This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287.

EJP-CONCERT

European Joint Programme for the Integration of Radiation Protection Research

H2020 – 662287

D 9.25: Case descriptions for characterization and response to uncertainty in past nuclear emergencies

Lead authors: Deborah Oughton, NMBU; Tanja Perko, Bieke Abelshausen, Joke Kenens, Michiel Van Oudheusden, Catrinel Turcanu, SCK•CEN; Roser Sala, Christian Oltra, CIEMAT; Yevgeniya Tomkiv, NMBU; Melanie Maître, Thierry Schneider, CEPN; Nadja Zeleznik, EIMV

Reviewers: Wolfgang Raskob (project coordinator) and CONCERT coordination team

Document number: CONFIDENCE(WP5)-(2018)-xx

Work package / Task	**WP 9 T: 9.1**	**ST 9.1.5**
Deliverable nature:	**Paper**	
Dissemination level: (Confidentiality)	**Public**	
Contractual delivery date:	**M37 (CONCERT) = M18 (CONFIDENCE)**	
Actual delivery date:	**M38**	
Version:	**1**	
Total number of pages:	**56**	
Keywords:	**Nuclear emergency; uncertainty; expected behaviour**	
Approved by the coordinator:	**M38**	
Submitted to EC by the coordinator:	**M38**	

Abstract

Seven different case studies of nuclear and radiological events have been evaluated as a preliminary basis for identifying and categorising different types of uncertainties associated with emergency response. These include five recent incidents affecting European countries (Fleurus, Belgium, Asco, Spain, Tricastin, France, Halden, Norway, and Krsko, Slovenia), a retrospective analysis of the management of uncertainties in Norway after the Chernobyl accident, and a study of citizen science after the Fukushima accident. The analysis is primarily based on a document review, with support from preliminary media analysis and interviews. The overall objective has been to elucidate the understanding and response to scientific and social uncertainties, and related ethical issues.

The intention is that the case descriptions will serve as a starting point for a more robust analysis of empirical and qualitative data collected in the context of the project work related to social, ethical and communicational aspects of uncertainty management. The document review identified a range of different uncertainties that have been roughly categorised in to uncertainties related to: 1) technical and measurement uncertainties; 2) societal impacts and societal framing; 3) contradictory information and communication aspects; 4) ethical aspects. While the Fukushima citizen science case took a slightly different point of departure from the other case studies – starting with interviews rather than document review, there was still some overlap with uncertainties identified for the European cases. The case discussed five types of uncertainties: 1. uncertainties related to nuclear accident management and safety implications; 2. uncertainties related to society and family life; 3. uncertainties related to governmental approach to post-accident recovery; 4. uncertainties related to the relationship between science and society; and 5. uncertainties related to citizen radiation measuring centres.

The characterisation of different uncertainties will continue to be refined following a more robust evaluation and comparison of the results of media analysis and structured interviews carried out with selected cases. Combined with other activities in CONFIDENCE WP5 the results will inform further work in the work package in order to investigate: i) Lay persons and emergency actors' understanding and processing of uncertain information, and subsequent behaviour, in nuclear emergency situations; ii) Societal uncertainties and ethical issues in emergency and post-accident situations, from the early phase to recovery; iii) Improved tools for communication of uncertainties, specifically for low radiation doses.

Contents

1. Introduction

This document describes a selection of past nuclear or radiological emergencies as the basis of analysis aimed at identifying and categorising the different types of uncertainties associated with emergency response. The deliverable collects important existing information related to the analysed cases. The intention is that the case descriptions will serve as a starting point for empirical and qualitative data collected in the context of the project work related to social, ethical and communicational aspects of uncertainty management. This will be complemented with media analysis and interviews with key actors and reported in subsequent publications, such as to obtain a thick description of these uncertainties.

Seven different case studies of nuclear and radiological events in or affecting different European countries have been evaluated: Halden, Fleurus, Asco, Tricastin and Krsko, as well as a retrospective analysis of the management of uncertainties in Norway after the Chernobyl accident and a study of citizen science initiatives following the Fukushima accident in Japan. The major part of the work is a document review, together with preliminary media analysis and interviews for a selection of the cases. The overall objective has been to elucidate with relevant actors their understanding and response to scientific and social uncertainties, and related ethical issues. The main focus is on the societal and communication uncertainties, and not an extensive analysis of the technical and scientific uncertainties, although these have been identified where possible.

The document concludes with a brief summary of different types of societal uncertainties that the affected population, stakeholders and emergency management actors have faced during the various emergencies, roughly categorised into different types of uncertainties. These categories are intended will be further elaborated through expert discussions and comparisons of results of ongoing media analysis and stakeholder interviews.

2. Belgian case: Accidental release of radioactive iodine from a facility producing radioisotopes for medical use, located in Fleurus, Belgium, INES 3

2.1 Case description

On Friday August 22nd 2008, radioactive iodine (^{131}I) was accidentally released from Institut des Radioelements (IRE), a facility producing radioisotopes for medical use, located in Fleurus, Belgium. The release was not noticed until after the weekend, and people living in neighbouring areas were informed no sooner than 6 days after the onset of the incident. It was only then that the Belgian authorities activated a nuclear emergency plan, taking protective actions for the population.

IRE produces isotopes for the medical sector, by extraction of fission products from highly enriched uranium targets irradiated in reactors such as the BR2 in SCK•CEN in Mol, Belgium. The production is a batch process and, after processing, waste liquids are collected in waste tanks. On 22nd of August, Friday, contents of smaller waste tanks were transferred to a larger tank, starting a chemical reaction and leading to the release of ^{131}I to the stack, through filter batteries. The bulk of the release took place over the weekend, after which smaller quantities kept being discharged for several days, amounting to a total of 50 GBq ^{131}I The release was not noticed till after the weekend, when a safety engineer started his work on Monday morning. The problem was first examined in cooperation with the technical support organisation, BEL-V, and the Belgian agency for nuclear control (AFCN-FANC) was eventually informed about the release at 5:15 p.m. on Monday evening.

On Tuesday, August 26th, the agency made its first mention of the event on its website, announcing that inspectors were being sent to the installation to examine the situation. More details were given in a press release the same afternoon that classified the event as a "serious incident" (INES-3), and that announced that production in the IRE as well as the neighbouring MDS Nordion facility were temporarily stopped. The statement specified the occurrence of a "very small release" to the environment that neither called for activation of the Belgian nuclear emergency plan nor for measures to protect the environment. The press release announced follow-up measurements by the Belgian automatic radiological measurement network TELERAD.

It may be worth mentioning that, in fact, four additional mobile TELERAD stations placed on and near the Fleurus site were not able to register the release, due to the characteristics of the release. The fact that only pure ^{131}I was discharged at a low concentration during a relatively long period, made it impossible for the TELERAD network to show any increase in dose rates due to the release.

On Wednesday August 27, AFCN-FANC (the Belgian nuclear safety agency) informed IAEA about the incident, stating "The waste division of the IRE has performed a transfer of liquid radioactive waste from one tank to another one. Immediately afterwards – for reasons still unknown – radioactivity was released through the stack. The quantity of radioactivity released into the environment is estimated at 45 GBq ^{131}I, which corresponds to a dose of 160 microsievert for a hypothetical person remaining permanently at the site's enclosure. This incident did not cause a contamination of the personnel, and their dose limits were neither exceeded." (BVS 2008)

On Thursday August 28, the first results for three environmental samples became available. These samples, taken by the agency in the close vicinity of the IRE, and analyzed in the laboratory of the Scientific Institute of Public Health ISP/WIV, shed new light on the situation. Radioactivity was established at up to 5000 Bq/kg for one grass sample, suggesting that the intervention limits for food production might have been exceeded and, therefore, activation of the Belgian emergency plan was needed. On Thursday evening governmental web sites issued the first recommendations to the population: People living in a zone of 5 km north east of the IRE were advised to neither to eat fruits and vegetables from their own gardens, nor use rain water. The press publicized these recommendations. Contrary to that, there were no restrictions imposed on selling the local vegetables on the market. Moreover, local and provincial emergency managers received a FAQ list specifically compiled for the occasion [Crisiscenter 2008]. The local police and the city of Fleurus communicated directly with the concerned population on Friday August 29th and an information phone line was opened. Further characterisation of potential water, air, grass, vegetables and milk contamination was carried out.

On Saturday August 30th, new measurements somewhat alleviated the concerns. These allowed a reduction of the area for which protective measures were recommended to 3 km-area north east of the IRE. In addition, they confirmed that no significant contamination of milk had occurred. (Maximum measurement was 17 Bq/liter where the intervention level is 500 Bq/liter). Nevertheless, a large-scale campaign for thyroid measurements was announced to start on Monday, September 1st. These measurements assess a potentially enhanced risk for thyroid cancers and are especially important for children (Public Health 2008).

In the next week, the crisis management team focused on ensuring with complete certainty that the release had stopped. It requested that the IRE installed extra filters between the waste tank and the stack, and it further monitored the situation by environmental sampling, and active charcoal air sampling. By Saturday September 6th, the situation was considered to be under control and all necessary information established : none of the measurements of over 100 samples of vegetables and fruits had been near the intervention levels (FAVV2008), the maximum was 86 Bq/kg, while the intervention level is 2000 Bq/kg (although the limit for baby food is 150 Bq/kg and the WHO recommends to take action when baby food exceeds 100 Bq/kg), and at no time had there been a need to trigger direct protective action for the population (sheltering, evacuation or intake of iodine tablets). Therefore, recommendations to avoid eating fruits and vegetables from the gardens were lifted, and the emergency plan scaled down to a U1 level. Nevertheless, thyroid testing for possible contamination continued to be offered to the local population, with the intentional that this would be re-assuring. Medical examinations, performed on Monday September 1st and Tuesday September 2nd, prioritized the most sensitive persons (children and pregnant women). A total of 1320 persons were examined, and no signs of contamination were found.

2.2 Protective actions applied

- Activation of the Belgian emergency plan.
- Restrictions on the use of local farming produce within 5 km of the release point for a period of two weeks.
- 1320 people have been tested for possible contamination in thyroid.

2.3 Communication aspects

The European Commission sent out a warning using the ECURIE-alert system (The European Community Urgent Radiological Information Exchange) on the 29th of August and the event got a level 3 on the INES scale.

The event was covered by all Belgian mass media and it remained a daily news item for several weeks. The news items were mostly informative, based on the information provided by the Crisis Centre or interviews with important actors: crisis managers, experts, managers from the installation and local and national politicians (B. Carlé at. al, 2010). The national media focused their attention on the accident and then placed it within the context of a possible lack of radioisotopes for medical use, which were produced in the facility and used for treating cancer. This framing didn’t appear in the local media, however. The incident was not sensationalised in the national mass media; there was neither amplification of negative messages nor stigmatisation of the technology. Discussions focused on the responsibility for the incident, with a focus on the unacceptably late response of the authorities and the lack of information to the population in the first days. Another issue of discussion was the failure of the automatic measuring network TELERAD to register the release; this failure was interpreted as another instance of poor performance of this network that had received some negative press earlier. Blame of the IRE management for their lack of communication was another theme, framed as an illustration of the existing problematic relation between IRE, the local authorities and the local population (Fleurus 2008).

Public meetings with the local community were organized in a sports centre, and the accident was discussed with all major stakeholders involved.

The table below summarizes the main messages communicated by the authorities during the event (Table I).

Table I: The messages of risk-communication that we analyzed in the research, aim and tools

Communicated message*	Basic information	Message about a protective action	Reassuring message	Main communication tool*
In the region of Fleurus there has been an accidental radiation release	✓			Local, national media
Release occurred in a facility producing isotopes for medical use	✓			National media
The influence of the radioactive release is only local.	✓		✓	Public meeting
The pollutant was radio-iodine	✓			Local media
Authorities advise not to consume vegetables from gardens for a period of 2 weeks		✓		Leaflets, public meeting
Radio-iodine can increase the risk of getting thyroid cancer	✓			Public meeting
The Belgian public health authorities organize a thyroid measurement campaign for the local population		✓		National media, leaflet
Evacuation of people is not needed			✓	Public meeting
Due to the accident there is a lack of isotopes for curing cancer patients in the hospitals	✓			National media

* We collected the published media news and public communication by authorities, and we selected the most relevant ones.

2.4 Interaction of first respondents (measurement team) with the public

Most members of the public did not ask more information. However, when an initiative was taken to provide them with more information, the majority reacted positively and asked for more information. A considerable minority considered the measurement campaign as a cover-up of the authorities, but nevertheless accepted the measurements.

The minority that asked more information on its own initiative was concerned whether the thyroid measurement itself could harm them and wanted to know more about the effect of ^{131}I and how harmful it was. In second place came questions how the measurements were performed and how reliable the measurements were.

Performing measurements on small children is an art in itself. The size of the Ge detectors was rather impressive for the youngest (0-5 years) and required adaptations like laboratory gloves blown as balloons. For that group the NaI detector of the University of Liège was less frightening since its size was much smaller, but its efficiency was also lower.

An additional disadvantage was that September 1st (which happened to be the first day of thyroid measurements) is the first school day, so the teachers were not yet acquainted with the children and had not yet established a bond of trust.

The vast majority considered SCK•CEN and the University of Liège as impartial and therefore trusted the quality and outcome of the measurements. It would be unlikely that this would have been the case if IRE (which has a similar role in the Belgian emergency plan to that of SCK•CEN), had carried out the measurements, since it was responsible for the release,.

The vast majority of the team on the first day consisted of native Dutch-speaking people, with one exception. Although many of them spoke French reasonably well, communication with the French-speaking population led sometimes to misunderstandings, certainly when it concerned children. It was decided for the second day to compose teams with a stronger French-speaking component.

2.5 Additional communication and societal aspects

Communication advice by the thyroid measurement team

The case underlined the clear need of the general public to be informed, and that the initiative for providing information should come from the experts. The public is reluctant to ask experts about their expertise, but is eager to listen and learn when something is explained. Therefore communication to the public should be prepared in advance, and be part of overall measurement strategy. This should foresee providing actively information about: health effects of radiation, and the radiation measurement principles and method. The communication of the measurement team should focus on various target audiences: Children, Pregnant women, Teachers and General public. (Van der Meer K., *2010)*

Level of agreement with communicated messages

The results of the information processing study in the case of Fleurus clearly demonstrate that specific knowledge is only dominant at the level of the reception of risk messages, while predictors such as psychometric risk characteristics, trust in risk management by the authorities and attitudes toward science and technologies are most influential at the level of the acceptance of risk messages. Several differences were identified among information processing in the general population and the affected population. The more one is affected by the risk, the less important factors such as gender, age or education will be for information processing (Perko T. et al, 2013).

Public opinion survey

A public opinion survey was conducted 11 months after the accident. The survey method used Computer Assisted Personal Interviewing (CAPI), which entailed face-to-face interviews at the home of the respondents. The survey was conducted in July and August 2009, on a large sample of the Belgian population (N=1031) in the language of their choice (French or Dutch). The sample was representative for the Belgian adult population with respect to the following variables: province, region, level of urbanization, gender, age and professionally active status. In the present study, this sample will be referred to as the 'general population'.

In addition to the general population, this survey was also conducted on a (stratified) sample of the population living in the area neighboring the radiological accident location (N=104). This area was defined on the basis of the postal code of the municipality in which the accident occurred, and the sample referred to as the 'affected population'.

Use of communication channels

The public opinion survey showed that 11 months after the accident 15% of the general population and 91% of the affected population remembered the accident. Among these, over 80% of the respondents in Fleurus watched TV daily in order to get information, while nearly 70% of the population in the rest of the country indicated they had followed the Fleurus incident daily on TV. Radio was the second most important information channel, around 50% both in the local population and in the rest of the country followed the news about the accident daily on the radio, and another 20% did so several times a week. Newspapers were the third mass communication channel, and were consulted daily or several times a week by 55% of the general population (or at least by the part of the general population who remembered the incident). For the local population, newspapers were less important, 50 % of the Fleurus population stated that they never read the newspaper or did so less than once a week during the incident. We differentiated between 3 types of internet use: internet online journals, replays of TV news on internet and replay of radio news on internet. In general, the internet was used less than the other media during the Fleurus accident; over 60% of the respondents indicated they never used internet in any of the three ways specified. About 25% of the Fleurus respondents said they used internet journals daily or at least several times a week, and 22% used the replays of TV and radio news as often. The responses for the general population indicate a marginally lower use of the internet sources.

References

B. Carlé, T. Perko, C. Turcanu and J. Schröder, in Third European IRPA Congress on Radiation Protection (Helsinki, 2010).

BVS, Newsletter 120,. IAEA news. Iodine-131 release in the environment; INES Rating 3; 2008 http://www.bvsabr.be/Newsletter/NWL-120.pdf p. 21

Crisiscenter Website of the Belgian federal crisiscenter. Newsitems. 2008 http://crisis.ibz.be/actualiteit/

FAVV, website. Incident IRE Alle voorzorgsmaatregelen opgeheven. Sept. 6th 2008. http://www.favv-afsca.be/home/press/_documents/2008-09-06_IRE-Fleurus_nl.pdf

Fleurus. INCIDENT A L'IRE DE FLEURUS - Réaction du Bourgmestre de la Ville de Fleurus – Actualisation de la situation – mercredi 3 septembre – 15h30, 2008, http://www.fleurus.be/informations-communales-24 (archive septembre 2008)

FOD Public Health. Service public Fédéral Santé Public. Communication to the public. 2008. http://www.fleurus.be/test_thyroide.pdf.

