**
Also, latency periods of malignant diseases have to be considered in order to get a complete picture of the health impacts. Considering the victims of this disaster, the claim by several government advisers in Fukushima that the nuclear catastrophe will have little to no effect on people's health is not only unscientific but also deeply immoral.

5 Critical analysis of the WHO and UNSCEAR reports

Report WHO 2013b

In its news release of 28 February 2013 the World Health Organization (WHO 2013b [Q554]) states:

> A comprehensive assessment by international experts on the health risks associated with the Fukushima Daiichi nuclear power plant (NPP) disaster in Japan has concluded that, for the general population inside and outside of Japan, the predicted risks are low and no observable increases in cancer rates above baseline rates are anticipated.

and:

> … the radiation doses from the damaged nuclear power plant are not expected to cause an increase in the incidence of miscarriages, stillbirths and other physical and mental conditions that can affect babies born after the accident.

and:

> A breakdown of data, …, does show a higher cancer risk for those located in the most contaminated parts. Outside these parts - even in locations inside Fukushima Prefecture - no observable increases in cancer incidence are expected.

and:

> "The WHO report underlines the need for long-term health monitoring of those who are at high risk, along with the provision of necessary medical follow-up and support services,"

With regard to the report this news release is based on (WHO 2013a Q553), the WHO states:

> This is the first-ever analysis of the global health effects due to radiation exposure after the Fukushima NPP accident and is the result of a two-year WHO-led process of analysis of estimated doses and their potential health implications. The independent scientific experts came from the fields of radiation risk modelling, epidemiology, dosimetry, radiation effects and public health.

On 31 May 2013 the UN Information Service published a press release stating:

> *"Radiation exposure following the nuclear accident at Fukushima-Daiichi did not cause any immediate health effects. It is unlikely to be able to attribute any health effects in the future among the general public and the vast majority of workers," concluded the 60 th session of the Vienna-based United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR).*

Report Rosen 2012b

Rosen 2012b [Q560] critically analysed the WHO rteports. See also Table 1.

What is the report WHO 2012 [Q609] not saying?

- Misleading information about the cause of the nuclear catastrophe (see section ###)

- Radiation exposures disregarded by the expert panel.

NAIIC 2012a Q496 states:

> "The central government was not only slow in informing municipal governments about the nuclear power plant accident, but also failed to convey the severity of the accident. (...) Specifically, only 20 percent of the residents of the town hosting the plant knew about the accident when evacuation from the 3km zone was ordered at 21:23 on the evening of March 11. Most residents within 10km of the plant learned about the accident when the evacuation order was issued at 5:44 on March 12, more than 12 hours after the Article 15 notification—but received no further explanation of the accident or evacuation directions. Many residents had to flee with only the barest necessities and were forced to move multiple times or to areas with high radiation levels. (...) Some people evacuated to areas with high levels of radiation and were then neglected, receiving no further evacuation orders until April."15

- Lack of differentiation between adults, children and infants below the age of one

The fact that is the children who suffer the most from radiation-induced effects, as can be seen from the results of the Chernobyl studies, is simply omitted in the report and adults, children and even infants pressed into a single estimated dose range.

- Uncritical view of the inadequate response to the nuclear catastrophe

The report acknowledges certain protective actions taken by the Japanese authorities in order to decrease the exposure of the population to radioactivity. No mention is made, however, of the many concrete actions by the Japanese authorities that have led to higher exposure. Ignoring the data of the System for Predicting Environmental Emergency Dose Information (SPEEDI) system, which could have been readily available to the responsible authorities, people were evacuated from areas of lower risk to highly contaminated regions.18

- Omission of the fact that there is no lower threshold for radioactivity-induced cancer

After the accident, the government unilaterally announced a benchmark on dosage without giving the specific information that residents needed, including answers to questions like: What is a tolerable level of exposure inlight of long-term health effects? How do health implications differ for individuals? How canpeople protect themselves from radioactive substances?"26

- Selective food sampling

Because of these inadequacies of the choice and analysis of food samples, it is not permissible to extrapolate the contamination levels found in the limited number of samples cited in the WHO report in order to calculate internal radiation exposure for large populations.

Omission of the effects of radioactively contaminated tap water

- Missing data on radioactive contamination of fish and sea-food

- No mention of ongoing problems in the Fukushima reactors

Omission of critical thyroid studies
As iodine-131 has an effective half-life of 7.3 days, this decay is, in fact, highly significant: at the time of monitoring (March 24th-30th), less than 50% of the initial amount of radioactive iodine-131 will have been left to be detected by radiometry. The rest will already have disintegrated, causing damage to the surrounding tissue through radioactive decay.

- Treatment of affected population as study subjects

3. Who wrote the report?
The report was compiled by a panel of 30 international experts, who, according to the report, have listed no competing interests.
...
While some of the panel members are well-known spokespersons for nuclear energy and work for the IAEA, an organization which has declared the promotion of nuclear energy its core mission, not a single scientist who has published critical articles on the health effects of nuclear energy was included in the panel. Radiobiologists who have warned of the long-term effects of internal radiation were not included in the panel, nor oncologists specializing in the connection between radiation and cancer. The findings of the independent Japanese Citizen's Radioactivity Measuring Station were not taken into account or even given mention.

