Food Control after a Major Nuclear Accident – the Need for Harmonisation

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Abstract: A restriction of food and drinking water is one of the first countermeasures after a nuclear accident. In 2011 after the Fukushima accident restrictions were put in place a few days after the beginning of the accident and in a course of the accident. Furthermore after the accident the EU, Brazil and several countries put restrictions on some food originating from Japan. Restrictions were put on some fishing areas. The restrictions require a comprehensive monitoring programme.

The guidelines regarding food contamination are published by international organisations, e.g. in the Codex Alimentarius or in the IAEA GSG-2 from 2011. In order to control potentially contaminated food from Japan the action levels prepared for so-called future accidents were used in Europe. The levels were established after the Chernobyl accident. They were used very soon after March 11, 2011. Later they were replaced by Japanese action levels where such levels existed. In the USA so-called "derived intervention levels" (DIL) were used in 2011. They somehow differ from levels mentioned above, e.g. while the Japanese values for Cs-137 are in the range 200-500 Bq/kg, depending on a type of food, the USA DIL is 1200 Bq/kg. Later, i.e. in 2012, new levels for caesium radioisotopes in food were applied in Japan. They are used also in the EU. The levels are lower than levels used before showing that new lessons learned can be gained. The lessons are related to the alive development of the accident which spans over months and to the influence of discharges on contamination of soil and sea.

After the accident quite different guidelines related to contamination of food are used in different parts of the world. The global trading requires harmonisation of approaches which could result in harmonisation of levels of radioisotopes in food as a result of an accident.

Key Words: contamination, radioactive, food, drinking water, nuclear accident

1. Introduction

The Fukushima accident which started on March 11, 2011, gives valuable lessons learned related to the development of a nuclear accident. The lessons learned tackle all life phases of a typical nuclear facility. Namely, new questions emerged related to its siting in the changing natural environment which is only partly understood and is also in some parts unpredictable. Furthermore, siting can be also a function of time due to man made environmental impacts including natural resources, e.g. water sources management. The valuable lessons related to construction as well as operation of nuclear facilities including management of spent fuel and radioactive waste management are gained, e.g. "misjudgement of operational situation of isolation condensers (IC) at Unit 1" as pointed out in Interim Report prepared by the Investigation Committee on the Accidents at the Fukushima Dai-ichi and Daini Nuclear Power Stations of the Tokyo Electric Power Company (TEPCO) [1]. In addition, a severe accident management area can obtain a new insight on capabilities of the operators as well as supporting organisations involving also government organisations in mitigating the effects of an accident of such scope. The decommissioning of a few nuclear facilities at one site affected by the accident opened a new area of expertise focused on a huge amount of only partly characterised radioactive waste.

Moreover, the accident also gives valuable lessons learned related to the implementation of emergency strategy. The first countermeasure was issued on the same day when earthquake and tsunami occurred. Namely, on March 11, 2011, the regulatory authority in Japan issued instructions for the evacuation of people around the Fukushima Dai-ichi NPP, which was heavily influenced by both natural disasters. The evacuation was based on the anticipated scenarios founded on the data obtained from the NPP site including the data from radiation monitoring instruments and network systems.

The development of the accident has some specific characteristics which were not always present during the development of the two other major nuclear accidents, namely the Three Miles Island accident in 1979 and the Chernobyl accident in 1986, or some of them were not present at the same time.

1. In the Fukushima accident the need for the evacuation was identified actually immediately after the start of the accident.
2. Prolonged and substantial discharge of radioactive materials lasted for weeks and months and lasted also in 2012.
3. Discharges of radioactive materials into the environment were partly done intentionally and partly accidentally.
4. Radioactive materials were not only discharged into the air, soil and inland water but also to the see.
5. At the beginning of the accident the protective actions related to the Fukushima NPP could not be managed isolated from other events, namely earthquake and tsunami. In addition, two nuclear sites were involved in the accident at the same time and the management team was forced to handle emergency countermeasures related to both sites at that time. The first instructions regarding evacuation and the situation at the Fukushima Dai-ichi NPP took place on March 11, 2011. They were followed by instructions related to the situation at the Fukushima Dai-ini NPP on March 12, 2011.

All these characteristics also strongly influenced the implementation of protective actions in Japan. Protective actions, usually related to post accidental phase, were applied in a time when discharges still took place. So-called immediate and intermediate phase of the accident as well as post accidental phase even partly lost their meaning regarding the time development of a typical nuclear accident. Generally an immediate phase is followed by an intermediate phase and the accident scenario ends with a post accidental phase. One of the most important countermeasures which was implemented very soon after the accident was the control of drinking water and food in Japan.

