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Arguments for revising radioecological transfer factors : how to improve and extend current syntheses

Pascal SANTUCCI, IRSN

Gabriele VOIGT, IAEA

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Introduction

Most of biosphere models for radiological impact assessments use transfer or accumulation factors requiring their associated values

Even if overall environmental impact assessments considered, most of the current biosphere models still need such parameters and associated values

Among the literature, overall syntheses are not very numerous and the scientific community has contributed to one important document :

the IAEA TRS No. 364, "Handbook of parameter values for the prediction of radionuclide transfer in temperate environments", published in collaboration with the IUR in 1994. Its contents reflected radioecological results up to 1992

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G. VOIGT, IAEA

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Introduction (cont.)

Reasons why TRS 364 is widely used as a major source of information :

it addresses numerous environmental transfers and radionuclides, enabling the performance of integrated assessments

it is deemed useful and reliable for most assessment contexts, even if amended / completed by
the scientific community (radiation protection, radioecology)

it is still used in recent international methodologies (IAEA SRS 19, 2001)

However, scientific results and efforts were produced during the nineties which were not all taken into account before the TRS publication :

on the field : Chernobyl-related studies

experimental studies (e.g. lysimeters)

international programmes devoted to the construction and validation of radioecological models : BIOMOVS, IAEA/ VAMP, IAEA/ BIOMASS, European Frameworks, etc.

critical reviews performed within the context of waste assessment, etc.

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Introduction (cont.)

There are arguments for updating TRS 364 and extending it, in terms of compartments, processes and radionuclides, and even for improving its current contents, because a critical analysis can highlight some weaknesses

This explains that the IAEA decided in 2003 the revision of TRS 364, as a topic of the EMRAS programme, "Environmental modelling for radiation safety"

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General features of the revision of IAEA TRS No. 364

Due to the large audience and use of TRS 364, need to keep such a document as relevant, accurate and consistent as possible :

relevant : the purpose is to cover various assessment contexts : routine releases / accidental conditions, atmospheric / liquid releases, etc.

accurate : mistakes should be corrected and avoided, up-to-date science should be incorporated (difficult when data are scarce : less mobile radionuclides)

consistent : consistency between tables should be ensured, especially with regards to the radionuclides considered, all the more since integrated assessments require it

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General features of the revision of IAEA TRS No. 364 (cont.)

Attention should be paid to the management of variability and uncertainty :

display best-estimates ; "conservative" values are too much context and model-dependent

uncertainty mostly addressed by giving ranges of variation ; in some cases pdf could be built through statistical analyses (e.g. Kds, soil-to-plant TFs ?)

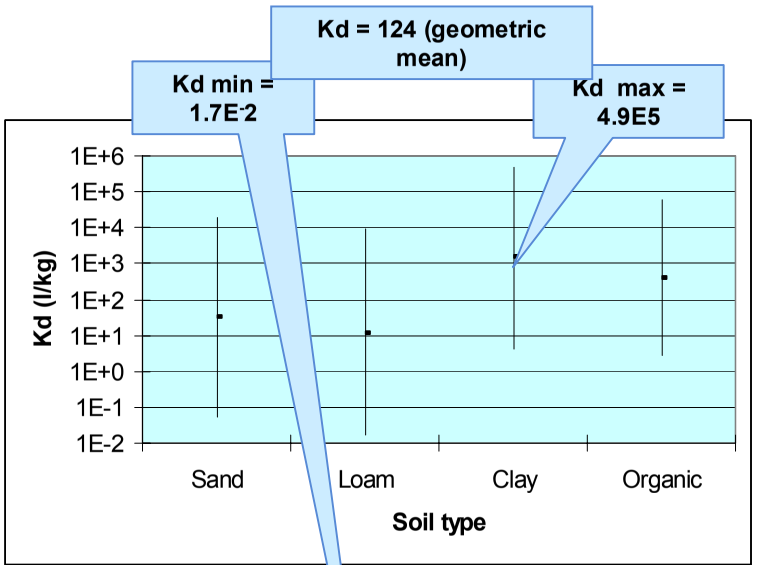
question about the extrapolation of statistical results on good samples to other categories (confidence intervals extrapolated from a radionuclide to another) ; discussion about chemical analogy

variability could be reduced by revising classification systems (e.g. crop groups) and introducing co-factors (e.g. Kds, soil-to-plant TFs)

General features of the revision of IAEA TRS No. 364 (cont.)

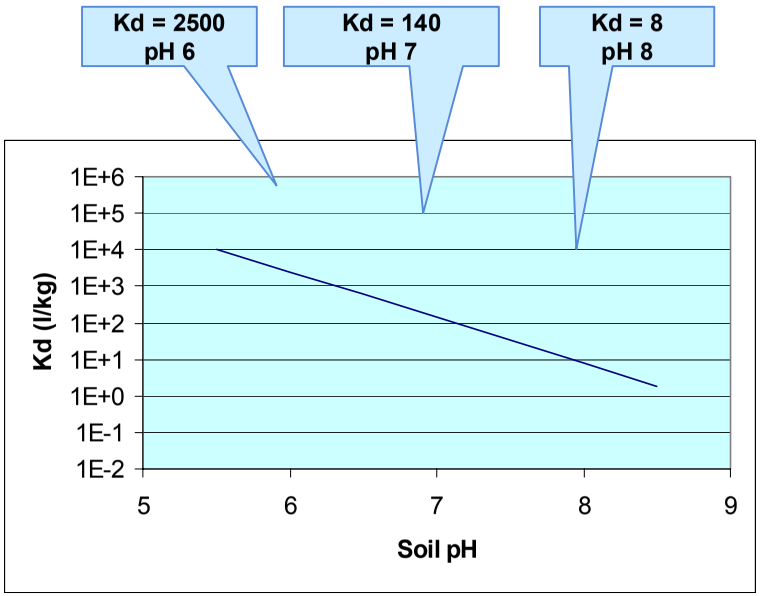
Introduction of co-factors for reducing variability : Kd of uranium against pH

