Joint Centre Questions & Answers - Nuclear Emergency Response for Food and Agriculture

The following questions and answers are intended to provide general background information only. They are not intended to give a complete overview of possible protective actions that can be implemented following a nuclear or radiological emergency as these will depend on site specific conditions.

Q: Can all nuclear or radiological emergencies affect food, feed and commodities grown on land or in water?

No, only emergencies that result in a release of radioactive material to the atmosphere or to water bodies outside of the facility can directly affect food and commodities.

Q: What are the immediate major impacts on agriculture?

Agricultural products and commodities may become contaminated with radionuclides. Also, radiation can affect agricultural plants and animals resulting in detrimental biological effects. Additional exposure of the workers during agricultural works should be also taken into account.

Q: Which radionuclides could present problems for food production?

- Experience so far has shown that radioactive iodine and caesium are the main radionuclide of concern following emergencies where large amounts of radionuclides have been released from nuclear power plants.

- Radioactive I-131 has a half-life of eight days and decays naturally within weeks. So although it is of concern, it may only be present in the environment for several weeks after the release has occurred.

- Radioactive caesium has a half-life longer than that of radioactive iodine (Cs-134 has a half-life of approximately 2 years and Cs-137 has a half-life of approximately 30 years) and because of this, radioactive caesium can persist in the environment for longer time. For example traces of caesium-137 have been found in the environment for several years after the accident at the power station at Chernobyl and this is also the case following the accident at the Fukushima Daiichi Power Plant.

Q: Are there guide line levels for radionuclides in foods for international trade?

There are internationally agreed Codex Guideline Levels for radionuclides in internationally traded food following a nuclear or radiological emergency. These Guideline Levels, for twenty radionuclides, were developed by the Codex Alimentarius Commission and are contained in the General Standard for Contaminants and Toxins in Food and Feed (CODEX STAN 193-1995, page 33-37).

Q: What are main ways that radionuclides can enter into the food chain?

There are three main pathways for radioactive substances to enter the food chain (See Fig. 1):

- Radioactive material carried by the wind (airborne), by water current (waterborne) and through soil or sediments.

- Radionuclides in air can be deposited on plants.

- Radionuclides in water bodies can also affect aquatic plants and animals in a similar way.

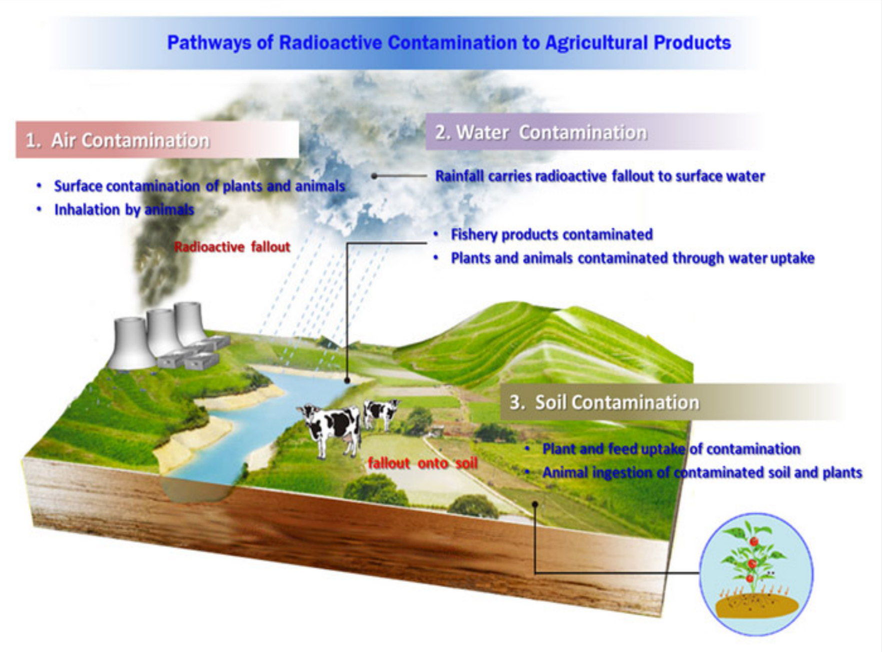

Figure 1. Major pathways of radioactive contamination to food

The relative importance of these contamination pathways depends on various factors. These factors include:

- The nature of the nuclear or radiological emergency.