The Japanese parliament's Investigation Commission (NAIIC 2012a Q496) called the accident a "manmade" disaster:

> "The TEPCO Fukushima Nuclear Power Plant accident was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties. They effectively betrayed the nation's right to be safe from nuclear accidents. Therefore, we conclude that the accident was clearly "manmade." We believe that the root causes were the organizational and regulatory systems that supported faulty rationales for decisions and actions, rather than issues relating to the competency of any specific individual."

The fact that members of the Japanese nuclear regulatory bodies played a role in drafting the WHO report does not raise confidence in its neutral and impartial character.

Conclusion
... With an expert panel mainly comprised of IAEA staff and members of nuclear regulatory bodies accused of collusion with the nuclear industry, and with findings that differ so significantly from other, independent research publications, the report reads more like an effort to downplay the effects of the nuclear catastrophe than like a meaningful scientific approach to the issue of radiation exposure in Fukushima. It is unclear why a report written mainly by the IAEA and collaborating nuclear institutions would need to be published in the name of the WHO if not to provide an unsuspicious cover.

Report NAIIC 2012a

Quotes from NAIIC 2012a [Q496]:
"The regulators did not monitor or supervise nuclear safety. The lack of expertise resulted in "regulatory capture," and the postponement of the implementation of relevant regulations. They avoided their direct responsibilities by letting operators apply regulations on a voluntary basis. Their independence from the political arena, the ministries promoting nuclear energy, and the operators was a mockery. They were incapable, and lacked the expertise and the commitment to assure the safety of nuclear power."

"The Commission recognizes that the residents in the affected area are still struggling from the effects of the accident. They continue to face grave concerns, including the health effects of radiation exposure, displacement, the dissolution of families, disruption of their lives and lifestyles and the contamination of vast areas of the environment. There is no foreseeable end to the decontamination and restoration activities that are essential for rebuilding communities."57

Report Rosen 2013

Rosen 2013 [Q561]: On February 28th, 2013, the World Health Organization (WHO) published its „Health risk assessment from the nuclear accident after the 2011 Great East Japan earthquake and tsunami". This report (WHO 2013a [Q553]) concluded that "for the general population inside and outside of Japan, the predicted risks are low and no observable increases in cancer rates above baseline rates are anticipated."[1] The assessment is based on preliminary dose estimations, published by the WHO in May 2012 [2], which were severely criticized by the German Section of IPPNW, independent researchers and Japanese ci]vil organizations. [3] This analysis discusses the eight main objections to the current WHO report and shows why it should not be considered a neutral scientific assessment of the actual health risks of the affected population, nor a valid basis for future decisions and recommendations.

1. The report is based on faulty assumptions

...

An assessment that relies on data, whose validity has to be questioned on the grounds of lacking neutrality, selective sampling, distortion and omission of relevant facts, cannot be accepted by the scientific community as a basis on which to make health recommendations.

2. The report ignores the health risks for people outside of Fukushima

...

As the health effects of low-dose radiation are stochastic in nature and as the generally accepted tool for calculating cancer risk is the linear nonthreshold (LNT) model, the exposure of a small population with a high amount of radioactivity can have the similar results in absolute numbers of cancer cases, as the exposure of a large population with a relatively small amount of radioactivity. While the effects by small amounts of low-dose radiation on large populations are generally more difficult to detect in epidemiologic studies, discounting them altogether disregards a large amount of cases in absolute numbers and can only be seen as an attempt to downplay the expected health effects of the nuclear catastrophe.

...

As many of the critical food samples and findings were not included in the original dose assessment, the importance of contaminated sea-food for the general public outside of Fukushima prefecture has not been properly accounted for in the current WHO report.

3. Continued radioactive emissions were not included in the assessment

The WHO report treats the nuclear catastrophe of Fukushima as a singular event and does not take into consideration continued emissions of radioactivity after the initial nuclear meltdowns in March 2011.

...

Similarly, the WHO report includes vegetable samples containing 2,200 Bq/kg of iodine-131 in month three of the catastrophe – further evidence for continued emissions of radioactive iodine after the initial explosions,12 most probably due to spontaneous fission or recriticality in one or several of the reactors. Beside iodine-131, other radioactive particles were also emitted continually for many months.

...

In Southern Germany, radioactive caesium-137 contained in mushrooms and wild boar still poses a health threat, even 25 years after the Chernobyl disaster.15 16

4. The report ignores the increased radiosensitivity of the unborn child

The authors of the report claim that the estimated dose levels of the population affected by the Fukushima catastrophe were too low to affect fetal development, and therefore excluded the possibility of miscarriages, increased perinatal mortality, congenital defects or cognitive impairments due to in utero exposure.17

...

How studies on the survivors of the mostly external radioactive exposure of the nuclear bombs, without any scientific knowledge from the first five years, including no records of miscarriages, neonatal mortality or congenital defects, could be transferred to a scenario where children and fetuses were exposed to mostly internal radioactivity after a nuclear catastrophe is not adequately addressed by the report's authors.

5. Recent clinical findings were not taken into considerations

According to the report, "no clinical conditions have been identified" as a result of the Fukushima nuclear catastrophe.22 Not mentioned in the report are the three cases of thyroid cancers nor the reported increase in infant mortality following the Fukushima nuclear meltdowns. While it is difficult to prove causality and further research is definitely necessary to investigate the extent and the probable cause of these phenomena, omitting them from the report altogether once more throws doubts on the report's neutrality.