Van der Meer K., (2010): Thyroid measurement campaign after an accidental release of 50 GBq 131I in Fleurus, Belgium, IRPA, Helsinki

Perko, T., Thijssen, P., Turcanu, C., & Van Gorp, B. (2014). Insights into the reception and acceptance of risk messages: nuclear emergency communication. Journal of Risk Research, 17(9), 1207-1232.

Additional publications to be studied

De Swaef, T (2016); *Use of New Media for Emergency Communication by Nuclear Emergency Management Authorities: An Application to Nuclear Emergencies,* Master thesis University Antwerp

3. Spanish case: Accidental release of radioactive particles with activated corrosion product isotopes from Ascó I Nuclear Power Plant (NPP) in Tarragona, Spain. INES 2.

3.1 Case description

The Ascó nuclear power plant is a second generation nuclear power station located in Ribera d'Ebre (province of Tarragona), between the towns of Ascó and Flix and on the right bank of the Ebro river. The nearest provinces' capital cities are Lleida (140.000 inhabitants), located about 62 km from the nuclear power station, and Tarragona (456.000 inhabitants) located about 71 km.

Figure 1. Photo of Ascó Nuclear Power Plant (Ascó I) and a map of the location.
Source: Google images

The plant has two nuclear reactors: Ascó I and Ascó II. The first reactor began operating on December 10, 1984, and the second on March 8, 1986. The reactors have a power of 1,032.5 MW and 1,027.2 MW. Both are thermal reactors cooled by pressurised water (PWR type). The cooling system uses the Ebro river water and consists of natural and forced towers.

An event in November 2007 in Ascó I NPP (Spain) led to the release of significant amounts of radioactive particles with activated corrosion product isotopes, through the discharge stack. The detection of the release and its subsequent notification to the Spanish Nuclear Regulatory Authority (CSN-Nuclear Safety Council-), took place four months after its occurrence, on April 4th 2008, when discrete radioactive particles in outdoor areas of the buildings were detected during a periodic radiological survey within the site.

The event was initiated in an operational incident occurring at the end of the 19th outage of Unit I (started on October 27th, 2007 and ended on December 1st, 2007). Contamination of the fuel building ventilation system with water originated from the cleaning of the fuel transfer canal, at the end of the outage of the reactor, resulted from a combination of incorrect practices and non-compliance of the operating standards (CSN, 2009).

During the refuelling operating procedure, the transfer of the irradiated fuel elements from the reactor to their storage in the fuel building is made through the refuelling canal, which crosses the containment and connects the refuel cavity to the storage pool. The separation gate at the entrance of the storage pool is opened during this process. Once finished it is closed, and the refuelling canal and cavity emptied of water and decontaminated. The decontamination includes blasting of walls and structures and entrainment of dirt and particles to the lowest level in which a collection well is located. The remaining water of the canal is extracted from that well, by means of a portable vacuum cleaner (CSN, 2009).

The ventilation system of the fuel building has some of its grilles located in the pool wall, between its upper edge and the surface of the water. In a manoeuvre not provided in the operating procedure, the deposit of the vacuum cleaner with the water and sludge was poured manually to the storage pool, and some of the water absorbed by the grilles either by direct spillage or by splashing.

The ventilation system of the fuel building has two extraction subsystems: one for normal operations, and another for emergency operations. In the first one, the sucked air is directed to a common collector and the stack without previous filtration, whereas in the second one, the air is led to a filtration system of high efficiency before it is directed to the common collector. Both subsystems share pipes between the grilles and the entrance to the filtration system and to the collectors behind the filters.

During all fuel-moving works, the emergency ventilation subsystem must be kept in operation, starting automatically when any of the two radiation area detectors registers a pre-set dose rate value. This start-up leads to the automatic shut-down of the normal ventilation subsystem, ensuring that any contamination present in the atmosphere of the fuel building is retained in the filter system and is not discharged through the stack.

The discharge of gaseous effluents through the stack is monitored continuously. These systems, on the dates when the discharge occurred, did not give rise to any alarm which might suggest that the emission of radioactive particles was taking place, except on the 22nd December 2007. On that day a peak occurred in particulate monitor, but was not taken into account as it did not match with the development of any operative procedure at that time (CSN, 2009).

The detection of the release and its subsequent notification took place four months after the occurrence of the event, through the periodic radiological survey of the site. The available automatic radiological control systems failed mainly due to the fact that they are designed to detect homogeneous radioactive emissions and not discrete particles such as those involved in the event. On March 14th 2008, hot particles were first detected in the containment hatch area. During the following days, a further extent of the area subject to the radiological survey lead to discover several hot points on the ground inside the double fencing the roofs of the buildings adjacent to the NPP stack (Gallego et al, 2010).

On April 4th, these findings were notified to the CSN, followed by press releases and official statements to the public, as well as a wide monitoring program to check more than 2,700 persons by whole body counting, including workers and visitors. No person was found to be contaminated. A team of experts from the European Commission's General Directorate of Energy and Transport visited Ascó on April 29th and verified the radiation protection control methodology that confirmed the non-radiological significance of the event and endorsed the technology employed to guarantee the control measures from the operative, administrative and quality points of view (Gallego et al, 2010).

3.2 Release characteristics

A physicochemical and radiological characterization of the particles collected was carried out as well as an estimation of the source term. The particles collected in the outdoor areas correspond to activated corrosion products, originating in the discharge to the fuel pool of the liquid contained in the vacuum cleaner (Diego and Briceño, 2008), with isotopic composition of mainly ^{58}Co and ^{60}Co.

The estimation of the source term made using the readings of the radiation monitors of the fuel building; the location of the vacuum cleaner during the discharge into the pool; the dimensions and materials of the vacuum cleaner; its activity once emptied; and the radioactive material collected outdoors, in the filters of the ventilation system and from the decontamination of the ventilation pipes.

The activity that accidentally passed through the ventilation system is approximately equivalent to the sum of the following (for the date 26/11/2007):

- Activity retained in the pipes of the ventilation system of the fuel building: 3,51E+04MBq
- Activity retained in the filters of the emergency ventilation subsystem: 2,46E+03MBq
- Activity retained in the outdoor areas: 4,09E+02MBq

A theoretical calculation to simulate the dispersion of the particles released the day of the incident was conducted. It took into account the physical characteristics of the stack, making possible to estimate the probability that a certain released particle, characterized by its size, could have reached a certain location. The study was developed using Computational Fluid Dynamics or CFD tools (Barbero et al, 2008).

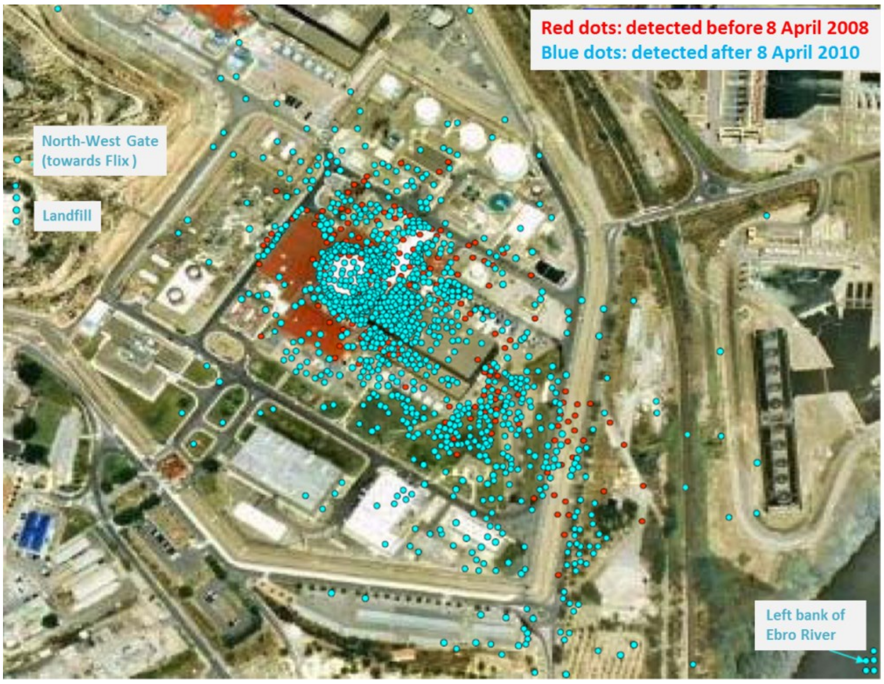


Figure 2. “Location of the hot particles found and collected to July 2008 on an aerial view of Ascó I site”. Ref: ANAV. Daily report to CSN of incident ISN-AS1-127. 28 July 2008.

The simulation took into account the orography of the NPP site, as well as significant buildings, to consider the movement of atmospheric air and particles. Due to the lack of information on the time when the particles where released, the calculations considered the atmospheric conditions on the periods where it was most likely to occur.

The results of the study (Barbero et al, 2008) show that the particulate deposition data are very similar regardless the time periods considered, with the larger diameter particles being deposited in the vicinity of the stack and moving further away as they decrease in size. The possibility of collecting large particles in regions far away would have its origin in the resuspension of particles by strong North-West winds.

An additional complementary simulation on the behaviour of smaller particles was also carried out concluding that the bulk of the small particles would be transported in the cloud, diluting the activity in the atmosphere (Montero, 2013).

3.2. Radiological consequences and protective actions applied (CSN, 2009)

Contamination of the ventilation system

The ventilation system of the fuel building was contaminated during the event. Cleaning and radiological control operations in different periods were carried out. The cleaning activities included vacuuming, brushing and mopping, the opening of logs as well as cuts in the pipes to facilitate the access and decontamination of their interior. The aspiration and change of the pre-filters of the two emergency units was also done.

A long-term radiological control program during the normal operation of the ventilation system (for the next two operating cycles), was established to verify the absence of particles in it. The operation of the ventilation system was kept through the emergency filtering units.

Contamination of the site

A radiological control of the site was carried out, to recover and analyse the particles found. In order to facilitate the identification and to be able to guarantee that the radiological survey had covered the whole site, it was divided into areas and within each, in smaller areas where the main individual structures were identified.

As a result of the radiological standardization process of the site, the surveillance program of the areas outside the controlled area already fixed, was expanded, being the survey carried out on a weekly, twice a year and yearly frequency, depending on the location.

Radiological survey off-site

Between 17th April and 14th May 2008, the CSN developed a special surveillance program to detect the possible radiological impact off-site the NPP in a distance to 3 km. The scope of the monitoring program was established taking into account the meteorological data and the available information related to the event.

The monitoring program included the Environmental Radiation Surveillance Program (PVRA) and its quality control, a specific surveillance control of the Ebro River and environmental gamma dose rate measurement stations. From the results obtained, it was concluded that the radiological activity off-site was not increased.

Radiological Impact Assessment

A monitoring program for the assessment of committed effective doses was established:

- Mandatory, for workers (staff and contracted personnel) and visitors, who had remained inside the double fencing, in the period between November 28th 2007 and April 8th 2008.
- Voluntarily, for those persons who, during that period, had acceded to the site, remaining outside the double fencing.

Monitoring of other groups (family members of the NPP staff, inhabitants of localities close to the site) was not considered justified because of the low risk of exposure.

As a result of the application of these criteria, the monitoring program, which was originally intended to cover some 800 persons, was expanded to include 2,717 persons. In this context, special attention was paid to the controls carried out on different groups of schoolchildren who, during the period selected, visited the NPP.

In addition, a representative sample of workers, whose activities had a greater risk of internal contamination (for instance those involved in the location and removal of particles), was selected, in order to subject them to an additional independent control in the CIEMAT internal dosimetry service. In none of the controls performed, the results obtained were above the detection limits of the measurement equipment used.

3.3 Communication aspects – Preliminary press coverage review

Information regarding the communication aspects during and after an incident was not found in secondary sources. The only comparable source was the Informe Quiral (2009), a media analysis of news about medicine and public health. Therefore, a preliminary analysis of the press coverage was made in order to get a first sight of the coverage of the incident made by the press.

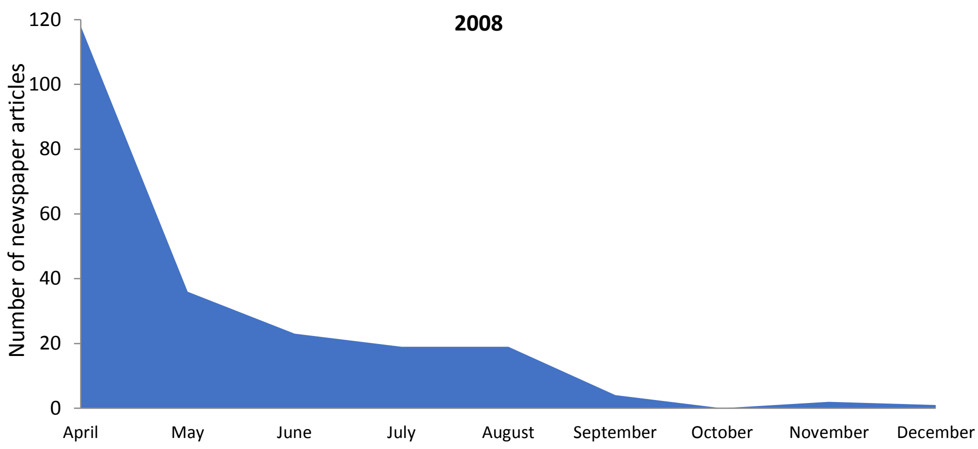
The incident was covered by both national and local mass media (newspapers, TV channels and radio stations). After the first newspaper article appeared on April 5th, 2008, the coverage about the incident remained in the media for several weeks, especially during April and May, with an important amount of news published. The information provided by the media was obtained fundamentally from the main actors involved: Ascó NPP, the regulator (*Consejo de Seguridad Nuclear*), environmental NGOs, authorities, national and local politicians and the affected population.

The information provided by both the national and the local press was very similar. There is certain unanimity in the way they dealt with the topic, although the local press provided more detailed information, probably due to the geographical proximity of the event. The incident was not excessively sensationalized by the media. We find very little evidence of amplification of negative messages or stigmatization of the nuclear technology.

During the first days after the public release of information about the incident, the media focused the attention on the detection of radioactive particles in the siting of the Ascó NPP. The messages provided in the media often aimed at calming down the population. The mass media also highlighted the fact that the leak had occurred in November 2007.

On April 14th, the press informed about some reports by Greenpeace, showing that the levels of radioactivity were higher than those informed the first days. The mass media showed a critical approach towards the inappropriate management of the incident and with the unacceptable information omission and the lack of openness by the NPP managers.

Figure 3. Evolution of the coverage of the incident in the studied newspapers



On April the 9th, we find news articles about the complaints of local city councils showing the lack of communication channels between them, the NPP and the CSN. On April the 17th, the news covered the dismissal of the Ascó's NPP Director and the Chief of NPP's Radiological Protection Service as well as the finding of radioactive particles outside de Nuclear Power Plant facility.

On April the 15th, the newspapers reported that groups of students from different schools visited the NPP after the incident. This caused a great alarm, especially within the families of the children and the school personnel. Following this, the mass media continued to give information about this issue, including the days in which the students took the medical checks, its results, etc. The media also reported the measures that were to be adopted to determine the possible presence of radioactive contamination in other potentially affected people.

During these days, some public administrations started to take part in the possible legal consequences for the Ascó NPP. On April 17th, Catalonia's ombudsman opened an ex-officio investigation. In addition, on April 24th Tarragona's Public Prosecutor's Office opened an investigation into the incident.

During May, the information in the media about the Ascó's incident started to decline and there was less news published about the incident. The radioactive check-ups carried out among the potentially affected population confirmed the absence of contamination. However, certain collectives called into question the reliability of the test results. On May 15th, news about an alteration of the radioactive detectors made by the Ascó NPP appeared on all newspapers. At the same time, both NGOs and the authorities defended a severe fine to the NPP managers. Moreover, some political parties requested the money collected by the fine should be invested in the region.

During the first days of June still appeared some news about the localization of new radioactive particles outside the installation. On June 10th, the Ascó NPP carried out a scheduled stop to perform the radiological cleaning of the plant and to obey the safety rules required by the CSN after the event. One month and a half after, on July 21st, Ascó NPP has connected again to the power supply. Nevertheless, no actions avoided a fine of 14.4 million Euros imposed by the Ministry of Industry for four major infractions and two minor infractions. It meant the highest economic fine in the history of Spain's nuclear power plants.

The object of the present study is to identify and analyse the societal uncertainties produced by a nuclear radiological incident in Spain. The final objective is to understand public and stakeholders' response to uncertainty during an incident.

