Chapter of the RODOS PV4.0 User Guide for the Aquatic Food Chain and Dose Module FDMA

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1 Overview

The final version of the User Guide will be part of the overall RODOS User Guide for version 4.0.

The task of the aquatic food and dose module FDMA in the RODOS system is to simulate the transfer of radioactive material in food chains following contamination of water (used for drinking, animal feeding and irrigation of crops), and for the assessment of doses from aquatic pathways (internal exposure via ingestion of drinking water, agricultural products, and fish) to the population. Individual as well as collective doses can be estimated.

Input to FDMA is essentially the output of the HYDRO module, i.e. the time-dependent concentration of activity in
- drinking water,
- water used for animal feeding,
- water used for irrigation of crops,
- fish,
- time of the year when deposition occurs.

The endpoints of FDMA are essentially the time dependent activity concentrations in a variety of feed and foodstuffs, and the resulting radiation exposure for the population via the exposure pathways
- consumption of foodstuffs contaminated by animal feeding water or irrigation,
- consumption of contaminated drinking water and fish,

Besides FDMA there are 3 additional modules in RODOS which handle food chain and dose assessment for those pathways which require special model approaches:
- the Food Chain and Dose Module for Terrestrial Pathways (FDMT) which considers the consequences of radioactive depositions onto agricultural crops or inhabited areas,
- the Food Chain and Dose Module for semi-natural (forest) pathways (FDMF), and
• the Food Chain and Dose Module for the transfer of the radionuclide Tritium (FDMH).

A Dose Combination Module (DCM) combines certain results of these different Food and Dose Modules (Figure: 1.1).

![Data flow of the Food and Dose Modules.](image)

The results of FDMA can be displayed to the user via the graphics system. FDMA calculates also data sets which are used by the long-term countermeasure module LCMA to estimate the effect of long term countermeasures.
A detailed description of FDMA is given in the Documentation of the Aquatic Food Chain and Dose Module FDMA in RODOS PV 4.0 (RODOS(WG3)-TN(99)10).
1.1 Input Data

A detailed description of the input data to FDMA can be found in chapter 3.2 of the FDMA documentation.

The following input data is transferred to FDMA from the HYDRO module via shared memory (a detailed list of variables is in the FDMA documentation):

- Number of time steps for which have been calculated (max. 50)
- Number of nuclides for which water contaminations have been calculated (max. 15)
- Number of water sources (parts of a river, lakes, water processing plants) for which water contaminations have been calculated (max. 50)
- Date and time when the time arrays start (year, month, day, hour and minute)
- Time grid of the water contamination calculation
- Names of the radionuclides
- Activity concentrations in drinking water (for each water source, radionuclide and time step)
- Activity concentrations in animal feeding water (for each water source, radionuclide and time step)
- Activity concentrations in irrigation water (for each water source, radionuclide and time step)
- Activity concentrations in fish (for each water source, radionuclide and time step)
- Radioecological regions (for each water source)

The following data needed by FDMA is coming from the RODOS geographical data base:

- Radioecological regions (for each location)
- Number of inhabitants (for each location)
- Amount of foodstuff production (for each location)
- Soilttype category (for each location)

A lot of model parameters describing the food chain transfer and radiation exposure are kept in a data base. Individual data sets exist for each radioecological region. Important model parameters are e.g.
• Season, frequency of irrigation, amount of irrigation water per irrigation event,
• Growing and harvesting times for different agricultural crops,
• Transfer factors (soil-plant, feed-animal),
• Location factors for different exposure pathways (for each radioecological region),
• Animal feeding diets,
• Food consumption rates.

A detailed description of the model parameter data base can be found in Chapter 3.1.3 of the FDMA documentation.

In addition, information on the required endpoints of calculation of FDMA is required as input. This is provided by the Operation System OSY (automatic mode) or the Graphical User Interface GUI (interactive mode).

1.2 Output data

The main results of the **Food Chain Module** in FDMA are time-dependent activities in feedstuffs and foodstuffs. Feed and foodstuff activities are estimated from activity concentrations in plants, transfer of radionuclides into animal products (if necessary), activity enrichment or dilution during processing and preparation, and also considering radioactive decay during processing and storage times.

Different types of feedstuffs can be considered:

- Grass (intensive + extensive cultivation): Grass is considered to be harvested continuously; weathering, translocation into/from root zone and growth dilution is considered explicitly.

- Hay (intensive + extensive cultivation): Contamination of hay is derived from the contamination of grass averaged over the hay harvest period and multiplied by a factor to consider the loss of water during hay preparation. Contamination of stored products is derived from average contamination of two harvest intervals.

- Maize, beet leaves: Weathering is considered explicitly, contamination of stored products is derived from contamination at end of harvesting period.

- Cereals (barley, wheat, rye, oats), potatoes, beets, maize bulbs: translocation is considered explicitly, Contamination of stored products is derived from contamination at end of harvesting period.
Distilling and brewing residues: contamination is derived from the contamination of the underlying plants and appropriate processing factors.

Skim milk, milk substitute, whey: the contamination of animal products used as feedstuffs is derived from activity concentrations in the feedstuffs for the animals, feeding rates, transfer factors from fodder to animal products and biological transfer rates.

The results can be displayed graphically in two different ways: maps and time dependency plots. Furthermore, some of the results are transferred to the Long Term Countermeasure Module LCMA and the Dose Combination Module DCM.

- Maps of the specific activities in a chosen feed- or foodstuff can be shown for each location for the time step with the maximum value, i.e. within one map the concentrations can be given for different times. Results can be given for single nuclides or for groups of radionuclides (e.g. iodine isotopes).

- Time dependency plots of specific activities in a chosen feed- or foodstuff can be shown for each time step of the ingestion time grid (see Glossary) for the location with the maximum value. Again the results can be given for single nuclides or for groups of radionuclides (e.g. iodine isotopes).

The main results of the **Dose Module** in FDMA are doses arising from different pathways:

- internal exposure due to ingestion of contaminated foodstuffs,
- external exposure from radionuclides in river or lake sediments (not included in the current version!).

In RODOS two types of individual doses are calculated:

- Potential doses which give an upper limit of individual doses.
- Expected doses which give a best estimate of the average exposure of the population.

In FDMA all doses are potential doses.

The results of the Dose Module can be displayed graphically in three different ways:

- Maps of individual doses can be shown for a single or the sum of the exposure pathways mentioned above and for the time step with the
maximum value for all locations of the RODOS grid. Results can be time integrated doses or doses / dose rates for a single time step. The results can be given for single nuclides or for groups of radionuclides (e.g. iodine isotopes), for one of 5 age groups and one of 12 organs (including effective dose).