6. Non-cancer diseases are not included in the health risk calculations

Non-cancer health effects, such as cardiovascular diseases (CVD), infertility or thyroid disease were not assessed quantitatively in the report. Furthermore, the possibility of such effects occurring as a result of the Fukushima nuclear catastrophe was disregarded altogether.29The authors assumed that only high levels of radioactivity could lead to such effects, discounting the research on the effects of low-dose radiation.30 31

7. The report relies solely on TEPCO's own data to assess workers' health risk

The WHO report also comments on the health risks of TEPCO workers and contractors due to exposure to radioactivity. Since the report bases its assumptions solely on measurements provided by TEPCO itself,xxxv these estimates cannot be considered adequate assessments of the workers' health risks, especially after reports of misleading information, falsified dosimetry readings and other irregularities have severely compromised the validity of the TEPCO data.32 33

8. The authors' neutrality has to be doubted

It remains unclear why a report, written mainly by the IAEA and collaborating nuclear institutions, would need to be published in the name of the WHO.

In order to understand why the WHO has to rely so heavily on experts from the nuclear sector, it has to be reiterated at this point that the WHO is subordinate in questions of nuclear safety to the IAEA. According to Articles 1.3. and 3.1. of the "Agreement between the IAEA and the WHO" from 1959, the WHO is bound by agreement not to publish anything concerning radiation without consent by the IAEA.36 The IAEA, however, was founded with the specific mission to "promote safe, secure and peaceful nuclear technologies" and to "accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world."37 With these motives, the IAEA and its national member organizations cannot be seen as impartial voices on nuclear energy. The influence of the IAEA on the work of the WHO has therefore rightly been criticized for obstructing independent research on the health effects of nuclear radiation.

Conclusion

As doctors and scientists, we are fully aware of the difficulties in calculating comprehensive health risks of a large catastrophe for such a large population and know of the problems that naturally arise in such an attempt.

- It is extremely important to base calculations such as these on reliable and valid data, which has been approved by a scientific consensus either through an impartial expert panel composed of scientists with contrary views, or through a critical peer review process.
- The possibility of a manipulation of data by a group, organization or industry with vested interests should be avoided at all costs.
- The calculations should encompass the entire population affected by the catastrophe and should give special consideration to groups with heightened vulnerability.
- Clinical findings should be thoroughly assessed and included in the final considerations.

After careful lecture of the WHO's health risk assessment, none of these fundamental principles seem to have been adhered to. The true health risks for the people of Fukushima and Japan remain to be assessed by independent scientific researchers, free of the suspicion of collusion and interference by the nuclear industry and the nuclear regulatory bodies. Attempts by the nuclear lobby, including the IAEA and many of the authors of this current WHO report, to downplay the effects of the continued emission of radioactive isotopes in air, soil and water through dubious risk assessments are to be disregarded by scientists, doctors and politicians, primarily concerned with giving the affected people proper recommendations and support. What is needed is for the WHO to regain its independence in assessing health risks related to radiation and reaffirm its claim to be guided solely by concerns for people's health and not by the interests of a specific industry.

Report UNSCEAR 2013b

Some notable aspects of 12 V.13-85727, A/68/46 (Fukushima) in UNSCEAR 2013b [Q573]:

- In the most carefully-worded statements, probably referring to childhood cancer, probably also to non-targeted and delayed effects, subjects for future programme of work are menstioned.
- Names of KiKK, Geocap and IPPNW reports not mentioned.
- Much emphasis on natural radiation sources and medical applications,
- Nothing said about chronic exposure to Cs-137 (food, water, soil),
- Nothing said about chronic exposure to other radionuclides, e.g Sr-90, H-3, C-14, I-129, Pu, U only I-131 and Cs-137 discussed, nothing about other radionuclides
- No plans of UNSCEAR for large-scale statistical epidemiological survey
- For first (?) time (very cautious) distinction between adults and childern/infants
- Psychological and mental problems emphasized

Quote from page 11/12:

> "No discernible increased incidence of radiation-related health effects are expected among exposed members of the public or their descendants."

Report UNIS 2013

Quote from UNIS 2013 [Q532] the first sentence:

> "Radiation exposure following the nuclear accident at Fukushima-Daiichi did not cause any immediate health effects. It is unlikely to be able to attribute any health effects in the future among the general public and the vast majority of workers," concluded the 60 th session of the Vienna-based United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR).

Report IPPNW 2013

Critique of UNSCEAR report (UNSCEAR 2013b [Q573]) by a large international group of physicians and doctors, including Nobel Peace Prize 1985 laureate IPPNW, IPPNW 2013 [Q574] identified ten critical issues:

1) It was mainly the direction of the wind that prevented a larger catastrophe in Japan

> One single day of wind blowing towards the coast, however, led to a large radioactive trace reaching dozens of kilometers inland from the crippled plant, forcing tens of thousands of people to evacuate from small towns and villages. Fukushima clearly showed that even a highly industrialized country such as Japan is unable to control the inherent dangers of nuclear energy.
>
> ...
>
> We are worried that statements such as "no discernible increased incidence of radiation-related health effects are expected among exposed members" could be understood as an all-clear for nuclear companies and nuclear regulators for future accidents and melt-downs. We are also concerned that the conclusions from the UNSCEAR report could affect radiation safety standards and emergency response guidelines in such a way that would risk higher exposure to future generations.

