CODEX ALIMENTARIUS COMMISSION

Food and Agriculture Organization of the United Nations

World Health Organization

Viale delle Terme di Caracalla, 00153 Rome, Italy - Tel: (+39) 06 57051 - E-mail: codex@fao.org - www.codexalimentarius.org

Agenda Item 16 **CX/CF 21/14/14**

April 2021

ORIGINAL LANGUAGE ONLY

JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON CONTAMINANTS IN FOODS

14th Session
(virtual)
3-7 and 13 May 2021

DISCUSSION PAPER ON THE RADIOACTIVITY IN FOOD AND FEED (INCLUDING DRINKING WATER) IN NON-EMERGENCY SITUATIONS

(Prepared by the Electronic Working Group chaired by the European Union and co-chaired by Japan)

BACKGROUND

1. Following discussions at the 13th Session of the Committee on Contaminants in Foods (CCCF13, 2019) the Committee agreed to establish an electronic working group (EWG) on radioactivity in food and feed (including drinking water) to produce a discussion paper for consideration at its next session, chaired by EU, co-chaired by Japan, working in English with the following terms of reference (REP19/CF, paras. 26-27):

   i. Provide factual information on the radioactivity of both human-made and natural origin that can be found in food (including drinking water) and feed in normal circumstances (i.e. not in an emergency exposure situation following a nuclear or radiological accident).

   ii. Identify the issues related to the presence in normal circumstances of radioactivity in food (including drinking water) and feed of both human-made and natural origin, such as food and feeod safety, transfer of radioactivity from feed to food of animal origin, possible public health risks via intake of food, trade issues, etc.

2. CCCF13 noted that this discussion paper would:

   i. result in an increased understanding of the presence of radioactivity in food (including drinking water) and feed in normal circumstances and related issues, and;

   ii. provide the Committee with the appropriate information enabling CCCF14 to take an informed decision in 2020 on possible follow-up actions.

3. Consequent to the postponement of CCCF14 due to the COVID19 pandemic from May 2020 to May 2021, discussion on possible follow-up actions are to take place in CCCF14 in 2021.

DISCUSSION

4. A first draft was circulated to the EWG. Comments from 11 Members of the EWG were received. Besides comments on the text, following general comments were made:

   - there needs to be a stronger case made to CCCF to work further on this issue.

   - the relation between the work to be possibly undertaken by CCCF and work already and planned to be undertaken by Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO), the International Atomic Energy Agency (IAEA), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

- clarification of the terms used and ensure consistent use of the terminology in particular the terms “normal circumstances”, “existing exposure situation”, and “non-emergency situation”.

5. The discussion paper, updated following the comments received, is enclosed as Appendix I and the list of participants to the EWG is enclosed as Appendix II.

6. From the information provided in the discussion paper it can be concluded that:

   i. Naturally occurring radionuclides are found in many different foods and tend to give radiation doses higher than those provided by artificially produced radionuclides in situations not affected by a nuclear emergency situation in the past, but no specific safety problem for food, feed or drinking water due to the presence of naturally occurring radionuclides has been identified.

   ii. No problems in international trade have been identified due to the presence of naturally occurring radionuclides in food, feed and drinking water.

RECOMMENDATIONS

7. CCCF14 is invited to consider on the follow-up actions below on radioactivity in food (including drinking water) and feed in non-emergency situations based on the information provided in the discussion paper provided in Appendix I and its annexes:

   i. to agree that no further work is required to be done by CCCF at this time given that naturally occurring radionuclides in food, feed and water do not seem to be an issue for food safety and trade,

   ii. to request IAEA, FAO and WHO, with assistance provided by the Codex Secretariat, to elaborate a document for publication on the Codex website providing the state of the art of natural radioactivity in food/feed/water.

   iii. to request to be kept informed of FAO/IAEA/WHO work to develop methodologies that can be used to produce criteria with which to assess radionuclides in food.

APPENDIX I

DISCUSSION PAPER

Radioactivity in Feed, Food and Drinking Water in Non-Emergency Situations[1]

I. Introduction

1. Following discussions at the 13th Session of the Committee on Contaminants in Foods (CCCF13, 2019) the Committee agreed to produce a discussion paper on radioactivity in food (including drinking water and feed) in non-emergency situation.

II. Relevance

2. It is normal for food, feed and drinking water to contain radioactive substances (radionuclides) resulting in a low level of radioactivity. As this paper will illustrate, radionuclides in food, feed and drinking water are mostly of natural origin but can also include human-made radionuclides and human activity can increase concentrations of naturally occurring radionuclides. Actions can be taken to lessen the human exposure to ionizing radiation from radionuclides in food, feed and drinking water.

Some of the radionuclides in these commodities are amenable to being controlled. In this respect, radiation safety standards use the concept of an "existing exposure situation" this is when exposure sources already exist when a decision on control is being taken. It includes exposure to natural sources including eg. radionuclides of natural origins, regardless of activity concentration, in commodities, including food, feed, drinking water, agricultural fertilizer and soil amendments; exposure due to residual radioactive material that derives from past practices that were never subject to regulatory control; and exposure due to residual radioactive material deriving from a nuclear or radiological emergency after an emergency has been declared to be ended[2].

3. There is a disparity between international guidance for radioactivity (radionuclides) in drinking water and those for food and feed. International Guidelines for Drinking Water Quality[3] establish criteria with which to determine the safety of both natural and human-made radionuclide levels in normal circumstances (i.e. planned and existing exposure situations). The emphasis for international standards and safety guides is the extreme circumstance of a nuclear or radiological accident and the establishment of radiation safety criteria to protect human populations (in an "emergency exposure situation"), but are established to assure the protection of the population in the subsequent exposure situation.

Therefore, radionuclide criteria in international food standards and guides focus on human-made radionuclides (presence of radionuclides as the result of an accidental release), contingency planning, emergency response, the protection of local populations[4,5] and radiological safety in terms of food trade with areas not directly affected by the accident[6]. The difference with other exposure situations is that the radionuclides that are addressed are the result of an accidental release and, usually are not in the natural environment.

---

1 In Annex II, explanatory notes are provided on the terminology "normal circumstance", "existing exposure situation" and "non-emergency situation"

2 An "Emergency Exposure Situation" arises as a result of a nuclear or radiological accident, a malicious act or other unexpected event that requires prompt action in order to avoid or to reduce adverse consequences. The emergency phase typically ends when the situation is under control, the off-site radiological conditions have been characterized sufficiently well to identify whether and where food restrictions and temporary relocation are required, and all required food restrictions and temporary relocations have been put into effect.

3 Chapter 9, Guidelines for Drinking Water Quality, Fourth Edition incorporating the first addendum. World Health Organization, 2017 https://www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/

4 Food and Agriculture Organization of the United Nations, International Atomic Energy Agency, International Civil Aviation Organization, International Labour Organization, International Maritime Organization, INTERPOL, OECD Nuclear Energy Agency, Pan American Health Organization, Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, United Nations Environment Programme, United Nations Office for the Coordination of Humanitarian Affairs, World Health Organization, World Meteorological Organization, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSR Part 7, IAEA, Vienna (2015). https://www.iaea.org/publications/10905/preparedness-and-response-for-a-nuclear-or-radiological-emergency

5 Operational Intervention Levels (OILs) for "food, milk and drinking water" are available in Food and Agriculture Organization of the United Nations, International Atomic Energy Agency, International Labour Office, Pan American Health Organization, World Health Organization, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-2, IAEA, Vienna (2011). https://www.iaea.org/publications/8506/criteria-for-use-in-preparedness-and-response-for-a-nuclear-or-radiological-emergency

6 Guideline Levels (GLs) for Radionuclides provided in the Codex General Standard for Contaminants in Food and Feed (CXS 193-1995) www.fao.org/fao-who-codexalimentarius/en/

4. There are differences between how drinking water and food are consumed and distributed. Therefore, some differences in approach are reasonable, for example, although some packaged waters are traded, consumers may rely on a single source of drinking water that is supplied to them directly. In contrast, there are many different types of food and it is likely that the different foods in the diet originate from different locations.