3.4 Communication aspects – Media analysis and Semi-structured Interviews

A media analysis was carried out by searching for the most read newspapers in the area during 2008, the year when the incident took place (AIMC, 2008), resulting in a total of 275 articles in 6 national, regional and local newspapers. The analysis consisted of a qualitative analysis and a quantitative analysis to identify the key uncertainties and concerns expressed. This was followed up by interviews with eleven members of the affected population (ie, 10 km from the plant), and 13 interviews with key persons selected from a sample of relevant actors during the emergency. They were classified into seven categories related to their role. There were politicians, authorities, industry representatives, experts and academics, media, ecologists and other actors like teachers from the schools who visited the NPP during the incident. Based on the results of these studies, the uncertainties were classified in the following categories: *Technical uncertainties, Uncertainties related to the effects of the incident, Uncertainties in the management of the incident, Communication aspects* and *Consequences of the incident*. The preliminary results of the content analysis is presented in Figure 4.

The results are currently being prepared for publication, but key points included that many of the newspapers referred to uncertainties in the communication process of the incident. These included delay in the communication of the incident and the fact that an environmental NGO informed the public about the leakage before than the nuclear authorities (CSN). The notification of the event by the CSN came an hour after the Greenpeace announcement and the ANAV (Ascó NPP managers) declaration came two hours later. Interviews with the affected population indicated that many of them knew about the leak due to the information appeared in the press. The lack of information from the NPP managers to the other actors was also important. The nuclear power plant did not communicate the leakage to the CSN, in fact, they hid the leak to the inspector that the CSN has in the nuclear plant. Regional and local authorities were not informed. NPP managers did not communicate the leakage either to the workers or to the schools that have visited the plant days after the incident. Many of the people interviewed consider that they did not receive enough information about the incident and communication about the incident is frequently portrayed as not transparent enough in the news articles. There are also some evidence of contradictions in messages between different actors but also from the same actor: *"The CSN confirms the irrelevance of the incident but states that a more detailed exploration is necessary"* and *"Ascó NPP and CSN claim that there has been no risk to people while Greenpeace puts in doubt".* Different parties also requested changes in the safety protocols, according to some of the actors portrayed in the articles, the incident and its management produced lack of trust in the management of nuclear energy in Spain.

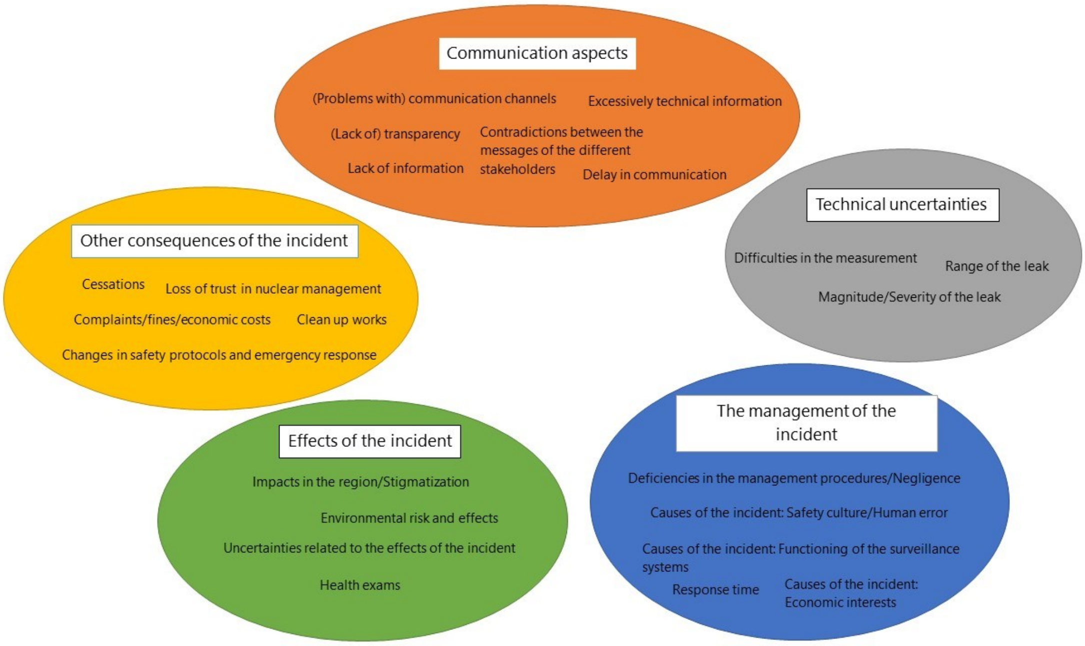


Figure 4. *Uncertainties around the incident*.
Source: elaboration based on content analysis

References

Barbero, R., Cuadra, D., Domingo, J., Iranzo, A., Gallego, E. (2008). Estudio de simulación de dispersión de partículas relacionado con el suceso ISN-AS1-127 ocurrido en C. N. Ascó I. Proyecto ANA01_082008. Análisis-DSC, Universidad Politécnica de Madrid, ANAV.

CSN, (2008). Información sobre la detección de partículas radiactivas en la central nuclear de Ascó (Tarragona). Nota de Prensa 5 de abril de 2008.

CSN, (2008). El CSN descarta riesgo radiológico en Tarragona. Nota de Prensa 7 de abril de 2008.

CSN, (2008). El CSN reclasifica el suceso de Ascó a nivel 2 en la Escala INES por suministrar la empresa información deficiente e incompleta. Nota de Prensa 14 de abril de 2008.

CSN, (2009). Informe sobre el suceso de liberación de partículas en la C.N. Ascó I. DPR/149/09.

de Diego, G., Gómez Briceño, D. (2008). Caracterización por SEM/EDX de muestras con partículas activas procedentes de la Unidad 1 de la C.N. de Ascó. Informe CIEMAT. División de Materiales DT/ME-09/IE-08.

Gallego Díaz, E. F., Barbero, R., Cuadra, D., Domingo, J., & Iranzo, A. (2010). Modelling with a CFD code the near-range dispersion of particles unexpectedly released from a nuclear power plant. Proceedings of the Third European IRPA Congress, 14-18 June, 2010, Helsinki, Finland.

Montero, M. (2013). Estudio de la Dispersión a media distancia de partículas menores de 50µm, relativo al incidente operativo de Noviembre 2007 en la CN Ascó. Proyecto ESPARTAS. Informe CIEMAT. Departamento de Medio Ambiente CIEMAT/DMA/UPRPYMA/08/13.

Observatorio de la Comunicación Científica; Fundación Vila Casas (2009). Informe Quiral 2008. Medicina, comunicación y sociedad. Barcelona. Rubes Editorial.

4. French case: Uranium leak in the Socatri plant, ensuring treatments of nuclear effluents coming from the AREVA facilities, in the Tricastin nuclear site (France), INES 1

4.1 Case description

In the night of the 7th July/8th July 2008, employees of the Socatri plan noticed overflowing of a storage tank containing uranium effluents. Thus, around 30 m^3 of radioactive liquid had been spread to the ground as well as to the waste water collection system, provoking discharges in the surrounding rivers.

The first emergency actions taken by AREVA consisted in limiting the leak consequences with the isolation of the rain water collection system and the performing of a drilling on the discharge area. Experts from the French Institute of Radiation Protection & Nuclear Safety (IRSN) were also mobilised to strengthen AREVA's team in the field and supported the crisis unit together with local decision-makers (Prefects of Drome and Vaucluse administrative departments).

Before getting the first contamination results from rivers and groundwater samplings, the local Prefects chose to impose restrictive actions on water use and consumption. Then, the first results showed that the radiological quality of drinking-water (around 10-50 µg/L of uranium) exceeded the WHO guidelines but only for a very short period of time corresponding to the pollution peak. Following this, post-accidental measurements on rivers, groundwater, bathing water (lake), sediments, fishes, aquatic plants had been jointly implemented by IRSN and AREVA to characterize the environment and estimate the radiological consequences of the Socatri incident.

After 15 days, the results showed that the water quality was back to normal and that the incident had very few radiation exposures and environmental impacts (indicative dose: 0,013 mSv/year). So the French Nuclear Safety Authority suggested that local decision-makers could lift the restrictive actions on water use and consumption. The lifting of restrictive actions was done by the Prefects on 22nd July 2008.

However, the environmental surveillance implemented since the Socatri incident, was adapted by IRSN with local authorities to establish a broader monitoring plan, better appropriate to the Tricastin situation and allowing quick reactions in case of new exceeding of WHO guideline values.

In September 2008, IRSN presented a first feedback of the results obtained since July 2008. This environmental assessment clearly showed that there was no persistent pollution linked to the uranium discharge of the 7th July in Socatri factory. However, the results clearly identified the presence of a former uranium contamination within Tricastin groundwater not directly linked with the Socatri incident.

In fact, it turned out that, before the Socatri incident, AREVA and IRSN were already working on uranium contamination in Tricastin groundwater. The results of this former study (IRSN, 2008a) were presented to the local information commission (CLIGEET) just before the Socatri incident, on July 4, 2008. These results put forward several hypotheses explaining the origin of this contamination (geological anomaly, anthropic uses related to pesticides, direct nuclear site activities) and highlighted the need to continue the work on the subject. The Socatri incident reinforced the need to monitor uranium contamination in the area. The fears, concerns and interrogations from local populations and local decision-makers pushed AREVA and IRSN to continue the research on the source and levels of uranium contamination. Taking into account the sensitive context associated with the leakage of uranium, IRSN and AREVA decided to implement their research with an innovative approach involving local stakeholders.

Site description

The Tricastin nuclear site is one of the most important industrial site in Europe where several factories dedicated to the nuclear fuel cycle (Eurodif, Socatri for example) as well as one NPP are installed. Localised in the Rhone Valley, at the South of France, this nuclear site covers an area of more than 600 hectares, and concerned two different administrative departments: Drôme and Vaucluse.

As for the environmental aspects, the TRICASTIN site is located on the edge of the Donzère-Mondragon canal and is also surrounded by two local rivers (La Gaffière and La Mayre Girarde) which are direct affluents of the Rhone river. Moreover, the Rhone alluvial groundwater is present under the site itself. Thus, the vulnerability assessment of the Tricastin site clearly shows the aquatic transfer issues.

Concerning the socio-economic aspects, Tricastin region is of course heavily boosted by the nuclear site which generates more than 4,500 direct and indirect jobs. Agricultural activities (vegetable-growing, fruit-growing) and tourism complete the socio-economic activities of the region.

Figure 5: Localisation of the Tricastin nuclear site

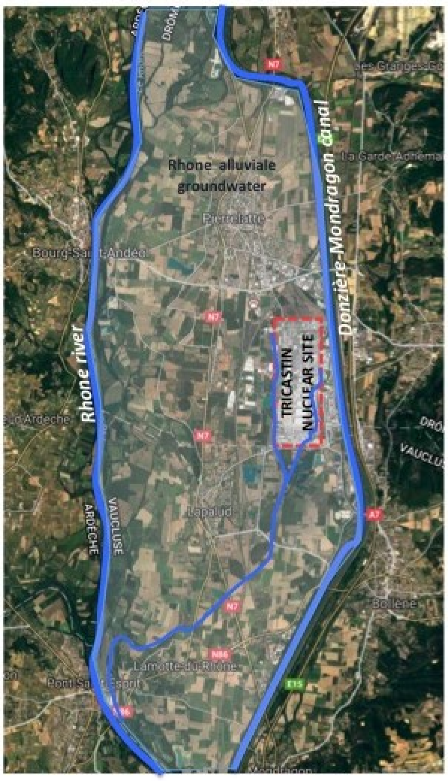


Figure 6: River system of the Tricastin region

4.2 Protective actions applied

Following the Socatri incident, some protective actions listed below have been applied from July 8, 2008:

- Activation of the Internal Emergency Plan of the Socatri factory
- Information to the French Nuclear Safety Authority and the French nuclear radiation protection and nuclear safety institute (IRSN)
- Information to the territorial authorities and local municipalities
- Publications of decrees (from prefects of Vaucluse and Drôme departments) prohibiting:
    - consumption of drinking water from private catchments,
    - agricultural irrigations which use La Gaffière and Lauzon rivers as springs,
    - water activities and bathing in certain waterbodies,
    - fishing and consumption of fishes in some waterbodies and rivers.
- Environmental measurements and analysis of the radiological situation at stake by IRSN, AREVA and regional health agencies.
- Urine analysis of inhabitants living near the SOCATRI factory

Following the first results of environmental measurements, attesting that the radiological exposure associated with the uranium leak was low, the Prefects decided to lift the prohibition decrees on July 22, 2008. However, on the advice of the French Nuclear Safety Authority, an expanded environmental monitoring system was set up by IRSN till December 2008.

The results of this monitoring were published in December 2008 (IRSN, 2008a) and attested that the pollution did not spread to the groundwater compartment.

4.3 Communication aspects

Despite the fact that the radiological exposure associated with the leak of uranium was considered low by the competent authorities, the SOCATRI incident has raised many emotions which have been strongly relayed by media tending sometimes to turn this incident into a major crisis.

Indeed, the SOCATRI incident was covered by all French mass media (television, press) and remained in daily news for several weeks, or even several months. The news published in media were focused on various aspects of which the most important are listed below:

- The delay of communication of SOCATRI to the competent authority which waited for the next day 13:00 (July 08, 2008) to launch the procedure of information, while the leak had occurred the day before at 23:00;
- The incomplete information, lack of transparency towards the population concerning the real situation and the real impacts of the incident;
- The lack of coherence between information disseminated by the various actors involved (IRSN, AREVA, ASN, etc.);
- The precise information regarding restrictions and prohibitions of water use and water consumption (name of the affected villages, name of the rivers and lake concerned, etc.);
- Some precisions on the uranium leak and the radiological situation and its possible health consequences;
- The unknown evolution of the uranium leak regarding its possible transfer in the groundwater and its impacts on private catchments;

- The major economic disruptions caused by the incident in the Tricastin region and reactions of the local populations (loss of crops, decrease of tourist activities, loss of images of typical products as wine);
- The unknown and long-term consequences of the Socatri incident (radiological exposures and associated health risks, possible impacts on agricultural activities, tourism, real-estate, etc.)
- The series of nuclear incidents in Tricastin region occurred in July 2008 and the reactions of various national politicians using this coincidence to criticize the energy strategy implemented in France;
- The parallel with the political context of the moment, as at that time, the French President of the Republic (N. Sarkozy) had announced the construction of a new EPR reactor by 2011;
- AREVA's reaction to this incident, whose CEO at the time (A. Lauvergeon) came to the affected territory to apologize for the occurrence of this incident;
- The various meetings organized by the Socatri with locals in order to find some consensus regarding compensations of the incident's impacts.

4.4. First interaction with public

The water consumption prohibition brought many questions and concerns from local populations on the uranium contamination and its potential health effects. Consequently, a sort of psychosis atmosphere, widely taken up by the media quickly settled down.

Fortunately, the rapid lifting of restrictive actions and the effort made by AREVA to compensate the economic losses resulted in a temporary relief of this climate of tension. However the results announced by IRSN in September 2008, highlighting an uranium contamination prior to the incident then caused new confusions among the population. Many mothers became worried again about the health of their children and doubted about the water quality: '*For 20 years we have been drinking water from the Tricastin groundwater. We had never thought of a radiological risk. What bothers me are our two young children who drink this water every day*'. Thus, populations became more and more skeptical about official information relayed on the Tricastin situation and so lost confidence on experts and decision-makers.

So in this context, AREVA and IRSN decided to respond to the scientific uncertainties associated with the origin of uranium contamination in the Tricastin groundwater. To achieve their goal, they chose to develop a pluralistic approach involving local decision-makers as well as local stakeholders, so as to build a peaceful and serene dialogue with the local population.

4.5. Additional communication and societal aspects

Implementation of a pluralistic approach to respond to scientific and social uncertainties

The overall goal of the joint approach proposed by IRSN and AREVA was to understand the origin of the uranium contamination in the Tricastin groundwater. From a technical point of view, this study was carried out by AREVA and IRSN (sampling, analysis and modeling) and by a local analysis laboratory (sampling and analysis) in order to compare the data and ensure the veracity of the values (IRSN, 2010a).

The progress of the research and the associated outcomes were discussed within a committee gathering experts form AREVA and IRSN as well as institutional representatives, various local decision-makers and local stakeholders as such as: representatives of Drome and Vaucluse departments, representative of the regional health agency, members of the Local Information Commission (with representatives of trade unions and environmental NGOs) and representative of an environmental

NGO, i.e.: the Commission for Independent Research and Information about RADiation (CRIIRAD) (IRSN, 2010a).

From February 2009 to September 2010, this pluralistic committee met 8 times at the occasion of plenary working meetings and twice at the occasion of thematic working meetings dedicated to the understanding of the potential health effects of low doses and the different associated mechanisms (IRSN, 2010a).

The aim of these working meetings was mainly to discuss the progress of the research work carried out by IRSN and AREVA, the different results obtained and the proposed interpretations. The challenge of this committee being to establish a pluralistic reflection, opened to stakeholders' expectations, the working meetings were also the occasion to discuss the implementation of additional actions proposed by members of the committee (IRSN, 2010a).

After almost 2 years, the results of the study followed by the pluralistic committee was summarized in a final report [3] and was also presented at a public meeting on September 22, 2010 (IRSN, 2010b, IRSN, 2010c).