- The physical and chemical properties of the released radionuclides.

- The time lapsed after the deposition.

- The ability of the plant and animals to accumulate radionuclides.

- The stage of the plant at which the emergency occurs (the time of the year).

- The land use.

- The agricultural practises.

Q: How can radioactive materials (radionuclides) enter plant products during the early stage of the nuclear emergency?

- Following radioactive release to the atmosphere, the deposition of radionuclides on vegetation, soil or surface of water represents the starting point of their transfer in food chains. There are two principal deposition processes for the removal of radionuclides from the atmosphere: dry deposition is the direct transfer to and absorption of gases and particles by natural surfaces such as vegetation, whereas wet deposition is the transport of a substance from the atmosphere to the ground in snow, hail or rain.

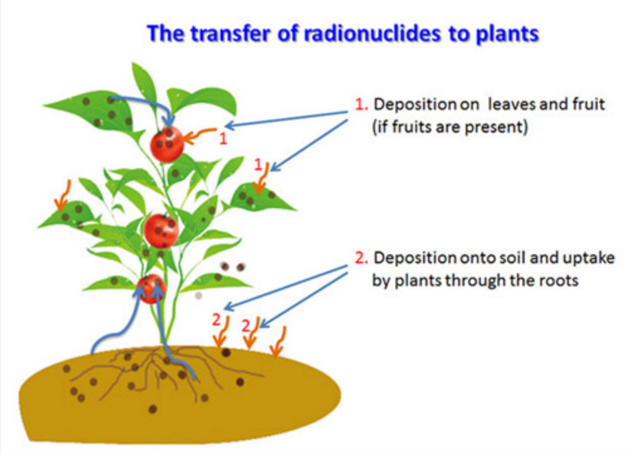

Figure 2. Schematic illustration of radionuclide transfers to plants

- Once deposited on vegetation, radionuclides are lost from plants due to removal by wind and rain and through leaching. The increase of biomass of plants during growth does not cause a loss of activity, but it does lead to a decrease of activity concentration due to effective dilution. There is also systemic transport (translocation) of radionuclides in plants, leading to the redistribution of a substance from the surface where it was deposited to the other parts of the plant that were not contaminated directly (for instance root beets or tubers). The surface of plant may be contaminated through resuspension: This occurs when the wind exerts a force that redistributes particles to the surface plants. Radionuclides in soil can also be taken up by plants (Figure 2).

- Contamination of plants may also occur via contaminated surface water (inundation, irrigation) or contaminated ground water (upwelling, irrigation) whilst contamination of animals may occur because of consumption of contaminated water.

Q: Do weather conditions play a role in the radioactive contamination of soils and crops?

- Yes. If radionuclides are released into the air, it is the wind (direction and speed), precipitation and the height of the cloud base when the radioactive cloud is forming that determines the amount of deposition in an area affected by the emergency.

- Thus, the weather may influence the spatial distribution of radionuclides in the air and on the ground. Subsequent weather events, especially rainfall will also have the effect of removing radionuclides deposited on vegetation and soil.

Q: In what ways can radionuclides contaminate farm animals and animal products after a nuclear accident?

- The most important transfer pathway to animals is through intake of contaminated feed. Intake via drinking water is in general only a relatively small contributor to the total radionuclide concentrations in animals.

- Radionuclides in soil can also be significant, but soil-associated radionuclides are not generally available to enter into animals. Inhalation is potentially more important than drinking water or ingestion of contaminated feedstuffs, because a wide range of different radionuclides in air can pass through the lungs and into the animal.

Q: What immediate actions could be taken in case of nuclear emergency?