2) The nuclear catastrophe is ongoing and continues to be a source of radioactivity

> The Fukushima nuclear disaster has to be considered an ongoing catastrophe, which requires constant reevaluation of the cumulative extent of contamination, especially considering the long half-lives of radioisotopes like cesium-137 or strontium-90.
>
> ...
>
> In the long run, these leaks into groundwater and the ocean will lead to an increase in internal exposure in the general population through radioactive isotopes from water and the food chain. This scenario is a realistic assessment, considering that all over Eastern and Central Europe, even in places like Bavaria, radioactive cesium-137 contained in mushrooms and wild game still poses a public health concern, even 25 years after the Chernobyl nuclear meltdown.13, 14

p.7/8 incomprehensible statements concenring source term:

> Kawamura states that "no direct release into the ocean was assumed before March 21st because the monitoring data were not available during this period."18 Also, the calculations of this study do not take into account any atmospheric emissions after April 6th, taking the pragmatic stance that "there is no information on the amounts released into the atmosphere from April 6. It was assumed, therefore, that the radioactive materials were not released into the atmosphere from April 6."19 Most incomprehensibly, however is the fact that all radioactive discharge after April 30th, 2011 is ignored, despite TEPCO's recent revelation that since the beginning of the disaster, about 300 tons of radioactive discharge reached the ocean every day, amounting to a total of about 290,000 tons during the past 31 months. Even Kawamura et al concedes that "it will probably be necessary to estimate the source term on oceanic and atmospheric releases more accurately at some point in the future."20

3) Estimates of radiation emissions and exposure should be based on neutral sources

4) The endorsement of Fukushima produce increases the risk of radioactive exposure

> ... but ignores the overwhelmingly rural character of the affected region, where many people rely on farmer markets and homegrown produce.

...

> Finally, it needs to be recalled that at the beginning of the nuclear catastrophe, residents suffered from shortage of fresh food and water due to the earthquake and the tsunami. During this period, there was no possibility for testing crops for radiation. People may therefore have consumed highly contaminated local food or water before proper testing and regulation came into effect. This fact receives no mention in the UNSCEAR report, and possibly presents an additional source of error in the calculation of internal radiation doses.

5) Whole Body Counters underestimate the extent of radioactive exposure

6) TEPCO's employee dose assessments cannot be relied upon

It is wrong to state that "no discernible increased incidence of radiation-related health effects are expected"[43] among exposed workers. Regarding chronic low-level radiation exposure, numerous studies have been able to show significant health effects in very diverse populations: from uranium miners, [44,45,46,47,48,49] downwinders of nuclear tests,[50,51,52] workers in nuclear factories,[53,54,55,56] people living in the vicinity of power plants,[57] all the way to the liquidators of Chernobyl.[58,59,60,61] In the end, it is a question of study design and strict adherence to the principles of scientific work. In the case of TEPCO, this cannot be assumed, judging from the vast amount of manipulation attempts in the past years.

7) The special vulnerability of the embryo to radiation has to be taken into account

In the scientific community, it is generally accepted that "*in utero exposure to ionizing radiation can be teratogenic, carcinogenic or mutagenic. The effects are directly related to the level of exposure and the stage of fetal development. The fetus is most susceptible to radiation during organogenesis (two to seven weeks after conception) and in the early fetal period.*"[64] Dismissing the physiological differences between an unborn and a grown child leads to a grave underestimation of health risks in this particularly vulnerable population.

8) Thyroid malignancies and other cancers have to be monitored for several decades

The UNSCEAR report to the UN General Assembly suggests that "the apparent increased rates of detection among children in Fukushima Prefecture are unrelated to radiation exposure."[73]

...

In addition to the thyroid ultrasound examination, screenings should be introduced in the coming years for leukemia, lymphomas and solid tumors, all of which have been found in the populations affected by the Chernobyl nuclear catastrophe and around nuclear power plants.[77,78]

9) Monitoring should also occur for non-cancer diseases and genetic radiation effects

Non-cancer health effects such as cardiovascular diseases, infertility, genetic mutations in offspring and miscarriages have been reported in medical literature but are not considered in the WHO/IAEA health assessment, which UNSCEAR bases its calculations on. This report states that prenatal radiation exposure would not increase the incidence of spontaneous abortion, miscarriages, perinatal mortality, congenital defects or cognitive impairment.[79]

...

Also, several Russian authors published studies on the non-cancer effects of radiation on the affected populations after the Chernobyl nuclear catastrophe.[82, 83]

10) Comparisons between nuclear fallout and background radiation are misleading

This natural background radiation is not harmless, as the effects of high exposure to cosmic background radiation (e.g. by frequent transatlantic flights) or high radon levels in homes or local soil on cancer incidence have shown.[85,86,87,88]

Conclusion

"Thus, a discernible increase in cancer incidence in this population that could be attributed to radiation exposure from the accident is not expected."