   Furthermore, there is significant trade in food, it is prepared in many ways, consumers can exercise a degree of choice over what food they eat and may also adopt different dietary habits. However, there is scope to explore the need for guidance on radionuclides in food in normal (i.e. “non emergency” or “planned and existing exposure”) situations. The need for guidance is mainly to be determined on the basis of possible health risk considerations with the additional benefit of providing consistency with guidance on drinking water.

5. The internationally accepted Guidelines for Drinking Water Quality provide a common framework to assess the safety of drinking water with respect to contaminants including radionuclides. Drinking water quality monitoring programmes are implemented in many countries and drinking water standards and monitoring requirements for public drinking water supplies are often established in national legislation. Drinking water providers and Competent Authorities are making use of the Guidelines for Drinking Water Quality and their legislation to ensure the safety and quality of drinking water supplies. This is important because some drinking water sources may have elevated levels of radionuclides, for example due to the local geology.

   There are populations where radionuclides in drinking water is a significant exposure pathway. In general, however, radionuclides in drinking water only contribute a small percentage of the total ingestion dose and radionuclides in food are the major source of exposure by ingestion. If it is acceptable to have guidelines for drinking water as some drinking water sources may have elevated levels of radionuclides, then some consideration also needs to be given to the development of safety related guidance for radionuclides in food as food is a more significant source of exposure.

6. In contrast to drinking water, trade in food is widespread, and the global food supply system is complex and interconnected. However, few monitoring programmes report levels of both natural and human-made radionuclides in food or feed. Where radionuclide levels are measured, competent authorities tend to address human-made radionuclides (presence of radionuclides as the result of an accidental release) in food production areas or in traded commodities (i to iii, below). Exceptions can be found in some countries, where some degree of monitoring for both natural and human-made radionuclides is included in studies of the national diet (iv, below). For background information, examples of monitoring and surveillance activities for radionuclides in food include:

i. Environmental monitoring including agriculture and animal production near facilities that release controlled amounts of radioactive gases and effluents into the environment. These controlled releases are usually from facilities that use or generate radioactive substances, e.g., human-made radionuclides discharged from hospitals, research institutions and nuclear related establishments such as those involved with radio-isotope production or power generation;

ii. Surveillance of food and food-production areas and local supplies (monitoring long after a nuclear accident in areas affected with residual levels of radionuclides). Here the key radionuclides of concern have been identified during the emergency response phase and any necessary restrictions are in place to limit exposure. The purpose of this surveillance is to manage and control the production and collection of food (and feed) in affected areas according to agreed levels for key radionuclides in the environment as well as in food and feed products.

   The surveillance also provides information on the evolution in time of the activity concentrations and to assess the effectiveness of the measures or recovery strategy implemented. In some cases, such levels may be found in legislation relating to food or feed safety (e.g. in relation to cesium ^{134}Cs and ^{137}Cs in areas affected by the 1986 accident at the Chernobyl power plant and areas affected by the 2011 accident at the Fukushima Daiichi power plant);

iii. Border checks on food trade (usually imports) against legislative limits on human-made radionuclides (e.g. ^{137}Cs and ^{134}Cs) to ensure compliance with controls on the distribution and sale of food and feed from specific regions, countries or areas where food and feed are affected by residual levels of human-made radionuclides, for example after a nuclear or radiological accident.

iv. Studies to estimate dietary exposures to food chemicals and nutrients for various population groups may also include measurements of radionuclides as a part of a broad national or regional food surveillance programme (e.g. dietary intake studies).

7. In an initiative to develop principles for harmonized guidance on radionuclide activity concentration in food and drinking water in non-emergency situations, the FAO, IAEA and WHO are working in a joint project with a steering group of national radiation safety experts from several Member Countries. Part of this on-going work has included a survey[7] of literature published in scientific journals from 1957 onwards.

This literature survey has identified 124 published studies providing assessments of exposure to radionuclides in food from 45 different countries. Of these countries, 9 had considered naturally occurring radionuclides in foods, 14 countries had focused on human-made radionuclides and 22 had assessed exposure to both natural and human-made radionuclides. This literature includes 71 different assessments of dietary exposure to at least one radionuclide in food (8 canteen meal surveys, 11 duplicate diet studies, 36 market basket surveys and 16 total diet studies)

8. Although other studies may be available in national reports, the literature survey of scientific journal publications supports the view that there are a limited number of food monitoring programmes that provide data on levels of both natural and human-made radionuclides and report dietary exposure assessments. It would be beneficial to encourage more countries to include human-made and natural radionuclides in exposure assessments in order to better define the potential for public health risks.

Although a study would be desirable to indicate a national baseline of typical levels of radionuclides in foods, it is not something that would need to be repeated frequently, given the limited change in levels over time. If necessary, further monitoring and measurements in the longer term could be efficiently focused on key radionuclides, foods, locations and populations if indicated by a baseline study. This may be important where food is produced in areas with enhanced levels of radioactivity either due to human-made radionuclides discharged into the environment or from naturally occurring radionuclides (for example, due to local geology or geological activity and in places where human activities or natural processes may enhance levels of naturally occurring radionuclides[8]).

III. Radioactivity in food, feed and drinking water

Food and drinking water

9. Food and drinking water can contain radioactive substances (radionuclides). Except in extreme circumstances (e.g. major accidents or malicious events that could result in food becoming contaminated with large amounts of radioactive material), risks from radionuclides in food and drinking water are likely to be small compared with the risks from microorganisms and chemicals present in food and water.

Nevertheless, the ionizing radiations emitted by ingested radionuclides can make a significant contribution – depending upon the origin of the foods (location) and the dietary preferences of a population or individual - (on average about 10 % based on the UNSCEAR 2000 report, see Figure 1) to the overall radiation dose that we receive from the many different sources of radiation to which we are exposed in our everyday lives.

10. There are five key radionuclides that make significant contributions (see para. 12) to the radiation dose from the ingestion of food and water and these all occur naturally. These radionuclides have been present in the environment since the earth was formed and include the radioisotope potassium-40, ^{40}K, plus isotopes of lead, polonium and two different isotopes of radium: ^{210}Pb; ^{210}Po; ^{226}Ra, and ^{228}Ra[9].

---

7 IAEA literature survey of radiation dose assessments from natural and/or human-made radionuclides in the diet, August 2019.

8 such as the agricultural use of sludge from waste water treatment facilities, the application of fertilizers, fertilizer processing facilities, mineral extraction and processing, steel production, oil and gas extraction etc.

9 Exposure to radon is almost exclusively through inhalation of the gas. Some groundwaters may contain measurable amounts of radon (^{222}Ra), but given its relatively low solubility in water, ^{222}Ra is readily liberated to the air when water is agitated or heated, and therefore the main exposure pathway is by inhalation and not by ingestion (piped water carrying Rn into living areas where people inhale it). This is why international guidance is that guideline levels for radon in drinking water should be based on inhalation (radon in air) rather than ingestion (radon due to water ingestion). See section 1.6 of the WHO publication "Management of radioactivity in drinking water" (https://www.who.int/water_sanitation_health/publications/management-of-radioactivity-in-drinking-water/en/) and section 9.7 of the WHO Guidelines for Drinking Water Quality (https://www.who.int/publications/i/item/9789241549950).

A small proportion of all naturally occurring potassium (0.012%) is present as radioactive ^{40}K, whereas the latter four heavy isotopes are produced naturally, from radioactive decay of heavier elements.

11. The human body maintains homeostatic control of potassium levels and this includes the proportion of potassium present as the radionuclide ^{40}K. Thus, a balance of ^{40}K is maintained in the body and this gives rise to a radiation dose of 165 µSv/year (microsievert per year) for adults and 185 µSv/year for children[10]. However, other radionuclides are not maintained under homeostatic control.

However, unlike ^{40}K, the amount of these radionuclides in the body is related to how much is consumed. For example, ^{210}Pb, ^{210}Po, ^{226}Ra and ^{228}Ra can be detected in different amounts in humans because they are found in different soils and waters and therefore also in foods and feed which are produced in these environments. Levels of these radionuclides in foods vary widely because of climatic and agricultural conditions and differences in concentrations in soils. The soil type also affects the retention and mobility of radionuclides and therefore their uptake into plants.

