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noraceh@ceh.ac.uk

Derivation of transfer parameters for use within the ERICA-Tool and the default concentration ratios for terrestrial biota

N.A. Beresford^{1*}, C.L. Barnett¹, B.J. Howard¹, W.A. Scott¹, J.E. Brown², D. Copplestone³

¹Centre for Ecology & Hydrology, CEH-Lancaster, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster, LA1 4AP, UK

²Norwegian Radiation Protection Authority, Department of Emergency Preparedness and Environmental Radioactivity, Grini næringspark 13 Postbox 55, NO-1332 Østerås, Norway

³Environment Agency, Richard Fairclough House, Knutsford Road, Warrington, Cheshire, WA4 1HG, UK

*Corresponding author email: nab@ceh.ac.uk, tel: +44 1524 595856, fax: +44 1524 61536

Abstract

An ability to predict radionuclide activity concentrations in biota is a requirement of any method assessing the exposure of biota to ionising radiation. Within the ERICA-Tool fresh weight whole-body activity concentrations in organisms are estimated using concentration ratios (the ratio of the activity concentration in the organism to the activity concentration in an environmental media). This paper describes the methodology used to derive the default terrestrial ecosystem concentration ratio database available within the ERICA-Tool and provides details of the provenance of each value for terrestrial reference organisms. As the ERICA-Tool considers 13 terrestrial reference organisms and the radioisotopes of 31 elements, a total of 403 concentration ratios were required for terrestrial reference organisms. Of these, 129 could be derived from literature review. The approaches taken to selecting the remaining values are described. These included, for example, assuming values for similar reference organisms and/or biogeochemically similar elements, and various simple modeling approaches.

Keywords: Concentration ratio, terrestrial biota, transfer parameters, ERICA

1. Introduction

An ability to predict the radionuclide activity concentrations in biota is an essential component of any approach assessing exposure of non-human biota (Higley et al. 2003a; Beresford et al. 2004).

In an overview of the availability of transfer parameters for wild terrestrial plants and animals, we previously highlighted that transparency in the method of estimating transfer parameters and the data provenance were sometimes lacking (Beresford et al. 2004). Whilst the overall methodology used to derive the default transfer parameters within the ERICA-Tool is explained in associated documentation (see Beresford et al. (2007a) and ERICA-Tool help file), the provenance of all default values is not given. This paper describes the general methodology applied to derive the transfer parameters that are available within the ERICA-Tool (Brown et al. this issue). The paper concentrates on the terrestrial ecosystem, presenting the default transfer parameter values for terrestrial biota in more detail than can be found within previous documents; a second paper presents default values for marine and freshwater ecosystems (Hosseini et al. this issue). For descriptions of the ERICA Integrated Approach and the ERICA-Tool the reader should consult Beresford et al. (2007a), Larsson (this issue) and Brown et al. (this issue).

1.1. Definition and requirements of transfer parameters within the ERICA Integrated Approach

Whole-body activity concentrations of radionuclides in terrestrial biota within the ERICA-Tool are predicted from media activity concentrations using equilibrium concentration ratios (CRs), where:

$$CR = \frac{\text{Activity concentration in biota whole - body (Bq kg}^{-1} \text{ fresh weight)}}{\text{Activity concentration in soil (Bq kg}^{-1} \text{ dry weight)}}$$

with the exception of chronic atmospheric releases of ^3H , ^{14}C , $^{32,33}\text{P}$ and ^{35}S where:

$$CR = \frac{\text{Activity concentration in biota whole - body (Bq kg}^{-1} \text{ fresh weight)}}{\text{Activity concentration in air (Bq m}^{-3}\text{)}}$$

The ERICA-Tool considers 13 terrestrial reference organisms¹ and the radioisotopes of 31 elements (see e.g. Table 3). The ERICA-Tool requires CR values for two purposes: (i) to derive environmental media concentration limits (ECMLs) for use within an initial screening tier (termed Tier 1 within the ERICA Integrated Approach); (ii) to provide a default CR dataset to enable the user to estimate whole-body activity concentrations, and hence dose rates, during more detailed assessments (Tiers 2 and 3 within the ERICA Integrated Approach). An environmental media concentration limit is defined as the activity

¹Note that whilst the ERICA-Tool has two terrestrial mammal reference organisms, Mammal (Rat) and Mammal (Deer), the same CR values are used for both. The distinction was introduced to enable the application of geometries proposed by the ICRP (2005) within dosimetric calculations.

concentration in the selected media (soil or air in terrestrial environments, water or sediment in aquatic environments) that would result in a dose-rate to the most exposed reference organism equal to the screening dose-rate (see Brown et al. this issue). To calculate the EMCL values used in Tier 1 a complete set of CR values was required (i.e. a total of 403 CR values for terrestrial biota). As the EMCL values are determined using a Monte Carlo approach, the specification of probability distribution functions, and where possible, standard deviations for the CRs values were also required. The probability distribution functions and standard deviations also provide the default values to enable probabilistic assessments using Tier 3 of the ERICA-Tool. Further details of the derivation of the ERICA-Tool EMCL values and the tiered assessment approach adopted within the ERICA Integrated Approach are given in Beresford et al. (2007a), Larsson (this issue) and Brown et al. (this issue).

2. Approaches

2.1 Literature review and data manipulation

The existing CR databases of the FASSET (Brown et al. 2003a) and EPIC (Brown et al. 2003b; Beresford et al. 2005) projects provided the starting point for our literature review. These databases have been supplemented and extended to encompass the greater number of radionuclides and modified suite of reference organisms considered within the ERICA integrated approach. Efforts were targeted at improving CR values for which the FASSET/EPIC databases had relatively few values and providing values for the additional reference organism-radionuclide combinations. Little effort was put into finding additional data for reference organism-radionuclide combinations when the FASSET/EPIC values were already based on many (>100) data (namely Cs and Sr data for some of those reference organisms considered in all three projects). For compilation of the ERICA databases, and implementation within the ERICA-Tool, different radioisotopes of a given element were all assumed to have the same CR value.

In preference, original references were consulted rather than adopting values recommended in reviews; where original references were not available and review values were used, this is noted with the ERICA-Tool databases (see section 2.2).

Data were often not available in the format required. Issues which had to be addressed were: (i) reporting of biota activity concentrations on a dry or ash weight basis; (ii) data available only for specific tissues (i.e. not whole-body); and, (iii) soil activity concentrations being presented as Bq m^{-2} .

Where information was not given within the source publications, to enable manipulation of the data into the format required for the ERICA default databases a set of standard assumptions were followed. Tables 1 and 2, respectively, present: conversion factors for data presented on an ash or dry weight basis to fresh weight; assumed percentages of total animal live-weight of required tissues and; distribution of radionuclides within different tissues for terrestrial systems. Corresponding information for aquatic systems is presented in Hosseini et al. (this issue). If source publications lacked the required information to convert soil activities from Bq m^{-2} to Bq kg^{-1} , a dry weight soil bulk density of 1400 kg m^{-3} and a sampling depth of 10 cm were assumed. All assumptions and

manipulations applying to a given data entry are recorded in the underlying databases but not in the summarised databases presented within the ERICA-Tool.

For terrestrial ecosystems, data collected during either the period of above ground nuclear weapons testing fallout (assumed to be before 1970) or the year of the Chernobyl accident (1986) were not used to derive transfer parameter values for radionuclides of Cs, Pu, Sr and Am to avoid effects of surface contamination of vegetation. Some CR values were derived using stable element data; in terrestrial ecosystems these data were often associated with studies of heavy metal pollution and only data from control ('uncontaminated') sites were used.