Using the standard international BEIR-VII dose-risk model, an exposure of a population of 10,000 people with an average of 1 mSv would cause one person to develop cancer as a result – similar to a radiation exposure of a population of 10 people with 1000 mSv, which would also lead to one additional cancer case.[92] As mentioned in the last chapter, the WHO Fukushima health assessment makes a strong case for using a factor twice as high.

To reduce the horrible effects of the Fukushima nuclear disaster on thousands of families to a statistical problem and to dismiss these individual stories of suffering by stating that “no discernible increased incidence of radiation-related health effects are expected among exposed members” seems cynical.

UNSCEAR should present a more realistic picture of what effects people can expect from the radioactive fallout in the coming decades. This should include predictions on thyroid cancer, leukemia, solid tumors, noncancer diseases and genetic defects, all of which have been found in the population affected by the Chernobyl nuclear catastrophe, as well as assessments of the psychological and social impact that the nuclear disaster has had on the entire population. It is important to note in this regard that the psychological repercussions are overwhelmingly due to the social dislocation and breakdown as a consequence of the radioactive contamination and the necessary subsequent evacuations, not due to overblown fears of radiation and the fear and stigma attached, as is oftentimes suggested by the nuclear lobby.

Japan’s success in avoiding power shortages over the more than two years since the disaster, when essentially all nuclear reactors were shut down without any time for preparation, proves that this is feasible.

The absence of both effective cancer registries in most prefectures in Japan and comprehensive registers of exposed persons with dose estimates that can be used to assess long term health outcomes means that a lot of potential impacts could well go undetected. Such registries should be created if it is truly the intention of the government to monitor and address future health effects of the radioactive contamination.

The people of Fukushima are not being helped by claims and reassurances that no health effects are to be expected.

Ultimately, what is at stake is the universal right to a standard of living adequate for the health and well being of the affected population. This should be the guiding principle in evaluating the health effects of the nuclear catastrophe: (quote John F Kennedy, July 26th, 1963).

6 Societal and economic effects of the Fukushima disaster

NAIIC 2012a [Q496]:

> “The Commission recognizes that the residents in the affected area are still struggling from the effects of the accident. They continue to face grave concerns, including the health effects of radiation exposure, displacement, the dissolution of families, disruption of their lives and lifestyles and the contamination of vast areas of the environment. There is no foreseeable end to the decontamination and restoration activities that are essential for rebuilding communities.”

Obviously the socio-economic impact of the Fukushima disaster is extensive. Many tens of thousands of people have been evacuated from their homes, without any prospect of a safe return. Various effects of Fukushima are discussed by Dorfman et al. 2013 [Q288].
Liabilities and compensation claims of the disaster might be measured in hundreds of billions of euros. The cleanup of the site is preliminary estimated at some €250bn (ndreport 2011 [Q524]).
One may wonder if these extreme costs will counterbalance the benefits of nuclear power. Fukushima might be not the last nuclear disaster of its class.

A survey of an important website of the nuclear world (World Nuclear Association WNA) proves that the report NAIIC 2012a [Q496] is not welcome in the nuclear world: there are strikingly few comments. The report seems to be kept dark by the nuclear industry.
How is the situation in Europe, USA, China, India, Korea, Russia?

7 Next disaster in Europe or in the USA?

Taking into account the 7-10-fold higher population density a disaster similar to Chernobyl in Germany would result in 1.7-12 million cancer deaths, the number depending on the assumptions the estimates are based on (IPPNW 2011 [Q452]).

Obviously the consequences of a Chernobyl-like or Fukushima-like explosion in the densely inhabited parts of Western Europe would be disastrous. Imagine a situation in which the fallout from Chernobyl would be deposited a 2000 kilometers more to the West. A major accident in a light-water reactor can lead to radioactive releases equivalent to the release at Chernobyl and about 1000 times the amount released by an exploding fission weapon. Relocation of the population can become necessary for large areas (some 100 000 km^2).

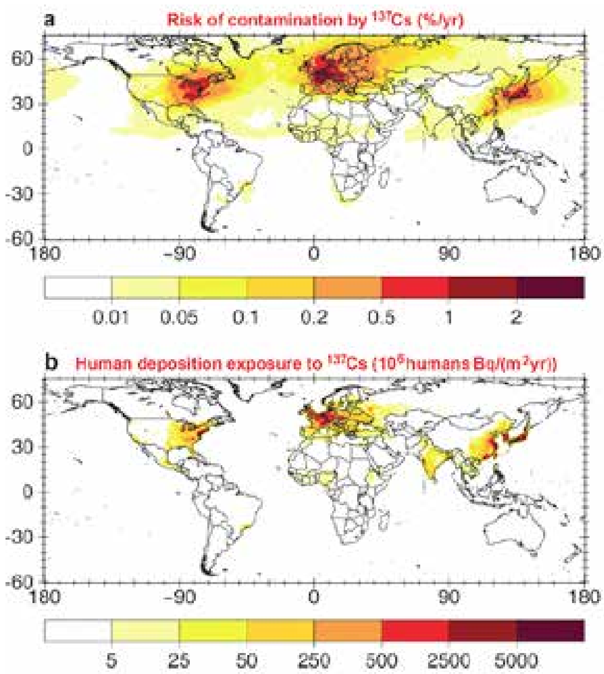

Figure 11

Maps of global risk of radioactive contamination by ^{137}Cs resulting from large nuclear accidents. (a) Based on the modelled deposition of 40 kBq m^{-2} yr^{-1} ^{137}Cs. The risk is the expected value normalized by 40 kBq m^{-2}. (b) Modelled risk of human exposure to ^{137}Cs deposition. An area with a deposition of ≥40 kBq m^{-2} ^{137}Cs is defned as 'contaminated'. Source: Lelieveld et al. 2012 [Q515]. An area with a deposition of more than40 kBq m^{-2} ^{137}Cs is defned as 'contaminated'.

