R-13-01

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December 2013

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ISSN 1402-3091
SKB R-13-01
ID 1391729
Updated 2016-10

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Update notice

The original report, dated December 2013, was found to contain both factual and editorial errors which have been corrected in this updated version. The corrected factual errors are presented below.

Updated 2016-10

Location	Original text	Corrected text
Page 43, Table 4-1, second column, seventh row.	“100·CC“	“1,000·CC“
Page 43, Table 4-1, fifth column, eighth row.	“DMC/1,000“	“DMC“

Abstract

This report comprise the element-specific parameters utilised for transport calculation in the biosphere modeling in the safety assessment SR-PSU. Distribution coefficients (K_d) for nine different soil types and particulate matter in the limnic and marine ecosystems, together with 55 concentration ratios (CR) for terrestrial, limnic and marine biota types and transfer coefficients (TC) for cow meat and milk are presented. A majority of the CR parameters are used for assessment of dose to biota itself. Geometric mean, geometric standard deviation, best estimate, minimum and maximum values are presented for each specific parameter and element case.

An extensive site-specific data set in combination with a compilation of literature data are utilised for the parameterisation. Data from different sources are compared and evaluated, and the supporting information from element analogues are used to assess the data quality. Site-specific data are given highest priority, since K_d and CR are affected by the local biogeochemical environment. Literature data are primarily used as supporting information. Element or parameter analogues are selected to fill the data gaps, in case of missing or scarce data. When the variation of the data are not satisfactorily determined, the parameter distributions are adjusted based on information from several elements, in order not to underestimate reported data ranges.

The parameter data set presented in this report is unique since it relies on site-specific data to a high degree. The systematic parameterisation method ensures that the most probable values are selected for each parameter, and that limitations and contradictions in the data are identified. The discussion of the uncertainties associated with the reported data enables an assessment of the reliability in selected parameter values and consequently, the dose calculation results.

Sammanfattning

I den här rapporten presenteras ämnesspecifika parametrar som används vid transportberäkningar i biosfärsen inom säkerhetsanalysen SR-PSU. Fördelningskoefficienter (K_d) har tagits fram för 9 jordtyper samt partikulart material i limniska och marina miljöer. Koncentrationskvoter (CR) har tagits fram för 55 organismer/organismgrupper i terrestra, limniska och marina miljöer och överföringskoefficienter (TC) för upptag i komjölk och nötkött. Majoriteten av CR-parametrarna används för beräkningar av dos till biota. För varje specifikt K_d, CR och TC-värde presenteras geometriskt medelvärde, geometrisk standardavvikelse, "best estimate" samt min- och maxvärden.

Parametriseringen baseras på ett stort platsspecifikt dataset och en sammanställning av tillgänglig litteraturdata. Data från olika datakällor jämförs och värderas och stödjande information från ämnesanaloger används för att bedöma datakvaliten. Platsspecifika data prioriteras eftersom K_d och CR i hög grad påverkas av den lokala biogeokemiska miljön. Litteraturdata används främst som stödjande information. I fall där data saknas eller är knapphändig används ämnes- och/eller parameteranaloger för att fylla dataluckor. När variationen inte kunnat skattas säkert har de statistiska fördelningarna justerats baserat på information från många ämnen för att säkerställa att de raporterade parameterintervallen inte underskattas.

Datasetet som presenteras i den här rapporten är unikt eftersom det till stor del bygger på platsspecifika data. Det systematiska arbetssättet vid parameteriseringen säkerställer att de mest sannolika parametervärdena ansätts och att begränsningar och motsättningar i dataseten identifieras. Osäkerheter som är associerade med det rapporterade datasetet diskuteras, vilket möjliggör en bedömning av tillförlitligheten i de ansatta parametervärdena och därmed också i modelleringsresultaten.

Contents

1 Introduction

1.1 The SR-PSU project

The final repository for short-lived low- and intermediate-level radioactive waste, SFR 1, is located in Forsmark in northern Uppland (Figure 1-1), in the immediate vicinity of the Forsmark nuclear power plant (Figure 1-2). A map of the Forsmark area is presented in Appendix 1. The SFR 1 repository consists of a set of disposal chambers situated in rock at ca 60 m depth beneath the sea floor, and is built to receive and after closure serve as a passive repository for low- and intermediate-level short-lived radioactive waste. The radioactive waste stored in SFR includes operational waste from Swedish nuclear power plants and from the interim storage facility for spent nuclear fuel, Clab, as well as radioactive waste from other industries, research institutions and medical care.

In order to be able to also store decommissioning waste from the Swedish nuclear power plants in SFR, an extension of the repository, referred to as SFR 3, is planned. An SFR repository extension called SFR 2 was included in earlier plans for disposal of reactor core components and internal parts. However, according to present plans a separate repository (SFL) will be built for disposal of these types of waste (SKB 2013a), and SFR 2 will not be built.

As a part of the license application for the extension of SFR, the Swedish Nuclear Fuel and Waste Management Company (SKB) has performed the SR-PSU project. The objective of SR-PSU is to assess the long-term radiological safety of the entire future SFR repository, i.e. both the existing SFR 1 and the planned SFR 3. SR-PSU is reported in a series of SKB reports, which includes a main report, here referred to as **SR-PSU Main report**, and a set of primary references. These include, among others, the reports denoted as **Climate report**, **Radionuclide transport report**, **FEP report**, **FHA report** and **Biosphere synthesis report**. In addition to these primary references, the safety assessment is based on a large number of background reports and other references.

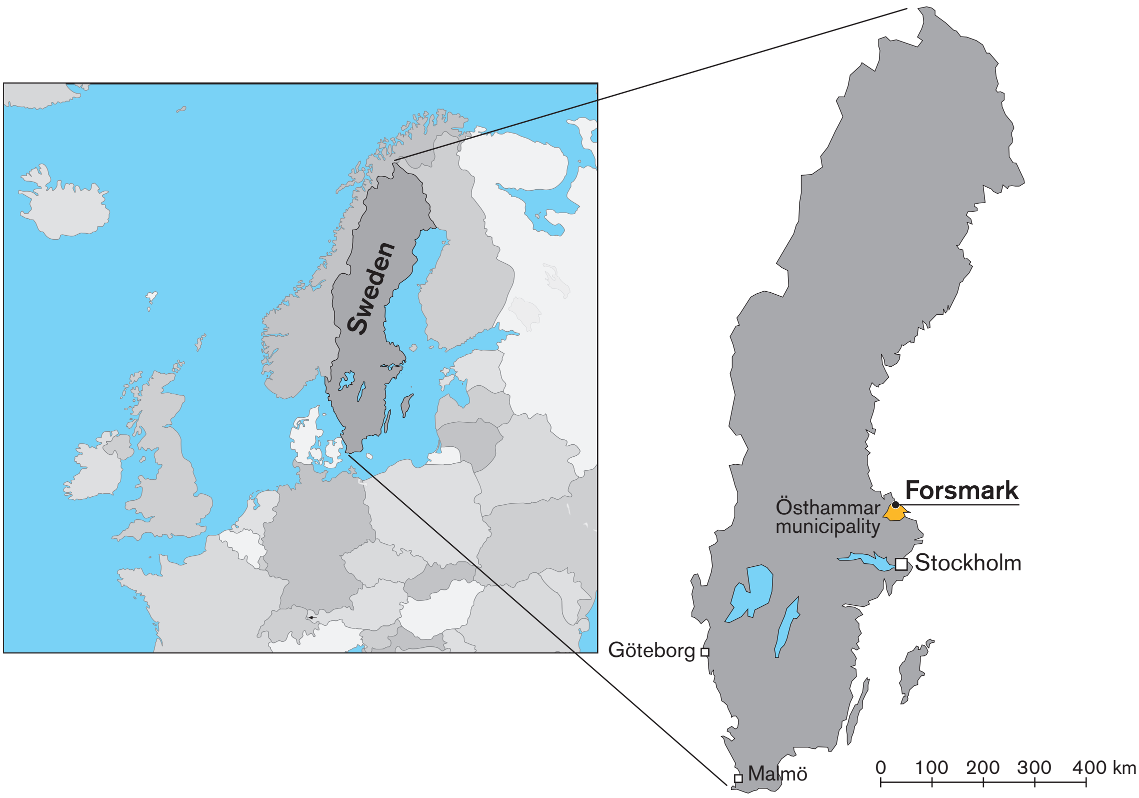

Figure 1-1. *Location of the Forsmark site in Sweden (right) and in context with the countries in Europe (left). The site is situated in the municipality Östhammars kommun, which belongs to the region of Uppsala län.*

Figure 1-2. The surface part of the SFR facility in the Forsmark harbour with the Forsmark nuclear power plant in the background.

The biosphere is a key part of the system considered in a safety assessment of a nuclear waste repository. This is where the main consequences of potential future radionuclide releases from the repository could arise, and hence near surface radionuclide transport and dose calculations are performed within the framework of the biosphere assessment. This report belongs to the sub-project of SR-PSU called SR-PSU Biosphere. SR-PSU Biosphere mainly describes the information needed to calculate effects on humans and the environment in the case of a radionuclide release from SFR. The calculated effects are then used to show compliance with regulations related to future repository performance for time spans up to 100,000 years after closure. Because of the uncertainties associated with the prediction of future development of the site in this time frame, a number of calculation cases are analysed to describe a range of possible site developments.

The SR-PSU Biosphere project is divided into the following tasks:

1. Identification of features and processes of importance for modelling radionuclide dynamics in present and future ecosystems in Forsmark.
2. Description of the site and its future development with respect to the identified features and processes.
3. Identification and description of areas in the landscape that may be affected by releases of radionuclides from the existing repository and its planned extension.
4. Calculation of the radiological exposure to a representative individual of the most exposed group of humans in the future Forsmark landscape, and the radiological exposure to the environment.

The SR-PSU biosphere assessment builds on previous safety assessments for the existing and planned nuclear waste repositories in Sweden. Between 2002 and 2008, SKB performed site investigations for a repository for spent nuclear fuel in Forsmark. Data from these site investigations were used to produce a comprehensive, multi-disciplinary site description (SKB 2008a). This description has been used as a basis for understanding and modelling of the site and its development.

The SFR repository has been in operation since 1988 and a number of safety assessments have been performed for the repository since SKB received permission to start building SFR 1 in 1983, including the SAFE project (Lindgren et al. 2001, Kautsky 2001) and SAR-08 (SKB 2008b). In addition, safety assessments have been performed for a planned repository for spent nuclear fuel, i.e. within the SR-Can (SKB 2006) and SR-Site (SKB 2011) projects, for which SKB handed in an application in 2011. This implies that the SR-PSU biosphere assessment is based on knowledge gathered from site data, site modelling and the previous safety assessments, together with modelling performed and data collected during the SR-PSU project.

1.2 The SR-PSU report hierarchy

The SR-PSU project is reported in a series of SKB reports, which includes a main report and a set of primary references that are referred to by abbreviated names in the SR-PSU reporting. The primary references and the names used (bold, in text) when referring to them in this and other SR-PSU reports are shown in Figure 1-3 and listed in Table 1-2. In addition to the primary references, the safety assessment is based on a large number of background reports and other references.

Table 1-2. The SR-PSU Main report and primary references to it produced within SR-PSU. FEP stands for features, events and processes and includes FEP for all disciplines in the assessment (e.g. waste, geosphere and climate). FHA is short for future human actions.

Report number	Short name used when referred to in the text	Full title
TR-14-01	SR-PSU Main report	Safety analysis for SFR. Long-term safety. Main report for the safety assessment SR-PSU.
TR-14-02	Initial state report	Initial state report for the safety assessment SR-PSU.
TR-14-03	Waste process report	Waste form and packaging process report for the safety assessment SR-PSU.
TR-14-04	Barrier process report	Engineered barrier process report for the safety assessment SR-PSU.
TR-14-05	Geosphere process report	Geosphere process report for the safety assessment SR-PSU.
TR-14-06	Biosphere synthesis report	Biosphere synthesis report for the safety assessment SR-PSU.
TR-14-07	FEP report	FEP report for the safety assessment SR-PSU.
TR-14-08	FHA report	Handling of future human actions in the safety assessment SR-PSU.
TR-14-09	Radionuclide transport report	Radionuclide transport and dose calculations for the safety assessment SR-PSU.
TR-14-10	Data report	Data report for the safety assessment SR-PSU.
TR-14-11	Model summary report	Model summary report for the safety assessment SR-PSU.
TR-14-12	Input data report	Input data report for the safety assessment SR-PSU.
TR-13-05	Climate report	Climate and climate-related issues for the safety assessment SR-PSU.

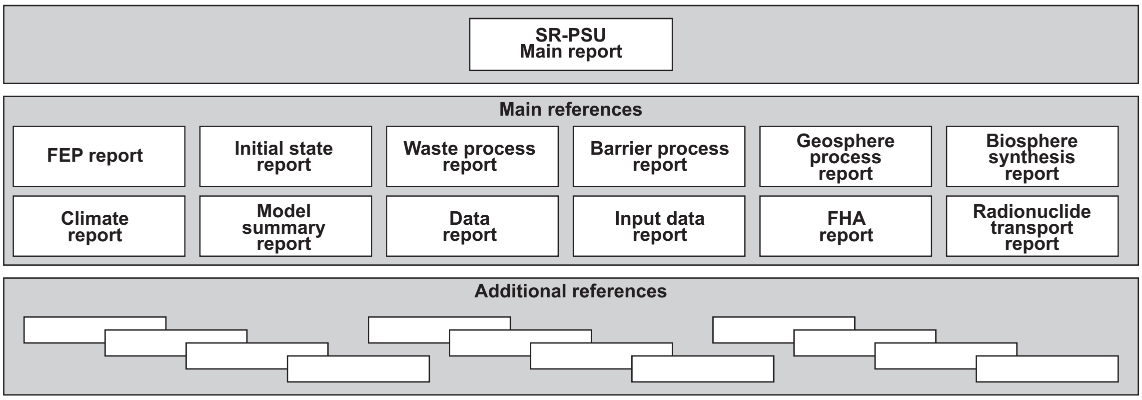

Figure 1-3. *Relationship between reports produced in the SR-PSU safety assessment.*

Table 1-3 presents the background reports produced within SR-PSU Biosphere. For these reports, conventional references are used in the present report (e.g. "Strömgren and Brydsten (2013)" for the DEM report); however, the short names/descriptions are in some cases used in the biosphere work and reporting, and are therefore listed in the table together with references and titles. The relationships between the background biosphere reports and the primary references are shown in Figure 1-4. The present report, the K_d and CR report, is one of the background reports listed in Table 1-3.

Table 1-3. Biosphere background reports produced within SR-PSU Biosphere; FEP stands for features, events and processes.

Report number	Short description and reference in text	Full title
R-12-03	DEM report, Strömgren and Brydsten (2013)	Digital elevation model of Forsmark. SR-PSU Biosphere.
R-13-01	K_d and CR report, Tröjbom et al. (2013)	K_d and CR used for transport calculations in the biosphere in SR-PSU.
R-13-18	Biosphere parameter report, Grolander (2013)	Biosphere parameters used in radionuclide transport modelling and dose calculations in SR-PSU.
R-13-19	Surface hydrology report, Werner et al. (2013a)	Hydrology and near-surface hydrogeology at Forsmark – synthesis for the SR-PSU project. SR-PSU Biosphere.
R-13-20	Hydrological data report, Werner et al. (2013b)	Meteorological, hydrological and hydrogeological monitoring data from Forsmark – compilation and analysis for the SR-PSU project. SR-PSU Biosphere.
R-13-22	RDM report, Sohlenius et al. (2013a)	Depth and stratigraphy of regolith at Forsmark. SR-PSU Biosphere.
R-13-27	RLDM report, Brydsten et al. (2013)	Landscape development in the Forsmark area from the past into the future (8500 BC–40,000 AD).
R-13-43	Biosphere process definition report, SKB (2013b)	Components, features, processes and interactions in the biosphere.
R-13-46	Biosphere radionuclide model report, Saetre et al. (2013a)	The biosphere model for radionuclide transport and dose assessment in SR-PSU.
R-14-02	Biosphere FEP handling report, SKB (2014)	SKB 2014. Handling of biosphere FEPs and recommendations for model development in SR-PSU.

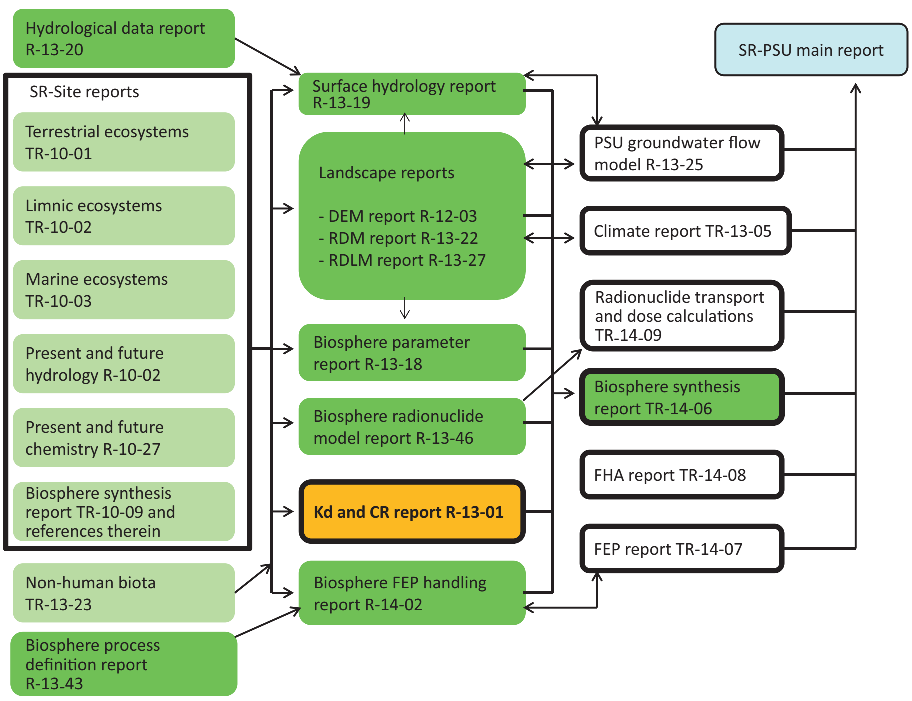

***Figure 1-4.** Relationship between reports produced in the SR-PSU Biosphere project (dark green boxes). The present report is marked in orange and bold. Supporting documents produced within other biosphere projects at SKB are shown as light green boxes, whereas other reports in the SR-PSU project are shown in white except the **SR-PSU Main report,** which is shown in blue.*

1.3 This report

This report is produced within the Biosphere part of SKB's assessment of the long-term safety of the final repository for radioactive operational waste, SFR 1 and planned extension of the repository, SFR 3 (cf. **SR-PSU main report**). The SR-PSU project is reported in a series of SKB reports, which includes a main report and a set of primary references. In addition, to the primary references, the safety assessment is based on a large number of background reports and other references. The main references and the background reports produced within SR-PSU Biosphere are listed in Table 1-1 and relationships between the background biosphere reports are shown in Figure 1-1. In this report the element specific parameter values used in the radionuclide model for the biosphere within the safety assessment SR-PSU are presented as well as the data and methods used to derive the selected parameter values.

In the Radionuclide Model for the biosphere, the retention of radionuclides in the regolith and their partition between suspended particles and the soluble phase in surface waters is modelled using element specific distribution coefficients (K_ds). This is currently the most widely used approach for modelling these types of processes in performance assessments of repositories. One reason for this is the mathematical simplicity of the K_d approach. Any model used for simulation of the transport of water can easily be modified to model the transport of elements and radionuclides, by introducing a retardation factor expressed as a function of the K_d. At the same time, experimental determinations of K_d values are also relatively easy to perform, which can explain that numerous K_d values have been reported in the literature covering a wide range of conditions (Avila et al. 2010).

The uptake of radionuclides by biota from the surrounding media (soil, water or animal feed) is represented by Concentration Ratios (CR) in the radionuclide model for the biosphere. The CR model is a simplistic model representing the ratio between concentration in the media and biota. This simplified model of uptake is the most commonly used model in performance assessments of repositories mostly due to the simple mathematical representation and the large available data set describing CR values from different conditions.

The simplified K_d and CR models are associated with several assumptions that will be a part of the overall uncertainties of the parameter values and the result of the performance assessment model. In Section 2.2 and 2.3 the concepts and assumptions made when using K_d and CR are discussed in more detail. Chapter 2 also contains a short description of the radionuclide model used in SR-PSU and all parameters included in this report are listed in Table 2-1 (dose to humans) and Table 2-2 (dose to other biota). General assumptions for the parameterisation, such as statistical representation, assumptions concerning site data and use of analogues, are also discussed. The data used for parameterisation is described in Chapter 3 and the parameterisation method in Chapter 4. The selected parameter values and details of the parameterisation process for K_d values, terrestrial, limnic and marine CR can be found in Chapter 5-8, respectively. Chapter 9 contains a discussion of the uncertainties and confidence in selected parameter values whereas some concluding remarks are given in Chapter 10.

2 Methodological background

This chapter comprise relevant background information on the parameterisation of K_d and CR for the radionuclide model for the biosphere of the SR-PSU assessment. It begins with a short description of the radionuclide model and its compartments, followed by the definitions of K_d and CR parameters included in the SR-PSU assessment. In Section 2.6 general assumptions used in the parameterisation are described and a compilation and explanations of utilised analogues is given in Section 2.7.

2.1 The radionuclide model for the biosphere

The radionuclide model for the biosphere is a compartment model. Radionuclides entering a compartment become homogeneously mixed in the compartment in the scale of the time stepping of the model. Figure 2-1 shows a graphical representation of the compartments and radionuclide fluxes identified for a coupled lake and mire ecosystem.

The arrows in Figure 2-1 represent radionuclide fluxes between the compartments and fluxes into and out of the system. Radionuclide fluxes are linked to mass fluxes of gas (1, light blue), water (2, dark blue) and solid matter (3, solids), to transitions between inorganic and organic forms of radionuclides (4, green), to diffusion in soil pore water (5), and to ingrowth of wetland vegetation (6). The atmosphere serves as a source and sink of radionuclides.

A detailed description of the radionuclide model and definitions of the model compartments are found in Saetre et al. (2013). In Table 2-1 below, the regolith compartments are briefly described based on the definitions of the radionuclide model, complemented with typical properties of the Forsmark regolith representative for these compartments. The physical properties of the regolith layers are further described in Grolander (2013). Besides the regolith compartments listed in the table below, are surface water and primary producers handled as separate compartments in the model.

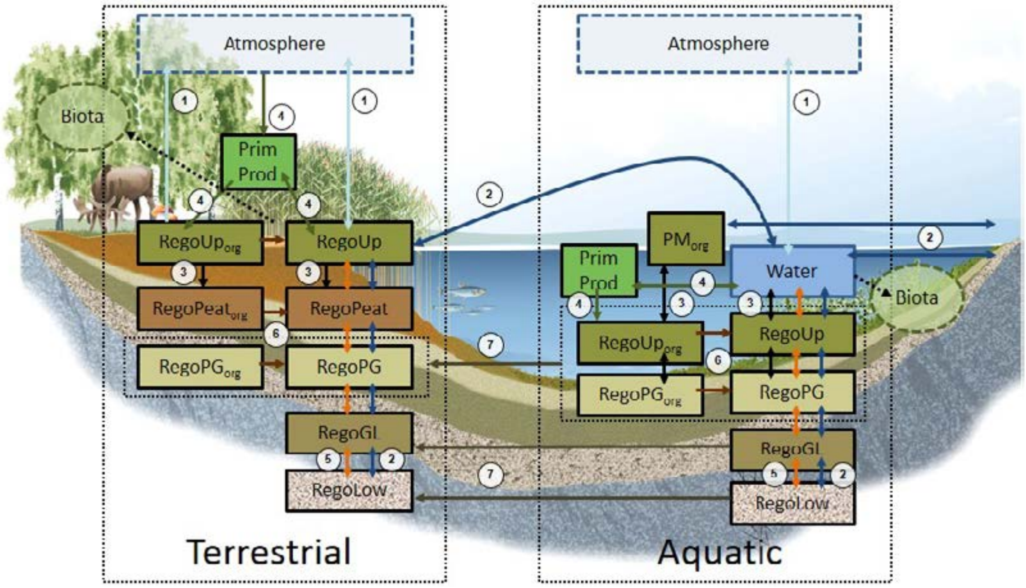

__Figure 2-1.__ A graphical representation of the radionuclide transport model used to simulate transport and accumulation in a discharge area with two natural ecosystems (black dotted boxes). Each box corresponds to a radionuclide inventory associated with a physical compartment. Arrows represents radionuclide fluxes between compartments and fluxes into and out of the system. Radionuclide fluxes are linked to mass fluxes of gas (1, light blue), water (2, dark blue) and solid matter (3, solids), to transitions between inorganic and organic forms of radionuclides (4, green), to diffusion in soil pore water (5), and to ingrowth of wetland vegetation (6). The atmosphere serves as a source and sink of radionuclides.

Table 2-1. The regolith compartments of the radionuclide model and typical physical and chemical properties of the regolith samples from Forsmark representative for these compartments.

Description and properties of the regolith compartments[1]					Typical properties of the regolith in Forsmark[2]				
Name	**Eco-system[3]**	**Redox condition**	**Hydrological condition**	**Description**	**Density (kg_{dw}/m^3)**	**Porosity (m^3/m^3)**	**LOI (%)**	**pH (H_2O)**	**CEC ((cmol(+)/kg dw))**
RegoUp_ter	Ter	Oxic	Saturated	Acrotelm/mesotelm peat, biologically active.	114	0.90	91	5.7	128
RegoPeat	Ter	Anoxic	Saturated	Catotelm peat (below mesotelm).	114	0.90	92	5.8	124
RegoUp_aqu	Aqu	Oxic	Saturated	Biologically active top sediments (0.1/0.05 m) of accumulation bottoms.	179	0.92			
RegoPG	Aqu/Ter	Anoxic	Saturated	Post glacial deposits (gyttja) including sediments deposited during both marine and lake stage.	182	0.92	13	4.5	19
RegoGL	Aqu/Ter	Anoxic	Saturated	Glacial clay. Typically overlayn by post glacial deposits.	673	0.75	3	8.0	21
RegoLow	Aqu/Ter	Anoxic	Saturated	Till. Typically overlaid by a layer of glacial clay.	2115	0.21	0	9.0	11
RegoUp_drain	Ter	Oxic	Unsaturated	Organic layer used for cultivation when lake/mire complex is drained.	274	0.75	50	5.7	25
RegoUp_io RegoUp_garden	Ter	Oxic	Unsaturated	Upper layer of a extensively cultivated (light) soil (0–0.25m), representing primary rooting depth of cereals.	1,626	0.36	8	7.4	22

1. These properties are based on the definitions of the radionuclide model.
2. Mean values of samples representative for the regolith compartment.
3. Terrestrial (Ter). Aquatic, limnic and marine, (Aqu).

Radionuclides from an underground repository are expected to reach the sediment layers in the biosphere via deep groundwater. Once dissolved, radionuclides reach uncontaminated sediments where they will equilibrate with the solid state through various chemical and biological processes.

The net outcome from the sorption processes is described by element specific constant solid/liquid distribution coefficients K_d, partitioning the compartmental inventories of elements into sorbed and dissolved fractions. This approach assumes that the retention processes are fast compared to the time stepping used in the model and that they are independent of the radionuclide concentrations (Saetre et al. 2013). In the schematic representation of the radionuclide model, Figure 2-2, compartments divided into a sorbed and dissolved fraction are marked orange and blue.

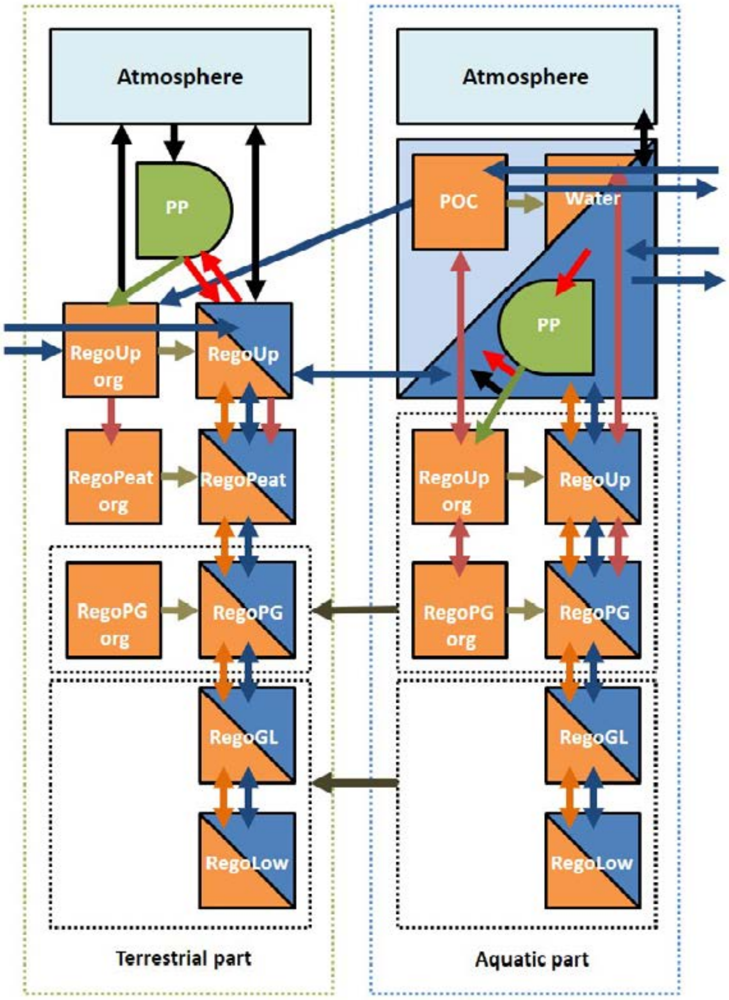

Figure 2-2. *Schematic representation of the radionuclide model for the biosphere. The compartments divided into orange and blue represent partitioning in sorbed and dissolved fractions modeled by partitioning coefficients, K_d. Red arrows represent the uptake of primary producers (PP) modeled by concentration ratios, CR. The "org" suffix and POC represent the organic forms of radionuclides in the upper soil layers and particulate matter in the surface water (cf. Saetre et al. 2013).*

The uptake of radionuclides in primary producers and consumers in both aquatic and terrestrial ecosystems are modelled with element-specific equilibrium constants, CR, indicated as red arrows in Figure 2-2. This approach assumes that the uptake is small in relation to the total inventory of radionuclides in soil, sediments and water, and that the long-term organism concentrations are in equilibrium with the long-term environmental concentrations in soil or water.

2.2 Parameters in the SR-PSU safety assessment

This section lists all parameters addressed in this report together with a short description. Table 2-2 lists K_d and CR parameters included in the radionuclide dose model for estimating environmental media concentrations and dose to humans, whereas CR parameters for estimating dose to non-human biota from environmental media concentrations are listed in Table 2-3. When applicable, the nomenclature of the parameters is based on the naming of the compartments of the radionuclide model (cf. Table 2-1). For a few parameters the names differ between this report and the model report according to column 2 in Table 2-2.

For each parameter, element-specific parameter values are selected for the 31 elements of primary concern: Ac, Ag, Am, Ba, Ca, Cd, Cl, Cm, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Np, Pa, Pb, Pd, Po, Pu, Ra, Se, Sm, Sn, Sr, Tc, Th, U and Zr. Carbon-14 and ^{3}H are also radionuclides of interest, though the K_d and CR values for these elements are not included with the other elements since they have been modelled differently (Saetre et al. 2013).

Table 2-2. Parameters utilised for estimation of dose to humans. If parameter names differ between this report and the model description this is noted in the second column.

Parameter name	Description
cR_agri_cereal	Concentration ratio between soil and cereal
cR_agri_fodder	Concentration ratio between soil and fodder
cR_agri_tuber	Concentration ratio between soil and potatoes
cR_agri_veg	Concentration ratio between soil and vegetables
cR_food_herbiv	Concentration ratio with respect to herbivores and their diet
cR_Lake_Cray	Concentration ratio for crayfish in lake water
cR_Lake_Fish	Concentration ratio for fish in lake water
cR_lake_pp_macro	Concentration ratio for macrophytes in lake water
cR_lake_pp_micro	Concentration ratio for microphytobenthos in lake water
cR_lake_pp_plank	Concentration ratio for plankton in lake water
cR_Ter_Mush	Concentration ratio between edible mushrooms and soil
cR_Ter_pp	Concentration ratio for terrestrial primary producers and soil
cR_Sea_Fish	Concentration ratio for fish in sea water
cR_sea_pp_macro	Concentration ratio for macrophytes in sea water
cR_sea_pp_micro	Concentration ratio for microphytobenthos in sea water
cR_sea_pp_plank	Concentration ratio for plankton in sea water
K_d_PM_lake	Distribution coefficient for particulate matter in lake water
K_d_PM_sea	Distribution coefficient for particulate matter in sea water
K_d_regoGL	Distribution coefficient in glacial clay
K_d_regoLow	Distribution coefficient in lower regolith (till)
K_d_regoPeat	Distribution coefficient anoxic layer of terrestrial regolith (peat)
K_d_regoPG	Distribution coefficient in post-glacial sediments
K_d_regoUp_aqu	Distribution coefficient in upper layer of aquatic regolith
K_d_regoUp_drain	Distribution coefficient in cultivated peat soils in industrial agricultural lands
K_d_regoUp_garden	Distribution coefficient in soils of a modern kitchen garden
K_d_regoUp_io	Distribution coefficient in sandy soils in early agricultural lands
K_d_regoUp_ter	Distribution coefficient of upper oxic layer of terrestrial regolith (peat)
TC_meat	Transfer coefficient from intake of radionuclides in fodder and water to cow meat
TC_milk	Transfer coefficient from intake of radionuclides in fodder and water to cow milk

Table 2-3. Parameters utilised for estimation of dose to non-human biota (NHB).

Parameter	Description
cR_Lake_amph_NHB	Concentration ratio between lake water and amphibians
cR_Lake_bent_fish_NHB	Concentration ratio between lake water and benthic fish
cR_Lake_bird_NHB	Concentration ratio between lake water and birds
cR_Lake_bivalve_NHB	Concentration ratio between lake water and bivalves
cR_Lake_crust_NHB	Concentration ratio between lake water and crustaceans
cR_Lake_Fish_NHB	Concentration ratio between lake water and fish
cR_Lake_gastr_NHB	Concentration ratio between lake water and gastropods
cR_Lake_ins_larvae_NHB	Concentration ratio between lake water and insect larvae
cR_Lake_mammal_NHB	Concentration ratio between lake water and mammals
cR_Lake_pel_fish_NHB	Concentration ratio between lake water and pelagic fish
cR_Lake_pp_plank_NHB	Concentration ratio between lake water and phytoplankton
cR_Lake_pp_vasc_NHB	Concentration ratio between lake water and vascular plants
cR_Lake_zoopl_NHB	Concentration ratio between lake water and zooplankton
cR_Sea_bent_fish_NHB	Concentration ratio between sea water and benthic fish
cR_Sea_bent_moll_NHB	Concentration ratio between sea water and benthic molluscs
cR_Sea_bird_NHB	Concentration ratio between sea water and birds
cR_Sea_crust_NHB	Concentration ratio between sea water and crustaceans
cR_Sea_Fish_NHB	Concentration ratio between sea water and fish
cR_Sea_mammal_NHB	Concentration ratio between sea water and mammals
cR_Sea_pel_fish_NHB	Concentration ratio between sea water and pelagic fish
cR_Sea_polych_NHB	Concentration ratio between sea water and polychaete worms
cR_Sea_pp_macro_NHB	Concentration ratio between sea water and macrophytes
cR_Sea_pp_plank_NHB	Concentration ratio between sea water and phytoplankton
cR_Sea_pp_vasc_NHB	Concentration ratio between sea water and vascular plants
cR_Sea_zoopl_NHB	Concentration ratio between sea water and zooplankton
cR_Ter_amph_NHB	Concentration ratio between soil and amphibians
cR_Ter_bird_egg_NHB	Concentration ratio between soil and bird eggs
cR_Ter_bird_NHB	Concentration ratio between soil and birds
cR_Ter_detr_inv_NHB	Concentration ratio between soil and detrivorous invertebrates
cR_Ter_fl_ins_NHB	Concentration ratio between soil and flying insects
cR_Ter_gastr_NHB	Concentration ratio between soil and gastropods
cR_Ter_mammal_large_NHB	Concentration ratio between soil and large mammals
cR_Ter_mammal_small_NHB	Concentration ratio between soil and small mammals
cR_Ter_pp_grass_NHB	Concentration ratio between soil, grass and herbs
cR_Ter_pp_lich_NHB	Concentration ratio between soil, lichens and bryophytes
cR_Ter_pp_NHB	Concentration ratio between soil and primary producers
cR_Ter_pp_shrub_NHB	Concentration ratio between soil and shrubs
cR_Ter_pp_tree_NHB	Concentration ratio between soil and trees
cR_Ter_rept_NHB	Concentration ratio between soil and reptiles
cR_Ter_soil_inv_NHB	Concentration ratio between soil and soil invertebrates

2.3 The distribution coefficient, K_d

In the radionuclide model for the biosphere, element-specific distribution coefficients, K_ds, are utilised to model the sorption of radionuclides in soils, deposits and on suspended matter in surface waters (Saetre et al. 2013).

For soils and deposits, K_d is defined as the ratio of a given element concentration in the soil solid phase divided by the equilibrium element concentration in the contacting soil liquid phase (pore water):

$$K_d = \frac{Conc_{soil\ solid}}{Conc_{soil\ liquid}} \qquad \text{Eq 2-1}$$

where K_d is the solid/liquid distribution coefficient in m^3/kg_{dw}, $Conc_{soil\ solid}$ is the activity concentration of an element in the solid phase of a soil in Bq/kg_{dw}. $Conc_{soil\ liquid}$ is the activity concentration of an element in the liquid phase of a soil in Bq/m^3.

For sorption to suspended matter in the aquatic environment the distribution coefficient is defined as:

$$K_d = \frac{Conc_{susp}}{Conc_{water}} \qquad \text{Eq 2-2}$$

where K_d is the solid/liquid partition or distribution coefficient in m^3/kg_{dw}, $Conc_{susp}$ is the activity concentration of an element in the solid phase of the suspended matter in Bq/kg_{dw}, $Conc_{water}$ is the activity concentration of an element in the water in Bq/m^3.

A high K_d value indicates that the element is strongly adsorbed in the solid phase and therefore is less likely to move throughout the soil; it has low mobility. In the case of suspended matter, a high K_d value indicates that an element is associated to particulate matter in the water, which implicates that the element could be retained in the sediments to a higher degree. An element with low K_d value is conversely more mobile in the soil system and more associated to the dissolved phase in the surface water.

The simplistic K_d model is based on several theoretical assumptions discussed by, for example, US EPA (1999) and IAEA (2010). In brief, the K_d model assumes:

1) that only trace amounts of contaminants exist in aqueous and solid phases,
2) that linear relationships exist between solid and liquid concentrations,
3) that equilibrium conditions exist between solid and liquid phases,
4) reversible sorption reactions, i.e. equally rapid adsorption and desorption kinetics,
5) that a relationship exists between one sorbate (aq) and one sorbent (soil),
6) that all sorption sites are assessable and have equal binding energies.

In practice, these theoretical assumptions are more or less disregarded when the model is parameterised. In the estimation of K_d values from naturally occurring stable isotopes at concentrations higher than trace amounts, the first, fifth and sixth assumptions might be violated. The inclusion of other processes than reversible sorption might violate the second, third and fourth assumptions, e.g. due to the effects of precipitation, matrix diffusion, biological uptake, chemical reactions and complexation.

Besides the conceptual uncertainties related to the simplistic K_d model, there are several types of variations and uncertainties associated with the implementation of the K_d model/concept, which are discussed below.

At spatial scale, the upscaling from site-specific samples or laboratory tests to landscape level introduces uncertainties regarding representativeness. The assigned distribution coefficients are assumed to represent the average values of the entire model compartment, and it is assumed that these 'effective' K_d values describe the net sorption processes at macro scale level. However, the variation assigned to specific K_d values should also account for the variation in the chemical environments among the possible discharge points in the model area.

At temporal scale, the dynamics of the sorption processes described by K_d in relation to the modelled temporal resolution introduces uncertainties. The use of K_ds, implies that the total inventory of a radionuclide in a model compartment is distributed between dissolved and sorbed phases at every time step in the dynamic modelling. If the estimated K_d values represent processes that would not reach equilibrium within the resolution of the dynamic model, the model might underestimate the mobility. The overall variation assigned to specific K_d values should also account for the long-term landscape evolution that will change the environmental conditions over time.

In addition to these conceptual, spatial and temporal uncertainties associated with the assignment of representative K_d values for the radionuclide model, the uncertainties due to analytical and methodological issues can be substantial. For example, the choice of digestion method when determining the sorbed fraction associated with the solid phase might lead to very different results, depending on the properties of the elements. The estimation of the dissolved phase can also vary, depending on the degree of colloidal matter included in this fraction. These examples as well as other differences in methods will be a part of the uncertainties associated with the reported K_d values.

In conclusion, several uncertainties at different levels contribute to the overall uncertainties when representative K_d values are assigned. The large variation in the reported K_d values are ultimately caused by differences in environmental, chemical and physical conditions (indicating both spatial and temporal variation in the landscape) as well as in differences in experimental methods. US EPA (1999) emphasise the limitations of the simplistic K_d model and stress that K_d measurements are only valid for the conditions prevailing at the sampling site. IAEA (2010) present K_d values per soil type or cofactor, in order to reduce variation caused by environmental factors, though point out that these literature K_d values must be considered as approximate values that are suitable for screening purposes only and not for specific risk assessments.

2.4 Concentration ratios, CR

In the radionuclide model for the biosphere, concentration ratios, CR, are utilised to model uptake of radionuclides in biota (Saetre et al. 2013). CRs of different units are utilised for the estimation of dose to humans and non-human biota.

For calculation of uptake of radionuclides in terrestrial vegetation, the soil to biota CR, is defined as the carbon normalised element activity concentration in edible plant/fungi tissues divided by the element activity concentration in the soil:

$$CR = \frac{\frac{Conc_{plant}}{CC}}{Conc_{soil}} \qquad \text{Eq 2-3}$$

where CR is the soil to biota concentration ratio in kg_{dw}/kg_C, $Conc_{plant}$ is the element activity concentration in plant/fungi tissue in Bq/kg_{dw}, $Conc_{soil}$ is the element activity concentration in dry soil in Bq/kg_{dw} and CC is the carbon content of plants/fungi in kg_C/kg_{dw}.

The uptake of radionuclides of wild herbivores from vegetation is modelled by CRs defined as the carbon normalised activity concentrations in animal muscle divided by the carbon normalised activity concentrations in green parts of vegetation:

$$CR = \frac{\frac{Conc_{herbivore}}{CC_{herbivore}}}{\frac{Conc_{vegetation}}{CC_{vegetation}}} \qquad \text{Eq 2-4}$$

where, CR is the unitless soil to biota concentration ratio, $Conc_{herbivore}$ is the element activity concentration in herbivore muscle in Bq/kg_{dw}, $Conc_{vegetation}$ is the element activity concentration in the green parts of vegetation in Bq/kg_{dw} and CC is the carbon content of herbivores and vegetation in kg_C/kg_{dw}.

For calculation of dose to non-human biota in the terrestrial ecosystem, the soil to biota CR is defined as the element activity concentration per fresh weight of biota tissue divided by the element activity concentration in the soil:

$$CR = \frac{Conc_{plant} \times DMC}{Conc_{soil}} \qquad \text{Eq 2-5}$$

where, CR is the soil to plant concentration ratio in kg_{dw}/kg_{fw}, $Conc_{plant}$ is the element activity concentration in plant tissue in Bq/kg_{dw}, $Conc_{soil}$ is the element activity concentration in dry soil in Bq/kg_{dw} and DMC is the dry matter content of plants expressed in kg_{dw}/kg_{fw}.

For calculation of dose to human in the aquatic ecosystem, the CR is defined as the carbon normalised element activity concentration in edible biota tissue (plant or animal) divided by the element activity concentration of the surrounding water:

$$CR = \frac{\frac{Conc_{biota}}{CC}}{Conc_{water}} \qquad \text{Eq 2-6}$$

where, CR is the water to biota concentration ratio in m^3/kg_C, $Conc_{biota}$ is the element activity concentration in plant or animal tissue in Bq/kg_{dw}, $Conc_{water}$ is the element activity concentration in filtered water in Bq/m^3 and CC the carbon content of plant or animal tissue per dry weight in kg_C/kg_{dw}.

For calculation of dose to non-human biota in the aquatic ecosystem, the CR is defined as the element activity concentration per fresh weight in biota (plant or animal) divided by the element activity concentration of the surrounding water:

$$CR = \frac{Conc_{biota} \times DMC}{Conc_{water}} \qquad \text{Eq 2-7}$$

where, CR is the water to biota concentration ratio in m^3/kg_{fw}, $Conc_{biota}$ is the element activity concentration in plant or animal tissue in Bq/kg_{dw}, $Conc_{water}$ is the element activity concentration in filtered water in Bq/m^3 and DMC the dry matter content of plant or animal tissue in kg_{dw}/kg_{fw}.

Higher CR values indicate a higher uptake in biota from the surrounding soil or water of that particular element.