With the exception of data for reindeer, data for any species falling within a given reference organism category were used in the review. Reindeer data were excluded as the air-lichen-reindeer pathway is unlikely to be representative of contamination routes for other terrestrial mammals and is likely to result in over predictions for the mammal reference organism category. The FASSET database (Brown et al. 2003a) did contain data for reindeer. For instance, the FASSET ^{210}Po CR value for herbivorous mammals was based solely on reindeer data. FASSET predictions of ^{210}Po activity concentrations in mammals were two to four orders of magnitude higher than those of other approaches in an international comparison exercise (see Beresford et al. submitted). Hence, alternative data were identified for ^{210}Po on which mammal CR values could be estimated for the ERICA default value. For consistency, reindeer data were excluded from the review of all radionuclides.

Where possible weighted (with respect to sample numbers and reported standard deviations) arithmetic mean CR values and standard deviations were estimated. Lack of information in some source publications again resulted in some assumptions and compromises having to be made to achieve this. These were: (i) a sample number of one was assumed if information on replication was not given and no error term was reported; (ii) if a measure of error (e.g. standard deviation or standard error) was reported without a sample number it was assumed that the sample number was three; and, (iii) if a measure of error was reported for either only media or biota activity concentrations this was carried through (proportionally) to give a standard deviation estimate on the calculated CR values; (iv) a sample number of two was assumed if a minimum and maximum were reported with no details of sample replication. However, for reference organism-radionuclide combinations for which there were many reported values, references which did not give all the required information were rejected.

The resultant default CR values and associated standard deviations are presented in Tables 3-15; source references are identified in Table 16. As noted above, probability distribution functions are used within the ERICA-Tool and the derivation of EMCL values. When standard deviations were available for default CR values, lognormal distribution functions were assumed. If no standard deviation was available then an exponential probability distribution function was assumed (for justification see Brown et al. this issue).

2.2 Approach taken to providing default values if CR values not identified by literature review

Of the 403 CR values required for terrestrial reference organisms, 129 were identified

by the literature review. It was not possible to derive a complete set of literature derived CR values for any radionuclide or any reference organism. To provide the remaining required default CR values an approach was developed based upon that originally described by Coppelstone et al. (2003) and later adapted by Brown et al. (2003a). The approach, described below, was the same for terrestrial and aquatic ecosystems (see Hosseini et al. (this issue) for application within the marine and freshwater ecosystems). The first four options described below were used in preference. With the exception of the last two options described, which were used as last resorts, the remaining options were applied depending upon availability of information (i.e. none were favoured more than others). Tables 3-15 present the complete default CR database as included in the ERICA-Tool for terrestrial reference organisms (as of July 2007). The approach used to derive each default value is identified in each table (and is evident to the user within the ERICA-Tool). The options used to provide default CR values, when values could not be derived from the literature, were:

1. *Use an available CR value for an organism of similar taxonomy within that ecosystem for the radionuclide under assessment (preferred option).* An example of application to derive default values in the ERICA terrestrial database was assuming values for (e.g.) flying insects were applicable to other terrestrial invertebrate reference organisms (see Tables 7,8 and 14 for examples). Note where there was more than one available value for various taxonomically similar reference organisms, then the highest available CR was generally used to provide missing values.

2. *Use an available CR value for a similar reference organism (preferred option).* Examples of use to derive default values in the ERICA databases were applying available CR values for one vertebrate reference organism to other vertebrate reference organisms. As above where, there was more than one available value for various similar reference organism then the highest available CR was generally used to provide missing values (e.g. the literature derived Th CR value for birds (Table 4) was higher than that for mammals (Table 11) and hence the bird value was assumed in the default database for amphibians and reptiles (Tables 3 and 12) as data were not available for these two reference organisms).

3. *Use CR values recommended in previous reviews or derive them from previously published reviews (preferred option).* For instance, in some cases, it was necessary to use broad reviews of stable element concentrations in media and biota to derive CR values or adopt previously recommended values without being able to go back to the source reference to confirm these (examples are clearly illustrated in Tables 3-7 and 9-15).

4. *Use specific activity models for ^3H and ^{14}C (preferred option).* No attempt was made to derive CR values for these two radionuclides from the literature. To derive CR values for ^3H and ^{14}C to FASSET and EPIC reference organisms specific activity models (described by Galeriu et al. (2005) and Brown et al. (2003a,b)) were developed. These were used to provide the default CR values for ^3H and ^{14}C within the ERICA-Tool where available. If CR values were not available for specific reference organisms one of the above three approaches was used (e.g. the ^{14}C CR value from FASSET for mammals (Table 11) was used to provide the default ERICA value for amphibians (Table 3)).

5. *Use an available CR value for the given reference organism for an element of similar biogeochemistry.* To derive default values in the ERICA database for terrestrial biota this option involved the following: available CRs for transuranic and lanthanide elements were assumed if CRs were not available for a member of these series; Zr CRs assumed for Nb; Se CRs assumed for Te. Again where there was more than one available CR value for biogeochemical similar elements for the reference organism in question then the highest available value was generally assumed.

6. *Use an available CR value for biogeochemically similar elements for organisms of similar taxonomy.* Examples of this option were: Th and Zr CR values for terrestrial invertebrates were assumed to be the same as those available for available U and Nb respectively (Tables 7, 8 and 14).

7. *Use an available CR value for biogeochemically similar elements available for a similar reference organism.* This option was used to derive some missing actinide CRs for terrestrial vertebrates (e.g. the Am CR for mammals was used to provide the default Cm CR for amphibians, birds and reptiles (Tables 3, 4 and 12)).

8. *Use allometric relationships, or other modelling approaches, to derive appropriate CRs* Examples of application to derive default values in the ERICA databases are: (i) the use of allometric (body weight dependent, see Higley et al. (2003b)) relationships to predict CRs for terrestrial mammals (Table 11); (ii) CRs for wild bird eggs were derived from the available CRs for wild birds and published relationships between radionuclide activity concentrations in eggs and meat of domestic poultry (taken from IAEA 1994) (Table 5).

9. *Assume the highest available CR (least preferred option).* For the terrestrial database this option was only used to provide Po and Tc CR values for invertebrate reference organisms (Tables 7, 8 and 14) and the Tc CR value for the lichen and bryophytes reference organism (Table 10).

In Tables 3-15, and the ERICA-Tool database, a CR value derived by one of the above approaches is coded by the number of the option used from the above description. For CR values derived by these approaches exponential probability distribution functions were generally assumed (see Brown et al. this issue).

In some instances, it was necessary to use combinations of the above approaches (e.g. the Zr CR value for amphibians was assumed to be the same as that for mammals which in itself was derived from a whole-body:diet concentration ratio (Table 11)). All CR values for P in terrestrial ecosystems fall into this category as it was assumed, due to the lack of available data, that the C CR values, derived from specific activity models, could be used for P (following the suggestion of Copplestone et al. (2003) that this should provide conservative CR values for P). This approach of combining rules is given the code number 11 within Tables 3-15 (note code number 10 denotes an option used in aquatic ecosystems only (Hosseini et al. this issue)).

On a few occasions the approaches outlined above were used in preference to values derived from the literature review for reasons of judgements made with regard to data quality/quantity. For instance, the default Pu CR value for birds was assumed to be the same as the value for mammals (based on 123 observations) rather than using the one value

identified in the literature for birds (Brisbin et al. 1993) as the reference contained four (out of a total of six) measurements recorded as '0'.

For a number of reference organisms, most notably amphibians (Table 3), birds (Table 4), bird eggs (Table 5) and reptiles (Table 12), the majority of CR values were derived by the approaches outlined above as data were unavailable.

The CR values derived by the methods described above are clearly identified within the ERICA-Tool databases and highlighted on appropriate screens within the Tool (within Tier 2 and 3 assessments) to prompt the user to review and edit the parameters as appropriate (Brown et al. this issue).

Tables 3-15 present the default terrestrial database as of July 2007 which will be updated periodically as new information becomes available, using the methodology described in this paper.