The probability of very large-scale nuclear accidents is much higher than usually estimated. The global risks of contamination with radioactive materials in densily populated regions with a high density of nuclear power plants are mapped by Lelieveld et al. 2012 [Q515]. Based on armospheric circulation models the dispersion of and contamination with Cs-137 and I-131 after a severe accident, similar to Chernobyl, are simulated.

Acoording to the simulations the surface area contaminated by ^{137}Cs above the dangerous level after a single core meltdown incident varies from 102000 -165000 km^2 , depending on the region, and the number of affected people may vary from 3-34 million, again depending on the region (Lelieveld et al. 2012 [Q515]).

How many Chernobyls and Fukushima's do we need to recognise nuclear is not the right choice but a dead end road?

References

Q288
Dorfman et al. 2013
Dorfman P, Fucic A & Thomas S,
Late lessons from Chernobyl, early warnings from Fukushima,
European Environment Agency (EEA),
Part C - Emerging Issues, Chapter 18, February 2013,
‹late lessons II Chapter 18-Late lessons from Chernobyl early warnings from Fukushima.pdf›
http://www.eea.europe.eu/publications/late-lessons-2/part-C-emerging-issues
retrieved 14 February 2013.

Q392
KiKK 2007
Kaatsch P, Spix C, Schmiedel S, Schulze-Rath R, Mergenthaler A & Blettner M,
Epidemiologische Studie zu Kinderkrebs in der Umgebung von Kernkraftwerken
(KiKK-Studie),
Vorhaben StSch 4334 (in German),
Im Auftrag des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherkeit und des Bundesamtes für Strahlenschutz, Germany, 2007,
4334_KiKK_Gesamt_T.pdf
www.bfs.de/de/bfs/druck/Ufoplan/

Q452
IPPNW 2011
Pflugbell S, Paulitz H, Claussen A & Schmitz-Feuerhake I,
Health effects of Chernobyl. 25 years after the reactor catastrophe,
German Affiliate of International Physicians for the Prevention ofr Nuclear War (IPPNW) and Gesellschaft für Stralenschutz (GFS), report, April 2011
http://www.medact.org/content/nuclear/IPPNW%20Germany%20chernob_report_2011_en_web.pdf

Q494
Geocap 2012
Sermage-Faure C, Laurier D, Goujon-Bellec S, Chartier M, Guyot-Goubin A, Rudant J, Hémon D & Clavel J,
Childhood leukemia around French nuclear power plants – The Geocap study, 2002-2007,
International Journal of Cancer, doi: 10.1002/ijc.27425, February 2012,
http://onlinelibrary.wiley.com/doi/10.1002/ijc.27425/pdf
download 5 March 2012.

Q496
NAIIC 2012a
The National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission,
The official report of The Fukushima Nuclear Accident Independent Investigation Commission - Executive summary, July 5, 2012
‹NAIIC_report_hi_res10.pdf›
http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/index.html

Q504
ZAMG 2012
Fukushima, Auswirkungen des Kernkraftwerksunfalls,
Zentralanstalt für Meteorologie und Geodynamik (ZAMG) & Agentur für Gesundheit und Ernährungssicherhet (AGES),
March 2012,
‹20120417_Fukushima_Bericht.pdf›
http://www.zamg.ac.at/cms/de/
download 20121013.

Q505
CEREA 2013
Winiarek V, Bocquet M, Roustan Y, Birman C & Tan P,
Atmospheric dispersion of radionuclides from the Fukushima Daichii nuclear power plant,
Centre d'Enseignement et de Recherche en Environnement Atmospheric (CEREA),
Joint Laboratory of Ecole des Ponts ParisTech & EdF R&D,
updated 30 June 2013.
http://cerea.enpc.fr/fr/fukushima.html
retrieved 12 October 2013, saved as:
‹Modelling the dispersion of Fukushima-Daichii nuclear power plant release.pdf›

Q506a
DataPoke 2011a
Study: Modeling Fukushima NPP Pu-239 and Np-239 Atmospheric Dispersion,
posted October 27, 2011,
http:/www.datapoke.org/blog/89/study-modeling-fukushima-npp-p-239-and-np-239-atmospheric-dispersion/
retrieved October 14, 2012.

Q506b
DataPoke 2011b
Study: Modeling Fukushima NPP Radioactive Contamination Dispersion utilizing Chino M., et al., source terms,
posted October 27, 2011,
http:/www.datapoke.org/blog/8/study-modeling-fukushima-npp-p-239-and-np-239-atmospheric-dispersion/
retrieved October 14, 2012.