- Time dependency plots of individual doses can be shown for the location with the maximum value containing results of all 56 time steps for different nuclides, age groups and organs.
- Maps of collective doses can be shown for a chosen exposure pathway, time step, nuclide, age group and organ.

Furthermore, some of the results are transferred to the Long Term Countermeasure Module LCMA and to the Dose Combination Module DCM.
2 Starting the model

2.1 Before the run

To run FDMA, results of a previous run of the HYDRO module is required as input data to FDMA.

2.2 Starting the Food Chain and Dose Module FDMA

An interactive computation run of the Food and Dose Modules FDMA is started in the following way:

- In the main menu of RODOS select the button [Interactive]

- The 'Interactive Manager' window appears. Choose [Configuration] and then [Importing Result_Dataset To] from the menu in the 'Interactive Manager'-window to select the results of a previous run of the Hydro module as input to FDMA.
A window called 'Target-Programs' appears, in which the button [FDMA] has to be selected.

Then a window appears in which all archived runs of the Hydro Module are listed. A run is selected by clicking on it and then pressing the button [Apply].

Click on the button [FDMA] in the 'Interactive Manager' -window to start a new run of FDMA.
• A 'Start Box'-window for the definition of the RunId pops up, a RunId has to be entered by the user.

![Start Box Window]

The RunID can be any character string using letters and numbers (maximum 32 characters) and must be different from the RunIDs of previous runs which are still in the database.

• The program run is started by clicking on [Start] in the 'Start Box'-window.

• To enable the graphics output of FDMA, the Graphics System of RODOS has to be started before FDMA is started by selecting the button [Graphics] in the main menu of RODOS!

After the program has been started, a 'Control & Services'-window appears. This control window is divided into an upper and lower part. The upper part contains the RunID of the currently selected run as well as four buttons to control the runs. The lower part contains four buttons with which various services can be chosen. Both types of buttons are described in detail in the User Guide for the Graphical System. The only button in the lower part which is of interest for FDMA is the button:

• [Process Status] Selecting this service opens a window with the list of all modules of the selected run and their actual state. The colour coding of the modules indicates whether the module has not yet started (blue), data is loaded from the database (yellow), the module is calculating (green), the results are archived in the database (red) or the module has finished it’s work (grey).
Some time after starting the run of FDMA some windows for selection of endpoints of calculation will show up automatically. These windows can be used to select the desired output which should be calculated by FDMA. The windows are described in detail in section 4.

After the first run of FDMA has finished (and has sent its results to the graphics system) the following window appears:

This window enables the user to choose between terminating FDMA or selecting further endpoints to calculate. These calculations can be performed very quickly since most of the required data is still kept in memory.
If the button "Yes" is selected and then [Update] is pressed, FDMA continues with the windows for selecting endpoints of calculation (see section 4). As default no preselections are made this time in the windows, i.e., all buttons in these windows are now deselected.

If the button "No" is selected and then [Update] is pressed, FDMA terminates.
2.3 Archived runs:

Archived graphical output of FDMA can be displayed by selecting [File] and further [Display Results] in the menu bar of the Interactive Manager of RODOS.

![Interactive Manager](image)

Thereafter, a window pops up with the program groups where a run can be selected.

![Program Groups](image)

In the Program Groups window the requested FDMA button has to be selected. By pressing for example the button [FDMA], a window pops up with the list of all FDMA runs.
One out of the list has to be selected and the button [Apply] has to be pressed. Thereafter, two windows appear: The Control & Service window (see above) and the Application list window.

The next step is first to selected the run in the Application list window by simply clicking on it (colour does not change), and in second to select the [Graphics] button in Control & Service window. Thereafter, a window with the list of results is displayed.
In this window either individual results can be selected by clicking through the context menu up to a result which is marked with a red cross. This can be selected by pressing the [Apply] button. Or it is also possible to select all results by pressing first the [All] button and thereafter the [Apply] button. The [Close] button can be selected if no further result is requested.
3 Initialization Windows for FDMA

In version 4.0 of FDMA the selection of the desired endpoints of calculation is done within a loop inside FDMA (see Chapter 4). Therefore, you don’t need to push the [Initialising] button in the ‘Start Box’ window before starting FDMA (as it was in previous versions)!
4 Windows for selecting the endpoints of calculation

4.1 Overview

After starting the run of FDMA some windows will show up automatically. These windows can be used to select the desired output which should be calculated by FDMA. The window hierarchy is shown below:

FDMA v4.0 MAIN MENU

+-- ACTIVITIES
  |   +-- FEEDSTUFF ACTIVITIES
  |     +-- FROM FEEDING WATER
  |     |   +-- All feedstuffs
  |     |   +-- (Feedstuff 1)
  |     |   +-- ...
  |     |   +-- (Feedstuff n)
  |     +-- FROM IRRIGATION
  |         +-- All feedstuffs
  |         +-- (Feedstuff 1)
  |         +-- ...
  |         +-- (Feedstuff n)
  |   +-- FOODSTUFF ACTIVITIES
  |     +-- FROM FEEDING WATER
  |     |   +-- All foodstuffs
  |     |   +-- (Foodstuff 1)
  |     |   +-- ...
  |     |   +-- (Foodstuff n)
  |     +-- FROM IRRIGATION
  |         +-- All foodstuffs
  |         +-- (Foodstuff 1)
  |         +-- ...
  |         +-- (Foodstuff n)
  |     +-- OTHER FOODSTUFFS
  |         +-- Drinking water
  |         +-- Fish
  |   +-- NUCLIDE SELECTION
  |     +-- All nuclides
  |     +-- All nuclide groups
  |     +-- Sum of iodine isotopes
  |     +-- Sum of cesium isotopes
  |     +-- Sum of strontium isotopes
  |     +-- Sum of alpha emitting isotopes
  |     |   +-- (Nuclide 1)
  |     |   +-- ...
  |     |   +-- (Nuclide n)

(to be continued)
### INGESTION DOSE

#### FROM FEEDING WATER
- All foodstuffs
- Sum of foodstuffs
  - (Animal product 1)
  - ...
  - (Animal product n)

#### FROM IRRIGATION
- All foodstuffs
- Sum of foodstuffs
  - Sum of plant products
  - Sum of animal products
  - Sum of vegetables
  - Sum of grain products
  - Sum of milk products
  - Sum of meat products
  - (Foodstuff 1)
  - ...
  - (Foodstuff n)

