TRS 364 Working Group : Revision of IAEA Technical Report Series No. 364, "Handbook of parameter values for the prediction of radionuclide transfer in temperate environments".

Minutes of the Sixth Interim Working Group Meeting
12th -16th June 2006, IAEA Headquarters, Vienna, Austria
By Ph. Calmon

List of Participants

Mr. Brittain, J.	Natural History Museum	Norway	
Mr. Calmon, P.	IRSN	France	Chairman
Ms. Carini, F.	UCSC	Italy	
Mr. Conney, S.	Food Standards Agency	U.K.	
Mr. Fesenko, S.	NAAL Seibersdorf	Austria	Scientific secretary
Mr. Galeriu, D.	IFIN-HH	Romania	
Mr. Garcia-Sanchez, L.	IRSN	France	
Mr. Golikov, S.	Institute of Radiation Hygiene	Russia	
Mr. Horyna, J.	SUJB	Czech Republic	
Ms. Kamboj, S.	Argonne National Laboratory	USA	
Mr. Kashparov, V.	UIAR	Ukraine	
Mr. Laptev, G.	UHMI	Ukraine	
Ms. Leclerc-Cessac, E.	ANDRA	France	
Ms. Melintescu, A.	IFIN-HH	Romania	
Mr. Proehl, G.	GSF	Germany	
Ms. Rantavaara, A.	STUK	Finland	
Ms. Reed, W.	SENES Oak Ridge Inc	USA	
Ms. Rigol, A.	Universitat de Barcelona	Spain	
Ms. Sanzharova, N.	RIARAE	Russia	
Mr. Shang, Z.	NNSC, SEPA	China	
Ms. Shubina, O.	RIARAE	Russia	
Mr. Slavik, O.	VUJE	Slovakia	
Ms. Strebl, F.	ARC Seibersdorf	Austria	
Ms. Tagami, K.	NIRS	Japan	
Mr. Thiry, Y.	SCK-CEN	Belgium	
Mr. Uchida, S.	NIRS	Japan	
Ms. Vandenhove, H.	SCK.CEN	Belgium	
Mr. Van Dorp, F.	NAGRA	Switzerland	
Mr. Velasco, H.	GEA-IMASL	Argentina	
Mr. Vidal, M.	Universitat de Barcelona	Spain	
Ms. Voigt, G.	NAAL Seibersdorf	Austria	Scientific secretary
Ms. Yankovich, T.	AECL	Canada	
Ms. Zeiller, E.	IAEA	Austria	
Mr. Zibold, G.	Hochschule Ravensb.-Weingarten	Germany	
Mr. Beresford, N.	CEH	U.K.	"Dose to biota" WG
Ms. Howard, B.	CEH	U.K.	"Dose to biota" WG
Mr. Monte, L.	ENEA	Italy	"Freshwater" WG
+			
Mr. Davis, P.	AECL	Canada	"^{3}H & ^{14}C" WG

Meeting objectives

Main objectives of the meeting were: (i) to examine and discuss the participant contributions to the different chapters for the revision of TRS-364, (ii) to examine and discuss the contributions from other working groups (C-14 and H-3 WG, River WG, Biota WG) and (iii) to plan the work for the next period with the perspective to provide a first draft for the November plenary meeting.

Foreword

I wish to thank all the participants for their contributions and their work during this week. It is the first time that so many people attend the meeting and it is a great opportunity to reach our objective to deliver a first draft in next November 2006.

1. Introductive chapters

During the last November plenary meeting, a group of four persons (Mr. Calmon, Mr. Fesenko, Mr. Proehl and Mr. Van Dorp) was constituted. The objective of this group was to draft this first chapter. Sergey Fesenko presented the contribution. Six items have been drawn:

1.1 Background and rationale for TRS 364 revision
1.2 Changes since the publication of TRS 364
1.3 Objectives
1.4 Scope
1.5 Radioecology for safety assessments
1.6 Structure

1.1 is based on critical review.
1.2 Refers to the increase of knowledge for time-dependency of radionuclide transfers, for temperate environments and also the emergence of data for other environments such as tropical, boreal and arctic ones. Data on rice are now available, new radionuclides are arising and new processes are presented such as run-off, sedimentation processes in rivers, etc. Classification for soil-to-plant transfers, even if not new, has been better defined in order to avoid too much variability in some transfer parameters.
1.3 Revision of TRS has to provide data and parameters and also guidance on how to use them for assessing radiation exposure to humans
1.4 Routine (or better continuous) and accidental (or better single) releases are of concern. Main features of radioecological models.
1.5 This item deals with sources, exposure pathways, radionuclides of concern, concepts, models and parameters for safety assessment.
1.6 It is the presentation of the different individual chapters.