This public meeting brought together local actors and inhabitants from the Tricastin region. Efforts made by IRSN and AREVA to work with transparency with the pluralistic committee and the adaptation of their research to respond to people's concerns were recognized and highly appreciated (IRSN, 2010b, IRSN, 2010c).

During this public meeting, the different steps of the study, the results obtained and the interpretations made were presented in a pedagogical way by IRSN experts. Then, exchanges with local participants were the occasion for experts to address people's fear and concerns about their local situation. It appears that this transparent process highly contributed to alleviate public concerns (IRSN, 2010b, IRSN, 2010c).

The map of the different samplings implemented during these two years and the associated results are presented in Figure 7.

The results of this 2-years study (IRSN 2010a) clearly show the 2 zones where uranium contamination still remained in the Tricastin groundwater. However, this research didn't conclude on the origin of the uranium contamination. It only delineated the existing lenses of pollution and thus informed local populations as to the actual radiological state of their environment.

The pluralistic approach

In the context of distrust following the Tricastin incident, the pluralistic approach implemented by IRSN and AREVA, under the supervision of the French safety authority, was an innovative approach that allowed to discuss uncertainties associated with the uranium contamination of the Tricastin groundwater. The participants of the pluralistic committee were able to realize the high level of technicity raised with scientific uncertainties. Comments from members of this committee revealed indeed that the debates during the working meetings were very often quite technical. So, some participants proposed that, in the framework of a similar approach, it would be interesting to leave the technical debate to experts and to create a "stakeholder group" with pedagogical explanations of what is at stake.

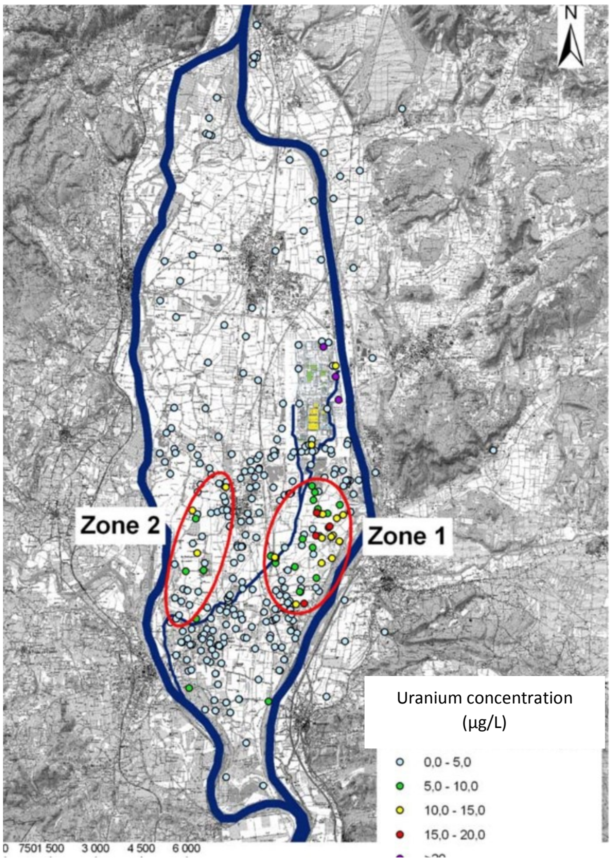


Figure 7 : Contamination map in the Tricastin area

In the case of the follow up of the Tricastin site, an epidemiological study assessing the incidence of cancer in the region was launched in parallel with the pluralistic committee [6]. As the leaders of these studies were different and that no common framework was designed at the beginning, the results of these two studies could not be compared. Thus, doubts remain about links between uranium contamination and cancer incidence in the region, and so another type of uncertainties has been highlighted (IRSN, 2010a; ORS, 2010)

References

IRSN (2008a). Radioactivité des eaux de forage autour du site de Tricastin-Pierrelatte. Note Technique DEI/SESURE n°2008-06 (juin 2008).

IRSN (2008b) Fiche présentant le bilan de la surveillance environnementale réalisée au 30 novembre 2008 et les conclusions de l'IRSN quant aux mesures de surveillance à maintenir. N° DEI/DIR/2008-0224, 10/12/2008.

IRSN (2010a). Etude sur l'origine du marquage par l'uranium dans la nappe alluviale de la plaine du Tricastin. N°DEI/2010-004

IRSN (2010b). Presentation et mise en debat du rapport portant sur l'origine du marquage par l'uranium de la nappe de la plaine du tricastin - reunion publique organisee a pierrelatte le 22 septembre 2010

IRSN (2010c). Réunion publique à Pierrelatte le 22 septembre. Présence d'uranium dans la nappe phréatique du Tricastin - La réponse des experts.

ORS Rhône-Alpes (2010). Etude sanitaire sur les cancers autour du site nucléaire du Tricastin

5. Norwegian case: Iodine release at the research reactor in Halden, Norway on October 24th 2016, INES 1

5.1 Description of the case

Institute for Energy Technology (IFE) is an independent research foundation that is located in Norway. It performs research in the fields of energy research, safety, environmental- petroleum- and nuclear technology[1]. IFE operates the only two existing nuclear research reactors in Norway.

Monday 24. October 2016 at 1.45 PM an unintended release of radioactive iodine occurred in relation to the handling of test fuel in the reactor hall of the Halden Reactor, situated in the Østfold county, 120 km south of Oslo (IFE 2016). Official press release from the Institute of Energy Technology (IFE) appeared only on October 25th, the Norwegian Radiation Protection Authority (NRPA) was also informed only the day after (20 h after the event). Reactor was closed for maintenance at the time of incident according to normal operational practices, and was restarted again in May 2017 after permission from NRPA.

The release of ^{131}I into the air was about 8% of what Halden reactor is allowed to release in a year under normal conditions, while release to water was about 15% of the yearly limit.

There is an ongoing discussion about the scale of the incident, which was originally classified as INES 1. There is no information on what kind of doses the workers would have received in the reactor hall had they not been evacuated.

5.2 Protective actions

The workers were evacuated. Ventilation systems at the reactor were shut down to avoid spreading of more iodine to the outside environment. The release was so small that it was not expected to have any consequences for the environment or human health. Reactor was closed for maintenance at the time of incident.

5.3 Communication aspects

The press release was published only the day after the incident. The news never made the first page of the national Norwegian media. The message about event was published as a tiny notice on October 26th. The local newspaper Halden Arbeiderblad paid more attention to the case (Figure 8), Although, analysis showed that several articles were copies of those written by the news agency NTB. Local newspapers ran several front pages focusing mainly on the bad information routines at IFE that resulted in delayed warning of authorities and public. Most of the articles were merely informing about the course of events. There were few opinion articles by local inhabitants, few written by NGO Bellona and two articles written by Institute for Energy Technology (IFE) that are responsible for the reactor.

[1] https://www.ife.no/en

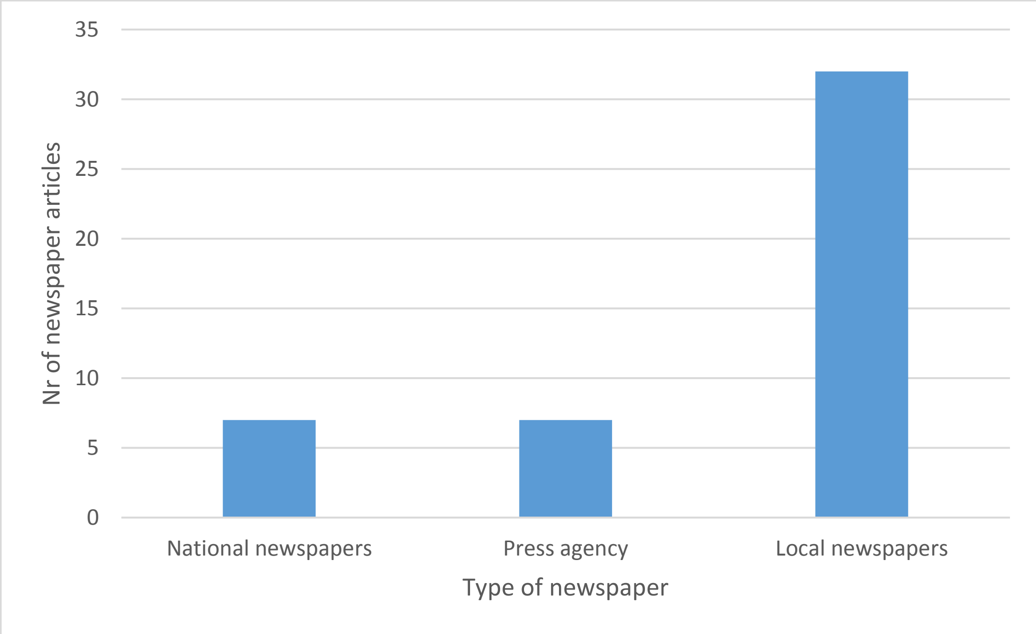


Figure 8. Newspapers that covered iodine release from Halden reactor

The type of uncertainties presented in the newspaper articles shifted over the time. In the first articles about the incident, uncertainty was expressed about the cause of the accident and its extent. It was also uncertain why it took 20 hours from time point of when the incident happened to the time when Norwegian Radiation Protection Authority (NRPA) was notified about it.

> *"Those who were in the reactor hall during the release evacuated when alarm went off. They have later on been inside and worked on identifying cause and extent of the leakage."*

> *"It is not a routine release. This should not happen and release should be stopped and put under control."*

Later, newspaper articles were focusing on the news about an external committee that was created to investigate the details of the incident. The committee was going to evaluate all aspects of the incident, including delayed notification and management of the consequences.

Articles citing NGO Bellona or written by them were expressing uncertainty about the potential effects the radioactive release could have on environment and inhabitants of the surrounding area. They were also questioning the safety culture at IFE and safety of the reactor itself. Given that NRPA was warned almost a whole day after the accident, Bellona was questioning whether measurements they performed to assess the potential contamination were useless as they took place too long after the release happened.

> *"IFE report of their webpage that release to the surroundings is about 5-8% of the amount they are allowed to release in a year. - But here, the release has happened over short time, so it would have bigger effect than if releases were spread over a bigger period of time, says Nils Bøhmer..."*

> *"In Bellona's opinion it is particularly concerning that reactor core can become unstable by mere closing of the ventilation system...The inhabitants of Halden were earlier calmed by warranties that the mountain hall behind the reactor can be hermetically closed in case of possible releases. The incident in October shows that that warranty does not exist anymore."*

Opinion articles expressed uncertainty about the levels of radiation and how far it was spread in the surroundings during the release. They question the way limits for releases are set and IFE's ability to maintain safety and security of the reactor.

Media speculations in Europe

In January 2017, small concentrations of iodine were detected in the atmosphere all over Europe. The origin of the iodine was unknown and none of the nuclear facilities in Europe or Russia took responsibility for the release. Finnish and French authorities released the information about the measured concentrations while NRPA chose not to do so as in their opinion concentrations were very low and had no news value (Nilsen 2017). On March 3rd 2017, Bellona[2] published an article on their webpage discussing the safety of the Halden reactor and the history of incidents on this reactor. This article has unexpectedly unleashed a wave of conspiracy articles claiming reactor meltdown is taking place in Norway, which is being the source of radioactive iodine clouds over Europe in January (Digges 2017). After several inquiries from international media, NRPA had to publish a rebuttal on March 17th denying any release of radioactive iodine in January and meltdown of the reactor to counteract the rumors (NRPA 2017).

Social media

There was not much activity on the social media with relation to the Halden accident. Both IFE and NRPA used their Facebook page to share the press release and post updates of the situation (figure 10).

Figure 10: Facebook post about the Halden accident from IFE (to the left) and NRPA (to the right).

[2] The Bellona Foundation is an independent non-profit organization that aims to meet and fight the climate challenges, through identifying and implementing sustainable environmental solutions (http://bellona.org/)

NRPA was also using Twitter as communication channel and posted the updates of the situation (Figure 11). NGO Bellona also appeared on Twitter to communicate about the articles they wrote about accident on their webpage (Viseth 2016). There was little or no discussion of the accident on the social media by members of general public.

Figure 11: Tweets from NRPA related to the Halden accident

Opinion poll

According to the results of the survey performed by NRPA in September- October 2017, Norwegian population considers potential accidents at one of Norway's research reactors as least likely from the list of radiological threats (Strålevernsbarometer 2017).

References:

Digges, C. (2017) How a Bellona report got swept up in a squall of fake news about a secret nuclear meltdown http://bellona.org/news/nuclear-issues/2017-03-how-a-bellona-report-got-swept-up-in-a-squall-of-fake-news-about-a-secret-nuclear-meltdown

Fretheim, A. (1986). *Tiltak mot kjernekraftulykker: delutredning 1 : erfaringene etter kjernekraftulykken i Tsjernobyl*. Oslo: Universitetsforlaget.

Helsedirektoratet (1986) Intervention level for radioactivity in the reindeer and game meat changed to 6,000 Bq per kg. Press release from the Norwegian Directorate of Health and Ministry of Agriculture, 20.11.1986IFE (2016) Unintended release of radioactive iodine at the Halden Reactor. IFE press release - https://www.ife.no/en/ife/ife_news/2016/pressemelding-utilsiktet-utslipp-av-radioaktivt-jod-ved-haldenreaktoren

Hernes, G. (1986). *Informasjonskriser*. Oslo: Universitetsforlaget.

Larsen Ø, Evensen, S. A., Gradmann, C. (2011) Tsjernobylulykken 1986 – hvordan reagerte norske myndigheter og fagmiljøer i dagene og månedene etter 26. april 1986? *Michael*:8:19-143 Available at http://www.dnms.no/index.php?seks_id=124789&a=1

Nilsen, T. (2017) Radioactive Iodine over Europe first measured in Finnmark. The Independent Barents Observer

NRPA (2017) Usanne rykter om nedsmelting ved IFE Halden. Available at https://www.nrpa.no/nyheter/93721/usanne-rykter-om-nedsmelting-ved-ife-halden

Oftedal, P. (1987). *Tsjernobyl-ulykken: rapport fra Helsedirektoratets rådgivende faggruppe : avgitt til Helsedirektøren 1. oktober 1986*. Oslo: Universitetsforlaget.

Skuterud L, Thørring H (2012). Averted doses to Norwegian Sami reindeer herders after the Chernobyl accident. Health Physics 102(2): 208-216.

Strand P, Selnæs TD, Bøe E, Harbitz O, Andersson-Sørlie A (1992). Chernobyl fallout: Internal doses to the Norwegian population and the effect of dietary advice. Health Physics 63(4): 385-392.

Tveten, U., L. I. Brynildsen, I. Amundsen and T. D. S. Bergan (1998). "Economic consequences of the Chernobyl accident in Norway in the decade 1986-1995." Journal of Environmental Radioactivity **41**(3): 233-255.

Viseth, E. (2016) Halden: Lekkasje av radioaktivt jod. Published on October 25th 2016. Available at http://bellona.no/nyheter/energi/atomkraft/2016-10-17988

6. Slovenian case: The Unusual Event at the NPP Krško, Slovenia, on 4 June 2008, INES 0

6.1 Case description

A leakage from the primary system to the containment was detected by the Nuclear Power Plant (NPP) Krško operating personnel at 15:07 on Wednesday, 4 June 2008. Since the leak was larger than allowed according to the Technical Specification of the NPP, the personnel started with controlled shutdown according to the procedures which requires to stop the power plant in 6 h after the event and to reach cold shut down in next 30 h. The power was reduced from 98.6% to 0 by the rate of 5 MW/min. The generator was disconnected from the grid at 19:30 and the reactor was subcritical at 19:50. The cold shut down of NPP was achieved on 5 June 2008 at 7.55 am. The power plant was shut down in a normal procedure and not with a "scram" which places considerable strain on the structural mechanics of the reactor and renders the re-activation process more time-consuming and complex (SNSA, 2009).

At the entrance into the containment it was found out that the leakage was on seal of the isolation valve on a bypass line for measuring the temperature of the primary system on the hot branch of the loop 2. The event had no important safety indications (SNSA, 2009).

The NPP Krško announced the unusual event on 4 June 2008 at 15:56 and classified it as level 0 on International Nuclear and Radiological Event Scale (INES) scale (events without safety significance are called "deviations" and are classified Below Scale / Level 0 on INES) based on internal procedures and State Emergency Preparedness and Response (EP&R) Plan. The Slovenian national and regional warning points (CORS – Center for information of RS, ReCO – Regional center for information) and the Slovenian Nuclear Safety Administration (SNSA, nuclear regulatory body) were notified as in the procedures. The SNSA inspector on duty was first called and he informed the SNSA director about the event at 16:09. The SNSA director promptly decided to partially activate the SNSA expert team for managing emergency situations.

The NPP Krško announced the termination of emergency 5 June 2008 at 12:40 when the operation state was achieved for which no further limitations and conditions were requested. The leakage was reduced due to decrease of pressure. NPP notified all national warning points about the termination. In the evening of the same day further examination of the valve and related systems and equipment was performed.

The total time from announcement of the unusual event to its termination lasted for 20 h and 44 minutes.