12. The UNSCEAR 2000 report was the most recent report by the Committee that included representative values for levels of the natural radionuclides ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra (uranium and thorium decay series) in food and drinking water[11]. The UNSCEAR plans to update its public exposure assessment from all sources (including food and drinking water) and has established an expert group.

The work of the UNSCEAR expert group will include a review of the UNSCEAR representative values used for assessing radiation doses from radionuclides in food and drinking water, it is scheduled to be conducted in 2020 – 2023, in close cooperation with the IAEA and WHO. UNSCEAR 2000 technical data on levels of natural radionuclides from different countries and regions were used to generate world-wide representative values for levels of the nine most prevalent natural radionuclides in food (Table 1). These global representative values together with the contribution from ^{40}K were used by UNSCEAR to calculate a worldwide averaged (age-weighted) annual effective dose from the ingestion of food and water of 310 µSv/year (typical range of 200 – 800 µSv/year)[12].

Most of the ingestion dose (>95%) presented in UNSCEAR 2000 is from food whereas natural radionuclides in drinking water typically account for less than 5 percent (approximately 10 µSv/year) of the annual effective dose. This estimated worldwide averaged annual ingestion dose of approximately 310 µSv/year for the consumption of food and drinking water is entirely due to ^{40}K ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra. The radionuclide ^{40}K is calculated to contribute approximately 170 µSv/year on average and ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra are together assessed as adding a further 140 µSv/year. Other natural radionuclides account for less than 2 µSv/year on average.

13. The average annual ingestion dose of approximately 310 µSv from natural radionuclides in food is about one tenth of the 2800 µSv total worldwide average annual effective dose from all radiation exposures (Figure 1). The worldwide average annual effective dose from exposure to human-made radionuclides, excluding medical diagnostic exposure, is estimated as 7.2 µSv/year. This indicates that the dose contribution of human-made radionuclides in food is not generally of concern in normal circumstances (planned and existing exposure situations).

Human-made radionuclides (e.g. from industrial, medical, nuclear and research establishments and other uses of radioactive materials) may enter food and drinking water supplies. However, the contributions to ingestion dose from these sources of human-made radionuclides in planned exposure situations are limited by regulatory control of the source or practice in the specific discharge authorization. Should such sources of human-made radionuclides cause concern, it is normally through such regulatory mechanisms that action is taken.

10 UNSCEAR 2000 REPORT Vol. I, Annex B: Exposures from Natural Radiation Sources, paragraph 75 (page 94). https://www.unscear.org/docs/publications/2000/UNSCEAR_2000_Annex-B.pdf

11 UNSCEAR 2000 REPORT Vol. I, Annex B: Exposures from Natural Radiation Sources, Table 15.

12 An ingestion dose of 310 µSv/year with approximately 170 µSv/year assessed as due to ^{40}K in the diet and 140 µSv/year from radionuclides of the uranium and thorium decay series with ^{210}Po as the main contributor to dose (85 µSv/year), followed by ^{210}Pb (28 µSv/year), ^{228}Ra (21 µSv/year) and ^{226}Ra (8 µSv/year). The sum of the dose contribution from the remaining long-lived radionuclides in the uranium and thorium decay series (^{230}Th, ^{232}Th, ^{234}U, ^{238}U, ^{228}Th and ^{235}U) was less than 2 µSv.

14. The radionuclide content of food may be affected by various food preparation activities. For example, concentrations may be elevated by dehydration or diminished by trimming, cooking and peeling[13].

15. The UNSCEAR 2000 representative activity concentration data for uranium and thorium decay series radionuclides in food were compiled in order to undertake an assessment of radiation dose. However, laboratories also refer to these representative activity concentrations when placing their analytical results into context, i.e. laboratories compare their measurements of natural radionuclides in food samples to the UNSCEAR 2000 representative values. In addition, although the UNSCEAR 2000 estimates of dose are worldwide averaged (age-weighted) annual effective dose and there will be significant variations for individual doses, many national dietary studies make estimates of dose that are in general agreement with those of UNSCEAR. For instance, the following examples indicate national monitoring of food and water:

- **Food**: National estimates of annual effective doses based on dietary surveys generally report doses from the consumption of food that are between 200 and 500 µSv/year (Table 2) but there are significant variations. For example, the dose range of approximately 200 – 3000 µSv/year for internal exposure received by the adult population in France is due to the presence of radionuclides from the uranium and thorium decay series in foodstuffs (not including drinking water)[14]. This study reports that the variation in dose to the adult population is mainly due to ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra, which are part of the thorium and uranium decay series. It also noted large variations in radionuclide concentrations and found that the assessed dose is entirely dominated by variations in ^{210}Po activity concentrations and the consumption of shellfish and crustaceans (foods that tend to have enhanced levels of ^{210}Po).

  However, the levels of ^{210}Po in seafood were, in general, higher than the representative values given in UNSCEAR 2000. Based on radionuclide measurements in foods as collected, the majority of the population was assessed to receive an annual effective dose of 319 µSv (i.e. approximately 500 µSv/year if ^{40}K is included), non-consumers of shellfish or crustaceans were calculated to receive an annual ingestion dose of 193 µSv (approximately 360 µSv/year if ^{40}K is included), regular consumers of shellfish and crustaceans were assessed as receiving 730 µSv (900 µSv/year including the contribution from ^{40}K) and high rate consumers of shellfish and crustaceans (135 to 161 kg/year), 2000 to 2600 µSv/year (2170 to 2770 µSv/year including the contribution from ^{40}K). Also in other studies elevated levels of ^{210}Polonium were found in seafood[15].

- **Drinking Water**: studies to obtain representative data on public exposure to radiation from natural radionuclides in public supplies of drinking water in Germany[16,17] between 2003 and 2008, involved the analysis of 582 samples from public water supplies. These covered urban areas and regions known to have elevated concentrations of naturally occurring radionuclides. The mean values of radiation exposure from drinking water (ingestion dose) obtained from the data were approximately 9 µSv/year for adults and about 50 µSv/year for infants. These results indicate that natural radionuclides in the drinking water supply make a minor contribution to the total mean radiation exposure. However, a considerable range in variation of radionuclide levels were observed for ^{238}U, ^{234}U, ^{226}Ra, ^{228}Ra, ^{222}Rn, ^{210}Pb and ^{210}Po.

Feed

16. Animal feed may contain radionuclides that could present a risk to human health through the ingestion of foods of animal origin. Therefore, in normal circumstances (planned and existing exposure situations) the key radionuclides of interest are no different to those in other foods (i.e. ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra). Except in extreme circumstances, these risks are usually small compared with the risks from microorganisms and chemicals that may be present in feed.

---

13 Work by Francés et al. on the influence of cooking temperatures have on ^{210}Po due to its volatilization, indicated a decrease in the activity concentration in many, but not all, seafood types with cooking. http://www.fisheriessciences.com/fisheries-aqua/210po-activity-concentrations-in-cooked-marine-food.php?aid=18057

14 Ph. Renaud, V. Parache, S. Roussel-Debet. Radioprotection (2015), DOI:10.1051/radiopro/2014034

15 Natural and Artificial Radioactivity in Coastal Regions of UK : https://link.springer.com/chapter/10.1007/978-94-011-3686-0_35
Orientating investigations of Polonium-210 and other natural radionuclides in Dutch aquatic ecosystems: https://www.rivm.nl/publicaties/elementair-analyses-tbv-project-orienterend-onderzoek-naar-polonium-210-en-andere

16 BfS SW 06/09, Salzgitter: 129 S (in German) (https://doris.bfs.de/jspui/handle/urn:nbn:de:0221-20100319945, accessed 21 August 2019).