3. Discussion

It is not our intention to provide a critique of the default CR values provided within the ERICA-Tool, the aim of this paper is to provide a description of the provenance for the default terrestrial CR dataset used within the ERICA-Tool. However, the ERICA terrestrial (and freshwater) CR values have been used in a model-model inter-comparison exercise of eight models by an IAEA working group (Beresford et al. submitted). The exercise included 13 elements and was applicable to five of the terrestrial reference organisms considered within the ERICA-Tool. The main finding of the exercise was that generally there was considerable variation, over orders of magnitude, between the predictions of the various models. It was concluded that future efforts be concentrated on the transfer components of the models as these are the major contributor to predicted variability in exposure estimates (see also Vives i Batlle 2007; Beresford et al. in press). Whilst, the exercise did not make any judgments with regard to the 'correct' prediction, reference organism-radionuclide combinations for which ERICA predicted outlying values compared to the other models, will be further investigated and the CR database modified if appropriate (the outlying predictions for terrestrial biota were comparatively high predictions for I transfer to bird eggs and comparatively low predictions for U transfer to herbivorous mammals and Sr to earthworms). Participation in this exercise led to the refinement of terrestrial mammal CR values by identifying that reindeer data needed to be excluded (as discussed above).

Towards the end of the development of the ERICA-Tool, a number of case study assessments were conducted including three sites for terrestrial environments. These were a coastal sand dune ecosystem close to the Sellafield reprocessing plant (UK), terrestrial ecosystems within the Chernobyl 30 km exclusion zone and areas with high levels of natural radionuclides in the Komi Republic (Russia) (Beresford et al. 2007b; Wood et al. this issue; Beresford et al. this issue). These case studies enabled comparisons of predicted and observed activity concentrations for a wide range of biota and radionuclides. In summary, the findings of the case studies with respect to the CR values were:

- *Chernobyl* (Beresford et al. 2007b; this issue) – whole-body ^{137}Cs , ^{90}Sr , ^{241}Am and Pu-isotope activity concentrations were typically predicted to be within one-order of

magnitude of the observed data. However, for some small mammal data the 95th percentile prediction was lower than the observed data range for ¹³⁷Cs and ⁹⁰Sr.

- *Coastal sand dune ecosystem* (Beresford et al. 2007b; Wood et al. this issue) – ¹³⁷Cs activity concentrations were consistently over predicted although there was reasonable agreement for ²⁴¹Am, ⁹⁰Sr, ²³⁹⁺²⁴⁰Pu and ⁹⁹Tc for all animal types. Activity concentrations of ²⁴¹Am were consistently under-predicted probably as a consequence of the main contamination route at this site being sea-land transfer.
- *Komi Republic* (Beresford et al. 2007b) – measured ²²⁶Ra activity concentrations were within predicted ranges for grasses, herbs and shrubs. However, ²²⁶Ra activity concentrations for trees were considerably under predicted. Comparisons of predicted and observed activity concentrations of ²³²Th and ²³⁸U in all vegetative reference organisms varied between different sites. The few data available for small mammals showed reasonable agreement for ²²⁶Ra but under-prediction of ²³⁸U and ²³²Th.

A few CR values were amended following the case study applications to incorporate novel data collected for the case studies and Tables 3-15 contain these revised values.

The organism-radionuclide combinations considered within the coastal sand dune case study included some of the most poorly represented within the ERICA-Tool CR database (because of the lack of reported data). Many of the CR values used in this case study were therefore based upon the approaches described above (see section 2.2) to derive default values. These include: Am and Pu CR values for birds, amphibians and reptiles; most Tc CR values and; the Cs CR value for reptiles (see Wood et al. this issue). The reasonable agreement between predictions and observations for most of these organism-radionuclides is therefore encouraging with regard to the approaches taken to provide default CR values within the ERICA Tool when empirical data were unavailable.

4. Conclusions

This paper has described the derivation of the default CR database for the terrestrial ecosystem within the ERICA-Tool presenting the default terrestrial database as available July 2007. The information provided gives the user of the ERICA-Tool with the ability to make more informed decisions on the use of the default CR database (note all CR values can be edited by the user if they wish). The ERICA-Tool will continue to participate within international comparison exercises (see <http://www-ns.iaea.org/projects/emras/emras-biota-wg.htm> and <http://www.ceh.ac.uk/PROTECT/>) and the CR databases will be updated as new information becomes available.

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The ERICA-Tool is freely available from: <http://www.project.facilia.se/erica/download.html>.

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Table 1. Assumed ash or dry weight to fresh weight conversion factors (expressed as ash or dry weight as a fraction of fresh weight).

Organism	Dry weight fraction	Ash weight fraction	Reference
Lichen	0.36	0.07	CEH ⁺ ; Sheard et al. (1988)
Grass/herb	0.25	N/R	CEH
Shrub (wood)	0.5	0.013	Assumed to be same as tree wood
Shrub (other parts)	0.1	0.003	CEH; Sheard et al. (1988)
Tree (wood)	0.5	0.013	Sheard et al. (1988); http://www.woodycrops.org/mechconf/nurmi.html
Tree (other parts)	0.1	0.003	Assumed to be the same as shrub
Small mammals (whole-body)	0.3	N/R	D. Copplestone (Environment Agency, UK) pers comm.
Mammal (bone)	0.8	0.5	CEH
Mammal (muscle)	0.25	N/R	CEH
Amphibians (whole-body)	0.21	N/R	S. Gaschak (IRL Slavutych, Ukraine) pers. comm.
Bird (whole-body)	0.3	N/R	Assumed to be same as small mammal
Detritivorous invertebrate	0.25	0.024	CEH; Mietelski et al. (2004)
Flying insect	0.25	N/R	Assumed to be the same as detritivorous invertebrate
Soil invertebrate (worm)	0.17	N/R	CEH
Gastropod	0.2	N/R	Gasó et al. (2002)

⁺Centre for Ecology Hydrology - in house measurements from various studies of the lead authors.
N/R – not required for this work.

Table 2. Assumed organ weights as percentage of live-weight and body distribution of radionuclides.

Organism	Radionuclide	Assumption	Reference
<i>Assumed organ weights as percentage of live-weight.</i>			
Mammal		Bone comprises 10% of body	CEH ⁺
Bird		Bone comprises 7% of live-weight	S. Gaschak (IRL Slavutych, Ukraine) pers. comm.
Bird		Bird is 25% muscle by dry matter	Brisbin (1993)
<i>Assumed distribution of radionuclides</i>			
Mammal	Am	45% body burden in bone	Coughtrey et al. (1984b)
Mammal	Cs, U, Th	Muscle assumed to represent whole-body	Coughtrey & Thorne (1983b) (Cs); assumed same as birds (U & Th)
Mammal	Pb	70% body burden in bone	Morgan (1991)
Mammal	Po	60% body burden in bone	ICRP (1979)
Mammal	Pu	45% body burden in bone	Coughtrey et al. (1984a)
Mammal	Sr	90% body burden in bone	Coughtrey & Thorne (1983b)
Bird	Cs, U, Th	Muscle/soft tissues assumed to represent whole-body	Assumed to be the same as for mammals (Cs); Beresford et al. (2007c) (U & Th)
Bird	Pu	55% body burden in bone	Assumed to be the same as mammal
Plants	All	Uniform distribution	

⁺In house measurements from various studies of the lead authors.

Table 3. The ERICA-Tool default CR values for amphibians.