2. Basic concepts

2.1 Main components of the biosphere

This item deals with the concept of the reference biosphere, but has been cancelled because it is not used in the following chapters and could bring some confusion.

2.2 Definition and units

They will be provided in each chapter. Only a reference to the ICRU report 65 will be noticed.

2.3 Data analysis

It seems that the general frame of the corresponding chapter in the former TRS could convene again. It is decided to just modify some parts according to the way we will finally present the data. Mr. Vidal proposes to send some comments on this issue directly to Mr. Fesenko.

2.4 The use of analogues (Ms. Leclerc-Cessac)

This chapter is particularly difficult to write. It must be stressed that the use of analogues is not an accurate way of modelling, but could be used if no data are available in the frame of screening models and with an objective of a poor accuracy of more that one order of magnitude.
Some questions must be raised :
Is the time-scale of processes and radionuclide half-lives similar ?
Are the physiology of plants or animals similar ?
Are the processes modelled similar ?

Analogues must be chosen taking into account the chemical properties of elements, the caracteristics of processes, the mass concentration of elements (trace or not, in comparison to the stable element, physiological role ?).
Ms. Carini reported that Mr Frissel published comparisons of soil-to-plant transfer factor for wheat and cabbage and observed a certain constant for a large set of radionuclides. She will send the reference of the paper to Ms Leclerc-Cessac and to Ms. Sanzharova.

3.1.1 Interception by vegetation (Mr. Proehl)

Very few remarks have been made. The paper is quite ready to be delivered for a draft. A table of data could be provided for the water storage capacity chapter to make this part clearer. Tables 1 and 2 could be checked for the first description column. In the conclusion, a paragraph could be added for limitations of the use of the models. Mr. Proehl has been asked to present the different processes (interception, absorption, weathering,…) in a few lines as an introduction in the chapter 3.1.

Weathering (Ms. Leclerc-Cessac)

This chapter has not been modified since the former meeting in November. The work is going on, taking into account the analysis of values of weathering factor for separate radionuclides. Some aspects are particularly examined such as: time-dependency, plant-dependency and isotope-dependency. It is important to specify if growth rate (dilution of radionuclides) is implicitly taken into account or not, because this phenomena is particularly important in terms of reduction of activity in plants, especially for grass. The definition of weathering (removal from vegetal surfaces by wind and rainfall,…) could be addressed at the beginning of the chapter.

Translocation (Ms. Leclerc-Cessac)

The definition of the translocation factor needs to distinguish two approaches related to a unit in m^2/kg or dimensionless. These two possibilities are exposed in the former TRS and data have to be

classified (if available) in these two categories. Consequently, two tables of translocation values could be presented. It must be mentioned if weathering is implicitly taken into account.
In case of continuous release, the calculation of a mean translocation coefficient could be appropriate for some modellers dealing with long-term assessment, but in case of acute releases, it is necessary to classify data according to the period before harvest or better according to the different vegetative cycles. This could avoid some discrepancies between different types of climate.
It is proposed that Mr. Proehl presents the interface of these different processes (interception, weathering and translocation) in the heading of the 3.1 chapter giving recommendation how to use these different parameters (translocation includes weathering and is used for plants such as fruits, fruit and root vegetables, tubers, and so on; only the weathering factor for plants that are consumed in totality such as leafy vegetables,…).

3.1.2 Assessment of soil-radionuclide interaction (Mr. Vidal and Ms. Rigol)

This chapter is in a good shape for a draft and really ameliorates the prediction of Kd for Cs and Sr because of the explicit dependency on co-factors. Question is open to report about discrimination factors such as pH for other radionuclides. In the case of a pH-dependency for some radionuclides, it may be important to extract some values only for soils for which pH is comprised from 5,5 and 7,5 that is currently found for cultivated soils, in order to reduce variability.