6.2 Exchange of information

The following exchange of information took place according to the established procedures:

- The NPP Krško announced the unusual event on June 4 at 15:56.
- The SNSA sent the first message about the event to the European Commission (EC) by the ECURIE system at 17:38.
- The ECURIE office head forwarded the SNSA message to all national centres in Europe at 18:00.
- The SNSA prepared and exchanged a draft summary of its press release for the public with the NPP Krško at 18:08 and then issued it at 18:16.
- The NPP Krško issued the same press release as well 15 minutes later.
- Between 18:35 and 19:00 the SNSA sent the report to the IAEA and competent authorities of Austria, Hungary, Croatia and Italy.
- At around 19:30 the EC issued a press release on the event, which set off extraordinary interest all across Europe.
- At 19:50 the reactor was subcritical.
- Due to the media pressure, SNSA at 21:20 again notified ECURIE about the status.
- ECURIE issued at 21:20 another media update with information on termination of event.

Immediately after that, the media pressure started on all competent authorities and continued until the next day. Because of high media pressure the SNSA published an additional press releases on the SNSA website and sent additional information to the ECURIE system (SNSA, 2009).

6.3 Response of different stakeholders

NPP Krško

Based on the analyses (SNSA, 2009) it was found out that the measures implemented by the NPP Krško took place according to the internal and state EP&R plan and corresponding procedures. NPP based its classification on accessible information and classified the event as unusual, level 0 on INES scale, which is anticipated operational occurrences according to the IAEA glossary. NPP also notified all responsible institutions in Republic of Slovenia, and started the procedures to shut down the NPP as prescribed in such events. The steps for identification of the extent of unusual event, condition of the system and consequences were also taken place according to the procedures along with the final termination of the event.

Administration of RS for protection and rescue (URSZR)

Within the responsible institution of Administration of RS for protection and rescue (URSZR - Uprava RS za zaščito in reševanje) there is a Center for information of RS (CORS-Center za obveščanje RS) which first received the information on the unusual event from NPP Krško, verified the information with NPP and contacted SNSA (inspector on duty) and Regional center for information (ReCO in Brežice – municipality next to NPP, responsible for regional EP&R). At 16.43 CORS required additional information from SNSA on the extent of event, agreement on the provision of information and their extent. It also harmonised the response with ReCO. At 16:54 the general director of URSZR was informed. At 18:03 CORS received the first ECURIE report about “Alert, leakage on primary system, reactor shut down”. CORS also receive a press release from SNSA at 18:18, which then was transmitted to the responsible institution in Slovenia, and also to Office of Prime Minister. At 21:32 CORS receive the third fax message from ECURIE “plant is safely shut down, situation under control, no impacts on environment”.

In approximately 2 hours (from 20:03 until 22:38) ReCO received 18 calls from citizens, which were worried and wanted to obtain further information on the developments. Most of the citizens in question obtained the information from abroad (SNSA, 2009) and after checking the reality of data on the emergency number 112.

Both CORS and ReCO were acting according to the state and regional EP&R plans.

Slovenian Nuclear Safety Administration

SNSA (Uprava RS za jedrsko varnost – URSJV), the inspector on duty, was informed about the event from NPP and forward the information to director of SNSA at 16:09. The expert team of SNSA for emergency respond was activated composed of group responsible for monitoring of the event development, internal and external communication officers, in total of 11 staff members. The function of emergency manager was taken by SNSA director (SNSA, 2009).

At 17:38 SNSA sent the message in ECURIE with the indication "ALERT". After the message, the head of ECURIE called the SNSA where more information on conditions in NPP were provided. ECURIE distributed the SNSA alert to all national centres in Europe. The first press release for Slovenia was given by SNSA at 18:16 and a bit later also by NPP.

Until 19:00 also the neighbouring countries were informed and also IAEA. But during the provision of information the form which was used had the label "EXERCISE" which was not crossed out. After the receipt of the form, the IAEA staff called and pointed out the mistake as they already received the correct information also by ECURIE system. The emergency manager apologized, asked for correction of the wrong label to cross it out (SNSA, 2009). IAEA did inform all the countries with correct message.

Due to the media reactions, which followed, and which were extremely intensive and sensational, SNSA issued several additional press releases on SNSA webpage and additional messages in the ECURIE system (SNSA, 2009). During next morning, also additional explanation message was sent to IAEA and to INES reporting system.

From the analyses of the communication which was prepared within SNSA and reported in (SNSA, 2009) and in (SNSA, 2010) it can be seen that the communication between NPP, CORS and SNSA was according to the procedures and EP&R plans (state, regional, institutions). The categorisation of event which was given by SNSA was the same as the one given by NPP. The communication of SNSA was according to the procedures and responsibilities (national, international, cross border agreements, conventions). The information for the public and media was adequate. There was a trivial mistake with the informing the IAEA, which was according to the SNSA consequence of the bad template of the IAEA. The informing in the ECURIE system was formally correct but the report was too conservative and underestimate the possible respond in public. The interpretation of ECURIE instructions was possibly having several meanings and SNSA was misinterpreting the instruction for providing the notification.

6.4 Protective actions applied

National level

The Slovenian government formed a commission composed of senior nuclear experts, civil protection authorities and NPP to investigate the event (Vlada RS, 2008). The commission found out that the actions were in accordance with expectations but with some deficiencies. The government commission suggested the procedures for emergency information should be improved, that emergency exercises should be regularly continued, that the Slovenian competent authorities and the EC should improve the procedures for similar cases and that the system for implementing emergency measures should be more rigorous. The following recommendations were adopted by the government (SNSA, 2009):

- The NPP Krško (NEK), the SNSA and the URSZR should carry out regular review of all their internal instructions relating to procedures and measures in cases of emergencies and to update them accordingly in accordance with the applicable legislation, in particular the Act on the Protection against Natural and Other Disasters and the implementing regulations issued on the basis thereof;
- NEK, SNSA, URSZR, the Headquarter of Civil Protection (ŠCZ RS) and Office of RS for communication (UKOM) should check the instructions and procedures that regulate information and mutual communication in the events of the NEK, especially in the event of events marked as "abnormal event";
- URSZR, together with the SNSA and the NPP Krško, should consider complementing the procedures for informing the competent authorities, authorized persons and the public in cases of "abnormal events";
- NPP Krško, the SNSA and the ŠCZ RS should, through appropriate procedures, ensure harmonized information to the domestic and foreign public and international institutions with clear delineation of responsibilities;
- In its annual exercises of the EP&R Plan (NUID), NEK should also include the SNSA and the URSZR. Particular attention should be paid to improving communication between individual emergency centers (NEK, SNSA, ŠCZ RS);
- The SNSA should investigate the procedures, criteria, forms and reporting methods in the ECURIE system with relevant international institutions;
- The SNSA should develop an internal procedure that will unambiguously identify the events that the SNSA will report to the ECURIE system and the IAEA. The procedure should also take into account international practice and the current practice. It is recommended that the SNSA develop the umbrella procedure, which relates to the NUID, be approved by the Expert Council for Radiation and Nuclear Safety prior to the enforcement.
- In the internal procedure, the SNSA should ensure that all press releases, media and external institutions (IAEA, ECURIE, ...) messages will be reviewed and approved by the Director for Emergency Management at the SNSA prior to shipment, which will ensure the proper quality of the messages. Through the signatures all important steps and decisions related to issuing a report or notification should be recorded in the process.

International level

There was a meeting of the ECURIE member states and EC in November 2008 in Brussels to discuss the event. It was found out that Slovenia in this case did **not need to send an alert message**, but on the other hand Slovenia was following the unofficial procedures to communicate transparently and to report minor events as well (SNSA, 2009). The members of the meeting agreed that EC published a press release which was too alarming, and which started a large media alarm throughout Europe. The EC prepared improved criteria for reporting to the ECURIE system. The provision when to report was explained in greater detail.

In the future, similar cases will be announced as information messages with a new keyword - »incident«. The EC representatives agreed that the press release was too alarming, however they kept the right to inform the public in similar cases also in the future. They agreed that before issuing press releases they would consult with the country of the event (SNSA, 2009).

6.5 Communication aspects

The unusual event produced an extreme and enormous response and coverage in the media. The thorough analysis was performed and reported in (Perko, 2011) where 207 media texts published or broadcasted between 4 and 14 June 2008 were analysed. According to the analyses performed the coverage (number of articles per single media) about the event was present in almost all EU countries, the major one in Italy, even more than the second one in Slovenia, followed by Germany and Switzerland. The news was on all major media, including international one, like CNN, Fox new, BBC and others. It was revealed that one important factor impacting the frequency in media was the presence of nuclear debate in the country. For example, in Italy the debate was at time very intensive and vivid, as the country was opening the possibility of reopening of nuclear programme. The major sources of information for media were depending on the country. In Slovenia the most important source of information was SNSA and NPP Krško, followed by secondary media sources without identified sources. In the neighbouring countries (Italy, Austria, Hungary and Croatia) the most quoted sources of information were by far the decision makers. In other countries the most quoted sources of information were other media.

The majority of the media reports pointed out the problem of communication and safety/risk aspects of the event. In Slovenia the international reaction was also presented in articles and other media. The event also opened other aspect of the Krško NPP, like co-ownership between Slovenia and Croatia and related political problems, funding problems for decommissioning and RW management and the future of nuclear option in Slovenia and region.

The analyses of the media reports also revealed that the media published articles and contributions with more negative connotation. The most contribution in Slovenia were using the keywords like Alarm, Danger, Dread, Panic, Nuclear accident and Chernobyl. The links with negative connotation was different between the other countries. The media mostly used negative words to describe the event, even there was no safety related impacts.

The question is why the reporting of media was negative, emotional and so intensive. There is no clear investigation behind, but possible answers could include:

- Media looking for stories: The nuclear accident, even if it is just an anticipated operational occurrence and categorised as level 0 on INES scale is in Europe and worldwide an event which attracts a lot of attention. One thing is for sure that nuclear accidents are big news, whatsoever. And this one was amplified with the EU communication pathways, also exposing the problematic ways how the events should be reported, and the fact that SNSA use non-conventional way of informing on minor events labelled the notice with ALERT.
- Eastern Europe stigma: The attention for the event was much greater than if it would be happened in the West as it was coming from the country of so called “Eastern bloc”. This is very strange for Slovenian, as we do not perceive and understand us as part of the Eastern bloc (in fact, we were never part of Eastern bloc from historical point of view). The fact that NPP Krško is PWR of Westinghouse origin it was not known to media or population (in Slovenia, and specially abroad).
- Media looking for best sellers: Part of the answer is also that the media reporting have the characteristics to use (or abuse) the events with high potential risk impacts and interpretation. Such news are best sellers and good stories to cover with a lot of attention from receivers – that is the public.

6.6 Additional communication and societal aspects

A summary of selected reports from the EuroTopics archive is provided below.

Accident at a Slovenian nuclear power plant (Accident at a Slovenian nuclear power plant, 2008)

Confusion surrounding an alleged accident in a nuclear power plant in the Slovenian town of Krško has reignited the discussion about the safety of nuclear energy in Europe. But critics are also dissatisfied with the EU Commission's information policy and the European nuclear alarm system "Ecurie".

Worst case information scenario in Slovenia (Worst case information scenario in Slovenia, 2008)

The newspaper comments that the confusion surrounding the alleged accident at the Krško Nuclear Power Plant highlights the weaknesses of the European warning system and an insufficient information policy: "Does anyone know what actually happened on Wednesday at the power plant in Krško? Did anything happen? Did nothing happen? Should we believe that someone 'simply' mistook one document for another and thus set off the European alarm? Even if this turns out to be a minor incident, one thing is clear: it was a nuclear worst case information scenario, demonstrating that the European alarm system does not work. Otherwise there could hardly have been so much confusion. ... Nevertheless, Slovenia did issue a report. The same cannot be said of all of us when a problem arises. This must be recognised. But please tell me, what will happen when something really serious happens? Who will be able to quickly assess the situation? What will be done? This debacle makes one fear the worst." (06/06/2008).

Bad for one's reputation (Pucelj, 2008)

The daily expresses concern about the damage to Slovenia's reputation following the incident at the Krško nuclear power plant: "Although the false report, or rather misunderstanding, was corrected within a matter of minutes, the whole affair threw a bad light on Slovenia's credibility, particularly as far as our northern neighbours are concerned, whose opinion of us was not good to start with. ... The mistake and the carelessness ... became catchwords for the political and media coverage, which carried the implications: what is really going on at the nuclear power plant? What are the Slovenians hiding? And then there's the fact that it is very unusual, to say the least, that such an important matter as the official reporting of an incident at a nuclear plant depends on a word being crossed out on a form to draw the distinction between a genuine accident and a test-run." (06/06/2008)

Europe's energy dilemma (Bahovski, 2008)

According to the Estonian daily the incident at the Krško nuclear power plant in Slovenia highlights once more the dilemma the EU faces: "Nuclear energy is not particularly popular with EU citizens, but at the same time the energy sector depends on it to a large extent. If less electricity is produced through nuclear power because incidents like that in Slovenia bring back memories of the Chernobyl disaster in 1986, more gas must be imported, and most of that comes from Russia. Some people point to the dangers of nuclear energy, while others emphasise the danger of dependence on Russia. Our politicians need to find answers to how we can get along without nuclear energy and at the same time reduce Europe's energy dependence - and the solution better be an environmentally friendly one, too, please." (06/06/2008)

References

Accident at a Slovenian nuclear power plant. (2008). Retrieved from EuroTopics: https://www.eurotopics.net/en/

Bahovski, E. (2008). Europa's energy dilemma. Retrieved from http://archiv.eurotopics.net/en/home/auarchiv.eurotopics.net/en/home/medienindex/media_articles/archiv_article/ARTICLE29282-Europe-s-energy-dilemma: archiv.eurotopics.net

Perko, T. (2011). Importance of Risk Communication During and After a Nuclear Accident . Integrated Environmental Assessment and Management, pp. 388-392.

Pucelj, G. (2008). Bad for one's reputation. Retrieved from http://archiv.eurotopics.net/en/home/autorenindex/autor_pucelj_gregor

SNSA. (2009, Debrua). Poročilo komisije o dogodku v NEK 4.6.2008. Retrieved from http://www.ursjv.gov.si/si/info/novica/5444/

SNSA. (2009). Razširjeno poročilo o varstvu pred ionizirajočimi sevanji in jedrski varnosti v Republiki Sloveniji leta 2008. Ljubljana: URSJV.

SNSA. (2010). The Fifth Slovenian Report on Nuclear Safety. Ljubljana: SNSA.

Vlada RS. (2008). Sklep o ustanovitvi, nalogah in imenovanju Komisije za preučitev dogajanja in načina poročanja ob dogodku v NEK, dne 4.6.2008. Ljubljana: Vlada RS.

Worst case information scenario in Slovenia. (2008). Retrieved from Der Tagesspiegel: https://www.tagesspiegel.de/weltspiegel/

7. A retrospective evaluation of Chernobyl in Norway: Lessons learned for uncertainty in decision making

The accident at the Chernobyl NPP took place in April 1986 on the territory of former Soviet Union. The accident has been classified as level 7 event (INES). As the result of the accident, parts of Belarus, Ukraine and Russia were heavily contaminated. A number of European countries received radioactive fallout, including Norway.

The impact of Chernobyl on Norway has been reviewed many times, so this section is not intended to be a repetition of that type of analysis. Instead, this case study attempts to focus on the ways in which uncertainty influenced the decisions made, and what types of uncertainty were present even when they were not acknowledged by decision-makers.

7.1 Description of the case

The first information about accident came to Norway through mass media on April 28th at 12:30 – the radioactive fallout was measured by NPP Forsmark near Uppsala, Sweden. The head of the *State Institute of Radiation Hygiene (SIS)* initiated measurements at one of the measuring stations. He was the first one to report that radioactive fallout was measured in Norway in the news at 16:00 the same day. He has announced that Chernobyl accident will have no effect in Norway, which later showed to be completely wrong.

Norway did not have a preparedness system for radiological emergencies. At that time, there were three measuring stations in Norway, all of them in Eastern Norway.

> *"It is sheer luck that nuclear cloud entered Norway via Sweden. If the radioactive fallout came from north or west, it could have covered Norway without our notice" Leiv Berteig, State Institute of Radiation Hygiene (Hernes 1986)*
>
> *"… nobody knew what happened… Neither did we know where it has happened, why it has happened, which course it was going to take, how should one understand what has happened, what effects it was going to have, how one should react and who should one trust."* Gudmund Hernes (Larsen et al 2011)

It was unclear who should be responsible to manage the fallout situation in Norway.

A project group "Kiev" was created by the *State Institute of Radiation Hygiene* on April 30th (it had been working unofficially up to that time). The group was working on getting measurements done, evaluating them and making decisions on samples to be taken (e.g. snow and rain samples were requested from parts of Norway on May 2-3rd). A lot of work was based on improvisation and the huge effort of the Institute's employees to produce a good deal of measurement results in a short time. SIS also had to deal with constant information requests from public and media.