17 Management of radioactivity in drinking water, ISBN 978-92-4-151374-6, World Health Organization (2018).

Animals can be contaminated with radionuclides by ingestion, inhalation and absorption through skin. Sources of radionuclides can be from feed, soil, drinking water, cosmic rays etc. Ingestion of contaminated feed and soil is the most important route for the uptake of radionuclides into the animal. Radionuclides associated with soil are in general less available for absorption into the animal. Therefore, it is contaminated feed and the processes influencing the absorption and retention of radionuclides in feeds that determine the radionuclide content in animals.

17. Although there is international trade in animal feed, few monitoring programmes measure levels of both natural and human-made radionuclides in this commodity. In general, radionuclide levels are measured where monitoring programmes are established in order to check levels of specific radionuclides in feeds that originate from areas affected by nuclear or radiological accidents. Therefore, this type of monitoring tends to focus on relatively persistent human-made radionuclides that are important for uptake into the food chain and were accidentally released into the environment in significant amounts at some time in the past (e.g., ^{90}Sr, ^{137}Cs and ^{134}Cs).

18. Such monitoring is generally undertaken by competent authorities responsible for the affected areas and the imposition of controls on the production and distribution of affected products and Competent Authorities at borders that are responsible for trade and imports of feed. In both cases the checks are against legislative limits on specific human-made radionuclides. Legislative limits for feed are derived according to calculations relating to levels of radionuclides in feed versus concomitant levels of these radionuclides in the animal derived food product (milk, eggs, meat etc.). For illustration only, Appendix I provides certain examples of legislative limits on human-made radionuclides in feeds related to emergency situations that are implemented in several countries together with examples of limits applied to radionuclides in foods.

19. The IAEA has published a handbook[18] that includes the transfer of radionuclides in the environment and provides data on the observed relationships between the activity concentration in feed and that subsequently observed in animal products, at equilibrium. Table 3 provides several selected values for such Concentration Ratios (the equilibrium ratio of the fresh weight radionuclide activity concentration in the food of animal origin product divided by the dry matter radionuclide concentration in the feed). When not in equilibrium, it is logic that a temporary exposure of food producing animals to contaminated feed has more potential influence on contamination of food such as eggs and milk, which are produced continuously, than on meat.

Summary

20. Internal exposure due to irradiation from ingested naturally occurring radionuclides can give rise to radiation doses of a few hundred micro sieverts per year on average to possibly two or three thousand micro sieverts per year. In general:

i. Radionuclide levels in the human body related to ingestion largely depend on levels in food and less so on levels in drinking water. Radionuclides in animal feed are also transferred to humans through the ingestion of foods of animal origin. Therefore, food other than drinking water is the main source of radiation exposure with regard to the ingestion component or pathway. However, ingestion contributes on average only for 10 % of the total radiation exposure from all sources.

ii. The radionuclide content of food may also be modified during preparation. For example, activity concentrations may be elevated by dehydration or diminished by trimming, peeling and cooking.

iii. The ingestion dose is dominated by natural radionuclides, i.e., mainly ^{40}K, ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra.

iv. Potassium (including ^{40}K) is more or less uniformly distributed in the human body and its concentration is maintained under homeostatic control.

18 International Atomic Energy Agency, Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Ecosystems, Technical Report Series 472, 2010

v. In contrast to potassium, radionuclides such as those of the thorium and uranium decay series (primarily ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra) are not maintained under homeostatic control and the amount of these radionuclides in the body is variable and related to how much is consumed and excreted.

vi. Foods, feeds and drinking waters can have a considerable range in variation of radionuclide concentrations. The radionuclides found in different foods, feeds and drinking waters reflect the radionuclide content of water, rocks, soil and fertilizers from where they originated.

vii. The radionuclide ^{210}Po can dominate radiation exposure for some populations, because it can be found at naturally elevated levels in some foods (e.g. seafood). However other radionuclides could also be important dependent on dietary habits and regional characteristics.

viii. The UNSCEAR 2000 report has the latest scientific information on worldwide representative values for levels of the natural radionuclides (uranium and thorium decay series) in food and drinking water. The UNSCEAR 2000 data are planned to be updated by 2023 as part of a new UNSCEAR assessment of public exposure.

IV. Issues related to food, feed and drinking water

21. **Food, feed and drinking water safety**: In normal circumstances (i.e. planned and existing exposure situations), International Radiation Safety Standards[19] require that the national regulatory body or other relevant authority shall establish specific reference levels[20] for exposure due to radionuclides in commodities such as food, feed and drinking water, each of which shall typically be expressed as, or based on, an annual effective dose to the representative person generally that does not exceed a value of about 1000 µSv/year. The issues here are:

i. Radiation is an issue of cumulative exposure from different radionuclides, different foods including drinking water, and all the other exposure routes shown in Figure 1. When setting maximum levels of activity concentration for a specific radionuclide for a specific commodity, these are expressed in becquerel per liter drink or per kilogram food (Bq/L or Bq/kg). The individual dose criterion is an additional risk management criterion for the commodity to take into account the sum of the different radionuclides in the product and is expressed in microsievert (µSv) or millisievert (mSv) per year for a reference person.

ii. Drinking water is the only commodity where specific reference levels (activity concentrations) for radionuclides are established at national level in different countries. These are based on the Guidelines for Drinking Water Quality. Therefore, the internationally accepted approach should be based on an 'individual dose criterion' (IDC) of 100 µSv/year and an upper-bound annual drinking water ingestion dose of 1000 µSv/year.

iii. For radionuclides in food, no international standards have yet been produced to support the establishment of specific reference levels (specific activity concentrations) for use in non-emergency situations. Most of the ingestion radiation dose is received through the consumption of food. Nevertheless, there is an absence of international standard/guideline[21] and no national competent authority seems to have established a comprehensive set of reference levels for natural and human-made radionuclides in foods in normal circumstances (i.e. planned and existing exposure situations[22]).

---

19 European Commission, Food and Agriculture Organization of the United Nations, International Atomic Energy Agency, International Labour Organization, OECD Nuclear Energy Agency, Pan American Health Organization, United Nations Environment Programme, World Health Organization, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014). https://www.iaea.org/publications/8930/radiation-protection-and-safety-of-radiation-sources-international-basic-safety-standards

20 reference levels in this context are clearly defined criteria to indicate the need for closer investigation or review (criteria such as dose criteria and/or specific activity concentrations, the latter can be measured by an analytical method).

21 TECDOC 1788 is not an international standard but a technical manuscript produced by the FAO, IAEA and WHO, suggesting a methodology for calculating generic radionuclide concentrations equivalent to or less than about 1 mSv/year

22 In existing exposure situations there is guidance in terms of the Codex guideline levels for radionuclides in food but the scope here is only in the special case of after a nuclear accident (not in general).

iv. There are no international standards for establishing specific reference levels for radionuclides in feeds for use in non-emergency situations. Further, human exposure due to radionuclides in feeds is related to the ingestion of products of animal origin, where the animal was raised on such feed (exposure due to direct irradiation of humans from radionuclides in feed is insignificant). It could be considered that a separate dose criterion for feed may be unnecessary because there is a criterion of about 1000 µSv/year for radionuclides in food and this includes food of animal origin raised on feed. On the other hand it could be considered that it is important to regulate radionuclides in feeds to ensure safe levels of radionuclides in foods of animal origin.

22. **Water sold as food:** Not all water for human consumption is covered by health-related water quality criteria for radionuclide content. There are no international criteria for radionuclides in natural mineral waters. Even though some natural mineral waters may contain enhanced levels of radionuclides, they are sold as foods and Codex Standards do not provide criteria for naturally occurring radionuclides in foods. In contrast, there is international guidance on radionuclide levels in public drinking water supplies (tap water) and in bottled/packaged waters as described below for the three categories of water that are internationally recognized:

i. **Drinking water**: Guidelines for Drinking Water Quality are provided by the World Health Organization (WHO)[23]. This international guidance is the basis for the setting of national legislation and standards for water safety in support of public health. These guidelines provide the IDC of 100 µSv/year from drinking water consumption but recognizes the 1000 µSv/year from International Radiation Safety Standards for drinking water as the upper bound[24] and it gives practical ways of measuring radionuclide content, for example activity concentrations (Bq/L) with which to measure water quality in terms of the IDC, regardless of whether the radionuclides are of natural or human-made origin. Here drinking water relates to the public water supply.

ii. **Packaged Waters** (other than natural mineral waters): A description for bottled/packaged waters is provided in the Codex Standard CXS 227-2001 “Packaged Drinking Waters (Other Than Natural Mineral Waters)”[25] The standard provides that no packaged water shall emit radioactivity in quantities that may be injurious to health. To this effect, all packaged water shall comply with the health-related requirements of the most recent “Guidelines for Drinking Water Quality” published by WHO (i.e., including the IDC of 100 µSv/year from radionuclides and with an upper-bound annual drinking water ingestion dose of 1000 µSv/year).

iii. **Natural Mineral Waters**: A definition and requirements for natural mineral waters is provided in the Codex Standard CXS 108-1981 “Natural Mineral Waters”[26] . The standard does not contain provisions related to the presence of radionuclides in natural mineral waters.