Q506c
DataPoke 2011c
Datafile:DATAPOKE Tepco(2011) P239 0-32 MAGL N America,
http:/www.datapoke.org/wiki/Datafile:DATAPOKE_Tepco(2011)_P239_0-32_MAGL_N_ America
retrieved October 14, 2012.

Q506d
DataPoke 2011d
PARTMOM, Particle Modeling, Observing, and Measuring,
http:/www.datapoke.org/partmom/a=114#
retrieved October 20, 2012.

Q507
Stohl et al. 2012
Stohl A, Seibert P, Wotawa G, Arnold D, Burkhart JF, Eckhardt S, Tapia C, Vargas A & Yasunari TJ,
Xenon-133 and caesium-137 releases into the atmosphere from the Fukushima Dai-ichi nuclear power plant: determination of the source term, atmospheric dispersion, and deposition,
Atmos. Chem. Phys, 12, 2313-2343, 2012
Abstract:
http://www.atmos-chem-phys-discuss.net/11/28319/2011/acpd-11-28319-2011.html
full document revised February 2012:
http://www.atmos-chem-phys.net/12/2313/2012/acp-12-2313-2012.pdf

Q508
NILU 2011
Flexpart Radiation plume weather forecasts,
Norsk institutt for luftforskning (NILU), Norwegian Institute for Air Research.
http://zardoz.nilu.no/~flexpart/fprinteractive/plots/
Web page can be reached via:
http://www.nuc.berkeley.edu/node/3908/
apparently removed from websites:
http://www.nilu.no
and

http://zardoz.nilu.no/
remark:
http://transport.nilu.no/products/fukushima/
Fukushima (last modified 2011-05-13 11:26)
Thank you for your interest in the FLEXPART products for Fukushima. The Forecast system is no longer running.
We have discontinued our Flexpart forecast of the atmospheric dispersal of radionucleides from Fukushima. This due to the fact that we do not have access to reliable release rates reflecting the current situation at the plant to be used as input to our simulations. It is likely that the release of radioactive material is significantly reduced compared to the initial period, and that levels no longer pose a health risk at distance from the plant.
Norsk institutt for luftforskning (NILU). (retrieved 2012-10-20)

Q515
Lelieveld et al. 2012
Lelieveld J, Kunkel D & Lawrence MG,
Global risk of radioactive fallout after major nuclear reactor accidents,
Atmospheric Chemistry and Physics, 12, 4245-4258, 2012
‹acp-12-4245-2012.pdf›
http://www.atmos-chem-phys.net/12/4245/2012/acp-12-4245-2012.pdf
retrieved October 2012

Q524
NDreport 2011
Farr H,
Fukushima: Implications on the Economy and the Road Ahead,
http://ndreport.com/fukushimaimpact-2/
retrieved January 2013.

Q532
UNIS 2013
No Immediate Health Risks from Fukushima Nuclear Accident Says UN Expert Panel - Long Term Monitoring Key,
Press Release, United Nations Information Service, May 31, 2013.
‹No Immediate Health Risks from Fukushima Nuclear Accident Says UN Expert Science Panel.pdf›
www.unis.unvienna.org/unis/en/pressrels/2013/unisinf475.html

Q553
WHO 2013a
Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on a preliminary dose estimation,
ISBN 978 92 4 150513 0
World Health Organization 2013
‹9789241505130_eng.pdf›
www.who.int/ionizing_radiation/pub_meet/fukushima_risk_assessment_2013/en/index.html
retrieved 11 October 2013

Q554
WHO 2013b
Global report on Fukushima nuclear accident details health risks,
News release, Geneva, 28 February 2013.
www.who.int/mediacentre/news/releases/2013/fukushima_report_20130228/en/
retrieved 11 October 2013

Q555
Masson et al. 2011
Masson O et al.,
Tracking of airborne radionuclides from the damaged Fukushima Dai-ichi nuclear reactors by European networks,
Environmental Science & Technology, 1011,45, 7670-7677.
‹2011-bucci.pdf›
www.arpat.toscana.it/notizie/notizie-brevi/2012/2011-bucci.pdf
retrieved 12 October 2013

Q556
Becker at al. 2011
Becker A, Ross O & Ceranna L,
How to tackle wet deposition of radionuclides? A proposal by the Global Precipitation Data Centre at Deutscher Wetterdienst and by the NDC Germany,
CTBT Science & Technology Conference, Vienna, 8-10 June 2011.
‹T4-09 A Becker On the potential of public available gridded precipitation.pdf›
www.ctbto.org/fileadmin/user_upload/SandT_2011/presentations/
retrieved 12 October 2013

Q557
Gay et al. 2012
Gay DA, Wetherbee GA, Debey TM, Lewhmann CMB & Nilles MA,
Radionuclide deposition: the Fukushima Dai-ichi nuclear power facility incident,
National Atmospheric Deposition Program + USGS, not dated, presumably 2012
‹2B-Gay_Presentation_Radionuclide_Deposition_Fukushima.pdf›
http://hps.ne.uiuc.edu/rets-remp/PastWorkshops/2012/presentations/2/
retrieved 12 October 2013

Q558
Rosen 2012a
Rosen A,
Effects of the Fukushima nuclear meltdowns on environment and health,
German Section of the International Physicians for the Prevention of Nuclear War (IPPNW Germany), March 9, 2012.
‹ippnw_health_effects_fukushima.pdf›
www.fukushima-disaster.de/information-in-english/
retrieved 12 October 2013