On the same day, the Minister of Social Affairs requested that an expert group be created under the Norwegian Directorate of Health with participants from SIS and State Institute for Public Health and contact to the Ministry of the Environment. This group would have responsibility for "*evaluating the situation and possible countermeasures in relation to the nuclear accident in the Soviet Union. The group will also have responsibility of providing public with information they consider necessary*" (Ministry of Social Affairs, 1986). The impression was that Norwegian Directorate for Health was going to take responsibility and manage the consequences of the accident. However, the representatives of the Norwegian Directorate for Health later denied that they had sole responsibility as in their opinion they were only responsible for evaluation of possible health effects. The Norwegian Directorate of Health did take responsibility over public information and insisting that all Chernobyl-related information was channelled through them. For SIS, this decision meant that they could not give information to public or press despite the enormous amount of requests they received (even the Norwegian Directorate of Health could not contact them since phone lines were busy). The Norwegian Directorate of Health considered it unnecessary to establish any special information procedures. They decided to not use the information arrangement suggested to them by the Ministry of Environment who had experience dealing with situations when information needs are high. They decided to not set up a call line for the weekend or to give contact information for public inquiries in their first press release. They "refrained from taking advice of any of the communication workers that directorate contacted and that had experience with crisis communication" (Hernes 1986).

There was a communication problem between the "Kiev"-group at SIS and the Norwegian Directorate of Health, which led to delay in information. For instance, the Norwegian Directorate of Health published a press release on 2nd of May stating that people in the southern part of Norway should not drink cistern water, while the note SIS sent them the same day stated that recommendation concerned whole Norway. Another example took place on May 4th, when the press release from the Norwegian Directorate of Health stated that contamination was decreasing and that county of Trøndelag had received same amount of fallout as county of Østfold, when SIS has informed them that the opposite has been observed. As a result, on May 6th the news programme Dagsnytt reported for the first time that information about increase in radiation levels was being kept secret and that experts performing measurements are "muzzled" in going public with results.

Evaluation of the accident management showed that the authorities were acting under false assumptions in adopting a homogenous model of distribution of the radioactivity based on their previous experience with fallout from nuclear bomb testing in 50-60s (Hernes 1986, Larsen et al 2011). They were also basing their conclusions on a very few observation points, which were not representative for the whole country (all three measurement stations were situated in the Eastern Norway – an area that was among least contaminated in Norway). In addition, the Norwegian Directorate of Health was paying more attention towards recommendations given by WHO rather than by Norwegian experts.

Only on May 16th did the Norwegian Directorate of Health for the first time confirmed that Trøndelag county was most affected by the fallout. First detailed maps showing the extent and distribution pattern of the radioactive fallout were presented on 27th of June. Nevertheless, there was still lack of clear assessment of the situation for the most affected areas. The delay in information from national and regional/local level resulted in affected counties (especially Trøndelag) starting to act on their own: taking samples and trying to understand the situation.

The Chernobyl accident coincided with a governmental crisis in Norway. The country was in the middle of shifting governments, which meant that it was hard to process decision e.g. about resources to conduct measurements.

Several institutions hosting relevant scientific communities were not contacted after the accident: The Norwegian Directorate of Health did not request weather maps from the Meteorological Institute that could help them to assess the fallout patterns over country. The Geological Survey of Norway (NGU) was another expert group that was not mobilized in the first week after the accident, although they had measuring equipment The Geological Survey of Norway (NGU), and had contacted the Directorate of Health as early as May 2nd. Both NGU and SIS repeatedly attempted to establish cooperation with the Norwegian Directorate of Health in order to develop a system of emergency preparedness prior the accident, but these attempts were not successful. The NGU, upon receiving a map of fallout from their 'sister-organization' in Sweden, started measurements in Trøndelag on their own. The measurement results NGU made public on May 6th were 10-fold higher than those presented by the Norwegian Directorate of Health the same day. The differences in the results were caused by different measurement techniques. There has also been disagreement between experts from SIS and NGU on how the measurement results should be interpreted. NGU was highly criticized by the Norwegian Directorate of Health and SIS for going public with their measurement results from Trøndelag. This critique was channeled through media as well and together with issues between SIS and the Norwegian Directorate of Health mentioned earlier, created speculations about censorship in the official institutions and whether some institutions get silenced and information is being held from public.

7.2 Protective actions

A range of countermeasures was applied in food production chain in order to reduce possible doses to population.

- Recommendation against drinking cistern water (accumulated rainwater) from 1.05.1986
- Recommendation against consumption of home grown leaf vegetables and prohibition of sale from 23.05.1986
- Clean feeding of the animals (sheep, reindeer)
- Change of pasturing areas
- Cesium-binders
- Dietary advice to population
- Increase of intervention limits
- Whole body counting of Sami population

Increase of intervention levels

Norway had experience from nuclear bomb testing fallout and knew that reindeer husbandry was going to be affected by Chernobyl fallout as well. Therefore, already in June, reindeer herders were involved in sampling in the grazing areas and slaughter of some reindeer in order to assess contamination levels. In July 1986 radioceasium levels in reindeer meat has reached up to 90,000 Bq/kg which resulted in ban of reindeer meat from central and southern Norway (permissible level for radioceasium in food stuffs was set to 600 Bq/kg in June). Later same year as winter and the main reindeer slaughter season approached, it was realized that radiocaesium levels in reindeer meat would exceed the permissible level 600 Bq/kg also in the less contaminated areas of northern Norway, were about 70 % of the reindeer meat production occurs. Given the very high contamination levels in central and southern Norway, and expected duration of the contamination problem based on experience from the 1960s, Norwegian health authorities in November 1986 chose to raise the permissible/intervention level for radiocaesium in marketed reindeer meat to 6,000 Bq/kg. In the press release announcing the change, one of the reasons given was: "A maintained intervention level of 600 Bq/kg will [...] result in production for condemnation and uneasiness among reindeer herders in the coming years. A despondent atmosphere, apathy and defection of young people will come forward in reindeer husbandry and the Sámi community [...]. If the limit is not raised, these problems will last for many years and can thereby threaten the Sámi lifestyle and culture, irrespective of monetary compensation" (Directorate of Health and the Ministry of Agriculture, 1986). If the permissible level had not been increased, about 85% of the total national reindeer meat production would have been condemned in 1986/1987.

From a radiation protection point of view the increase was justified by low consumption of reindeer meat by the average Norwegian consumer (about 0.5 kg/year) and corresponding neglectable radiation doses. Authorities expected extremely big problems with media and public reactions towards this decision, but extreme reactions didn't come and the decision was widely accepted by the Norwegian population.

Whole body counting

Whole-body monitoring of the reindeer herders in the most contaminated areas in central Norway was initiated in spring 1987. The purpose of the monitoring has been twofold: To survey and control ingestion doses and time-trends and to give herders' an opportunity to check whether their efforts to reduce radiocaesium intake were working. It was also an important tool that gave reindeer herders a feeling of control and visualized the effort they made to reduce intake of contaminated food (Larsen et al 2011). The whole body monitoring showed the decrease in internal doses over time, but it is hard to estimate if health of exposed reindeer herders has been affected.

The whole body counting is still ongoing and is likely to be continued as long as contamination is an issue.

7.3 Communication aspects

Monday 28th of April 1986 news programme *Dagsnytt* reported that increased levels of radioactivity were measured in Sweden and Finland. Later the same day, an expert from the Institute for Radiation Hygiene was interviewed. He reported that elevated levels of radiation were also measured in Oslo, that it originates from Eastern Europe and that it won't be of any danger to Norwegian citizens. This was the first message to population about the Chernobyl accident.

Authorities were highly criticized for their communication about the Chernobyl accident, therefore, Norwegian government set up a committee to evaluate how authorities and media handled the information in the aftermath of the accident in order to learn and improve preparedness for the similar situations to come.

The main conclusion of the evaluation committee stated that an information crisis was formed as soon as accident was announced. There was high demand for information about accident from the population, which health authorities didn't manage to address. This lead to a crisis of trust between authorities on one side and media and public on the other. It showed that health authorities held some information back.

Information from Norwegian health authorities was not complete and contained mistakes. The authorities responsible for information population lacked overview of the situation and drew wide conclusions on the basis of lack of information. The lack of coordination of information between different institutions or even within one institution (e.g. Norwegian Directorate of Health) resulted in contradictory messages to public:

1. Permissible limits has been exceeded, but it's not dangerous
2. You should not eat certain products, but it's ok if you do
3. Any increase in radiation causes cancer, but it is insignificant.

In addition to factual mistakes, information from authorities was inaccurate, ambiguous and some of the questions were left unanswered. This contributed further to the increasing lack of trust.

Information from the national to local authorities was delayed as press releases were sent with B-priority post (Larsen et al 2011).

7.4 Other aspects

Public opinion poll (from Hernes 1986)

A public opinion survey was organized in May-June 1986. It included a country representative sample of 1000 respondents over 15 years old and was performed by Gallup/Norwegian Opinion Survey (now KANTAR TNS). 93 % of respondents answered that they were badly prepared for a threat like nuclear reactor accident. Three out of four admitted poor knowledge about how to protect themselves from radioactive fallout. 38% of the respondents said they understood everything or most of the information reposted in the media in the aftermath of the accident. Also, three out of four did not consider information that was given to them from authorities or through media channels satisfactory.

8. Citizen Science initiatives after the Fukushima Daiichi nuclear accident

The Fukushima nuclear accident in 2011 sent shockwaves throughout Japanese society and has left a deep scar in the memory of the area in addition to the March 11 earthquake and the tsunami. In the wake of the accident networks of citizens measuring radiation were established. Seven years after the accident these citizen radiation measuring centres continue to monitor as the aftermath of the accident is still felt. The aim of the report is to analyse to what extent bottom-up engagement can help to cope with scientific and social uncertainties. For this purpose the report researches Citizen Science initiatives in the Fukushima area and Tokyo in order to identify the uncertainties citizens experience. The report comprises a qualitative study. Data is collected through a series of semi-structured interviews and participatory observation obtained during a research visit to ten organizations were visited in Tokyo, Fukushima City, Minami Soma, Aizu Wakamatsu, Iitate, Iwaki, Nasu and Sendai during a period of 6 weeks (17/02-30/30/2018). The study resulted in the identification of five topics: 1. uncertainties related to nuclear accident management and safety implications; 2. uncertainties related to society and family life; 3. uncertainties related to governmental approach to post-accident recovery; 4. uncertainties related to the relationship between science and society; and 5. uncertainties related to citizen radiation measuring centres.

8.1 Citizen Science and history of Citizen Science in radiological measurements

Citizen Science describes the relationship between the citizen and science. The European white paper on Citizen Science interprets Citizen Science as "[…] the general public engagement in scientific research activities when citizens actively contribute to science either with their intellectual effort or surrounding knowledge or with heir tools and resources." (Socientize, 2015, p.8) The definition provided by the European White Paper encompasses a multitude of projects, such as bird counting or environmental pollution monitoring, where citizens are invited as participants in science and contribute in a positive way to scientific research. Yet it falls short to address those Citizen Science projects in which citizens decide and design the research agenda from the very onset of the scientific project. Alan Irwin (1995) provides us with a broader definition of Citizen Science: Citizen Sciences "evokes a science which assists the needs and concerns of citizens […]. At the same time, 'Citizen Science' implies a form of science developed and enacted by citizens themselves." (p.XI)

The Citizen Science initiatives subject of this report fit into the second category Irwin offers. In the aftermath of the Fukushima nuclear accident (2011) citizens, confronted by a contaminated environment, gathered to form citizen radiation measuring centres. As a part of a bottom-up movement within Japanese society, the centres are initiated and driven by citizens. Within a couple of months after the accident the first initiatives were launched and started to measure amongst others food, air and soil. Operating independently from the government and other institutions, they depend on funding through for example crowdfunding, personal investments or membership fees. In most cases these organizations are organized locally, although networks exist, such as Minna no Data Site, which operate on a national or even a global scale, such as Safecast. In Haklay's pyramid of participation (Figure 12) these organizations are placed at the very top, under the concept of 'extreme' Citizen Science (Haklay, 2013).

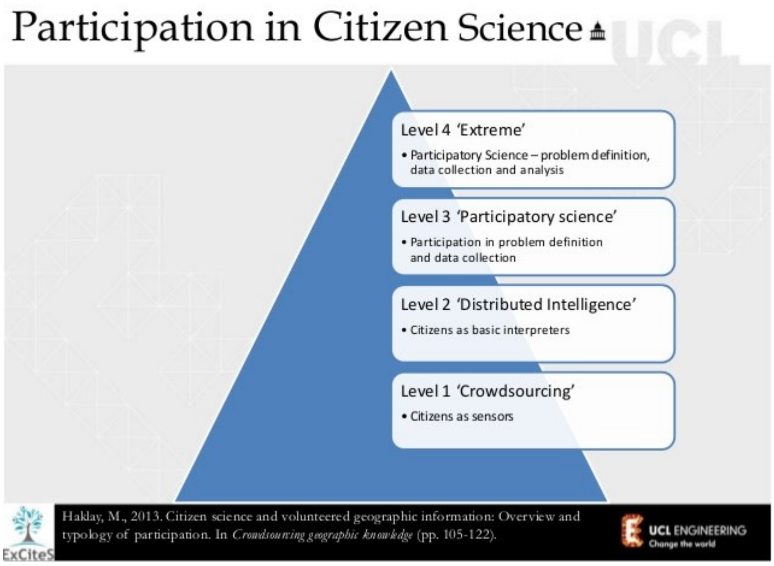


Figure 12. Haklay, Muki (2016). Participatory [Citizen] Science. Available at: https://www.slideshare.net/mukih/participatory-citizen-science

The upsurge of citizen science organizations, initiated after the Fukushima nuclear accident is however not a new tendency. Already after the Three Mile Islands accident (1979) researchers experimented with forms of citizen involvement in a post-disaster situation (Gray Cricar AND Baratta, 1983). Likewise after the Chernobyl nuclear accident (1986) a global rise of citizen radiation monitoring associations is witnessed. Even in Japan organizations were established concerned with the contamination from Chernobyl. Amongst these organizations a few continue their activities until today. One organization, based in Tokyo, is also subject of this study.

8.2 Aim of the case study

The aim of the study is to analyse to what extent bottom-up engagement can help to cope with scientific and social uncertainties. Uncertainty is

> "a situation which involves imperfect and/or unknown information related to the investigated nuclear emergency case. Uncertainty is the lack of certainty, a state of having limited knowledge or information where it is impossible to exactly describe the existing state related to the emergency, a future outcome, or more than one possible outcome including consequences. Due to a lack of knowledge, lack of information or lack of trust in information the emergency stakeholders have difficulties to make informed decisions what to do or not to do, how to react and what actions (advised or not advised) will they take. In such situation stakeholders need to make decisions under uncertainty." (Perko, 2017, p.13).

Considering this definition, uncertainties play an important role for policy on nuclear emergencies and in the lives of individuals affected by the nuclear incident or accident.

The case provides a unique insight into the experiences and motivations of citizens who became involved with radiation monitoring. Therefore the analysis relates directly to the coming about of Citizen Science and pinpoints uncertainties as causes for citizens to react against. Identifying these uncertainties can generate a better understanding of Citizen Science. Furthermore it can help to improve modelling and decision making in nuclear emergencies, as it uncovers the needs of the affected population and teaches that citizens should be considered as actors in emergency management and post-disaster recovery in order to produce the most appropriate approach.

8.3. Methodology

The methodology includes a series of semi-structured interviews and participatory observation and constitutes of a qualitative study of citizen radiation monitoring based in Fukushima prefecture, Tokyo, Tochigi and Miyagi prefecture in Japan. Organizations were contacted via email with the help of Ueda Akifumi from the Citizen Science Initiative Japan. During a period of 6 weeks (17/02-30/30/2018) ten organizations were visited in Tokyo, Fukushima City, Minami Soma, Aizu Wakamatsu, Iitate, Iwaki, Nasu and Sendai. At nine organizations the opportunity was provided to interviews its members. A total of twelve interviews were recorded with the permission of the members. Afterwards each organization was contacted again and a copy of this report will be sent to each organization. Although the individuals interviewed gave permission to use their names, their personal data is anonymized considering that the report contains an analysis of personal views and experiences. Apart from interviews, data was also collected through participatory observation. During research visits the researcher was invited to participate in activities of different organizations, such as measuring radiation and a roundtable debate. An opportunity was also provided to record how radiation is measured at a centre in Aizu Wakamatsu.

Based on the interviews and notes taken during research visits at citizen radiation measuring centres, uncertainties were identified per organization. Uncertainties were distinguished based on the definition provided in Section 1, 2. Attention was also given to markers such as anxiety (不安, *fuan*) or worry (悩み, *nayami*) during the interviews. This process resulted in tentative list of the uncertainties experienced by members of citizen measuring centres. The same process was repeated a second time. However additional information related to the identified uncertainty was written down. Uncertainties related to one topic, e.g. concerning food or future prospects, were then grouped together in overarching topics. The topics were decided based on the inherent cause of the uncertainty. This resulted into five topics: 1. uncertainties related to nuclear accident management and safety implications; 2. uncertainties related to society and family life; 3. uncertainties related to governmental approach to post-accident recovery; 4. uncertainties related to the relationship between science and society; and 5. uncertainties related to citizen radiation measuring centres. Some uncertainties are addressed in several topics, as they are connected to several causes. This highlights the complexity of a nuclear accident and post-disaster recovery. Each topic will be addressed in the analysis below.