In addition, the accident in Japan also gives valuable lessons learned in implementation of countermeasures in other countries. Such countermeasures include the control of contamination of cargo and passengers, the control of agriculture products on a territory where the accident could have an influence and contamination of food which can be imported. While the majority of such protective actions are not necessary some of them could last for decades, taking into account the experiences from the Chernobyl accident. For example the European Union (EU) control of food from areas affected by this accident is going to last till 2020.

The direct discharges into the sea as well as discharges into the air contributed to further contamination of the Pacific Ocean also caused a concern [2, 3]. A specific control was given to fish, fishery products and other marine products caught in FAO Major Fishing Areas 61, 67, 71 and 77 and food and feed processed or contained items mentioned and, as put in the EC note, “(possibly) originating in/caught in the Pacific region” [2]. Figure 1 based on the FAO available data shows FAO Major Fishing Areas which are affected by the Fukushima accident.

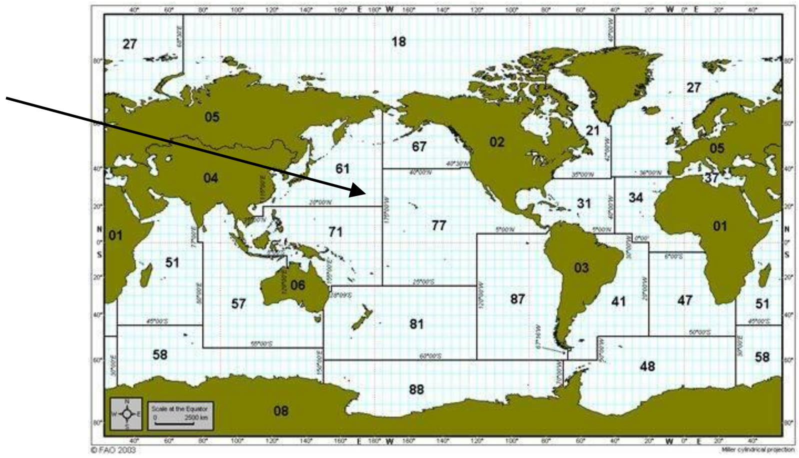

Figure 1. FAO Major Fishing Areas 61, 67, 71 and 77 are affected by the Fukushima accident.

2. Implementation of Countermeasures

The implementation of countermeasures in Japan followed a standard pattern, e.g. it started with evacuation and sheltering. Table 1 gives a very brief description of main protective actions in the first weeks of the accident. Some consequences can be only estimated, e.g. the number of evacuees could be difficult to estimate [4].

Table 1. Main countermeasures of the early and intermediate phase of the nuclear accident in Japan implemented in the first weeks after the earthquake.

Evacuation and Sheltering		
Date	Scope of Countermeasures	Consequences
March 12	Evacuation 20 km around the Fukushima Dai-ichi NPPs	Around 78 000 people were evacuated.
	Evacuation 10 km around the Fukushima Dai-ni NPPs	
March 15	Sheltering of the population living between 20 to 30 km from the Fukushima NPPs	The exact number of evacuees is not published because many people decided to leave the area.
April 21, 22	Evacuation of north-west area of the plant beyond 30 km from the Fukushima NPPs[a] within 30 days. Irregular shaped area extends to nearly 50 km from the NPP.	-
	The "Deliberate Evacuation Area" was defined as well as the "Evacuation Prepared Area" defined as the area where people should be constantly prepared for evacuation. It contained most of the area within the perimeter of 30 km around the Fukushima NPPs.	Evacuation in the "Deliberate Evacuation Area" took place and a preparation for evacuation took place at "Evacuation Prepared Area". As a result many people decided to evacuate temporarily.
	The radius of the evacuation area around the Fukushima Dai-ni NPPs changed, i.e. from 10 to 8 km.	-
Iodine Prophylaxis		
Date	Scope of Countermeasures	Consequences
March 16	Iodine tablets were distributed to evacuation centres around the Fukushima NPPs.	230 000 units were distributed
Ingestion Restriction		

Date	Scope of Countermeasures	Consequences
March 16	Advice not to use contaminated food	-
March 21	Shipment restriction of raw milk and some vegetables in four prefectures	-
March 22	Ingestion restriction of some food in four prefectures	Provisional values for contamination of food applied later used in the regulations.[b]
Ingestion and Shipment Restriction		
Date	Scope of Countermeasures	Consequences
April 4	Ingestion and shipment restriction of some food in four prefectures and three towns	The basic inspection policy including restriction policy of items was published.
Agriculture Countermeasure		
Date	Scope of the Countermeasures	Consequences
April 7	Basic policy on rice cropping was published.	The prohibition of cropping is based on measurements of caesium concentration in soil.
April 22	Rice cropping prohibition for 2011 in some areas, among others all areas within 20 km zone around the Fukushima NPPs	-

[a] The provisions are based on the ICRP reference levels for an emergency exposure situation [5] and on the calculation showing that people living in that area would receive over 20 mSv over the next years.