23. **Trade Controls and issues related to radionuclide concentrations**: Competent authorities for food safety and quality tend to address human-made radionuclides in food and sometimes in feed but not natural radionuclides. However, they are the natural radionuclides in food that dominate the radiation exposure by ingestion in circumstances, not affected by a nuclear emergency situation in the past. In practice, trade controls relate to food or feed that originates from locations affected by radiological or nuclear accidents, for example, where there are residual levels of persistent radionuclides such as ^{90}Sr and ^{137}Cs and to some extent ^{134}Cs.

It may be more appropriate for trade controls to consider all of the most significant radionuclides for food safety, both natural and human-made (e.g., ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra plus human-made radionuclides including those that may persist in the environment for some time after a nuclear or radiological accident, e.g., ^{90}Sr, ^{137}Cs and ^{134}Cs).

On the other hand it has to be considered that natural and human-made radionuclides are not distributed in the same way and optimization process related to the human-made radionuclides may not lower the exposure due to ingestion of natural radionuclides and therefore defining a reference level for the ingestion of both human-made and natural radionuclides might not be that appropriate.

23 Chapter 9, Guidelines for Drinking Water Quality, Fourth Edition incorporating the first addendum. World Health Organization, 2017 https://www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/

24 Management of radioactivity in drinking water, ISBN 978-92-4-151374-6, World Health Organization (2018)

25 CXS 227-2001 Codex Standard for Packaged Drinking Waters (other than natural mineral waters)

26 CXS 108-1981 Codex Standard for Natural Mineral Waters

24. **Easiness of measurement**: ^{137}Cs and ^{134}Cs are gamma emitters and can be relatively easily screened using gamma spectrometry. ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra are alpha emitters which require more special analytical capability.

25. **Mean activity concentration levels and distributions for natural radionuclides in food**: The indicative values for levels of natural radionuclides in food included in the UNSCEAR 2000 report are the most comprehensive data available. These indicative values provide the central tendency (generally represented by geometric means of Log Normal distributions) of natural radionuclide concentrations derived from literature data published before 1999. These indicative levels for radionuclides of the uranium and thorium decay series are used for comparison of measurements, e.g., to place analytical results into a world-wide context, even though these indicative values were derived in order to perform a dose calculation. In the 20 years since this UNSCEAR report, many more scientific and technical reports have been published on natural radionuclide levels in foods.

It would be advantageous to develop a comprehensive dataset from this more recent literature that would provide both geometric means and indicate the distributions of radionuclide concentrations (upper-percentiles) for radionuclides of the uranium and thorium decay series. This would provide additional and necessary information related to food safety and acceptable ranges of natural radionuclide levels that may be found in different foods internationally.

26. **Radioactivity in feed**: Many countries have established activity concentrations for human-made radionuclides (especially ^{134}Cs and ^{137}Cs post Chernobyl and post Fukushima accidents) in feed, but there are no similar control levels for natural radionuclides such as ^{210}Po, ^{210}Pb, ^{228}Ra and ^{226}Ra.

V. Ongoing and future activities of FAO, IAEA and WHO

27. FAO, IAEA and WHO technical experts are working on an international project to harmonize international guidance and criteria for radionuclides in food, drinking water and feed in non-emergency situations which includes the consideration of both natural and human-made radionuclides.

Work to date has included:

- A literature review of measurements of natural radionuclides in food in the period 1998 – 2017 and the compilation of these measurements into a database of natural radionuclides in food;
- Statistical evaluations of the above data;
- IAEA member states (28 countries) providing their results of measurements of natural radionuclides in food in the period 1998 – 2017;
- The production of estimates of ingestion-dose based on radionuclide concentrations published in the scientific literature; and
- An IAEA literature review of journal publications covering total diet studies of radionuclides in food for the period 1957 – 2019 and reporting assessments of ingestion doses received from both natural and/or artificial radionuclides.

28. In its first phase of work, the FAO/IAEA/WHO project has considered natural radionuclide levels in food world-wide. As indicated above, two data sources have been developed: published data and data sets provided by national authorities.

Data was collected from existing published papers for nine different natural radionuclides of the uranium and thorium decay series (^{210}Po, ^{210}Pb, ^{228}Ra, ^{226}Ra, ^{230}Th, ^{232}Th, ^{238}U, ^{228}Th and ^{235}U). Over 8,000 observations have been analyzed from 187 papers that were published between 1998 and 2017.

A series of statistical methods have been used to provide a better understanding of the radionuclide concentration levels and also the variability in levels across the different foods and within food groups. These data and references have been provided to the UNSCEAR secretariat, so that they may inform their next assessment of public exposure.

29. The IAEA literature review of total diet studies reported in journal publications for the period 1957 – 2019 identified 71 different assessments of dietary exposure from 45 different countries (paragraph 8). These assessments included at least one radionuclide and report ingestion doses received from both natural and/or human-made radionuclides.

From an evaluation of the reported doses, those from naturally occurring radionuclides are broadly comparable with the weighted average population dose estimated by UNSCEAR in 2000 from naturally occurring radionuclides in food.

30. More recent work of the FAO/IAEA/WHO project has involved undertaking a similar exercise with the data provided by national authorities. In general data published in scientific journals could be combined with data sets provided by national authorities. Where there are reasonably large datasets, the activity concentrations of radionuclides in different foods can be represented by lognormal distributions, as is typically observed for many food and environmental samples.

From these analyses, the FAO, IAEA and WHO aim to produce upper and lower bounds on the activity levels for each subset and provide accurate estimates of the mean and variability of the radionuclide levels in different categories of foods. This information could form the basis of international guidance on natural radionuclide activity concentrations in food that provide both means and percentiles for the four key natural radionuclides in terms of overall food ingestion dose (^{210}Po, ^{210}Pb, ^{228}Ra, ^{226}Ra).

Work is continuing to explore a similar approach for a further five radionuclides in the uranium and thorium decay series that can also be detected in foods (i.e.^{230}Th, ^{232}Th, ^{238}U, ^{228}Th and ^{235}U).

31. The second phase of FAO, IAEA and WHO work is currently building on phase one and integrating an approach for guidance on both natural and human-made radionuclides in food. The aim is to develop material that can be used as guidance by national regulatory bodies or other relevant authorities to establish specific reference levels (Bq/kg) for radiation exposure due to radionuclides in food. As with phase one, the approach is to be as consistent as possible with that for drinking water, as provided in the Guidelines for Drinking Water Quality.

A technical document will be produced by the IAEA to record and report the work of the project. A separate IAEA technical document will also put forward recommendations for guidance related to both natural and human-made radionuclides in food.

VI. CONCLUSIONS

32. **Water**: International Guidelines for Drinking Water Quality establish criteria with which to determine the quality and safety of both natural and human-made radionuclide levels in normal circumstances (i.e. planned and existing exposure situations).

These guidelines provide guidance to national authorities responsible for water quality and/or radiation safety by assisting national authorities in establishing reference levels (activity concentrations expressed as becquerel per litre) for radionuclides in drinking water according to international radiation safety standards (requirement 51 of General Safety Requirements (GSR) part 3).

33. **Food**: An international standard is not available to assist national authorities in establishing reference levels (activity concentrations expressed as becquerels per kilogram) for radionuclides in food in non-emergency situations and this is a requirement, according to international radiation safety standards.