Element	Mean	SD	n	Method[†]	Reference*
Ag	2.86E-01			(11) Assumes Ag CR value for mammal	-
Am	4.08E-02			(2) Assumes Am CR value for mammal	-
C	1.34E+03			(2) Assumes C CR value for mammal	-
Cd	1.47E-02	7.86E-03	5	Literature review	1
Ce	6.13E-04			(11) Assumes Ce CR value for mammal	-
Cl	7.00E+00			(11) Assumes Ag CR value for mammal	-
Cm	4.08E-02			(7) Assumes Am CR value for mammal	-
Co	2.95E-01			(2) Same as mammal	-
Cs	5.37E-01	8.97E-01	107	Literature review	3-6
Eu	2.04E-03			(11) Assumes Eu CR value for mammal	-
H	1.50E+02			(2) Assumes H CR value for mammal	-
I	4.00E-01			(11) Assumes I CR value for mammal	-
Mn	2.49E-03			(11) Assumes Mn CR value for mammal	-
Nb	1.90E-01			(2) Assumes Nb CR value for mammal	-
Ni	7.15E-02			(2) Assumes Ni CR value for mammal	-
Np	4.08E-02			(7) Assumes Am CR value for mammal	-
P	1.34E+03			(11) Assumes C CR value for mammal	-
Pb	1.20E-01	5.20E-01	24	Literature review	7,8
Po	2.78E-03			(2) Assumes Po CR value for mammal	-
Pu	2.34E-02			(2) Assumes Pu CR value for mammal	-
Ra	3.62E-02			(2) Assumes Ra CR value for bird	-
Ru	1.20E-01			(11) Assumes Ru CR value for mammal	-
S	5.0E+01			(3) Assumes value of Copplestone et al. (2001)	-
Sb	2.15E-06			(11) Assumes Sb CR value for mammal	-
Se	6.32E-02			(2) Assumes Se CR value for mammal	-
Sr	8.25E-01	1.22E+00	21	Literature review	4,6
Tc	5.75E-01	5.30E-01	2	Literature review	6
Te	2.08E-01			(2) Assumes Te CR value for mammal	-
Th	3.89E-04			(2) Assumes Th CR value for bird	-
U	4.98E-04			(2) Assumes U CR value for bird	-
Zr	1.19E-05			(11) Assumes Zr CR value for mammal	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

*See Table 16.

Table 4. The ERICA-Tool default CR values for birds.

Element	Mean	SD	n	Method[†]	Reference*
Ag	2.86E-01			(11) Assumes Ag CR value for mammal	-
Am	4.08E-02			(2) Assumes Am CR value for mammal	-
C	1.34E+03			(4) Specific activity model (Brown et al. 2003b; Galeriu et al. 2005)	-
Cd	2.00E+00			(2) Assumes Cd CR value for mammal	-
Ce	6.13E-04			(11) Assumes Ce CR value for mammal	-
Cl	7.00E+00			(11) Assumes Cl CR value for mammal	-
Cm	4.08E-02			(7) Assumes Am CR value for mammal	-
Co	2.95E-01			(2) Assumes Co CR value for mammal	-
Cs	7.50E-01	1.65E+00	158	Literature review	6,9-16
Eu	2.04E-03			(11) Assumes Eu CR value for mammal	-
H	1.50E+02			(4) Specific activity model (Brown et al. 2003b; Galeriu et al. 2005)	-
I	4.00E-01			(11) Assumes I CR value for mammal	-
Mn	2.49E-03			(11) Assumes Mn CR value for mammal	-
Nb	1.90E-01			(2) Assumes Nb CR value for mammal	-
Ni	7.15E-02			(2) Assumes Ni CR value for mammal	-
Np	4.08E-02			(7) Assumes Am CR value for mammal	-
P	1.34E+03			(11) Assumes C CR value for bird	-
Pb	6.15E-02	1.73E-01	424	Literature review	15,17
Po	2.78E-03			(2) Assumes Po CR value for mammal	-
Pu	2.34E-02			(2) Assumes Pu CR value for mammal	-
Ra	3.62E-02		>29	Literature review	18,19
Ru	1.20E-01			(11) Assumes Ru CR value for mammal	-
S	5.0E+01			(3) Assumes value of Copplestone et al. (2001)	-
Sb	2.15E-06			(11) Assumes Sb CR value for mammal	-
Se	6.32E-02			(2) Assumes Se CR value for mammal	-
Sr	5.49E-01	9.94E-01	69	Literature review	6,9-11,13,15,16
Tc	2.70E-01		1	Literature review	6
Te	2.08E-01			(2) Assumes Te CR value for mammal	-
Th	3.89E-04		Unknown	Literature review	19
U	5.41E-04		Unknown	Literature review	19
Zr	1.19E-05			(11) Assumes Zr CR value for mammal	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

*See Table 16.

Table 5. The ERICA-Tool default CR values for bird eggs.

Element	Mean	SD	n	Method [†]	Reference*
Ag	2.86E-01			(11) Assumes Ag CR value for mammal	-
Am	4.08E-02			(2) Assumes Am CR value for mammal	-
C	8.90E+02			(4) Specific activity model (Brown et al. 2003a; Galeriu et al. 2005)	-
Cd	2.00E+00			(2) Assumes Cd CR value for mammal	-
Ce	6.13E-04			(11) Assumes Ce CR value for mammal	-
Cl	7.00E+00			(11) Assumes Cl CR value for mammal	-
Cm	4.08E-02			(7) Assumes Am CR value for mammal	-
Co	2.95E-01			(2) Assumes Co CR value for mammal	-
Cs	3.00E-02	6.60E-02		(8) Ratio of egg:meat concentrations (of 0.04) for domestic poultry estimated from IAEA (1994) applied to CR value for bird (whole-body). Ratio applied to mean and SD	-
Eu	2.04E-03			(11) Assumes Eu CR value for mammal	-
H	1.50E+02			(4) Specific activity model (Brown et al. 2003a; Galeriu et al. 2005)	-
I	1.60E+02			(11) Ratio of egg:meat concentrations (of 400) for domestic poultry estimated from IAEA (1994) applied to CR value for mammal (whole-body)	-
Mn	2.49E-03			(11) Assumes Mn CR value for mammal	-
Nb	5.71E-01			(8) Ratio of egg:meat concentrations (of 3.0) for domestic poultry estimated from IAEA (1994) applied to CR value for mammal (whole-body). Ratio applied to mean and SD.	-
Ni	7.15E-02			(2) Assumes Ni CR value for mammal	-
Np	4.08E-02			(7) Assumes Am CR value for mammal	-
P	8.90E+02			(11) Assumes C CR value for bird egg	-
Pb	6.15E-02			(1) Assumes Pb CR value for bird	-
Po	2.78E-03			(1) Assumes Po CR value for mammal	-
Pu	2.34E-02			(2) Assumes Pu CR value for bird	-
Ra	3.62E-02			(1) Assumes Ra CR value for bird	-
Ru	1.20E-01			(11) Assumes Ru CR value for mammal	-
S	5.0E+01			(3) Assumes value of Copplesstone et al. (2001)	-
Sb	2.15E-06			(11) Assumes Sb CR value for mammal	-
Se	6.32E-02			(2) Assumes Se CR value for mammal	-
Sr	1.37E+00	2.49E+00		(8) Ratio of egg:meat concentrations (of 2.5) for domestic poultry estimated from IAEA (1994) applied to CR value for bird (whole-body). Ratio applied to mean and SD.	-
Tc	2.70E+01			(11) Ratio of egg:meat concentrations (of 100) for domestic poultry estimated from IAEA (1994) applied to CR value for bird (whole-body).	-
Te	2.08E+00			(8) Ratio of egg:meat concentrations (of 10) for domestic poultry estimated from IAEA (1994) applied to CR value for mammal (whole-body)	-
Th	3.89E-04			(1) Assumes Th CR value for bird	-
U	5.41E-04			(8) Ratio of egg:meat concentrations (of 1.0) for domestic poultry estimated from IAEA (1994) applied to CR value for bird (whole-body)	-
Zr	1.19E-05			(11) Assumes Zr CR value for mammal	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

*See Table 16.

Table 6. The ERICA-Tool default CR values for detritivorous invertebrate.

