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

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**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:

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

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

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

The ERICA-Tool considers 13 terrestrial reference organisms[1] 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

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[1]Note 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 Copplestone 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 $^{3}H$ 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 $^{3}H$ 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 $^{3}H$ 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 $^{137}Cs$ and $^{90}Sr$.

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

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 | Gaso 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 |
|---|---|---|---|
| *Assumed organ weights as percentage of live-weight.* | | | |
| 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) |
| *Assumed distribution of radionuclides* | | | |
| 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 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 | 1.37E+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 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 | 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 $5.75 \times 10^{-1}$) (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 $5.75x10^{-1}$) (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 $5.75 \times 10^{-1}$) (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 | | Unknown | 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 | Literature review | 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 $5.75x10^{-1}$) (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 (Copplestone 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 Copplestone 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 | Jagoe 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 | Efroymson 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.