34. **Feed:** An international standard is not available to assist national authorities in establishing reference levels (activity concentrations expressed as becquerels per kilogram) for radionuclides in feed for food producing animals in non-emergency situations.

However, human exposure due to radionuclides in feeds is related to the ingestion of foods of animal origin (exposure due to direct irradiation of humans from radionuclides in feed is insignificant). International radiation safety standards (requirement 51 of GSR part 3) allocate a radiation dose criterion to feed related to human exposure from food of animal origin. As there is a specific dose criterion for radionuclides in food, including food of animal origin, it could be considered that a separate dose criterion for feed may be unnecessary.

On the other hand it could be considered that it is important to regulate radionuclides in feeds to ensure safe levels of radionuclides in foods of animal origin.

35. **Health-risks associated with the presence of radionuclides in food, feed and water** are generally low compared to those from microorganisms and chemicals. Any health risks due to radionuclides in food, water and feed, particularly in non-emergency situations, will not be acute or immediate but can be in the long term.

Except in unusual circumstances, such as following a nuclear accident, the radiation dose resulting from the ingestion of radionuclides in food or feed is lower than that received from other sources of radiation; the radiation dose resulting from the ingestion of radionuclides in drinking water is generally much lower.

Table 1 Worldwide Indicative Levels of Natural Radionuclides in Food and Drinking water (Bq/kg), adapted from UNSCEAR 2000.

Table 1. Worldwide Indicative Levels of Natural Radionuclides in Food and Drinking water (Bq/kg), adapted from UNSCEAR 2000.

	^{210}Po	^{210}Pb	^{228}Ra	^{226}Ra	^{230}Th	^{232}Th	^{238}U	^{228}Th	^{235}U
Milk products	0.015	0.015	0.005	0.005	0.0005	0.0003	0.001	0.0003	0.00005
Meat products	0.06	0.08	0.01	0.015	0.002	0.001	0.002	0.001	0.00005
Grain products	0.06	0.05	0.06	0.08	0.01	0.003	0.02	0.003	0.001
Leafy Vegetables	0.1	0.08	0.04	0.05	0.02	0.015	0.02	0.015	0.001
Root vegetables and fruits	0.04	0.03	0.02	0.03	0.0005	0.0005	0.003	0.0005	0.0001
Fish products	2 (3.3)* {2.4 – 15}**	0.2	-	0.1	0.01	0.01	0.03	0.1	-
Drinking water	0.005	0.01	0.0005	0.0005	0.0001	0.00005	0.001	0.00005	0.00004

* 3.3 Bq/kg ^{210}Po for fresh fish products. A reduction factor of 0.6 is used to account for the radioactive decay of ^{210}Po (half-life 138 days) for a proportion of fish products that are stored as canned, frozen etc. before they are consumed, hence the value of 2 Bq/kg.

Table 2. Various estimates* of total ingestion dose from measurements of radionuclides in food (not including dose from ^{40}K)

Country	Age group	Total dose (µSv/year)
Austria	adult	331
Brazil	adult	439
Brazil	adult (rural areas)	432
	adult (urban areas)	285
France	typical adult	319
	adult non seafood consumer	193
	Adult high rate consumer of seafood	2000 – 2600
	Adult, moderate rate seafood consumer	730
Germany	<1 year	271
	1-2 years	181
	2-7 years	141
	7-12 years	138
	12-17 years	160
	adult	410
Japan	adult	427
New Zealand	1-2 years	<120
	2-7 years	<91
	12-17 years	<70
	adult male	<152
	adult female	<89
United Kingdom	adult	191
Viet Nam	adult	198

*Data compiled by an IAEA literature survey (Review of worldwide studies of doses from the total diet, J. Brown and Y. Park, IAEA, Vienna, 3 September 2019) that covering data published in peer reviewed journals from 1957 to 2019. Note that doses from drinking water and from ^{40}K have been excluded from the total annual effective doses.

In addition estimates of ingestion dose from measurements of naturally occurring in food for Australia are available at https://www.arpansa.gov.au/news/national-food-study-provides-insight-radiation-australian-diet. The estimates of ingestion range from 51 to 280 µSv/year depending on the age group.

Canada has recent, unpublished dietary exposure estimates for ^{40}K, which are consistent with those in this table (300-400 µSv/year).

Table 3. Concentration Ratios for the transfer of elements and therefore radionuclides from feed to animal products (adapted from IAEA Technical Report Series 472, 2010)

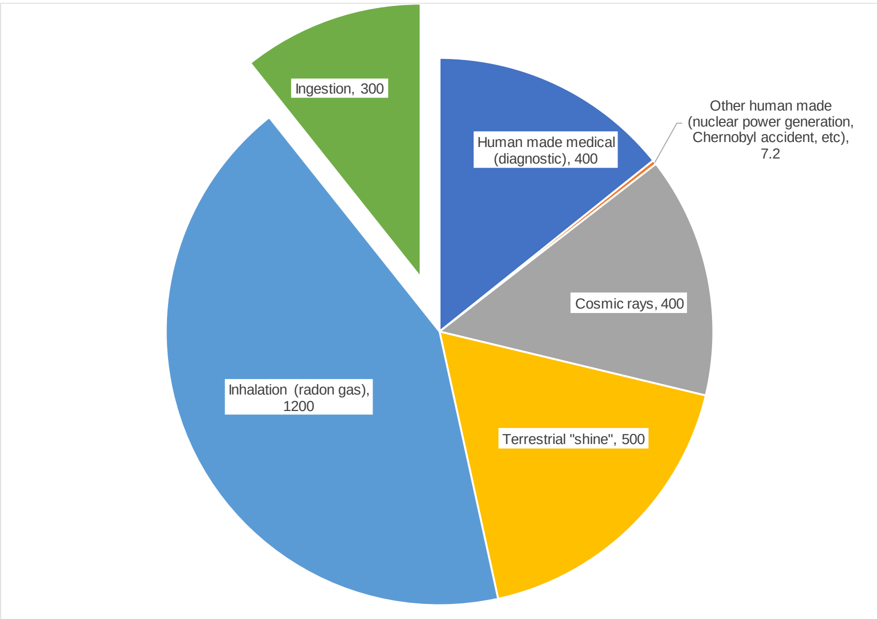
Element	Animal Product	Concentration Ratio*
Strontium (^{90}Sr)	Cow milk	2.3×10^{-2} kg/l
Iodine (^{131}I)	Cow milk	3.0×10^{-1} kg/l
Caesium (^{137}Cs)	Cow meat	2.3×10^{-1}
	Sheep meat	6.4×10^{-1}
	Pig meat	9.2×10^{-2}
	Generic (meat)	3.9×10^{-1}
	Cow milk	1.1×10^{-1} kg/l
	Sheep milk	1.7×10^{-1} kg/l
	Goat milk	1.8×10^{-1} kg/l
	Milk Generic	1.5×10^{-1} kg/l
	Poultry meat**	3.4×10^{-1}
	Poultry eggs**	5.0×10^{-2}
Polonium (^{210}Po)	Cow meat	1.4×10^{-1}
	Cow milk	2.4×10^{-3} kg/l
	Poultry meat**	3.0×10^{-1}
	Poultry eggs**	3.9×10^{-1}

* Calculated as (Bq/kg or Bq/l $_{\text{animal product (fresh weight)}}$ ÷ Bq/kg $_{\text{feed (dry matter)}}$)

** calculated using an assumed feed intake of 125 g/day

Figure 1. Worldwide average annual effective radiation dose (microsievert/year), adapted from UNSCEAR 2000

Figure 1. Worldwide average annual effective radiation dose (microsievert/year), adapted from UNSCEAR 2000



ANNEX I

EXAMPLES OF LEGISLATIVE LIMITS FOR HUMAN-MADE RADIONUCLIDES IN FOOD AND FEED ESTABLISHED FOLLOWING NUCLEAR INCIDENTS

This annex is for illustration only as the legislative limits mentioned in this Annex are related to emergency situations.