Seek information and instructions from the relevant radiation protection authority, for example by radio, TV or internet. If there is time before the contamination reaches your area, and if it is safe to do so, it is possible to take immediate actions to prevent or minimize the radioactive contamination of agricultural products.

- Protect growing crops, vegetables and animal fodder by covering them with plastic sheets or tarpaulins;

- Close the ventilation of greenhouses / poly-tunnels to protect growing vegetables and fruits;

- Bring livestock in from pastures and move animals into a closed shed or barn; and

- Harvest any mature crops and store them where they are protected from deposition of radioactivity.

After contamination has been recorded in your area and until further instructions have been received from the appropriate authorities:

- Do not harvest crops;

- Do not consume locally produced milk or vegetables;

- Do not slaughter animals;

- Do not harvest or consume aquatic animals and plants (fish, shellfish, and algae), and

- Do not hunt fish or gather animals or plants / fungi (fish, game, wild fruits, mushrooms or other "free-food" products).

Q: How protect crops can be protected from direct contamination if there is a possibility that radionuclides will be released into the air?

- The standing plants can be covered with plastic sheets or waterproof tarpaulin for a limited period of time until deposition has ceased (for a maximum of a few days). This option is mostly effective when it is dry but may also help when it is raining (hailing or snowing). It is precautionary, and only useful if implemented before the radioactive cloud has reached the crops.

- Some actions also can be implemented to protect crops grown in glass-houses or poly-tunnels. In particular, switching off ventilation systems and minimising air circulation during the time of passage of the radioactive plume (closing windows, doors, vents to prevent airborne radionuclides entering the growing area).

- Covering plants not be possible for large areas of outdoor crops. Radionuclides may be retained on the surface of growing crops immediately after fallout. The transfer of this contamination to the soil may be minimized by removing such crops as soon as possible after fallout has stopped. The removed crop materials can then be buried by deep ploughing beyond the rooting depth of vegetating crops.

Q: What can be done to mitigate the effects of radioactive contamination on livestock and contamination of animal products in the early period after the nuclear accident?

The ingestion of contaminated feedstuffs and water should be limited as much as possible. Recommended management options may include:

- Moving the animals from pasture and keeping them in pens, sheds or barns where they can be given water and feed (preferably from areas where there is no contamination).
- Leaving contaminated feed until it can be monitored for radioactivity
- Avoiding slaughter of animals indiscriminately until they can be monitored and assessed with the aid of live monitoring.
- Processing of milk and meat for subsequent human consumption and application of decontamination techniques for animal products.

Q: What should be done if dairy products are found to be contaminated with I-131?

Consumption of fresh milk should be constrained as much as possible. However, keeping in mind the short radioactive lifetime of I-131, many options can be used to produce milk products fully applicable for human consumption. For example, dairy products such as dried milk powder, cheese and butter can be produced and stored until I-131 activity concentrations have declined sufficiently to be well below levels of concern. However, in any case, activity concentrations of some other radionuclides should also be checked because high concentrations of I-131 in the accidental release can be accompanied with relatively high levels of other contaminants such as radiocaesium.

Q: Can crops accumulate radioactive materials from contaminated soils even when they are planted after the deposition (fallout) of radionuclides has ceased?

Yes, contaminated soil can be a source for radionuclide transfer to plants over long periods of time. However, the rate of the transfer into plants depends on the chemico-physical form in which the radionuclides enter (e.g. as particles, as aerosol or in solution) or are found in the soil, the time after entry into the soil, along with the properties of soil (presence of clay minerals, organic matter), type of crop; crop management practices (application of fertilizers, irrigation, ploughing, liming, etc.) and climatic conditions.

Q: What are main factors determining contamination of plants in the long-term after the deposition?

In general, there are six main factors determining variability in radionuclide transfer to plants, these are the:

- form in which the activity enters or is present the soil (e.g. as particles, as aerosol or in solution);
- physicochemical properties of the radionuclide; time after entry into the soil;
- type of soil and the physicochemical characteristics of the soil environment;
- type of crop;
- crop management practices (application of fertilizers, irrigation, ploughing, liming, etc.);
- climatic conditions; and the experimental conditions under which the transfer factors were obtained (see IAEA TRS 472).