#### OTHER FOODSTUFFS
- Drinking water
- Fish

#### AGE GROUP
- 1 year
- 5 years
- 10 years
- 15 years
- Adults

#### ORGAN
- Lung
  - Red bone marrow
  - Thyroid
  - Uterus
  - Effective dose
  - Skin
  - Bone surface
  - Breast
  - Stomach
  - Colon
  - Liver
  - Pancreas

#### NUCLIDE
- Sum of nuclides
  - All nuclides
  - All nuclide groups
  - Sum of iodine isotopes
  - Sum of cesium isotopes
  - Sum of strontium isotopes
  - Sum of alpha emitting isotopes
  - (Nuclide 1)
  - ...
  - (Nuclide n)

#### GRAPHICAL OUTPUT TYPE
- Maps
- Time Plots
- Collective doses

#### INTERFACE DATA
- LCM Interface
- DCM Interface
4.2 Description

After starting the run of FDMA the window 'FDMA: Main Menu' for the Food and Dose Module FDMA appears. In various sub-windows the results which should be calculated by FDMA can be selected. These sub-windows can be accessed by clicking on one of the main topics in the Main Menu.

Selecting the button [Close] closes the window, the button [Help] opens a help window including some comments for this main menu.
4.2.1 Activities

Choosing [Activities] in the 'Main Menu'-window brings up the following window:

- 'Feedstuff Activities' for the selection of one or more feedstuffs, for which the activity concentrations should be calculated
- 'Foodstuff Activities' for the selection of one or more foodstuffs, for which the activity concentrations should be calculated
- 'Nuclide selection' allows to select those nuclides for which the activity concentration is to be calculated
- '- (unused) -' has no meaning in this context; it provides a link to the loop window but selections in this window are not considered at this point

Selecting the button [Close] closes the window, the button [Help] opens a help window.
4.2.1.1 Feedstuff Activities

If 'Feedstuff Activities' is selected, the following window appears in which the source of feedstuff contamination - feeding water or irrigation water - can be chosen:

Selecting the button [Close] closes the window, the button [Help] opens a help window.
4.2.1.1 Feedstuff activities - From feeding water

If 'Feedstuff Activities' and 'from feeding water' is selected, the following window appears in which feedstuffs can be chosen. For the chosen feedstuffs the activity concentrations resulting from contamination of feeding water will be calculated:

- **All feedstuffs**: activity concentration is calculated separately for all feedstuffs. The available list of feedstuffs depends on the product definitions for the actual radioecological regions.

- **(Individual feedstuffs)**: Each of the given feedstuffs can be selected individually. The available list of feedstuffs depends on the product definitions for the actual radioecological regions.

Only feedstuffs produced from animal products can be contaminated from feeding water!

There is no preset selection in this window.

[Close] exits the window without storing any selections,  
[Update] confirms any selections,  
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.1.2 Feedstuff activities - From irrigation

If 'Feedstuff Activities' and 'from irrigation' is selected, the following window appears in which feedstuffs can be chosen. For the chosen feedstuffs the activity concentrations resulting from contamination of feeding water will be calculated:

- **‘All feedstuffs’**: activity concentration is calculated separately for all feedstuffs. The available list of feedstuffs depends on the product definitions for the actual radioecological regions.

- **‘(Individual feedstuffs)’**: Each of the given feedstuffs can be selected individually. The available list of feedstuffs depends on the product definitions for the actual radioecological regions.

The preset selection is 'Grass (intensive cultivation)'.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.1.2 Foodstuff activities

If 'Activity in Foodstuffs' is selected, the following window appears in which either for agricultural products the source of contamination - feeding water or irrigation water - or other foodstuffs (drinking water or fish) can be chosen:

Selecting the button [Close] closes the window, the button [Help] opens a help window including some comments.
4.2.1.2.1 Foodstuff activities - From feeding water

If 'Foodstuff Activities' and 'from feeding water' is selected, the following window appears in which foodstuffs can be chosen. For the chosen foodstuffs the activity concentrations resulting from contamination of feeding water will be calculated:

- **All foodstuffs**: activity concentration is calculated separately for all foodstuffs. The available list of foodstuffs depends on the product definitions for the actual radioecological regions.

- **(Individual foodstuffs)**: Each of the given foodstuffs can be selected individually. The available list of foodstuffs depends on the product definitions for the actual radioecological regions.

Only animal products can be concerned by contaminated feeding water!

![Foodstuff selection window]

The preset selection is ‘Milk’.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.1.2.2 Foodstuff activities - From irrigation

If 'Foodstuff Activities' and 'from irrigation' is selected, the following window appears in which foodstuffs can be chosen. For the chosen foodstuffs the activity concentrations resulting from contamination of irrigation water will be calculated:

- **‘All foodstuffs’**: activity concentration is calculated separately for all foodstuffs. The available list of foodstuffs depends on the product definitions for the actual radioecological regions.

- **‘(Individual foodstuffs)’**: Each of the given foodstuffs can be selected individually. The available list of foodstuffs depends on the product definitions for the actual radioecological regions.

The preset selection are 'Leafy vegs.' and 'Milk'.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.1.2.3 Foodstuff activities - Other foodstuffs

If 'Foodstuff Activities' and 'other foodstuffs' is selected, the following window appears in which drinking water and/or fish can be chosen. For the chosen foodstuffs the activity concentrations will be calculated.

There is no preset selection in this window.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.1.3 Activities - Nuclide selection

Choosing 'Nuclide selection' in the 'Activities'-window opens a window in which those nuclides can be selected for which activity concentration in feed and foodstuffs are to be calculated. It is possible to select

- 'All nuclides': the activity for each of the nuclides (up to 15) included in the source term provided by the Atmospheric Dispersion Module is presented.

- 'All nuclide groups': The activities summed up over all nuclides of the individual nuclide groups is presented for each nuclide group.

- 'All iodine isotopes': Results are calculated for the sum of all iodine isotopes included in the source term; these can be at maximum $^{129}$I, $^{131}$I, $^{132}$I, $^{133}$I, $^{134}$I and $^{135}$I.

- 'All cesium isotopes': Results are calculated for the sum of all cesium and other long lived (halflife > 10 d) isotopes included in the source term; these can be at maximum $^{54}$Mn, $^{58}$Co, $^{60}$Co, $^{86}$Rb, $^{91}$Y, $^{95}$Zr, $^{95}$Nb, $^{103}$Ru, $^{106}$Ru, $^{110m}$Ag, $^{127m}$Te, $^{129m}$Te, $^{134}$Cs, $^{136}$Cs, $^{137}$Cs, $^{138}$Cs, $^{140}$Ba, $^{141}$Ce, $^{144}$Ce, $^{147}$Pr, and $^{147}$Nd.