Legislative levels can be maximum (permitted) levels, action levels, control levels and permissible levels. The measures taken following exceedance of legislative measures can be different.

Maximum (permitted) level or permissible level: is the maximum concentration of the radionuclide to be legally permitted. A food or feed containing a concentration of the radionuclide above the maximum (permissible) level cannot be placed on the market.

Action level: "Action levels" represent limits at or above which a competent authority will take legal action to prevent products from entering the food supply or market.

Control level: is radionuclide concentration in food/feed above which it is prohibited to export and/or import the food/feed and it is generally not allowed to be sold or used domestically without the permission of an appropriate national competent authority.

1. European Union

The European Union has long-standing values of activity concentrations of various radionuclides in food and feed that are legally binding on all its Member States. These were established in the aftermath of the Chernobyl accident in 1986 and updated on a number of occasions thereafter. While maximum permitted levels have been established for several different radionuclides and food groups[27], the values established for feed are only for the sum of ^{134}Cs plus ^{137}Cs (Table A).

Table A. European Union Maximum Permitted Levels for ^{134}Cs and ^{137}Cs in Feed and Food to be rendered applicable in the event of a radiological emergency,

	Maximum permitted radiocaesium concentration (Bq/kg)
Food	
Infant Food	400
Dairy Products and Liquid Foodstuffs	1,000
Other foods*	1,250
Feed	
Pigs	1,250
Poultry, Lambs and Calves	2,500
Other Animals	5,000
* The maximum permitted concentration in minor foods, such as spices and food additives, is ten times higher than that for 'other foods'.	

In the aftermath of the Chernobyl Nuclear Power Plant Accident in 1986, the European Union established maximum levels for food and feed originating in or consigned from third countries (countries outside the EU) affected by the Chernobyl Nuclear Power Plant Accident in 1986/ The most recent update[28], established a maximum level for ^{137}caesium of 370 Bq/kg for milk and milk products and for food for infants and young children and of 600 Bq/kg for all other products concerned.

[27] Official Journal of the European Union, Council Regulation (Euratom) 2016/52 of 15 January 2016.

[28] Official Journal of the European Union, Commission Implementing Regulation (EU) 2020/1158 of 5 August 2020

In the aftermath of the Fukushima Daiichi Nuclear Power Plant Accident in 2011, the European Union established maximum levels for food and feed originating in or consigned from Japan[29], reflecting the action levels applicable in Japan shortly after the accident. These values were established for iodine-131 (^{131}I) and radiocaesium, these being the only radionuclides identified as being present in food by the authorities in Japan.

Japan established maximum levels on 1 April 2012 (see point 2 of this appendix) to replace the action levels and the EU updated consequently the maximum levels applicable for food and feed originating in or consigned from Japan

2 Japan

On 1 April 2012, the authorities in Japan established maximum levels for radionuclides in food and feed (Table B). This was approximately one year after the Fukushima Daiichi accident and ^{131}I was no longer detectable in food (^{131}I has a half-life of approximately eight days). Therefore, levels were established for radioceasium (^{134}Cs + ^{137}Cs)[30]. Iodine-131 and radiocaesium were the only radionuclides identified at significant levels in food and feed after the accident in Fukushima.

Table B. Maximum Levels for ^{134}Cs and ^{137}Cs in Food and Feed

Established in Japan - 2012

	Maximum Level (Bq/kg)
Food	
Infant Foods	50
Milk	50
Other foods	100
Drinking water*	10
Feed	
Poultry	160
Cattle and Horses	100
Pigs	80
Fish	40

* includes water used for cooking food and making tea drinks.

These values were subsequently adopted by the European Union applicable to the import of feed and food from Japan[31].

[29] Official Journal of the European Union, Commission Implementing Regulation (EU) No. 351/2011 of 11 April 2011.
[30] Ministry of Agriculture, Fisheries and Food http://www.maff.go.jp/j/syouan/soumu/saigai/supply.html
[31] Official Journal of the European Union, Commission Implementing Regulation (EU) No. 284/2012 of 29 March 2012.

3 Russian Federation

In the aftermath of the Chernobyl accident, the Russian Federation established ‘control levels’ for both ^{90}Sr and radiocaesium in a range of food products. Corresponding control levels for these radionuclides in animal feed and feed additives were established in 1994[32].

Table C. Control levels of ^{134}Cs, ^{137}Cs and ^{90}Sr in Feed and Feed Additives in the Russian Federation

Type of Feed	Control level, Bq/kg or Bq/l	
	$^{134}Cs + {}^{137}Cs$	^{90}Sr
Roughage (hay, straw, chaff)	600	100
“Moist feed”/ fresh feed (silage, haylage, roots, melons, etc.)	600	100
Green forage (natural grass, planted grass, etc.)	370	50
Concentrated feed (grain, cereals and legumes, bran), compound feed	600	65
Beet pulp, molasses, press cake, grist, pomace, beet-vinasse, brewer's spent grain, etc.	600	100
Meat, fish, offal, fat, etc.	600	100
Dry feed of animal origin (meat feed; meat and bone feed, including bone meal; meat feed with plant and other additives)	600	100
Canned feed of animal origin (with or without plant and other additives)	600	100
Milk substitutes, milk, dairy feed	370	50
Powdered milk mixtures, milk substitutes, etc.	600	100
Protein-vitamin mineral additives, premixes, microbiologically synthesized feed	370	50

The corresponding permissible levels for ^{90}Sr and ^{137}Cs in various foods are given in Table D below[33].

32 Instruction No. 13-7-2/216 of 1 December 1994 of the Chief State Veterinary Inspector of the Russian Federation on radiological control of animal feed quality and on caesium-134, caesium-137 and strontium-90 in animal feed and additives.

33 Technical Regulations of the Eurasian Customs Union (EACU) “On the safety of food products” (TP TC 021/2011)

Table D. Permissible levels of ^{90}Sr and ^{137}Cs in Foods in the Russian Federation

Food	Permissible level, Bq/kg (Bq/l)	
	^{137}Cs	^{90}Sr
Meat, meat products and by-products	200	–
Venison, meat of wild animals	300	–
Fish and fish products	130	100
Dried and jerked fish	260	–
Milk and milk products (except condensed, concentrated, canned, dry, cheese and cheese products, butter and butter paste from cow's milk, creamy spread and creamy ghee mixture, milk protein concentrates, lactulose, milk sugar, casein, caseinates, milk protein hydrolysates)	100	25
Milk protein concentrates, lactulose, milk sugar, casein, caseinates, milk protein hydrolysates	300	80
Milk processing products (dry, freeze-dried)	500	200
Cheese and cheese products	50	100
Milk processing products (concentrated, condensed); tinned milk products, tinned compound milk products, tinned milk-containing products	300	100
Butter, butter paste from cow's milk	200	60
Milk fat	100	80
Creamy spread, creamy ghee mixture	100	80
Milk-based dry nutrient media	160	80
Vegetables, roots (including potatoes)	80	40
Dried vegetables, roots (including potatoes)	600	200
Bread and bakery products	40	20
Flour, cereals, flakes, food grains, pasta	60	–
Wild berries and tinned products from wild berries	160	–
Dried wild berries	800	–
Fresh mushrooms	500	–
Dried mushrooms	2500	–
Ready-to-eat specialty baby foods*	40	25
Vegetable oils	40	80
Transesterified refined deodorized oils (fats); hydrogenated refined deodorized oils (fats); margarines; specialty fats (including cooking, confectionery, baking fats); milk fat substitutes; cocoa butter equivalents, SOS-type cocoa butter improvers, POP-type cocoa butter substitutes, non-tempered cocoa butter substitutes, vegetable-fat spreads, melted vegetable-fat mixtures, sauces based on vegetable oils, mayonnaise, mayonnaise sauces, creams based on vegetable oils	60	80

* activity concentration is determined in rehydrated food for freeze-dried food

4 Republic of Kazakhstan

The Republic of Kazakhstan has established maximum permissible concentrations of ^{90}Sr and ^{137}Cs in food and in animal feeds[34]. These are summarized in table E.