Element	Mean	SD	n	Method [†]	Reference*
Ag	7.00E-01			(3) Estimated from stable Ag data presented for Insecta (Bowen 1966) and soils (Coughtrey & Thorne 1983a)	-
Am	1.01E-01	2.18E-01	61	Literature review	20,21
C	4.30E+02			(1) Assumes C CR value for soil invertebrate	-
Cd	2.11E+00	9.33E-01	411	Literature review	22-25
Ce	3.66E-04			(1) Assumes Ce CR value for soil invertebrate	-
Cl	3.04E-01	1.20E-01	31	Literature review	26
Cm	1.37E-01	6.03E-02	2	Literature review	27
Co	3.52E-03		Unknown	Literature review	28
Cs	1.34E-01	5.56E-01	127	Literature review	20,21, 29-33
Eu	7.93E-04			(1) Assumes Eu CR value for soil invertebrate	-
H	1.50E+02			(1) Assumes H CR value for soil invertebrate	-
I	3.01E-01	1.35E-01	32	Literature review	26
Mn	4.65E-02			(1) Assumes Mn CR value for gastropod	-
Nb	5.05E-04			(1) Assumes Nb CR value for soil invertebrate	-
Ni	8.55E-03		Unknown	Literature review	28
Np	1.01E-01			(6) Assumes Am CR value for gastropod	-
P	4.30E+02			(11) Assumes C CR value for soil invertebrate	-
Pb	7.53E-01	4.06E-01	288	Literature review	24,34,35
Po	2.78E-03			(9) Assumes maximum available Po CR value for animals (mammal)	-
Pu	3.88E-02	6.46E-02	91	Literature review	20,21,36
Ra	9.00E-02		Unknown	Literature review	18,32
Ru	6.37E-03			(1) Assumes Ru CR value for flying insect	-
S	5.0E+01			(3) Assumes value of Copplesstone et al. (2001)	-
Sb	2.53E-01			(1) Assumes Sb CR value for gastropod	-
Se	1.48E+00			(1) Assumes Se CR value for soil invertebrate	-
Sr	4.07E-01	1.93E+00	31	Literature review	27,30,31
Tc	3.70E-01			(9) Assumes maximum available Tc CR value for animals (mammal)**	-
Te	3.83E-02			(11) Assumes Te CR value for gastropod	-
Th	8.84E-03			(6) Assumes Th CR value for soil invertebrate	-
U	8.84E-03			(1) Assumes U CR value for soil invertebrate	-
Zr	5.05E-04			(6) Assumes Nb CR value for soil invertebrate	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

**Note this is the value currently (July 2007) in the ERICA-Tool database however it should be replaced with that for amphibian (of 5.75×10^{-1}) (see Table 3) which became available late within the ERICA project.

*See Table 16.

Table 7. The ERICA-Tool default CR values for flying insects.

Element	Mean	SD	n	Method ⁺	Reference*
Ag	7.00E-01			(3) Estimated from stable Ag data for Insecta (Bowen 1966) and soils (Coughtrey & Thorne 1983a)	-
Am	1.27E-01	4.03E-01	25	Literature review	20,21
C	4.30E+02			(1) Assumes C CR value for soil invertebrate	-
Cd	2.04E+01	6.97E+00	29	Literature review	22
Ce	3.66E-04			(1) Assumes Ce CR value for soil invertebrate	-
Cl	3.04E-01			(1) Assumes Cl CR value for detritivorous invertebrate	-
Cm	1.37E-01			(1) Assumes Cm CR value for detritivorous invertebrate	-
Co	6.08E-03	5.09E-03	17	Literature review	28,37
Cs	5.51E-02	2.19E-01	>67	Literature review	20,21,29,31,37
Eu	7.93E-04			(1) Assumes Eu CR value for soil invertebrate	-
H	1.50E+02			(1) Assumes H CR value for soil invertebrate	-
I	3.01E-01			(1) Assumes I CR value for detritivorous invertebrate	-
Mn	4.65E-02			(1) Assumes Mn CR value for gastropod	-
Nb	5.05E-04			(1) Assumes Nb CR value for soil invertebrate	-
Ni	8.55E-03		Unknown	Literature review	28
Np	1.27E-01			(5) Assumes Am CR value for flying insect	-
P	4.30E+02			(11) Assumes C CR value for soil invertebrate	-
Pb	6.09E-02	1.26E-02	18	Literature review	34,38
Po	2.78E-03			(9) Assumes maximum available Po CR value for animals (mammal)	-
Pu	1.69E-02	1.77E-02	25	Literature review	20,21,39
Ra	9.00E-02			(1) Assumes Ra CR value for detritivorous invertebrate	-
Ru	6.37E-03	7.62E-03	16	Literature review	37
S	5.0E+01			(3) Assumes value of Copplestone et al. (2001)	-
Sb	2.53E-01			(1) Assumes Sb CR value for gastropod	-
Se	1.48E+00			(1) Assumes Se CR value for soil invertebrate	-
Sr	6.32E-02		>20	Literature review	31
Tc	3.70E-01			(9) Assumes maximum available Tc CR value for animals (mammal)**	-
Te	3.83E-02			(11) Assumes Te CR value for gastropod	-
Th	8.84E-03			(6) Assumes U CR value for soil invertebrate	-
U	8.84E-03			(1) Assumes U CR value for soil invertebrate	-
Zr	5.05E-04			(6) Assumes Nb CR value for soil invertebrate	-

⁺Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

**Note this is the value currently (July 2007) in the ERICA-Tool database however it should be replaced with that for amphibian (of 5.75×10^{-1}) (see Table 3) which became available late within the ERICA project.

*See Table 16.

Table 8. The ERICA-Tool default CR values for gastropods.

Element	Mean	SD	n	Method[†]	Reference*
Ag	7.00E-01			(1) Assumes Ag CR value for flying insect	-
Am	1.99E-01	1.42E-01	8	Literature review	21
C	4.30E+02			(1) Assumes C CR value for soil invertebrate	-
Cd	6.43E-01	4.69E-01	47	Literature review	40
Ce	3.66E-04			(1) Assumes Ce CR value for soil invertebrate	-
Cl	1.66E-01	1.05E-01	20	Literature review	26
Cm	1.37E-01			(1) Assumes Cm CR value for detritivorous invertebrate	-
Co	6.08E-03			(1) Assumes Co CR value for flying insect	-
Cs	4.27E-02	2.89E-02	18	Literature review	21,41
Eu	7.93E-04			(1) Assumes Eu CR value for soil invertebrate	-
H	1.50E+02			(1) Assumes H CR value for soil invertebrate	-
I	1.80E-01	5.65E-02	12	Literature review	26
Mn	4.65E-02	1.64E-02	7	Literature review	41
Nb	5.05E-04			(1) Assumes Nb CR value for soil invertebrate	-
Ni	1.78E-02	1.02E-02	7	Literature review	41
Np	1.99E-01			(6) Assumes Am CR value for soil invertebrate	-
P	4.30E+02			(11) Assumes C CR value for soil invertebrate	-
Pb	7.27E-03	1.29E-02	47	Literature review	40,41
Po	2.78E-03			(9) Assumes maximum available Po CR value for animals (mammal)	-
Pu	1.12E-01	8.58E-02	8	Literature review	21
Ra	4.77E-02	4.81E-02	10	Literature review	41
Ru	6.37E-03			(1) Assumes Ru CR value for flying insect	-
S	5.0E+01			(1) Assumes S CR value for detritivorous invertebrate	-
Sb	2.53E-01	2.37E-01	7	Literature review	41
Se	3.47E-02	3.12E-02	7	Literature review	41
Sr	9.24E-02	3.16E-02	7	Literature review	41
Tc	3.70E-01			(9) Assumes maximum available Tc CR value for animals (mammal)**	-
Te	3.83E-02			(8) Assumes whole-body:diet CR from Madoz-Escande et al. (2005) with diet consisting of grass	-
Th	8.84E-03			(6) Assumes U CR value for soil invertebrate	-
U	8.84E-03			(1) Assumes U CR value for soil invertebrate	-
Zr	5.05E-04			(6) Assumes Nb CR value for soil invertebrate	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

**Note this is the value currently (July 2007) in the ERICA-Tool database however it should be replaced with that for amphibian (of 5.75×10^{-1}) (see Table 3) which became available late within the ERICA project.