3.1.3 Vertical migration (Ms. Strebl)

Most data originates from undisturbed grassland soils. Since last November, the text has been shortened and a link has been made between Kd and vertical migration. The calculation of a retardation factor with the use of Kd is presented, but there is a place to present a table of some parameter values needed for this calculation (porosity and density of soils). The variability of the diffusion coefficient (from 0,1 to 1, so one order of magnitude) is far lesser that the Kd variability (3 orders of magnitude or more).
It is asked to Mr. Calmon to provide Ms. Strebl with data on vertical migration obtained in the frame of the PEACE and RESSAC programmes experimented on lysimeters in Cadarache during the nineties.

3.1.4 Plant uptake from soil

Temperate environments except for natural radionuclides (Ms. Sanzharova)

738 literature sources (from 1957 to 2005) have been registered in the database, giving information for 32 elements. Some factors affect root transfer such as soil and plant types. It was then decided during our last meeting to group soils and plants in a limited number of categories. Concerning soils, their grouping mainly follows the soil texture classification: organic (more than 20% organic matter), clay, loam and sand (that are classified according to the content of clay and sand particles). A last category has been created for some special soils that do not correspond to these categories and is called “others”. Plants are grouped in 24 categories. There was some discussion about groups concerning different types of natural grasses, but it was agreed to group some of them.
50% of the transfer factor data concerns only two radionuclides: cesium and strontium.
30% of the data concerns transfer to cereals, then leafy vegetables and pasture grass.
Generally speaking, transfer factors are higher for sandy than for loamy than for clay than for organic soils.

A small group will be constituted on Wednesday to discuss about statistical analysis of data, some aspects seem to be important such as geometric mean rather than arithmetic one, range and number of references.

Tropical and sub-tropical environments and south American countries (Mr. Velasco)

It would be suitable if some lines could be written about the main characteristics of tropical environments (geographical position, heavy rainfall, rainy seasons, high temperature, weathering of clay minerals, etc). It would be suitable if Mr. Velasco and Mr. Proehl could contribute to this introduction.
Mr. Velasco presented a database on root transfer factors and vertical migration parameters for these ecosystems or countries.
In sub-tropical environments, most of the transfer factor values are less than 1. In tropical ecosystems, transfer factors are frequently above 1. In general, transfer factors for Zn are higher than Sr higher than Cs higher than Co. The lowest values of root transfer factors are for U. There are a few data on mobility of radionuclides in soils.
Several gaps have been identified such as a heterogeneous geographical distribution of data and most of data deal with Cs, Sr, Co and Zn, some data exist for Ra, K, Pb, Mn, I, and U, but not for other radionuclides.
It seems that it is possible to integrate these data in the soil-to-plant transfer database. Mr. Velasco is asked to send his data to Ms. Sanzharova and Ms. Vandenhove in order to integrate them in special items corresponding to tropical and sub-tropical ecosystems. The same could be done with Asian root transfer parameters for plants other than rice.

Temperate environments and natural radionuclides (Ms. Vandenhove)

For natural radionuclides such as U, Th, Ra, Pb and Po, there are not so much information about soil characteristics. Also, data concern a limited number of plants corresponding to well defined soil textures.
Uranium tailings, red mud and phosphogypsum will be classified in the category "other soils", because the structure is very special and do not correspond to any agricultural soil.
For most of these natural radionuclides (except for Ra), the presentation of root transfer coefficients according to the soil texture decreases the variation coefficient value and then ameliorates the predictions.
For berries, fruits, heather and moss, data are available for the forest and semi-natural ecosystem groups.

Transfer to rice (Ms. Tagami, Mr. Uchida, Mr. Shang, Mr. Choi)

Japanese, Chinese and Korean data have been gathered for this specific chapter dealing with wet cultivation of rice (paddy soils). Data are available for ^{90}Sr, ^{137}Cs, I and Tc. Not published data are available also for several stable elements such as Th, U, … These data could be used for assessment of continuous releases.
In order to complete gaps, the use of analogues has to be done carefully distinguishing brown rice and polished rice. For instance, U and Th behave similarly for polished rice, but not for brown rice for which U and Eu are better correlated.
Even if a separate chapter will be created for rice, data are needed to be registered in the soil-to-plant database. Consequently Japanese, Chinese and Korean colleagues are kindly asked to send their data to Ms. Vandenhove and Ms. Sanzharova. Ms. Sanzharova will check if Korean data on plant (other than rice) uptake from soil are already in the database or not.