The use of CRs to model uptake of elements in biota is associated with conceptual uncertainties. CRs are constants by definition and their use implies a linear and zero-intercept relationship between biota and surrounding media concentrations of elements at steady state conditions. This assumption is only valid when elements are taken up by passive uptake processes. Many elements are taken up by active processes or affected by exclusion processes in biota and, in this case, the simple linear relationship is not valid and the CR approach only provides simplistic approximation (Sheppard and Evenden 1988, Greger 2004).

In the case of terrestrial vegetation, the only transfer route into the plants accounted for by CR is via root uptake of radionuclides present in the soil, although it is known that radionuclides also can be taken up through, for example, plants' foliage via atmospheric deposition. Furthermore, the model does not account for the effects of plant-soil interaction. Plants are known to have active mechanisms that change the chemical environment in the rhizosphere and facilitating or restricting uptake of certain elements (Kabata-Pendias 2010). Transfer of radionuclides via root uptake in the aquatic environment, e.g. from bottom sediments, relating biota concentrations to concentrations of water are not explicitly accounted for by the CR model.

Observed relationships between plant element concentrations and environmental concentrations have indicated enormous variations. IAEA (2010) list several factors that governs this variability including: factors that regulate plant properties such as growth, transpiration rate and root distribution, e.g. plant type, climate, nutrient status of growth media, plant management practices; factors that regulate an element's availability for uptake, e.g. element properties and interactions, as well as growth media properties that will affect an elements availability for plant uptake.

On theoretical grounds, there should be a negative relationship between CR soil to plant and K_d in soil (Sheppard and Evenden 1988, IAEA 2010). A high K_d value represents high sorption of elements to the soil solid phase and a small amount of elements is available for plant uptake and more is available for the plants at low K_d. When K_d and CR models are coupled, inconsistencies can occur if generic K_d and CR values are utilised without taking their expected inverse correlation into account (Avila et al. 2010). A significant fraction of the variation in CR among elements and soils could be explained by the underlying variation in K_d, which is implicitly included in the CR value.

The variation attributed to experimental design, sampling, preparation and analysis can be substantial when estimating CRs. Concentrations of biota and soil can be determined on either dry or fresh weight basis. The sampling of soils can be performed at different depths in different studies, depending on assumed rooting and ploughing depth. Some studies determine CRs under natural conditions, while others determine them in greenhouse conditions (Centofanti et al. 2005). In different studies, various plant parts are sampled and analysed (Vandenhove et al. 2009). Similar to K_d, the utilised digestion methods can have substantial influence when soil concentrations are determined. The most common methods to determine element availability do not always give the best results, as far as representing element levels in the natural environment (Kabata-Pendias 2010).

2.5 Transfer coefficients, TC

Transfer coefficients are used to quantify uptake of radionuclides in milk and meat in domestic animals. The Transfer coefficient is defined as the ratio of the radionuclide activity concentration in meat or milk and the daily dietary radionuclide intake. In this study cow is the domestic animal considered. The daily intake of radionuclides is the sum of the radionuclide intake from feed, soil and water consumption.

$$TC\_meat = \frac{Conc_{meat}}{Daily\_intake} \qquad \text{Eq 2-8}$$

where TC_meat is the transfer coefficient for cow meat (day/kg_{fw}), $Conc_{meat}$ is the concentration of radionuclide in cow meat (Bq/kg_{fw}) and *Daily_intake* is the total daily intake of radionuclide in (Bq/day).

$$TC\_milk = \frac{Conc\_milk}{Daily\_intake} \qquad \text{Eq 2-9}$$

where TC_milk is the transfer coefficient for cow milk (day/m^3), $Conc_{milk}$ is the concentration of radionuclide in cow milk (Bq/m^3) and *Daily_intake* is the total daily intake of radionuclides in (Bq/day).

When calculating Transfer coefficients, equilibrium between the daily intake and the concentration in milk and meat is assumed. This assumption could be violated for radionuclides with for example radionuclides with long half-lives. This means that the concentration in milk and meat might not be in equilibrium by the time of slaughter. Another factor affecting the uncertainties in TC is the fact that the daily intake of radionuclides needs to be assessed. This can be problematic and lead to increased uncertainties, and sometimes, the daily intake have to be assessed by "expert judgment".

2.6 General assumptions for the parameterisation

This section lists a number of guiding principles and assumptions that serve as a basis for the parameterisation work described in this report.

2.6.1 Statistical representation of the parameters

The K_d and CR parameters are described by probability density functions (PDFs) defined by the geometric mean (GM) and the geometric standard deviation (GSD) of the assumed lognormal distributions. The PDFs, which are utilised at the probabilistic simulations, are complemented by best estimates (BEs) that constitute the most probable values utilised at the deterministic simulations, and minimum and maximum values. The minimum value represents the lowest value of the reported minimum and the 5th percentile of the theoretical distribution defined by GM and GSD, and similarly, the maximum value represents the highest value of the reported maximum or the 95th percentile of the theoretical distribution.

By definition, the PDF should include the variability over time and space that a specific parameter could attain in a specific biome, e.g. soil type, water type, in Forsmark over the simulation period of 100,000 years. This means that the PDF should include the natural variation currently at the site and the variation due to the long-term landscape evolution. The natural variation could be divided into spatial, temporal and biological components. The spatial component comprises variation due to heterogeneities within the defined model compartments, e.g. due to variability in chemical environment, soil properties etc. The temporal component encompasses uncertainties due to seasonal variability as well as interannual variability in a perspective corresponding to the temporal resolution in the radionuclide model, i.e. 50 years. The biological component comprises variation due to e.g. differences among plant or animal species.

2.6.2 Site data are generally prioritised over literature data

The empirical parameter values described in this report reflect the integrated effects of many environmental and ecological processes between soil, water and biota. These constants are usually greatly dependent on the specific environment in which they are determined, and it is commonly argued that they are not applicable outside the assessed environment (US EPA 1999, IAEA 2010). This implies that literature data usually have limited value other than for screening purposes and that site-specific data should be utilised when available. Hence, site data are generally prioritised over literature data in the parameterisation. The rationale for this principle is that literature data usually are a compilation of data from disparate sources and studies, where the environmental context of the data is not always available. Thus, literature data are often highly variable and inconsistent, which are unfavourable in the assessment context, whereas site data usually have been sampled to represent the specific modelled conditions.

Literature data have an important role as reference for comparisons and plausibility control of selected site data in this report. Literature data have been utilised for the parameterisation in lack of other data.

2.6.3 Data from Laxemar-Simpevarp are assumed representative for the future conditions in Forsmark.

Site data are available for Forsmark (FM), the site of concern in this safety assessment, and for the Laxemar-Simpevarp area (LX), an area situated approximately 460 km south of FM. In general, the current chemical and biotic environment of the two sites correlates well. This is due to their relative proximity and location in the same vegetation zone, their coastal position and comparable temperature and precipitation situations. However, upon further examination some pronounced differences between the two sites are noticed, primarily due to the more immature landscape in FM. FM has a presence of calcite in the regolith and the dissolution of this calcite will probably play a key role in the shift in the chemical environments, which is expected to occur within a few thousand years. The shift in the chemical environments will affect ecosystem structures (Tröjbom and Grolander 2010). Future morphological changes in the landscape, due to the ongoing land-rise, will also affect the existing ecosystem structures as well as introduce new types of ecosystems that are not currently present in the FM area. The expected future chemical shift in FM is thought to alter the environment more alike the environment of present-day LX. Therefore, site data from both FM and LX are considered representative site data for the FM area across the modelled time period.

It is assumed that the BEs of element-specific parameters are best represented by GMs of measurements exclusively from the present-day FM site. The deterministic simulations are based on these BEs.

The combined data from FM and LX are assumed to represent the current and future conditions at FM. The PDFs, which are utilised for probabilistic calculations, are estimated by GMs and GSDs of both FM and LX data.

2.6.4 It is assumed conservative to expand the PDFs

When the observed variation for an element-specific parameter is very low, the variation range is expanded in order to compensate for a possible underestimation of variation, which could be a result of for example limited data. This correction approach is assumed to be conservative and the magnitude of the correction is determined by the assessed reliability of the available data. In order to assign a realistic variation for element-specific cases, the general patterns of variation observed across a large number of elements for specific parameters are analysed, which are described further in Section 4.3.

2.6.5 Analogues are utilised when data are insufficient or missing

Three general types of analogues are utilised in this work, depending on the actual situation to parameterise: isotope analogues, element analogues and parameter analogues.

Isotope analogues are commonly utilised in this work without further recognition, assuming that the behaviour of element isotopes in the environment is identical. However, this assumption is primarily valid for isotopes that are in similar physico-chemical forms in equilibrium with a long-term release or occur naturally in the environment. If this is not the case, e.g. due to differing transfer routes or very different half-lives of the isotopes, this assumption might be less valid (IAEA 2010).

The second type of analogue, the element analogue (EA) is utilised when data for an element are not available but data for an element with similar biogeochemical properties are available. In general, elements of the same group of the periodic table have similar chemical properties since they have the same number of outer electrons that can participate in chemical reactions. However, even if elements are chemically similar their behaviour in natural environments can differ, which is especially true for uptake in biota. Thus, an analogue can for example be used to describe element mobility of a certain element although (at the same time) be unusable to describe uptake. EAs are utilised in the parameterisation when element-specific data are missing or as supporting data for comparison and evaluation of data. The EA-approach always implies an increased level of uncertainty compared to the situation when the data of the proper element are available (IAEA 2010).

The third type of analogue utilised in this work is the parameter analogue (PA). When using PAs, data for similar species or soil types are utilised to fill data gaps, assuming the element behaves similarly in both organisms and materials in the given environmental context. For example, data regarding one soil or biota type can be utilised for parameterisation of other soil and biota types where data are missing. The use of PAs is also associated with increased level of uncertainty compared to the situation when the data of the proper parameter are available (IAEA 2010).

PAs and EAs can also be utilised in combination, which attributes to even greater uncertainties. EAs and PAs may also be applied to literature data.

2.6.6 Data representing different ecosystem compartments are not merged in the statistical handling

The rationale behind the division of ecosystems into the selected compartments, is that they are functional units with unique properties. There might, or might not, be a difference between the compartments regarding the modelled processes, depending on the element. The limited number of available samples usually restricts the possibilities to detect statistical significant differences among the defined compartments. Specific K_d and CR values are estimated for a large number of ecosystem compartments in this safety assessment, which might give a false impression of high accuracy in the data. Data representing different ecosystem compartments are, however, not merged in the statistical handling in this report. Reasons for this decision are the practical implications of the vast number of parameter and element combinations to handle, and the reduced comparability among elements based on different sets of data.

2.7 Utilised element analogues

This section presents the elements for which analogues were utilised, their possible analogues and the accompanying literature information and site-specific considerations. Discussions are provided on the suitability of the proposed analogues and, in some cases, the chemical modelling utilised to support the selection of EAs. The selection of EA/EAs is/are based on these assumptions.

2.7.1 The alkaline earth metals (Ca, Sr, Ba, Ra)

Four of the alkaline earth metals (Ca, Sr, Ba and Ra) are of interest in the current safety assessment. The alkaline earth metals have similar chemical properties and these elements exist in the oxidation state +II in natural environments. Ca is a macronutrient and is actively taken up by biota.

The use of analogues in this group is complicated by the occurrence of calcite/aragonite and barite in the FM area. Many soil types in FM have high concentrations of $CaCO_3$, which often controls the pools of Ca (Tröjbom and Grolander 2010). This may also affect the mobility of Sr, probably by co-precipitation, and the site-specific K_d values for Ca and Sr correlate well throughout the investigated FM sites. This indicates that Ca and Sr have similar behaviour and, therefore, supports the use of Ca and Sr as analogues for each other.

Ba and Ra ions are assumed less affected by precipitation of $CaCO_3$ due to their greater ionic radius. However, Ba is well known to precipitate as barite ($BaSO_4$) in sea water, and barite may occur as a primary mineral in Swedish soils. Additionally, many soil types in the FM area have a pronounced marine history, e.g. sediments that were deposited under marine conditions, and may contain marine barite. The presence of barite is primarily expected to affect the mobility of Ra, which readily co-precipitates with barite. Therefore, the use of analogues among the alkaline earth metals has been restricted to Ca and Sr, and, Ba and Ra (Jaremalm et al. 2014).

2.7.2 Lanthanides and trivalent actinides (Ac, Am, Cm, Eu, Ho, Sm)

The lanthanides and the trivalent actinides Ac, Am and Cm are another group of EAs utilised in this study. The actinides Ac, Am and Cm exist as trivalent cations in the natural environment and are commonly accepted as elements suitable as analogues. Ac, Am and Cm are assumed to behave similarly to the trivalent lanthanides as well.

The lanthanide series are noted for their similar geochemical properties. All the lanthanides, with the exception of Lu, are characterized by the filling of the 4f electron shell. As the atomic number increases, so does the nuclear charge, however, the shielding effect of the 4f electrons is relatively poor, causing an increased force on the outer shell electrons with increasing nuclear charge. Hence, the ionic radii of the lanthanides tend to decrease with increasing atomic number known as the lanthanide contraction. The 4f shell influence is minimal on the formation of chemical bonds, since it is located comparatively close to the nucleus. All the lanthanides occur in trivalent state in natural waters and the differences among them are primarily due to their variation in ionic radius. As a result, lanthanides often display similar biogeochemical behaviour, although often with a slight variation between light and heavy lanthanides.

Lanthanides have the ability to form fairly strong carbonate complexes, although the investigations from FM, based on thermodynamic modelling, indicated that carbonate will not be important for the mobility of lanthanides in these environments. Instead, the aqueous speciation of La and other lanthanides will be dominated by DOC and, possibly, Fe colloids (Rönnback et al. 2008). Two important exceptions are Ce and Eu that sometimes occur in other oxidation states in minerals. Ce can be oxidized to the tetravalent oxidation state easier than other lanthanides, which occasionally causes a so-called Ce anomaly. Eu may be reduced to Eu^{2+}, causing it to occur in other minerals, which can give rise to a Eu anomaly. This is primarily relevant for the mobilisation of these elements by weathering.

The biogeochemistry of Ac, Am and Cm is not well examined, primarily because their rare occurrence in the natural environment. Am and Cm are predominately artificial elements, while ^{227}Ac occurs in small amounts as a radioactive decay product of ^{235}U. The actinides are characterized by the filling of the 5f electron shell. Compared to the systematic behaviour of the lanthanides, the actinides show much more variation in the valance states. Ac, however, is stable in the trivalent state just like the lanthanides and because Ac has a similar electron structure and ionic radius as La, it is expected to behave similar to the lanthanides. Cm also occurs in the trivalent valence state, which is the most stable valence state of Am as well. There is a similar contraction effect in the actinides series as it is in the lanthanide series, causing the Am^{3+} and Cm^{3+} to be somewhat smaller than the Ac^{3+}. This makes them even more similar to the lanthanides in terms of ionic radii, which is the reason that Am and Cm are expected to behave similar to the lanthanides in general.

Actinium occurs as Ac^{3+} and is expected to have a similar affinity for organic matter as Am. Based on this assumption, the aqueous speciation of Ac is believed to be dominated by organically bound Ac and, possibly Fe colloids. No mobile carbonate or other complexes are expected to occur in significant amounts.

Besides U(VI), Am is the only actinide for which the Stockholm Humic Model (SHM) (Gustavsson 2001) contains parameters for the interaction with DOC. Am is believed to occur exclusively as a trivalent ion. Modelling of the aquatic speciation of Am in Eckarfjärden, utilising Visual MINTEQ 3.0 (Gustavsson 2001), suggests that the aquatic speciation of Am in the calcite-influenced waters of FM is completely dominated by association to DOC. However, Fe colloids were not included in the calculations and they may also contribute significantly to the speciation. The importance is that there are no indications of formation of carbonate complexes or other potentially mobile complexes. Am seems to behave in a similar manner as the lanthanides in the FM area (Rönnback et al. 2008).

Cm occurs as Cm^{3+} and is expected to share the high affinity for organic matter that is displayed by Am. Consequently, the aquatic speciation is expected to be dominated by DOC and, possibly, Fe colloids. No carbonate complexes of importance or other potentially mobile complexes could be identified based on thermodynamic modelling using Visual MINTEQ 3.0.

Am, Cm and Ac always lack site data and site data for a selected lanthanide are preferred over reported literature data (the lanthanide with the highest reported sample number is chosen as EA). In some cases, site data on Eu, Ho and Sm are missing and site data on an element of the lanthanides series is utilised as EA.

2.7.3 Redox sensistive actinides (Np, Pu)

Site data on the actinides Np and Pu are often missing. Np and Pu are redox sensitive and can be present in several different oxidation states. Np is expected to occur as Np(IV) or as Np(V) depending on the redox conditions, while Pu may occur as Pu(III), Pu(IV), Pu(V) or Pu(VI).

Based on the hydrochemistry in one of the groundwater tubes in Forsmark (groundwater tube with the SKB identification number SFM00002), Np(IV) is predicted to prevail if Eh falls below approximately 200 mV, while Np(V) will prevail if Eh is above 200 mV (Figure 2-3). Oxidation/reduction of Fe will occur at a slightly higher Eh (~225 mV). However, since the reactions from a thermodynamic perspective should be almost concurrent, Fe should be an acceptable redox indicator for Np (Figure 2-3). To find suitable analogues for Np, a similar argument to that for Tc (see Section 2.7.12) will be utilised. If Fe displays high K_d values, it is assumed to indicate the presence of Fe(III), and then Np is assumed to be present as Np(V). In contrast, Fe(II) is assumed to dominate if Fe displays low K_d values, and then Np is assumed to be present as Np(IV). In the latter case, Th is utilised as an analogue for Np, since Th is present as Th(IV). The mobility of Np(V) is discussed below.

All four oxidation states are possible for Pu in the waters of FM. Based on the groundwater chemistry in groundwater tube SFM00002, Pu(VI) is expected to dominate at Eh above 680 mV. Pu(V) will dominate in the Eh range 480–680 mV. Pu(III) will dominate at Eh below approximately –10 mV, which leads to the wide range of –10 to 480 mV for Pu(IV).

Another potential redox indicator is Mn, whose K_d values have a distinct bipolar distribution in the FM area (Sheppard et al. 2011). Mn(II) is calculated to be stable at Eh below approximately 620 mV, based on SFM00002. If low K_d values for Mn are interpreted as a prevalence of Mn(II), the Mn can be utilised as a redox indicator for Pu. Hence, if Mn displays high K_d values it indicates that the Eh is above 620 mV and, thus, Pu is expected to be present as Pu(V) and Pu(VI). Then U is utilised as an analogue for Pu because in the hexavalent state, present as the plutonyl ion (PuO_2^{2+}), Pu shares the ability of the isostructural uranyl ion (UO_2^{2+}) to form strong carbonate complexes. Since these complexes often are neutral or negatively charged, they will no longer be retained by the same processes as cations. Consequently, U is one of the elements in FM that displays the highest variation in observed K_d values (Sheppard et al. 2011). Accordingly, Pu is expected to be highly mobile under oxidizing conditions when the carbonate concentrations are high. One significant difference between Pu and U is that Pu(VI) is reduced considerably easier than U(VI). While reduction of Pu(VI) is expected to occur below 680 mV, reduction of U(VI) is only expected at Eh below approximately –150 mV.

It is challenging to find suitable analogues for the pentavalent species, Np(V) and Pu(V). NpO_2^+ and PuO_2^+ can form anionic carbonate complexes, such as the uranyl and plutonyl ions, which potentially could make them as mobile as U in calcite-rich environments. However, these carbonate complexes are not as strong as that of U(VI) and Pu(VI) and therefore are not expected to dominate the speciation as in the case of uranyl ion. In this sense, the pentavalent ions are similar to the lanthanides and the trivalent actinides. Consequently, this group contains the preferred choice of analogues, which should result in a somewhat higher mobility than the tetravalent actinides.

One important aspect of the geochemistry of actinides, is the low solubility of tetravalent ions, particularly as AnO_2. This pertains to Th, U, Np and Pu, which all may occur in the tetravalent state. As Th only occurs in this state, it is a good analogue for U(IV), Np(IV) and Pu(IV). Precipitation of AnO_2 is potentially an important retention mechanism for tetravalent ions, although it depends on both the redox conditions and the concentrations of the actinides in question. In a pessimistic scenario, where all radioactivity in the repository is released during the course of 1,000 years, it is estimated that concentrations of ^{237}Np in the biosphere will peak at 24 Bq m^{-3}. This corresponds to a concentration of 1.2E–13 µM. Pu will consist of a mixture of ^{239}Pu (67%), ^{240}Pu (24%), ^{241}Pu (1%) and ^{242}Pu (8%), in terms of mass. This corresponds to a total Pu concentration of 2.2E–14 µM. Thermodynamic modelling suggests that this would be enough to precipitate both Np and Pu, provided that the redox potential is suitable (Figure 2-3). However, it is common that the model also indicates strong supersaturation of ThO_2, which apparently is incorrect, since the observed concentrations evidently are present in the water samples. The problem occurs since the model does not contain parameters for the association to DOC, which leads to an overestimation of the free An^{4+} ions in the aqueous solution. Fe colloids were not considered in the model either. Therefore, the conclusions pertaining to the precipitation of AnO_2 are uncertain and further work is necessary to determine whether it is a reasonable possibility.

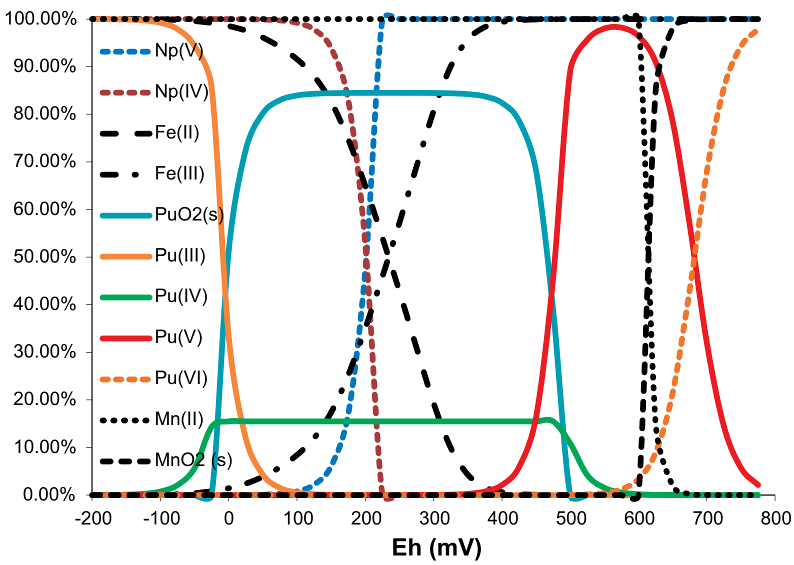

Figure 2-3. *Modelled valence states for Np, Pu, Fe and Mn in the groundwater tube SFM00002, utilising Visual MINTEQ 3.0 as a function of Eh. Precipitation of MnO_2 has been allowed for Mn, Np and Pu, though as the model does not account for formation of organic and inorganic colloids; predicted precipitation by the model does not necessarily imply that precipitation should be expected. Instead, the results should be interpreted in terms of thermodynamically favorable oxidation states under varying redox conditions.*

No site data are available for Np and when literature data are missing, EAs are assigned depending on the expected redox state. The element Th will be utilised as an EA for Np for reducing environments and lanthanides or trivalent actinides are used for oxidising environments.

For Pu, EAs are assigned depending on the expected redox state. Lanthanides or trivalent actinides are utilised for reducing environments. For oxidising environments, Pu is assumed to dominate as Pu(V) and U is selected as EA.

2.7.4 Protactinium (Pa)

Pa is expected to occur as Pa(V). Relatively nominal knowledge exist about the biogeochemistry of Pa since is not very abundant, though observations have been made that it is generally less particle reactive than Th in sea water (Geibert and Usbeck 2004). This is consistent with the observation that the residence time of ^{231}Pa in sea water is longer than that of ^{230}Th (Gasse et al. 1997). Therefore, other trivalent actinides or lanthanides are utilised as analogues for Pa.

2.7.5 Overview of transition metals

The transition elements are characterised by the filling of the d shell orbitals (The elements of the periodic groups 3–12, here Cd, Mo, Ni, Nb, Ag, Pd and Tc). The d-orbitals are located inside the outermost s-orbitals, which may contain one or two electrons; a circumstance that leads to several irregularities among the transition metals. One effect is that the transition metals show similarities with the horizontal neighbours in the periodic table, i.e. among different groups, while vertical similarities, i.e. within groups, generally dominate in other parts of the periodic table. This implies that analogues may be found outside of the group in the periodic table and elements from of the same period can be of interest.

2.7.6 Cadmium (Cd)

Zn and Cd exclusively occur in the divalent valence state in natural water and generally exhibit similar biogeochemical properties. However, while Zn is an essential element, Cd is not. The toxicity of Cd seems to be partly related to its ability to replace Zn in proteins. This supports the use of Zn as analogue for the uptake of Cd.

2.7.7 Molybdenum (Mo)

Mo is expected to occur primarily as molybdate (MoO_4^{2-}) except in strongly reducing environments, where it can be reduced. Suitable analogues for Mo are therefore similar oxyanions, e.g. pertechnetate (TcO_4^-), chromate (CrO_4^{2-}) and perrhenate (ReO_4^-), all of which are adjacent to Mo in the periodic table. However, both pertechnetate and chromate are generally more easily reduced than molybdate, and Tc(IV) and Cr(III) are not expected to be good analogues for Mo(VI). Therefore, Tc and Cr were only utilised as analogues for Mo in environments where they are expected to occur in the oxidized forms.

2.7.8 Nickel (Ni)

Zn and Ni exist as divalent cations in natural environments and generally exhibit similar biogeochemical properties. The toxicity of Ni is due to its similarities to Zn and that it can replace Zn in essential enzymes or proteins.

2.7.9 Niobium (Nb)

Nb has no known biological function; it is immobile and can be expected to behave similar to Zr or Ta.

2.7.10 Silver (Ag)

According to Connell et al. (1991), Ag is strongly bound to cell surfaces over a wide range of chemical conditions, thus suggesting that Ag is less available than for instance Cu and Zn. Zn is an essential element and Cu are only present as a Cu(I) in strongly reducing environments. None of these elements are a good analogue for Ag, though these elements are utilised as analogues since they are closest to Ag, in lack of better data or analogues.

2.7.11 Palladium (Pd)

Pd belongs to the platinum group metals, and they generally are considered to have similar chemical and physical properties and often occur in the same minerals. However, they often occur in different valence states in natural waters, which complicate the use of analogues within the platinum group. Data from the platinum group metals are scarce. Pd is known to have a strong affinity for organic matter and occurs as Pd(II) (Turner et al. 2007). Pd has also been observed to covary with Ni in sea water and marine sediments, which suggest that they follow similar biogeochemical pathways (Lee 1983). Given that both Pd and Ni occur as divalent ions and belong to group 10 in the periodic table of the elements, Ni can be a reasonable analogue for Pd. At the FM sites where Pd has been analysed, the K_d values correlate reasonably well with the K_d values of Ni.

2.7.12 Technetium (Tc)

Tc is redox sensitive and can exist in oxidation states +VII to –I. The most stable oxidation states of Tc in natural environments are +IV and +VII, in reducing and oxidizing environments, respectively. Tc(VII) forms pertechnetate, TcO_4^-, which is highly mobile and essentially not adsorptive. TcO_4^- is stable in the entire pH range of natural waters and no complexes are known to be formed. Therefore, K_d for Tc in oxidizing environments is considered to be close to zero. Tc will be reduced to Tc(IV) in reducing environments and a tetravalent cation will form. Tc(IV) is considered to be immobile, since it forms strong complexes with iron and aluminum oxides and clay minerals. It can also form the TcO_2 solid that is barely soluble. If complex forming agents are available, Tc(IV) can form soluble complexes that would enhance mobility of Tc. Colloids can also be formed and then Tc would be more mobile (US EPA 2004).

Even if Eh suggests that Tc(VII) is the dominant stable oxidation form, the reduced form of Tc(IV) can co-exist in the same environment (US NRC 2003). This is probably due to reduction caused by organic matter and the presence of other reducing agents, e.g. Fe(II). In some cases, microenvironments can be formed in the soil matrix and reducing conditions can prevail in these microenvironments and cause the reduction of Tc(VII). This will affect the mobility of Tc and the reduction of Tc(VII) to Tc(VI) will cause an increase in sorption by a factor 10^3 (US NRC 2003).

Tc is located in group 7 of the periodic table together with Mn and Re. These elements along with Mo, Ru, W and Os, located in groups 6 and 8, have similar chemical properties as they all have electrons of similar energy levels in the d-shell (US NRC 2003). The electrons in the d-shell participate together with the s-electrons in reactions.

The large difference in mobility of Tc(IV) and Tc(VII) complicates the choice of analogues for Tc, as it requires an assessment of which oxidation state will dominate in different cases. Re appears to be the obvious choice of analogue, since both Tc and Re occur predominately as tetravalent or heptavalent ions in natural waters. In the heptavalent state, they occur as perrhenate (ReO_4^-) and pertechnate (TcO_4^-). The tetravalent state is characterized by the low solubility of ReO_2 and TcO_2. However, a major problem with utilising Re as an analogue for Tc is that Tc(VII) is easier to reduce than Re(VII). The mobile perrhenate is stable over a wider Eh-pH range than pertechnate and, as a consequence, Re may not always be a suitable analogue for Tc.

A potentially crucial difference between Re and Tc is that Tc(VII) normally is reduced by Fe(II) (Peretyazhko et al. 2008, 2012), while Re(VII) is not (Reinoso Maset et al. 2006). Thus, Re is not a suitable analogue for Tc under anoxic, Fe-reducing conditions. To resolve this problem, two other redox sensitive elements, Mn and Fe, have been utilised as indicators of the redox potential in various soil types. Sheppard et al. (2011) have previously noted that the K_d values for Mn and Fe display a characteristically bipolar distribution, where the high K_d values presumably are associated with Fe(III) and Mn(IV), which both have low solubility, while the low K_d values indicate the predominance of the mobile Fe(II) and Mn(II) species. The K_d values of Mn and Fe exhibit low and high values in the same type of soils, though there are two exceptions where the K_d value of Mn is low and the Fe value is high. However, this does not contradict the assumptions above as Mn(IV) is easier reduced than Fe(III). At sites with high K_d for Fe, Tc is assumed to be present as Tc(VII). Re, which should be present in the heptavalent state whenever Tc is, is used as an analogue for Tc in this case. In the opposite case, when the K_d values for Fe are low, Fe(II) is assumed to be present and Tc(VII) is assumed to have been reduced to Tc(IV). In this case, other tetravalent metals such as Th, Hf and Zr are assumed to be more adequate analogues for Tc.

Re or Zr are utilised as EA for parameters depending on the expected redox condition of the modeled compartment. In cases where an oxidation environment can be expected to dominate, e.g. in agricultural soils, Re data are utilised to parameterise Tc. Zr are utilised as EA in cases where a reducing environment are expected to dominate the tetravalent.

2.7.13 Chlorine (Cl)

The anion Br is utilised as EA for Cl. These elements are both anion with the oxidation state –I in natural environments.

2.7.14 Polonium (Po)

When data for Po are missing, the adjacent elements of the periodic table Bi or Pb are utilised as EA.

2.7.15 Selenium (Se)

Se can be expected to have similar chemical properties as the adjacent element Te.

2.7.16 Tin (Sn)

The biogeochemistry of Sn is not well researched and relatively little is known about its mobility in the environment. One important aspect of the biogeochemistry of Sn is that it is redox-sensitive, occurring as Sn(II) or Sn(IV), with the latter thought to dominate in surface water. Sn(II) has a similar ionic radius as Fe(II), while Sn(IV) has a similar ionic radius as Fe(III), which often causes Sn to be considered siderophilic. For instance, Sn has a high affinity for Fe-bearing minerals, such as garnet and mica, and it is also common in Fe and Pb sulphides (Yi et al. 1995). The sorption of Sn onto goethite has been observed to decrease with increasing DOC concentrations, indicating that Sn has a high affinity for organic matter and that DOC is important for its mobility (Ticknor and McMurry 1996). This is also supported by Pokrovsky et al. (2005), who studied Sn in peat soil solutions from western Russia. Most of the Sn was present in the >1 kDa fraction along with elements such as Al, Ti, rare earth elements (REEs), Zr, Th and U, while 20–30% was found in the <1 kDa. This suggests that the mobility of Sn in organic soils is primarily controlled by organic colloids and that Sn has a high affinity for organic matter. pH, on the other hand, is thought to have little effect on the sorption of Sn(IV) onto goethite and other minerals (Ticknor and McMurry 1996, Kedziorek et al. 2007). Studies of Japanese river and marine sediments indicate that the mobility and bioavailability of Sn is lower than that of Cu, Ni, Pb and Zn (Baasansuren et al. 2002).

The thermodynamic constants for Sn have been reviewed by Séby et al. (2001). However, there seem to be no available constants for the binding of Sn to DOC, which according to the observations above, should be important for Sn. Therefore, it is currently not possible to draw any certain conclusions regarding the speciation of Sn in the FM area based on thermodynamic modeling. However, it is possible to study the redox transitions and using Visual MINTEQ 3.0, reduction of Sn(IV) to Sn(II) is expected to occur at an Eh between –300 mV and –400 mV based on the hydrochemistry of Lake Eckarfjärden. Accordingly, Sn(IV) is expected to be the dominant valence state of Sn. In inorganic solutions, Sn(IV) may form an anionic hydroxide complex ($Sn(OH)_4^{2-}$), although in natural waters where both DOC, Al and Fe colloids are present, there are no indications that this complex would be important for the mobility of Sn.

Data on Sn are missing in many cases. Since Sn can be expected to behave as a tetravalent metal ion (low mobility, high affinity to organic matter and colloids) the tetravalent ions of Zr, Hf or Th can be expected to be suitable EA for Sn.

3 Description of data

This chapter describes the general properties of the data sources utilised in this report for parameterisation of the radionuclide dose model. Both site-specific and literature data are used for parameterisation of K_d and CR parameters.

3.1 Site data from Forsmark and Laxemar-Simpevarp areas

Site-specific data have been measured by SKB, 2002–2007, through extensive site investigations at Forsmark (FM) and Laxemar-Simpevarp (LX), the two candidate sites for the repository for spent nuclear fuel. Additional data have been sampled in the FM area for the current safety assessment for the extension of the SFR repository, SR-PSU. The FM data collected during the site investigations are highly relevant to this safety assessment, since the SFR repository is situated in the FM area. Although the LX site is at later stage in the land rise succession process, the data from LX are considered highly relevant since the two sites represent similar costal ecosystems and LX might therefore represent future conditions at the FM site. Data from FM and LX areas will be combined and used as site-specific data in this study.

The chemistry data collected during the investigations at LX and FM preceding the SR-Site safety assessment have been reported in several reports. A summary and description of these data can be found in Chapter 2 in Tröjbom and Nordén (2010). Additional K_d and CR measurements were performed in 2010 by Sheppard et al. (2011). Since new data are available and the radionuclide model has been updated, data selected for parameterisation in the SR-PSU safety assessment can differ from the data selected during SR-Site. Data included in the SR-PSU safety assessment are described in the sections below and in Section 3.1.5 detailed references are given to the SKB database Sicada.

3.1.1 K_d data for soil and particular matter

In the previous safety assessment conducted by SKB, SR-Site, K_d data for soil, sediments and suspended particular matter from Engdahl et al. (2008), Kumblad and Bradshaw (2008) and Sheppard et al. (2009) were considered to be relevant site data, suitable to use for parameterisation (Tröjbom and Nordén 2010, Nordén et al. 2010). These studies contain chemical data for centrifuged soil/filtered sediment and corresponding pore water, measured at both LX and FM. The data presented in these studies are also considered relevant as site data in this study. An additional study was conducted in the FM area in 2010, where element concentrations in centrifuged soils, marine sediments and corresponding pore water concentrations were analysed (Sheppard et al. 2011). These data are also considered suitable to use for parameterisation in this study.

3.1.2 Element concentration data for marine biota and sea water

To be consistent with the extensive reporting in the SR-Site safety assessment, the term marine (ecosystem, species) has been used in a broader meaning, representing a sea ecosystem or species living in the sea. Thus, organisms that can tolerate the low salinity (~ 5‰) of the brackish water of the Baltic Sea outside Forsmark have been classified as marine organisms.

Element concentration data for marine primary producers are available for phytoplankton (FM), microphytobenthos (FM), macroalgae (both sites) and for macrophytes (both sites) (Kumblad and Bradshaw 2008, Engdahl et al. 2006, Roos et al. 2007).

Data for marine fauna includes data for zooplankton (FM), benthic fauna (both sites) and fish (both sites) (Kumblad and Bradshaw 2008, Engdahl et al. 2006, Roos et al. 2007).

Site-specific chemistry data for marine water were reported in Engdahl et al. (2008) (both sites) and Kumblad and Bradshaw (2008) (FM). The concentrations measured in these water samples are used in combination with the measured concentrations in biota for CR calculations.

3.1.3 Element concentration data for limnic biota and lake water

Element concentrations of limnic primary producers are available for microphytobenthos, and macroalgae (FM) and for macrophytes (both sites) (Hannu and Karlsson 2006, Engdahl et al. 2006, Roos et al. 2007, Grolander and Roos 2009).

Chemistry data for limnic fauna are available for mussels and fish (both sites) (Hannu and Karlsson 2006, Engdahl et al. 2006, Roos et al. 2007).

Lake water element concentrations were reported in Engdahl et al. (2008) (both sites) and data on radionuclides were reported in Grolander and Roos (2009) (FM). These measured lake water concentrations are used in combination with the element concentrations in biota for CR calculations.

3.1.4 Element concentration data for terrestrial biota and soil

Concentration measurements of various terrestrial primary producers were compiled in Hannu and Karlsson (2006), Sheppard et al. (2011) (FM), Engdahl et al. (2006) (LX) and Grolander and Roos (2009) (both sites). The data sets include green parts, wood and roots from natural vegetation as well as stems, roots and grains of cereals.

Mushroom and soil samples from Forsmark were analysed in Johanson et al. (2004). The aim was to investigate the CRs and accumulation of various elements in mushrooms in forest ecosystems. Concentrations were measured in mushroom fruit bodies and mycelia, and in three different soil fractions; the bulk soil, the rhizosphere fraction and the soil-root interface fraction.

Chemistry data for muscle tissues of terrestrial mammals were available for small rodents, large herbivores and carnivores at both sites (Hannu and Karlsson 2006, Engdahl et al. 2006, Roos et al. 2007).

Soil samples from both FM and LX were analysed in Engdahl et al. (2006), Hannu and Karlsson (2006), Sheppard et al. (2009, 2011), Johanson et al. (2004) and Tröjbom and Söderbäck (2006). Soil samples can be prepared differently depending on the purpose of the concentration analysis. In Engdahl et al. (2006), Sheppard et al. (2009, 2011), the soil samples were analysed after aqua regia digestion while the soil samples in Hannu and Karlsson (2006), Johanson et al. (2004) and Tröjbom and Söderbäck (2006) were analysed after total digestion. When soil samples are digested completely (total digestion), the total mineral fraction of a soil sample is digested, which for some elements result in lower CR values than if a non-total extraction such as aqua regia is used. The total digestion includes elements otherwise locked in mineral structures and that would not be accessible to biota. Using aqua regia for digestion is assumed to be a better representation of the potentially bio available fraction of an element in the soil particles. Based on this assumption, the data in Hannu and Karlsson (2006) and Tröjbom and Söderbäck (2006) are not included in this study.

3.1.5 Detailed references to site data used in this report

In the SKB main database (Sicada), data on element concentrations in biota, water and regolith from FM and LX are primarily stored (among other data). Each data entry in Sicada has a unique sample number that makes it possible to trace conditions at sampling and analysis. Within the SR-PSU project a compilation of quality controlled data on element concentrations in water, regolith and biota from both FM and LX are used[1]. This quality controlled data compilation is based on two data files[2] originally assembled for the previous safety assessment SR-Site, in turn based on Sicada orders 09_28_2, 09_010_1, 09_010, 09_007_2, 09_001 and 08_187), combined with recent data from Sicada (Sicada orders 2011_52, 2011_60 and 2011_67).

[1] File stored at SKB server at location (svn://svn.skb.se/projekt/SFR/SR-PSU/Indata/Chemistry/SKB_Chemistry_SR_PSU.xlsx)

[2] Files stored at SKB server at location svn://svn.skb.se/projekt/SrSite-Bio/Generic/Indata/Element_specific/Forsmark%20Chemistry%20water%20deposits%20%20biota%20090313.xls and svn://svn.skb.se/projekt/SrSite-Bio/Generic/Indata/Element_specific/Simpevarp%20Chemistry%20water%20deposits%20%20biota%20090317.xls

3.2 Sources of literature data

A literature data review has been conducted within this study. Data reported by three major data sources (IAEA 2010, ERICA (Beresford et al. 2008a, Hosseini et al. 2008) and ICRP 2011) has been compiled. Even though the data compilations from these three sources are independent, they rely to some extent on the same original data and, therefore, are fairly interconnected. These three data sources are described below.

3.2.1 IAEA technical reports

The International Atomic Energy Agency (IAEA) has supported authorities, industries and others performing radiological impact assessments for many years by compiling and publishing transfer data. The data, published in different technical reports, have been used as key references in environmental impact assessments (IAEA 2010). The first IAEA report that contained K_d and CR data for marine environments was published in 1985 (IAEA 1985). In 1994 a second report containing K_d and CR values for terrestrial and limnic environments was published (IAEA 1994). Since new data have become available over the years, an updated version of IAEA (1985) comprehending revised CR and K_d data for marine environments, was published in 2004 (IAEA 2004). In 2003 a revision of IAEA (1994) was initiated within the Environmental Modelling for Radiation Safety (EMRAS) project resulting in a report containing updated CR and K_d values for terrestrial and limnic environments (IAEA 2010). This publication was supported by a technical document where the radiological and modelling concepts included in IAEA (2010) were described (IAEA 2009).

The IAEA (2010) report and the attached technical document (IAEA 2009) have been used as major references in this study. The transfer data presented in IAEA (2010) have been computed, using CR and K_d data from different literature sources, and categorised into soil type and biota type transfer data, according to a categorisation scheme. The categorisation of the transfer data makes it possible to select relevant and representative data, given a specific assessment context. Below is a short description of transfer data from IAEA (2010) that are used in this study.

K_d data for various soil types, such as mineral soil, organic soil, loam and sand, are available for several elements. K_d values for the category all soils, where all available K_d values were combined, are included as well. The report also categorised the K_d values by soil properties defined by soil texture and organic matter content. The data categorised per soil type were included in this study and the data categorized by soil texture and organic matter were excluded. In addition to the K_d values for soil, K_d values for limnic particular matter are included in IAEA (2010). These data for particular matter are included in this study.

CR values are presented for various crop types, such as cereals, tubers and vegetables. The values are divided into plant parts, for example cereal-grains, cereal-stems, cereal-shoots, or vegetable-leaves, vegetable-seeds-pods. CRs are also reported for different soil types. The categorisation of CRs makes it possible to select data for a specific crop type, crop part and soil type that is representative for the modelling situation of concern. These reported CRs are included in this study.

CRs for the limnic system are reported in IAEA (2010). The water to organism CRs for edible aquatic plants, fish (muscle tissues as well as whole organisms) and invertebrates are used in this study.

Transfer factors for meat and milk from domestic animals, such as cows, sheep and goats are presented in IAEA (2010). The featured transfer coefficients relate intake of fodder and water by the animal to the concentration of a given element, in an animal's meat and milk. Additionally, the report included CRs relating element concentrations in fodder to element concentrations in meat and milk from domestic animals. These transfer coefficients and CR are included in this study.

Conversion factors for dry weight and carbon content of different biota types were reported by IAEA (2010) and these are included in the SKB database used in this study. These conversion factors are used to convert data into one common unit, in order to make values comparable (see Section 3.2.4).

A compilwation of available CR and K_d values for marine environments are reported in IAEA (2004). The aim of this report was to update the values that were presented in IAEA (1985). Since a full review of data was not possible, the focus was placed on elements where new data were available and on elements considered important in safety assessment contexts. The report presents recommended CR and K_d values for various elements, however, no information regarding data distributions is provided. Instead, it is suggested that modellers can assume maximum and minimum values that are one order of magnitude above respectively and below the reported recommended values. It is stated that due to limited data, empirical distributions were not possible to assign to data. These estimated values are recommended to use in cases when site-specific data are absent. Since a distribution of data is required in this study, the data in IAEA (2004) were not included in this study.

3.2.2 ERICA

The project Environmental Risks from Ionising Radiation in the Environment: Assessment and Management, ERICA, was co-funded by the European Union and fifteen organisations in seven European countries. The purpose of the project was to develop an approach to assess the impact of ionising radiation on the environment. It resulted in an assessment tool and a database, with transfer factors for biota in freshwater, marine and terrestrial ecosystems (Beresford et al. 2007, Brown et al. 2008). The transfer data compiled within the ERCA project focus on dose assessments to non-human biota and, therefore, the data compilation focuses on uptake to the whole organism. This differs from the data compiled by IAEA (2010) where the focus is on dose calculations to humans and therefore the uptake to edible parts of biota, such as muscle tissue of fish, are of interest.