- 'All strontium isotopes': Results are calculated for the sum of all strontium isotopes included in the source term; these can be at maximum $^{89}$Sr, $^{90}$Sr, $^{91}$Sr, and $^{92}$Sr.

- 'All alpha emit. isotopes': Results are calculated for the sum of all cesium and other long lived (halflife > 10 d) isotopes included in the source term; these can be at maximum 15 radionuclides of $^{54}$Mn, $^{58}$Co, $^{60}$Co, $^{86}$Rb, $^{91}$Y, $^{95}$Zr, $^{95}$Nb, $^{103}$Ru, $^{106}$Ru, $^{110m}$Ag, $^{127m}$Te, $^{129m}$Te, $^{134}$Cs, $^{136}$Cs, $^{137}$Cs, $^{138}$Cs, $^{140}$Ba, $^{141}$Ce, $^{144}$Ce, $^{147}$Pr, and $^{147}$Nd.

- 'Individual nuclides': Each of the nuclides of the source term can be selected individually.
The preset selection is 'All nuclide groups'.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.2 Ingestion dose

Choosing [Ingestion dose] in the 'Main Menu'-window brings up the following window for the selection of doses, from which one can branch into 7 succeeding windows:

- 'from feeding water' branches into windows for specification of foodstuffs contaminated by animal feeding water contributing to the ingestion dose.

- 'from irrigation' branches into windows for specification of foodstuffs contaminated by irrigation of crops contributing to the ingestion dose.

- 'Other foodstuffs' opens a windows for selecting the ingestion dose from drinking water and/or fish.

- 'Age group' allows to select those age groups for which all doses are to be calculated.

- 'Organ' allows to select those organs for which all doses are to be calculated.

- 'Nuclide' allows to select those nuclides for which all doses are to be calculated.

Selecting the button [Close] closes the window, the button [Help] opens a help window including some comments.
4.2.2.1 Ingestion dose - From feeding water

If 'Ingestion dose' and 'from feeding water' is selected, the following window appears in which the foodstuffs or groups of foodstuff can be chosen for the calculation of ingestion doses:

- ‘All foodstuffs’: ingestion dose is calculated separately for all foodstuffs (animal products only). The available list of foodstuffs depends on the product definitions for the actual radioecological regions.
- ‘Sum of foodstuffs’: ingestion dose is calculated as the total dose from all foodstuffs.
- ‘(Individual foodstuffs)’: Each of the animal products which are considered in the dose calculation can be selected individually. The available list of foodstuffs depends on the product definitions for the actual radioecological regions.

The preset selection is ‘Sum of foodstuffs’.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.2.2 Ingestion dose - From irrigation

If 'Ingestion dose' and 'from irrigation' is selected, the following window appears in which the foodstuffs or groups of foodstuff can be chosen for the calculation of ingestion doses:

- **'All foodstuffs'**: ingestion dose is calculated separately for all foodstuffs. The available list of foodstuffs depends on the product definitions for the actual radioecological regions.
- **'Sum of foodstuffs'**: ingestion dose is calculated as the total dose from all foodstuffs.
- **'Sum of (group of foodstuffs)'**: ingestion dose is calculated as the total dose from all foodstuffs included in the respective group of foodstuffs.
- **'(Individual foodstuffs)'**: Each of the foodstuffs which are considered in the dose calculation can be selected individually. The available list of foodstuffs depends on the product definitions for the actual radioecological regions.

The preset selection is ‘Sum of foodstuffs’.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.2.3 Ingestion dose - Other foodstuffs

If 'Ingestion dose' and 'Other foodstuffs' is selected, the following window appears in which drinking water and/or fish can be chosen for the calculation of ingestion doses:

There is no preset selection in this window.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.2.4 Ingestion dose - Age groups

Choosing [Age group] in the 'Ingestion Dose'-window brings up the following window for the selection of age groups for all dose calculations.

Up to 5 age groups can be selected:

- infants of 1 year
- children of 5 years
- children of 10 years
- children of 15 years
- adults

This selection mainly determines the dose factors that are used in the dose calculations. Furthermore, this selection determines the food consumption rates in the ingestion dose calculation.

The preset selection is the age group 'Adults'.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.2.4.1 Ingestion dose - Organ

Choosing [Organ] in the 'Ingestion dose'-window brings up the following window for the selection of organs for all dose calculations:

Up to 12 organs can be selected: Lung, red bone marrow, thyroid, uterus, effective dose, skin, bone surface, breast, stomach, colon, liver, and pancreas.

This selection determines the dose factors that are used in the dose calculations.

The preset selections are 'effective dose' and 'thyroid'.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
Choosing [Nuclide] in the 'Ingestion Dose'-window brings up the following window for the selection of nuclides. It is possible to select

- **'Sum of all nuclides'**: Doses are calculated for the sum of all nuclides (up to 10) for which data was provided by the Hydro Module.
- **'All nuclides'**: Doses for each of the nuclides (up to 10) included in the source term provided by the Hydro Module are calculated.
- **'All nuclide groups'**: Doses summed up over all nuclides of the individual nuclide groups are calculated.
- **'All iodine isotopes'**: Doses are calculated for the sum of all iodine isotopes included in the source term; these can be at maximum $^{129}$I, $^{131}$I, $^{132}$I, $^{133}$I, $^{134}$I and $^{135}$I.
- **'All cesium isotopes'**: Doses are calculated for the sum of all cesium and other long lived (half-life > 10 d) isotopes included in the source term; these can be at maximum 15 radionuclides out of $^{54}$Mn, $^{58}$Co, $^{60}$Co, $^{86}$Rb, $^{91}$Y, $^{95}$Zr, $^{95}$Nb, $^{103}$Ru, $^{106}$Ru, $^{110m}$Ag, $^{127m}$Te, $^{129m}$Te, $^{134}$Cs, $^{136}$Cs, $^{137}$Cs, $^{138}$Cs, $^{140}$Ba, $^{141}$Ce, $^{144}$Ce, $^{143}$Pr, and $^{147}$Nd.
- **'All strontium isotopes'**: Doses are calculated for the sum of all strontium isotopes included in the source term; these can be at maximum $^{89}$Sr, $^{90}$Sr, $^{91}$Sr, and $^{92}$Sr.
- **'All alpha emit. isotopes'**: Doses are calculated for the sum of all cesium and other long lived (half-life > 10 d) isotopes included in the source term; these can be at maximum 15 radionuclides out of $^{54}$Mn, $^{58}$Co, $^{60}$Co, $^{86}$Rb, $^{91}$Y, $^{95}$Zr, $^{95}$Nb, $^{103}$Ru, $^{106}$Ru, $^{110m}$Ag, $^{127m}$Te, $^{129m}$Te, $^{134}$Cs, $^{136}$Cs, $^{137}$Cs, $^{138}$Cs, $^{140}$Ba, $^{141}$Ce, $^{144}$Ce, $^{143}$Pr, and $^{147}$Nd.
- **'Individual nuclides'**: Each of the nuclides of the source term can be selected individually.