[b] The value for seafood of 2000 Bq/kg of iodine radioisotope was established on April 5, 2011.

Table 1 also shows the changes of these protective actions which were necessary in order to adjust the actions to a very alive development of the accident. The changes were also necessary because during the accident new or detailed data regarding the characteristics of the accident were obtained. For example additional radiation monitoring systems in affected areas were established and the new data were obtained. Furthermore, mobile cars and airplanes with radiation monitoring systems provided detailed data. Extra analyses of contamination of soil with caesium radioisotopes and analyses of contamination of food and drinking or underground water were used.

In addition to the countermeasures presented in Table 1 many other protective measures were applied to persons or groups of the general public, which were not involved in the recovery work and emergency preparedness in Japan. Such groups include workers of fishing industry, teachers in Fukushima prefecture, who were due to the accident obliged to use pocket dosimeters, port authorities, who were obliged to monitor dose rate of the atmosphere and seawater, and customs officers at the harbour and ship operators, who were obliged to control contamination of containers and ships. Some additional protective measures were also applied for screening and decontamination of persons from the general public and of specific items. Also specific countermeasures were related to hospitalised patients whose evacuation was delayed. Furthermore, additional protective actions were applied when persons temporary returned home in the evacuation area.

Table also shows that the control of food is very strongly linked not only to restrictions related to agriculture but also to any transfer of food. As for example the food produced could be without radioactive contamination when it was produced but it can be contaminated later when transferred from one place to another. In addition it can be contaminated later during any other process related to it, e.g. packaging.

3. Control of Food

In order to apply protective actions in a due time during the progress of a nuclear accident, the triggers should be developed as a part of protection strategy initiating actions. The triggers for a specific protection action can be operational intervention levels (OILs), emergency action levels (EALs) or other indicators of conditions on the scene as given in [6]. As a rule protection of the public is not internationally harmonised, sometimes even not among the neighbouring countries. In addition, due to the unpredictability of a scenario of a nuclear accident, a certain degree of flexibility must be a part of emergency strategy planning. General guidance for actions is published by different organisations e.g. WHO, IAEA.

The IAEA published in [7] generic OILs based on the avertable dose for three urgent actions, namely evacuation, sheltering and iodine prophylaxis as well as the generic action levels for foodstuff expressed in activity concentration in kBq/kg. In addition, the IAEA published re-evaluated default operational interventional levels [8] in 2011 based on field measurements giving also comprehensive explanation of the limitation when using the proposed OILs. It also published EALs for light water reactors. Altogether, six OILs and a comprehensive system related to all appropriate protection actions are applied. Two OILs are related to the measurements of contamination of food, milk and water, one to the screening using gross beta and gross alpha activity concentration in Bq/kg and another using activity concentration for specific radionuclides.

The EU also started emergency preparedness activities after the Chernobyl accident in order to assure a harmonised approach in case of a radiological or nuclear emergency. Nevertheless, only partly harmonisation of emergency strategies has been achieved among European countries till today. Among others, harmonisation is assured by publishing the so-called future accident legislation which is related to the contamination of food and feedingstuffs [9].

The intervention levels used as a trigger used widely in the last decades are not recommended [4, 10] due to the fact that very often optimisation of protection was not considered below the intervention levels. In addition, intervention levels were used not as a part of the overall protection strategy and, as a rule, overall exposure was easily neglected. If only external exposure is taken into account and internal contamination is neglected, the overall strategy is not correct. Nevertheless, intervention levels can be still useful as inputs to develop an overall strategy. Today many countries are going through a transition period in developing their protection strategy, namely intervention levels are still used in their protection strategies. The countries are fully aware that reference levels in case of an "emergency exposure situation" are recommended by the ICRP [4]. It is obvious that "emergency exposure situation" approach is necessary for control the situation in Japan. At the same time the protective actions implemented by other countries, especially by very distant ones, could be even close to the actions usually related to "planned exposure situation" from the ICRP 103.

The restriction on food and water was put in place in Japan on March 17, 2011 by using provisional OILs for food and drinking water regarding the three groups of the radioisotopes. The groups are related to the radiotoxicity or radionuclides, namely:

- sum of specific activities of isotopes of iodine
- sum of specific activities of alpha-emitting isotopes of plutonium and transplutonium elements
- sum of specific activities of other radionuclides with half-life greater than 10 years, except ^{14}C and ^{3}H.