In ERICA CR data are reported for 13 terrestrial, 12 limnic and 14 marine reference organisms coupled to 31 elements (Beresford et al. 2008a (terrestrial) and Hosseini et al. 2008 (aquatic)). A gap filling method was utilised in ERICA in cases when data were missing for certain elements or reference organisms. The gap filling method is based on assumptions on analogue behaviour of elements with similar chemical properties (element analogues) or assumptions on similarities between reference organisms (parameter analogue). That is, data are reported for all studied elements and reference organisms, even though measured data were not always available. It is important to note these assumptions before utilising data reported in ERICA for parameterisation.

3.2.3 The Wildlife Transfer Parameter Database (ICRP 2011)

A database that gathers transfer data for wildlife (ICRP 2011) have been developed in a joint collaboration between the Environment Agency of England and Wales, the Norwegian Radiation Protection Authority (NRPA), the British Natural Environment Research Council's (NERC) Centre for Ecology and Hydrology (CEH) and the University of Stirling. The data were compiled together with the International Union of Radioecologists (IUR). The aim of the Wildlife Transfer Parameter Database was to aid the International Commission on Radiological Protection (ICRP) in deriving transfer data for Reference Animals and Plants (RAPs) (ICRP 2009) and to support the IAEA in the publishing of a handbook on wildlife transfer parameters (Howard et al. 2012). The complete Wildlife Transfer Parameter Database is published online and available to the public without charge (http://www.wildlifetransferdatabase.org). Data from this database, accessed in February 2011, have been used in this study and is sited as ICRP (2011). Data are available for four different ecosystem types: terrestrial, freshwater, marine and estuarine. The data for the latter were primarily from Japanese coastal environments and the Baltic Sea (ICRP 2009), and were considered more relevant to the conditions of the present day Forsmark area than actual marine areas. The focus of the joint collaboration to develop the Wildlife Transfer Parameter Database, was on deriving transfer parameters that could be used to calculate doses to RAPs, and therefore, the data are primarily suitable for non-human biota dose calculations. The database includes data from ERICA and other sources, and this has to be taken in to consideration when using the Wildlife Transfer Parameter and ERICA data for parameterisation, in order to prevent duplicate use of identical values.

3.2.4 Data on dry matter content, carbon content and tissue conversions

The presence of different units in the data sources compiled in this work and different units needed for the radionuclide model makes unit conversions necessary. CR values for non-human biota are for example related to fresh weight while CRs used in the assessments for exposure to humans are normalised to carbon (cf. definitions of K_d and CR in Chapter 2). In case of non-human biota parameters conversions from muscle tissue to whole organism body are necessary for some elements.

Sample specific data on dry matter and carbon content are available for site data and these data are used for unit conversions at sample level. When site-specific data are missing, or in case of conversions of literature data, generic data on dry matter and carbon content from IAEA (2010) are used.

In case of non-human biota parameters a conversion from muscle tissue to whole organism body is necessary for some elements and this conversion has been performed using the factors given in Yankovich et al. (2010).

Methods used for unit conversions are described in Section 4.2.3. Consequences of unit conversions on the confidence of selected parameter values are discussed in Section 9.1.4.

4 Methods

The parameterisation process starts with definitions of the compartments and functional units of the radionuclide model for the biosphere, which is used in dose calculations in the SR-PSU safety assessment. The model is described in detail in Saetre et al. (2013) and a short overview of the model and definition of parameters are provided in Chapter 2. The major challenge of the parameterisation process is to find parameter values and probability density functions which in the best possible way reflect the average conditions and the natural variation of significant element-specific processes for each parameter of the model. Detailed knowledge of available site data and literature data are necessary in order to select appropriate parameter values. Data collected in the SKB site investigation program are described in detail in a large number of reports, whereas detailed information of literature data are usually limited (cf. Chapter 3).

This chapter describes the methods behind the parameterisation process including detailed descriptions of selection criteria and the iterative process leading to a complete set of parameter values. Some basic principles and assumptions for the parameterisation work are described in Section 2.6.

4.1 The parameterisation process – overview

The aim of the parameterisation process is to find the best available and most probable element-specific parameter values for featured elements, based on various data sources in combination with general information on chemical analogues. Multiple data sources are available; both site-specific and literature data. Data are compiled in a database further referred to as the K_d/CR compilation from which parameter values are selected. The data compilation process is summarised in Section 4.2 and the data included in the K_d/CR compilation is further described in Chapter 3. In the list below the iterative parameterisation process consisting of three sequential steps is described (Figure 4-1):

1. **Data selection.** The initial data selection process can be divided into two subtasks.
   a) Data from the K_d/CR data compilation are assigned to each given parameter, which gives a sub-set of representative data with several data sources connected to each parameter. The assigned data can be both site-specific data and literature data from different sources. The literature data are ranked from L1 to L4 as described in Section 4.4.1.
   b) From this sub-set of representative data an initial data selection is made based on statistical selection criteria as described in Section 4.4.2.
2. **Comparison of data**. The initially selected data are "sense checked" by various comparisons of the ranges of available data as described in Section 4.5.
3. **Manual evaluation and selection.** The comparisons made in step 2 are performed in order to facilitate the final, manual evaluation and selection of parameter values (Section 4.6). In a final parameter selection step, selected data are evaluated individually, using information from the sense checks in combination with information from possible element and parameter analogues (EAs and PAs respectively).

In cases were the initial selected data are changed by manual data selection, for instance when data are missing and an EA or PA are assigned, the manually assigned data are subjected to a new sense check and an updated manual evaluation (step 2 and 3). This iterative process continues until a complete dataset being as consistent as possible is achieved.

The parameterisation process has been made as transparent as possible, using general guiding principles and set conditions for evaluating, selecting and sense checking data. This ensures a uniform handling of all selected parameter values.

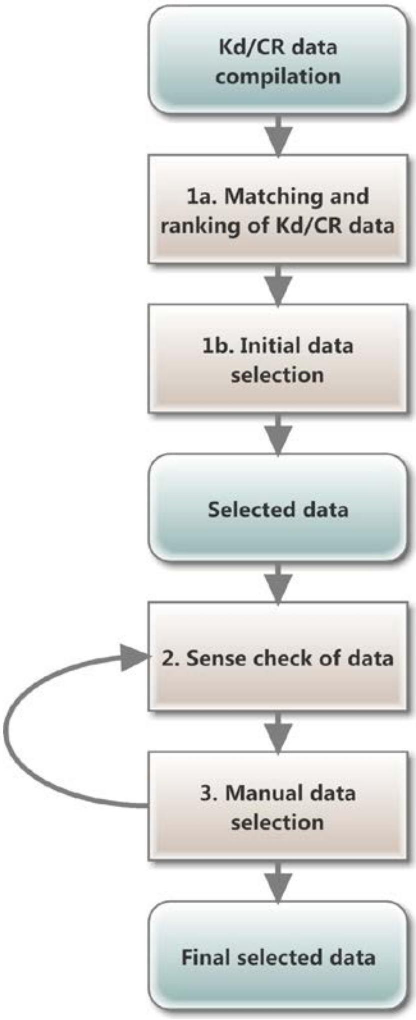

Figure 4-1. *A flowchart depicting the iterative process of parameter value selection. This iterative process ends when the data consistency cannot be further improved.*

4.2 The K_d/CR data compilation

A K_d/CR data compilation including both site-specific data and literature data is created within this study. The data included in this compilation is not restricted to elements and parameters of interest in this study, as data for many different K_d and CR parameters for a long list of elements are included. The gathering of data into one single database makes it possible to work with the whole set of data in an efficient way. In this section, the methods of estimating site-specific K_d and CR values are described as well as the methods of collecting literature data and converting it to common units and statistical measures. The process is illustrated in Figure 4-2.

4.2.1 Estimation of site-specific CR and K_d values

This section describes the methods and principles utilised in the estimation of site-specific parameter values. All calculations are handled in a Microsoft Access database, where a traceable link between the original concentration measurements and the final output parameters (site-specific K_d and CR values) is available. That is, specific samples, on which a specific parameter value is based and all the details and considerations behind any given data selection are fully traceable. General principles behind the data handling are described below and data used are described in Chapter 3.

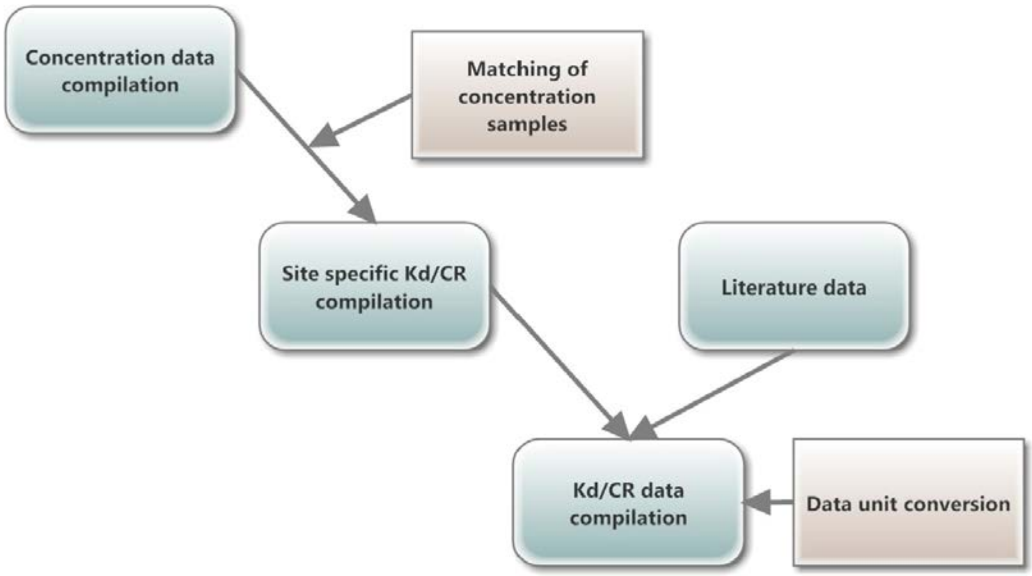

Figure 4-2. *Site-specific K_d and CR values are calculated by using paired concentration measurements in soil and biota, and soil and water respectively. Literature data are added to the site-specific data and all data are gathered in the so called K_d/CR data compilation, which together with the possibility to convert data into common units makes it possible to work with data in an efficient and comparable way.*

Samples where the concentration of the analysed element are below the specified reporting limit have been given a negative value corresponding to the reporting limit in the Sicada database. These reporting limits for a specific element can vary depending on the specific chemical analysis method used. In the present parameterisation, values below reporting limits have been omitted in the statistical handling. There are sophisticated methods to deal with such below-limit data, but a preliminary evaluation indicated that the gain of implementing such methods was in this case not justified by the uncertainties introduced by these alternatives. The practice of substituting values below reporting limits with a value corresponding to half the reporting limit was also discarded, in order to prevent introducing false variation in the material. Instead, the information of the fraction of omitted values is handled in the final discussion of uncertainties and confidence in the selected parameter values.

Site-specific K_d and CR values are estimated by calculating the ratio of paired concentration measurements. The challenge is to find matching concentration measurements that capture the natural variation of the underlying processes for a specific environment which is represented by a compartment in the biosphere model.

In the case of K_d, simultaneous measurements of soil solid and pore water element concentrations are available and K_d values calculated from such measurements represent true concentration pairs sampled at selected sampling sites at specific depths. If several replicates are available ratios are formed for all possible combinations between pore water and the solid fraction of each such sampling site and soil depth subset.

In the case of CR, exact spatial and temporal matching of concentration samples are usually not possible. Therefore, all possible combinations, permutations, of available concentration samples are used for estimating CRs. Sample matching and permutations are performed separately for each sampling site (FM and LX).The whole population of ratios for FM and LX combined, form the statistics and no additional weighting between the sites are conducted. In some situations, this practice can lead to the combination of one soil or water sample to several biota samples or one biota sample combined to several water or soil samples. In such cases the geometric standard deviation (GSD) as the variation measure is most likely underestimated, though this is managed by the use of GSD adjustments (Section 4.3).

Technically, the matching of site data starts with an initial coupling of subcategories of concentration data (e.g. representing soil types, biota types etc.) to model parameters. Secondly, individual samples corresponding to these subcategories are automatically selected and combined according to the matching principles described above. This two-step procedure is motivated by the large quantity of samples in the original concentration files. The exclusion of individual samples is handled separately, for example due to suspected contamination, which makes all abbreviations from the original files traceable.

These paired estimates are the basis for the reported statistical measures (min, max, GM, GSD) of K_d and CR values (cf. definitions in Chapter 2). There are several possible ways of reporting the sample number (N) for a given K_d or CR estimation. K_ds can be estimated using different number of soil and pore water samples and CRs can be estimated using a different number of biota and soil/ water samples. In the compilations in this report, N is reported for both the denominator (Nfrom) and numerator (Nto) data and the minimum value of these two estimates is regarded as the critical N used in the selection criteria.

4.2.2 Compilation of literature data

Literature data have been collected from different literature sources. CR and K_d values from IAEA (2010) are derived from the electronically downloadable version of the report (available as a pdf file). Since this step involves manual handling of data and possible conversion errors, all figures have been manually checked. Data from the assessment tool ERICA are also included in the compilation: CR and K_d values from ERICA are presented in two publications; Beresford et al. (2008a) (terrestrial data) and Hosseini et al. (2008) (aquatic data). CR and K_d values from ICRP (2009) have been downloaded from the webpage (IAEA 2011). Literature data added to the K_d/CR compilation are stored in original units together with meta-information describing the parameters. Further information on the literature data can be found in Chapter 3.

4.2.3 Conversion of units and different statistical measures

The presence of different units in the data sources compiled in this work and different units of selected parameter values needed for the radionuclide model makes unit conversions necessary. CR values for estimating dose to non-human biota are for example related to fresh weight while CRs used in the assessments for exposure to humans are normalised to carbon (cf. definitions of K_d and CR in Chapter 2). In case of non-human biota parameter conversions from muscle tissue to whole organism body are necessary for some elements. Generic data used for these conversions are described in Chapter 3 and listed in Appendix C.

Site-specific concentration data for stable isotopes are given in the unit mg/m^3 for water concentrations and mg/ kg_{dw} for regolith and biota concentrations. Radionuclide activity measurements are given in the units Bq/m^3 or Bq/ kg_{dw}, respectively.

When K_d are calculated from concentration measurements, these ratios get the unit m^3/kg_{dw} irrespective of mass concentrations or activity concentrations used (cf. definition of K_d in Chapter 2). Factors for conversions to and from this unit are listed in Table 4-1.

CRs for estimating dose to humans are given per carbon weight calculated from sample-specific measurements of carbon content, when available. If carbon content data are missing for site data or if literature data have to be converted, generic values on dry matter and carbon content from IAEA (2010) are assigned. Factors for conversions to and from the units kg_{dw}/kg_C or m^3/kg_C are listed in Table 4-1.

CRs for estimating dose to non-human biota are given per fresh weight. CR values estimated from site data are related to dry weight during the statistical handling described in previous section. In a second step these parameter values related to dry weight (dw) are converted to fresh weight (fw) using conversion factors based on generic dry matter content of different plant and animal species from IAEA (2010). At this step conversions from muscle tissue to whole body data are also made for some elements using factors given in Yankovich et al. (2010). Factors for conversions to and from the units kg_{dw}/kg_{fw} or m^3/kg_{fw} are listed in Table 4-1.

Table 4-1. A compilation of formulas for calculation of conversion factors. CC is the carbon content per dry weight (kg_C/kg_{dw}) and DMC the dry matter content (kg_{dw}/kg_{fw}).The units in the columns are obtained when values of the units in the rows are multiplied with the conversion factors.

	kg_{dw}/kg_{fw}	kg_{dw}/kg_C	kg_{dw}/kg_{dw}		
kg_{dw}/kg_{fw}	1	1/(CC·DMC)	1/DMC		
kg_{dw}/kg_C	CC·DMC	1	CC		
kg_{dw}/kg_{dw}	DMC	1/CC	1		
	L/kg_{dw}	m^3/kg_C	m^3/kg_{dw}	m^3/kg_{fw}	L/kg_{fw}
L/kg_{dw}	1	1/(1,000*CC)	1/1,000	DMC/1,000	DMC
m^3/kg_C	1,000·CC	1	CC	CC·DMC	1,000·CC·DMC
m^3/kg_{dw}	1,000	1/CC	1	DMC	1,000·DMC
m^3/kg_{fw}	1,000/DMC	1/(CC*DMC)	1/DMC	1	1,000
L/kg_{fw}	1/DMC	1/(CC·DMC·1,000)	1/(DMC·1,000)	1/1,000	1

In the K_d/CR data compilation, most data are assumed to be lognormally distributed characterised by GM and GSD. In some literature compilations data are given as normal distributed data presented in arithmetic measures. In order to make these data comparable the arithmetic measures are transformed into corresponding geometric estimates using the following formulas derived from Gelman and Hill (2007).

$$GM = \frac{\mathrm{AM}}{\sqrt{\mathrm{e}^{\sigma^2}}}, \qquad GSD = \mathrm{e}^{\sigma}, \qquad \sigma = \sqrt{ln\left(\left(\frac{SD}{AM}\right)^2 + 1\right)}$$

4.3 Defining plausible parameter variation

In order to identify and adjust situations where limitations in data or data artefacts may lead to under-estimated or unrealistically high variation in selected parameter values, the plausible range of variation of a parameter is estimated from the distribution of the GSD values obtained for each element with available site data for this parameter or a group of parameters which the parameter belongs to. Parameters joint into a group describe similar processes for different organisms or soil type.

The plausible GSD variation range per parameter group is estimated based on site-specific data. The GSD is expected to vary between elements or element groups, by including all available elements in the analysis, and not only elements included in the SR-PSU safety assessment, it is assumed that the overall range of the GSD variation in a parameter group is better captured. It is further assumed that this information could be utilised to adjust individual parameter ranges, in order to increase the probability that the selected ranges actually reflect the natural variation.

An analysis of GSDs measured for site data shows that among all studied elements, there is a substantial variation in the GSD measure. The observed GSDs usually vary between 2 and 8, depending on the parameter (or parameter group). In Table 4-2, the actual distribution of observed GSDs per parameter is shown as the fraction (%) of the observed GSDs for the included elements that fall within the intervals of length 1 limited by the integer numbers 0 to 11 and the the range “> 11” .

It is evident from Table 4-2 that the distributions of the GSD are skewed. The QQ-plots, in Figure 4-3 compare the quantiles of the empirical data to the quantiles of a normal distribution and log-normal distribution the later parameterised by the empirical arithmetic mean (AM) and standard deviation (SD) for the normal and geometric mean (GM) and geometric standard deviation (GSD) for the log-normal distribution. (The QQ-plot shows the curve $(x=Q_1(p), y=Q_2(p))$ with $Q_i(p)$ denoting the quantile of distribution i for probability p. Q_i is the inverse of the corresponding cumulative distribution function.)

Table 4-2. The percentage of the observed GSDs among elements for each parameter that falls within each of the defined intervals is shown in this table (The intervals are shown in the column headings, where "1–2"denotes GSD >=1 and GSD <2). The colour coding is added in order to facilitate the interpretation of the distributions.

Parameter	Unit	<1	"1-2"	"2-3"	"3-4"	"4-5"	"5-6"	"6-7"	"7-8"	"8-9"	"9-10"	"10-11"	>11
cR_food_herbiv	kg_c/kg_C	0	16	18	21	14	11	13	2	4	0	2	0
cR_foodToHerbiv_NHB	kg_c/kg_C	0	16	18	21	14	11	13	2	4	0	2	0
cR_lake_bivalve	m^3/kg_C	0	53	36	5	3	2	0	0	0	0	0	0
cR_lake_bivalve_NHB	m^3/kg_C	0	53	36	5	3	2	0	0	0	0	0	0
cR_lake_fish	m^3/kg_C	0	27	54	8	6	4	0	0	0	0	0	0
cR_lake_fish_NHB	m^3/kg_C	0	27	54	8	6	4	0	0	0	0	0	0
cR_lake_pp_macro	m^3/kg_C	0	14	19	7	5	12	12	19	9	0	0	2
cR_lake_pp_micro	m^3/kg_C	2	87	2	6	4	0	0	0	0	0	0	0
cR_lake_pp_macro	m^3/kg_C	0	23	26	40	2	0	2	5	0	0	0	2
cR_sea_bent_moll_NHB	m^3/kg_C	0	42	35	13	9	0	2	0	0	0	0	0
cR_sea_crust_NHB	m^3/kg_C	0	90	8	0	0	0	3	0	0	0	0	0
cR_sea_fish	m^3/kg_C	0	43	20	15	11	2	9	0	0	0	0	0
cR_sea_fish_NHB	m^3/kg_C	0	43	20	15	11	2	9	0	0	0	0	0
cR_sea_pp_macro	m^3/kg_C	0	16	16	14	9	12	7	7	7	9	0	4
cR_sea_pp_micro	m^3/kg_C	0	91	7	0	0	0	0	2	0	0	0	0
cR_sea_pp_plank	m^3/kg_C	0	89	8	0	0	0	3	0	0	0	0	0
cR_sea_zoopl_NHB	m^3/kg_C	5	86	7	0	0	0	0	2	0	0	0	0
cR_agri_cereal	kg_{dw}/kg_C	0	6	28	17	7	17	15	3	4	0	1	1
cR_ter_mammal_large_NHB	kg_{dw}/kg_C	0	8	33	29	16	4	4	4	0	0	2	0
cR_ter_mammal_NHB	kg_{dw}/kg_C	0	2	42	21	18	11	2	4	2	0	0	0
cR_ter_mammal_small_NHB	kg_{dw}/kg_C	0	7	43	25	14	2	5	4	0	0	0	0
cR_ter_Mush	kg_{dw}/kg_C	0	10	35	35	10	5	0	0	0	5	0	0
cR_ter_pp	kg_{dw}/kg_C	0	7	32	28	16	12	2	2	0	0	2	0
cR_ter_pp_lich_NHB	kg_{dw}/kg_C	0	8	26	21	34	5	2	2	3	0	0	0
cR_ter_pp_NHB	kg_{dw}/kg_C	0	7	32	28	16	12	2	2	0	0	2	0
K_d_regoUp_aqu	m^3/kg_{dw}	0	26	37	20	9	2	2	0	3	0	0	2
K_d_PM_lake	m^3/kg_{dw}	0	29	58	3	6	0	3	0	0	0	0	0
K_d_regoLow	m^3/kg_{dw}	0	51	36	10	0	1	0	0	1	0	0	0
K_d_regoGL	m^3/kg_{dw}	0	48	39	6	5	0	0	0	2	0	0	0
K_d_regoPG	m^3/kg_{dw}	0	24	24	33	10	4	0	1	1	1	0	0
K_d_regoPeat	m^3/kg_{dw}	0	46	39	12	0	0	1	0	1	0	0	0
K_d_regoUp_drain	m^3/kg_{dw}	0	9	41	38	9	1	0	3	0	0	0	0
K_d_regoUp_garden	m^3/kg_{dw}	0	87	9	4	0	0	0	0	0	0	0	0
K_d_regoUp_io	m^3/kg_{dw}	0	34	19	29	10	4	1	1	0	0	0	0
K_d_regoUp_nat	m^3/kg_{dw}	0	9	65	15	1	3	3	1	0	0	0	3
K_d_regoUp_ter	m^3/kg_{dw}	0	12	57	19	4	0	0	1	1	1	0	3
K_d_PM_sea	m^3/kg_{dw}	0	39	32	11	2	6	0	0	2	2	3	3

From these examples, it can be concluded that the shape of the GSD distributions are skewed and varies greatly depending on the parameter. Consequently, no general assumptions of the nature of the GSD distributions can be made; therefore, the plausible limits for the GSD are defined as percentiles of the empirical distribution of the GSD for each parameter (or group of parameters).

Three different measures GSDmin, GSDmean and GSDmax are estimated from the variation analysis of the GSD described above. GSDmin denotes the lowest reasonable GSD expected for a parameter group, and GSDmax the highest expected GSD. GSDmean could be interpreted as the best estimate of the GSD for a parameter group. The values of the parameters of the parameter group are expected to vary consistently under given environmental conditions (see Table 4-3).

GSDmin and GSDmax are estimated from the 5^{th} and 95^{th} percentiles, respectively, of the observed GSD distribution of a parameter group (e.g. cR_lake_animals, cR_ter_plants or K_d_ter). This implies that the ranges defined by these limits cover approximately 90% of the variation in observed GSDs of the parameter group. The choice of using 5^{th} and 95^{th} percentiles to define GSDmin and GSDmax, respectively, is arbitrary and primarily based on the assumption that the variation is captured correctly for the majority of the studied elements (i.e. 90%). GSDmean is based on the median of the GSD distribution of each parameter group.

Table 4-3 shows percentiles of observed GSDs for each parameter group. These tabulated percentiles represent arithmetic means of the percentiles of the individual parameters of a parameter group in order to give each parameter equal weight (the parameters included in each parameter group is listed in the table foot). The final figures defining the GSDmin, GSDmean and GSDmax limits are based on these "average percentiles" and have been slightly adjusted by rounding upwards in order to achieve practical limits. It should be noted that the procedure of defining these limits is to some extent subjective and based on the general assumption that it is conservative to widen the PDFs of selected parameter data.

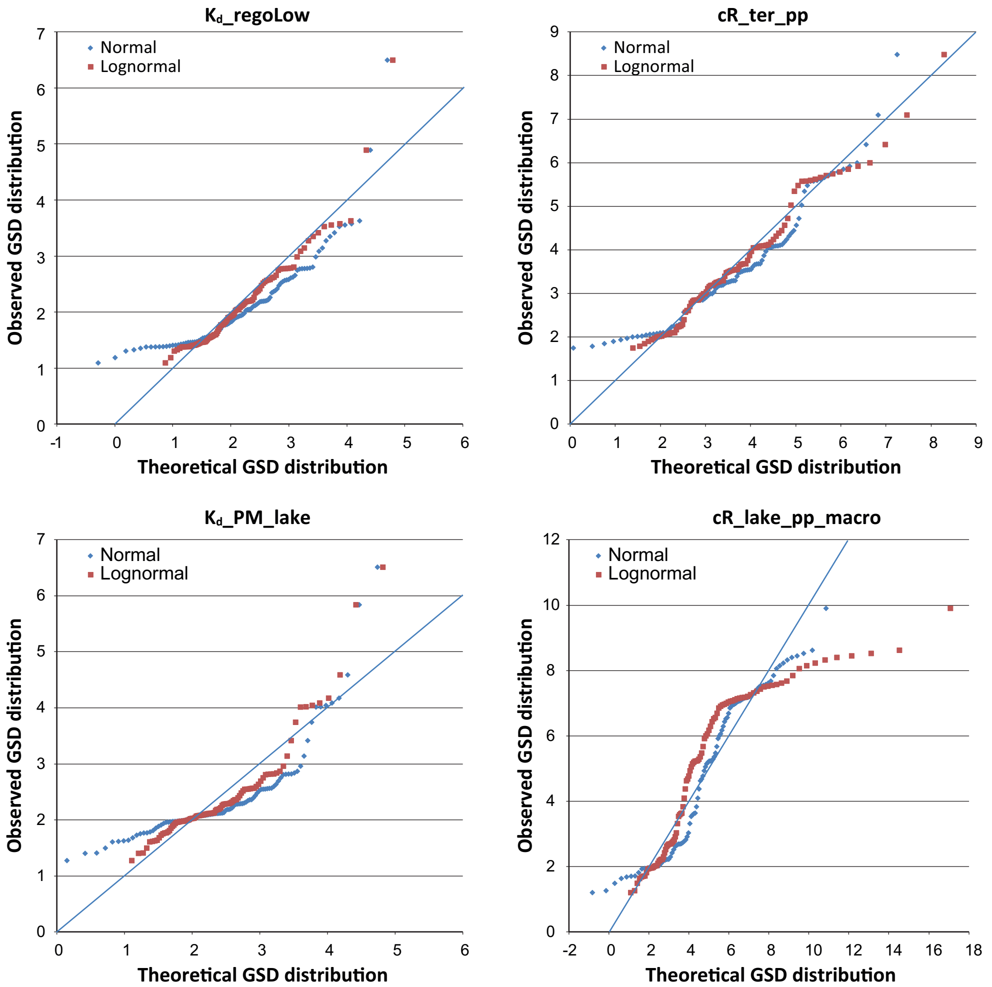

Figure 4-3. The QQ-plots compare the quantiles of the empirical distribution to a normal and lognormal distribution for four parameters K_d_regoLow, K_d_PM_lake (on the left) and CR_ter_pp and CR_lake_pp_macro (on the right). The parameters for the normal (AM, SD) and lognormal (GM, GSD) distribution are derived from the empirical data. Each point represents one percentile from 1% to 100%.

Table 4-3 . Estimated GSDmin, GSDmean and GSDmax for each parameter group (the individual parameters included in each group in the table are listed below). The tabulated percentiles (5th, 50th, and 95th) represent the average percentile per parameter group of the included parameters.

	5p	GSDmin	50p	GSDmean	95p	GSDmax
cR_ter_animals	1.8	2	3.7	4	8.1	9
cR_lake_animals	1.3	2	2.2	3	4.0	5
cR_lake_plants	1.4	2	3.1	4	6.3	7
cR_sea_animals	1.1	2	1.9	3	4.8	5
cR_sea_plants	1.2	2	2.0	3	4.2	5
cR_ter_plants	1.9	3	3.3	4	6.5	7
K_d_ter	1.6	2	2.3	3	5.1	6
K_d_pm	1.5	2	2.2	3	7.1	5

cR_ter_animals: cR_food_herbiv, cR_foodToHerbiv_NHB, cR_Ter_mammal_large_NHB, CR_Ter_mammal_small_NHB
cR_lake_animals: cR_Lake_bivalve_NHB, cR_Lake_fish_NHB, cR_Lake_Fish
cR_lake_plants: cR_lake_pp_macro, cR_lake_pp_micro, cR_Lake_pp_macro
cR_sea_animals: cR_Sea_bent_moll_NHB, cR_Sea_crust_NHB, cR_Sea_Fish, cR_Sea_Fish_NHB
cR_sea_plants: cR_sea_pp_macro, cR_sea_pp_micro, cR_sea_pp_plank, cR_Sea_zoopl_NHB
cR_ter_plants: cR_agri_cereal, cR_Ter_Mush, cR_Ter_pp, cR_Ter_pp_lich_NHB, cR_Ter_pp_NHB
K_d_ter: K_d_regoUp_aqu, K_d_regoLow, K_d_regoGL, K_d_regoPG, K_d_regoPeat, K_d_regoUp_drain
K_d_regoUp_garden, K_d_regoUp_io, K_d_regoUp_ter
K_d_pm: K_d_PM_sea, K_d_PM_lake

These GSD limits are used to adjust GSD depending on different criteria described in Section 4.3 in order to reduce the risk of underestimating the variation. The rationale for this approach is to assure that the selected parameter ranges cover the variation with enough confidence and that it is conservative to increase the variation when data are limited. GM values and best estimates of parameter values are not affected by the estimate of the uncertainty of a parameter obtained by this method.

4.4 Initial selection of data

This section describes the selection criteria used for the initial data selection. The process starts with matching of data to specific parameters and is followed by selection of data based on statistical criteria.

4.4.1 Matching of data and ranking of literature data sources

Among the available site and literature data in the K_d/CR data compilation, data that are assumed to be representative for the model parameters of interest are identified and assigned to the specific parameters. This is done in an initial, manual step and results in sub-sets of representative data connected to each parameter. These sub-sets of data consists of both site data (if available) and literature data. Since there are many cases where data from more than one literature source or category could be representative for a specific parameter, the literature data are categorised into literature source classes 1–4, depending on the quality of the data and how well the data represents the parameter of interest in the radionuclide model. The literature source classes are assigned according to relevance as follows; literature source class 1 (L1) is assigned to the literature data that are assessed to be the most representative available data, literature source class 2 (L2) is assigned to the second most relevant literature source, literature source class 3 and 4 (L3 and L4, respectively) data are assigned to be the third and fourth most relevant literature sources. These subjective classifications are mainly based on similarities in environmental conditions such as soil type, species etc, but also take the number of underlying observations into account. The classification is described in detail per parameter in Chapters 5 to 8.

4.4.2 Initial data selection criteria

The initial parameter value selection is made for each parameter and element case based on data from the sub-sets of representative data selected in the preceding step (Section 4.4.1). Site data are prioritised over literature data and therefore selected first, according to the assumptions described in Chapter 2. In cases where site data are not available literature data from the highest ranked available literature source are assigned.

In order to assign min, max and GSD for the parameters, selection criteria based on sample number (N) and observed variation (GSD) of data are used. For site data the reported GSDs are compared to the plausible GSD ranges defined in Section 4.3. If the GSD falls below the interval of plausible GSD range a correction is made. Depending on N, the reported GSDs are adjusted using the estimated GSDmin, GSDmean or GSDmax limits. For site data the critical N is defined as the smallest number of samples in one of the paired concentration measurements (Section 4.2.1). The chosen N limits are arbitrarily and mainly set to give a reasonable division of data, while the GSD limits are based on the GSD analysis in Section 4.3. The criteria for adjusting GSD in cases where site data is selected depending on N is listed below:

- GSDmin is used as criteria when there is relatively high confidence in estimated values ($N \geq 10$). If the reported GSD is lower than GSDmin, the selected GSD is adjusted to GSDmin.
- When the confidence in estimated values is relatively good ($3 < N < 10$), GSDmean is used implying that reported GSDs less than GSDmean will be adjusted to GSDmean.
- GSDmax is used to adjust reported GSDs when the confidence in estimated values is relatively low ($N \leq 3$) implying that reported GSDs less than GSDmax will be adjusted to GSDmax.

For literature data two criteria listed below are used:

- GSDmean is used as criteria when $N \geq 3$. If the reported GSD is lower than GSDmean, the reported GSD is adjusted to GSDmean.
- When the confidence in selected literature data is relatively low $N \leq 3$, GSDmax is used implying that observed GSDs less than GSDmax will be adjusted to GSDmax.

Also the minimum and maximum vales are adjusted to ensure that the range is not underestimated. The selected minimum value is the lowest of the reported minimum or the 5th percentile calculated based on the GM and the GSD (in case where GSD is adjusted, the adjusted GSD is used to calculate the percentiles). The maximum value is the highest of the reported maximum or the 95th percentile calculated based on the GM and the GSD (in case were GSD is adjusted, the adjusted GSD is used to calculate the percentiles).

In cases where site data are selected, BE are based on FM data alone, while GM are based on FMLX data. In cases where literature data are selected the BE and GM are identical (see Section 2.6.3).

The initial parameter value selection process of GM, GSD, min and max values is summarised in the flowchart in Figure 4-4 and described in detail in the nine conditions below.

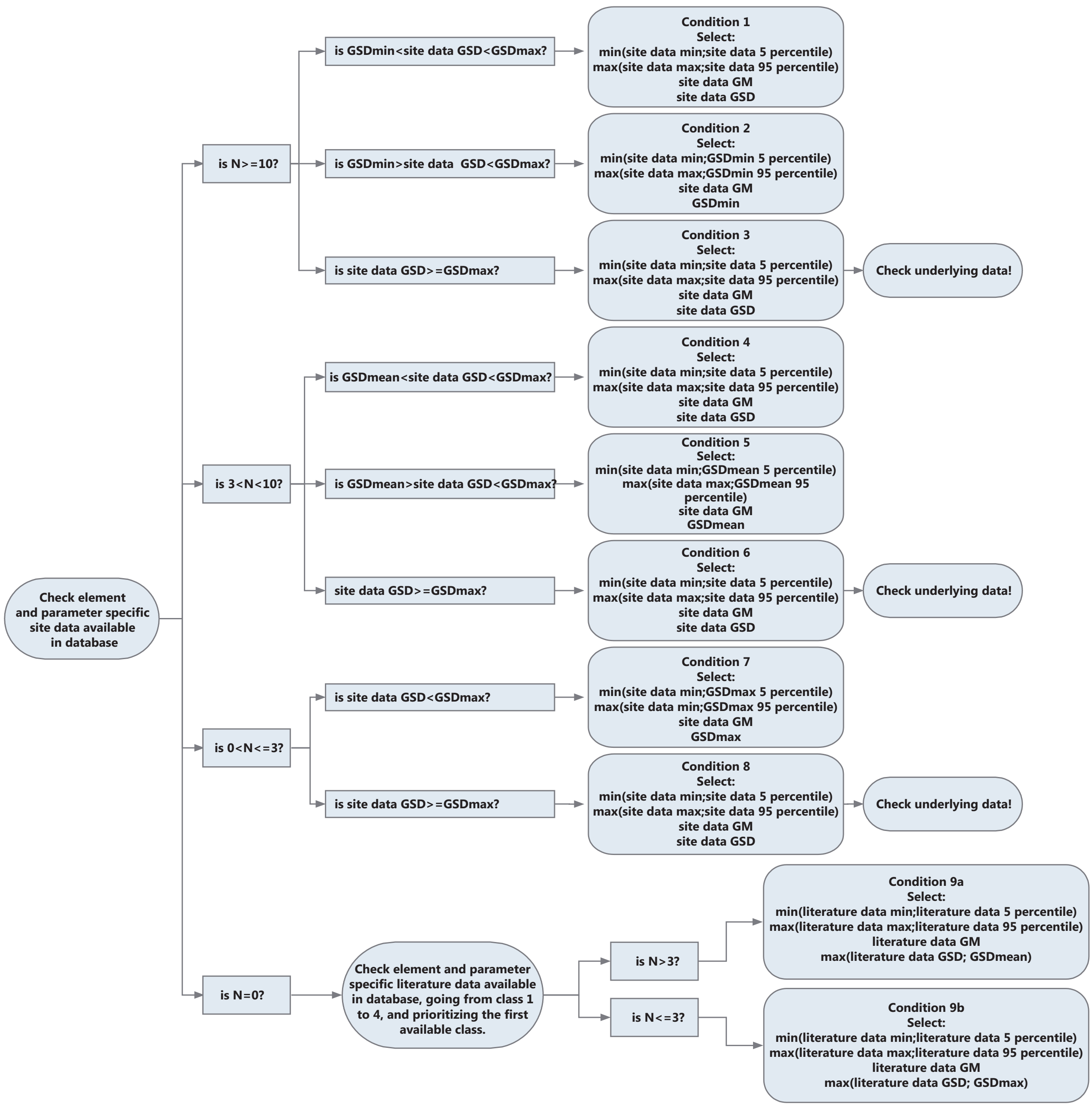

Figure 4-4 . *A flowchart depicting the parameter data selection based on statistical arguments (sample number (N) and variation (GSD)) alone. Selections are made from the total available dataset, i.e. both site and literature data. Revised minimum (min), maximum (max), geometric mean (GM) and geometric standard deviation (GSD) values are selected based on site data and literature data.*

1. If site data are available, if N ≥ 10, and if the site data GSD is within the plausible range of GSD (GSDmin < GSD < GSDmax), then the characteristics of the parameter PDF are assigned as follows:
   - → min = min(site data min, the theoretical 5th percentile calculated from site data GM and GSD)
   - → max = max(site data max, the theoretical 95th percentile calculated from site data GM and GSD)
   - → GM = the site data GM
   - → BE = Forsmark GM (if not available, site data GM)
   - → GSD = the site data GSD
2. If everything is the same as condition 1, except that GSD calculated from site data are smaller than what is assessed to be plausible (GSD < GSDmin), then the characteristics of the parameter PDF is assigned as follows:
   - → min = min (site data min, the theoretical 5th percentile calculated from site data GM and GSDmin)
   - → max = max (site data max, the theoretical 95th percentile calculated from site data GM and GSD min)
   - → GM = the site data GM
   - → BE = Forsmark GM (if not available, site data GM)
   - → GSD = GSDmin
3. If everything is the same as condition 1, except the GSD calculated from site data are larger than what is plausible (GSD ≥ GSDmax), then the characteristics of the parameter PDF is assigned as follows and a manual check of the underlying data is required:
   - → min = min (site data min, the theoretical 5th percentile calculated from site data GM and GSD)
   - → max = max (site data max, the theoretical 95th percentile calculated from site data GM and GSD)
   - → GM = the site data GM
   - → BE = Forsmark GM (if not available, site data GM)
   - → GSD = the site data GSD
4. If site data are available, if N>3 and N<10, and the site data GSD is within the plausible range of GSD (GSDmean < GSD < GSDmax), then the characteristics of the parameter PDF is assigned as follows:
   - → min = min (site data min, the theoretical 5th percentile calculated from site data GM and GSD)
   - → max = max (site data max, the theoretical 95th percentile calculated from site data GM and GSD)
   - → GM = the site data GM
   - → BE = Forsmark GM (if not available, site data GM)
   - → GSD = the site data GSD
5. If everything else is the same as in condition 4, except the GSD calculated from site data are smaller than what is reasonable (GSD < GSDmean), then the characteristics of the parameter PDF is assigned as follows:
   - → min = min (site data min, the theoretical 5th percentile calculated from site data GM and GSDmean)
   - → max = max (site data max, the theoretical 95th percentile calculated from site data GM and GSDmean)
   - → GM = the site data GM
   - → BE = Forsmark GM (if not available, site data GM)
   - → GSD = GSDmean

6. If everything else is the same as in condition 4, except the GSD calculated from site data are larger than what is reasonable (GSD ≥ GSDmax), then the characteristics of the parameter PDF is assigned as follows and a manual check of the underlying data is required:
   - → min = min (site data min, the theoretical 5th percentile calculated from site data GM and GSD)
   - → max = max (site data max, the theoretical 95th percentile calculated from site data GM and GSD)
   - → GM = the site data GM
   - → BE = Forsmark GM (if not available, site data GM)
   - → GSD = the site data GSD
7. If site data are available, the N ≤ 3, and the site data GSD is lower than what is reasonable (GSD < GSDmax), then the characteristics of the parameter PDF is assigned as follows:
   - → min = min (site data min, the theoretical 5th percentile calculated from site data GM and GSDmax)
   - → max = max (site data max, the theoretical 95th percentile calculated from site data GM and GSDmax)
   - → GM = the site data GM
   - → BE = Forsmark GM (if not available, site data GM)
   - → GSD = GSDmax
8. If everything else is the same as in condition 7, except the GSD calculated from site data is larger than what is reasonable (GSD ≥ GSDmax), then the characteristics of the parameter PDF is assigned as follows and a manual check of the underlying data is required:
   - → min = min (site data min, the theoretical 5th percentile calculated from site data GM and GSD)
   - → max = max (site data max, the theoretical 95th percentile calculated from site data GM and GSD)
   - → GM = the site data GM
   - → BE = Forsmark GM (if not available, site data GM)
   - → GSD = the site data GSD
9. If no site data are available, literature class 1 data (min, max, GM , BE and GSD values) are selected. If no literature class 1 data exists, literature class 2 data are selected and so forth until literature class 4 data are evaluated and possibly selected.
   a. If the literature data N > 3, then the characteristics of the parameter PDF are assigned as follows:
      - → min = min (literature data min, the theoretical 5th percentile calculated from literature data GM and the highest value of the literature data GSD or GSDmean)
      - → max = max (literature data max, the theoretical 95th percentile, calculated from the literature data GM and the highest value of the literature data GSD or GSDmean)
      - → GM = the literature data GM
      - → BE = the literature data GM
      - → GSD = max(literature data GSD, GSDmean)

   b. If the literature data N ≤ 3, then the characteristics of the parameter PDF is assigned as follows:
      - → min = min (literature data min, the theoretical 5th percentile value calculated from the literature data GM and the highest value of the literature data GSD and GSDmax)
      - → max = max (literature data max, the theoretical 95th percentile calculated from the literature data GM and the highest value of the literature data GSD and GSDmax)
      - → GM = the literature data GM
      - → BE = the selected literature data GM
      - → GSD = max(literature data GSD, GSDmax)

4.5 Comparisons of data sources

Several comparisons are made among the available data sources in order to screen for discrepancies. The following so called "sense checks" are performed for each parameter and element-specific case:

1. The initially selected parameter value range is compared to the total range of all literature data.
2. The FMLX data range is compared to the total range of all literature data.
3. The FM data range is compared to the total range of literature data.
4. The LX data range is compared to the total range of literature data.
5. Data ranges for FM and LX are compared.
6. Data ranges for the various literature sources from the K_d/CR data compilation are mutually compared.

These comparisons provide a qualitative evaluation of the relations between data sources, and the information constitutes part of the decision basis for the final, manual parameter value selection described in Section 4.6. The performed data comparisons are described in more detail in the following subsections.

4.5.1 Comparison of ranges of selected data versus total literature data (SC SelData)

The 5^{th} and 95^{th} percentiles of selected data are compared to the theoretical lowest 5^{th} and the highest 95^{th} percentiles reported among the literature data sources in the K_d/CR data compilation. For both selected data and literature data, these percentiles comprise the theoretical 5^{th} and 95^{th} percentiles calculated from GM and GSD (in case of literature sources, original GM and GSD are used, i.e. without any adjustments). In other words, the value range where 90% of the selected data are found is compared to the value range where approximately 90% of the total available literature data are found. It should be noted that when selected data are based on literature data, there could be an apparently good match when identical or closely related literature sources are compared.

Four different situations may occur in this kind of comparison (Figure 4-5):

- S1) The selected data range lies within the literature data range.
- S2) There is a partial overlap between the selected data range and the literature data range. In order to assess how large the overlap is, the percentage of the selected data range that overlaps with the literature data range is calculated. Whether the selected data range is in the upper or lower range of the literature data range is also recorded.
- S3) The literature data range lies within the selected data range.
- S4) There is no overlap between the selected data range and the literature data range.