All the above selections depend on the data provided by the HYDRO Module. If data for some of the selected nuclides is not provided, FDMA will not calculate results for these nuclides.
The preset selection is 'Sum of all nuclides'.

[Close] exits the window without storing any selections,
[Update] confirms any selections,
[Default] resets the preset selections, and
[Help] brings up a comment window.
4.2.3 Graphical output type

Choosing [Graphical output type] in the ‘Main menu’ brings up the following window in which up to three different types of graphical output can be selected:

- **Maps**: Results are displayed as a colour-coded map for all locations of the RODOS grid. Assigning various colours to ranges of the results is automatically done by the system, the exact value at each location can be accessed via the mouse cursor.

- **Time plots**: Results are shown as a time dependency plot, which displays the results for all according time steps (see Glossary for definition of various time resolutions) for the location with the maximum results (a selection of other locations is not yet possible).

- **Collective doses**: Collective doses for the chosen exposure pathways are displayed as colour-coded maps for all locations for the time step with the maximum results. Collective doses from ingestion are estimated from the activity concentrations in processed foodstuffs at each location, the amount of foodstuff production at the according location and ingestion dose factors for adults. This means, collective ingestion doses can only be calculated for those foodstuffs where production data is available.
One, two or all of the three types can be selected at the same time. The preset selections are 'Maps' and 'Time plots'. This means, if no selection is made by the user all results can be displayed with these two types of graphical output.

[Close] exits the window without storing any selections,  
[Update] confirms any selections,  
[Default] resets the preset selections, and  
[Help] brings up a comment window.
4.2.4 **Interface data**

Choosing [**Interface data**] in the 'Main Menu'-window brings up the following window for the selection of interface data to be calculated by FDMA.

Two selections can be made:

- interface data to the Long Term Countermeasure Module LCMA. LCMA mainly requires activity concentrations in all feedstuffs and in all raw foodstuffs, and doses from ingestion, and
- interface data to the Dose Combination Module DCM.

Since the interface to DCM requires a lot of calculation time, it is recommended to select only those items which are needed for future work.

The preset selection is that the interface data for LCMA is calculated.

[**Close**] exits the window without storing any selections,
[**Update**] confirms any selections,
[**Default**] resets the preset selections,
[**Help**] brings up a comment window.
5 Results and Data Output

5.1 Output to the Graphics system

5.1.1 Possible results

If selections are made in the Initialization Windows of FDMA, the results which are calculated in FDMA and the graphical output of these results are defined by all possible combinations of these selections, with some logical exceptions.

All chosen activities (feedstuff and/or foodstuff activities) and ingestion doses are displayed for both graphical output types, 'Maps' and 'Time plots', if these types are chosen. Only doses can be displayed as 'Collective doses'.

The following tables provides an overview on the possible results. The two tables show possible results in form of maps. Time plots are only provided for the location with maximum contamination/dose. The time function always cover the lifetime period of 70 years.

<table>
<thead>
<tr>
<th>From feeding water</th>
<th>From irrigation</th>
<th>other</th>
<th>Nuclides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foodstuffs (Bq/kg fresh weight)</td>
<td>- All foodstuffs</td>
<td>- All foodstuffs</td>
<td>- Drinking water</td>
</tr>
<tr>
<td></td>
<td>- 15 individual foodstuffs</td>
<td>- 33 individual foodstuffs</td>
<td>- Fish</td>
</tr>
<tr>
<td></td>
<td>- Sum of nuclides</td>
<td>- All nuclides</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- All nuclide groups</td>
<td>- Individual nuclide groups</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Up to 15 individual nuclides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedstuffs (Bq/kg fresh weight)</td>
<td>- All feedstuffs</td>
<td>- All feedstuffs</td>
<td>- Sum of nuclides</td>
</tr>
<tr>
<td></td>
<td>- 4 individual feedstuffs</td>
<td>- 21 individual feedstuffs</td>
<td>- All nuclides</td>
</tr>
<tr>
<td></td>
<td>- All nuclide groups</td>
<td>- Individual nuclide groups</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Up to 15 individual nuclides</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Activities (maps + time plots)
<table>
<thead>
<tr>
<th>Nuclides</th>
<th>Age groups</th>
<th>Organs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingestion(^1) (mSv)</td>
<td>As for activities</td>
<td>Up to 11 organs + effective dose</td>
</tr>
</tbody>
</table>

\(^1\) from: feeding water, irrigation, other foodstuffs, for details see previous table

**Table 2: Doses (individual + collective, time plots)**

The selection in 'Activities in feedstuffs - feeding water' and in 'Activities in feedstuffs - irrigation' determines which feedstuffs will be calculated and listed in the Graphical system under '/ Maps/ Activities in/' and/or '/ Time plots/ Activities in/'.

The selection in 'Activities in foodstuffs - feeding water', 'Activities in foodstuffs - irrigation' and in 'Activities in foodstuffs - other foodstuffs' determines which foodstuffs will be calculated and listed under '/ Maps/ Activities in/' and/or '/ Time plots/ Activities in/'.

The selection in 'Activities: Selection of nuclide' determines for which nuclides all calculations for activities in FDMA are made. For each of the results in the graphical output (as described above) the list of nuclides is added, e.g. '/ Maps/ Activities in/ milk/ from irrigation/ Cs-137/' and/or '/ Maps/ Activities in/ milk/ from irrigation/ I-131/' etc.

The selection in 'Ingestion dose - feeding water', 'Ingestion dose - irrigation' and in 'Ingestion dose - other foodstuffs' determines which foodstuffs will be used to calculate ingestion doses and to list the results under '/ Maps/ Doses from/ ingestion/ milk/ from irrigation/' etc.