8.3 Identification of Uncertainties

a. Uncertainties – nuclear accident management and safety implications

1. Uncertainties before the accident

Nuclear energy and the concern for a possible nuclear accident is a recurring topic in interviews with citizen scientists. During the interviews it became clear that past accidents and incidents in- and outside Japan, but also through connections with the anti-nuclear movement, or other associations and/or personal circumstances or other associations, most members of citizen radiation measuring centres first came in touch with and studied about nuclear energy and radiation before the Fukushima accident. One member of a citizen measuring centre in Aizu Wakamatsu for example mentioned the sudden death of a Russian baby she was taking care of at her day-care centre. Both parents lived in the affected area of the Chernobyl accident and later moved to Japan. The member referred to this incidence as a trigger to start measuring and protect children herself after Fukushima.

2. Evacuation

During the interviews the members were asked to compare their situation seven years after the accident and at the time of the accident and discuss their concerns and uncertainties. The evacuation in the immediate aftermath of the nuclear accident was addressed by several members, both male and female, at measuring centres in Aizu Wakamatsu, Fukushima city, Sendai, Iitate village and Tokyo. The members interviewed at the centres in Aizu Wakamatsu, Fukushima and Sendai all decided to evacuate alarmed by the news of the explosion at the nuclear power plant and encouraged by family members, acquaintances at official institutions or the evacuation of US citizens from the area. The members from the Aizu Wakamatsu, Fukushima and Sendai centres evacuated voluntarily. Nevertheless the decision to evacuate entailed difficult choices. One member in Aizu Wakamatsu felt she was forced in a position where she had to choose what she considered best for her child and leave behind family members, as they were not mobile enough to evacuate. Another member from the same centre needed to consider her position and her role within the local community as evacuating might be perceived as abandoning her community.

During the evacuation members from Aizu Wakamatsu, Fukushima and the Sendai centres expressed they were uncertain how long they would and could evacuate. Not only was this cause for uncertainty about their situation, it was also a cause for stress as they had to adapt to new living conditions and an unknown environment. Fear of social stigmatization by people living in other areas of Japan was also felt during evacuation. Some members of the Aizu Wakamatsu centre revealed that they felt relieved to drive a car with a number plate of Aizu instead of Fukushima so that people would not associate them with the Fukushima area.

The evacuation had a great impact on family ties and on the local community. For some members interviewed the evacuation continues seven years after the accident and has led to social disruption. One citizen in Fukushima city is living apart from his wife and child, who have moved to a different part of Japan. The wife and child of another member from a measuring centre in Tokyo are living abroad. However as many people evacuated Fukushima area, it is yet to be seen whether the villages will survive as especially young families have built their lives outside their hometown and refuse to return.

Yet the importance of timely evacuation was also mentioned, especially by the member of the measuring centre in Fukushima city. As his family decided to evacuate more than a week after March 11, he now feels responsible for exposing his wife and child to radiation.

3. Living in a contaminated zone: uncertainties concerning health, food, radiation exposure and safety

In the immediate aftermath of the Fukushima accident, safety was the primary concern for the members of the citizen measuring centres interviewed. The lack of information provided by the government as well as the insufficiency of information at the time caused concerns over health, radiation exposure and safety of food products. As citizens could not find adequate answers to questions concerning their personal situation (e.g. the consumption of home-grown vegetables or one's child's health), citizen measuring centres were at first occupied with verifying safety through radiation measurement:

> "Right after the accident at the nuclear power plant, in the midst of confusion of the pollution by the radiation, we started to measure radioactivity, thinking 'anyhow, let's

verify the safety by measuring radiation and protect our children'."[3] (Newsletter Iwaki citizen radiation measuring centre, 2017)

Since citizen measuring centres are citizen-initiated and citizen-driven, they are in close contact with the local community. Moreover the measurement performed at the centres are low-cost (free of charge or a small fee of 500 Yen up to 2000 Yen) and in most cases shared online. Therefore the centres are able to reach the local community and are prime locations to directly address the concerns of individuals concerning radiation exposure and provide them with a means to verify the situation by themselves:

> "[…] Citizen science does connect directly to our lives: is the dose of my meal today okay, is the school where my child goes to contaminated? I think it readily produces information that I can use in my life. How can I put it… Saying that for this percentage out of so many thousands of people, it is like this, I know that that must be serious or that it is valuable data, but what I want to know is not that, what I want to know is how can I really know, how can I get the data that tells me about my child, my family, my body."[4] (Interview staff member 2 Iwaki city, 2018)

However considering that most citizen measuring centres were established months after the accident due to for example evacuation and the delivery of equipment, the centres failed to measure the situation immediately after the accident and cannot provide information on radiation exposure in this timeframe.

Seven years after the accident the centres interviewed all indicate they have developed an understanding of the local situation. The urgency of providing basic, ad hoc information has evolved into a long-term monitoring of the local situation. Although the number of measurement requests is decreasing, most organizations continue to provide independent data.

Besides monitoring staple products, organizations such as those based in Minami Soma and Iitate also monitor less accessible zones, such as mountainous areas, and vegetables that are grown in these areas, such as mushrooms and wild vegetables (*sansai,* 山菜). Measuring can also be identified as a way to adapt to a new environment as it facilitates understanding and evaluation of the impact on basic daily life activities. The measuring centre in Fukushima city for example measures the radiation levels alongside routes children take to go to school in order to determine which route has the lowest exposure.

Some measuring centres have expanded their activities to the requests of the local community, and integrated radiation measuring into broader healthcare activities. The citizen measuring centre in Iwaki city has opened a health clinic in 2017, as they noticed that the number of children taking medicine increased. The clinic offers general health examinations and psychological support.

---

[3] 「原発事故直後、放射能の汚染で混乱していた時期に「とにかく、放射能を測って安全を確かめ、子どもたちを守る！」ということから放射能測定活動を開始しました。」

[4] 「[…] 市民科学って私たちのその生活に本当に直結する：今日食べるもののご飯の線量大丈夫なのかとか、自分の子供が通う学校は汚染はどうなのかっていうその生活に約立てる情報をちゃんと出していくことだな〜って思いますね。なんかあの、ね、何万人中何人の割合でこうだから、こうだとかっていうのは、なんとなくそれが大変だったり、なんかすごいデータなんだなっていうことわかるんですけど、私たちが知りたいのは、そこじゃなくて、本当は自分の子供だったり、家族だったり、自分の体だったり、そういうところのデータをどういう風にちゃんと知れたり、もらえたりするかというところだと思いますね。」

4. *Uncertainties related to lack of information*

The uncertainties concerning food, health, radiation exposure and safety and the need for citizens to establish citizen radiation centres are not only caused by the aftermath of the nuclear accident at the Fukushima Daiichi nuclear power plant, but are also informed by the lack of information and data from the government. From the interviews it became apparent that as citizens were oblivious to the level of exposure to radiation, a gap between the needs of the affected public and information provided by the government was created. To fill this gap the citizens themselves stepped forward. A member at the centre in Iwaki referred to their functioning in the early days as a "field hospital" (「野戦病院」; Interview staff member 2 Iwaki city, 2018), as the centre assessed the safety of the environment and products and acted as an on-site post for the affected population to gain essential information.

The above mentioned discrepancy between the needs of the affected public and the information provided by the government is also manifested in the attention centres attribute to the situation of children living in the contaminated areas. A centre in Fukushima city uses a stroller to measure at three different heights: at 1m, 50cm and 10cm in order to gauge the radiation dose a small child or a baby is exposed to. Although this approach to measuring radiation is unique, it illustrates the consideration all centres attribute to the vulnerability of children, which is felt lacking from governmental data.

The role of citizen measurement centres in knowledge production is changing with time. Citizens engaged in the citizen measuring centres do not only consult their own data, but also official data provided by governmental bodies. As the data offered by the official institutions has increased some citizen measuring centres concentrate increasingly on providing an analysis and interpretation of raw data in order to make official data more accessible to a wider audience.

b. Uncertainties – society and family life

1. Uncertainties related to family or community life

During the interviews uncertainty on whom to consult about concerns regarding radiation was frequently mentioned by the interviewees. Especially mothers, who are responsible for raising the children, often have no ties to a company and have close ties with the community, experience difficulties expressing their worries. Moreover regional differences in Fukushima (*Hama dōri, Naka dōri* and *Yama dōri*) also play a role in the social structure of the community, the coastal area being more open than land inward. However as individuals find themselves obstructed in expressing their concerns, it can cause additional stress.

Although radiation measurement is an important role of the citizen measuring centres, they have also developed into community centres. A centre in Tokyo, active since Chernobyl describes its functioning as "a plaza" (「広場」; Interview member Tokyo 1986, 2018), "a place to communicate and to exchange" (「交流の場」; id.). A member at the organization considers that "[..] rather than people gathering to measure, the role as an open space gathered people."[5] (Id.) From this perspective citizen radiation measuring centres have outgrown their function as measuring stations to become community networking hubs where people are free to voice concerns and anxiety "to prevent that people feel lonely"[6] (Interview member 1 Aizu Wakamatsu, 2018).

2. Uncertainties related to future prospects

Although the areas where the evacuation order is released are steadily increasing and the government greatly invests into decontamination actions, the consequences of the nuclear accident will be felt for a long while. A group in Nasu, Tochigi prefecture comprised entirely of retired individuals who had all

[5] 「[…] 測定で人が集まったというよりも、広場としての機能が人を集めたんですね。」
[6] 「孤独にさせておかないっていうこと。」

moved to Nasu to enjoy their retirement and live of the land, feel their dreams are shattered due to the accident. Besides these personal consequences the accident also had a considerable impact on the farmers in the Fukushima area. Some organizations, for instance in Minima Soma, work together with the community to reinvigorate farming in their town, yet other farmers involved in citizen measuring centres in Iitate and Sendai are uncertain whether their land can be profitable again.

c. Uncertainties – governmental approach to post-accident recovery

1. Uncertainties related to reliability and trustworthiness of the government

原子力ムラ (*genshiryoku mura*) or the nuclear village is a Japanese concept used

> "to refer to the institutional and individual pro-nuclear advocates who comprise the utilities, nuclear vendors, bureaucracy, Diet (Japan's parliament), financial sector, media and academia. This is a village without boundaries or residence cards, an imagined collective bound by solidarity over promoting nuclear energy. If it had a coat of arms the motto would be "Safe, Cheap and Reliable"." (Kingston, 2012)

The members expressed their feeling that the "nuclear village" leaves little room for checks and balances, but also for citizens to criticize or to contribute to decision-making. It creates a black box in which decisions are made without much transparency. At the time of the nuclear accident the lack of transparency and the lack of information undermined the trust in official institutions, prompting citizens to search for alternative information sources to gain oversight on the accident. As the nuclear village was exposed to citizens the perception that decisions were not made in the best interest of the affected population left ample room for doubts against the government and associated individuals:

> "You can trust this data [official data]. Scientifically speaking it is correct data. Yet your point of view changes if you think: "this is good for politics, let's publish this data", and when you think "no, no, let's take the most strict data for the sake of our children." Depending on who you are. I am just a parent, so I think it is better to look at this one [most strict one]."[7] (Interview member Fukushima city, 2018)

Considering this, decisions made at the central government are set in a framework where the affected people are distanced from the government: "A system of nuclear energy realized by sacrificing somebody. We happened to be the victims."[8] (Id.) The feeling of being "resources" (「利用素材」; id.) underscores the distrust towards the government and raises questions whether citizens can truly trust the government. During the interviews the changed relation between citizens and the government was frequently addressed. The perception that the government will not protect its citizens at time of emergency was generally shared:

> "The most [worrisome] is that I cannot trust what the government says. This [distrust] is absolute. I used to be carefree and I would believe [the government], however now I will always doubt."[9] (Interview member 2 Nasu, 2018)

The establishment of citizen measuring centres can be viewed as a reaction to the uncertainty caused by a loss in reliability in the government. Contrary to the government's response to the nuclear accident citizen measuring centres provide open and transparent data. Within this perspective science

---

[7] 「これは信頼できる数値。 だって科学的には正確な数値。だから、だけど、政治的がいいと思って、じゃ、この数値を発表しようというのと、いやいや、こどものために一番厳しい数値を取りましょうというのは立場が変えるわけ。自分がだれかによって。僕はただの一の保護者に過ぎないから、こっちで見るべきだよねと思うんじゃない」

[8] 「誰かを犠牲にして、成り立つ制度の原子力発電 。誰かというのはたまたまわれわれだった。」

[9] 「一番なのはやはり国の言っていることは信用できないって、これは徹底的ですね。昔はのんびりして、信じていたんですが、今は必ず疑います。」

is employed as a tool to empower oneself to decide their own safety standard. However it can also be employed to level the distance between citizens and politics:

> "Of course you also have instances where we go against the persons in power or what the government says, however [what is important about citizen science is that] we can talk together with them. Science is indeed necessary to begin the conversation on the kind of society we want to place our next generation in."[10] (Interview member 1 Aizu Wakamatsu, 2018)

2. Uncertainties related to decontamination

The decontamination of the affected areas was identified as an uncertainty during the interviews. Especially the long-term storage, communication concerning the transportation of contaminated soil and the lack of temporary storage in prefectures outside the Fukushima prefecture are of concern of the interviewed members. Moreover they indicated that decontaminating once is not enough, as radioactive particles move and gather in different places, so that after decontamination the soil might be contaminated again. Yet as the government refuses to continue the decontamination members are worried about the radiation levels. Thus continued monitoring by citizens is deemed necessary.

3. Safety limit 20 mSv vs. 1 mSv: double standard

Uncertainty whether the annual dose limit set for the Fukushima Prefecture of 20 mSv is truly safe is a topic recurrent in multiple interviews. Especially in comparison to the annual dose limit of 1 mSv for the rest of Japan 20 mSv is deemed unfair and leaves citizens wondering why 20 mSv is also considered safe as opposed to other parts of Japan. On top of the distrust concerning the regulatory dose limits there is a common perception that a double standard is employed concerning the Fukushima prefecture.

4. Uncertainties related to fuhyō higai (Reputation damage)

After the nuclear accident consumers avoided buying food products coming from the Fukushima area. The reputation of the Fukushima prefecture was severed amongst others due to a worsened perception of Fukushima products and fear of potential radiation contamination. Lacking foundations and truth, rumours generating false perceptions, were said to have a negative effect on the reputation, altering the perception of the public, causing reputation damage (不評被害, fuhyō higai) and changing the consumer's attitude towards Fukushima products, and resulting in economic damage. (Kentaka, 2017). Interestingly however the interviewees in Iwaki, Sendai, Fukushima city, Nasu and Tokyo identified the reputation damage as a cause for concern and uncertainty. The idea of reputation damage obstructs in their view open communication and a complete assessment of the radiation level. In Nasu volunteers at the local citizen measuring centre were refused to measure in schools as the city is worried about the damage the rumours that a potential radiation contamination could cause. A member in Sendai refers to farmers in the area, who, although worried about contamination, were eventually unable to voice their concern and to undertake action as it might be considered reputation damage. Considering these examples, members of citizen measuring centres argue that measuring and providing transparency in a situation is less harmful and generates less anxiety than sustaining a system that constraints data accumulation and paradoxically sustains the illusion of harmful radiation contamination in Fukushima.

---

[10] 「国の言う通りとか権力者などにやっぱりそれに抵抗するっていうもあるだろうけど、そことこ「話し合う」をしていくというかな。次の世代をどういう風な社会にしていくかっていうことの話し合いのとっかかりとしてはやっぱり科学というのは必要でしょうね。」

5. Uncertainties related to remembering the accident

At the time of the interviews the government decided to remove 2400 posts of a total of 3000 monitoring posts that were placed after the nuclear accident in the Fukushima prefecture. Monitoring posts in the evacuation zone will remain (The Fukushima Minyū Shimbun, 2018). As the contamination can only be visualised through data, the loss of monitoring posts symbolizes for the members of the citizen measuring centres nothing less than the premature closure of the nuclear emergency and also the end of the public display of accident recording. Nevertheless according to citizen measuring centres the emergency situation and the nuclear accident are not yet over, as levels have yet to return to the levels before the accident. Moreover as monitoring posts will disappear concern that the general public will forget the accident and will lower their safeguards, is shared amongst most centres. Although the government will continue monitoring the situation the detailed information on the local radiation levels will be in the hands of citizen measuring centres.