The hypothesis behind this sense check is that selected data ranges should show variations that are comparable to corresponding variations of the more generic total literature data ranges. The total literature data ranges are thought of as more generic than the selected data ranges, since the literature data ranges originate from various studies, conditions, times and locations around the world. Therefore, both site and one source-literature data (selected data) are expected to have ranges that are comparable to or less than the total literature range. Thus the selected data would ideally represent a subset of the larger set of the more generic (literature) data.

Linking these hypotheses to the four overlap situations presented in Figure 4-5, the following can be concluded. In S1, the selected data show variability that is in line with the hypothesis of the sense check. The selected data range is a subset of the literature data range with less variation. In S2, the proportion of the partial overlap will determine whether or not the situation is in agreement with the hypothesis of the sense check. If a high percentage of the selected data range is within the literature data range, then the compared data ranges are most likely in line with the hypothesis. If not, extra care should be taken when manually reviewing the data selections. In S3, the selected data show a larger variability than the literature data set. Since this is in contrast to the hypothesis, additional attention is necessary in these cases when manually reviewing and selecting data. In S4, there is no overlap between the two compared data ranges and there is a clear discrepancy. Extra care should be taken in these cases when manually reviewing and selecting data.

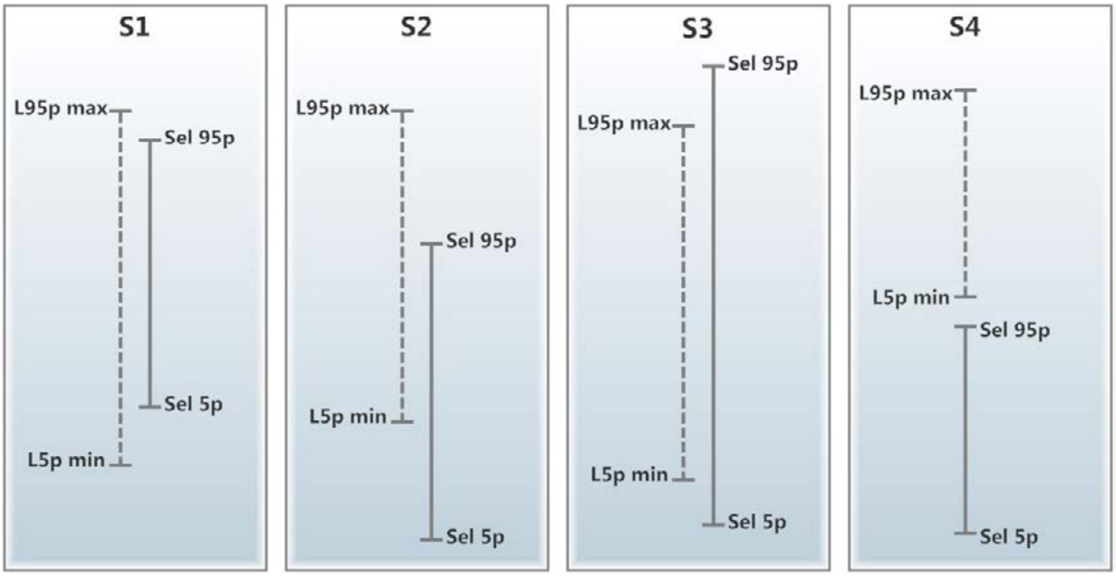

Figure 4-5 . *Four different types of overlap situations can occur when selected data are compared to literature data. These are; S1) selected data 5th and 95th percentiles both fall within the literature data range (Lmin-Lmax), S2) there is a partial overlap between selected data and literature data ranges, S3) selected datas 5th and 95th percentiles encompass the literature data range and, S4) there is no overlap between selected data and literature data.*

4.5.2 Comparison of available site and total literature data ranges (SC FMLX, SC FM, SC LX)

Similarly to the selected data, the 5th and 95th percentiles of site data ranges (FMLX data, FM data and LX data, respectively) are compared to the total literature data ranges available in the K_d/CR data compilation. Four comparison situations (S1 to S4) may occur (see Section 4.5.1).

4.5.3 Comparison of Forsmark versus Laxemar site data (SC FMvsLX)

The 5th and 95th percentiles of the FM data and those of the LX data are compared, and the same four situations (S1 to S4) can occur as described in Section 4.5.1, and shown in Figure 4-5.

Data from FM are not expected to be significantly different than data from LX, and have as such been grouped together to represent "site data" (Section 4.2.1). Therefore, the hypothesis when comparing the FM and LX data ranges is that they will show comparable ranges. In contrast to the comparison made between selected data ranges and total literature data ranges (Section 4.5.1), the reasoning behind this sense check does not assume that one data source is less generic than the other. On the contrary, in this comparison the two datasets are assumed to represent (close to) equal environments and sampling situations.

The overlap situations S1, S2 and S3 are all in line with the assumption of this sense check as long as the variation differences among the compared data ranges are not too large. In the case of the partial overlap situation (S2), extra care should be taken in the later manual revision and selection of data if the overlap between compared data ranges is shown to be small. S4 is generally not in line with the assumption behind the performed sense check, and therefore these cases should be given extra attention in the latter manual data selection (Figure 4-1).

4.5.4 Comparison of the different classes of literature data (SC Lit)

In the comparison of literature data ranges, the theoretical 5th and 95th percentiles of each literature data set in the K_d/CR data compilation are compared. In other words, the value range where 90% of the data from a given literature class is found is compared to the value range where 90% of the data from another literature class is found. The number of possible comparisons depends on the number of available literature classes for a given element and parameter case. Among two available literature sources, one comparison is possible. Among three available literature sources, three different comparisons are possible. At most, four literature data classes are compared.

The results of this sense check are reported in the tables of Chapters 5–8 in the following format:

No. of available data sources: No. of overlaps/No. of possible overlaps.

For example a reported “3:2/3” means that there are three available literature sources, where two out of three possible comparisons show a partial overlap.

The general sense check hypotheses regarding available literature data set overlaps are similar to that for the site data comparison (Section 4.5.3). Consequently, when comparing literature data, no particular data range is expected to be a subset of another data range and data from different literature sources are expected to show comparable ranges.

4.5.5 Comparisons of parameters across elements

An additional type of sense check performed in this report is comparisons of parameters across elements. Plotted in log scale, with each point representing a different element, general trends and outliers could be outlined. This type of check is especially important when data sources are mixed to assure that related parameters are consistent. These checks are included in the summary sections of the chapters presenting selected values (Chapters 5–8).

4.6 Final parameter value evaluation and selection

All initially selected and subsequently sense checked parameter values are manually evaluated and reassessed in a last step of each iteration of the parameter value selection process (Figure 4-1). This procedure ensures that the best available parameterisation options are selected and that the selected values are consistent with as many data sources and analogues as possible. This manual data evaluation and selection supersedes the previous (the initial) selection.

There are multiple reasons for a manual evaluation and selection of parameter values. Initially, selected values should be evaluated and the possible use of EAs and PAs should be considered. The manual evaluation and selection is especially important for the specific cases, where sufficient data are not available and, therefore, no parameter values are selected in the initial selection process. Also, unexpected situations identified both in the initial parameter value selection and in the performed sense checks need to be examined. Figure 4-6 summarises the information basis that has to be handled for each parameter and element-specific case during the manual evaluation. Ultimately, the evaluation leads to an improved parameter value selection. The improved selection is sense checked and can be updated repeatedly if needed.

In order to facilitate the manual parameter value selection, some guiding principles are established. In line with IAEA’s (2010) recommendations of the general order in which different types of analogues are used, the guiding principles for selecting parameter values are summarised in the following preference ranking of different data types:

1 Sufficient site, element and parameter specific data.

2 Site-specific analogue data of sufficient quality (where the internal order is; i) use of EA, ii) use of PA, iii) use of EA and PA combined).

3 Element and parameter specific literature data that is of sufficient relevance and quality.

4 Literature analogue data of sufficient quality (where the internal order is; i) use of EA, ii) use of PA, iii) use of EA and PA combined).

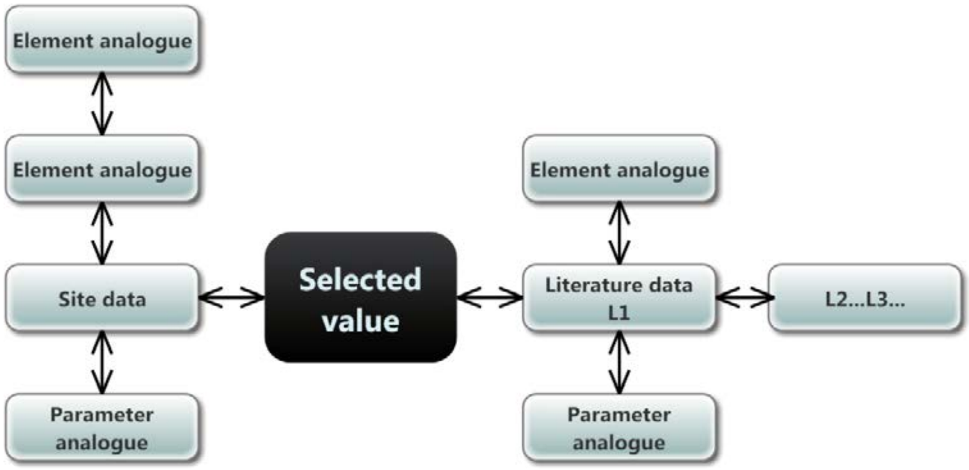

Figure 4-6 . *A schematic picture of the manual parameterisation process. For an element-specific parameter value, several sources of information are compared and evaluated in order to select a representative value. The automated selection process gives a first data selection based on the statistical criteria and available data, but the final manual step evaluating all sources of information together is crucial in selecting the most probable value for a parameter. The sense checks present information on how site data and selected data relate to literature data, as well as how different literature data sources are related. At the manual evaluation further comparisons are made among element- and parameter analogues mainly based on comparisons of ranges in log-log plots.*

These guiding principles are case specific, depend on available data and will therefore vary substantially from case to case. If, for example, selected data are thought not to adequately represent a given element and parameter specific case, the guiding principles could be overruled and another data source could be selected as the highest ranked data. When PAs are assigned to a case in the manual evaluation and selection step, a GSDmax (compare to the initial parameter value selection criteria in Section 4.4.2) is selected in order to reflect the higher uncertainty level when using this kind of analogue.

The specific parameter value selection choices made for elements and parameters of concern are reported in Chapters 5–8, where also all considerations made in the manual selection step are described. Two examples are given below to illustrate the manual evaluation and selection step:

Example 1: Site data for a parameter and element combination is not available and literature data is selected in the automated initial selection. In the manual check it is found that site data for a plausible EA is available. By assigning an EA for that parameter and element combination in the manual step, the EA site data is selected instead of the literature data in the next iteration. The described situation is generally the case for e.g. Ac, Pa and Pd.

Example 2: Poor (or no) correlation for different data sources is found in the sense checks of a parameter and element combination. The reason for the deviation is in such cases analysed. This type of deviation can be expected in cases when for example data for organisms which are not comparable are compared (e.g. crustaceans from true marine versus brackish environments). In such a case the difference is probably relevant and it has to be decided which data to use. In other cases, the poor correlations are not expected. If divergence is found for site and literature data, site data are as a rule considered more relevant and are selected (a good agreement between data from FM and LX further strengthen this decision). If the divergence is found between two literature sources and no site data are available, the source with the highest sample number (N) is most often selected.

5 Selected K_d values

In this chapter the selected values for the element-specific K_d parameters listed in Table 2-2 are compiled together with considerations behind the selections. Available data sources are discussed and compared per parameter for 31 elements (Ac, Ag, Am, Ba, Ca, Cd, Cl, Cm, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Np, Pa, Pb, Pd, Po, Pu, Ra, Se, Sm, Sn, Sr, Tc, Th, U and Zr). In the final section in this chapter comparisons are made over all selected parameters.

A brief introduction to the radionuclide model and its compartments, and a listing of the parameters handled in this report are found in Chapter 2. Definitions of the K_d parameters and a short review of uncertainties related to the K_d concept are also found in this chapter. General assumptions for the parameterisation are also described in Section 2.6 including a detailed overview of element analogues, EA, assigned when data are missing.

Data sources included in this work are compiled and described in Chapter 3. Methods for the selection and estimation of parameter values are described in Chapter 4.

The nomenclature of the parameter names is based on the naming of the compartments in the radionuclide model. For example "K_d_regoLow" denotes the K_d value assigned to the "regoLow" compartment, i.e. the deep till layer. The physical and chemical properties of each compartment are defined in Saetre et al. (2013).

Abbreviations used in the tables and figures in this chapter are explained in Table 5-1.

5.1 K_d_regoLow

In the biosphere model, the RegoLow model compartment represents the loose, minerogenic and water-saturated anoxic sediments, which overlay the bedrock in the terrestrial and aquatic systems (Saetre et al. 2013). In the Forsmark (FM) area, this layer primarily consists of glacial till, which is the dominating quaternary deposit covering approximately 65% of the terrestrial areas and 30% of the marine area in FM (Hedenström and Sohlenius 2008).

Representative site data for the RegoLow compartment consists of till samples from different depths in machine dug trenches in undisturbed areas that have not been farmed. Five samples characterised as sandy silty till were sampled between 0.3 and 3.5 m depth in the soil profiles. Soil samples were incubated, the pore water extracted by centrifuge and then the near-total element content extracted with aqua regia prior to analysis. K_d values were estimated from corresponding soil and porewater samples (Sheppard et al. 2011).

Table 5-1. Abbreviations used in the tables of this chapter.

Abbrevation	Description
FM N (from/to)	Number of samples in FM site data. Number of independent samples in denominator (from) and numerator (to) of the ratio.
LX N (from/to)	Number of samples in LX site data. Number of independent samples in denominator (from) and numerator (to) of the ratio.
FMLX (from/to)	Number of samples in FMLX site data. Number of independent samples in denominator (from) and numerator (to) of the ratio.
L1 N, L2 N, L3 N, L4 N	Number of samples for literature source L1, L2, L3, L4, respectively.
FM GSD, LX GSD, FMLX GSD	Geometric standard deviation of site data from FM, LX and FMLX data.
L1 GSD, L2 GSD, L3 GSD, L4 GSD	Geometric standard deviation for literature source L1, L2, L3 and L4.
SC FM	Sense check comparing ranges for FM site data and literature data.
SC LX	Sense check comparing ranges for LX site data and literature data.
SC FMLX	Sense check comparing ranges for FMLX site data and literature data.
SC FMvsLX	Sense check comparing ranges for FM and LX data.
SC Lit	Sense check comparing ranges for literature data sources.

Literature K_d values for various soil types are available for comparison in IAEA (2010), and even though the IAEA (2010) source represents rooting-zone soils, they are considered a surrogate for the anaerobic RegoLow layer. Reported data regarding mineral soil, and the sub-categories sand and clay soils are considered the most representative for the RegoLow layer. Mineral soil data are categorised as L1 data (first choice), sandy soil data are categorised as L2 data (second choice) since sand are expected to have notably different K_d than other soil types. K_d data concerning all soils combined are categorised as L3 data (third choice), because these data include organic soils that are expected to have distinctly different K_d values than mineral soils.

As shown in Table 5-2, FM site data are available for Ag, Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Se, Sm, Sn, Sr, U and Zr. Literature data alone are available for Ac, Am, Cm, Np, Pa, Po, Pu and Tc. There are no comparable data available from Laxemar-Simpevarp (LX). When FM data are compared to literature data, Ca, Sm and Nb show little or no overlap between the ranges. The observations available in various literature data sources correlate in all element cases, which is expected since the "mineral" (L1) and "sand" (L2) soil classes are subsets of the "all soils" (L3) class.

Ca site data show no overlap with the "all soils" range from IAEA (2010). This could be explained by the specific conditions in the FM area, with its high contents of calcite in the till (cf. Tröjbom and Nordén 2010). At digestion with aqua regia, this source of calcium is included in the sorbed phase even though much of this Ca is from within the calcite mineral particles and thus might contribute to the high K_d value. On the other hand, according to Figure 5-1, the ranges of the possible chemical analogues Sr and Ba overlap with the range for Ca, which supports that the observed site-specific Ca range is reasonable.

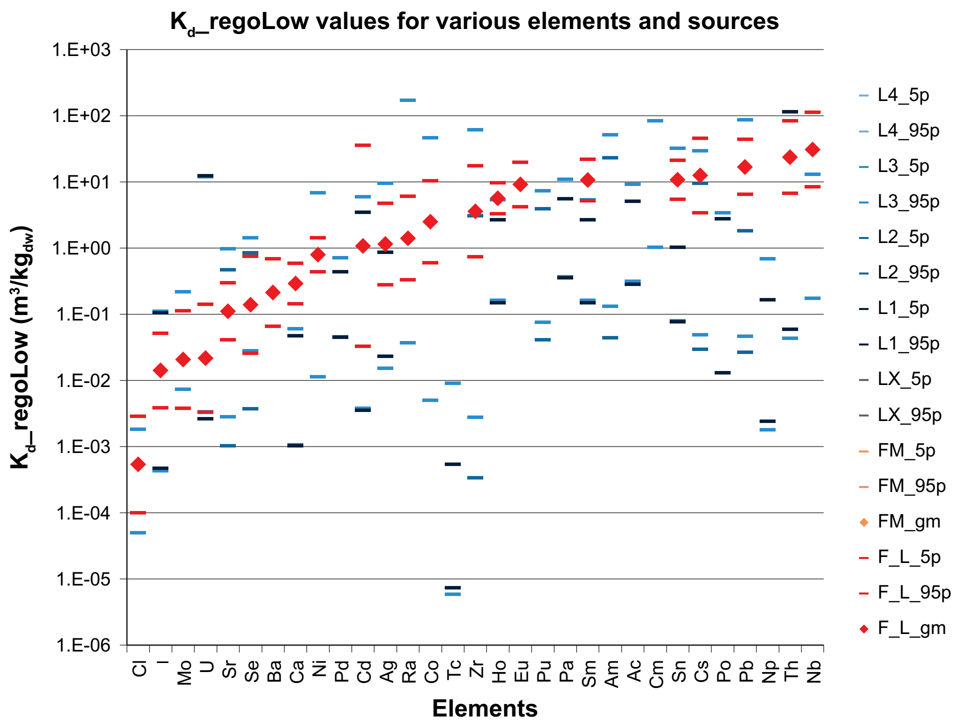

Figure 5-1. *Data ranges for the sources that are considered representative for K_d_regoLow (m^3/kg_{dw}). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5^{th} (5p) and 95^{th} (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.*

Table 5-2. Available data for K_d_regoLow for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010, mineral soil, L2 = IAEA 2010, sand, L3 = IAEA 2010, all soils. See Table 5-1 for description of headings.

Ele-ment	FM N (from/ to)	LX N (from/ to)	FMLX (from/ to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac				3		4					2.4		2.8						2:1/1
Ag	7/7		7/7	5		9		2.4		2.4	3.0		7.1		S1		S1		2:1/1
Am					17	62						6.7	6.1						2:1/1
Ba	7/7		7/7			1		2.0		2.0									1:0/0
Bi	7/7		7/7	4		6		3.6		3.6	2.1		2.3		S2 (U0%)		S2 (U0%)		2:1/1
Ca	7/7		7/7	33		34		1.5		1.5	3.2		3.4		S4		S4		2:1/1
Cd	2/2		2/2	39		61		8.4		8.4	8.1		9.4		S2 (U74%)		S2 (U74%)		2:1/1
Cl	7/7		7/7			22		2.8		2.8			3.0		S2 (U86%)		S2 (U86%)		1:0/0
Cm						18							3.8						1:0/0
Co	7/7		7/7			118		2.4		2.4			16.0		S1		S1		1:0/0
Cs	7/7		7/7		114	469		2.2		2.2		5.8	7.0		S2 (U83%)		S2 (U83%)		2:1/1
Eu	6/6		6/6					1.6		1.6									0:0/0
Ho	7/7		7/7	3		4		1.4		1.4	2.4		2.9		S2 (U45%)		S2 (U45%)		2:1/1
I	7/7		7/7	196		250		2.2		2.2	5.2		5.4		S1		S1		2:1/1
Mo	7/7		7/7			9		2.8		2.8			2.8		S2 (L80%)		S2 (L80%)		1:0/0
Nb	7/7		7/7		2	11		2.2		2.2			3.7		S2 (U16%)		S2 (U16%)		2:0/0
Ni	7/7		7/7			64		1.4		1.4			7.0		S1		S1		1:0/0
Np				22		26					3.6		6.1						2:1/1
Pa				3		4					2.3		2.8						2:1/1
Pb	7/7		7/7		9	23		1.8		1.8		3.6	9.9		S1		S1		2:1/1
Pd				4		6					2.0		2.3						2:1/1
Po				43		44					5.1		5.4						2:1/1
Pu					11	62						4.0	4.0						2:1/1
Ra	7/7		7/7			51		2.4		2.4			13.0		S1		S1		1:0/0
Se	7/7		7/7		15	172		2.8		2.8		5.2	3.3		S1		S1		2:1/1
Sm	7/7		7/7	3		4		1.6		1.6	2.4		2.9		S2 (U2%)		S2 (U2%)		2:1/1
Sn	7/7		7/7	4		12		1.5		1.5	2.2		6.2		S1		S1		2:1/1
Sr	7/7		7/7		65	255		1.8		1.8		6.4	5.9		S1		S1		2:1/1
Tc				22		33					3.7		9.3						2:1/1
Th	7/7		7/7	25		46		2.2		2.2	10.0		10.0		S1		S1		2:1/1
U	7/7		7/7	146		178		3.1		3.1	13.0		12.0		S1		S1		2:1/1
Zr	7/7		7/7		4	11		2.6		2.6		16.0	21.0		S1		S1		2:1/1

The narrow distribution for Sm falls just outside the literature data range for "all soils" (IAEA 2010). It could be expected that all lanthanides as well as the actinides Ac, Am and Cm should show K_d values of the same magnitude. Site data for the lanthanides Sm, Ho and Eu agree according to Figure 5-1 and Ho show a minor overlap with literature data. The literature intervals of Am and Cm are broad and overlap site data for Sm, Ho and Eu. From these observations, it could be concluded that the site-specific K_d values for Ac, Am and Cm are reasonable for the FM area, but literature data indicates that site data could possibly be slightly overestimated. The original literature data for Sm cited in IAEA (2010), however, represent interpolated plant/soil CR data (Sheppard and Thibault 1990), and are thus less representative for K_d_regoLow.

Nb shows the highest site-specific K_d of all selected elements. This value is, however, in line with site data as well as literature data for other elements with low solubility, such as Zr and Th.

The selected data for K_d_regoLow are compiled in Table 5-3. In the case of Ag, Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Ra, Se, Sm, Sn, Sr, U and Zr, site-specific data are used for the parameterisation of the K_d_regoLow parameter. Sm site data are utilised as EA for Ac, Am, Cm and Pa. Bi site data are used as EA for Po. Zr site data are selected as EA for Tc, due to the assumed reducing conditions. Ni is utilised as EA for Pd. Th site data is used as EA for Np and Sm site data is used as EA for Pu due to the reducing environment. Due to the limited sample numbers and low variation of data for many of the elements, many ranges are expanded by utilising GSDmean (Section 4.3). See Section 2.7 for further information on the selected EAs.

In Figure 5-2, the selected values for K_d_regoLow are sorted from low sorption on the left, to high sorption on the right. Cl is an anion that usually shows negligible sorption and is consequently found at the lower left side of the range. U and Mo, which are mobile elements in some environments, also plot at the left side of the figure (U is usually very mobile in the alkaline environment prevailing in the FM area). Many of the elements located to the right have a high affinity for particles/surfaces, e.g. Eu, Ho, Sm, Sn ,Pb, Th, Nb and Cs and, as expected, show low mobility in this environment.

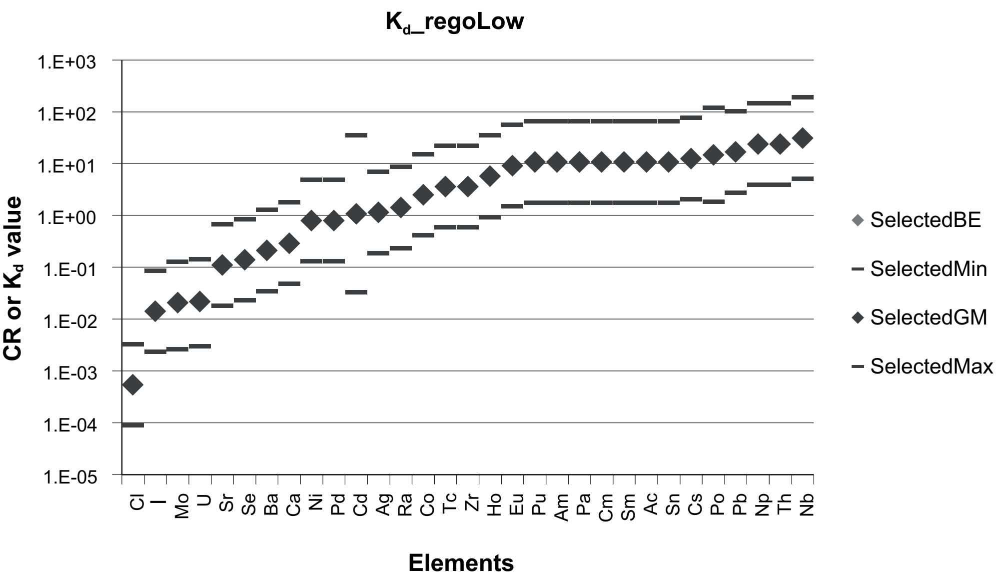

__Figure 5-2.__ The selected parameter values (best estimate (BE), geometric mean (GM), min and max values) arranged in ascending order based on the GM value (m^3/kg_{dw}). In the case of K_d_regoLow, GM and BE are identical.

Table 5-3. Selected data, references and comments for the parameter K_d_regoLow (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or the sample numer of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		7	1.7E+00	1.1E+01	1.1E+01	6.5E+01	3.0	GSDmean	Site data FM	FM	Data for EAs REE, Ac, Am, Cm are consistent.
Ag			7	1.8E–01	1.1E+00	1.1E+00	7.0E+00	3.0	GSDmean	Site data FM	FM	
Am	Sm		7	1.7E+00	1.1E+01	1.1E+01	6.5E+01	3.0	GSDmean	Site data FM	FM	Data for EAs REE, Ac, Am, Cm are consistent.
Ba			7	3.5E–02	2.1E–01	2.1E–01	1.3E+00	3.0	GSDmean	Site data FM	FM	
Ca			7	4.8E–02	2.9E–01	2.9E–01	1.8E+00	3.0	GSDmean	Site data FM	FM	
Cd			2	3.3E–02	1.1E+00	1.1E+00	3.5E+01	8.4	GSD	Site data FM	FM	
Cl			7	8.8E–05	5.4E–04	5.4E–04	3.3E–03	3.0	GSDmean	Site data FM	FM	
Cm	Sm		7	1.7E+00	1.1E+01	1.1E+01	6.5E+01	3.0	GSDmean	Site data FM	FM	Data for EAs REE, Ac, Am, Cm are consistent.
Co			7	4.1E–01	2.5E+00	2.5E+00	1.5E+01	3.0	GSDmean	Site data FM	FM	
Cs			7	2.0E+00	1.2E+01	1.2E+01	7.6E+01	3.0	GSDmean	Site data FM	FM	
Eu			6	1.5E+00	9.1E+00	9.1E+00	5.5E+01	3.0	GSDmean	Site data FM	FM	Data for EAs REE, Ac, Am, Cm are consistent.
Ho			7	9.3E–01	5.6E+00	5.6E+00	3.4E+01	3.0	GSDmean	Site data FM	FM	Data for EAs REE, Ac, Am, Cm are consistent.
I			7	2.3E–03	1.4E–02	1.4E–02	8.6E–02	3.0	GSDmean	Site data FM	FM	
Mo			7	2.6E–03	2.1E–02	2.1E–02	1.3E–01	3.0	GSDmean	Site data FM	FM	
Nb			7	5.0E+00	3.1E+01	3.1E+01	1.9E+02	3.0	GSDmean	Site data FM	FM	
Ni			7	1.3E–01	7.9E–01	7.9E–01	4.8E+00	3.0	GSDmean	Site data FM	FM	
Np	Th		7	3.9E+00	2.4E+01	2.4E+01	1.4E+02	3.0	GSDmean	Site data FM	FM	Th(IV) used as EA in reducing environment for NP(IV).
Pa	Sm		7	1.7E+00	1.1E+01	1.1E+01	6.5E+01	3.0	GSDmean	Site data FM	FM	Sm(III) is used as EA.
Pb			7	2.7E+00	1.7E+01	1.7E+01	1.0E+02	3.0	GSDmean	Site data FM	FM	
Pd	Ni		7	1.3E–01	7.9E–01	7.9E–01	4.8E+00	3.0	GSDmean	Site data FM	FM	Site data for Ni are consistent with lit. data for Ni and Pd.
Po	Bi		7	1.8E+00	1.5E+01	1.5E+01	1.2E+02	3.6	GSD	Site data FM	FM	Site data for Bi higher than lit. data for Po and sitedata for possible EA Te: overestimated value?.
Pu	Sm		7	1.7E+00	1.1E+01	1.1E+01	6.5E+01	3.0	GSDmean	Site data FM	FM	Sm used as EA in reducing environment. Lit. data for Pu consistent with REE, Ac, Am, Cm.
Ra			7	2.3E–01	1.4E+00	1.4E+00	8.6E+00	3.0	GSDmean	Site data FM	FM	
Se			7	2.3E–02	1.4E–01	1.4E–01	8.4E–01	3.0	GSDmean	Site data FM	FM	
Sm			7	1.7E+00	1.1E+01	1.1E+01	6.5E+01	3.0	GSDmean	Site data FM	FM	Data for EAs REE, Ac, Am, Cm are consistent.
Sn			7	1.8E+00	1.1E+01	1.1E+01	6.5E+01	3.0	GSDmean	Site data FM	FM	
Sr			7	1.8E–02	1.1E–01	1.1E–01	6.7E–01	3.0	GSDmean	Site data FM	FM	
Tc	Zr		7	5.9E–01	3.6E+00	3.6E+00	2.2E+01	3.0	GSDmean	Site data FM	FM	Reducing environment. Tc immobile and analogue to Zr(IV).
Th			7	3.9E+00	2.4E+01	2.4E+01	1.4E+02	3.0	GSDmean	Site data FM	FM	
U			7	2.9E–03	2.2E–02	2.2E–02	1.4E–01	3.1	GSD	Site data FM	FM	
Zr			7	5.9E–01	3.6E+00	3.6E+00	2.2E+01	3.0	GSDmean	Site data FM	FM	

5.2 K_d_regoGL

In the biosphere model, the RegoGL compartment represents water saturated, anaerobic, minerogenic glacial deposits (clay) of sediments in both the terrestrial and aquatic systems. This type of clay layer is typically located between postglacial deposits and the till layer.

Representative site data for the RegoGL layer, classified as glacial clay, have been sampled at 5 sites in the FM area. This glacial clay is characterised by low contents of organic carbon, though it contains some inorganic carbon most likely originating from calcite, which explains the high pH in the samples. Postglacial clays from the FM area have similar properties as glacial clay, however it lacks calcite (Sheppard et al. 2011).

Literature data for various soil types are available for comparison in IAEA (2010). Even though IAEA (2010) represents rooting-zone soils, they are considered a surrogate for the anaerobic RegoGL materials. The reported data regarding mineral soil and the sub-categories sand and clay, are considered the most representative for the RegoGL compartment (the same selection as for K_d_regoLow). "Mineral" soil data are categorised as L1 class data, "sand" data are categorised as L2 class data and K_d data concerning "all soils" combined are categorised as L3 class data.

As shown in Table 5-4, FM site data are available for Ag, Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Se, Sm, Sn, Sr, U and Zr. Literature data alone are available for Ac, Am, Cm, Np, Pa, Po, Pu and Tc. There are no comparable data available from the LX area (Table 5-4). When FM data are compared to literature data, several elements show discrepancies (Ca, Cl, Cs, Ho, Nb, Ni and Sm). These deviating elements are spread over the whole K_d range, perhaps with some emphasis on the higher end of the interval, representing strong sorption. This general discrepancy may be explained by the larger specific surface area of the clay particles included in the glacial clay samples and that literature data probably represent more coarse soils than glacial clay. For Ca, the discrepancy between literature and site data could be explained by the presence of calcite, similar to K_d_regoLow, whereas the difference for Cl is harder to explain (cf. Section 5.11.1).

The single site-specific value of Cd is supported by the range of the possible EAs Zn and Hg, and literature data, according to Figure 5-3.

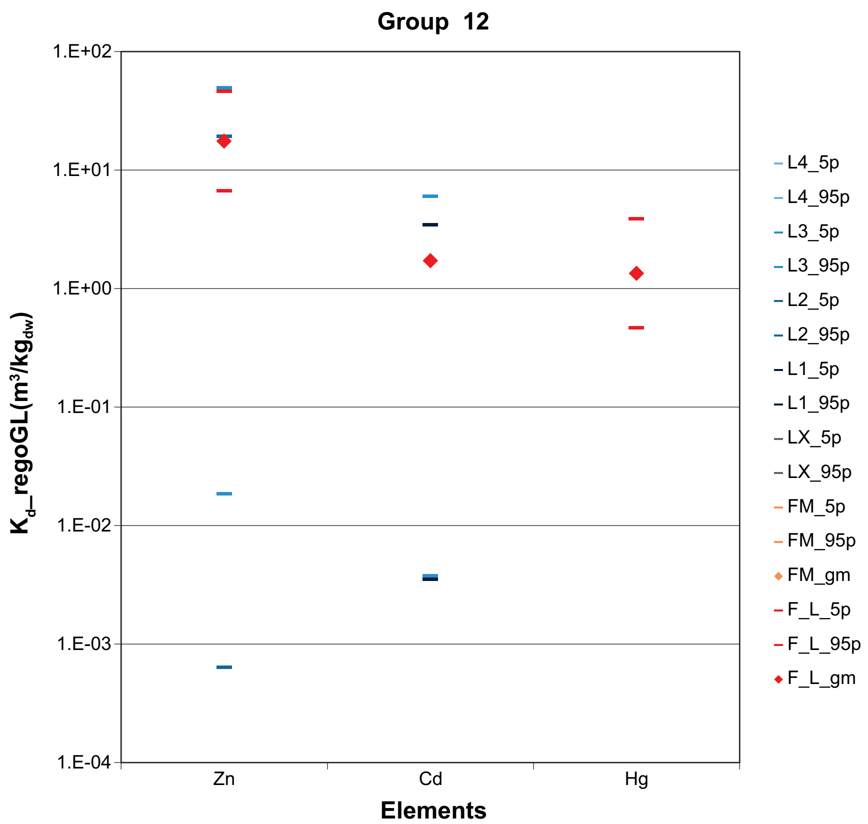

Figure 5-3. *K_d_regoGL. Comparisons among group 12 elements: Zn, Cd and Hg.*

Table 5-4. Available data for K_d_regoGL for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010, mineral soil, L2 = IAEA 2010, sand, L3 = IAEA 2010, all soils. See Table 5-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac				3		4					2.4		2.8						2:1/1
Ag	5/5		5/5	5		9		2.0		2.0	3.0		7.1		S1		S1		2:1/1
Am					17	62						6.7	6.1						2:1/1
Ba	5/5		5/5			1		1.6		1.6									1:0/0
Bi	5/5		5/5	4		6		1.7		1.7	2.1		2.3		S4		S4		2:1/1
Ca	5/5		5/5	33		34		1.8		1.8	3.2		3.4		S4		S4		2:1/1
Cd	1/1		1/1	39		61					8.1		9.4						2:1/1
Cl	5/5		5/5			22		1.5		1.5			3.0		S4		S4		1:0/0
Cm						18							3.8						1:0/0
Co	5/5		5/5			118		1.6		1.6			16.0		S2 (U9%)		S2 (U9%)		1:0/0
Cs	5/5		5/5		114	469		1.5		1.5		5.8	7.0		S4		S4		2:1/1
Eu	3/3		3/3					3.7		3.7									0:0/0
Ho	5/5		5/5	3		4		2.5		2.5	2.4		2.9		S4		S4		2:1/1
I	5/5		5/5	196		250		2.4		2.4	5.2		5.4		S2 (U24%)		S2 (U24%)		2:1/1
Mo	5/5		5/5			9		4.6		4.6			2.8		S2 (U49%)		S2 (U49%)		1:0/0
Nb	5/5		5/5		2	11		1.9		1.9			3.7		S4		S4		2:0/0
Ni	5/5		5/5			64		1.6		1.6			7.0		S4		S4		1:0/0
Np				22		26					3.6		6.1						2:1/1
Pa				3		4					2.3		2.8						2:1/1
Pb	5/5		5/5		9	23		2.5		2.5		3.6	9.9		S2 (U19%)		S2 (U19%)		2:1/1
Pd				4		6					2.0		2.3						2:1/1
Po				43		44					5.1		5.4						2:1/1
Pu					11	62						4.0	4.0						2:1/1
Ra	4/4		4/4			51		2.1		2.1			13.0		S1		S1		1:0/0
Se	2/2		2/2		15	172		1.6		1.6		5.2	3.3		S2 (U80%)		S2 (U80%)		2:1/1
Sm	5/5		5/5	3		4		3.1		3.1	2.4		2.9		S4		S4		2:1/1
Sn	5/5		5/5	4		12		1.5		1.5	2.2		6.2		S1		S1		2:1/1
Sr	5/5		5/5		65	255		1.2		1.2		6.4	5.9		S1		S1		2:1/1
Tc				22		33					3.7		9.3						2:1/1
Th	5/5		5/5	25		46		1.8		1.8	10.0		10.0		S2 (U60%)		S2 (U60%)		2:1/1
U	5/5		5/5	146		178		8.4		8.4	13.0		12.0		S2 (U97%)		S2 (U97%)		2:1/1
Zn	5/5		5/5		17	92		1.8		1.8		23.0	11.0		S1		S1		2:1/1
Zr	5/5		5/5		4	11		1.4		1.4		16.0	21.0		S2 (U62%)		S2 (U62%)		2:1/1

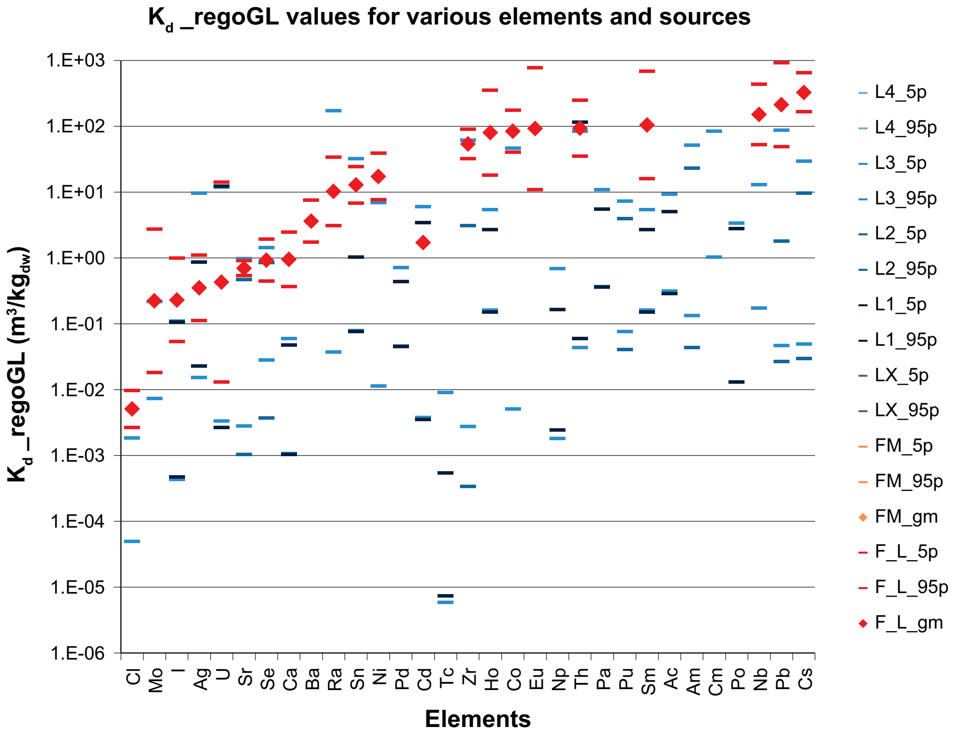

Figure 5-4. *Data ranges for the sources that are considered representative for K_d_regoGL (m^3/kg_{dw}). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5th (5p) and 95th (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.*

The selected data for K_d_regoGL are compiled in Table 5-5. In the case of Ag, Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Ra, Se, Sm, Sn, Sr, Th, U and Zr, site-specific data are used for parameterisation of the K_d_regoGL parameter. Sm is selected as EA for Ac, Am, Cm and Pa. Bi is used as EA for Po. Zr site data are utilised as EA for Tc, due to the assumed reducing conditions. Ni is used as EA for Pd. Th site data is used as EA for Np and Sm site data is used as EA for Pu due to the reducing environment. See Section 2.7 for further information on the assumptions behind the selected EAs.

Data ranges are expanded around respective GMs for several elements, by the use of GSDmean (Section 4.3). Among site data, U exceeds GSDmax with a total range of 3 orders of magnitude, which is significantly more compared to for example U in K_d_regoLow. In addition, literature data (IAEA 2010) show a similar wide range, supporting that the variation is large for U in K_d_regoGL.

In Figure 5-5, the selected values for the K_d_regoGL parameter are sorted from low sorption on the left, to high sorption on the right. K_d for the selected elements ranges over almost 7 orders of magnitude, which exceeds the total range of 5 to 6 orders of magnitude displayed by K_d_regoLow. The relative order among the elements is similar to K_d_regoLow, with the exception of Cs. Perhaps this could be explained by Cs high affinity for mineral surfaces in combination with the high specific surface area of glacial clay. For Ag, the mobility is somewhat higher for K_d_regoGL compared to K_d_regoLow. This could be an indication that the marine environment (Cl) is of importance for the difference in mobility of Ag in these soils. The Cl concentrations are significantly lower in the glacial clay compared to the till in the RegoLow layer.