A decrease with time in the radionuclide activity concentrations both in farm and wild food is a typical phenomenon observed in the environment. A variety of processes are involved, including fixation to soil minerals, incorporation by microorganisms, and migration to deeper soil layers. As a result, the biological availability of radionuclides for incorporation into food chains is reduced after deposition.

Q: Can we use surface water to irrigate crops?

- If an emergency situation has resulted in significant amounts of radionuclides being released directly into a stream or river, do not use this water to irrigate crops or to water animals.
- If the emergency situation has not directly released radioactive material into the stream or river of concern it is still possible that radionuclides will eventually find their way into the water course. However, radionuclides in water are normally diluted rapidly – the contamination is distributed between bottom sediments and water itself. Radionuclide activity concentrations found in the water column generally are much lower than in the bottom sediments. Therefore using surface water to irrigate plants should not provide a significant additional accumulation of radionuclides in soil or a substantial increase of contamination of plants.
- Rivers passing through highly contaminated regions can carry radionuclides downstream and transfer the contamination to other areas and ultimately the sea. Rivers can be a source of secondary contamination in areas downstream and measurements and assessments may be necessary for a period of time after an emergency to ensure that water is fit for irrigation purpose.
- Therefore try to seek detailed information and instructions from the relevant government authority which is responsible for environmental monitoring in your area.

Q: How long after the accident can food still be exposed to radioactive contamination?

- The period of time when food is affected by radionuclides (i.e. the time span when activity concentrations of radionuclides in foodstuffs exceed action levels) depends in particular on the amount of radionuclides deposited, the half-lives of the radionuclides present in the deposition and their chemical form; the properties of soil and the prevailing weather.
- For short-lived radionuclides such as I-131 (half-life is of 8.04 days) such a time span can be from a few days to a few months. For longer lived radionuclides such as Cs-137 (half-life is of 30 years), such a time period can be measured in years depending on the factors mentioned earlier.

Q: How can we reduce contamination of arable land, once deposition (fallout) of radioactive material has ceased?

Figure 3. Removal of contaminated topsoil with a 'Bobcat' mini-bulldozer in the Bryansk region in 1997
(Courtesy of Risø - DTU National LaboratoryRoskilde, Denmark)

- The top few centimetres of soil can be removed, for example using road construction equipment such as graders, bulldozers, front end loaders, excavators and scrapers or a turf harvester (See Fig. 3). Removal of the upper soil will remove much of the contamination.

- The depth of the soil layer which can be removed depends on the thickness of the fertile layer of contaminated soil and the radionuclide content of any remaining "clean" fertile layer soil used to replace that removed. However, the removal of surface soil can result in a large volume of contaminated soil which will need to be either stored or disposed of in a safe manner.

- For a fertile soil with a depth of more than 50 cm, such as peaty soils and chernozems an ordinary single-furrow mouldboard plough can be used to invert the top 0-45 cm of the soil profile. Much of the contamination at the surface will be buried more deeply in the vertical profile, which may reduce radionuclide uptake by plant roots and reduce resuspension of radionuclides and subsequent soil adhesion onto plants.

Q: How can the spread of radioactivity from contaminated soil be minimized?

Actions that minimize soil, water and wind erosion can reduce the spread of radioactive contamination from soil. In addition, activities that generate soil-dust such as digging, ploughing and vehicles moving over the land should be avoided or at least minimized to reduce spreading the radioactivity.

Q: What can be done to reduce contamination of plants once the deposition (fallout) of radioactive material has ceased?

There are many options for decreasing radionuclide transfer to plants, and these include:

- Liming (adding lime to the soil) may reduce the transfer of Sr-90 and Cs-137 from soils to farm crops but the ability to do this depends on soil factors (such as the original soil pH, cation exchange capacity (CEC) and calcium status, hydrological regime of the soil, productivity) as well as the type of crops involved'

- Adding organic materials (manure, compost etc.) may reduce Sr-90 and Cs-137 transfer to plants. This works best with poor soils such as light sandy soil.