*See Table 16.

Table 9. The ERICA-Tool default CR values for grasses and herbs.

Element	Mean	SD	n	Method [†]	Reference*
Ag	2.87E+00	3.68E+00	13	Literature review	43,44
Am	4.96E-03	4.95E-03	40	Literature review	45,46
C	8.90E+02			(4) Specific activity model (Brown et al. 2003a; Galeriu et al. 2005)	-
Cd	2.05E+00	2.03E+00	530	Literature review	22,23,47
Ce	7.50E-03			(1) Assumes value from IAEA (1994) for 'unspecified' crop	-
Cl	1.71E+01	1.63E+01	22	Literature review	48
Cm	2.75E-04		20	(3) Assumes value from IAEA (1994) for grass	-
Co	1.35E-02		112	(3) Assumes value from IAEA (1994) for grass	-
Cs	6.93E-01	1.08E+00	433	Literature review	33, 49-53
Eu	5.20E-03			(1) Estimated from stable element data presented for soils and angiosperms in Coughtrey & Thorne (1983b)	-
H	1.50E+02			(4) Specific activity model (Brown et al. 2003a; Galeriu et al. 2005)	-
I	1.40E-01	3.40E-01	39	Literature review	54
Mn	1.70E-01		100	(3) Assumes value from IAEA (1994) for grass	-
Nb	4.25E-02			(3) Assumes value from Lisk (1972)	-
Ni	1.88E-01	6.75E-01	111	Literature review	47
Np	1.72E-02		20	(3) Assumes values from IAEA (1994) for grass	-
P	8.90E+02			(11) Assumes C CR value for grasses & herbs	-
Pb	6.65E-02	2.16E-01	223	Literature review	47,55-57
Po	1.24E-01	3.22E-01	34	Literature review	55-57
Pu	1.44E-02	2.08E-02	73	Literature review	46,48
Ra	3.94E-02	5.23E-02	32	Literature review	55,56
Ru	2.00E-02		Unknown	Literature review	58
S	1.5E+02			(3) Assumes value of Copplestone et al. (2001)	-
Sb	2.50E-02			(3) Assumes value from Coughtrey et al. (1983) for natural vegetation	-
Se	5.62E-01	2.18E+00	158	Literature review	47
Sr	2.07E-01	2.82E+00	33	Literature review	15,50
Tc	2.00E+01	1.28E+01	18	Literature review	45
Te	5.62E-01			(5) Assumes Se CR value for grasses & herbs	-
Th	4.37E-02	7.40E-02	12	Literature review	55
U	1.46E-02	4.38E-02	84	Literature review	55,56,59
Zr	5.30E-04			(1) Estimated from stable element data presented for soils and angiosperms in Coughtrey & Thorne (1983b)	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

*See Table 16.

Table 10. The ERICA-Tool default CR values for lichen and bryophytes.

Element	Mean	SD	n	Method [†]	Reference*
Ag	9.72E-02			Literature review	60
Am	1.03E-01			(5) Assumes Th CR value for lichen & bryophytes	-
C	8.90E+02			(2) Assumes C CR value for grasses & herbs	-
Cd	1.23E+00			(3) Estimated from stable element data (Bowen 1979); median soil and highest lichen/bryophyte concentrations used	-
Ce	4.03E-02			(3) Estimated from stable element data (Bowen 1979); median soil and highest lichen/bryophyte concentrations used	-
Cl	9.64E-01		1	Literature review	61
Cm	1.03E-01			(5) Assumes Th CR value for lichen & bryophytes	-
Co	2.16E-01			(3) Estimated from stable element data (Bowen 1979); median soil and highest lichen/bryophyte concentrations used	-
Cs	5.60E+00	4.14E+00	51	Literature review	15
Eu	6.84E-02			(3) Estimated from stable element data (Bowen 1979); median soil and highest lichen/bryophyte concentrations used	-
H	1.50E+02			(2) Assume same as grasses & herbs	-
I	3.60E-01			(3) Estimated from stable element data (Bowen 1979); median soil and highest lichen/bryophyte concentrations used	-
Mn	3.60E-04			(3) Estimated from stable element data (Bowen (1979); median soil and highest lichen/bryophyte concentrations used	-
Nb	1.62E-02			(3) Estimated from stable element data Bowen 1979); median soil and highest lichen/bryophyte concentrations used	-
Ni	8.64E-02			(3) Estimated from stable element data (Bowen 1979); median soil and highest lichen/bryophyte concentrations used	-
Np	1.03E-01			(5) Assumes Th CR value for lichen & bryophytes	-
P	8.90E+02			(11) Assumes C CR value for grasses & herbs	-
Pb	6.00E+00	4.55E+00	98	Literature review	15,16,62
Po	6.28E+00	3.39E+00	12	Literature review	15,62
Pu	1.03E-01			(5) Assumes Th CR value for lichen & bryophytes	-
Ra	2.12E-01	5.91E-02	15	Literature review	63
Ru	2.00E+01			(5) Assumes maximum CR value for lichen & bryophytes (Se)	-
S	1.5E+02			(3) Assumes value from Copplestone et al. (2001)	-
Sb	3.24E-01			(3) Estimated from stable element data (Bowen 1979); median soil and highest lichen/bryophyte concentrations used	-
Se	2.00E+01			(3) Estimated from stable element data presented for soils and lichen in Coughtrey et al. (1983)	-
Sr	8.68E+00	7.90E+00	55	Literature review	15
Tc	2.00E+01			(9) Assumes maximum CR value for lichen & bryophytes (Se)	-
Te	2.00E+01			(5) Assumes Se CR value for lichen & bryophytes	-
Th	1.03E-01	6.99E-02	18	Literature review	63
U	7.09E-02			Unknown	19
Zr	1.71E-02			(3) Estimated from stable element data (Bowen 1979); median soil and highest lichen/bryophyte concentrations used	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

*See Table 16.

Table 11. The ERICA-Tool default CR values for terrestrial mammals.

Element	Mean	SD	n	Method [†]	Reference*
Ag	2.86E-01			(11) Estimated from stable element data presented for soil and humans in Coughtrey & Thorne (1983a).	-
Am	4.08E-02	9.34E-02	121	Literature review	21, 64-67
C	1.34E+03			(4) Specific activity model (Brown et al. 2003a; Galeriu et al. 2005)	-
Cd	2.00E+00	2.82E+00	415	Literature review	22,68
Ce	6.13E-04			(8) Allometric prediction using USDoE (2002) and Beresford et al. (2005)	-
Cl	7.00E+00			(8) Model estimate (Brown et al. 2003a)	-
Cm	4.08E-02			(5) Assumes Am CR value for mammal	-
Co	2.95E-01	3.73E-01	29	Literature review	69
Cs	2.87E+00	4.25E+00	1784	Literature review	6,10,12-15, 20,21,65,70-73
Eu	2.04E-03			(8) Allometric prediction using USDoE (2002) and Beresford et al. (2005)	-
H	1.50E+02			(4) Specific activity model (Brown et al. 2003a; Galeriu et al. 2005)	-
I	4.00E-01			(8) Model estimate (Brown et al. 2003a)	-
Mn	2.49E-03	8.19E-04	4	Literature review	74
Nb	1.90E-01			(3) Estimated from stable element data presented for soil and (predominantly wild) animals in Coughtrey & Thorne (1983b).	-
Ni	7.15E-02	9.92E-02	2	Literature review	74
Np	4.08E-02			(7) Assumes Am CR value for mammal	-
P	1.34E+03			(11) Assumes C CR value for mammal	-
Pb	3.88E-02	3.57E-02	502	Literature review	34,42,68,75,76
Po	2.78E-03	1.57E-03	36	Literature review	42,77
Pu	2.34E-02	8.13E-02	123	Literature review	21,64-67,78
Ra	2.65E-02	3.40E-02	73	Literature review	19,42
Ru	1.20E-01			(8) Model estimate (Brown et al. 2003a)	-
S	5.0E+01			(3) Assumes value from Copplestone et al. (2001)	-
Sb	2.15E-06			(8) Assumes whole-body:diet CR from Beresford et al. (2004) with diet consisting of shrubs	-
Se	6.32E-02	3.81E-01	12	Literature review	79
Sr	1.74E+00	2.35E+00	196	Literature review	10,13,15,67
Tc	3.70E-01			(8) Model estimate (Brown et al. 2003a)	-
Te	2.08E-01			(3) Estimated from stable element data presented for soil and wild animals in Coughtrey et al. (1983).	-
Th	1.22E-04	1.77E-04	18	Literature review	42
U	1.06E-04	1.29E-04	2	Literature review	77
Zr	1.19E-05			(8) Assumes whole-body:diet CR from Beresford et al. (2004) with diet consisting of grass	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

*See Table 16.