Table 5-5. Selected data, references and comments for the parameter K_d_regoGL (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or the sample number of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		5	1.6E+01	1.0E+02	1.0E+02	6.8E+02	3.1	GSD	Site data FM	FM	Site data for REE higher than lit. data for REE. Am and Cm are consistent with site data for REE. Lit. data for Ac lower.
Ag			5	5.7E-02	3.5E-01	3.5E-01	2.1E+00	3.0	GSDmean	Site data FM	FM	
Am	Sm		5	1.6E+01	1.0E+02	1.0E+02	6.8E+02	3.1	GSD	Site data FM	FM	Site data for REE higher than lit. data for REE. Am and Cm are consistent with site data for REE. Lit. data for Ac lower.
Ba			5	5.9E-01	3.6E+00	3.6E+00	2.2E+01	3.0	GSDmean	Site data FM	FM	
Ca			5	1.6E-01	9.5E-01	9.5E-01	5.8E+00	3.0	GSDmean	Site data FM	FM	
Cd	Zn		5	2.9E+00	1.7E+01	1.7E+01	1.1E+02	3.0	GSDmean	Site data FM	FM	Zn regarded as analogue due to few Cd data.
Cl			5	8.3E-04	5.1E-03	5.1E-03	3.1E-02	3.0	GSDmean	Site data FM	FM	
Cm	Sm		5	1.6E+01	1.0E+02	1.0E+02	6.8E+02	3.1	GSD	Site data FM	FM	Site data for REE higher than lit. data for REE. Am and Cm are consistent with site data for REE. Lit. data for Ac lower.
Co			5	1.4E+01	8.4E+01	8.4E+01	5.1E+02	3.0	GSDmean	Site data FM	FM	
Cs			5	5.3E+01	3.3E+02	3.3E+02	2.0E+03	3.0	GSDmean	Site data FM	FM	
Eu			3	4.8E+00	9.2E+01	9.2E+01	1.8E+03	6.0	GSDmax	Site data FM	FM	Lanthanides are consistent.
Ho			5	1.3E+01	8.0E+01	8.0E+01	4.9E+02	3.0	GSDmean	Site data FM	FM	Lanthanides are consistent.
I			5	3.8E-02	2.3E-01	2.3E-01	1.4E+00	3.0	GSDmean	Site data FM	FM	
Mo			5	1.8E-02	2.2E-01	2.2E-01	3.0E+00	4.6	GSD	Site data FM	FM	
Nb			5	2.5E+01	1.5E+02	1.5E+02	9.2E+02	3.0	GSDmean	Site data FM	FM	
Ni			5	2.8E+00	1.7E+01	1.7E+01	1.0E+02	3.0	GSDmean	Site data FM	FM	
Np	Th		5	1.5E+01	9.3E+01	9.3E+01	5.7E+02	3.0	GSDmean	Site data FM	FM	Th(IV) used as EA in reducing environment for NP(IV).
Pa	Sm		5	1.6E+01	1.0E+02	1.0E+02	6.8E+02	3.1	GSD	Site data FM	FM	Sm(III) is used as EA.
Pb			5	3.5E+01	2.1E+02	2.1E+02	1.3E+03	3.0	GSDmean	Site data FM	FM	
Pd	Ni		5	2.8E+00	1.7E+01	1.7E+01	1.0E+02	3.0	GSDmean	Site data FM	FM	Lit. data for Ni and Pd consistent. Site data for Ni higher.
Po	Bi		5	2.1E+01	1.3E+02	1.3E+02	7.9E+02	3.0	GSDmean	Site data FM	FM	Site data for Bi higher than lit. data for Po and sitedata for possible EA Te.
Pu	Sm		5	1.6E+01	1.0E+02	1.0E+02	6.8E+02	3.1	GSD	Site data FM	FM	Sm used as EA in reducing environment. Lit. data for Pu consistent with REE, Ac, Am, Cm.
Ra			4	1.7E+00	1.0E+01	1.0E+01	6.2E+01	3.0	GSDmean	Site data FM	FM	
Se			2	4.8E-02	9.2E-01	9.2E-01	1.7E+01	6.0	GSDmax	Site data FM	FM	
Sm			5	1.6E+01	1.0E+02	1.0E+02	6.8E+02	3.1	GSD	Site data FM	FM	Lanthanides are consistent.
Sn			5	2.1E+00	1.3E+01	1.3E+01	7.8E+01	3.0	GSDmean	Site data FM	FM	
Sr			5	1.1E-01	7.0E-01	7.0E-01	4.2E+00	3.0	GSDmean	Site data FM	FM	
Tc	Zr		5	8.8E+00	5.4E+01	5.4E+01	3.3E+02	3.0	GSDmean	Site data FM	FM	Reducing environment. Tc immobile and analogue to Zr(IV).
Th			5	1.5E+01	9.3E+01	9.3E+01	5.7E+02	3.0	GSDmean	Site data FM	FM	
U			5	1.3E-02	4.3E-01	4.3E-01	1.8E+01	8.4	GSD	Site data FM	FM	U shows a large spread similar to the literature interval. Large variation in porewater conc.
Zr			5	8.8E+00	5.4E+01	5.4E+01	3.3E+02	3.0	GSDmean	Site data FM	FM	

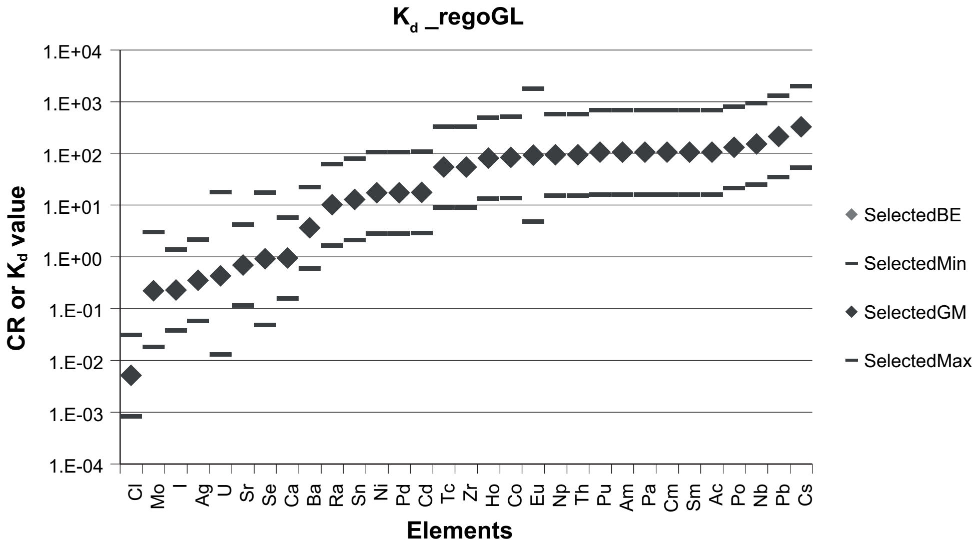

Figure 5-5. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{dw}).*

5.3 K_d_regoPG

In the biosphere model, the RegoPG compartment represents the postglacial sediments in both aquatic and terrestrial ecosystems characterised by water saturated anaerobic, deposits (clay gyttja and gyttja). In the FM area, the postglacial clay contains organic material and therefore, is characterised as clay gyttja (clay with an organic content between 6 and 20%). Some of the lake sediments attributed to RegoPG have an even higher organic content than 20% and are in fact characterised as gyttja (Saetre et al. 2013).

Suitable site data representing the RegoPG compartment (terrestrial and aquatic) consist of 4 samples of clay gyttja at 0.5 m depth in the soil profile, and 2 marine sediment samples at 0.2 m depth in the profile. The marine sediment samples were collected below the redox front, or at approximately 0.25–0.35 m depth if a redox front was not detected (Sheppard et al. 2011).

Literature data for various soil types are available for comparison in IAEA (2010). Suitable data are available in IAEA (2010) for the following, aggregated soil types: “clay+organic”, “loam”, “loam+clay”, “loam+clay+organic”, “sand+loam”. “Loam+clay” data were most abundant and, therefore, categorized as L1 data, “sand+loam” as L2 data and data for “all soils” as L3 data.

Site data are available for Ag, Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Se, Sm, Sn, Sr, U and Zr. Literature data alone are available for Ac, Am, Cm, Np, Pa, Po, Pu and Tc (Table 5-6).

When FM data are compared to literature data, I and Se show major discrepancies with no overlap between site and literature distributions, with the higher values found among site data. Site data for Cl, Mo and Nb also deviate from the literature distributions (cf. Table 5-6 and Figure 5-8). There are no comparable data available from the LX area. Comparisons among literature data are less relevant, since the compared sources originate from the same reference.

The site data interval for I does not overlap the literature data interval. However, there is an increasing tendency in site data among the halogens, which may support the higher value for I (Figure 5-6). The relative order among these elements is expected, with higher sorption for I than Cl (Section 2.7.13).

Site data for Se indicate a very small range, perhaps due to the limited amount of available data (Figure 5-7). In relation to the possible element analogue Te, for which more site observations are available, GMs are comparable and the literature ranges for Te and Se overlaps. Therefore, it can be concluded that the site data in combination with an expanded GSD (GSDmax) for Se is reasonable, despite the limited overlap with literature data.

Table 5-6. Available data for K_d_regoPG for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010, loam and clay, L2 = IAEA 2010, sand and loam, L3 = IAEA 2010, all soils. See Table 5-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac						4							2.8						1:0/0
Ag	5/5		5/5			9		4.3		4.3			7.1		S2 (U67%)		S2 (U67%)		1:0/0
Am				32		62					5.6		6.1						2:1/1
Ba	5/6		8/9			1		2.5		11.7									1:0/0
Bi	5/6		5/6			6		1.4		1.4			2.3		S4		S4		1:0/0
Ca	5/6		8/9			34		1.5		1.6			3.4		S2 (U86%)		S2 (U73%)		1:0/0
Cd	4/4		7/7			61		1.5		1.7			9.4		S1		S1		1:0/0
Cl	5/5		5/5			22		3.0		3.0			3.0		S2 (U7%)		S2 (U7%)		1:0/0
Cm						18							3.8						1:0/0
Co	5/6		8/9		89	118		3.7		3.8		16.0	16.0		S1		S1		2:1/1
Cs	5/6		7/8	227		469		2.6		2.3	3.6		7.0		S2 (U37%)		S2 (U40%)		2:1/1
Eu	5/6		8/9					4.2		3.2									0:0/0
Ho	5/6		8/9			4		3.5		2.8			2.9		S2 (U64%)		S2 (U63%)		1:0/0
I	5/5		5/5			250		2.2		2.2			5.4		S4		S4		1:0/0
Mo	5/6		8/9			9		8.0		5.5			2.8		S2 (U9%)		S2 (U1%)		1:0/0
Nb	5/6		7/8	8		11		2.1		2.1	2.5		3.7		S2 (U12%)		S2 (U23%)		2:1/1
Ni	5/6		8/9		40	64		3.8		3.1		7.8	7.0		S2 (U92%)		S1		2:1/1
Np						26							6.1						1:0/0
Pa						4							2.8						1:0/0
Pb	5/6		8/9	7		23		2.1		2.0	3.6		9.9		S1		S1		2:1/1
Pd						6							2.3						1:0/0
Po						44							5.4						1:0/0
Pu				37		62					3.3		4.0						2:1/1
Ra	5/5		5/5		39	51		2.0		2.0		12.0	13.0		S1		S1		2:1/1
Se	2/2		5/5	134		172		1.0		4.2	3.0		3.3		S4		S2 (U80%)		2:1/1
Sm	5/6		8/9			4		3.5		2.8			2.9		S2 (U60%)		S2 (U59%)		1:0/0
Sn	5/6		5/6			12		9.6		9.6			6.2		S2 (U52%)		S2 (U52%)		1:0/0
Sr	5/6		8/9			255		2.2		2.0			5.9		S1		S1		1:0/0
Tc						33							9.3						1:0/0
Th	5/6		8/9			46		1.7		1.8			10.0		S1		S1		1:0/0
U	5/6		8/9			178		1.4		2.2			12.0		S1		S2 (U77%)		1:0/0
Zr	5/6		8/9	4		11		3.8		4.3	2.1		21.0		S1		S1		2:1/1

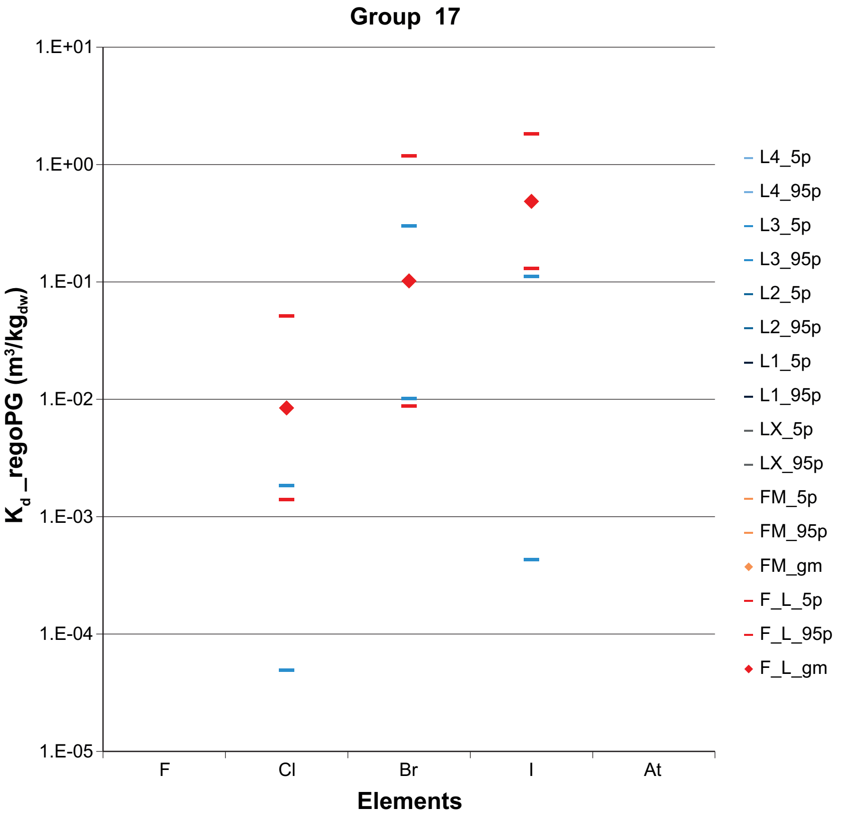

Figure 5-6. *K_d_regoPG. Comparisons among halogens.*

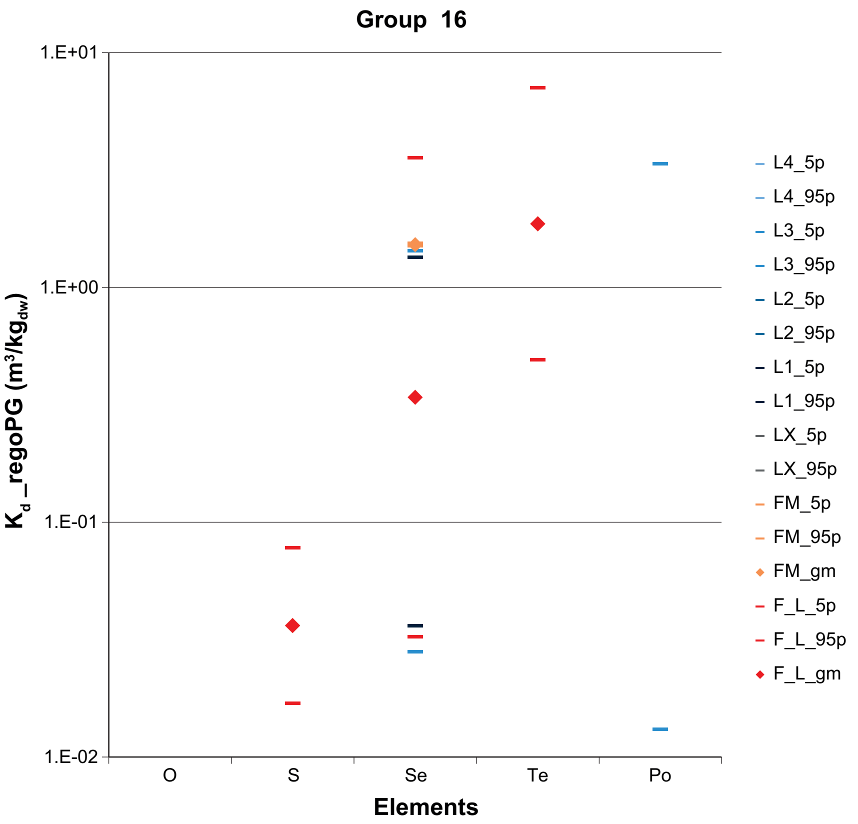

Figure 5-7. *Comparisons among group 16 elements: O, S, Se, Te and Po.*

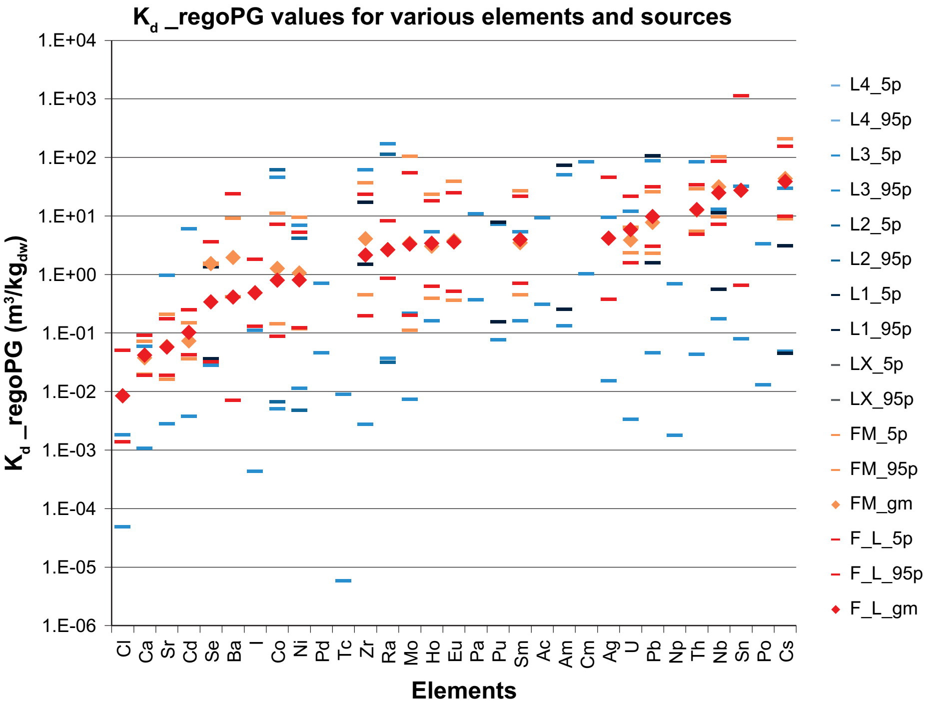

Figure 5-8. *Data ranges for the sources that are considered representative for K_d_regoPG (m^3/kg_{dw}). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5th (5p) and 95th (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.*

For Tc, the literature range of "all soils" in IAEA (2010) presumably mainly represents oxidizing conditions in agricultural soils. Tc is redox sensitive and the mobility is significantly lower under reducing conditions. The literature range for Tc is significantly lower compared to site data for the possible EA Zr (cf. Section 2.7 for EA assumptions). This could support that the literature range for Tc might underestimate K_d in the anoxic RegoPG layer.

For Mo and Sn, the variations are large and exceed GSDmax. There are no indications in the underlying concentration data that any data points are less reliable. The combination of data from marine and terrestrial sediments could perhaps contribute to the extended variation for these specific elements, for example due to redox effects.

The selected data for K_d_regoPG are compiled in Table 5-7. In the case of Ag, Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Ra, Se, Sm, Sn, Sr, Th, U and Zr, site-specific data are used for the parameterisation of the K_d_regoPG parameter. Sm is selected as EA for Ac, Am, Cm and Pa. Bi is used as EA for Po and Ni is utilised as EA for Pd. Zr site data are used as EA for Tc, due to the assumed reducing conditions. Th site data is used as EA for Np and Sm site data is used as EA for Pu due to the reducing environment. See Section 2.7 for further information on the assumptions behind the selected EAs.

Data ranges are expanded around GM for several elements, by the use of GSDmean (cf. Section 4.3). Among site data, Mo and Sn exceed GSDmax by showing a range of 3 orders of magnitude. No discrepancies could be found in the underlying data to explain this enhanced variation.

In Figure 5-9 the selected values for the K_d_regoPG parameter are sorted from low sorption on the left, to high sorption on the right. K_ds for the selected elements range over almost 6 orders of magnitude. The relative order among the elements is similar to the relative order found in K_d_regoLow and K_d_regoGL (cf. Section 5.11 for parameter comparisons).

Table 5-7. Selected data, references and comments for the parameter K_d_regoPG (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or the sample numer of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		8	6.4E–01	3.9E+00	3.5E+00	2.4E+01	3.0	GSDmean	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Ag			5	3.7E–01	4.1E+00	4.1E+00	5.2E+01	4.3	GSD	Site data FM	FM	
Am	Sm		8	6.4E–01	3.9E+00	3.5E+00	2.4E+01	3.0	GSDmean	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Ba			8	7.2E–03	4.1E–01	2.0E+00	2.4E+01	11.7	GSD	Site data FM	FM	
Ca			8	6.8E–03	4.2E–02	3.7E–02	2.5E–01	3.0	GSDmean	Site data FM	FM	
Cd			7	1.7E–02	1.0E–01	7.3E–02	6.2E–01	3.0	GSDmean	Site data FM	FM	Possibly underestimated K_d compared to possible EAs Zn and Hg.
Cl			5	1.4E–03	8.4E–03	8.4E–03	5.1E–02	3.0	GSDmean	Site data FM	FM	
Cm	Sm		8	6.4E–01	3.9E+00	3.5E+00	2.4E+01	3.0	GSDmean	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Co			8	8.7E–02	7.9E–01	1.3E+00	7.2E+00	3.8	GSD	Site data FM	FM	
Cs			7	6.4E+00	3.9E+01	4.3E+01	2.4E+02	3.0	GSDmean	Site data FM	FM	Site data for Cs significantly higher than literature data. Site data for Na, K, Rb, Cs show consistent trend. Support the high value of Cs.
Eu			8	5.1E–01	3.6E+00	3.8E+00	3.3E+01	3.2	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Ho			8	5.5E–01	3.4E+00	3.0E+00	2.1E+01	3.0	GSDmean	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
I			5	7.9E–02	4.8E–01	4.8E–01	2.9E+00	3.0	GSDmean	Site data FM	FM	Reasonable range compared to the other halogens.
Mo			8	2.0E–01	3.3E+00	3.4E+00	5.4E+01	5.5	GSD	Site data FM	FM	Large GSD. A possible reason for the large spread could be the inclusion of both marine and terrestrial sediments.
Nb			7	4.1E+00	2.5E+01	3.1E+01	1.5E+02	3.0	GSDmean	Site data FM	FM	Nb shows similar sorption properties as Pb, Sn and Zr, as expected.
Ni			8	1.2E–01	8.0E–01	1.1E+00	6.2E+00	3.1	GSD	Site data FM	FM	
Np	Th		8	2.1E+00	1.3E+01	1.3E+01	7.8E+01	3.0	GSDmean	Site data FM	FM	Th(IV) used as EA in reducing environment for NP(IV).
Pa	Sm		8	6.4E–01	3.9E+00	3.5E+00	2.4E+01	3.0	GSDmean	Site data FM	FM	Sm(III) is used as EA.
Pb			8	1.6E+00	9.7E+00	7.7E+00	5.9E+01	3.0	GSDmean	Site data FM	FM	
Pd	Ni		8	1.2E–01	8.0E–01	1.1E+00	6.2E+00	3.1	GSD	Site data FM	FM	Site data for Ni consistent with lit. data for Ni and Pd.
Po	Bi		5	6.1E+00	3.7E+01	3.7E+01	2.3E+02	3.0	GSDmean	Site data FM	FM	Site data for Bi higher than lit. data for Po and sitedata for possible EA Te.
Pu	Sm		8	6.4E–01	3.9E+00	3.5E+00	2.4E+01	3.0	GSDmean	Site data FM	FM	Sm used as EA in reducing environment. Lit. data for Pu consistent with REE, Ac, Am, Cm.
Ra			5	4.3E–01	2.6E+00	2.6E+00	1.6E+01	3.0	GSDmean	Site data FM	FM	
Se			5	3.2E–02	3.4E–01	1.5E+00	3.6E+00	4.2	GSD	Site data FM	FM	Comparable with element analogue Te.
Sm			8	6.4E–01	3.9E+00	3.5E+00	2.4E+01	3.0	GSDmean	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Sn			5	6.6E–01	2.7E+01	2.7E+01	1.1E+03	9.6	GSD	Site data FM	FM	Large GSD. A possible reason for the large range could be the inclusion of both marine and terrestrial sediments.
Sr			8	9.4E–03	5.7E–02	5.8E–02	3.5E–01	3.0	GSDmean	Site data FM	FM	
Tc	Zr		8	2.0E–01	2.1E+00	4.1E+00	5.8E+01	4.3	GSD	Site data FM	FM	Reducing environment. Tc immobile and analogue to Zr(IV).
Th			8	2.1E+00	1.3E+01	1.3E+01	7.8E+01	3.0	GSDmean	Site data FM	FM	
U			8	9.6E–01	5.8E+00	3.8E+00	3.5E+01	3.0	GSDmean	Site data FM	FM	
Zr			8	2.0E–01	2.1E+00	4.1E+00	5.8E+01	4.3	GSD	Site data FM	FM	

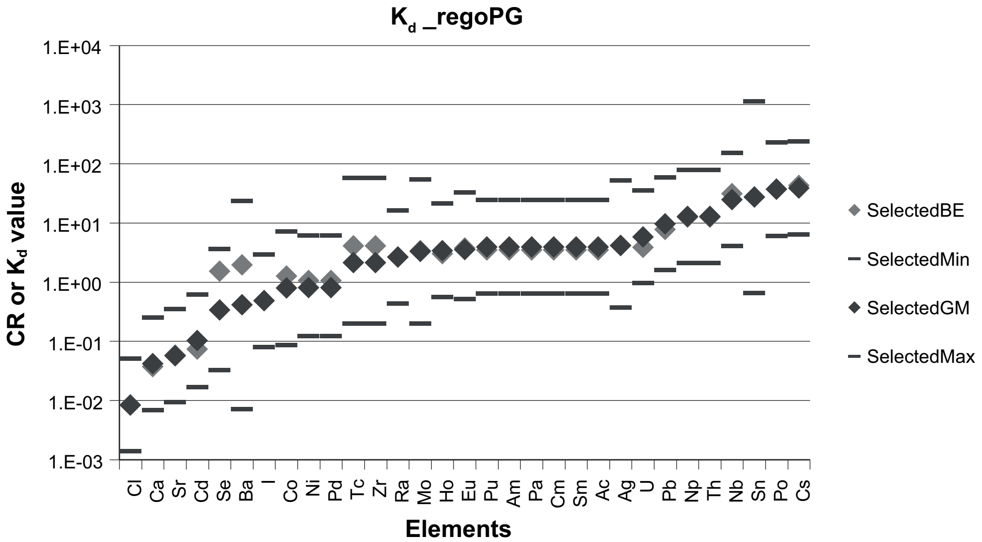

Figure 5-9. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{dw}).*

5.4 K_d_regoPeat

In the biosphere model, the RegoPeat layer represents the anoxic, water saturated organic sediment in wetland/peatland ecosystems, characterized by little biological activity and a low decomposition rate.

Available site data representing the RegoPeat compartment are wetland peat samples from 5 sites taken at a depth of 0.5 m. These samples are characterized by reducing conditions close to the surface. The vegetation at these sites varies from dominance of Sphagnum species, reflecting the nutrient poor conditions at that site, to richer wetlands dominated by sedge or reed (Sheppard et al. 2011).

Literature data are available in IAEA (2010) for organic soils, which are classified as L1 data. Data for "all soils" are classified as L2 data.

Site data are available for Ag, Ba, Ca, Cd, Cl Cs, Eu, Ho, I, Mo, Nb, Ni, Se, Sm, Sn, Sr, U and Zr (Table 5-8). Literature data alone are available for Ac, Am, Cm, Np, Pa, Po, Pu, and Tc. There are no comparable data available from the LX area.

When FM site data are compared to literature data, several elements show discrepancies. K_d site data are higher than literature data in the case of Ca, Cl, Ho, I, Mo and Sm, and site data for most of the other elements are located in the upper part of the literature distributions. This general vertical shift could be explained to some part by differing physical properties in the sampled soils in FM and the drained agricultural organic soils in IAEA (2010). The wetland peat soils display a loss on ignition of 92–97%, which means that the mineral content is very low (Sheppard et al. 2011). The organic soils in IAEA (2010) probably have higher bulk densities and mineral contents in general, compared to the sampled wetland peat soils. This could to some extent explain the nominal difference in K_d between these datasets (a K_d difference of 1 order of magnitude might be explained by this type of physical factors, cf. Section 9.1).

The selected site data for K_d_regoPeat parameter are compiled in Table 5-9. In the case of Ag, Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pd, Ra, Se, Sm, Sn, Sr, Th, U and Zr, site-specific data are used for the parameterisation. Sm is selected as EA for Ac, Am, Cm and Pa. Bi is utilised as EA for Po. Zr site data are selected as EA for Tc, due to the reducing conditions prevailing in the RegoPeat layer. Th site data is used as EA for Np and Sm site data is used as EA for Pu due to the reducing environment. See Section 2.7 for further information on the assumptions behind the selected EAs.

Data ranges are expanded by the use of GSDmean for several elements. The variation among the 5 peat samples are for most elements usually very low (Table 5-8). In the case of Se, GSDmax is assigned due to limited data.

Table 5-8. Available data for K_d_regoPeat for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010, organic, L2 = IAEA 2010, all soils. See Table 5-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac				1	4							2.8							2:0/0
Ag	5/5		5/5	2	9			1.9		1.9		7.1			S1		S1		2:0/0
Am				13	62						4.6	6.1							2:1/1
Ba	6/6		6/6		1			4.9		4.9									1:0/0
Bi	5/5		5/5	1	6			2.2		2.2		2.3			S4		S4		2:0/0
Ca	5/5		5/5	1	34			1.5		1.5		3.4			S4		S4		2:0/0
Cd	6/6		6/6	13	61			7.1		7.1	6.0	9.4			S2 (U45%)		S2 (U45%)		2:1/1
Cl	5/5		5/5		22			3.9		3.9		3.0			S4		S4		1:0/0
Cm					18							3.8							1:0/0
Co	6/6		6/6	17	118			1.7		1.7	9.5	16.0			S1		S1		2:1/1
Cs	5/5		5/5	108	469			2.1		2.1	6.8	7.0			S1		S1		2:1/1
Eu	2/2		2/2					3.8		3.8									0:0/0
Ho	5/5		5/5	1	4			1.9		1.9		2.9			S2 (U8%)		S2 (U8%)		2:0/0
I	5/5		5/5	11	250			2.2		2.2	3.3	5.4			S2 (U4%)		S2 (U4%)		2:1/1
Mo	6/6		6/6		9			2.3		2.3		2.8			S4		S4		1:0/0
Nb	5/5		5/5	1	11			2.4		2.4		3.7			S2 (U53%)		S2 (U53%)		2:0/0
Ni	5/5		5/5		64			1.6		1.6		7.0			S1		S1		1:0/0
Np				4	26						1.4	6.1							2:1/1
Pa				1	4							2.8							2:0/0
Pb	6/6		6/6	5	23			3.0		3.0	2.5	9.9			S2 (U99%)		S2 (U99%)		2:1/1
Pd	1/1		1/1	1	6							2.3							2:0/0
Po				1	44							5.4							2:0/0
Pu				6	62						3.7	4.0							2:1/1
Ra	5/5		5/5	2	51			1.6		1.6		13.0			S1		S1		2:0/0
Se	1/1		1/1	2	172							3.3							2:0/0
Sm	6/6		6/6	1	4			2.5		2.5		2.9			S2 (U29%)		S2 (U29%)		2:0/0
Sn	5/5		5/5	1	12			3.5		3.5		6.2			S2 (U77%)		S2 (U77%)		2:0/0
Sr	6/6		6/6		255			1.5		1.5		5.9			S1		S1		1:0/0
Tc				11	33						2.9	9.3							2:1/1
Th	6/6		6/6	5	46			3.4		3.4	44.0	10.0			S1		S1		2:1/1
U	6/6		6/6	9	178			3.1		3.1	6.1	12.0			S2 (U66%)		S2 (U66%)		2:1/1
Zr	6/6		6/6	2	11			2.1		2.1		21.0			S1		S1		2:0/0

Table 5-9. Selected data, references and comments for the parameter K_d_regoPeat (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or the sample number of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		6	1.6E+00	1.0E+01	1.0E+01	6.1E+01	3.0	GSDmean	Site data FM	FM	Site data for REE consistent with lit. data for Ac, Am, Cm.
Ag			5	4.3E–01	2.6E+00	2.6E+00	1.6E+01	3.0	GSDmean	Site data FM	FM	
Am	Sm		6	1.6E+00	1.0E+01	1.0E+01	6.1E+01	3.0	GSDmean	Site data FM	FM	Site data for REE consistent with lit. data for Ac, Am, Cm.
Ba			6	2.5E–02	5.6E–01	5.6E–01	7.6E+00	4.9	GSD	Site data FM	FM	
Ca			5	6.3E–02	3.8E–01	3.8E–01	2.3E+00	3.0	GSDmean	Site data FM	FM	No overlap between site and literature data. Calcite influence in FM possible explanation.
Cd			6	6.1E–01	1.7E+01	1.7E+01	4.2E+02	7.1	GSD	Site data FM	FM	
Cl			5	2.8E–03	2.7E–02	2.7E–02	2.5E–01	3.9	GSD	Site data FM	FM	No overlap between site and literature data. General tendency for Cl for many parameters.
Cm	Sm		6	1.6E+00	1.0E+01	1.0E+01	6.1E+01	3.0	GSDmean	Site data FM	FM	Site data for REE consistent with lit. data for Ac, Am, Cm.
Co			6	4.9E–01	3.0E+00	3.0E+00	1.8E+01	3.0	GSDmean	Site data FM	FM	
Cs			5	7.6E–02	4.7E–01	4.7E–01	2.8E+00	3.0	GSDmean	Site data FM	FM	
Eu			2	6.8E–01	1.3E+01	1.3E+01	2.5E+02	6.0	GSDmax	Site data FM	FM	Site data for REE are consistent, though they differ from available literature data. Comparable with lit. data for Cm and Am.
Ho			5	2.1E+00	1.3E+01	1.3E+01	7.6E+01	3.0	GSDmean	Site data FM	FM	Site data for REE are consistent, though they differ from available literature data. Comparable with lit. data for Cm and Am.
I			5	1.2E–01	7.3E–01	7.3E–01	4.4E+00	3.0	GSDmean	Site data FM	FM	
Mo			6	6.5E–01	3.9E+00	3.9E+00	2.4E+01	3.0	GSDmean	Site data FM	FM	Site data for Mo significantly higher than the interval for literature data. Site specific property due to the chemical environment in FM?.
Nb			5	1.9E+00	1.2E+01	1.2E+01	7.1E+01	3.0	GSDmean	Site data FM	FM	
Ni			5	4.3E–01	2.6E+00	2.6E+00	1.6E+01	3.0	GSDmean	Site data FM	FM	
Np	Th		6	4.2E–01	3.2E+00	3.2E+00	3.6E+01	3.4	GSD	Site data FM	FM	Th(IV) used as EA in reducing environment for NP(IV).
Pa	Sm		6	1.6E+00	1.0E+01	1.0E+01	6.1E+01	3.0	GSDmean	Site data FM	FM	Sm(III) is used as EA.
Pb			6	2.4E+00	1.4E+01	1.4E+01	8.8E+01	3.0	GSDmean	Site data FM	FM	
Pd			1	2.2E–01	4.3E+00	4.3E+00	8.1E+01	6.0	GSDmax	Site data FM	FM	Site data for Pd consistent with site and lit. data for Ni.
Po	Bi		5	2.4E+00	1.5E+01	1.5E+01	9.0E+01	3.0	GSDmean	Site data FM	FM	Site data for Bi higher than lit. data for Bi and Po.
Pu	Sm		6	1.6E+00	1.0E+01	1.0E+01	6.1E+01	3.0	GSDmean	Site data FM	FM	Sm used as EA in reducing environment. Lit. data for Pu consistent with REE, Ac, Am, Cm.
Ra			5	3.4E–01	2.1E+00	2.1E+00	1.3E+01	3.0	GSDmean	Site data FM	FM	
Se			1	2.3E–02	4.4E–01	4.4E–01	8.4E+00	6.0	GSDmax	Site data FM	FM	GSDmax assumed due to sparse data. Site data for Se comparable to the possible analogues S and Te.
Sm			6	1.6E+00	1.0E+01	1.0E+01	6.1E+01	3.0	GSDmean	Site data FM	FM	Site data for REE are consistent, though they differ from available literature data. Comparable to lit. data for Cm and Am.
Sn			5	1.3E+00	1.0E+01	1.0E+01	8.2E+01	3.5	GSD	Site data FM	FM	
Sr			6	6.5E–02	3.9E–01	3.9E–01	2.4E+00	3.0	GSDmean	Site data FM	FM	
Tc	Zr		6	4.2E–01	2.6E+00	2.6E+00	1.6E+01	3.0	GSDmean	Site data FM	FM	Zr(IV) used as EA due to the reducing conditions in peat.
Th			6	4.2E–01	3.2E+00	3.2E+00	3.6E+01	3.4	GSD	Site data FM	FM	
U			6	1.8E+00	1.3E+01	1.3E+01	8.1E+01	3.1	GSD	Site data FM	FM	
Zr			6	4.2E–01	2.6E+00	2.6E+00	1.6E+01	3.0	GSDmean	Site data FM	FM	

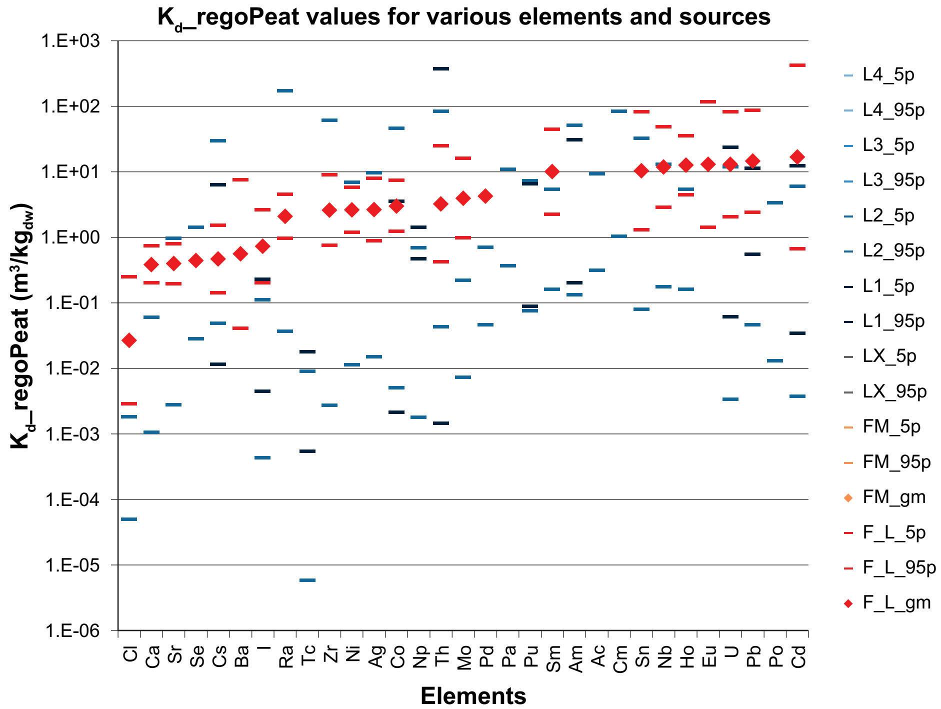

Figure 5-10. *Data ranges for the sources that are considered representative for K_d_regoPeat (m^3/kg_{dw}). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5th (5p) and 95th (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.*

In Figure 5-11, the selected values for the K_d_regoPeat parameter are sorted from low sorption on the left, to high sorption on the right. K_ds for the selected elements range over approximately 3 orders of magnitude, which is significantly lower than for example K_d_regoLow. It can be noted that U show relatively low mobility in this soil compared to e.g. K_d_regoLow, where the mobility is high. Also metals as Pb and Cd stand out by showing the highest K_d among the selected elements. The sorption of these elements is probably enhanced by the presence of organic matter in this soil type. Cs shows relatively low mobility compared to e.g. K_d_regoGL, where Cs has the highest K_d among the selected elements.

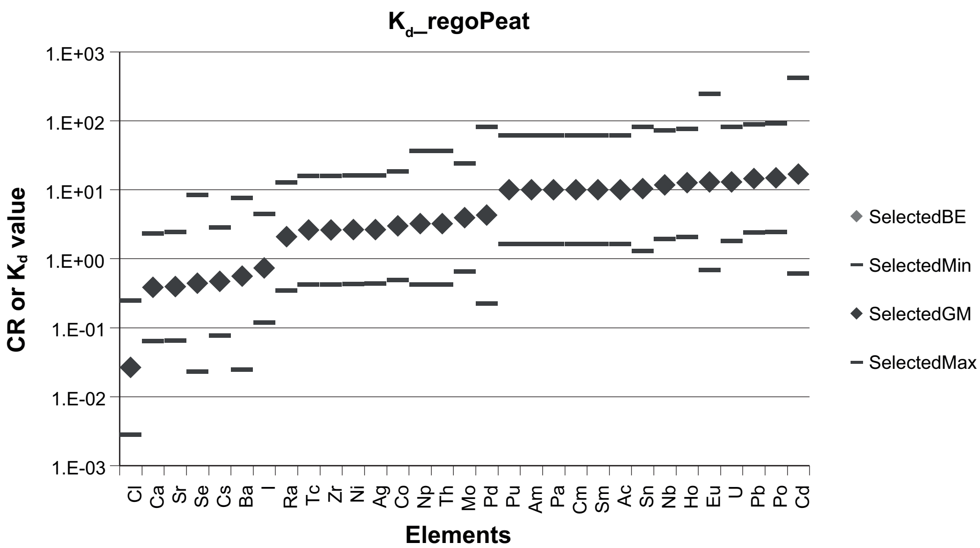

Figure 5-11. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{dw}).*

5.5 K_d_regoUp_io and K_d_regoUp_garden

In the biosphere model, the RegoUp_io and RegoUp_garden layers represent the upper layers of agricultural soils (or top soil) influenced by ploughing and bioturbation, where crops primarily take up nutrients and trace elements. The soil is assumed to be well drained and not in contact with ground water, with a high soil biological activity and a corresponding high rate of mineralisation (Seatre et al. 2013).

Suitable site data corresponding to the RegoUp_io and RegoUp_garden compartments are samples of the upper levels of cultivated clayey till and glacial clay. Five of the sampled sites were fields with regolith classified as clay till, and five sites as glacial clay (Sheppard et al. 2011).

Literature data representing these layers are reported by IAEA (2010). "Mineral" soil samples and "sand" data from IAEA (2010) are categorised as L1 and L2 data, respectively. Data for "all soils" are categorised as L3 data.

Site data are available for Ag, Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Ra, Se, Sm, Sn, Sr, Th, U and Zr. Literature data alone are available for Ac, Am, Cm, Np, Pa, Po, Pu and Tc.

When FM site data are compared to literature data, a few elements show major discrepancies (Ca, Cl and to some extent Cs, Ho, Sm, and I). There are no comparable data available from the LX area.

Site data for Ca deviate from literature data for several parameters, by showing higher K_d. This is most likely an effect of the calcite influence in the FM area (cf. K_d_regoLow). For Cl, the overall higher site data could be explained by the inclusion of dissolved Cl in the sorbed fraction. When the sorbed fraction is estimated, evaporation of remaining porewater onto the solids might overestimate the sorbed fraction up to 1 order of magnitude (cf. Section 9.1). In this case, the deviation is minor and the Cl value is not corrected for the porewater inclusion.

For Cs, K_d for site data are significantly higher than for literature data. The same tendency can also be seen for other elements in the same periodic group, such as Na, K, and Rb (Figure 5-12). This gives support to the higher site-specific K_d for Cs. The overall higher site-specific values compared to literature data for this element group, may be explained by the possibly large specific surface area of clay present in the samples. A similar tendency is also evident in the deeper glacial clay samples (cf. Section 5.2). Alternatively, the reason could be that the indigenous element analogues measured at FM are not appropriate for newly added elements, i.e. the sorbed fraction is overestimated due to the use of aqua regia as a solvent.

When literature data for Tc are compared to the possible EA Re (Figure 5-13), site-specific K_d for Re is considerably higher than the reported literature data for Tc in "sand" soils. This indicates that literature data for Tc is not consistent with site data for the supposed EA Re. At oxic conditions, like the environment in these layers, Tc is usually regarded as very mobile, (Section 2.7.12). If site-specific K_d for Re also is valid for Tc, it indicates that the literature value for Tc is underestimated by approximately 2–3 orders of magnitude.

Selected values for the K_d_regoUp_io and K_d_regoUp_garden parameters are compiled in Table 5-11. In the case of Ag, Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Pd, Ra, Se, Sm, Sn, Sr, Th, U and Zr, site-specific data are used for the parameterisation. Sm site data are selected as EA for Ac, Am, Cm and Pa. Bi is utilised as EA for Po. Re is used as EA for Tc, Sm is used as EA for Np and U is used as EA for Pu, due to the assumed oxic conditions in this environment (cf. EA assumptions in Section 2.7).

In Figure 5-15, the selected values for the K_d_regoUp_io and K_d_regoUp_garden parameters are sorted from low sorption on the left, to high sorption on the right. K_ds for the selected elements range over almost 7 orders of magnitude. The relative rank of the elements over the K_d range is similar to K_d_regoLow. For U, I, Mo, Se, Ba, Pd, Cs and Cl, these parameters are 10-fold higher than K_d_regoLow, if GMs are compared.