The selection in 'Ingestion doses - nuclide selection' determines for which nuclides all dose calculations in FDMA are made. For each of the results in the graphical output (as described above) the list of nuclides is added, e.g. '/ Maps/ Doses from/ ingestion/ milk/ Cs-137/' and/or '/ Maps/ Doses from/ ingestion/ milk/ I-131/' etc.
A selection in 'Selection of interface data' does not result in a graphical output, but is necessary if a run of LCMA or DCM should be based on the results of the actual run of FDMA!

If no selections are made in the Initialization Windows, FDMA uses the default settings of the automatic mode!

The aquatic Food and Dose Modules FDMA produces various types of results which can be displayed via the Graphical System of RODOS. All map results are displayed on a grid; this grid is defined by the location number of each of the grid cells. This output is divided into 4 blocks of data:

- **map data**: up to 200 maps (each with 2520 locations) can be created; the total number of maps is given and for each map a description string and the index of the location with the maximum value are provided.
- **time plot data:** up to 200 time dependency plots (each with up to 56 time steps) can be created; the total number of plots is given and for each time plot a description string, the number, values and unit of the time steps and the index of the time step with the maximum value are provided.
- **Maps for collective doses**: up to 200 maps (each with 2520 locations) can be created; the total number of maps is given and for each map a description string and the index of the location with the maximum value are provided.
5.1.2 Default results

If the preset selections in the Input Windows are not changed by the user (the default selections in the different Input Windows are given in Chapter 4.2), the following results will be calculated by FDMA and are accessible in the Graphics system (these results correspond to the results calculated in the automatic mode!):

Maps

Activity (for all nuclide groups included in the source term)
  from irrigation in
    Grass I
    Leafy vegs.
    Milk
  from feeding water in
    Milk

Dose (for the sum of all nuclides; for adults) from ingestion
  from irrigation
    Sum of all foodstuffs
    thyroid
effective dose
  from feeding water
    Sum of all foodstuffs
    thyroid
effective dose

Time plots

Activity (for all nuclide groups included in the source term)
  from irrigation in
    Grass I
    Leafy vegs.
    Milk
  from feeding water in
    Milk

Dose (for the sum of all nuclides; for adults) from ingestion
  from irrigation
    Sum of all foodstuffs
    thyroid
effective dose
  from feeding water
    Sum of all foodstuffs
thyroid
effective dose
5.2 Interface data

FDMA produces data needed by other modules of RODOS:

- the Aquatic Long Term Countermeasure Module LCMA
- the Dose Combination Module DCM

These interface data are calculated only if the according selection was made in the "Interface data"-window.

Detailed descriptions of these interfaces are given in the FDMA documentation.

5.2.1 FDMA - LCMA interface

For estimation of the effect of countermeasures the following data are produced for the Long Term Countermeasure Module LCMA:

- Specific activities in processed feedstuffs resulting from contaminated feeding and irrigation water, for all water sources.
- Specific activities in foodstuffs, resulting from contaminated feeding and irrigation water, for all water sources.
- Specific activities in drinking water, for all drinking water sources.
- Specific activities in fish for all fish sources.

In addition, several other model and program steering parameters are included in the interface. A complete description of the FDMA-LCMA interface is given in chapter 3.2.2 of the FDMA documentation (RODOS(WG3)-TN(99)-10).

5.2.2 FDMA - DCM interface

For summing up doses estimated by FDMA with doses from other food and dose modules, the following doses (effective dose integrated from time of deposition up to 7 different points in time, for 7 different population groups) are produced:

- Ingestion doses resulting from contamination of animal feeding water.
- Ingestion doses resulting from contamination of irrigation water.
- Ingestion doses from drinking water consumption
- Ingestion doses from fish consumption

A complete description of the FDMA-DCM interface is given in chapter 3.2.2 of the FDMA documentation (RODOS(WG3)-TN(99)-10).
6 Error Correction Procedures

General error messages

read-error = nn in file filnam

An error occurred when reading data from an ASCII file. nn is a FORTRAN error code (see FORTRAN manual). filnam is the name of the file to be read.

not enough data in file filnam

An error occurred when reading data from an ASCII file. The required data were not found before end-of-file. filnam is the name of the file to be read.

Error in subroutine RADIOHT: cant open file 'halflifes'!

The file '../data/fdm/isotopes/halflifes' in which the half-lifes of all isotopes are given, could not be opened.

Error in subroutine RADIOHT: nuclide nuclide not available in data base

The nuclide nuclide could not be found in the file '../data/fdm/isotopes/halflifes'

Error in subroutine CHKDAT: Date dd.mm.yyyy hh:mm is incorrect

The date of the begin of the release (transferred from the RODOS system via shared memory in the form dd.mm.yyyy hh:mm) is given in a wrong way.

Error in subroutine SCANREG: Too many radioecological regions needed

The radioecological regions needed to consider the given locations (grid points) exceed the maximum possible number (at present 5). Coarser radioecological regions have to be defined in order to cover the whole area.

Error in subroutine NUCCONV: nuclide nucnam not available in data base
The nuclide nucnam (which was transferred via shared memory from the atmospheric dispersion module) is not included in the FDM data base.

**Error in subroutine DFGRO_TIMEDEP: ntim > mtre**

Internal problem in Subroutine DFGRO_TIMEDEP: The number of required time steps exceeds the limit mtre.

**Error in subroutine SKIP: dummy value READ-Error**

An error occurred when skipping a line during reading data from a file.

**Error when reading file filnam: not existing**

The program tried to open the data file *filnam* which does not exist in the directory where it should be.

**Function ENUV: exponential function overflow (Warning only, program continues!)**

The program tried to calculate exponential function \( \exp(x) \) for \( x > 79 \)

**Error when reading file /products: error in plant definitions**

Error in a product definition file ‘...data/fdm/regionnnn’ : The indices of the plants are not a consecutive sequence.

**Error when reading file /products: wrong task atom in plant definitions**

Error in a product definition file ‘...data/fdm/regionnnn’ : A task atom for a plant does not consist of 4 characters or it does not begin with ‘f...’

**Error when reading file /products: error in animal product definitions!**

Error in a product definition file ‘...data/fdm/regionnnn’ : The indices of the animal products are not a consecutive sequence.

**Error when reading file /products: wrong task atom in animal product definitions!**
Error in a product definition file '...data/fdm/regionnnn':
A task atom for an animal product does not consist of 4 characters or it does not begin with 'f....'

Error when reading file /products: error in feedstuff definitions!

Error in a product definition file '...data/fdm/regionnnn':
The indices of the feedstuffs are not a consecutive sequence.

Error when reading file /products: wrong plant# in feedstuff definitions!