- Adding minerals (zeolites, caolins, clays etc) to soil can enhance the ability of the soil to hold onto the radionuclides (increase the "sorption capacity" of the soil) so that it is soil-bound and unavailable for up-take into plants.

- Applying mineral fertilizers at specific rates recommended for contaminated soils can reduce Sr-90 and Cs-137 transfer to plants. As a soil management option, this involves changing both the ratio and application-rates of individual elements that are needed by plants.

- Growing crops with the lowest rates of radionuclide accumulation.

Q: What measures can be taken to reduce the levels of radiocaesium in contaminated livestock in the long term after the nuclear accident?

A variety of management and remedial options may be considered to reduce the radiocaesium level in animal and animal products including:

- Using hexacyanoferrate(1) as a feed supplement for animals can help prevent radiocaesium being absorbed in the gut. Adding this chemical to animal feed or using it in salt licks or administering boli containing hexacyanoferrate can therefore reduce levels of radiocaesium in animals. Hexacyanoferrate is highly effective at binding radiocaesium and only relatively small amounts of this chemical need to be ingested by animals for it to be effective. This measure can be relatively inexpensive and easy to implement on a large scale, for example, hexacyanoferrate can be added to the animal's diet as a powder, or incorporated into the feed as a pelleted concentrate (See Fig. 4).

Figure 4. Administration of the hexacyanoferrate boli to a sheep
(Courtesy of Centre for Ecology & Hydrology, Lancaster Environment Centre, Lancaster, UK)

- Adding natural "sorbents" to feed in order to bind the radiocaesium in the gut. Natural sorbents include clay minerals such as bentonites, vermiculites, and also zeolites. Therefore, when added to feed, preferably by being incorporated into a concentrate mix (at 5 or 10%), they reduce gut uptake of radiocaesium by livestock. These binders, therefore, reduce activity concentrations of radiocaesium in the meat, milk, offal and other animal products.

- Using "clean" feed which involves agricultural animals being given nutritionally balanced diets comprising uncontaminated feed or feed with low levels of radionuclides;

- Carefully choosing slaughter times. This involves manipulating the slaughter time and taking the animals meat in a season of the year when the contamination level is at its lowest.

- Selecting a grazing regime, that takes into account different contamination levels in different pastures and available feedstuffs.

- Processing animal products once they have been collected can also be useful, for example boiling or pickling meat, or soaking in salt (salting) or acid solution (marinating).

(1) Hexacyanoferrate compounds (also known as Prussian blue) are caesium binders which may be added to the diet of livestock to reduce radiocaesium transfer to milk, meat and other animal products by reducing absorption in the gut. The form most commonly used for remediation is ammonium ferric hexacyanoferrate (AFCF).

Q: How can radionuclides in the soil be measured and why is this information needed?

- The activity concentrations of radionuclides in the environment are the most important initial criterion when identifying future management options for productive agriculture, food production and forestry. Initially, in the early stage of the accident, the most important issue is to characterize how the contamination is spread across the environment. This is why it is necessary to measure radionuclide concentrations (either in situ or in a laboratory) and map the results for making decisions.

- In situ soil measurements provide a quick way of obtaining a large amount of data; it helps reduce uncertainty and can be used to make accurate maps of the spatial variation of the different radionuclides. If possible, it should be carried out in a "scanning mode" with the measurements being taken by instruments mounted on vehicles such as cars, vans, tracks, aeroplanes or helicopters.

- Taking soil samples and analysing them in the laboratory can give detailed information on radioactivity that is present in the sample but is more time consuming.

- Soil samples can be measured in addition to in-situ measurements to provide complimentary data to make assessments of soil contamination (mainly at early stage of the accident) or can be used separately to produce superior levels of detail on radioactive contamination and give important additional information of the area under consideration.