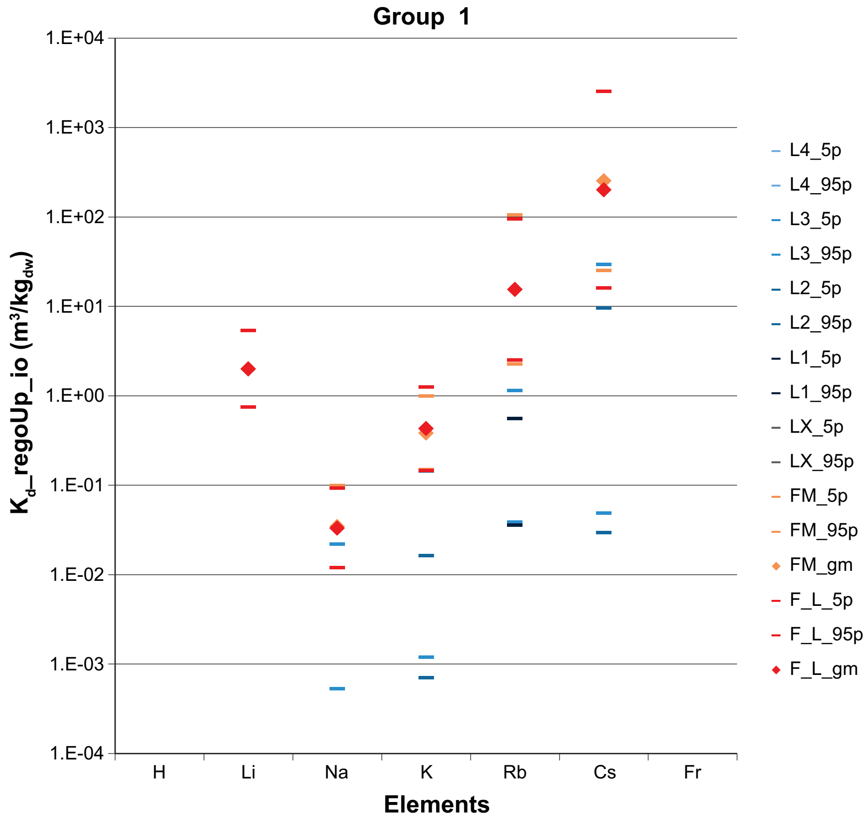

Figure 5-12. *K_d_regoUp_io and K_d_regoUp_garden. Comparisons among group 1 elements: H, Li, Na, K, Rb, Cs and Fr.*

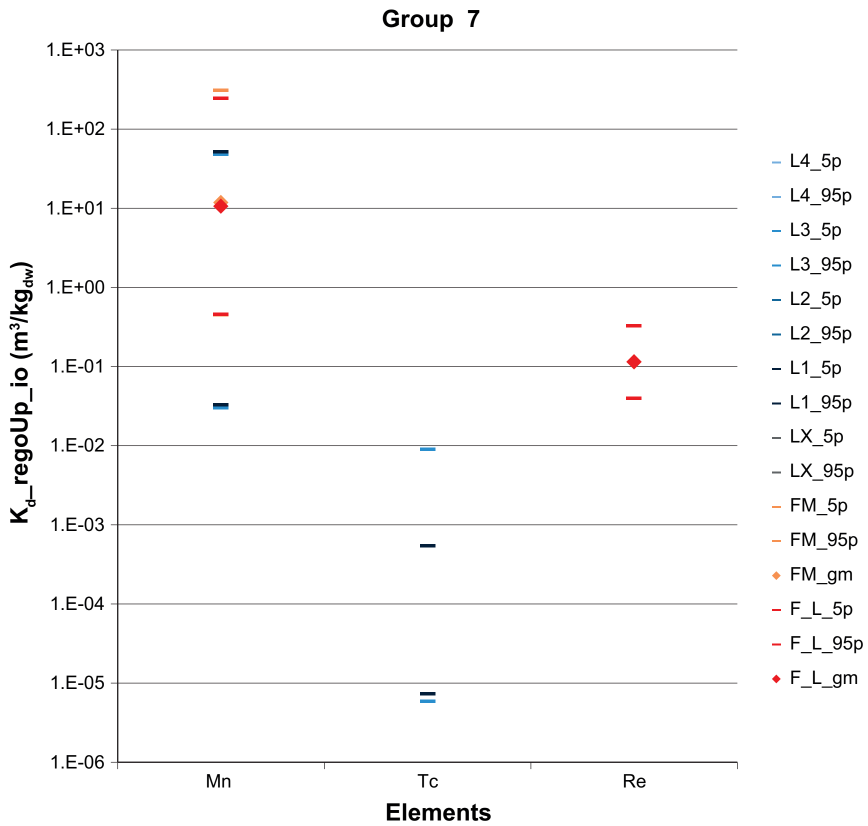

Figure 5-13. *K_d_regoUp_io and K_d_regoUp_garden. Comparisons among group 7 elements: Mn, Tc and Re.*

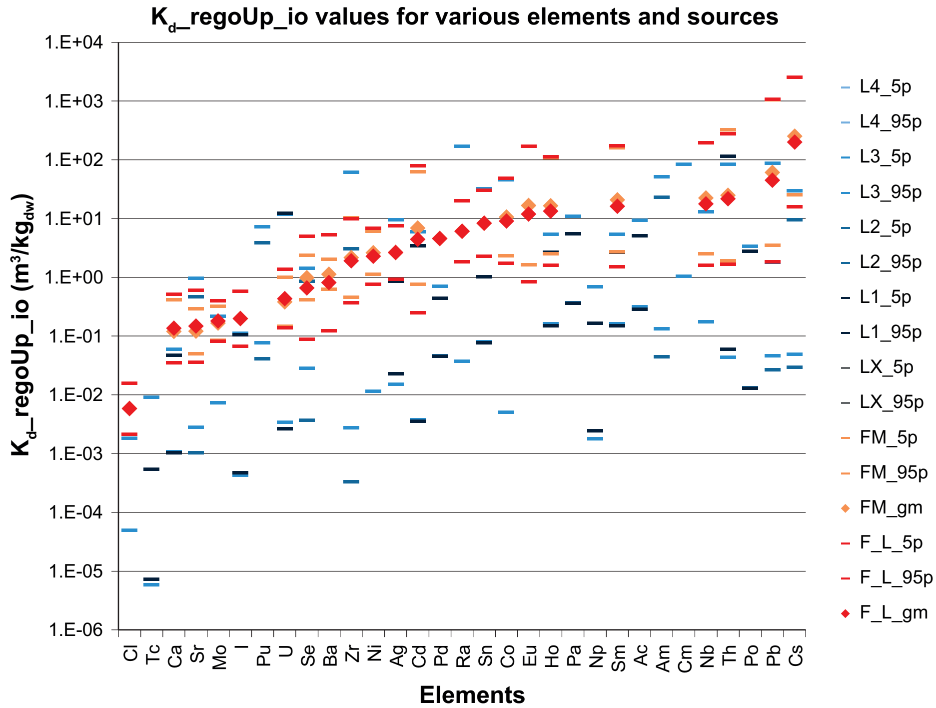

Figure 5-14. *Data ranges for the sources that are considered representative for K_d_regoUp_io and K_d_regoUp_garden (m^3/kg_{dw}). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5th (5p) and 95th (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.*

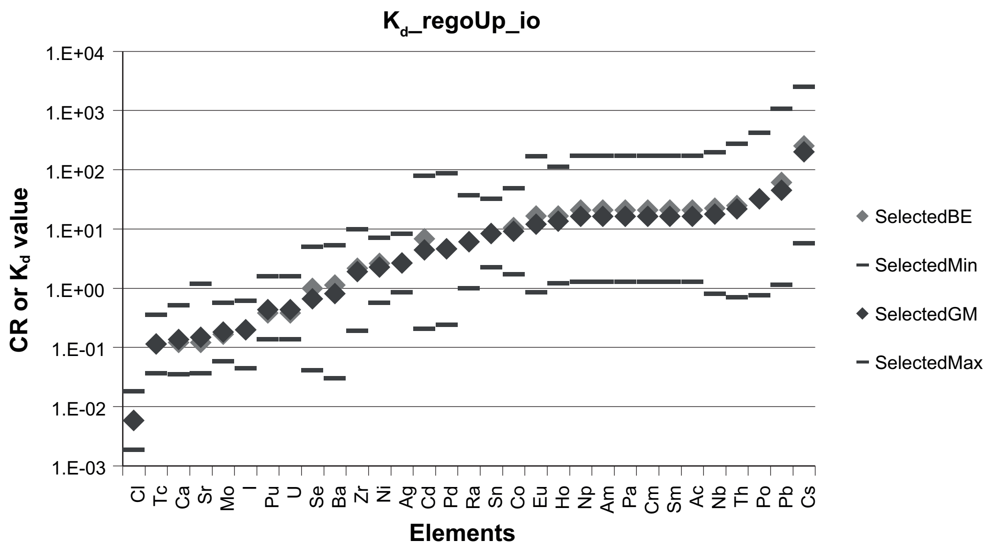

Figure 5-15. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{dw}).*

Table 5-10. Available data for K_d_regoUp_io and K_d_regoUp_garden for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010, mineral, L2 = IAEA 2010, sand, L3 = IAEA 2010, all soils. See Table 5-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac				3		4					2.4		2.8						2:1/1
Ag	10/10		10/10	5		9		1.9		1.9	3.0		7.1		S1		S1		2:1/1
Am					17	62						6.7	6.1						2:1/1
Ba	10/10		11/11			1		1.4		3.1									1:0/0
Bi	10/10		10/10	4		6		4.8		4.8	2.1		2.3		S4		S4		2:1/1
Ca	10/10		11/11	33		34		2.1		2.3	3.2		3.4		S2 (U21%)		S2 (U19%)		2:1/1
Cd	7/7		8/8	39		61		3.8		5.8	8.1		9.4		S2 (U46%)		S2 (U55%)		2:1/1
Cl	10/10		10/10			22		1.8		1.8			3.0		S4		S4		1:0/0
Cm						18							3.8						1:0/0
Co	10/10		11/11			118		2.5		2.8			16.0		S2 (U98%)		S2 (U98%)		1:0/0
Cs	10/10		11/11		114	469		4.1		4.7		5.8	7.0		S2 (U3%)		S2 (U12%)		2:1/1
Eu	7/7		8/8					4.1		5.0									0:0/0
Ho	10/10		11/11	3		4		3.1		3.6	2.4		2.9		S2 (U20%)		S2 (U28%)		2:1/1
I	10/10		10/10	196		250		1.9		1.9	5.2		5.4		S2 (U23%)		S2 (U23%)		2:1/1
Mo	10/10		11/11			9		1.5		1.6			2.8		S2 (U70%)		S2 (U61%)		1:0/0
Nb	10/10		11/11		2	11		3.7		4.3			3.7		S2 (U37%)		S2 (U43%)		2:0/0
Ni	10/10		11/11			64		1.7		1.9			7.0		S1		S1		1:0/0
Np				22		26					3.6		6.1						2:1/1
Pa				3		4					2.3		2.8						2:1/1
Pb	10/10		11/11		9	23		5.7		6.9		3.6	9.9		S2 (U56%)		S2 (U60%)		2:1/1
Pd	1/1		1/1	4		6					2.0		2.3						2:1/1
Po				43		44					5.1		5.4						2:1/1
Pu					11	62						4.0	4.0						2:1/1
Ra	9/9		9/9			51		2.1		2.1			13.0		S1		S1		1:0/0
Re	10/10		10/10					1.9		1.9									0:0/0
Se	7/7		8/8		15	172		1.7		3.4		5.2	3.3		S2 (U71%)		S2 (U69%)		2:1/1
Sm	10/10		11/11	3		4		3.4		4.2	2.4		2.9		S2 (U16%)		S2 (U26%)		2:1/1
Sn	10/10		10/10	4		12		2.2		2.2	2.2		6.2		S1		S1		2:1/1
Sr	10/10		11/11		65	255		1.7		2.4		6.4	5.9		S1		S1		2:1/1
Tc				22		33					3.7		9.3						2:1/1
Th	10/10		11/11	25		46		4.7		4.7	10.0		10.0		S2 (U79%)		S2 (U82%)		2:1/1
U	10/10		11/11	146		178		1.8		2.0	13.0		12.0		S1		S1		2:1/1
Zr	10/10		11/11		4	11		2.6		2.7		16.0	21.0		S1		S1		2:1/1

Table 5-11. Selected data, references and comments for the parameter K_d_regoUp_io and K_d_regoUp_garden (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or the sample numer of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		11	1.3E+00	1.6E+01	2.1E+01	1.7E+02	4.2	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Ag			10	8.4E–01	2.6E+00	2.6E+00	8.3E+00	2.0	GSDmin	Site data FM	FM	
Am	Sm		11	1.3E+00	1.6E+01	2.1E+01	1.7E+02	4.2	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Ba			11	3.0E–02	8.1E–01	1.1E+00	5.3E+00	3.1	GSD	Site data FM	FM	
Ca			11	3.5E–02	1.4E–01	1.2E–01	5.2E–01	2.3	GSD	Site data FM	FM	Site data higher than literature data interval. Could perhaps be explained by calcite influence in FM.
Cd			8	2.1E–01	4.4E+00	6.8E+00	7.9E+01	5.8	GSD	Site data FM	FM	
Cl			10	1.9E–03	5.8E–03	5.8E–03	1.8E–02	2.0	GSDmin	Site data FM	FM	No overlap between site and literature data. General tendency for Cl for many parameters. Could this be explained by no porewater correction?.
Cm	Sm		11	1.3E+00	1.6E+01	2.1E+01	1.7E+02	4.2	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Co			11	1.7E+00	9.1E+00	1.1E+01	4.8E+01	2.8	GSD	Site data FM	FM	
Cs			11	5.7E+00	2.0E+02	2.5E+02	2.5E+03	4.7	GSD	Site data FM	FM	Site data significantly higher than literature data. This is a general trend within the group 1 elements, e.g. Rb and K.
Eu			8	8.4E–01	1.2E+01	1.7E+01	1.7E+02	5.0	GSD	Site data FM	FM	Site data for REE are higher than lit. data though consistent with lit. data for Cm and Am.
Ho			11	1.2E+00	1.3E+01	1.6E+01	1.1E+02	3.6	GSD	Site data FM	FM	Site data for REE are higher than lit. data though consistent with lit. data for Cm and Am.
I			10	4.4E–02	2.0E–01	2.0E–01	6.2E–01	2.0	GSDmin	Site data FM	FM	Site data for I higher than lit. Range. The value for I consistent with trend for Br and Cl. .
Mo			11	5.8E–02	1.8E–01	1.6E–01	5.6E–01	2.0	GSDmin	Site data FM	FM	
Nb			11	8.0E–01	1.8E+01	2.2E+01	2.0E+02	4.3	GSD	Site data FM	FM	
Ni			11	5.7E–01	2.3E+00	2.6E+00	7.1E+00	2.0	GSDmin	Site data FM	FM	
Np	Sm		11	1.3E+00	1.6E+01	2.1E+01	1.7E+02	4.2	GSD	Site data FM	FM	Sm(III) used as EA in oxidicing environment for Np(V).
Pa	Sm		11	1.3E+00	1.6E+01	2.1E+01	1.7E+02	4.2	GSD	Site data FM	FM	Sm(III) is used as EA.
Pb			11	1.1E+00	4.5E+01	6.1E+01	1.1E+03	6.9	GSD	Site data FM	FM	
Pd			1	2.4E–01	4.6E+00	4.6E+00	8.7E+01	6.0	GSDmax	Site data FM	FM	Site data for Pd consistent with lit. data for Pd and site and lit. data for Ni.
Po	Bi		10	7.5E–01	3.2E+01	3.2E+01	4.2E+02	4.8	GSD	Site data FM	FM	Site data for Bi higher than lit. data for Po and Bi but overlaps with site data for Te.
Pu	U		11	1.4E–01	4.3E–01	3.8E–01	1.6E+00	2.0	GSD	Site data FM	FM	U EA in oxidicing environment.
Ra			9	9.9E–01	6.0E+00	6.0E+00	3.7E+01	3.0	GSDmean	Site data FM	FM	
Se			8	4.1E–02	6.6E–01	9.8E–01	5.0E+00	3.4	GSD	Site data FM	FM	
Sm			11	1.3E+00	1.6E+01	2.1E+01	1.7E+02	4.2	GSD	Site data FM	FM	Site data for REE are higher than lit. data though consistent with lit. data for Cm and Am.
Sn			10	2.3E+00	8.3E+00	8.3E+00	3.2E+01	2.2	GSD	Site data FM	FM	
Sr			11	3.6E–02	1.5E–01	1.2E–01	1.2E+00	2.4	GSD	Site data FM	FM	
Tc	Re		10	3.6E–02	1.1E–01	1.1E–01	3.6E–01	2.0	GSDmin	Site data FM	FM	Re used as EA due to assumed oxic conditions. Lit. data for Tc is lower than site data for Re.
Th			11	7.0E–01	2.2E+01	2.5E+01	2.8E+02	4.7	GSD	Site data FM	FM	
U			11	1.4E–01	4.3E–01	3.8E–01	1.6E+00	2.0	GSD	Site data FM	FM	
Zr			11	1.9E–01	1.9E+00	2.2E+00	9.8E+00	2.7	GSD	Site data FM	FM	

5.6 K_d_regoUp_drain

In the biosphere model, the RegoUp_drain compartment represents the upper soil layers of cultivated peat and clay gyttja influenced by ploughing and bioturbation. Crops primarily take up nutrients and trace elements from this compartment. The soil is assumed to be of organic origin (peat and post-glacial sediments of aquatic origin) and drained through ditching, resulting in high soil biological activity and a corresponding high rate of mineralisation. Moreover, it is assumed that the agricultural soil is in contact with contaminated ground water in underlying minerogenic deposits (glacial clay and till) (Saetre et al. 2013).

Suitable site data representing the RegoUp_drain compartment in the model are the upper, oxic layer of cultivated peat samples. These sites are all situated in former fens where the ground water table has been lowered artificially, which has caused oxidising conditions in the uppermost peat layers. The peat is almost entirely composed of organic material. Additionally, 5 samples of the upper levels of clay gyttja have been included. These samples represent cultivated, drained soils that are characterized by the contents of organic material (c 20% organic contents) and low pH (Sheppard et al. 2011). 4 samples from FM and LX representing clay gyttja and peat from Sheppard et al. (2009), have not been included due to expected reducing conditions.

Literature data representing the RegoUp_drain compartment are available in IAEA (2010). Data for "organic" soils are classified as L1 data, whereas data for "all soils" are classified as L2 data.

Site data are available for Ag, Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Ra, Se, Sm, Sn, Sr, Th, U and Zr (Table 5-12). Literature data alone are available for Ac, Am, Cm, Np, Pa, Po, Pu and Tc.

When site data from FM are compared to literature data, in Table 5-12, a few elements show major discrepancies (Ca, Cl and Mo). There are no comparable data available from the LX area.

The deviation from literature data for the site-specific K_d for Ca is similar to the other K_d parameters, which usually show higher values than literature data. One explanation for this discrepancy could be the overall high content of calcite in the FM area (cf. Section 5.1). The high K_d for Cl is also a general trend among site data (cf. Section 5.5).

The mobility of Mo is lower in the FM area compared to most literature data. Mo is usually regarded as a mobile element (cf. Section 2.7.7), which is also noticed in samples from the RegoLow layer. K_d for Mo and U seem to correlate, and for U the presence of carbonate complexes enhance the mobility of the element. The relative difference between the parameters is, however, larger for U than Mo when the RegoUp_drain and the RegoLow layers are compared. In the case of samples representing the RegoUp_drain compartment, the organic content and low pH could be factors influencing the mobility of both these elements (Sohlenius et al. 2013).

Re could be regarded as an EA for Tc. There are significant discrepancies between literature data for Tc and site data for Re for many parameters. In case of RegoUp_drain this discrepancy is not so pronounced, which may reflect that both site data and literature data represent cultivated, oxic, organic soils (Figure 5-16 and Section 2.7.12).

The variation is large for Cd and the data range exceeds GSDmax. There are no obvious erroneous data that could be discarded as artefacts when the concentrations of the data sources are evaluated. However, there is a systematic difference in pore water concentrations between clay gyttja (higher concentration in pore water) and cultivated peat samples that increase the overall variation. Similarly, differences between these soil types are seen with some other metals. This could be an indication of a response to a common environmental factor, e.g. differences in pH (lower pH in clay gyttja due to oxidation of sulphides).

Selected values for K_d_regoUp_drain parameter are compiled in Table 5-13. In the case of Ag, Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Ra, Se, Sm, Sn, Sr, Th, U and Zr, site-specific data are used for the parameterisation. Sm site data are selected as EA for Ac, Am, Cm and Pa. Bi is utilised as EA for Po. Re is used as EA for Tc, Sm is used as EA for Np and U is used as EA for Pu, due to the assumed oxic conditions in this environment (cf. EA assumptions in Section 2.7).

In Figure 5-18, the selected values for the K_d_regoUp_drain parameter are sorted from low sorption on the left, to high sorption on the right. K_ds for the selected elements range over almost 4 orders of magnitude when all elements are taken into account. If the 5 lowest elements are excluded (Tc, Cl, Ca, I, Sr), GM for the remaining elements spread over only 1 order of magnitude, which is very low compared to the other parameters.

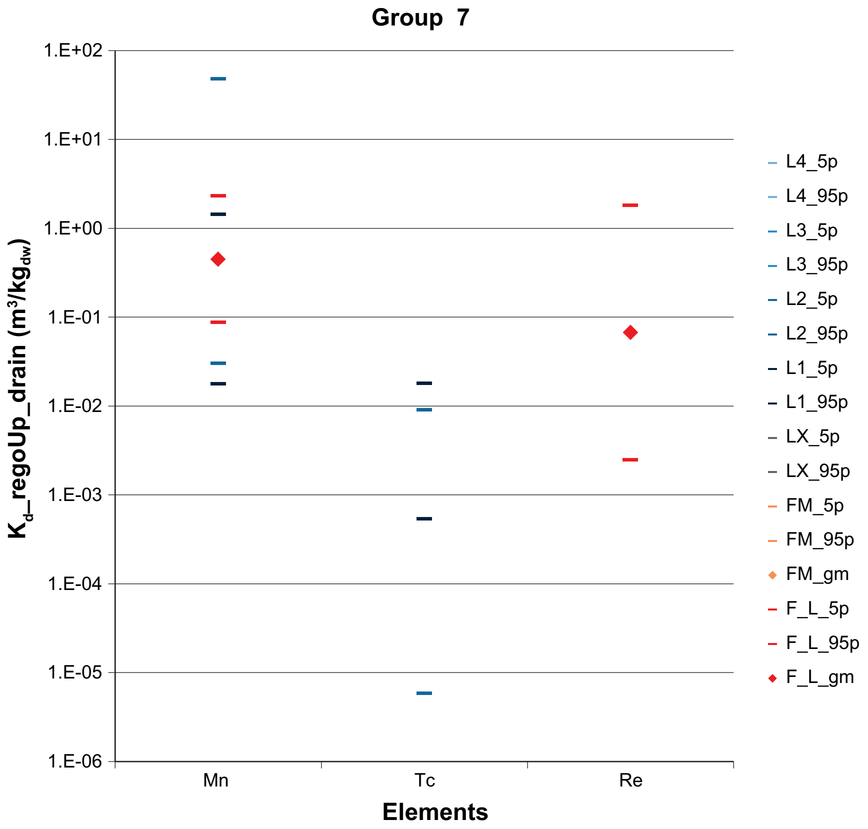

Figure 5-16. *K_d_regoUp_drain. Comparisons among group 7 elements: Mn, Tc and Re.*

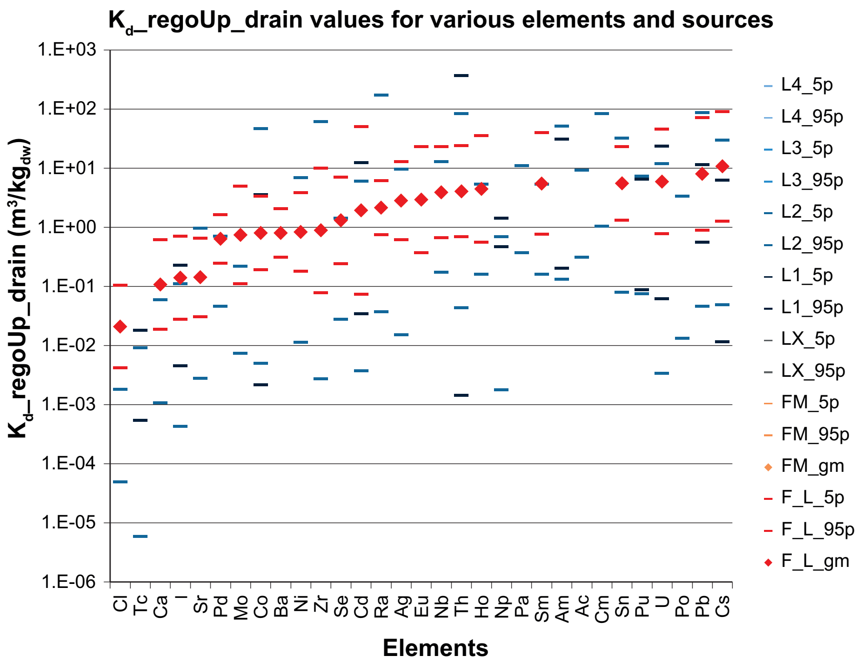

Figure 5-17. *Data ranges for the sources that are considered representative for K_d_regoUp_drain (m^3/kg_{dw}). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5th (5p) and 95th (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.*

Table 5-12. Available data for K_d_regoUp_drain for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010,organic, L2 = IAEA 2010, all soils. See Table 5-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac				1	4							2.8							2:0/0
Ag	10/10		10/10	2	9			2.5		2.5		7.1			S2 (U90%)		S2 (U90%)		2:0/0
Am				13	62						4.6	6.1							2:1/1
Ba	10/10		10/10		1			1.8		1.8									1:0/0
Bi	10/10		10/10	1	6			3.4		3.4		2.3			S2 (U16%)		S2 (U16%)		2:0/0
Ca	10/10		10/10	1	34			2.9		2.9		3.4			S2 (U33%)		S2 (U33%)		2:0/0
Cd	10/10		10/10	13	61			7.2		7.2	6.0	9.4			S2 (U78%)		S2 (U78%)		2:1/1
Cl	10/10		10/10		22			2.7		2.7		3.0			S4		S4		1:0/0
Cm					18							3.8							1:0/0
Co	10/10		10/10	17	118			2.4		2.4	9.5	16.0			S1		S1		2:1/1
Cs	10/10		10/10	108	469			3.6		3.6	6.8	7.0			S2 (U73%)		S2 (U73%)		2:1/1
Eu	6/6		6/6					3.5		3.5									0:0/0
Ho	10/10		10/10	1	4			3.5		3.5		2.9			S2 (U54%)		S2 (U54%)		2:0/0
I	10/10		10/10	11	250			2.7		2.7	3.3	5.4			S2 (U65%)		S2 (U65%)		2:1/1
Mo	10/10		10/10		9			3.2		3.2		2.8			S2 (U17%)		S2 (U17%)		1:0/0
Nb	10/10		10/10	1	11			2.9		2.9		3.7			S2 (U83%)		S2 (U83%)		2:0/0
Ni	10/10		10/10		64			2.5		2.5		7.0			S1		S1		1:0/0
Np				4	26						1.4	6.1							2:1/1
Pa				1	4							2.8							2:0/0
Pb	10/10		10/10	5	23			3.8		3.8	2.5	9.9			S1		S1		2:1/1
Pd	2/2		2/2	1	6			1.8		1.8		2.3			S2 (U55%)		S2 (U55%)		2:0/0
Po				1	44							5.4							2:0/0
Pu				6	62						3.7	4.0							2:1/1
Ra	10/10		10/10	2	51			1.9		1.9		13.0			S1		S1		2:0/0
Re	10/10		10/10					7.4		7.4									0:0/0
Se	6/6		6/6	2	172			2.8		2.8		3.3			S2 (U52%)		S2 (U52%)		2:0/0
Sm	10/10		10/10	1	4			3.3		3.3		2.9			S2 (U49%)		S2 (U49%)		2:0/0
Sn	10/10		10/10	1	12			2.4		2.4		6.2			S1		S1		2:0/0
Sr	10/10		10/10		255			2.5		2.5		5.9			S1		S1		1:0/0
Tc				11	33						2.9	9.3							2:1/1
Th	10/10		10/10	5	46			2.9		2.9	44.0	10.0			S1		S1		2:1/1
U	10/10		10/10	9	178			3.4		3.4	6.1	12.0			S2 (U83%)		S2 (U83%)		2:1/1
Zr	10/10		10/10	2	11			4.4		4.4		21.0			S1		S1		2:0/0

Table 5-13. Selected data, references and comments for the parameter K_d_regoUp_drain (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or the sample number of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		10	4.8E–01	5.5E+00	5.5E+00	4.0E+01	3.3	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Ag			10	6.0E–01	2.8E+00	2.8E+00	1.3E+01	2.5	GSD	Site data FM	FM	
Am	Sm		10	4.8E–01	5.5E+00	5.5E+00	4.0E+01	3.3	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Ba			10	2.6E–01	8.0E–01	8.0E–01	2.5E+00	2.0	GSDmin	Site data FM	FM	
Ca			10	1.9E–02	1.1E–01	1.1E–01	6.2E–01	2.9	GSD	Site data FM	FM	Ca is higher than literature data though this is a general trend among site data.
Cd			10	7.4E–02	1.9E+00	1.9E+00	5.0E+01	7.2	GSD	Site data FM	FM	
Cl			10	4.1E–03	2.1E–02	2.1E–02	1.0E–01	2.7	GSD	Site data FM	FM	Cl higher than literature, though this is a general trend among several parameters.
Cm	Sm		10	4.8E–01	5.5E+00	5.5E+00	4.0E+01	3.3	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Co			10	1.0E–01	8.0E–01	8.0E–01	3.4E+00	2.4	GSD	Site data FM	FM	
Cs			10	1.3E+00	1.1E+01	1.1E+01	9.9E+01	3.6	GSD	Site data FM	FM	
Eu			6	3.7E–01	2.9E+00	2.9E+00	2.3E+01	3.5	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Ho			10	3.2E–01	4.4E+00	4.4E+00	3.5E+01	3.5	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
I			10	1.3E–02	1.4E–01	1.4E–01	7.0E–01	2.7	GSD	Site data FM	FM	
Mo			10	1.1E–01	7.4E–01	7.4E–01	6.3E+00	3.2	GSD	Site data FM	FM	Mo higher than literature data. Same trend as for U for organic soils.
Nb			10	4.8E–01	3.9E+00	3.9E+00	2.6E+01	2.9	GSD	Site data FM	FM	
Ni			10	1.3E–01	8.3E–01	8.3E–01	3.8E+00	2.5	GSD	Site data FM	FM	
Np	Sm		10	4.8E–01	5.5E+00	5.5E+00	4.0E+01	3.3	GSD	Site data FM	FM	Sm(III) used as EA in oxidicing environment for Np(V).
Pa	Sm		10	4.8E–01	5.5E+00	5.5E+00	4.0E+01	3.3	GSD	Site data FM	FM	Sm(III) is used as EA.
Pb			10	5.3E–01	8.0E+00	8.0E+00	7.2E+01	3.8	GSD	Site data FM	FM	
Pd			2	3.3E–02	6.4E–01	6.4E–01	1.2E+01	6.0	GSDmax	Site data FM	FM	
Po	Bi		10	6.0E–01	7.3E+00	7.3E+00	5.4E+01	3.4	GSD	Site data FM	FM	Site data for Bi slightly higher than lit. data for Bi and Po.
Pu	U		10	6.1E–01	5.9E+00	5.9E+00	4.5E+01	3.4	GSD	Site data FM	FM	U EA in oxidicing environment.
Ra			10	6.8E–01	2.1E+00	2.1E+00	6.7E+00	2.0	GSDmin	Site data FM	FM	
Se			6	2.1E–01	1.3E+00	1.3E+00	7.9E+00	3.0	GSDmean	Site data FM	FM	
Sm			10	4.8E–01	5.5E+00	5.5E+00	4.0E+01	3.3	GSD	Site data FM	FM	Data for REE, Ac, Am, Cm are consistent.
Sn			10	1.3E+00	5.5E+00	5.5E+00	3.8E+01	2.4	GSD	Site data FM	FM	
Sr			10	3.1E–02	1.4E–01	1.4E–01	6.5E–01	2.5	GSD	Site data FM	FM	
Tc	Re		10	2.5E–03	6.7E–02	6.7E–02	2.7E+00	7.4	GSD	Site data FM	FM	Re used as EA due to oxic conditions. Lit. data for Tc overlaps site data for Re.
Th			10	3.7E–01	4.0E+00	4.0E+00	2.4E+01	2.9	GSD	Site data FM	FM	
U			10	6.1E–01	5.9E+00	5.9E+00	4.5E+01	3.4	GSD	Site data FM	FM	
Zr			10	6.0E–02	8.9E–01	8.9E–01	1.0E+01	4.4	GSD	Site data FM	FM	

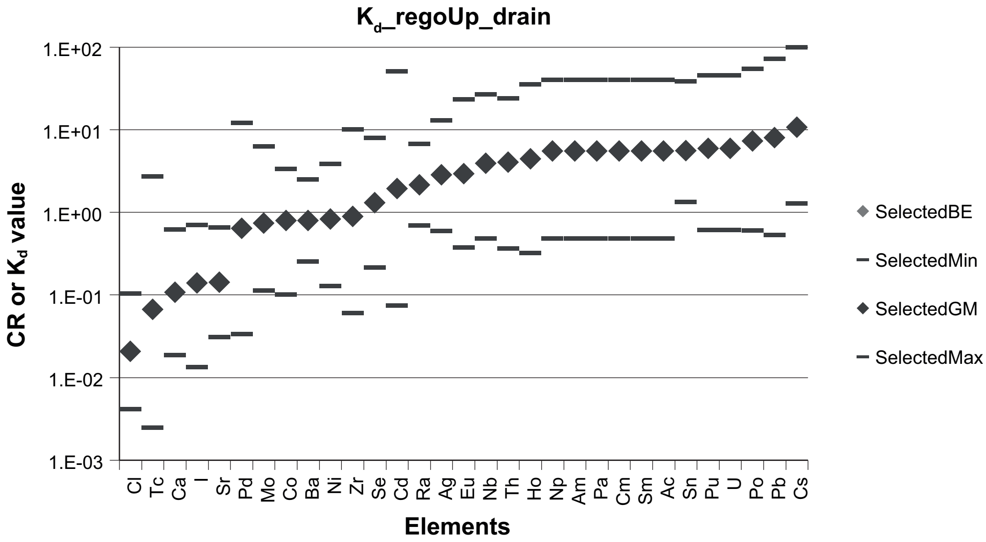

Figure 5-18. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{dw}).*

5.7 K_d_regoUp_ter

In the biosphere model, the RegoUp_ter compartment represents the upper oxic layer of terrestrial regolith (peat). This uppermost layer is biologically active, with relatively high rates of decomposition and root activity. The depth of the layer is fairly constant (c.10 cm) and limited by the diffusion of oxygen (Saetre et al. 2013).

Representative site data for the RegoUp_ter compartment are samples from the upper layer of wetland peat extracted at 5 sites in the FM area. The groundwater table is situated close to the surface in these wetlands and in contrast to the cultivated peat areas, reducing conditions may occur close to the ground surface. The sampled wetlands have somewhat different vegetation, ranging from high proportion of Sphagnum species, reflecting the nutrient poor conditions at that site, to richer wetlands dominated by sedge or reed (Sheppard et al. 2011).

Literature data comparable to the RegoUp_ter compartment are available in IAEA (2010). Data for organic soils are considered the most representative and, therefore, data for "organic" soils are classified as L1 data. Data for "all soils" are classified as L2 data.

Site data are available for Ag, Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Ra, Se, Sm, Sn, Sr, Th, U and Zr. Literature data alone are available for Ac, Am, Cm, Np, Pa, Po, Pu and Tc (Table 5-14).

When FM site data are compared to LX data as well as literature data from IAEA (2010), some elements show major discrepancies (Table 5-14). For Ca and to some extent Sr, data from FM deviate from literature data. For these elements, data from LX are closer to the literature range, which implies that FM indicates deviating K_d due to the site-specific conditions influenced from calcite (Tröjbom and Grolander 2010).

For Mo, data from FM and LX are consistent, although both data sources deviate significantly from the literature range.

Selected values for K_d_regoUp_ter parameter are compiled in Table 5-15. In the case of Ag, Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Ra, Se, Sm, Sn, Sr, Th, U and Zr, site-specific data are used for the parameterisation. Ni is used as EA for Pd. Sm site data are selected as EA for Ac, Am, Cm and Pa. Bi is utilised as EA for Po. Re is used as EA for Tc, Sm is used as EA for Np and U is used as EA for Pu, due to the assumed oxic conditions in this environment (cf. EA assumptions in Section 2.7).

Table 5-14. Available data for K_d_regoUp_ter for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010, organic, L2 = IAEA 2010, all soils. See Table 5-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac				1	4							2.8							2:0/0
Ag	5/5		5/5	2	9			2.7		2.7		7.1			S2 (U42%)		S2 (U42%)		2:0/0
Am				13	62						4.6	6.1							2:1/1
Ba	5/5		5/5		1			2.0		2.0									1:0/0
Bi	5/5		5/5	1	6			2.4		2.4		2.3			S4		S4		2:0/0
Ca	5/5		5/5	1	34			1.9		1.9		3.4			S4		S4		2:0/0
Cd	4/4		4/4	13	61			5.6		5.6	6.0	9.4			S2 (U49%)		S2 (U49%)		2:1/1
Cl	5/5		5/5		22			2.5		2.5		3.0			S4		S4		1:0/0
Cm					18							3.8							1:0/0
Co	5/5		5/5	17	118			1.3		1.3	9.5	16.0			S1		S1		2:1/1
Cs	5/5		5/5	108	469			2.3		2.3	6.8	7.0			S1		S1		2:1/1
Eu	1/1		1/1																0:0/0
Ho	5/5		5/5	1	4			2.0		2.0		2.9			S2 (U24%)		S2 (U24%)		2:0/0
I	5/5		5/5	11	250			2.3		2.3	3.3	5.4			S2 (U54%)		S2 (U54%)		2:1/1
Mo	5/5		5/5		9			1.9		1.9		2.8			S4		S4		1:0/0
Nb	5/5		5/5	1	11			2.4		2.4		3.7			S2 (U70%)		S2 (U70%)		2:0/0
Ni	5/5		5/5		64			1.6		1.6		7.0			S1		S1		1:0/0
Np				4	26						1.4	6.1							2:1/1
Pa				1	4							2.8							2:0/0
Pb	5/5		5/5	5	23			3.2		3.2	2.5	9.9			S2 (U91%)		S2 (U91%)		2:1/1
Pd				1	6							2.3							2:0/0
Po				1	44							5.4							2:0/0
Pu				6	62						3.7	4.0							2:1/1
Ra	5/5		5/5	2	51			2.5		2.5		13.0			S1		S1		2:0/0
Re	5/5		5/5					1.8		1.8									0:0/0
Se	3/3		3/3	2	172			2.4		2.4		3.3			S2 (U62%)		S2 (U62%)		2:0/0
Sm	5/5		5/5	1	4			2.2		2.2		2.9			S2 (U20%)		S2 (U20%)		2:0/0
Sn	5/5		5/5	1	12			3.9		3.9		6.2			S2 (U90%)		S2 (U90%)		2:0/0
Sr	5/5		5/5		255			2.1		2.1		5.9			S2 (U96%)		S2 (U96%)		1:0/0
Tc				11	33						2.9	9.3							2:1/1
Th	5/5		5/5	5	46			1.9		1.9	44.0	10.0			S1		S1		2:1/1
U	5/5		5/5	9	178			1.9		1.9	6.1	12.0			S2 (U89%)		S2 (U89%)		2:1/1
Zr	5/5		5/5	2	11			2.0		2.0		21.0			S1		S1		2:0/0

Table 5-15. Selected data, references and comments for the parameter K_d_regoUp_ter (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or sample number of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		5	1.9E+00	1.2E+01	1.2E+01	7.1E+01	3.0	GSDmean	Site data FM	FM	Data consistent among REE, Ac, Am and Cm, for both FM and LX as well as lit. data.
Ag			5	2.0E+00	1.2E+01	1.2E+01	7.4E+01	3.0	GSDmean	Site data FM	FM	
Am	Sm		5	1.9E+00	1.2E+01	1.2E+01	7.1E+01	3.0	GSDmean	Site data FM	FM	Data consistent among REE, Ac, Am and Cm, for both FM and LX as well as lit. data.
Ba			5	1.3E-01	8.2E-01	8.2E-01	5.0E+00	3.0	GSDmean	Site data FM	FM	All group 2 elements, Ca, Sr and Ba, show higher K_d in FM compared to LX as well as lit. data. High GSD due to site differences.
Ca			5	5.0E-02	3.1E-01	3.1E-01	1.9E+00	3.0	GSDmean	Site data FM	FM	All group 2 elements, Ca, Sr and Ba, show higher K_d in FM compared to LX as well as lit. data. High GSD due to site differences.
Cd			4	7.5E-01	1.3E+01	1.3E+01	2.1E+02	5.6	GSD	Site data FM	FM	Large variation also for the possible EA Zn.
Cl			5	3.4E-03	2.1E-02	2.1E-02	1.3E-01	3.0	GSDmean	Site data FM	FM	Similar to many other parameters significantly higher K_d for site data compared to lit. data.
Cm	Sm		5	1.9E+00	1.2E+01	1.2E+01	7.1E+01	3.0	GSDmean	Site data FM	FM	Data consistent among REE, Ac, Am and Cm, for both FM and LX as well as lit. data.
Co			5	2.8E-01	1.7E+00	1.7E+00	1.0E+01	3.0	GSDmean	Site data FM	FM	
Cs			5	7.6E-02	4.6E-01	4.6E-01	2.8E+00	3.0	GSDmean	Site data FM	FM	Discrepancies between FM and LX data increase GSD. General trend among group1 elements supports the high K_d measured for Cs.
Eu			1	2.1E-01	4.0E+00	4.0E+00	7.6E+01	6.0	GSDmax	Site data FM	FM	Data consistent among REE, Ac, Am and Cm, for both FM and LX as well as lit. data.
Ho			5	1.6E+00	9.6E+00	9.6E+00	5.9E+01	3.0	GSDmean	Site data FM	FM	Data consistent among REE, Ac, Am and Cm, for both FM and LX as well as lit. data.
I			5	3.3E-02	2.0E-01	2.0E-01	1.2E+00	3.0	GSDmean	Site data FM	FM	
Mo			5	7.2E-01	4.4E+00	4.4E+00	2.7E+01	3.0	GSDmean	Site data FM	FM	K_d for Mo consistent for FM and LX, though higher than lit. data.
Nb			5	1.2E+00	7.3E+00	7.3E+00	4.4E+01	3.0	GSDmean	Site data FM	FM	
Ni			5	3.2E-01	1.9E+00	1.9E+00	1.2E+01	3.0	GSDmean	Site data FM	FM	
Np	Sm		5	1.9E+00	1.2E+01	1.2E+01	7.1E+01	3.0	GSDmean	Site data FM	FM	Sm(III) used as EA in oxidicing environment for Np(V).
Pa	Sm		5	1.9E+00	1.2E+01	1.2E+01	7.1E+01	3.0	GSDmean	Site data FM	FM	Sm(III) is used as EA.
Pb			5	2.6E+00	1.8E+01	1.8E+01	1.2E+02	3.2	GSD	Site data FM	FM	
Pd	Ni		5	3.2E-01	1.9E+00	1.9E+00	1.2E+01	3.0	GSDmean	Site data FM	FM	Site data for Ni consistent with lit. data for Pd and Ni.
Po	Bi		5	2.0E+00	1.2E+01	1.2E+01	7.5E+01	3.0	GSDmean	Site data FM	FM	Site data for Bi higher than lit. data for Bi and Po. Site data for Te overlap site data for Bi and lit. data for Po.
Pu	U		5	1.6E+00	1.0E+01	1.0E+01	6.1E+01	3.0	GSDmean	Site data FM	FM	U EA in oxidicing environment.
Ra			5	3.5E-01	2.1E+00	2.1E+00	1.3E+01	3.0	GSDmean	Site data FM	FM	K_d for Ra consistent with lit. data and the tendency among group 2 elements.
Se			3	5.3E-02	1.0E+00	1.0E+00	1.9E+01	6.0	GSDmax	Site data FM	FM	Consistent with the possible EA Te.
Sm			5	1.9E+00	1.2E+01	1.2E+01	7.1E+01	3.0	GSDmean	Site data FM	FM	Data consistent among REE, Ac, Am and Cm, for both FM and LX as well as lit. data.
Sn			5	5.7E-01	5.2E+00	5.2E+00	4.9E+01	3.9	GSD	Site data FM	FM	Data consistent with lit. data and possible EA Zr(IV).
Sr			5	5.3E-02	3.2E-01	3.2E-01	2.0E+00	3.0	GSDmean	Site data FM	FM	All group 2 elements, Ca, Sr and Ba, show higher K_d in FM compared to LX as well as lit. data. High GSD due to site differences.
Tc	Re		5	6.8E-02	4.1E-01	4.1E-01	2.5E+00	3.0	GSDmean	Site data FM	FM	Lit. data for Tc is significantly lower than site data for Re. Oxic environment assumed.
Th			5	4.5E-01	2.8E+00	2.8E+00	1.7E+01	3.0	GSDmean	Site data FM	FM	Data consistent between LX and FM. Large spread among literature data.
U			5	1.6E+00	1.0E+01	1.0E+01	6.1E+01	3.0	GSDmean	Site data FM	FM	Low mobility of U compared to e.g. K_d_regoLow. Consistent data between FM and LX.
Zr			5	3.8E-01	2.3E+00	2.3E+00	1.4E+01	3.0	GSDmean	Site data FM	FM	

In Figure 5-20, the selected values for K_d_regoUp_ter are sorted from low sorption on the left, to high sorption on the right. Tc and Cl usually show insignificant sorption and are found at the lower end of the range. Many of the elements located to the right usually have a high affinity for particles, e.g. Eu, Ho and Sm.