Error in a product definition file '...data/fdm/regionnnn':
A plant index given in the feedstuff definitions is <1 or exceeds the number of plants which have been defined.

Error when reading file /products: wrong animal# in feedstuff definitions!

Error in a product definition file '...data/fdm/regionnnn':
An animal product index given in the feedstuff definitions is <1 or exceeds the number of animal products which have been defined.

Error when reading file /products: wrong feedstuff definition!

Error in a product definition file '...data/fdm/regionnnn':
For a feedstuff a plant and an animal product index is given. A feedstuff can either be produced from a plant or from an animal!

Error when reading file /products: wrong task atom in feedstuff definitions!

Error in a product definition file '...data/fdm/regionnnn':
A task atom for a feedstuff does not consist of 4 characters or it does not begin with 'f....'

Error when reading file /products: error in foodstuff definitions!

Error in a product definition file '...data/fdm/regionnnn':
The indices of the foodstuffs are not a consecutive sequence.

Error when reading file /products: wrong plant# in foodstuff definitions!

Error in a product definition file '...data/fdm/regionnnn':
A plant index given in the foodstuff definitions is <1 or exceeds the number of plants which have been defined.

Error when reading file /products: wrong animal# in foodstuff definitions!

Error in a product definition file '...data/fdm/regionnnn' :

An animal product index given in the foodstuff definitions is <1 or exceeds the number of animal products which have been defined.

Error when reading file /products: wrong foodstuff definition!

Error in a product definition file '...data/fdm/regionnnn' :

For a foodstuff a plant and an animal product index is given. A foodstuff can either be produced from a plant or from an animal!

Error when reading file /products: wrong task atom in foodstuff definitions!

Error in a product definition file '...data/fdm/regionnnn' :

A task atom for a foodstuff does not consist of 4 characters or it does not begin with 'f....'

Warning in Subr. RTDPING:

iclast(itsk) must be 0 or 9 ! (and similar warnings)

Warnings like this indicate that there is a problem in program flow control. The indicated parameter (iclast(tclas) in the above example) has a value which it must not have. This might lead to unreliable results. Inform the program developers for exploring the reason.
Error messages from checking model parameters

Region \textit{nnn} : Model parameter error!

\textit{explanation}

\textit{message}

At least one of the model parameters (which were read from the data base) is beyond allowed limits. \textit{nnn} is the number of the radioecological region, i.e. the wrong data is in the directory \texttt{data/fdm/regionnnn}.

A description of all model parameters is given in section 3.2.3 'Data Files'.

\textit{explanation} specifies which of the parameters is wrong. This can be one or more of the following informations:

<table>
<thead>
<tr>
<th>Explanation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>nuclide (m)</td>
<td>A nuclide dependent model parameter for the (m)-th nuclide in the nuclide list which was input to FDMA or FDMA is wrong</td>
</tr>
<tr>
<td>soil type (m)</td>
<td>A model parameter for the (m)-th soil type ((m=1): pasture with intensive cultivation, (m=2): pasture with extensive cultivation, (m=3): arable land) is wrong</td>
</tr>
<tr>
<td>plant type (m)</td>
<td>A model parameter for the (m)-th plant type is wrong</td>
</tr>
<tr>
<td>animal (m)</td>
<td>A model parameter for the (m)-th animal is wrong</td>
</tr>
<tr>
<td>feedstuff (m)</td>
<td>A model parameter for the (m)-th feedstuff in the animal feeding data file is wrong</td>
</tr>
</tbody>
</table>

\textit{message} gives the name of the variable and tells which limit is exceeded. This can be one of the following informations:

<table>
<thead>
<tr>
<th>Message</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>\textit{param} must not be less than \textit{lolim}</td>
<td>The model parameter \textit{param} is below its minimum value \textit{lolim}</td>
</tr>
</tbody>
</table>
Error messages from checking input data and model parameters

<table>
<thead>
<tr>
<th>Message</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>param</code> must not be greater than <code>hilim</code></td>
<td>The model parameter <code>param</code> is below its minimum value <code>hilim</code></td>
</tr>
<tr>
<td><code>param</code> must not be less than zero</td>
<td>The model parameter <code>param</code> is negative</td>
</tr>
<tr>
<td><code>param</code> must be greater than zero!</td>
<td>The model parameter <code>param</code> is zero or negative</td>
</tr>
</tbody>
</table>

Error in input data!

*explanation*

*message*

At least one of the input data (transferred via shared common from the atmospheric dispersion module, from the RODOS system or from the rodos gridded data base) is beyond allowed limits. A description of all input data is given in section 3.2.1 and 3.2.2.

*explanation* specifies which of the input data is is wrong, e.g. 'Number of radionuclides'.

*message* gives the name of the variable and tells which limit is exceeded. This can be one of the following informations:

<table>
<thead>
<tr>
<th>Message</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>variable</code> must not be less than <code>lolim</code></td>
<td>The input data <code>variable</code> is below its minimum value <code>lolim</code></td>
</tr>
<tr>
<td><code>variable</code> must not be greater than <code>hilim</code></td>
<td>The input data <code>variable</code> is below its minimum value <code>hilim</code></td>
</tr>
<tr>
<td><code>variable</code> must not be less than zero</td>
<td>The input data <code>variable</code> is negative</td>
</tr>
<tr>
<td><code>variable</code> must be greater than zero!</td>
<td>The input data <code>variable</code> is zero or negative</td>
</tr>
</tbody>
</table>
Error messages from checking input tasklist

Error: ⇒ Routine: TASKANA
⇒ TASK: erroneous task
⇒ TASK Number: number of erroneous task
⇒ Warning: warning

At least one of the taskatoms with the key characters ‘x’, ‘c’ or ‘g’ are erroneous.
warning specifies the parameter classes of the erroneous code, and the type of error. This can be done by one or more of the following information:

Warning: input task starts with wrong key parameter: task ignored!

For results: 1st taskatom does not start with ‘c’
for interfaces: 1st taskatom does not start with ‘x’

Warning: data class not identified
‘c’-taskatom is not identified

Warning: graphical output type not identified
‘g’-taskatom is not identified

Error: ⇒ Routine: TASKEX
⇒ TASK: erroneous task
⇒ TASK Number: number of erroneous task
⇒ Warning: warning

warning specifies the type of error in the respective input task.

Warning: unidentified code

At least one of the taskatoms with the key characters ‘i’, ‘t’, ‘e’, ‘n’, ‘l’, ‘0’, ‘1’, ‘p’, ‘a’, ‘o’, or ‘m’ are erroneous.