- Assessments of ambient concentration of radionuclides in the environments others than soil are always based on a sampling program and the further measurements of samples in the laboratory.

Q: Can radionuclide activity concentrations be measured in live animals or only in slaughtered animals?

Figure 5. Live monitoring of animals
(Courtesy of Russian Institute forAgricultural Radiology and Agroecology, Obninsk, the Russian Federation)

There are techniques to monitor live animals for radionuclides. These techniques can be used to measure concentrations of radionuclides (gamma-emitters, such as caesium isotopes) in animals. Monitoring live animals is helpful as it can be carried out at the farm and / or in slaughterhouses in order to ensure that meat is safe to enter the food chain.

In areas where there is an elevated background level of radioactivity, it can be necessary to take precautions to ensure that the readings are not affected by the background radiation. (See Fig. 5).

Q: Are there techniques for rapid measurements of radioactivity in food?

Yes, there are monitoring techniques, analytical methods and instruments that have been developed specifically for such a purpose.

Sensitive food screening and assay systems can be used to measure radionuclides in foods and in practice these methods are optimised to ensure that samples can be analysed quickly and efficiently.

Q: What should be sampled and how many samples should be taken?

- Samples of food in the markets and at food processing plants should be taken; but it is also important to measure at locations where food is produced. Sampling should include soil, field produce, animal food products and live animals. The exact number of samples that should be taken depends on the circumstances of the emergency, the heterogeneity of the radionuclides in a unit area ("deposition density" in Bq/m2), the complexity of the landscape and the purpose for which the data are needed (for example, to map affected areas or to define where specific food restrictions are applicable). The number of samples will also depend on the size of the area under consideration.

- In general, more intensive sampling will create greater statistical confidence. However, in practice there will be constraints and limitations on the number of samples that can be analysed. Using other data, such as external dose rate measurements (in situ) can be used to target the locations and the number of samples that should be taken. This targeted approach can improve sampling efficiency.

Q: Why and how should contaminated agricultural products be disposed?

- Agricultural products and commodities produced in affected areas can be contaminated with radionuclides in concentrations exceeding action levels. If there are no feasible and economically justifiable options to process such products, making them acceptable for human consumption, such contaminated products may need to be discarded and disposed of effectively.

- Agricultural produce may be disposed on location by composting, land spreading of milk and/or slurry and "ploughing in" standing crops. This is because, the concentration of radionuclides in crops and commodities are lower than in the soils on which they are produced (See Figure 6).

Figure 6. Disposal of milk with high Cs-137 concentrations

- Off-site options include digestion of milk, burial of carcasses, disposal of contaminated milk to sea, incineration of crops, disposal at a landfill, processing and storage of milk products for disposal and rendering of animal carcasses (which converts waste animal tissue into stable, value-added materials). In all cases, the safety of the specific measure needs to analysed and evaluated.

- Burning should be avoided or performed in specially designated facilities equipped with adequate filters and according to safety regulations. Radionuclide levels in ash may be enhanced, and it may be necessary to dispose it in special landfill sites.

- In some specific situations, where radionuclide activity concentrations in products are found to be high, it may be necessary for the agricultural products or commodities to be disposed in special landfill sites according to the regulatory authorities.

Q: Why is it that "wild-foods" from natural and semi-natural environments can be found with higher levels of radionuclides that foods produced on farms?

Foods that can be gathered from natural or semi-natural environments (like deer meat, wild boar, mushrooms, berries, fresh water fish etc.) can accumulate radionuclides to a greater extent than foods from farmed land. This is due to the behaviour of radionuclides in natural and semi-natural systems, which differs substantially from that in agricultural environments. In natural and semi-natural ecosystems the soil is generally poor and there is an efficient recycling of nutrients and minerals between the soil and plants and animals.
In this way, radionuclides can be efficiently recycled in these ecosystems. Radionuclides may persist in these environments and be available for uptake into plants and animals for a greater period of time than they would in agricultural environments.