Table 12. The ERICA-Tool default CR values for reptiles.

Element	Mean	SD	n	Method [†]	Reference*
Ag	2.86E-01			(11) Assumes Ag CR value for mammal	-
Am	4.08E-02			(2) Assumes Am CR value for mammal	-
C	1.34E+03			(2) Assumes C CR value for mammal	-
Cd	2.00E+00			(2) Assumes Cd CR value for mammal	-
Ce	6.13E-04			(11) Assumes Ce CR value for mammal	-
Cl	7.00E+00			(11) Assumes Cl CR value for mammal	-
Cm	4.08E-02			(7) Assumes Am CR value for mammal	-
Co	2.95E-01			(2) Assumes Co CR value for mammal	-
Cs	3.59E+00	9.91E+00	8	Literature review	6,30,80
Eu	2.04E-03			(11) Assumes Eu CR value for mammal	-
H	1.50E+02			(2) Assumes H CR value for mammal	-
I	4.00E-01			(11) Assumes I CR value for mammal	-
Mn	2.49E-03			(11) Assumes Mn CR value for mammal	-
Nb	1.90E-01			(2) Assumes Nb CR value for mammal	-
Ni	7.15E-02			(2) Assumes Ni CR value for mammal	-
Np	4.08E-02			(7) Assumes Am CR value for mammal	-
P	1.34E+03			(11) Assumes C CR value for mammal	-
Pb	6.15E-02			(2) Assumes Pb CR value for bird	-
Po	2.78E-03			(2) Assumes Po CR for mammal	-
Pu	2.34E-02			(2) Assumes Pu CR for mammal	-
Ra	3.62E-02			(2) Assumes Ra CR value for bird	-
Ru	1.20E-01			(11) Assumes Ru CR value for mammal	-
S	5.0E+01			(3) Assumes value from Copplestone et al. (2001)	-
Sb	2.15E-06			(11) Assumes Sb CR value for mammal	-
Se	6.32E-02			(2) Assumes Se CR value for mammal	-
Sr	1.18E+01	2.35E+01	4	Literature review	6,30,80
Tc	3.70E-01			(11) Assumes Tc CR value for mammal	-
Te	2.08E-01			(2) Assumes Te CR value for mammal	-
Th	3.89E-04			(2) Assumes Th CR value for bird	-
U	4.98E-04			(2) Assumes U CR value for bird	-
Zr	1.19E-05			(11) Assumes Zr CR value for mammal	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

*See Table 16.

Table 13. The ERICA-Tool default CR values for shrubs.

Element	Mean	SD	n	Method [†]	Reference*
Ag	6.18E+00			(3) Estimated from stable element data for soils, woody angiosperms and woody gymnosperms presented in Bowen (1979)	-
Am	4.96E-03			(1) Assumes Am CR value for grasses & herbs	-
C	8.90E+02			(1) Assumes C CR value for grasses & herbs	-
Cd	6.23E-01	1.07E+00	210	Literature review	47,81
Ce	4.86E-02	2.50E-01	64	Literature review	82
Cl	1.04E+00	2.06E+00	79	Literature review	61,82
Cm	9.35E-03			(1) Assumes Cm CR value for tree	-
Co	7.50E-01	5.42E+01	11	(3) Assumes value for understorey vegetation quoted by Smith & Beresford (2005)	-
Cs	3.97E+00	4.78E+00	196	Literature review	15,51,83,84
Eu	2.40E-01		12	(3) Assumes value for understorey vegetation quoted by Smith & Beresford (2005)	-
H	1.50E+02			(1) Assumes H CR value for grasses & herbs	-
I	1.40E-01			(1) Assumes I CR value for grasses & herbs	-
Mn	1.02E+00	2.60E+00	64	Literature review	82
Nb	3.40E-02			(3) Estimated from stable element data for soils, woody angiosperms and woody gymnosperms presented in Bowen (1979)	-
Ni	3.39E-02	7.46E-02	64	Literature review	82
Np	3.1E-01	4.07E+00	13	(3) Assumes CR for native vegetation from Coughtrey et al. (1984a).	-
P	8.90E+02			(11) EA R&D128 approach = C14	-
Pb	3.08E-01	5.29E-01	120	Literature review	56,59,82,84
Po	9.85E-02	6.15E-02	14	Literature review	15,56
Pu	3.15E-02			(3) Assumes value From Coughtrey et al. (1984a)	-
Ra	2.40E-02	9.00E-03	10	Literature review	56
Ru	4.89E-03		12	(3) Assumes value for understorey vegetation quoted by Smith & Beresford (2005)	-
S	1.5E+02			(3) Assumes value from Copplestone et al. (2001)	-
Sb	2.39E-03		12	(3) Assumes value for understorey vegetation quoted by Smith & Beresford (2005)	-
Se	1.81E+00	1.40E+00	73	Literature review	85
Sr	4.96E-02	5.12E-02	175	Literature review	15,82
Tc	2.00E+01			(1) Assumes Tc CR value for grasses & herbs	-
Te	1.81E+00			(5) Assumes Se CR value for shrub	-
Th	1.60E-02		?	Literature review	19
U	7.06E-03	1.44E-02	496	Literature review	56,59
Zr	9.43E-05	8.05E-05	64	Literature review	82

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

*See Table 16.

Table 14. The ERICA-Tool default CR values for soil invertebrates.

Element	Mean	SD	n	Method ⁺	Reference*
Ag	7.00E-01			(1) Assumes Ag CR value for flying insect	-
Am	9.99E-02	1.17E-01	12	Literature review	21
C	4.30E+02			(4) Specific activity model (Brown et al. 2003a; Galeriu et al. 2005)	-
Cd	2.10E+00	9.79E-01	15	Literature review	74,86,87
Ce	3.66E-04		Unknown	Literature review	87
Cl	1.78E-01	5.97E-02	17	Literature review	26
Cm	1.37E-01			(1) Assumes Cm CR value for detritivorous invertebrate	-
Co	6.08E-03			(1) Assumes Co CR value for flying insect	-
Cs	8.94E-02	1.64E-01	19	Literature review	21,87,89
Eu	7.93E-04		Unknown	Literature review	87
H	1.50E+02			(4) Specific activity model (Brown et al. 2003a; Galeriu et al. 2005)	-
I	1.56E-01	6.70E-02	10	Literature review	88
Mn	1.55E-02	9.10E-03	5	Literature review	74,87
Nb	5.05E-04		Unknown	Literature review	87
Ni	6.52E-02	6.82E-02	>77	Literature review	74,87,90,92
Np	9.99E-02			(5) Assumes Am CR value for soil invertebrate	-
P	4.30E+02			(11) Assumes C CR value for soil invertebrate	-
Pb	2.85E-02	4.40E-02	264	Literature review	17,34,74,86,87
Po	2.78E-03			(9) Assumes maximum available Po CR value for animals (mammal)	-
Pu	2.90E-02	3.15E-02	8	Literature review	21
Ra	9.00E-02			(1) Assumes Ra CR value for detritivorous invertebrate	-
Ru	6.37E-03			(1) Assumes Ru CR value for flying insect	-
S	5.0E+01			(3) Assumes value from Copplestone et al. (2001)	-
Sb	5.95E-03		Unknown	Literature review	87
Se	1.48E+00		Unknown	Literature review	93
Sr	8.97E-03			Literature review	87
Tc	3.70E-01			(9) Assumes maximum available Tc CR value for animals (mammal)**	-
Te	3.83E-02			(11) Assumes Te CR value for gastropod	-
Th	8.84E-03			(6) Assumes U CR value for soil invertebrate	-
U	8.84E-03		Unknown	Literature review	87
Zr	5.05E-04			(5) Assumes Nb CR value for soil invertebrate	-