Q559
Paulitz 2012
von Paulitz H,
The Fukushima Disaster. Part 1,
German Section of the International Physicians for the Prevention of Nuclear War (IPPNW Germany), March 12, 2012.
‹fukushima_disaster_accident.pdf›
www.fukushima-disaster.de/information-in-english/
retrieved 12 October 2013

Q560
Rosen 2012b
Rosen A,
Analysis of WHO report on Fukushima catastrophe,
German Section of the International Physicians for the Prevention of Nuclear War (IPPNW Germany), August 3, 2012.
‹ippnw_analysis_WHO_report_Fukushima.pdf›
www.fukushima-disaster.de/information-in-english/
retrieved 12 October 2013

Q561
Rosen 2013
Rosen A,
Critical Analysis of the WHO's health risk assessment of the Fukushima nuclear catastrophe,
German Section of the International Physicians for the Prevention of Nuclear War (IPPNW Germany), March 1, 2013.
‹WHO_Fukushima_Report2013_Criticism_en.pdf›
www.fukushima-disaster.de/information-in-english/
retrieved 12 October 2013

Q562
WHO 2009
Basic Documents. Forty-seventh Edition,
World Health Organization, 2009.
‹basic-documents-47-en.pdf›
http://apps.who.int/gb/bd/PDF/bd47/EN/
retrieved 15 October 2013

Q563
IRSN 2012
Summary of the Fukushima accident's impact on the environment in Japan, one year after the accident,
Institut de Radioprotection et de Sûreté Nucléaire, 28 February 2012.
‹IRSN_Fukushima_Environment_consequences_28022012.pdf›
www.irsn.fr/EN/publications/thematic/fukushima/Documents/IRSN/
retrieved 15 October 2013

Q564
NAIIC 2012b
The National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission (NAIIC),
July 5, 2012
full report English: Preface, Introduction, Chapters 1-6, Appendix 1-3, separate files
http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/index.html
retrieved 18 October 2013
(Executive Summary: Q496)

Q573
UNSCEAR 2013b
Report of the United Nations Scientific Committe on the Effects of Atomic Radiation,
Sixtieth Session (27-31 May 2013),
General Assembly Official Records, Sixty-eigth session, Supplement No. 46,
New York 2013
‹V1385727.pdf›
http://daccess-dds-ny.un.org/doc/UNDOC/GEN/V13/857/27/PDF/V1385727.pdf?OpenElement
retrieved 1 November 2013

Q574
IPPNW 2013
coproduction of IPPNW and international sister organisations in USA, Switzerland, France, Italy, Nigeria, Malaysia, Egypt, The Netherlands and Independent WHO,
Annotated Critique of United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) October 2013 Fukushima Report to the UN General Assembly,
October 2013.
‹Ausfuehrlicher_Kommentar_zum_UNSCEAR_Fukushima_Bericht_2013.pdf›
www.ippnw.de/commonFiles/pdfs/Atomenergie/
retrieved 31 October 2013

Q577
Zheng et al. 2012
Zheng J, Tagami K & Uchida S,
Release of plutonium isotopes from the Fukushima Daiichi Nuclear Power Plant accident,
Proceedings International Symposium on
Environmental monitoring and dose estimation of residents after accident of TEPCO's Fukushima Daiichi Nuclear Power Stations,
Kyoto, December 2012.
‹Topics_4-02.pdf›
www.rri.kyoto-u.ac.jp/anzen_kiban/outcome/Proceedings_for_Web/

Q609
WHO 2012
Preliminary dose estimation from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami,
World Health Organization (WHO), May 13rd, 2012,
‹9789341503662_eng.pdf›
http://shqlibdoc.who.int/publications/2012/9789241503662_eng.pdf
retrieved 29 August 2014.

Q611
ZMMG 2011
Wotawa G,
Accident in the Japanese NPP Fukushima: Large emissions of Cesium-137 and Iodine-131,
Dividion for Data Methods and Modelling,
Zentralanstalt für Meteorologie und Geodynamik (ZAMG),
Vienna, Austria, 24 March 2011
‹Japan2011-03-24_1600_E.pdf›
http://www.zamg.ac.at/docs/aktuell/Japan2011-03-24_1600_E.pdf

Q612
TEPCO 2011
Report of the Japanese Government to the IAEA Ministerial Conference on Nuclear Safety – The Accident at TEPCO's Fukushima Nuclear Power Stations –
Attachment IV-2, June 2011,
http://japan.kantei.go.jp/kan/topics/201106/iaea_houkokusho_e.html

Q613
Bannai 2011
Bannai T,
Regarding the evaluation of the conditions on reactor cores of Units 1, 2 and
3 related to the accident at Fukushima Dai-ichi nuclear power station.
Tokyo Electric Power Co. Inc. Tokyo, Nuclear and Industrial Safety Agency, 2011

Q614
Chino et al. 2011
Chino M et al. Preliminary estimation of release amounts of 131I and 137Cs accidentally
discharged from the Fukushima Daiichi nuclear power plant into the atmosphere.
Journal of Nuclear Science and Technology, 2011, 48(7):1129–1134.