Secondary contamination of plants by resuspension of soil particles (Mr. Jourdain)

Mr Jourdain (CEA, France) did not participate in the meeting and did not provide a contribution. It is asked to Mr. Calmon to take care about the finalisation of this chapter with Mr Jourdain for the next meeting.

4.2 Radionuclide transfer in forests

Transfer to trees (Mr. Thiry)

From 580 articles, mainly based of Cs, only 14 articles have been selected for this contribution with the addition of the Seminat report (2000) and the book from Shcheglov et al. (2001). Very few studies deal with forest radioecology. The Chernobyl accident renewed the interest, but focused on cesium. For forests, two cycles are existing : biological and geochemical ones. The stock of available elements have, in fact, little relation with the fluxes. Consequently, it is difficult to apply transfer factors. For instance, ten years after the Chernobyl accident, the internal translocation processes mobilize from 1,6 to 2 times more 137Cs than root uptake. The annual root uptake represents an average of 0,3 to 0,5% of the 137Cs pool in soil. The influencing factors are first the soil type, then the moisture regime, then the stand composition, then the stand age and then the tree species. Aggregated transfer factors are appropriate for steady-state conditions in zones without hot particles deposition.

Transfer to mushrooms and berries (Mr. Calmon)

The paper has been little been changed from the precedent version in last November. Values of transfer parameters have been given for berries for Cs, Sr and some other radionuclides. Japanese data on Tc could be added also. It has been asked to provide a table of correspondence between fresh and dry weight for berries (Ms. Rantavaara could help). Values for transfer coefficients for mushrooms are presented for cesium, plutonium and strontium. It has been asked to provide geometric means in all the tables and no more arithmetic means in order to be consistent in the whole TRS. The rule is as follows : for 2 data a range is presented and from 3 data on, geometric mean is applied. It has been asked also to indicate if mushrooms are edible or not, but not to suppress not edible ones. It is advised to put in tables the exact number and not to specify with the unit, a coefficient (10^{-3}) in the heading of table.

Transfer to game animals (Mr. Zibold)

This chapter is now extended to a large set of game animals. No data were found for chamois ; in case somebody has some, please send them to Mr. Zibold. It is advised to place in an introductive part at the beginning some contextual data such as : number of shot animals (updated if possible), data on human diets concerning game (could be extended to wild products), description on hunting seasons and information about seasonal changes of animal diet and metabolism with seasons (Ms. Rantavaara will write some lines).

Transfer to fruits (Ms. Carini)

To be placed with the soil-to-plant transfer chapter.
Data collected during the IAEA BIOMASS programme have been presented. To present transfer factors to fruits, some distinctions could be made between :
- woody trees, bushes and herbaceous plants

- perennial or annual
- evergreen or deciduous.

230 data on soil-to-plant transfer factors for fruits have been extracted from the Martin Frissel's database and 180 have been collected from the literature (also grey literature) and could probably be integrated in the TRS database. These data concern about 15 radionuclides. Generally speaking, values for root transfer to fruits are close to those for green vegetables or even for cereals. Concerning translocation factors, a particular phenomena occurs as it is for trees : in autumn, before leaves fall, a part of minerals but also radionuclides are transferred and stored in the woody parts of the tree and are re-translocated to leaves and fruits (for fruit-trees) in spring. Ms. Rantavaara will send the description of the forest model integrated in RODOS as information for Ms. Carini to see how these phenomena are modelled.
The determination of average values seems to be difficult because of very different types of experimental conditions. However, in any case, the definition of this factor has to be very precisely specified.