Taking also into account different types of food, e.g. liquid foodstuff, as well as radiosensitivity of children, the specific levels are established for infants and young children. A part of the Japanese OILs is presented in Table 2, where levels for iodine and caesium isotopes are given. For a comparison, the values of European legislation that are already prepared for future accidents are also given. They were also immediately, i.e. on March 25, 2011, applied for a control of contaminated food originating from Japan. These levels published in the Council Regulation (Euratom) No 3954/87, were based on the Codex Alimentarius. In a course of the Fukushima accident some levels were a month later replaced by the Japanese levels. Namely, those OILs from the Japanese legislation which were available were used. As shown in all cases OILs from Japan are lower than pre-defined levels in EU legislation, i.e. levels before the accident in Japan. The details regarding OILs used in Japan and EU levels are given in legislation available in [9]. Table 2 also presents the Food and Drug Administration (FDA) USA values for triggering protective actions, showing the so-called Derived Intervention Levels (DILs) for a particular radionuclide group [11]. No details are given for different types of food in the USA. In addition to establishment the OILs for food and drinking water the regulatory authorities in Japan also put in place a comprehensive inspection system for controlling food and drinking water. In general iodine poses a specific issue in the beginning of the accident while later only caesium radioisotopes are controlled.

In Japan the levels for food were later revised and were published on February 24, 2012 [12]. The levels have been applied from April 1, 2012. Only caesium radioisotopes posed a concern at that time. The levels are also given in the table. These levels are also used in the EU from the same date. Additional details are related to dried products as well as to so-called other foodstuffs and liquid foodstuffs. The details are given in [12]. As a rule new values are lower for an order of magnitude comparing to the values given at the beginning of the accident.

Comparing data given in the table it is evident that OILs spans over one order of magnitude. Therefore the OILs pose a specific problem to the regulatory authorities and technical supporting organisations providing measurements as well as other stakeholders, e.g. companies involved in a global trade.

Table 2. The Japanese OILs for food and drinking water for iodine and caesium radioisotopes used at the time of the accident (Japan 2011). The EU values are taken from the Council Regulation (Euratom) No 3954/87 published in 1987 [9]. The USA values in the term of Derived Intervention Levels (DILs) are also given. Data are taken from [11]. The new values for caesium radioisotopes used in Japan from April 1, 2012, are also given. These values (Japan 2012) were also adopted by the EU. For dried products additional details are given. In addition, values related to so-called other foodstuffs and liquid foodstuffs are specified differently taking into account among others also soybean and soybean products. Details are given in [12].

Radioisotopes	Country	Food for infants and young children [Bq/kg]	Milk [Bq/kg]	Other foodstuffs, except liquid foodstuff [Bq/kg]	Liquid foodstuff [Bq/kg]
Iodine	Japan 2011	100	300	2 000	300
	Japan 2012	50	50	100*	10*
	EU	150	500	2000	500
	USA	170			
Caesium	Japan 2011	200	200	500	200
	EU	400	1000	1250	1000
	USA	1200			

* Explanation is given in the text.

The contamination of food originating from Japan can be a challenging issue in the following decades. In Japan the specific agriculture countermeasures are taking place, e.g. control of soil before planting, control of feedingstuffs etc. It should be also pointed out that not only the EU countries but also some other countries put in place extensive food monitoring programme for screening all or some food imported from Japan, e.g. the USA [11] and Brazil etc. At the beginning of the accident some countries geographically closer to the accident than Europe also implemented appropriate screening programmes of some food originating from their countries in order to avoid any contamination from the fallout due to the Fukushima accident [11]. Additional challenging issue is a contamination of fish and fishery or other marine products in the Pacific Ocean as already given above.

4. Conclusions

Food contamination is one of the main long-lasting issues related to nuclear accident which poses a concern all over the world. It affects the quality of life as well as the economic situation of persons whose income depends on the production or trade of food. The countermeasures also require the establishment of an appropriate monitoring programme which can pose a significant financial burden to a community.

After the nuclear accident in Chernobyl in 1986 it became evident that protective actions and consequently intervention levels or reference levels as appropriate must be harmonised on the international level. The comparison of triggering values regarding the contamination of food used in 2011 immediately after the Fukushima accident shows that no harmonisation is applied yet causing concern of the regulatory authorities as well as of other stakeholders. Moreover as given in [13] no harmonisation exits regarding the evacuation or sheltering based on the contamination of air.

Today the new triggering levels for caesium radioisotopes contaminating the food from Japan are applied. From the April 1 2012 these levels are also used in the EU. They are lower than levels used before showing that the new lessons learned from the Fukushima accident can be gained. The lessons are related to the time development of the accident which spans over months and to the influence of discharges on contamination of food from the land and the sea.

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