Table E. Maximum Permissible Levels of ^{90}Sr and ^{137}Cs in Food and Feed in the Republic of Kazakhstan

	Maximum Permissible Level (Bq/kg)
^{90}Sr in Food	
Meat Products	50
Milk and milk products	25
Vegetables and gourds	40
^{90}Sr in Feed	
All feeds	111
^{137}Cs in Food	
Meat Products	200
Milk and milk products	100
Vegetables and gourds	120
^{137}Cs in Feed	
All feeds	74

5. *Canada*

Canadian Guidelines for Intervention During a Nuclear Emergency - November 2003

http://publications.gc.ca/site/eng/9.689331/publication.html

or the direct link:

https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/radiation/guide-03/interventions-eng.pdf

[34] Ministry of Healthcare, Temporary permissible levels of radionuclide concentrations in the objects not under the control of the Ministry of Agriculture of the Republic of Kazakhstan

ANNEX II

EXPLANATORY NOTES ON THE TERMS “NORMAL CIRCUMSTANCES”, “EXISTING EXPOSURE SITUATION” AND “NON-EMERGENCY SITUATION”.

Clarification of the terms “normal circumstances”, “existing exposure situation” , “non- emergency situation” as used in the discussion paper refer to the same concept.

The concept that is attempted to be conveyed by “normal circumstances”, “existing exposure situation” and “non- emergency situation” are situations that are not due to a nuclear or radiological emergency (not an emergency exposure situation). So this would be either planned exposure situations or existing exposure situations.

In international radiation safety standards, radiation exposure is categorized according to three broad circumstances that individuals may experience, namely: planned exposure situations; emergency exposure situations; and existing exposure situations. These are defined in the IAEA glossary [see “exposure situations” pages 90 and 91 in the online document at: https://www.iaea.org/publications/11098/iaea-safety-glossary-2018-edition and have the following meanings:

1. A planned exposure situation arises from the planned operation of a radiation source or from a planned activity that results in an exposure due to a source;
2. An emergency exposure situation arises as a result of an accident, a malicious act or other unexpected event, and requires prompt action in order to avoid or to reduce adverse consequences; and
3. An existing exposure situation is one that is extant when a decision on the need for control needs to be taken.

Planned exposure situations introduce new sources of radiation exposure; protection measures can be planned before the exposures take place, and exposures can be reasonably predicted. Direct control over the source of radiation and a degree of choice is involved, and exposures are normally subject to some form of control or authorization by the operator and a regulatory body.

In contrast, emergency exposure situations and existing exposure situations do not include a degree of choice or direct control over the radiation exposure – when either an emergency or existing exposure situation occurs, a decision needs to be taken on what actions, if any, are justified to reduce exposure. Emergency exposure situations develop into existing exposure situations, often referred to as the ‘recovery phase’ following a nuclear or radiological emergency.

The situation of having radionuclides present in food, drinking water and feed could be considered as any one of the three exposure situations. For example:

1. The radionuclides are from a regulated activity such as an authorized discharge from a nuclear facility or a hospital. Therefore, it is a planned exposure situation and regulatory control has ensured that levels of radionuclides are limited to acceptably low levels;
2. A nuclear or radiological incident may have result in the accumulation of radionuclides in food, drinking water and feed. Therefore, this is an emergency exposure situation and urgent protective actions might be required, depending on the concentration of radionuclides in the food;
3. The radionuclides are present in the environment, they can therefore accumulate in food, drinking water and feed and this is an existing exposure situation because it is not a nuclear emergency, but a decision needs to be made on the need for controls to protect people.

However, when an individual detects any given radionuclide in a food and is to make a decision on the need for control, it might not be possible to identify the origin of that radionuclide. For example, ^{137}Cs detected in a food sample could originate from several different sources: nuclear weapons testing, authorized discharges from a licensed nuclear facility or from a previous accident. For this reason, the international radiation safety standards require that radiation doses from radionuclides in food and drinking water are managed as either an emergency exposure situation or an existing exposure situation.

Therefore, in this discussion paper, when we say situations that are not emergency exposure situations we are referring to planned and existing exposure situations, but in practice this reduces to existing exposure situations.

To which extent these situations (“normal circumstances”, “existing exposure situation”, “non-emergency situation”) include the residual presence of persistent man-made radionuclides that were accidentally released in the environment in the past (“post emergency situation”).

In international radiation safety standards, the “existing exposure situation” includes the residual presence of radionuclides that were accidentally released in the environment in the past. Existing exposure situations include exposure to natural background radiation that is amenable to control; exposure due to residual radioactive material that derives from past practices that were never subject to regulatory control; and exposure due to residual radioactive material deriving from a nuclear or radiological emergency after an emergency has been declared to be ended. [see “existing exposure situation” page 91 in the IAEA Safety Glossary that is online at: https://www.iaea.org/publications/11098/iaea-safety-glossary-2018-edition].

APPENDIX II

LIST OF PARTICIPANTS

CHAIR

Mr Frans Verstraete
European Union

CO-CHAIR

Mrs Yukiko Yamada
Japan

ARGENTINA

Codex Secretartiat (Punto Focal Codex)

AUSTRALIA

Mr Matthew Joseph O'Mullane
Food Standards Australia New Zealand

Mr Glenn Paul Stanley
Food Standards Australia New Zealand

BELGIUM

Mr Jurgen Claeys
Federal Agency for Nuclear Control

Mrs Christine Vinkx
FPS Health, Food Chain Safety and Environment

BRAZIL

Mrs Lígia Schreiner
Brazilian Health Surveillance Agency - ANVISA

Mrs Larissa Bertollo Gomes Porto
Brazilian Health Surveillance Agency - ANVISA

Mrs Carolina Araújo Vieira
Brazilian Health Regulatory Agency

CANADA

Mrs Elizabeth Elliott
Bureau of Chemical Safety, Health Products and Food Branch
Health Canada

CHINA

Mr Yongning Wu
China National Center of Food Safety Risk Assessment (CFSA)
Key Lab of Food Safety Risk Assessment, National Health and Family Planning Commission

Mrs Yi Shao
Division II of Food Safety Standards
China National Center of Food Safety Risk Assessment (CFSA)

COSTA RICA

Mrs Amanda Lasso Cruz
Ministerio de Economía Industria y Comercio

CUBA

Mr Roberto Dair García de la Rosa
Public Health Ministry

EUROPEAN UNION

Mr Stefan Mundigl
European Commission

GREECE

Mrs Elena Bellou
Hellenic Ministry of Rural Development and Food

IRAN

Dr Mansooreh Mazaheri
ISIRI-Standard Research Institute

JAPAN

Codex Japan
Ministry of Health, Labour and Welfare

KAZAKHSTAN

Dr Zhanar Tolysbayeva
The Ministry of Healthcare

MEXICO

Mrs Tania Daniela fosado Soriano
Secretaría de Economía

NEW ZEALAND

Mr Andrew Pearson
Ministry for Primary Industries

NORWAY

Norwegian Codex Contact Point
Norwegian Food Safety Authority

REPUBLIC OF KOREA

Codex Secretariat
Ministry of Agriculture, Food and Rural Affairs

SPAIN

Mrs Violeta García Henche Agencia
Española de Seguridad Alimentaria y
Nutrición

SWITZERLAND

Mrs Lucia Klauser
Federal Food Safety and Veterinary
Office (FSVO)

UNITED KINGDOM

Mr Christopher Thomas
Food Standards Agency

UNITED STATES OF AMERICA

Mrs Lauren Posnick Robin
US Food and Drug Administration

Mr Henry Kim
US Food and Drug Administration

INTERNATIONAL NON-GOVERNMENTAL ORGANISATIONS

INTERNATIONAL FEED INDUSTRY FEDERATION

Mrs Alexandra de Athayde

INTERNATIONAL FEDERATION OF WINES AND SPIRITS (FIVS)

Mrs Laura Gelezuinas

INTERNATIONAL COUNCIL OF GROCERY MANUFACTURERS ASSOCIATIONS (ICGM

Mrs Nancy Wilkins

INTERNATIONAL FRUIT & VEGETABLE JUICE ASSOCIATION

Mr John Collins