Kd of U(VI) in soils closely linked to pH :
Acid pH ➔ uranyle cation, UO_2^{2+} **➔ high sorption**
Alkaline pH ➔ anionic carbonate complexes, $UO_2(CO_3)n^{(2n-2)-}$ **➔ low sorption**



Use of generic values

TRS 364, IAEA (1994)



Use of pH as co-factor

log (Kd)= -1.25 × pH + 10.9 (after Echevarria et al., 2001)

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General features of the revision of IAEA TRS No. 364 (cont.)

Implicit modelling assumptions :

Most often, steady-state modelling is assumed. The "old-fashioned" transfer factors should be kept for consistency with most existing methodologies (previous assessments, IAEA documents), but also due to scientific necessity (lack of better knowledge)

But there are domains where time dependency is prominent : accidental release, discrete routine releases ; equilibrium assumptions may be wrong (e.g. animal physiology) ; enhancement may be envisaged by the introduction of half-lives completing simple-box models

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Analysis and completion of the existing TRS 364

The critical review of the existing report has already started ; section by section (based on ecological domains), the methodology was the following :

list the processes of interest

review the modelling aspects (compartments and processes, alternative modelling, co-factors)

radionuclides currently taken into account

classification systems

weaknesses and mistakes

availability of new data

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Analysis and completion of the existing TRS 364 (cont.)

The section on foliar interception should be entirely rewritten :

- it is a prominent process after initial release from a nuclear facility
- the current modelling is difficult to understand
- distinguish interception / retention, wet / dry deposition, accidental / averaged conditions
- introduce aspersion (irrigation required by waste assessment)

Soil Kds should be revised :

- the classification system could be simplified (focus on agricultural soils)
- data should be kept consistent with agricultural conditions (some experimental data are not compatible)
- some mistakes should be corrected (iodine)
- co-factors should be introduced (pH, Ca^{++}, Na^{+}, K^{+}, etc.) in order to reduce the potential variability

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Analysis and completion of the existing TRS 364 (cont.)

Soil-to-plant transfer factors :

- introduce the now classical classification system : leafy, root, fruit vegetables, cereals, pasture ... fruits, Asian crops
- check latest data from IUR ; see also IAEA CRP on tropical systems
- introduce co-factors, consistent with Kds

Transfers to animal products :

- little recent data available
- there could be information about dynamic modelling

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Analysis and completion of the existing TRS 364 (cont.)

Aquatic systems ; this chapter should be rewritten, for instance in consistency with IAEA SRS 19 :

- distinguish bottom sediments and water particles
- distinguish trophic levels for fish

Semi-natural systems : focus on forest compartments and improve the current section by addressing more radionuclides

Food processing : simplify the tables by focusing on the most efficient processes for radioactivity reduction

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Extension of TRS 364 in scope, compartments and processes

At a methodological level, a discussion on chemical analogy should be introduced as a way to overcome the lack of data for some radionuclides, especially if consistency between the tables should be reached

Question of the special radionuclides : H^3, C^{14}, I, Cl, etc.

New compartments : it has been suggested to extend TRS 364 by introducing Asian food chains and tropical environments in the current sections

New processes : atmospheric resuspension (terrestrial domain) and wash-off (terrestrial to aquatic) should be introduced because they are prominent secondary pathways of contamination

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Revision of TRS 364 in practice

The revision of TRS 364 is one of the main activities of the IAEA programme EMRAS (Environmental Modelling for RAdiation Safety), 2003-2006(7)

The overall work plan is the following :

- September 2003, EMRAS plenary : about 20 participants ; agreement on work and milestones

- November 2004, EMRAS plenary : first draft on the critical analysis of TRS 364, synthesis on new available data, draft of computerised database ; identification of responsible experts by section

- End 2005 : final documents on the TRS critical analysis and on data availability, draft of TRS concerning already included parameters, draft on new parameters/ processes to be included, draft CD-rom with new data

- End 2006 : draft of overall new TRS, draft 2 of CD-rom with source data

- 2007 : finalisation of TRS and edition

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G. VOIGT, IAEA

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Revision of TRS 364 in practice (cont.)

Material :

- almost 90% of the TRS 364 references have been recovered (about 200)

- about 400 new references of interest have been found (later than 1992), including reviews and syntheses ; the grey literature should not be discarded (institutional reports)

- some databases : IUR on soil-to-plant transfers, IAEA CRP on tropical systems, EU RadFlux (multi-compartments), national databases (NRPB, IRSN) on Kds, soil-to-plant TFs, animals and food processing

Collaboration with IUR :

- TRS 364 was issued in collaboration with IUR

- most of the involved participants belong to IUR

- some source data managed and compiled through IUR (databases)

- there are IUR working groups of interest for the revision (radioecology of rice, radioecology and waste (special radionuclides))

- an agreement between IAEA and IUR is about to be officially approved

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Conclusion

The revision of the IAEA TRS No. 364, "Handbook of parameter values for the prediction of radionuclide transfer in temperate environments", published in collaboration with the IUR, is an effort which is required by the progress of radioecology, expected by numerous users, and made possible by an international collaboration launched through the IAEA/EMRAS programme

Since such an activity demands expertise and resources, all institutions, all experts are welcome to contribute and participate through the available possibilities : IAEA/EMRAS, IUR or even personal contacts

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