3.2 Transfer to animals (Ms. Howard and Mr. Beresford)

In a first step, the database from "Green & Woodman" (NRPB report, mainly based on Cs, Sr and I) has been checked with references and other inputs come from references after 1991 and in Russian. The intention is to propose transfer factors but also concentration ratios when available and also some specific activity modelling for radionuclides such as ^{3}H, ^{14}C and ^{35}S.
Concerning biological half-life, it is not possible to use a statistical approach, consequently only a general guidance will be proposed.
Data on gastro-intestinal absorption will be delivered for Cs, Sr, I and Pu in different forms.
For November, a draft will be available.

Statistical procesing and presentation of data (Mr. Vidal)

In transfer factor tables only, data will be presented as follows:
- Number of data
- TF mean (arithmetic)
- Standard deviation
- TF geometric mean
- Geometric standard deviation
- Minimum and maximum (range)
- Number of references

For soils, the criteria used are those described by the FAO and refer to mineral soils (all % refer to mineral matter). The classification is as follows:

- Sand	sand fraction superior or equal to 65% and clay lower than 18%
- Clay	clay superior or equal to 35%
- Loam	rest of cases
- Organic soils	superior or equal to 20% of organic matter.
- Other	(to enter special substracts)

Arctic environments (Mr. Golikov)

The presentation concerns the lichen-reindeer-man pathway and the development of a specific model with the corresponding parameters.

Lichens are quite exclusively contaminated by atmospheric deposition and not by root transfer, so this transfer is not considered in the model. The definition and parameterization of the model are based on 40 years observations. Ecological half-lives are proposed for lichens and reindeers. Some input could be asked by experts from Nordic countries and the influence of the summer feeding of reindeers from vascular plants on the loss of radionuclides at this period could be explained.
The place of this contribution is not yet decided, but the priority is to write a draft and get input from Nordic countries if possible.
For the moment, it is the only contribution for the semi-natural environments. An input would be welcome on uplands or alpine environments. Some presentations on these subjects have been made during the Lancaster conference in December 2005.

Run-off / Wash-off (Mr. Garcia-Sanchez)

This contribution has been ameliorated since the last meeting in November. The main processes are now described, the table summarizing the usual parameters has been simplified and new references have been added to the database and some irrelevant data have been excluded. Processing of data is still on-going.
All parameters for run-off are site-specific, however it is possible to present some deterministic factors such as :
- direct deposition
- plant covering
- climate, rainfall, season,
- slope,
- soil/solution equilibrium, …

The qualitative ranking of such co-factors could help modellers.

Transfer to freshwater biota (Ms. Yankovich)

The database is regularly filled with new references about different types of aquatic animals whether consumed by man or for biota dose assessment purposes. An example of the use of analogous elements or tissues for piscivorous fishes has been presented. The last step is to present the result of this work in a draft for the next meeting.

Food processing (Mr. Kashparov and Mr. Conney)

During the past months, a database has been created and is currently updated. Data come from the work done in the frame of the French-German initiative and also from Food Standards Agency (Mr. Conney gave these data) and also from some other references. About 700 data are now in the database and concern mainly Cs and Sr. No new information has been found for fishes (freshwater and marine environments).
The food processing retention factor is defined as the fraction of the radionuclide activity that is retained in the processed food. It is important to notice that washing of vegetables is not considered as a processing factor since measurements of vegetables should be made after washing in order to not measure surface contamination. Thus, values for transfer factors should take into account this washing and should not be accounted for a second time in this chapter. A draft will be delivered for September.

^{3}H and ^{14}C modelling (made by Mr. Calmon based on the input from Mr. Davis)

Mr. Davis prepared within his group a contribution for the modelling of these two radionuclides. A presentation was made in Paris last Friday. Mr. Calmon attended this meeting and reports on the presentation and the main discussions.
The contribution refers separately to tritium, carbone-14, for releases to air and to water. This has the advantage to describe the different aspects without confusion. For this first draft, in some chapters, several ways of modelling are presented, but Mr. Davis group proposed to only keep the best model (the simplest, most accurate and with the largest set of associated parameters). For some parameters, a unique value is given as a best estimate, specifying that there is some variability. It would be better to add some information about this variability range and to what conditions it refers to, when available.
The TRS WG appreciated this contribution because complete and simple. A very few recommendations have been made. It seems effectively not possible to present for the TRS some dynamic models, but it must be said somewhere that the use of steady-state models is not possible to treat the acute phase, because the principal assumption of equilibrium will never be reached. Some flow diagrams could be efficient to have an easy view of the different equilibrium relations between compartments. It would be also interesting to have the units defined in all the equations. The modifications proposed by Mr. Davis are accepted by the group and a definitive draft should be delivered for October.