Warning: global parameter must not be combined with other parameter
A global and a special parameter of at least one parameter class is used.
7 Glossary

In this glossary a lot of terms appearing in this paper are defined, further explained, related to other terms or provided with a list of possible values. Terms appearing in the explanation of another term of the glossary are written in italics.

Collective dose

The calculation of collective doses for all exposure pathways besides ingestion of contaminated foodstuffs is based on expected time integrated doses of adults at the locations and the number of people related to the locations.

The calculation of collective doses from ingestion of contaminated foodstuffs is based on the potential specific activities in raw foodstuffs at the locations, the amount of foodstuffs related to the locations and the effective dose factors of adults for ingestion.

Since the interpretation of the spatial dimension is different for both types of calculations, it is not possible to add up these types of collective doses.

Consumption rate

Amount of foodstuffs consumed per day by humans. The data used are average values for the age groups considered. Time dependent values are created by linear interpolation of the data for the age groups.

Dose factors

The dose factors used in the calculation of the internal exposure from inhalation and ingestion were calculated using the NRPB internal dosimetry program PLEIADES, which is consistent with publications ICRP-68, ICRP-72, and IAEA BSS.

Feedstuff

Product consumed by animals. The feedstuffs which may be considered at present are given in the list below. At present, the only possible feedstuff in the aquatic mode is feeding water; all other feedstuffs except feeding water can be used in the terrestrial mode only:

- grass/hay (intensive cultivation)
- maize
- grass/hay (extensive cultivation)
- maize bulbs
- potatoes
- beets
Foodchain module

The foodchain module is a part of FDMA in the analyzing subsystem of RODOS. The endpoints of the foodchain module are the specific activities in *feedstuffs* and *foodstuffs* calculated on basis of the *atmospheric dispersion data*. The specific activities in *foodstuffs* are transmitted to the *dose module* for the calculation of ingestion doses.

**Foodstuff**

*Product* consumed by humans. The foodstuffs which may be considered at present are given in the list below:

- spring wheat (whole)
- spring wheat (flour)
- spring wheat (bran)
- winter wheat (whole)
- winter wheat (flour)
- winter wheat (bran)
- rye (whole)
- rye (flour)
- rye (bran)
- oats
- potatoes
- leafy vegetables
- root vegetables
- fruit vegetables
- fruits
- berries
- cow's milk

- condensed milk
- cream
- butter
- cheese (rennet)
- cheese (acid)
- goat's milk
- sheep milk
- beef (cow)
- beef (bull)
- veal
- pork
- lamb
- chicken
- eggs
- beer
- drinking water
- fish

**Foodstuff group**

*Foodstuffs* in the list of *processed foodstuff* can be summarized in foodstuff groups for the output of doses resulting from the ingestion of some types of *foodstuffs*. Possible foodstuff groups are:
Location

A spatial unit for which hydro data are given in the input interface. The data arrays are designed for analysis of 2520 locations according to the dimension of the dynamic grid of RODOS. However, the spatial distribution of locations as well as their interpretation is not subject of the foodchain module or the dose module. Of course, all the input interface data related to locations must be related to the same spatial units.

In addition to a normal selection of locations, the location with the highest deposition or the highest dose may be chosen.

Long term ...

'Long term' is related to an analysis of specific activities, doses or dose rates during a time interval between the beginning of a deposition event up to 100 years after deposition with a time resolution not better than one day. A long term analysis is made for the exposure pathway ingestion of contaminated foodstuffs including the evaluation of specific activities in feedstuffs and foodstuffs.

Nuclide

In the foodchain transport module and in the ingestion dose calculation, up to 10 nuclides may be considered. The following nuclides may be included in the calculation:

- Ag 110m
- Am 241
- Ba 140
- Ce 141, Ce 143, Ce 144
- Cm 242, Cm 244
- Co 57, Co 58, Co 60
- Cr 51
- Cs 134, Cs 136, Cs 137, Cs 138
- Fe 59
- I 129, I 131, I 132, I 133, I 134, I 135
- Kr 85m, Kr 87, Kr 88
- La 140
Mn 54  
Mo 99  
Na 24  
Nb 95  
Nd 147  
Np 239  
Pr 143  
Pu 238, Pu 239, Pu 240, Pu 241  
Rb 86, Rb 88  
Rh 105  
Ru 103, Ru 105, Ru 106  
Sb 127, Sb 129  
Sr 89, Sr 90, Sr 91, Sr 92  
Tc 99m  
Te 127m, Te 127, Te 129m, Te 129, Te 131, Te 131m, Te 132  
Te 133m, Te 133, Te 134  
Xe 133, Xe 135, Xe 138  
Y 90, Y 91  
Zn 65  
Zr 95, Zr 97

Nuclide group

According to the limits of specific activities in the EC-regulations, *nuclides* are divided into the groups iodine isotopes, strontium isotopes, alpha emitters and other long lived radionuclides with a half life of more than 10 days. In the last group, the cesium isotopes Cs-134 and Cs-137 are supposed to be of greatest importance, therefore, this group is denoted 'cesium isotopes' in this paper.

Processed product

*Feedstuff* or *foodstuff* taking into account a minimum storage time and an enrichment or dilution of activity due to processing. A minimum value, presently set to 6 hours, is applied in the calculation of activities in processed products.

Product

Generic term for *feedstuffs* and *foodstuffs*. Both types of products are subdivided into *raw products* and *processed products*.

Raw product

*Feedstuff* or *foodstuff* without consideration of a minimum storage time and an enrichment or dilution of activity due to processing.
**Region**

Area for which the model parameters (e.g. growing times of crops, feeding habits, human consumption habits) are assumed to be constant. The parameters defined for a region are applied for all locations which are located within this radioecological region.

**Results**

Endpoints of the *automatic mode* and the *interactive mode* of the system to be presented to the user in order to describe the radiological situation. Results are subdivided into maps of specific activities and individual doses, time dependency plots, maps of collective doses and frequency distributions.

**Time resolution**

The result vectors showing the time dependency of a dose or a specific activity are given with 'high' time resolution. This comprises 56 time steps with variable time resolution:

- each day of week 1 and 2,
- end of week 3, 4, 5, 6, 7, 8, (7 days a week)
- end of each month from 3 to 24, (30 days a month)
- end of year 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100.

**Units**

Specific activities in *feedstuffs* and *foodstuffs* are given in [Bq/kg], time integrated specific activities in [Bq.d/kg], time integrated doses in [mSv], dose rates in [mSv/h] and *collective doses* in [manSv].