⁺Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

**Note this is the value currently (July 2007) in the ERICA-Tool database however it should be replaced with that for amphibian (of 5.75×10^{-1}) (see Table 3) which became available late within the ERICA project.

*See Table 16.

Table 15. The ERICA-Tool default CR values for trees.

Element	Mean	SD	n	Method [†]	Reference*
Ag	6.18E+00			(3) Estimated from stable element data for soils, woody angiosperms and woody gymnosperms presented in Bowen (1979)	-
Am	1.07E-04			(8) Assumes CR value for fruit tree from Brown et al. (2003a)	-
C	1.30E+03			(4) Specific activity model (Coppelstone et al. 2001)	-
Cd	7.14E-01	1.26E+00	228	Literature review	
Ce	4.86E-02			(1) Assumes Ce CR value for shrub	-
Cl	1.42E+00	1.19E+00	11	Literature review	48
Cm	9.35E-03	1.08E-02	2	(3) Estimated from data presented by Coughtrey et al. (1984b)	-
Co	1.83E-02	1.53E-02	3	(3) Estimated from stable element data presented in Coughtrey & Thorne (1983a)	-
Cs	1.63E-01	2.54E-01	181	Literature review	12,51,94,95
Eu	2.40E-01			(1) Assumes Eu CR value for shrub	-
H	1.50E+02			(1) Assumes H CR value for grasses & herbs	-
I	1.40E-01			(1) Assumes I CR value for grasses & herbs	-
Mn	4.02E-02	5.25E-02	3	Literature review	96
Nb	3.40E-02			(1) Assumes Nb CR value for shrub	-
Ni	1.82E-02	4.27E-03	3	Literature review	96
Np	3.11E-01			(1) Assumes Np CR value for shrub	-
P	1.30E+03			(11) Assumes C CR value for tree	-
Pb	7.59E-02	1.10E-01	42	Literature review	56
Po	3.84E-02	2.24E-02	20	Literature review	56
Pu	3.15E-02			(1) Assumes Pu CR value for shrub	-
Ra	6.75E-04	7.52E-04	20	Literature review	56
Ru	4.89E-03			(1) Assumes Ru CR value for shrub	-
S	1.5E+02			(3) Assumes value from Coppelstone et al. (2001)	-
Sb	2.38E-03			(1) Assumes Sb CR value for shrub	-
Se	1.81E+00			(2) Assumes Se CR value for shrub	-
Sr	4.89E-01	1.51E-01	7	Literature review	12
Tc	2.70E-01			(8) Assumes CR value for fruit tree from Brown et al. (2003a)	-
Te	1.81E+00			(5) Assumes Se CR value for shrub	-
Th	1.08E-03	1.12E-03	83	Literature review	59,97
U	6.79E-03	1.41E-02	521	Literature review	56,59,97
Zr	2.09E-04			(3) Estimated from stable element data presented in Coughtrey & Thorne (1983b)	-

[†]Number in parenthesis identifies the approach used to derive a default CR value in the lack of literature data (see section 2.2) and is consistent with coding used in the ERICA-Tool. Note code 11 denotes a combination of approaches was used.

*See Table 16.

Table 16. References cited within Tables 3-15.

Ref. no.	Reference	Ref. no.	Reference	Ref. no.	Reference
1	Karasov et al. 2005	34	Andrews et al. 1989	67	Ryabokon et al. 2005
2	Bondarkov et al. 2002	35	Roberts et al. 1978	68	Read & Martin 1993
3	Jago et al. 2002*	36	Little 1980	69	Bastian & Jackson 1975
4	Gaschak pers comm. (IRL Slavutych Ukraine)	37	Crossley 1973	70	Cristaldi et al. 1991
5	Stark et al. 2004	38	Williamson & Evans 1972	71	Johanson & Bergstrom 1994
6	Wood et al. this issue	39	Whicker et al. 1974	72	Nelin 1995
7	James et al. 2004	40	Notten et al. 2005	73	Johanson 1994
8	Karasov et al. 2005	41	Gaso et al. 2002	74	Hendriks et al. 1995
9	Brisbin et al. 1993	42	RIFE 1995-2004	75	Haschek et al. 1979
10	Gaschak et al. 2003***	43	Beresford 1989	76	Johnson & Roberts 1978
11	Gaschak et al. 2005	44	Jones et al. 1985	77	Green et al. 2002
12	Brown et al. 2003b***	45	Sheppard 1995	78	Mietelski 2001
13	Miretsky et al. 1993	46	Davidson et al. 1997	79	Sample & Sutter 2002
14	Rantavaara 1990	47	Efroymsen et al. 2001	80	Radbourne 2002
15	RCSI	48	Sheppard et al. 1999	81	Prince et al. 2001
16	Troitskaya 1981	49	Bunzl et al. 2000	82	Sheppard & Evenden 1990
17	Scheuhammer et al. 2003	50	Gastberger et al. 2000	83	Borghuis et al. 2002**
18	Pokarzhevskii & Krivolutzkii 1997	51	Johanson et al. 1994	84	Bunzl & Kracke 1984
19	Verhovskaya 1972	52	Pietrzak Flis et al. 1996	85	Sharma & Shupe 1977
20	Copplestone et al. 1999	53	Varskog et al. 1994	86	Morgan & Morgan 1990
21	Copplestone 1996	54	Deitermann et al. 1989	87	Yoshida et al. 2005
22	Andrews & Cooke 1984	55	Lapham et al. 1989	88	Pokarzhevskii & Zhulidov 1995
23	Hunter et al. 1984	56	Mahon & Mathews 1983	89	Janssen et al. 1996
24	Hussein et al. 2006	57	Pietrzak Flis & Skowronskasmolak 1995	90	Beyer et al. 1982
25	Skubala & Kafel 2004	58	Prosser 1994	91	Pietz et al. 1984
26	Pokarzhevskii & Zhulidov 1995	59	Sheppard & Evenden 1988	92	Ma 1982
27	Mietelski et al. 2004	60	Jones et al. 1985	93	Nielsen & Gissel-Nielsen 1975
28	Peterson et al. 2003	61	Sheppard et al. 1999	94	Ertel & Ziegler 1991
29	Gilhen 2001	62	Holtzman et al. 1966	95	Pálsson et al. 1994
30	Cooper 2002	63	Litver et al. 1976	96	Stanica 1999
31	Crossley 1963	64	Hanson 1980	97	Hinton et al. 2005
32	Gaso et al. 2005	65	Ferenbaugh et al. 2002		
33	Toal et al. 2002	66	Markham et al. 1978		

*Supplemented with media activity concentration data by Gaschak pers comm. (IRL Slavutych, Ukraine).

**Data collated for work described in Borghuis et al. accessed from project database.

***The databases from the EPIC and FASSET projects contained some unpublished data provided to the projects by collaborators in the former Soviet Union, the references cited provide some information on the data and their sources.