Physical processes in freshwater ecosystems (Mr. Monte, Leader of the Working Group on model validation for radionuclide transport in the aquatic system "Watershed-River" and in estuaries)

Main physical processes are diffusion-transport-exchanges between particulate and dissolved fractions-deposition and suspension of sediments.
Vertical diffusion is mainly influenced by thermal stratification of water that is strongly dependent on seasons, especially for lakes.
Transversal and longitudinal diffusion is caused by currents and wind for lakes and water velocity and fluxes for rivers. Ranges of values will be given for both.
Transport is only related to water velocity and consequently refers to hydraulic models.
Radionuclide interaction with sediment is strongly dependent on the chemical nature of contaminants. Compartmental models consider fast and low exchanges processes. Migration to sediment can also use a migration velocity. Equilibrium between solid and dissolved fractions is generally reached in hours to weeks, but rarely more.
It would be interesting to have tables of parameter values expressed with a range and a best estimate if available, but also some information about co-factors that influence these values. Radionuclide-not dependent and dependent on processes might be better highlighted.
It would be also valuable if parameters and eventually models could be differentiated for rivers and lakes. Marine and estuary environments are not in the scope of TRS.
Concerning river Kds, Mr. Ciffroy (EDF, France) did not participate in the meeting and did not provide a contribution. In case Mr. Ciffroy cannot finally write this chapter, it is asked to Mr. Monte if he could provide some data on Kd values. Mr. Fesenko has also advised to pay attention to the data on the aquatic Kds given in TRS 364.

Chlorine-36 (Ms. Leclerc-Cessac)

This chapter deals only with specific activity modelling. Values for the classical approach for Kds and transfer factors will be provided in each chapter. Some input were promised during the last

meeting of Ms. Howard and Mr Guetat, but have not been sent. Ms. Leclerc-Cessac will remind them to do so. The basis of this specific activity modelling is the assumption that the ratios in water and in the plant are equal. Parameter values are now given and this contribution is almost finished. The opportunity to collect more data could be arranged by a BIOPROTA forum that would be organised in September 2006. BIOPROTA is a working group based on waste management for long term safety assessment. It seems possible to extend the limitations of the specific activity modelling for chlorine-36 to the other ^{3}H and ^{14}C.
Mr. Kashparov then presented some experimental results on chlorine behaviour in cows. The addition of various quantities of stable chlorine in the diet of cows does not at all change the concentration of chlorine-36 in milk or meat, confirming the interest to use specific activity modelling for this radionuclide. Experiments on pigs are now in progress.

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6. Specific activity modelling
7. Food processing
Annex 1. List of parameters
Annex 2. List of tables

TRS and Tecdoc (Ms. Voigt)
After discussion, it has been agreed as follows:

- The contributions from the different participants of the group are in a format corresponding to a publication as a Tecdoc. The compilation of all the contributions could be made by next November.
- In order to give more value to the work freely performed by the participants, it is also proposed to publish, maybe chapter by chapter, in a special issue of JER (Ms. Voigt is one of the editors). This work could be started during our next plenary meeting.
- Mr. Thorne, with maybe the help of some other experienced radioecologists, will probably be invited by the IAEA to write the TRS in a concise format requested by the IAEA from the Tecdoc.

However, this "migration" should respect some considerations:

- To take into account the increase (as asked by the IAEA) of data, processes and ecosystems taken into account and also a much better accuracy and traceability of data.
- To show a better accuracy of the modelling described in TRS than in the SRS 19.
- To avoid the separation (as it was in the former TRS) between data and their context (definitions, explanations, co-factors and limitations).
- To allow initial contributors to review this TRS when drafted.

Next meeting and deliverables

In order to prepare the TECDOC, participants of the group are kindly asked to provide their new contributions, as Word documents, for September. In case of difficulties, please do it as soon as possible and in any case before the end of October.
The Vienna plenary meeting will be organized from the 6th to the 10th of November this year.