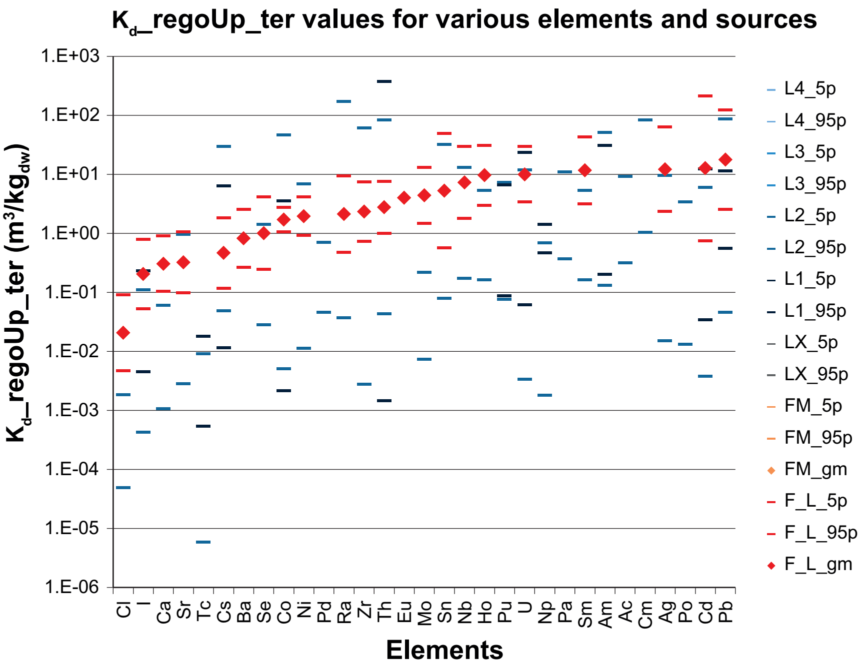

Figure 5-19. *Data ranges for the sources that are considered representative for K_d_regoUp_ter (m^3/kg_{dw}). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5^{th} (5p) and 95^{th} (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.*

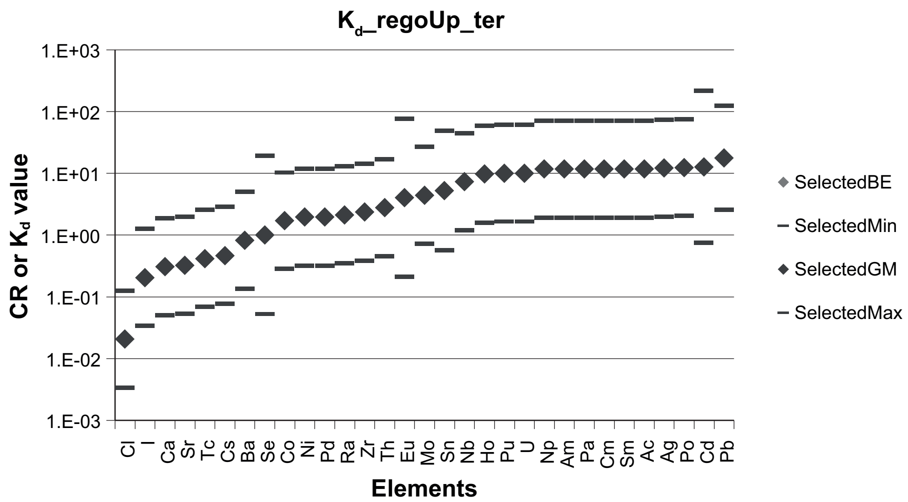

Figure 5-20. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{dw}).*

5.8 K_d_regoUp_aqu

In the biosphere model, the RegoUp_aqu compartment represents the upper layer of aquatic regolith (Saetre et al. 2013). In the Baltic Sea, these sediments are aerobic, biologically active and approximately 0.10 m deep. In lakes and streams this layer is about 0.05 m deep (Håkanson et al. 2004, Andersson 2010).

Representative site data for the RegoUp_aqu compartment are two analyses (partial and total extraction, respectively) of 1 marine sediment sample from 0-0.05 m depth (Sheppard et al. 2011), and 8 sediment samples representing total analyses of marine and limnic sediments (Engdahl et al. 2008).

Two different digestion methods were used to estimate the sorbed fraction in the Sheppard et al. (2011) samples and, therefore, the results from the studies are expected to differ. A comparison of the two methods indicate that the median of K_d total digestion/K_d aqua regia digestion ratios is 2-fold, implying that overall, aqua regia extracted half of the elements from the solid fraction. The ratio is higher for a few elements, e.g. Hf, Si, Ta and Zr (Sheppard et al. 2011). Therefore, it can be concluded that the estimated K_d_regoUp_aqu probably is slightly overestimated compared to other K_d parameters based on aqua regia digestion, especially for elements that are included in the mineral matrix in the solid fraction, for example Zr.

Representative literature data for the K_d_regoUp_aqu parameter are K_d data available in IAEA (2010), representing the distribution between particulate matter and dissolved fractions in the limnic environments. The literature data are based on studies of both particulate matter and top sediments (0-0.5 m), and thus comparable to the aerobic, superficial sediments sampled in FM and LX. Data in Beresford et al. (2008) representing suspended matter could also be relevant for comparisons. As the K_d_regoUp_aqu parameter represents both the limnic and marine environments, literature data from both systems are relevant for comparisons. Data for particulate matter and top sediments in the limnic system from IAEA (2010) are classified as L1 data and field from IAEA (2010) as L2 data. Limnic and marine data for suspended matter in Beresford et al. (2008) are classified as L3 and L4, respectively.

Site data are available for Ag, Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Ra, Se, Sm, Sn, Sr, Th, U and Zr. Literature data alone are available for Am, Cm, Np, Po, Pu and Tc (Table 5-16). No data are available for Ac and Pa.

When FM site data are compared to LX data, the observations are consistent for most of the elements.(Table 5-16 and Figure 5-21).

The selected values for K_d_regoUp_aqu parameter are compiled in Table 5-17. In the case of Ag, Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Sr, Th, U and Zr, site-specific data are used for the parameterisation. Sm site data are utilised as EAs for Ac, Am, Cm and Pa. Bi site data are selected as EA for Po. Re site data are used as EA for Tc, Sm site data are used as EA for Np, U site data are used as EA for Pu, due to the assumed aerobic conditions in this environment. Ni site data are utilised as EA for Pd. Ba site data is used as EA for Ra (only one site specific sample is available for Ra and Ba is therefore used as EA to estimate the variation). The single sample of Ra is consistent with the range for Ba (cf. EA assumptions in Section 2.7).

In Figure 5-22, the selected values for K_d_regoUp_aqu are sorted from low sorption on the left, to high sorption on the right. Tc and Cl usually indicate low sorption and are found at the lower end of the range. Many of the elements located to the right usually have a high affinity for particles, e.g. Pb, Cd, Th, Nb and the lanthanides.

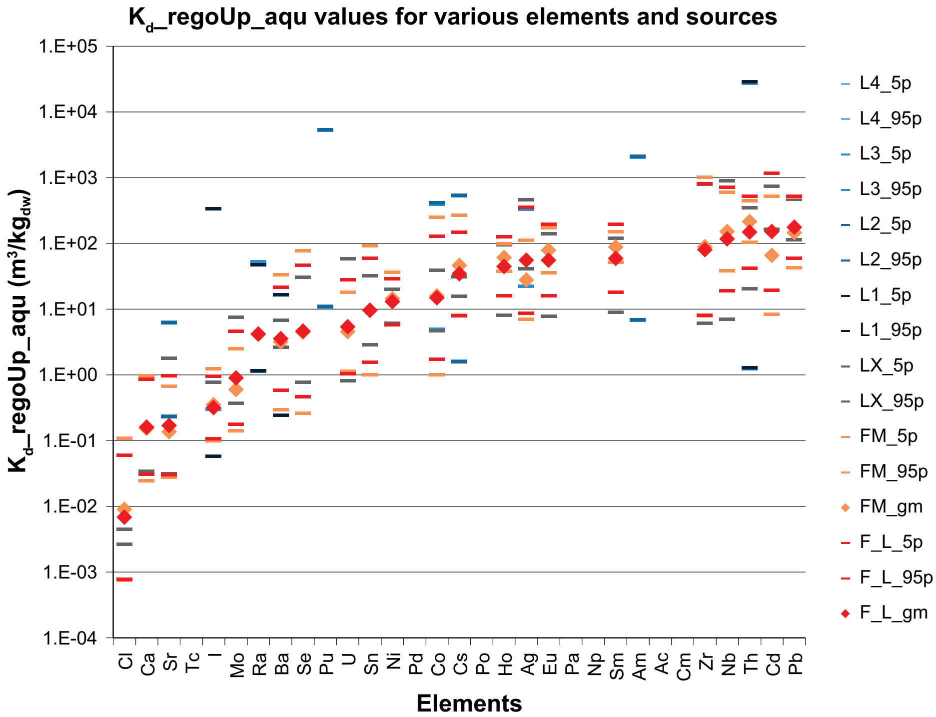

Figure 5-21. Data ranges for the sources that are considered representative for K$_d$_regoUp_aqu (m^3/kg$_{dw}$). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5th (5p) and 95th (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.

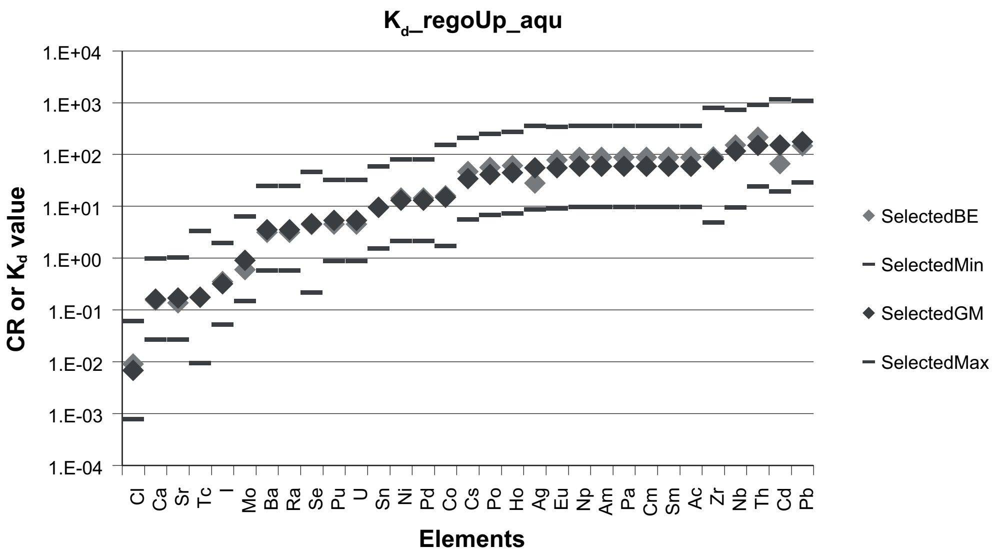

Figure 5-22. Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg$_{dw}$).

Table 5-16. Available data for K_d_regoUp_aqu for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010, suspended matter, freshwater, L2 IAEA 2010, suspended matter, freshwater, field, L3 = ERICA (Beresford et al. 2008a), suspended matter, freshwater. See Table 5-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag	4/4	3/3	7/7			1	1	2.3	2.1	3.1			2.3		S2 (L58%)	S2 (U86%)	S3	S2 (L36%)	2:0/0
Am					42	1	1					5.7	5.7						3:1/1
Ba	5/6	4/4	9/10	49				4.2	1.3	3.0	3.6				S2 (U84%)	S1	S2 (U92%)	S3	1:0/0
Bi	5/6	4/4	9/10					2.0	1.7	2.1								S2 (U52%)	0:0/0
Ca	5/6	4/4	9/10					3.1	2.7	2.7								S3	0:0/0
Cd	4/4	4/4	8/8			1	1	3.5	1.6	3.5								S2 (L28%)	2:0/0
Cl	5/5	2/2	7/7			1	1	4.5	1.2	3.7								S3	2:0/0
Cm						1	1												2:0/0
Co	5/6	4/4	9/10		29	1	1	5.3	1.9	3.7		3.9	3.8		S2 (L72%)	S1	S2 (L76%)	S3	3:1/1
Cs	5/6	4/4	9/10		219	1	1	2.9	1.2	2.4		5.9	5.8		S1	S1	S1	S3	3:1/1
Eu	5/6	4/4	9/10			1	1	1.6	2.4	2.1								S2 (U86%)	2:0/0
Ho	5/6	4/4	9/10					1.3	2.1	1.9								S2 (U97%)	0:0/0
I	5/5	4/4	9/9	124		1	1	2.1	1.8	1.9	14.0		1.0		S1	S1	S1	S3	3:1/1
Mo	5/6	4/4	9/10					2.4	2.5	2.7								S2 (L66%)	0:0/0
Nb	5/6	4/4	9/10			1	1	2.3	4.4	3.0								S1	2:0/0
Ni	5/6	4/4	9/10			1	1	1.7	1.4	1.6								S3	2:0/0
Np						1	1												2:0/0
Pa																			0:0/0
Pb	5/6	4/4	9/10			1	1	2.1	1.5	1.9								S3	2:0/0
Pd																			0:0/0
Po						1	1												2:0/0
Pu					79	1	1					6.6	6.5						3:1/1
Ra	1/1		1/1	75		1	1				3.1		3.2						3:1/1
Re	1/2		1/2					1.3		1.3									0:0/0
Se	5/5	4/4	9/9			1	1	5.6	3.1	4.1								S3	2:0/0
Sm	5/6	4/4	9/10					1.4	2.2	2.1								S2 (U77%)	0:0/0
Sn	5/6	4/4	9/10					4.0	2.1	3.0								S3	0:0/0
Sr	5/6	4/4	9/10		13	1	1	2.6	3.4	2.9		2.7	2.7		S2 (L33%)	S2 (L50%)	S2 (L41%)	S2 (L95%)	3:1/1
Tc						1	1												2:0/0
Th	5/6	4/4	9/10	63		1	1	1.6	2.4	2.1	21.0		20.8		S1	S1	S1	S2 (U83%)	3:1/1
U	5/6	4/4	9/10			1	1	2.3	3.7	2.7								S1	2:0/0
Zr	5/6	4/4	9/10			1	1	4.4	4.4	4.0								S2 (U94%)	2:0/0

Table 5-17. Selected data, references and comments for the parameter K_d_regoUp_aqu (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or the sample number of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		9	9.7E+00	5.9E+01	8.8E+01	3.6E+02	3.0	GSDmean	Site data FMLX	FMLX	REE consistent with Th. No lit. data for Ac, Am, Cm available. Higher values compared to K_d_regoUp_ter.
Ag			7	8.6E+00	5.5E+01	2.8E+01	3.5E+02	3.1	GSD	Site data FMLX	FMLX	
Am	Sm		9	9.7E+00	5.9E+01	8.8E+01	3.6E+02	3.0	GSDmean	Site data FMLX	FMLX	REE consistent with Th. No lit. data for Ac, Am, Cm available. Higher values compared to K_d_regoUp_ter.
Ba			9	5.8E-01	3.5E+00	3.2E+00	2.4E+01	3.0	GSDmean	Site data FMLX	FMLX	
Ca			9	2.6E-02	1.6E-01	1.5E-01	9.8E-01	3.0	GSDmean	Site data FMLX	FMLX	
Cd			8	1.9E+01	1.5E+02	6.6E+01	1.2E+03	3.5	GSD	Site data FMLX	FMLX	
Cl			7	7.8E-04	6.8E-03	9.0E-03	6.0E-02	3.7	GSD	Site data FMLX	FMLX	
Cm	Sm		9	9.7E+00	5.9E+01	8.8E+01	3.6E+02	3.0	GSDmean	Site data FMLX	FMLX	REE consistent with Th. No lit. data for Ac, Am, Cm available. Higher values compared to K_d_regoUp_ter.
Co			9	1.7E+00	1.5E+01	1.6E+01	1.5E+02	3.7	GSD	Site data FMLX	FMLX	
Cs			9	5.6E+00	3.4E+01	4.6E+01	2.1E+02	3.0	GSDmean	Site data FMLX	FMLX	
Eu			9	9.1E+00	5.5E+01	7.9E+01	3.4E+02	3.0	GSDmean	Site data FMLX	FMLX	REE consistent with Th. No lit. data for Ac, Am, Cm available. Higher values compared to K_d_regoUp_ter.
Ho			9	7.3E+00	4.4E+01	6.1E+01	2.7E+02	3.0	GSDmean	Site data FMLX	FMLX	REE consistent with Th. No lit. data for Ac, Am, Cm available. Higher values compared to K_d_regoUp_ter.
I			9	5.2E-02	3.2E-01	3.5E-01	1.9E+00	3.0	GSDmean	Site data FMLX	FMLX	
Mo			9	1.5E-01	9.0E-01	5.9E-01	6.3E+00	3.0	GSDmean	Site data FMLX	FMLX	
Nb			9	9.5E+00	1.2E+02	1.5E+02	7.2E+02	3.0	GSD	Site data FMLX	FMLX	
Ni			9	2.1E+00	1.3E+01	1.4E+01	7.9E+01	3.0	GSDmean	Site data FMLX	FMLX	
Np	Sm		9	9.7E+00	5.9E+01	8.8E+01	3.6E+02	3.0	GSDmean	Site data FMLX	FMLX	Sm(III) used as EA in oxidicing environment for Np(V).
Pa	Sm		9	9.7E+00	5.9E+01	8.8E+01	3.6E+02	3.0	GSDmean	Site data FMLX	FMLX	Sm(III) is used as EA.
Pb			9	2.9E+01	1.7E+02	1.5E+02	1.1E+03	3.0	GSDmean	Site data FMLX	FMLX	
Pd	Ni		9	2.1E+00	1.3E+01	1.4E+01	7.9E+01	3.0	GSDmean	Site data FMLX	FMLX	Site data for Ni consistent for FM and LX.
Po	Bi		9	6.7E+00	4.1E+01	5.6E+01	2.5E+02	3.0	GSDmean	Site data FMLX	FMLX	Site data for Bi consistent for FM and LX.
Pu	U		9	8.8E-01	5.4E+00	4.5E+00	3.3E+01	3.0	GSDmean	Site data FMLX	FMLX	U EA in oxidicing environment.
Ra	Ba		9	5.8E-01	3.5E+00	3.2E+00	2.4E+01	3.0	GSDmean	Site data FMLX	FMLX	Ba used as EA due only one sample available for Ra. Site data for Ra and Ba are consistent.
Se			9	2.2E-01	4.6E+00	4.4E+00	4.6E+01	4.1	GSD	Site data FMLX	FMLX	
Sm			9	9.7E+00	5.9E+01	8.8E+01	3.6E+02	3.0	GSDmean	Site data FMLX	FMLX	REE consistent with Th. No lit. data for Ac, Am, Cm available. Higher values compared to K_d_regoUp_ter.
Sn			9	1.5E+00	9.6E+00	9.6E+00	5.9E+01	3.0	GSD	Site data FMLX	FMLX	
Sr			9	2.7E-02	1.7E-01	1.4E-01	1.0E+00	3.0	GSDmean	Site data FMLX	FMLX	
Tc	Re		1	9.2E-03	1.8E-01	1.8E-01	3.4E+00	6.0	GSDmax	Site data FM	FM	Site data for Re consistent with site data for Re in K_d_regoUp_ter, though higher than lit. data for Tc for organic soils.
Th			9	2.4E+01	1.5E+02	2.1E+02	9.0E+02	3.0	GSDmean	Site data FMLX	FMLX	
U			9	8.8E-01	5.4E+00	4.5E+00	3.3E+01	3.0	GSDmean	Site data FMLX	FMLX	
Zr			9	4.9E+00	8.0E+01	8.9E+01	8.0E+02	4.0	GSD	Site data FMLX	FMLX	

5.9 K_d_PM_lake

In the biosphere model, the K_d_PM_lake parameter describes the partitioning of elements in the limnic water column into an aqueous (dissolved) and a solid fraction (Saetre et al. 2013).

Available site data representing the limnic water column and the partitioning between aqueous and the solid fraction, are corresponding measurements of particulate matter and filtered water. In Engdahl et al. (2008) 3 samples are available from the FM area and 3 from the LX area. Each sample is composed of several subsamples, which gives an integrated measure of the whole water column from bottom to surface. Since a mixture of hydrofluoric acid and nitric acid was used for digestion of the solid phase, the solid fraction represents the total contents of the particulate matter.

Literature data representing suspended matter in the limnic environment are available in IAEA (2010) and Beresford et al. (2008). Suspended matter in IAEA (2010) are categorised as L1 data, "suspended matter field measurements" in IAEA (2010) as L2 data, while suspended matter in Beresford et al. (2008) are categorised as L3 data.

Site data are available for Ag, Ba, Ca, Cd, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sr, Th, U and Zr (Table 5-18). Literature data alone are available for Am, Cl, Cm, Np, Po, Pu, Ra, and Tc. No data are available for Ac, Pa, Pd and Sn.

When FM data and are compared to LX data as well as literature data, a few discrepancies are found. The large variation shown by many sources can be one reason that the tests in Table 5-18 correlate well. However, discrepancies can be noticed for U. The difference is probably site specific because of the alkaline chemical environment in FM that enhances the mobility of U, due to carbonate complexation. See Section 5.11.5 for comparisons between lake and sea water parameters.

Selected values for the K_d_PM_lake parameter are compiled in Table 5-19. In the case of Ag, Ba, Ca, Cd, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sr, Th, U and Zr, site-specific data are used for the parameterisation. Sm site data are utilised as EAs for Ac, Am, Cm and Pa. Bi site data are selected as EA for Po. Re site data are used as EA for Tc, Sm site data are used as EA for Np, U site data are used as EA for Pu, due to the assumed aerobic conditions in this environment. Ni site data are utilised as EA for Pd. Ba site data is used as EA for Ra. Zr site data is used as EA for Sn (cf. EA assumptions in Section 2.7).

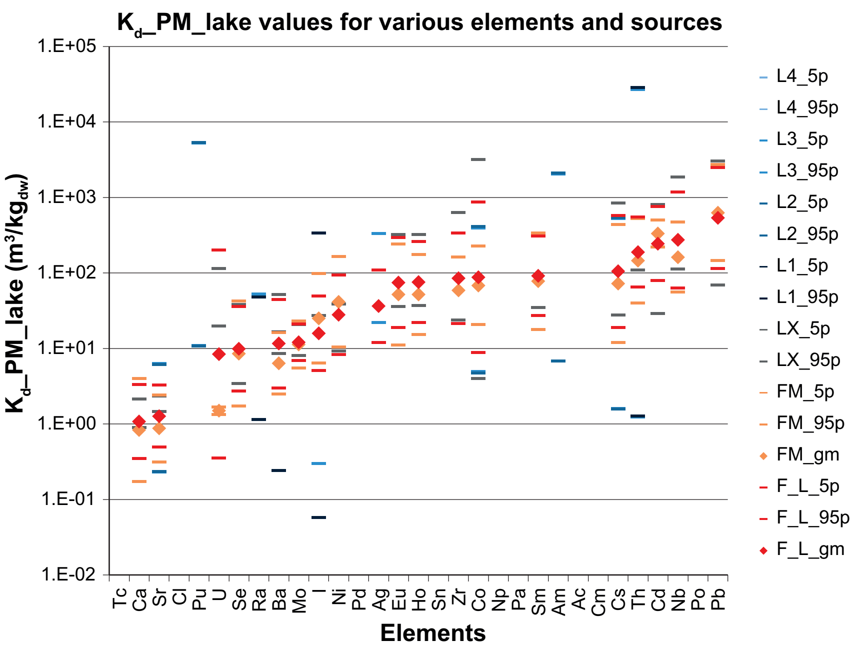

__Figure 5-23.__ Data ranges for the sources that are considered representative for K_d_PM_lake (m^3/kg_{dw}). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5^{th} (5p) and 95^{th} (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.

In Figure 5-24, the selected values for K_d_PM_lake are sorted from low sorption on the left, to high sorption on the right. The relative order among the elements are most similar to the terrestrial K_ds.

Table 5-18. Available data for K_d_PM_lake for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010, suspended matter, freshwater, L2 IAEA 2010, suspended matter, freshwater, field, L3 = ERICA (Beresford et al. 2008a), suspended matter, freshwater. See Table 5-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag		2/2	2/2			1			2.0	2.0			2.3			S2 (L72%)	S2 (L72%)		1:0/0
Am					42	1						5.7	5.7						2:1/1
Ba	3/3	3/3	6/6	49				1.8	1.7	2.3	3.6				S1	S2 (U36%)	S2 (U63%)	S2 (L34%)	1:0/0
Bi	1/1	2/2	3/3						1.7	3.5									0:0/0
Br	3/3	3/3	6/6					1.8	3.6	4.0								S2 (U57%)	0:0/0
Ca	3/3	3/3	6/6					2.6	1.3	2.0								S3	0:0/0
Cd	3/3	2/2	5/5			1		1.3	2.7	2.0								S1	1:0/0
Cl						1													1:0/0
Cm						1													1:0/0
Co	3/3	3/3	6/6		29	1		2.1	7.6	4.0		3.9	3.8		S1	S3	S2 (U83%)	S1	2:1/1
Cs	3/3	3/3	6/6		219	1		3.0	2.8	2.8		5.9	5.8		S1	S2 (U87%)	S2 (U97%)	S2 (L76%)	2:1/1
Eu	3/3	3/3	6/6			1		2.6	1.9	2.3								S2 (L61%)	1:0/0
Ho	3/3	3/3	6/6					2.1	1.9	2.1								S2 (L63%)	0:0/0
I	2/2	3/3	5/5	124		1		2.3	1.7	2.0	14.0		1.0		S1	S1	S1	S2 (U53%)	2:1/1
Mo	3/3	3/3	6/6					1.5	1.3	1.4								S3	0:0/0
Nb	3/3	3/3	6/6			1		1.9	2.3	2.4								S2 (L66%)	1:0/0
Ni	3/3	3/3	6/6			1		2.3	1.5	2.1								S2 (U47%)	1:0/0
Np						1													1:0/0
Pa																			0:0/0
Pb	3/3	3/3	6/6			1		2.4	3.2	2.6								S1	1:0/0
Pd																			0:0/0
Po						1													1:0/0
Pu					79	1						6.6	6.5						2:1/1
Ra				75		1					3.1		3.2						2:1/1
Re	3/3	2/2	5/5					2.8	2.9	3.0								S2 (U68%)	0:0/0
Se	3/3	3/3	6/6			1		2.6	2.1	2.2								S3	1:0/0
Sm	3/3	3/3	6/6					2.5	2.0	2.1								S3	0:0/0
Sn																			0:0/0
Sr	3/3	3/3	6/6		13	1		1.9	1.2	1.8		2.7	2.7		S1	S1	S1	S3	2:1/1
Tc						1													1:0/0
Th	3/3	3/3	6/6	63		1		2.2	1.6	1.9	21.0		20.8		S1	S1	S1	S2 (L61%)	2:1/1
U	3/3	3/3	6/6			1		1.1	1.7	6.9								S4	1:0/0
Zr	3/3	3/3	6/6			1		1.8	2.7	2.3								S2 (L94%)	1:0/0

Table 5-19. Selected data, references and comments for the parameter K_d_PM_lake (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or sample number of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		6	1.5E+01	9.1E+01	7.7E+01	5.6E+02	3.0	GSDmean	Site data FMLX	FMLX	Site data for REE consistent with lit. data for Am.
Ag			2	2.6E+00	3.6E+01	3.6E+01	5.1E+02	5.0	GSDmax	Site data LX	LX	
Am	Sm		6	1.5E+01	9.1E+01	7.7E+01	5.6E+02	3.0	GSDmean	Site data FMLX	FMLX	Site data for REE consistent with lit. data for Am.
Ba			6	1.9E+00	1.2E+01	6.4E+00	7.0E+01	3.0	GSDmean	Site data FMLX	FMLX	
Ca			6	1.8E-01	1.1E+00	8.3E-01	6.5E+00	3.0	GSDmean	Site data FMLX	FMLX	
Cd			5	4.0E+01	2.4E+02	3.3E+02	1.5E+03	3.0	GSDmean	Site data FMLX	FMLX	Similar to the possible EA Zn, when both LX and Fm data are considered.
Cl	Br		6	2.0E-01	2.3E+00	6.1E+00	2.3E+01	4.0	GSD	Site data FMLX	FMLX	Site data for Br consistent for FM and LX.
Cm	Sm		6	1.5E+01	9.1E+01	7.7E+01	5.6E+02	3.0	GSDmean	Site data FMLX	FMLX	Site data for REE consistent with lit. data for Am.
Co			6	8.9E+00	8.8E+01	6.8E+01	1.2E+03	4.0	GSD	Site data FMLX	FMLX	
Cs			6	1.7E+01	1.0E+02	7.2E+01	6.4E+02	3.0	GSDmean	Site data FMLX	FMLX	
Eu			6	1.2E+01	7.4E+01	5.2E+01	4.5E+02	3.0	GSDmean	Site data FMLX	FMLX	Site data for REE consistent with lit. data for Am.
Ho			6	1.2E+01	7.5E+01	5.2E+01	4.6E+02	3.0	GSDmean	Site data FMLX	FMLX	Site data for REE consistent with lit. data for Am.
I			5	2.6E+00	1.6E+01	2.5E+01	9.7E+01	3.0	GSDmean	Site data FMLX	FMLX	
Mo			6	2.0E+00	1.2E+01	1.1E+01	7.4E+01	3.0	GSDmean	Site data FMLX	FMLX	
Nb			6	4.5E+01	2.7E+02	1.6E+02	1.7E+03	3.0	GSDmean	Site data FMLX	FMLX	
Ni			6	4.6E+00	2.8E+01	4.1E+01	1.7E+02	3.0	GSDmean	Site data FMLX	FMLX	Site data for Ni consistent between FM and LX.
Np	Sm		6	1.5E+01	9.1E+01	7.7E+01	5.6E+02	3.0	GSDmean	Site data FMLX	FMLX	Sm(III) used as EA in oxidicing environment for Np(V).
Pa	Sm		6	1.5E+01	9.1E+01	7.7E+01	5.6E+02	3.0	GSDmean	Site data FMLX	FMLX	Sm(III) is used as EA.
Pb			6	8.8E+01	5.4E+02	6.3E+02	3.3E+03	3.0	GSDmean	Site data FMLX	FMLX	
Pd	Ni		6	4.6E+00	2.8E+01	4.1E+01	1.7E+02	3.0	GSDmean	Site data FMLX	FMLX	
Po	Bi		3	2.5E+01	3.5E+02	1.4E+03	4.9E+03	5.0	GSDmax	Site data FMLX	FMLX	Site data for Bi consistent between FM and LX as well as with site data for Te.
Pu	U		6	3.5E-01	8.4E+00	1.5E+00	2.0E+02	6.9	GSD	Site data FMLX	FMLX	U EA in oxidicing environment.
Ra	Ba		6	1.9E+00	1.2E+01	6.4E+00	7.0E+01	3.0	GSDmean	Site data FMLX	FMLX	Site data for Ba consistent with lit. data for Ra.
Se			6	1.6E+00	9.9E+00	8.5E+00	6.0E+01	3.0	GSDmean	Site data FMLX	FMLX	
Sm			6	1.5E+01	9.1E+01	7.7E+01	5.6E+02	3.0	GSDmean	Site data FMLX	FMLX	Site data for REE consistent with lit. data for Am.
Sn	Zr		6	1.4E+01	8.5E+01	5.9E+01	5.2E+02	3.0	GSDmean	Site data FMLX	FMLX	
Sr			6	2.1E-01	1.3E+00	8.7E-01	7.7E+00	3.0	GSDmean	Site data FMLX	FMLX	
Tc	Re		5	7.0E-02	4.3E-01	6.7E-01	2.6E+00	3.0	GSD	Site data FMLX	FMLX	Site data for Re significantly higher than lit. data for Tc.
Th			6	3.1E+01	1.9E+02	1.5E+02	1.1E+03	3.0	GSDmean	Site data FMLX	FMLX	Large spread among literature data.
U			6	3.5E-01	8.4E+00	1.5E+00	2.0E+02	6.9	GSD	Site data FMLX	FMLX	Large GSD due to discrepancies between FM and LX, due to calcite influence in FM.
Zr			6	1.4E+01	8.5E+01	5.9E+01	5.2E+02	3.0	GSDmean	Site data FMLX	FMLX	Consistent with Hf.

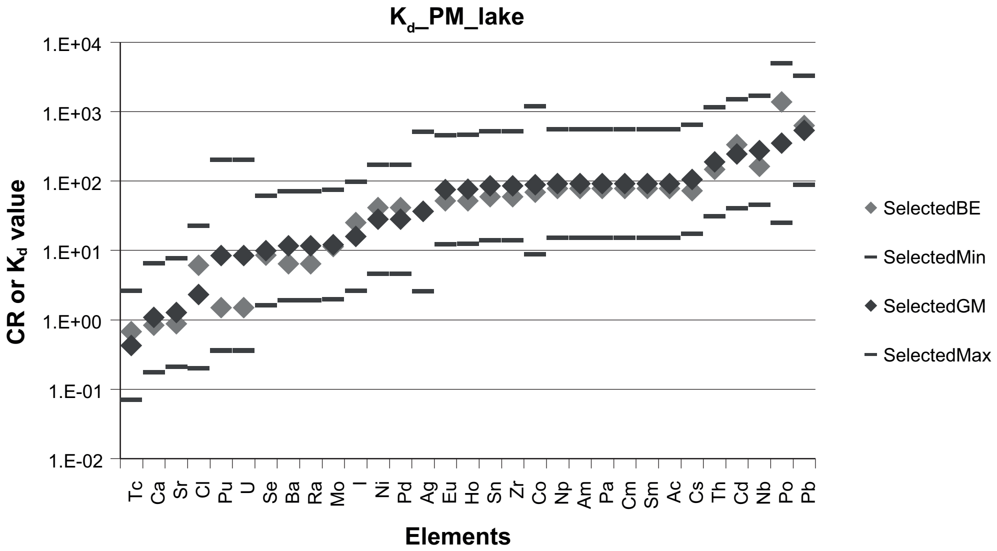

Figure 5-24. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{dw}).*

5.10 K_d_PM_sea

In the biosphere model, the K_d_PM_sea parameter describes the partitioning of elements in the marine water column into an aqueous (dissolved) and a solid fraction (Saetre et al. 2013).

Available site data representing the limnic water column and the partitioning between aqueous and solid phase, are corresponding measurements of particulate matter and filtered water. In Engdahl et al. (2008) 5 samples are available from the FM and the LX areas. Each sample is composed of several subsamples, which gives an integrated measure of the whole water column from bottom to surface. Since a mixture of hydrofluoric acid and nitric acid was used for digestion of the solid phase, the solid fraction represents the total contents of the particulate matter. Suspended matter and filtered water was also analysed in Kumblad and Bradshaw (2008) at 3 marine sites in FM.

Comparable literature data for suspended matter in marine environments are reported by Beresford et al. (2008). These data are categorised as L1 data.

Site data are available for Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Sr, Th, U and Zr. Literature data alone are available for Ag, Am, Cm, Np, Po, Pu, Ra, and Tc. No data are available for Ac, Pa and Pd (Table 5-20).

When FM data are compared to LX data as well as literature data, there are some discrepancies although both sites represent brackish water in the Baltic Sea. There are an extended variation around the GM for some elements among FM site data (Ca, Mo, Cd and Ba), which includes data from two different studies. There are no obvious erroneous data that could be discarded as artefacts when the concentrations of the data sources are evaluated. This discrepancy could perhaps be explained by systematic differences between the two studies (cf. Section 5.11.5).

Selected values for K_d_PM_sea parameter are compiled in Table 5-21. In the case of Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Sr, Th, U and Zr, site-specific data are used for the parameterisation. Sm site data are selected as EA for Ac, Am, Cm and Pa. Ag site data for K_d_PM_lake is utilised as PA for Ag. Bi site data are selected as EA for Po. Ba site data are used as EA for Ra. Ni site data are used as EA for Pd. Re site data are used as EA for Tc, Sm site data are used as EA for Np, U site data are used as EA for Pu, due to the assumed aerobic conditions in this environment (cf. EA assumptions in Section 2.7).

In Figure 5-26 the selected values for K_d_PM_sea are sorted from low sorption on the left, to high sorption on the right. In Section 5.11.5 K_d for particulate matter in the limnic and marine environments are compared and further discussed.

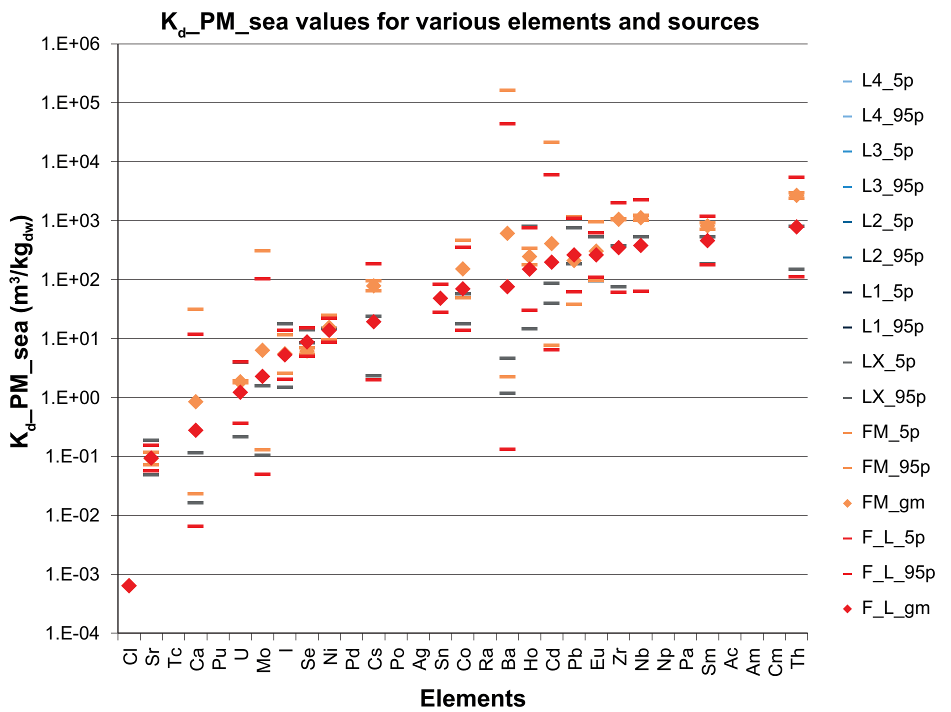

Figure 5-25. *Data ranges for the sources that are considered representative for K_d_PM_sea (m^3/kg_{dw}). The order of the elements are arranged to match the ranking of the selected values for the parameter. The coding of the legend denotes geometric mean (GM), theoretical 5^th^ (5p) and 95^th^ (95p) percentile of the different literature sources Forsmark (FM), Laxemar-Simpevarp (LX), both sources combined (F_L) and literature data L1 to L4.*

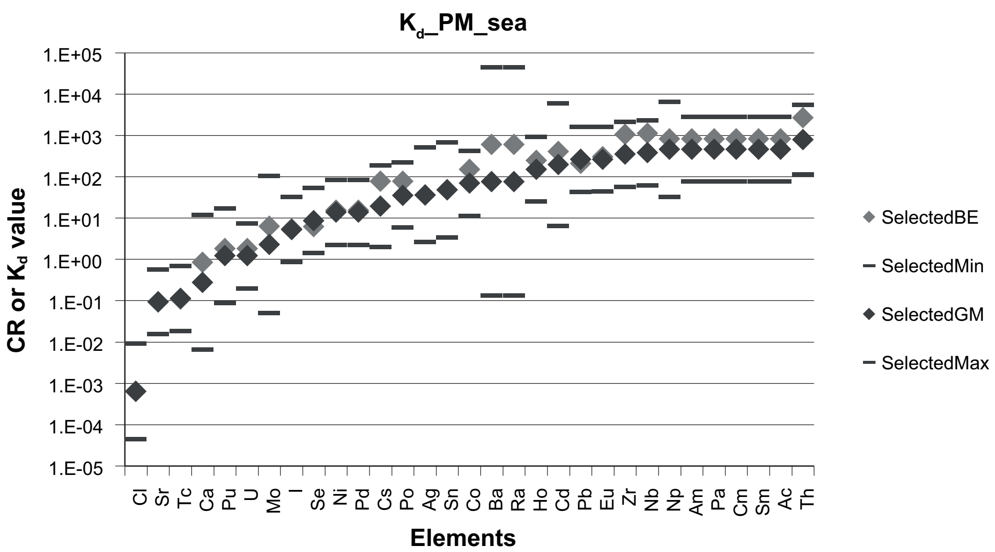

Figure 5-26. *Figure showing selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{dw}).*

Table 5-20. Available data for K_d_PM_sea for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ERICA (Beresford et al. 2008a), suspended matter, Sea water. See Table 5-1 for description of headings.

Element	FM N (from/ to)	LX N (from/ to)	FMLX (from/ to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC wFM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba	5/5	3/3	8/8					30.1	1.5	47.7								S2 (U6%)	0:0/0
Bi	2/2	3/3	5/5					1.2	2.2	2.5								S2 (U45%)	0:0/0
Ca	5/5	3/3	8/8					8.9	1.8	9.8								S2 (U22%)	0:0/0
Cd	5/5	3/3	8/8	1				11.2	1.3	8.0								S3	1:0/0
Cl	1/1		1/1	1															1:0/0
Cm				1															1:0/0
Co	3/3	3/3	6/6	1				2.0	1.4	2.7								S2 (U6%)	1:0/0
Cs	2/2	3/3	5/5	1				1.1	2.0	4.0								S4	1:0/0
Eu	2/2	2/2	4/4	1				2.0	1.7	1.7								S2 (U74%)	1:0/0
Ho	2/2	3/3	5/5					1.2	3.4	2.6								S1	0:0/0
I	2/2	3/3	5/5	1				1.6	2.1	1.8								S1	1:0/0
Mo	5/5	3/3	8/8					10.6	2.3	10.2								S2 (U32%)	0:0/0
Nb	2/2	3/3	5/5	1				1.1	1.9	3.0								S4	1:0/0
Ni	5/5	3/3	8/8	1				1.3	1.2	1.3								S2 (U45%)	1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb	5/5	3/3	8/8	1				2.8	1.5	2.4								S3	1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				1															1:0/0
Ra				1															1:0/0
Re	2/2	3/3	5/5					1.2	1.6	1.4								S1	0:0/0
Se	2/2	3/3	5/5	1				1.1	1.2	1.4								S4	1:0/0
Sm	2/2	3/3	5/5					1.1	1.4	1.8								S4	0:0/0
Sn		3/3	3/3						1.4	1.4									0:0/0
Sr	2/2	3/3	5/5	1				1.2	1.5	1.3								S1	1:0/0
Tc				1															1:0/0
Th	2/2	3/3	5/5	1				1.1	1.7	3.3								S4	1:0/0
U	2/2	3/3	5/5	1				1.0	2.4	2.1								S1	1:0/0
Zr	2/2	3/3	5/5	1				1.0	1.6	2.9								S4	1:0/0

Table 5-21. Selected data, references and comments for the parameter K_d_PM_sea (m^3/kg_{dw}). In the EA and PA columns, the use of element analogues and parameter analogues are noted. N represents either the number of unique observations in the selected site data or the sample number of the selected literature data. Statistical measures presented are minimum (min), geometric mean (GM), best estimate (BE), maximum (max) and geometric standard deviation (GSD). The GSD comment describes the method for deriving the GSD, and Reference and DataSource describe the selected data source.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Sm		5	7.5E+01	4.6E+02	8.1E+02	2.8E+03	3.0	GSDmean	Site data FMLX	FMLX	Site data for REE and Th consistent.
Ag		K_d_PM_lake	2	2.6E+00	3.6E+01	3.6E+01	5.1E+02	5.0	GSDmax	Site data LX	LX	Underestimated K_d due to Cl in sea water?.
Am	Sm		5	7.5E+01	4.6E+02	8.1E+02	2.8E+03	3.0	GSDmean	Site data FMLX	FMLX	Site data for REE and Th consistent.
Ba			8	1.3E-01	7.5E+01	6.0E+02	4.3E+04	47.7	GSD	Site data FMLX	FMLX	Very large range for Ba due to discrepancies between sampling campaigns.
Ca			8	6.5E-03	2.8E-01	8.4E-01	1.2E+01	9.8	GSD	Site data FMLX	FMLX	High GSD due to discrepancies between campaigns.
Cd			8	6.3E+00	2.0E+02	4.0E+02	6.0E+03	8.0	GSD	Site data FMLX	FMLX	
Cl			1	4.5E-05	6.4E-04	6.4E-04	9.0E-03	5.0	GSDmax	Site data FM	FM	One site sample for Cl available used in combination with GSDmax.
Cm	Sm		5	7.5E+01	4.6E+02	8.1E+02	2.8E+03	3.0	GSDmean	Site data FMLX	FMLX	Site data for REE and Th consistent.
Co			6	1.1E+01	6.9E+01	1.5E+02	4.2E+02	3.0	GSDmean	Site data FMLX	FMLX	
Cs			5	2.0E+00	1.9E+01	7.8E+01	1.8E+02	4.0	GSD	Site data FMLX	FMLX	Consistent with K_d_PM_lake.
Eu			4	4.3E+01	2.6E+02	3.0E+02	1.6E+03	3.0	GSDmean	Site data FMLX	FMLX	Compared to other parameters large differences among REE.
Ho			5	2.5E+01	1.5E+02	2.5E+02	9.1E+02	3.0	GSDmean	Site data FMLX	FMLX	Compared to other parameters large differences among REE.
I			5	8.6E-01	5.3E+00	5.5E+00	3.2E+01	3.0	GSDmean	Site data FMLX	FMLX	
Mo			8	5.0E-02	2.3E+00	6.3E+00	1.0E+02	10.2	GSD	Site data FMLX	FMLX	
Nb			5	6.2E+01	3.8E+02	1.1E+03	2.3E+03	3.0	GSDmean	Site data FMLX	FMLX	
Ni			8	2.2E+00	1.4E+01	1.5E+01	8.3E+01	3.0	GSDmean	Site data FMLX	FMLX	
Np	Sm		5	3.2E+01	4.6E+02	8.1E+02	6.5E+03	5.0	GSDmax	Site data FMLX	FMLX	Sm(III) used as EA in oxidicing environment for Np(V).
Pa	Sm		5	7.5E+01	4.6E+02	8.1E+02	2.8E+03	3.0	GSDmean	Site data FMLX	FMLX	Sm(III) is used as EA.
Pb			8	4.3E+01	2.6E+02	2.1E+02	1.6E+03	3.0	GSDmean	Site data FMLX	FMLX	
Pd	Ni		8	2.2E+00	1.4E+01	1.5E+01	8.3E+01	3.0	GSDmean	Site data FMLX	FMLX	Site data for Ni consistent between FM and LX, and similar to K_d_PM_lake for Ni.
Po	Bi		5	5.8E+00	3.5E+01	7.7E+01	2.2E+02	3.0	GSDmean	Site data FMLX	FMLX	Bi EA. Site data for Bi consistent between FM and LX.
Pu	U		5	8.6E-02	1.2E+00	1.8E+00	1.7E+01	5.0	GSDmax	Site data FMLX	FMLX	U EA in oxidicing environment.
Ra	Ba		8	1.3E-01	7.5E+01	6.0E+02	4.3E+04	47.7	GSD	Site data FMLX	FMLX	
Se			5	1.4E+00	8.7E+00	6.1E+00	5.3E+01	3.0	GSDmean	Site data FMLX	FMLX	
Sm			5	7.5E+01	4.6E+02	8.1E+02	2.8E+03	3.0	GSDmean	Site data FMLX	FMLX	Compared to other parameters large differences among REE.
Sn			3	3.4E+00	4.8E+01	4.8E+01	6.8E+02	5.0	GSDmax	Site data LX	LX	
Sr			5	1.5E-02	9.3E-02	9.1E-02	5.7E-01	3.0	GSDmean	Site data FMLX	FMLX	
Tc	Re		5	1.8E-02	1.1E-01	1.1E-01	6.8E-01	3.0	GSDmean	Site data FMLX	FMLX	Site data for Re consistent between FM and LX, as well as lit. data for Tc.
Th			5	1.1E+02	7.8E+02	2.7E+03	5.4E+03	3.3	GSD	Site data FMLX	FMLX	
U			5	2.0E-01	1.2E+00	1.8E+00	7.4E+00	3.0	GSDmean	Site data FMLX	FMLX	
Zr			5	5.7E+01	3.5E+02	1.0E+03	2.1E+03	3.0	GSDmean	Site data FMLX	FMLX	Consistent with EA Hf.