> "As opposed to the current state in which the accident is being forgotten, we demonstrate once more through data that the contamination has not disappeared. This is to us who have been doing this, some sort of mission, what we should do."[11] (Interview member Tokyo, 2018)

Considering that the future prospects of these centres is precarious in most instances the fear of being forgotten creates uncertainty about the future.

d. Uncertainties – relationship science and society

1. Uncertainties related to communication

The risk advisors, in particular Yamashita Shunichi, dispatched by the government after the nuclear accident are repeatedly identified as a topic of critique. A member of the citizen measuring centre in Aizu Wakamatsu recalls that during the meetings people reacting to the government's policy related to the accident were deprived of voicing their criticism: they would be urged to keep quiet as they would find themselves surrounded and the microphone was taken from them. Moreover comments made by risk advisors during meetings, such as:

- "He said: 'Everything is okay. In comparison to Hiroshima and Nagasaki, Fukushima has won.' 'What do you mean by "has won"?' [Risk advisor:] 'It became more famous.'"[12] (Interview with member 1 Aizu Wakamatsu, 2018);
- "There is a national emergency now. The people must obey the state."[13] (Id.)

failed to meet the concerns and worries of residents in Fukushima prefecture. On the contrary it created a discrepancy between citizens' and experts' interpretation of risk:

> "[…] It is now sometimes said that there are words of the scientists and words of the ordinary citizens and that the words scientists possess, do not include any words of

[11] その忘れられたという状態に対して、汚染はなくなていないという現実をデータを通して今一度出していくとういことが、あの、こういうことやった私たちのある種、使命っていうか、やるべきこと。
[12] 「大丈夫ですよって。もう広島や長崎より福島は勝った。っていうが、何勝ったのって？もっと有名になっちゃった。」
[13] 「今は国家の緊急時。国民は国家に従わなきゃいけない。」

> ordinary citizens. That is why scientists say it is safe, it is safe and that is why ordinary citizens say we are afraid, we are afraid, we worry, we worry."[14] (Id.)

One member, a doctor, who volunteers at the citizen measuring centre in Aizu Wakamatsu, refers to the type of communication used by experts as "the discourse of safety and reassurance" (安全安心論) (Interview doctor Aizu Wakamatsu, 2018). However by focusing on safety of radiation and on reassurance, the concerns and worries of citizens are circumvented, thus paradoxically failing to generate a feeling of safety amongst the population. Such public meetings tend to become a ceremony, a mere "proof" that the public has been heard.

2. Uncertainties related to data and data accuracy

The uncertainty over the government's reliability discussed in point a.1, the style of communication and the relation between citizen and experts undercuts the trustworthiness of experts. Although a distinction between individual experts is made, members of citizen measuring centres in Nasu, Iitate and Fukushima city are in general very critical of experts and identify them as part of the nuclear village. The data commissioned by governmental bodies are subject to doubt, as they are regarded as 'political data':

> "We measure data that aren't lies, and we properly make our data public. Let aside whether it is good or bad. It is not up to us to say this. The one who should judge is the individual."[15] (Interview member 5 Nasu, 2018)

> "You can trust this data [official data]. Scientifically speaking it is correct data. Yet if you think: "this is good for politics, let's publish this data", and when you think "no, no, let's take the most strict data for the sake of our children." Depending on who you are. I am just a parent, so I think it is better to look at this one (children)."[16] (Interview member Fukushima city, 2018)

This contrasts the policy of the government against citizens' need to be able to take informed decisions by themselves concerning their own safety and daily life. Within this framework citizen-driven data becomes necessary in order to produce data that is trustworthy. The data produced by citizen scientists is also used to crosscheck official data, in order to assert its validity.

3. Uncertainties related to relation between science and society

> "We were told that if you are not an expert you cannot do it, and since we thought it is best to leave it to the expert, this accident happened, so it's actually not like that."[17] (Interview member Fukushima city, 2018)

The relationship between the citizen and the expert is an unbalanced one. Notwithstanding that the scientist has access to knowledge and has accumulated expertise, therefore looked up to, the

---

14 「[…] やっぱり科学者の言葉と生活者の言葉って今時々言われるんだけれども、科学者の言葉、科学者にはその生活者の言葉がない。だから安全だ安全だっていう。それで、生活者は生活者の言葉で言って怖い、怖と言っている。不安だ不安だって言っている。」

15 「我々は嘘のない数値を測って、それをちゃんと公表する。それがいい、わるいはいいんですよ。我々が言う問題じゃない。それは判断するのは個人です。」

16 「これは信頼できる数値。 だって科学的には正確な数値。だから、だけど、政治的がいいと思って、じゃ、この数値を発表しようというのと、いやいや、こどものために一番厳しい数値を取りましょうというのは立場が変えるわけ。自分がだれかによって。僕はただの一の保護者に過ぎないから、こっちで見るべきだよねと思うんじゃない。」

17 「専門家じゃないとできないっていわれて、で、専門家に任せとけばいいやってと思ってたら、こんな事故になっているんだから、そうじゃなかったって。」

unbalanced relationship also distances science from society. The perception that science is not always aligned with societal needs, becomes apparent during interviews with centres in Fukushima city, Nasu, Sendai, Aizu Wakamatsu and Tokyo. This gap however can cause uncertainties as citizens might feel their concerns are not sufficiently addressed by experts. A doctor, volunteering in Aizu Wakamatsu city for example refers to mothers who come to see him at the centre, since doctors at the hospital disregard their worries.

Initiated, formulated and inspired directly by citizens living in the affected areas, members of citizen measuring centres view the centres as an answer to bring science closer in touch with their problems:

> "Rather than citizen science I have the feeling that science is been brought to the citizen. There is no need for citizens to become academics. Better is to lower the bar of science, in alliance with reality. Because experts have their own fixed ideas and because they don't try to do anything more than their own research, it [science] has nowadays surpassed reality by far, don't you agree? There is no conception that it is better to take that [reality] as the base. This is from our viewpoint what laymen see as their starting point when they start [doing science]."[18] (Interview member Fukushima city, 2018)

e. Uncertainties – Citizen radiation measuring centres

Citizen science can be viewed as a response to dealing with uncertainties. Still citizen science can in turn also create uncertainties. When discussing the future prospects of citizen measuring centres many centres indicated that they were uncertain whether they can continue their activities, due to a lack of funding, declining requests for measurements and difficulties in attracting and maintaining members. Establishing a citizen measuring centre requires much personal investment from the volunteers or staff involved, however the outcome is uncertain. Moreover dealing with radiation and reminding oneself of the accident everyday can become a burden to the members of citizen measuring centres:

> "In Japanese we say that there are two sides to the same coin. Because I am involved in the centre I have to think about radiation and I have to think about the uncertainties of radiation. However if I was not involved in the centre, perhaps I wouldn't really think about radiation and I would have forgotten a little about the accident. I would maybe be able to live thinking only about my own life and not about the radiation and the accident. However if I become anxious, I wouldn't really have a way to get rid of it. [I would be left with] just nothing but anxious feelings."[19] (Interview member 2 Aizu Wakamatsu, 2018)

Social stigma as an anti-governmental and anti-nuclear organizations does not benefit the image of citizen measuring centres, since they are seen as biased. Moreover as citizens are operating the measuring devices the accuracy of data is also put to question. Their status as citizen also weakens their position to make valid claims. Data accuracy is deemed by all members interviewed as a crucial

---

[18] 「市民科学というよりも科学を市民側によせてくるっていう感じだよね。市民が科学者になる必要ない。科学のハーダルを下げればいいだけ。現実に即して。専門家ほど自分たちの固定観念があって、自分たちの研究してきたこと以上のことはやろうとしないから、現実ってもはるかに超えているわけじゃない。今。それをもとにして考えたほうがいいっていう発想にならないね。そこは僕たち見て素人が始めればそこがスタートみているから。」

[19] 「表裏遺体という言葉が日本語にあって[...]。センターに関わっているから、放射能のことを考えなきゃいけないし、放射能の不安を考えなきゃいけない。が、センターに関わっていなければもしかしてたらもう特に放射能のことあまり考えないで、原発事故のこともちょっと忘れて、あの、自分の生活のことだけを、[...]、放射能[のこと]、原発事故のことを考えないで、暮らせるのかもしれない。でも、不安になった時に、あの、解消する方法があまりない。ただ不安なだけ。」

element of citizen science. For this purpose they ask other centres, university professors or other experts to conduct crosschecks to validate their data.

8.4 Conclusions

In the wake of the Fukushima nuclear accident Citizen Science has provided a response for the affected population to cope with uncertainties experienced in relation to the accident, the governmental and the scientific approach and society. However as uncertainties of citizens living in a contaminated environment changed, so did the responsibilities the citizen measuring centres took upon themselves. From emergency response some centres were able to develop into community centres and alternative information hubs. As the centres are operated by local residents they are intrinsically connected to community life. This in turn attributes to their high responsiveness to the local community's needs.

Not only does citizen science directly connect to community life, it also provides individuals a means to empower themselves amidst a situation they are unwillingly confronted with. Considering that a nuclear accident or incident may concern health issues and affects food consumption, it becomes a highly personal issue. Therefore measuring can be a tool to provide citizens with a means to decide on their own health and safety and adapt one's life to a new environment.

The Japanese case study showcases that citizens have laid down an alternative approach in addition to the one formulated by the government. Although most centres are founded on distrust towards to official institutions, their inclination towards independency does not imply that there is no room for collaboration with institutions. However the institutionalization of interactions between citizen science and the government is momentarily lacking in Japan. Therefore preparing guidelines describing how to include citizen science in the event of a nuclear incident or accident and identifying the role of citizen science in order to determine potential fields of cooperation, can improve modelling and decision making in nuclear emergencies.

This report only considered citizen science as subject for its study, but it important to note that citizen science is not the only approach to citizen involvement. Although in the case of Japan citizen radiation measuring centres have proven to be an adequate way for citizens to respond to their situation, a European context should be taken into account and other options of citizen engagement should be considered too. Hereby features of citizen measuring centres, such as citizen-driven, problem-solving, independency and empowerment can be examined. Notwithstanding the approach being taken, it is however paramount to also raise questions on how to approach citizen involvement, as it "should not be construed as a necessary evil but rather as a public willingness to take an active role in raising significant questions about the issue at hand." (Gray Gricar and Baratta, 1983, p.47)

References

Aruga, Kentaka (2017). *Consumer Reaction, Food Production and the Fukushima Disaster: Assessing Reputation Damage Due to Potential Radiation Contamination*. Cham: Springer, 2017.

福島民友 (*Fukushima Minyū*, The Fukushima Minyu Shimbun). 福島県内「放射線監視装置」撤去へ　避難12市町村以外2400台 (*Fukushima kennai 'hōshanō kanshi sōchi' tekkyo e hinan 12 shichōson igai 2400 dai*, Within Fukushima prefecture towards the removal of radiation monitoring posts, except for 12 evacuated municipalities). 21/03/2018.

Gray Gricar, Barbara and Baratta, Anthony J. (1983). Bridging the Information Gap at Three Mile Island: Radiation Monitoring by Citizens. *The Journal of Applied Behavioral Science* 19,1: pp.35-49.

Haklay, Muki (2013). Citizen Science and Volunteered Geographic Information – overview and typology of participation. IN Sui, D.Z., Elwood, S. and M.F. Goodchild (2013). *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*. Berlin: Springer. Pp. 105-122.

Irwin, Alan (1995). *Citizen Science: A Study of People Expertise and Sustainable Development*. London: Routledge.

Kingston, Jeff (2012). Japan's Nuclear Village 日本の原子力ムラ. *The Asia-Pacific Journal* 10,37: pp.1-23.

Perko, Tanja and Abelshausen, Bieke (2017). Methodological document for case studies: Guidelines for researchers.

Serrano Sanz, Fermin, Holocher-Ertl, Teresa, Kieslinger, Babara, Sanz García, Francisco AND Candida G., Silva (2015). White Paper on Citizen Science for Europe. Available at: https://ec.europa.eu/futurium/en/system/files/ged/socientize_white_paper_on_citizen_science.pdf.

Interviews cited

	Place	Time
Member Tokyo	Tokyo, Tokyo prefecture	01/03/2018
Member 1 Aizu Wakamatsu	Aizu Wakamatsu, Fukushima prefecture	15/03/2018
Member 2 Aizu Wakamatsu	Aizu Wakamatsu, Fukushima prefecture	16/03/2018
Doctor Aizu Wakamatsu	Aizu Wakamatsu, Fukushima prefecture	16/03/2018
Staff member 2 Iwaki city	Iwaki city	19/03/2018
Member Fukushima city	Fukushima city, Fukushima prefecture	21/03/2018
Member 2 Nasu	Nasu, Tochigi prefecture	25/03/2018
Member 5 Nasu	Nasu, Tochigi prefecture	25/03/2018
Member Tokyo 1986	Tokyo, Tokyo prefecture	08/03/2018

9. Preliminary Identification of Uncertainties: Observations and Conclusions.

The seven cases span from 1986 to 2017 and vary in degree of severity, impact and response. Nevertheless some general conclusions and traits can be seen, including a range of different challenges and uncertainties. All cases initially **underestimated the potential impact** of the accident in terms of the societal impact and communication challenges (including the communication challenges from the Krsko "non-event"). There was clearly a range of **technical uncertainties** that generate, in turn, societal unecertainties. In the early phases these included questions about the magnitude and range of the contamination (all cases), but also included measurement uncertainties linked to both environmental monitoring (data and measurement quality, different instrumentation and measurement techniques, etc.) and health monitoring (eg., thyroid measurements). The question of whether the discharges had been detectable off-site was a particular issue for the Asco case in Spain and Fleurus in Belgium. The need for retrospective analysis and modelling added an additional layer to technical uncertainty, for example in the Asco (4 months) and Tricastin (uncertain length of release) cases.

The **reporting and interpretation of measurements** added another level of uncertainty, including whether ranges or, more commonly (e.g. Fleurus and Halden), maximum measured values were reported. Variability and inhomogeneity of measurements raised challenges in Norway after Chernobyl and Asco, Spain. Documenting undetectable levels of contamination in both workers (Asco) and the public (Fleurus, Asco) was deemed important for reassurance. Fleurus offered thyroid screening to potentially affected populations. Public monitoring was also offered in Norway after Chernobyl, as was monitoring of local produce, although here the focus was on documenting low levels rather than undetectable amounts. Data accuracy was deemed to be a crucial element of citizen science measurement initiatives in Fukushima. The tendency was that the public, or at least those that expressed an opinion, wished for more monitoring and health follow-up than had been initially offered by authorities.

Some degree of **contradictory information** was seen in all cases, most usually in the communication of health effects (e.g., no expected health effects, but monitoring carried out anyway – Asco, Fleurus, Tricastin, Fukushima), but also linked to food stuff use: farmers can sell their produce, but you should not consume your own (Fleurus) and water use restrictions (Tricastin). Fukushima, Asco and Chernobyl (Norway) also reported differences in expert opinion, particularly on **health effects**. Media analysis also revealed quite divergent interpretations of risk between experts (no health impact whatsoever) and NGO’s (possible serious impacts).

Although all cases highlighted possible **societal impacts** these varied from case to case. Tricastin, Asco and Chernobyl/Norway all highlighted possible impacts on agriculture and farming. Asco also showed concerns for tourism and stigmatisation for the affected areas, Fleurus for the possible lack of medical isotopes, and Fukushima from a wide range of impacts, including stigma. The question of compensation to farmers for losses was quickly raised in Norway and France. The incidents also resulted in important changes in safety protocols and procedures at many of the installations.

There were also differences in **societal framing** of the cases. The incidents raised questions on acceptability of nuclear energy in Belgium, Spain, France, Slovenia and Japan. In Belgium discussion of thyroid monitoring pointed out difficulties with the timing of measurements, given the screening was planned on the first day of school, before teachers and children had bonded. In Norway the accident coincided with a change in government, which created uncertainties about available resources. Not surprisingly the citizen monitoring in Fukushima occurred in a complex situation of disruption on family life and breakdown on trust between society, science and authorities.

The most important **communication uncertainties** for all cases were delays in providing information to the public, incomplete information and a perceived lack of transparency, the latter only being contradicted by the Krsko case. Nearly all cases also revealed problems with uncertainties as to who had responsibilities, and communication pathways. Interestingly the aftermath of the Tricastin case sparked a successful dialogue and **stakeholder engagement** initiative, underlining the importance of a pluralistic approach. Likewise the **citizen science initiatives** in Fukushima, while not without their own challenges, also offered important alternative mechanisms of public communication and dialogue.

Ethical aspects of the cases included the focus on vulnerable populations (e.g., children seen in Asco and Fleurus; and minority cultures seen in Norway/Chernobyl), sensitivity to differences in distribution of exposures and impacts, initiatives to empower and increase control of affected populations and issues with information transparency highlighted above.

While the Fukushima citizen science case took a slightly different point of departure from the other case studies – starting with interviews rather than document review, there was still some overlap with uncertainties identified for the European cases. Five separate topics were discussed: 1. uncertainties related to nuclear accident management and safety implications; 2. uncertainties related to society and family life; 3. uncertainties related to the governmental approach to post-accident recovery; 4. uncertainties related to the relationship between science and society; and 5. uncertainties related to citizen radiation measuring centres.

To conclude, this deliverable is intended to provide a first, preliminary identification of different uncertainties from a societal, communication and ethical perspective. The characterisation of different uncertainties and their inter-connection will continue to be refined following a more robust evaluation and comparison of the results of media analysis and structured interviews carried out with selected cases. Combined with other activities in CONFIDENCE WP5 the results will inform further work in the work package in order to investigate: i) Lay persons and emergency actors' understanding and processing of uncertain information, and subsequent behaviour, in nuclear emergency situations; ii) Societal uncertainties and ethical issues in emergency and post-accident situations, from the early phase to recovery; iii) Improved tools for communication of uncertainties, specifically for low radiation doses