5.11 Evaluation of selected K_d values

Within this study, there are in total eight K_d parameters describing sorption in terrestrial and aquatic regolith, soils and sediments. In addition, two K_d parameters describes the sorption to particulate matter in the limnic and marine environments, respectively. These parameters can be expected to correlate to different degrees, and in this section the relations between the parameters are evaluated as part of the quality assurance and sense check of selected data. It should be noted that all comparisons in this section are made for selected values that could be based on either site data or literature data and EA and PA when applicable. In Table 5-22, best estimates for all parameters are compared. The colour coding shows that there is consistence in the overall pattern for both parameters and elements. The same elements show high sorption or low sorption, respectively, for all parameters. The differences are further explored below in pair wise comparisons among the parameters.

5.11.1 Deep till and glacial clay

K_d values used for till and glacial clay both represent minerogenic, anoxic soils not influenced by organic material. The K_d_regoLow and K_d_regoGL data are plotted in Figure 5-27. The K_d values for glacial clay correlates well with the values used for till even if the glacial clay values in general are tenfold higher. A generally higher sorption for clay soils could be expected by the higher sorption capacity of the clay minerals (higher CEC) in combination with the grain size difference between the soil types (small grain size implies larger surface area). The contents of larger particles in the unconsolidated clayey till also contributes to this difference due to dilution of the possible sorption sites, i.e. an effect of the so called "gravel issue" (US EPA 1999). In case of Pa, Pu and Np, values are identical for both parameters because they are based on the same literature data sources. If the general pattern seen among elements based on site data also applies to Pa, Pu and Np, it could be argued that K_d for these elements might be underestimated 10 times in the glacial clay.

5.11.2 Glacial clay and post glacial clay

K_d values representing glacial clay are plotted against K_d values for post glacial gyttja clay in Figure 5-28. The main difference between these soil types are the organic contents (and hence density) and pH according to Table 2-1. It can be seen that the K_d values for many of the elements with high sorption is higher in the glacial clay, e.g. Cs, Nb, Pb and Th. In case of Cs, the strong sorption to mineral surfaces for this element could be an explanation for the higher value in glacial clay. In the medium range, U, Mo and Ag deviate by showing lower mobility in the postglacial clay. Other metals, such as Cd, Co and Ni show contrary higher mobility (lower K_d) in the postglacial clay. These differences might be explained by differences in pH, which is significantly lower in the postglacial clay (pH 4.5) compared to the glacial clay (pH 8.0), or the presence of organic matter in the postglacial clay. In case of U and Mo, decreased carbonate complexion at lower pH might decrease the mobility of these elements. In case of Cd, Co and Ni, the mobility usually increase when pH decrease. The higher K_d in the calcite rich glacial clay for Ca and Sr is probably an effect of the inclusion of calcite in the sorbed fraction and thus leading to higher K_d values.

Table 5-22. Comparisons among BE (best estimates) of the K_d parameters. The values in the table represent the 10-logarithm of the BE values expressed in m^3/kg_{dw}. The parameters are sorted from the lowest layer, RegoLow, at the bottom of the table, in the order that they appear in the soil profile. The line divides the anaerobic from aerobic environments (anaerobic below line).The elements are sorted from left to right in ascending order based on the mean value of the terrestrial parameters. Due to the use of logarithms the colour coding represents differences in the order of magnitudes.

Parameter	Cl	Sr	Ca	I	Np	Se	Ba	Mo	Ra	U	Ni	Pd	Ag	Tc	Sn	Co	Cd	Zr	Ho	Pu	Pa	Eu	Ac	Am	Cm	Sm	Po	Th	Nb	Pb	Cs
K_d_PM_sea	-3.2	-1.0	-0.1	0.7	-2.0	0.8	2.8	0.8	2.8	0.3	1.2	1.2	1.6	-1.0	1.7	2.2	2.6	3.0	2.4	2.4	3.4	2.5	2.9	2.9	2.9	2.9	1.9	3.4	3.0	2.3	1.9
K_d_PM_lake	0.8	-0.1	-0.1	1.4	-2.0	0.9	0.8	1.1	0.8	0.2	1.6	1.6	1.6	-0.2	1.8	1.8	2.5	1.8	1.7	2.4	2.2	1.7	1.9	1.9	1.9	1.9	3.1	2.2	2.2	2.8	1.9
K_d_regoUp_aqu	-2.0	-0.9	-0.8	-0.5	-2.0	0.6	0.5	-0.2	0.5	0.7	1.2	1.2	1.4	-0.8	1.0	1.2	1.8	1.9	1.8	2.4	2.3	1.9	1.9	1.9	1.9	1.9	1.7	2.3	2.2	2.2	1.7
K_d_regoUp_garden	-2.2	-0.9	-0.9	-0.7	-1.7	0.0	0.1	-0.8	0.8	-0.4	0.4	0.7	0.4	-0.9	0.9	1.0	0.8	0.3	1.2	-0.4	0.1	1.2	1.3	1.3	1.3	1.3	1.5	1.4	1.3	1.8	2.4
K_d_regoUp_io	-2.2	-0.9	-0.9	-0.7	-1.7	0.0	0.1	-0.8	0.8	-0.4	0.4	0.7	0.4	-0.9	0.9	1.0	0.8	0.3	1.2	-0.4	0.1	1.2	1.3	1.3	1.3	1.3	1.5	1.4	1.3	1.8	2.4
K_d_regoUp_drain	-1.7	-0.8	-1.0	-0.9	-0.1	0.1	-0.1	-0.1	0.3	0.8	-0.1	-0.2	0.5	-1.2	0.7	-0.1	0.3	-0.1	0.6	-0.1	0.8	0.5	0.7	0.7	0.7	0.7	0.9	0.6	0.6	0.9	1.0
K_d_regoUp_ter	-1.7	-0.5	-0.5	-0.7	-0.1	0.0	-0.3	0.6	0.3	0.9	0.3	0.3	1.1	-0.4	0.7	0.3	0.8	0.3	1.0	-0.1	0.8	0.6	0.9	0.9	0.9	0.9	1.1	0.6	0.9	1.1	-0.3
K_d_regoPeat	-1.6	-0.4	-0.4	-0.1	-0.1	-0.4	0.0	0.7	0.3	1.3	0.4	0.6	0.4	0.5	1.0	0.4	1.5	0.5	1.1	-0.1	0.8	1.1	1.1	1.1	1.1	1.1	1.2	0.3	1.1	1.3	-0.3
K_d_regoPG	-2.1	-1.2	-1.4	-0.3	-1.5	0.2	0.3	0.5	0.4	0.6	0.0	0.0	0.6	0.6	1.4	0.1	-1.1	0.6	0.5	0.0	0.3	0.6	0.5	0.5	0.5	0.5	1.6	1.1	1.5	0.9	1.6
K_d_regoGL	-2.3	-0.2	0.0	-0.6	-1.7	0.0	0.6	-0.7	1.0	-0.4	1.2	1.2	-0.5	1.7	1.1	1.9	1.2	1.7	1.9	-0.4	0.1	2.0	2.0	2.0	2.0	2.0	2.1	2.0	2.2	2.3	2.5
K_d_regoLow	-3.3	-1.0	-0.5	-1.9	-1.7	-0.9	-0.7	-1.7	0.1	-1.7	-0.1	-0.1	0.1	0.6	1.0	0.4	0.0	0.6	0.8	-0.4	0.1	1.0	1.0	1.0	1.0	1.0	1.2	1.4	1.5	1.2	1.1

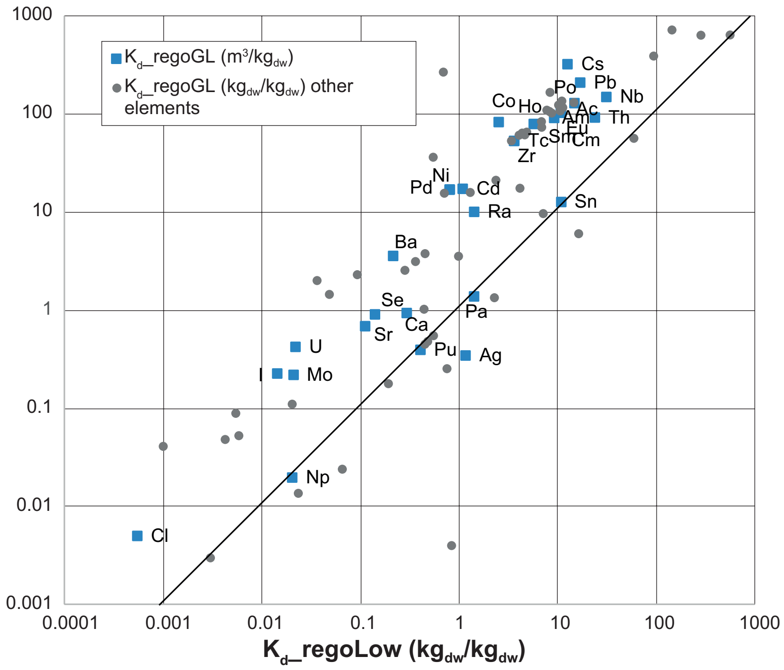

Figure 5-27. K_d values for glacial clay (K_d_regoGL) are generally higher than the K_d values for till (K_d_regoLow).

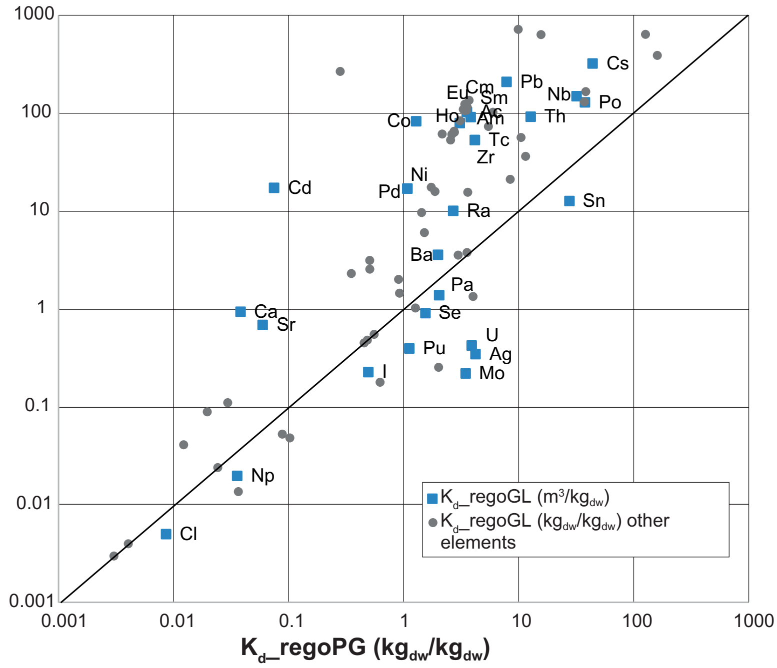

Figure 5-28. K_d values for glacial clay plotted against K_d values for post glacial gyttja clay.

5.11.3 Peat layers

Peat overlays the post glacial gyttja clay. The peat layer is divided into a lower, anoxic layer, K_d_regoPeat, and an oxic top layer of peat, K_d_regoUp_ter. It could be expected that these layers differ mainly for redox sensitive elements. The K_d values of these two parameteters are plotted in Figure 5-29. The two datasets correlate well for most elements and no general difference could be seen for the redox sensitive elements (for example Fe, Re and Mn) except for Tc, with lower K_d value for the upper peat layer (K_d_regoUp_ter). The K_d value for Tc is in turn based on the EA Zr in the anoxic regoPeat layer and Re in the oxic regoUp_ter layer.

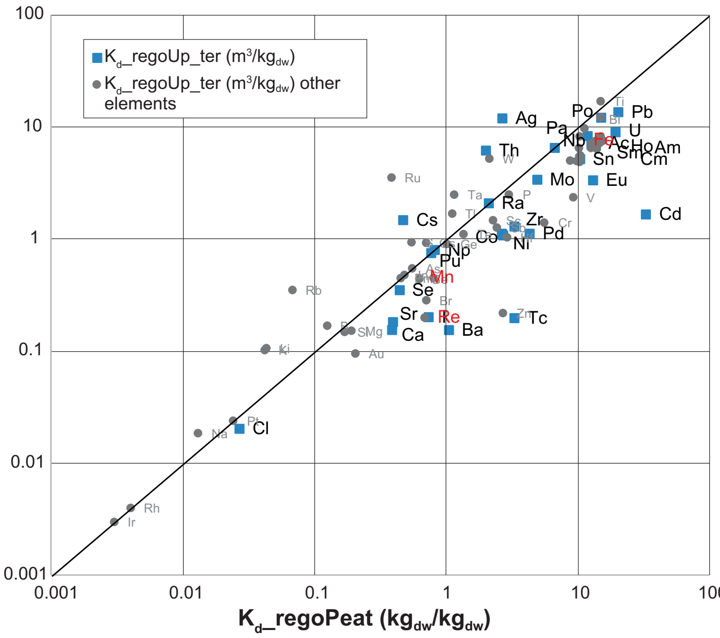

Figure 5-29. *K_d values for the oxic peat layer, K_d_regoPeat, plotted against K_d values for the anoxic layer, K_d_regoUp_ter, correlate relatively well.*

5.11.4 Aquatic sediments and postglacial clay

The upper aquatic sediments, K_d_regoUp_aqu are compared to the underlying post glacial clay sediments. The former is according the definitions in previous sections aerobic, whereas the latter is anaerobic, and K_d for these layers might be expected to correlate for non-redox sensitive elements. A comparison between these parameters in Figure 5-30 shows generally higher values in aquatic sediments for lanthanides and other elements associated with particles in the environment, e.g. Pb, Th, Zr and Nb. For several elements that usually show high mobility in the environment, there is no significant difference between the parameters, e.g. Cl, Ca, Sr and I. The large difference for the redox sensitive element Tc is explained by the use of different EAs in the aerobic (Re) and anaerobic (Zr) environments.

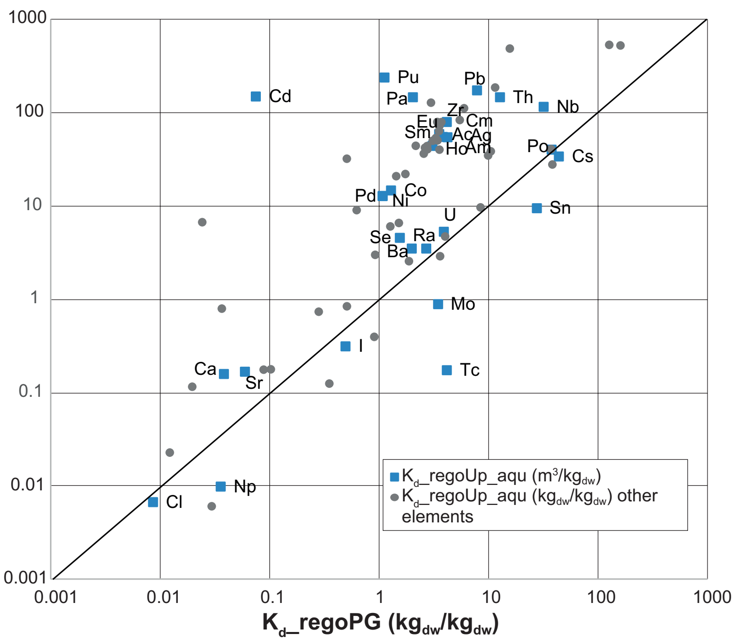

Figure 5-30. *K_d values for aquatic sediments, K_d_regoUp_aqu, plotted against the terrestrial post glacial sediments, K_d_regoPG.*

5.11.5 Particulate matter in lake and sea water

K_d values for particular matter in lake water and sea water respectively are plotted in Figure 5-31. The K_d values for ions present at high concentrations in sea water is generally higher for lake water than sea water, e.g. Na, Mg, K, Cl, Br and S. Several factors might contribute to this pattern. Saturation of sorption sites in sea water could give this effect for cat ions as Na^+, Mg^{2+} and K^+. "Contamination" of the sorbed fraction by dissolved ions could also give a similar pattern for negative ions such as Cl^- and Br^-. The latter explanation is most probable as both cat ions and anions are influenced in a similar way. Also K_d for trace elements that occur at higher concentrations in sea water could be influenced by the same reason, for example U and Mo. The difference seen for Ba with higher sorption in sea water probably reflects precipitation of $BaSO_4$ in the marine environment. The pattern for elements such as Si, Ti and Al might indicate that more mineral particles are included in the samples of sea water compared to lake water (total digestion is used for these samples, cf. Sections 5.9 and 5.10). This implicates that the general pattern when K_d for lake and sea water is compared mainly might be explained by varying influence of two factors: the inclusion of dissolved ions in the sorbed fraction and varying inclusion of elements origination from the mineral matrix of the particles. The location along the hypothetical trend marked in Figure 5-31 by a dashed line might be interpreted as the relative influence of these two artefacts, and deviations from this line might point out elements that are significantly influenced from other factors. For example the deviation for the nutrient P, that occurs at low concentrations in the oligotrophic lakes in the Forsmark area, might reflect that this element is taken up especially active by biota in the limnic environment. The deviation for Ba, might reflect the precipitation of $BaSO_4$ in the marine environment, as described above.

5.11.6 Agricultural soils

In addition to the parameters describing sorption in natural environments two parameters describing sorption in agricultural soils are parameterised within this study.

K_d_regoUp_io and K_d_regoUp_garden represents a minerogenic agricultural soil that could be expected to correlate to the K_d_regoLow (till) and K_d_regoGL (glacial clay) parameters. In Figure 5-32, where these parameters are plotted, it can be seen that the data for deep till is in general lower and the K_d values for glacial clay is in general higher than the K_d for the agricultural soil. This could be explained by the fact that the K_d_regoUp_io is parameterised using independent data from the upper parts of agricultural soils on glacial clay and till. The general difference between K_d_regoLow and K_d_regoGL could be explained due to grain size effects, as described earlier in this section.The discrepancy for Tc is due to different redox conditions in the aerobic K_d_regoUp_io environment compared to the anaerobic environments of the RegoLow and Rego_GL layers (Tc is parameterised using site data for Zr in the reducing environments and Re in the oxidizing environment).

K_d_regoUp_drain represent sorption in a drained peat soil where clay gyttja has been included due to ploughing. Therefore these K_d values could be expected to correlate to the K_d for post glacial clay gyttja and the K_d values for the oxic peat. In Figure 5-33, where these data are plotted, it could be concluded that K_d_regoUp_drain is most similar to K_d_regoUp_ter. The K_d_regoUp_drain parameter is most similar to other parameters that are reflecting aerated organic soils, for example K_d_regoUp_ter, with, for example, low mobility of U. Although in comparison to for example K_d_regoPeat, Cs show lower mobility, which could be explained by the clay contents in the K_d_regoUp_drain samples. The mobility of Cl is also significantly lower for K_d_regoUp_drain compared to e.g. K_d_regoLow. This is expected for organic soils and indigenous Cl versus recent Cl, both of which could explain this pattern.

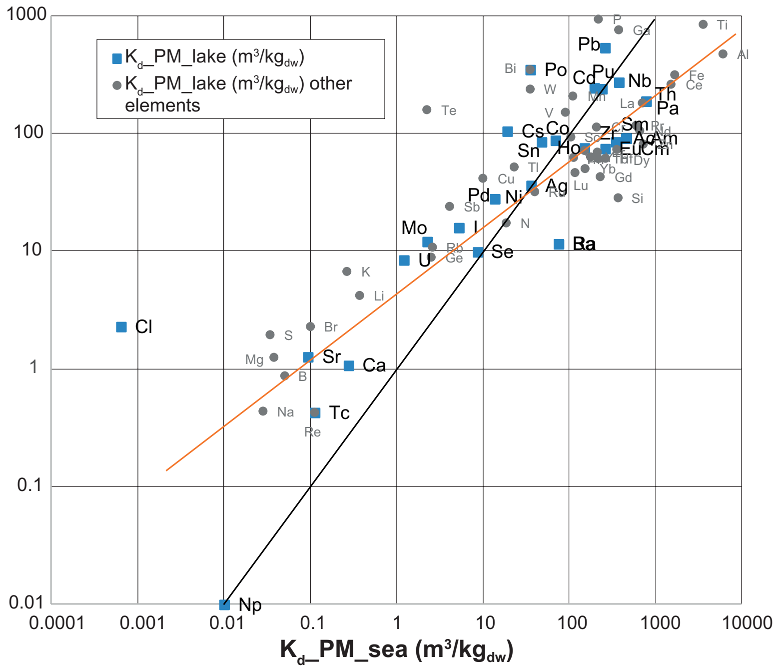

Figure 5-31. *K_d values for particular matter in lake water plotted against values for sea water. The dashed line indicates a hypothetical trend between influence of dissolved ions and dissolution of the mineral matrix (see text).*

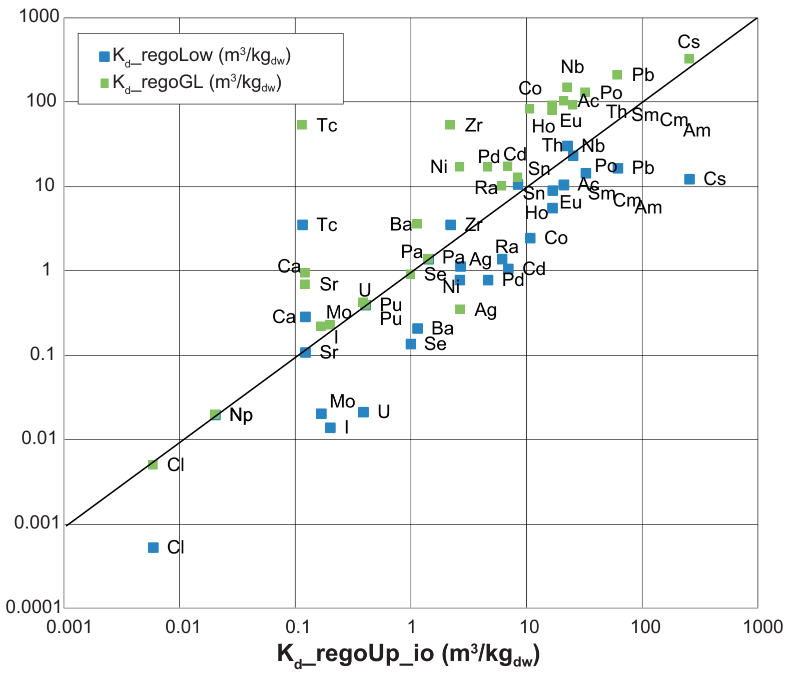

Figure 5-32. *K_d values for glacial clay and till are plotted against the K_d values cultivated minerogenic soil. The K_d values for agricultural soil are higher than the values for till but lower than the values for glacial clay.*

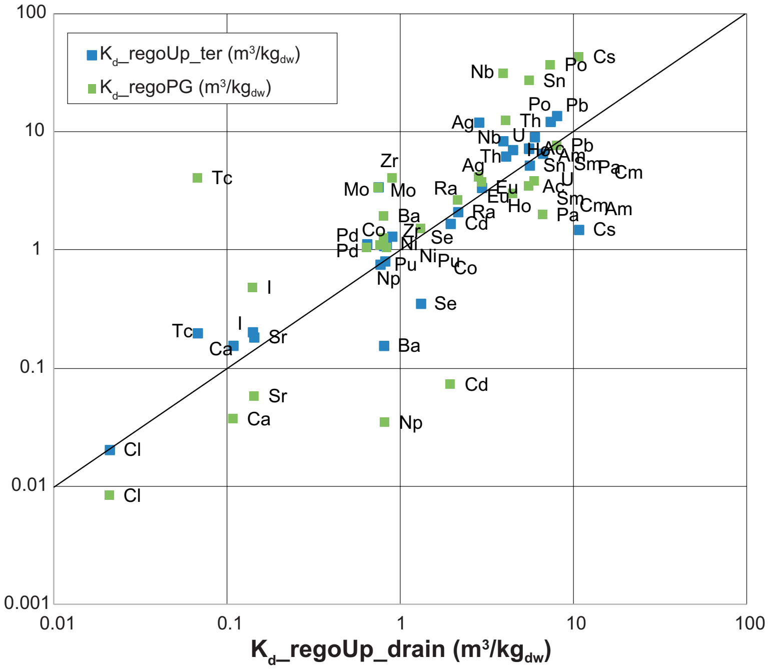

Figure 5-33. *K_d values for post glacial clay, K_d_regoMid, and the upper peat layer, K_d_regoUp_ter, are plotted against the K_d values cultivated organic agricultural soil, K_d_regoUp_drain.*

6 Selected CR for the terrestrial ecosystem

The uptake in terrestrial biota is assessed by using CR values, which relate element concentrations in biota to element concentrations in soils (or fodder in the case of herbivores or domestic animals). The transport of radionuclides is related to the flow of carbon in the environment in this safety assessment and, therefore, CR values are based on carbon content and given in the unit of kg dry weight/kg carbon (kg_{dw}/kg_{C}). The CR values utilised for dose assessment to non-human biota (NHB) are based on fresh weight concentrations (technical reasons) and are given in the unit of kg dry weight/kg fresh weight (kg_{dw}/kg_{fw}). Conversions between the different units are described in Section 4.2.3.

When selecting representative CR values for terrestrial biota, it is important to consider what the parameters are thought to represent in the radionuclide model for the biosphere. This section presents the terrestrial CR values utilised for calculation of transport of radionuclides in the biosphere and the CR values used for dose calculation to non-human biota.

In the radionuclide model, the terrestrial biota are divided into several compartments, representing primary producers, consumers and mushrooms. The uptake in consumers and mushrooms is represented by 1 parameter each; CR_food_herbivore and cR_Ter_Mush, respectively. The primary producers are divided into 5 parameter groups; wild vegetation (cR_Ter_pp), cultivated vegetables (cR_agri_veg), pasturage (cR_agri_fodder), cereals (cR_agri_cereall) and tubers (cR_agri_tuber). The uptake of elements in the defined groups can be expected to differ and, therefore, specific CR values are selected for each parameter group to calculate the uptake. The reason for not dividing wild vegetation into smaller units is the small variation in element composition in green parts of field, shrub and tree layers, as described in Section 6.7 (cR_Ter_pp, cR_Ter_pp_grass_NHB, cR_Ter_pp_shrub_NHB, cR_Ter_pp_tree_NHB). Uptake in terrestrial consumers is defined as a concentration ratio between animal and its food (wild vegetation).

For calculation of dose to NHB, the organism groups identified as reference organisms in ERICA (Beresford et al. 2007) are utilised. Lichens and bryophytes, grasses, shrubs and trees are considered representative primary producers for the terrestrial environment. The representative fauna include detritivorous invertebrates, flying insects, gastropods, soil invertebrates, amphibians, reptiles, birds, bird eggs and small and large mammals. Mushrooms are not included as reference organisms in ERICA (Beresford et al. 2007) and are, therefore, not included. Important information, such as radiosensitivity of mushrooms, is not available, which is making a proper safety assessment very difficult.

The main difference in CR values when estimating dose to humans or to NHB, is that the concentration in edible part is of interest for organisms seen as human food, whereas the whole body concentration is relevant when estimating dose to the organism itself. The terrestrial biota, which is assumed to be consumed by humans, consists of cereals, tubers, vegetables, mushrooms and meat from wild herbivores. The uptake is calculated by using CR values based on concentrations in edible parts of the food substances (grain, tuber, green part, fruit, crop or muscle tissue). Milk and meat from domestic animals are also considered part of the human diet, although the uptake is not modelled using CRs, instead Transfer Factors are used, see Section 6.4 and 6.5.

For dose estimation to terrestrial biota, CR values based on whole body concentrations are utilised. Biota data from FM and LX are commonly measured on the green part of vegetation or the muscle of animals. When possible, a conversion of the data to whole body concentrations are performed by using the conversion factors in Yankovich et al. (2010). Conversion factors for primary producers are not available in any data compilation utilised in this study.

Biota data from FM and LX are coupled with soil samples from the corresponding sites. The same set of soil samples are used when calculating CRs for most terrestrial biota types. Therefore, the soil samples are presented here, while the various terrestrial biota samples are described in their respective subsections that follow. Soil concentrations have been measured at FM and LX on several occasions (see Section 3.1.4).

The soil samples selected for parameterisation of uptake in the terrestrial biota are; inorganic and organic soil samples from Engdahl et al. (2006) (LX), Sheppard et al. (2009) (FM and LX) and agricultural soil samples of clay gyttja, clayey till, glacial clay, cultivated peat and wetland peat from Sheppard et al. (2011) (FM). The selected samples were extracted with aqua regia before analysis, in order to better represent the soluble fraction of elements present in the soil. The extracted fraction is considered to be available for uptake in plants and further assimilation in terrestrial animals, whereas fractions that are more closely bound to the soil matrix are less available. Available and selected CR data for terrestrial biota are presented and discussed in the following subsections.

Abbreviations used in the tables and figures in this chapter are explained in Table 6-1.

6.1 cR_Ter_pp_lich_NHB

The parameter cR_Ter_pp_lich_NHB describes the element uptake in terrestrial lichens and bryophytes, for use in dose estimates to this organism type. The concentration in mosses/lichen is divided by soil concentration in this study, in order to mimic element uptake, although this is not the case in nature. Mosses and lichens in particular, get their elemental content largely from the atmosphere and computing a CR to soil thus call for the assumption that atmospheric dust is largely derived from local soil, which is probably a poor assumption, especially for sea-source aerosols. However, the CR to soil is selected since it is the parameter utilised in the ERICA tool (Beresford et al. 2008a), on which our non-human biota assessments are based.

Site data are available: data for bottom layer from Hannu and Karlsson (2006) (FM), Engdahl et al. (2006) (LX), Roos et al. (2007) (both sites, radionuclides). Soil data are selected from Sheppard et al. (2009) (both sites), Sheppard et al. (2011) (FM) and Engdahl et al. (2006) (LX) (see Section 3). Site data are available for 22 elements and are described further below. Literature data from ERICA (Beresford et al. 2008a) are available and it is the only data source for 6 elements: Am, Cm, Np, Po, Pu and Tc. Data are missing for Ac, Pa and Pd. Available data are shown in Table 6-2 and Figure 6-3.

Moss samples (bottom layer in Figure 6-1) from FM (n=5) are compared to other FM vegetation types (above ground samples of tree layer, shrub layer, field layer and crop), and the moss samples consistently indicate higher element concentrations for many elements. The tendency is especially apparent for the elements in the lower range of the concentration values (Figure 6-2). Due to this discrepancy, data for other terrestrial primary producers are not used for the parameter cR_Ter_pp_lich_NHB. When comparing moss data with samples of roots, the two sample types show very similar concentrations of elements (Figure 6-1). None of the studied element concentrations differ more than 1 order of magnitude between the 2 sample types.

When CR based on site data are compared to ERICA data (Beresford et al. 2008a) (Figure 6-3), cases where both sources are available (Cs, Sr, Ra, Pb and Th) revealed that the literature data range are always in the upper part of or higher than the site data range. This discrepancy could be due to that ERICA data (Beresford et al. 2008a) for these particular elements are based on reviews and the data could be for lichens rather than for mosses. That is the case with one of the original references utilised in ERICA (Holtzman 1966), though we have not been able to confirm the other references (in Russian). Due to this noted difference, it is important to prioritise site data.

Table 6-1. Abbreviations used in the tables of this chapter.

Abbrevation	Description
FM N (from/to)	Number of samples in FM site data. Number of independent samples in denominator (from) and numerator (to) of the ratio.
LX N (from/to)	Number of samples in LX site data. Number of independent samples in denominator (from) and numerator (to) of the ratio.
FMLX (from/to)	Number of samples in FMLX site data. Number of independent samples in denominator (from) and numerator (to) of the ratio.
L1 N, L2 N, L3 N, L4 N	Number of samples for literature source L1, L2, L3, L4, respectively.
FM GSD, LX GSD, FMLX GSD	Geometric standard deviation of site data from FM, LX and FMLX data.
L1 GSD, L2 GSD, L3 GSD, L4 GSD	Geometric standard deviation for literature source L1, L2, L3 and L4.
SC FM	Sense check comparing ranges for FM site data and literature data.
SC LX	Sense check comparing ranges for LX site data and literature data.
SC FMLX	Sense check comparing ranges for FMLX site data and literature data.
SC FMvsLX	Sense check comparing ranges for FM and LX data.
SC Lit	Sense check comparing ranges for literature data sources.

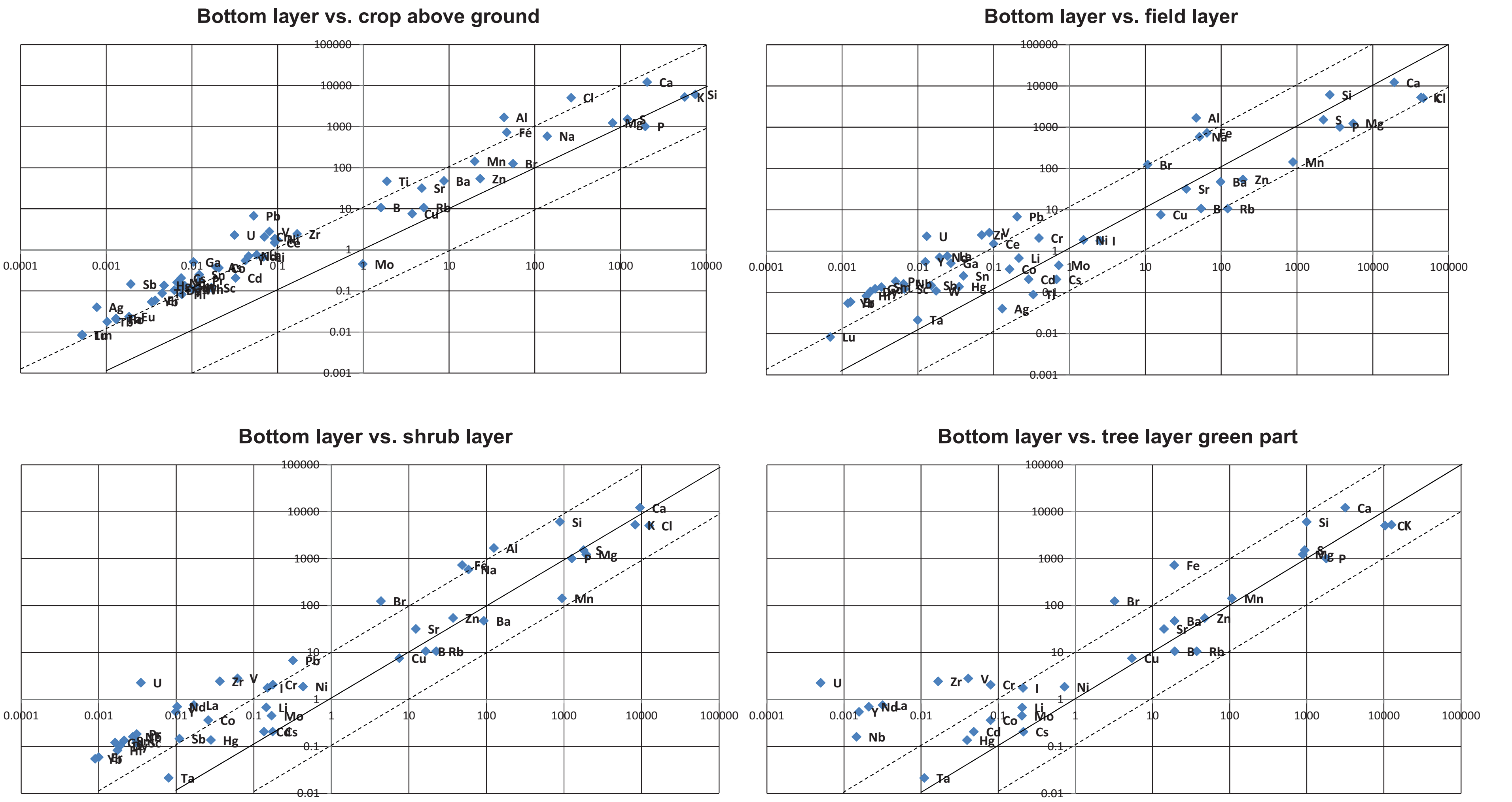

Figure 6-1. Element concentrations of bottom layer samples (moss) compared to element concentrations of crop above ground samples (upper left figure), field layer samples (upper right figure), shrub layer samples (lower left figure) and tree layer green part samples (lower right figure). All of the samples are from FM. In all 4 cases, the compared data show a large number of elements with concentrations that vary more than 1 order of magnitude between the compared vegetation types. This is especially true for elements in the lower range of the total concentration range. Most of the elements that indicate a relatively large variation have higher element concentrations in the bottom layer samples than in the compared vegetation type.

Ag data from FM and LX do not overlap. However, the data are based on only one sample from each so the fact that the values deviates 1 order of magnitude is reasonable. For U, large variations in U concentrations in soil samples gives a large parameter range (larger than GSDmax). No revision are made.

La site data are utilised as EA for Ac, Am, Cm, Np and Pa, whereas Ni site data are used as EA for Pd. Th site data are selected as EA for Np and Pu.

ERICA presented 1 value without range for Tc and GSDmax (7) is assigned to this parameter. The GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean or GSDmax).

The selected CR values are presented in and Table 6-3 and Figure 6-4.

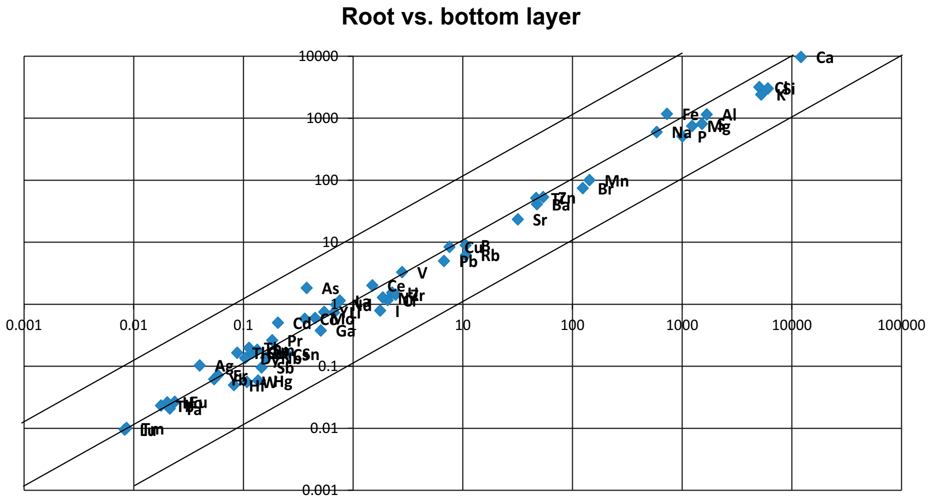

Figure 6-2. Element concentrations of root samples compared to bottom layer samples (from FM).

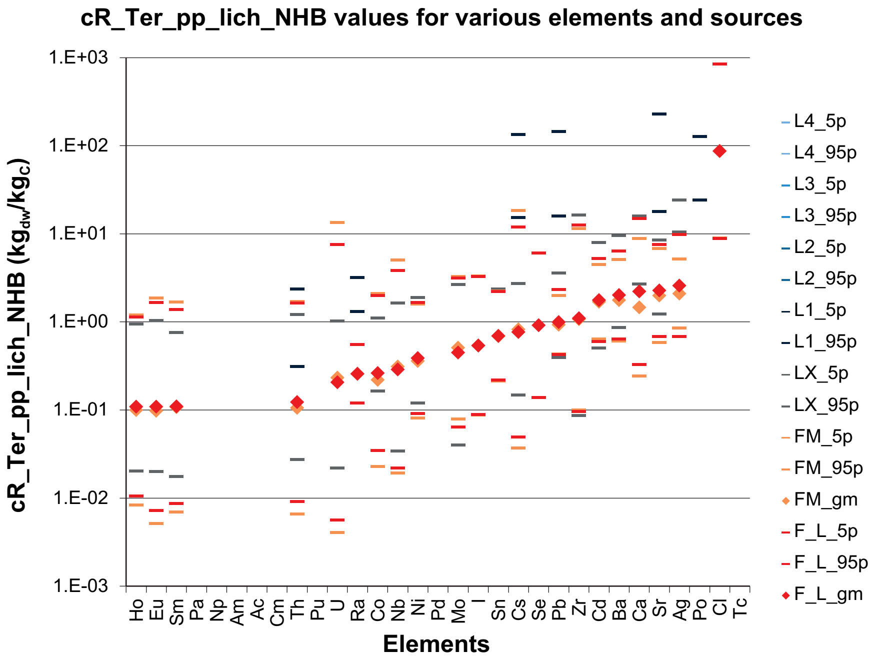

Figure 6-3. Total available data ranges for the parameter cR_Ter_pp_lich_NHB (kg_{dw}/kg_C). The elements are arranged in the same order as in Figure 6-4 *showing selected parameter values.*

Table 6-2. All available data for the parameter cR_Ter_pp_lich_NHB for the elements of primary concern and selected EAs. Sense checks with the corresponding results are included. L1 = ERICA (Beresford et al. 2008a) Terrestrial Lichen & bryophytes.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag	26/1	1/3	27/4	1				1.7	1.3	2.2								S4	1:0/0
Am				1															1:0/0
Ba	28/3	8/4	36/7					1.9	2.1	2.0								S2(L83%)	0:0/0
Ca	28/3	8/4	36/7					3.0	1.7	3.2								S2(L33%)	0:0/0
Cd	28/3	8/4	36/7	1				1.8	2.3	1.9								S1	1:0/0
Cl	25/3		25/3	1				4.0		4.0									1:0/0
Cm				1															1:0/0
Co	28/3	8/4	36/7	1				4.0	1.8	3.4								S3	1:0/0
Cs	28/3	8/4	36/7	51				6.6	2.4	5.3	1.9				S2(L2%)	S4	S4	S3	1:0/0
Eu	27/3	8/4	35/7	1				6.0	3.3	5.2								S3	1:0/0
Ho	27/3	8/4	35/7					4.5	3.2	4.1								S3	0:0/0
I	25/3		25/3	1				3.0		3.0									1:0/0
La	28/3	8/4	36/7					5.1	2.6	4.4								S3	0:0/0
Mo	28/3	8/4	36/7					3.1	3.6	3.3								S2(U94%)	0:0/0
Nb	28/3	8/4	36/7	1				5.4	3.2	4.8								S3	1:0/0
Ni	28/3	8/4	36/7	1				2.5	2.3	2.4								S2(L86%)	1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb	28/3	8/4	36/7	98				1.6	2.0	1.7	2.0				S4	S4	S4	S1	1:0/0
Pd																			0:0/0
Po				12							1.7								1:0/0
Pu				1															1:0/0
Ra	25/1		25/1	15				1.6		1.6	1.3				S4		S4		1:0/0
Se		8/2	8/2	1					3.2	3.2									1:0/0
Sm	28/3	8/4	36/7					5.3	3.1	4.7								S3	0:0/0
Sn	28/3	8/3	36/6					2.0	2.1	2.0								S2(L99%)	0:0/0
Sr	28/3	8/4	36/7	55				2.1	1.8	2.1	2.2				S4	S4	S4	S2(L69%)	1:0/0
Tc				1															1:0/0
Th	28/3	8/4	36/7	18				5.4	3.2	4.8	1.8				S2(L30%)	S2(L35%)	S2(L31%)	S3	1:0/0
U	28/3	8/4	36/7	1				11.8	3.2	8.9								S3	1:0/0
Zr	28/3	8/4	36/7	1				4.2	4.9	4.4								S1	1:0/0

Table 6-3. Selected data properties, references and comments for the parameter cR_Ter_pp_lich_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La		7	1.2E–03	1.4E–02	1.5E–02	7.0E–01	4.4	GSD	Site data FMLX	FMLX	La used as EA (site data are available).
Ag			4	3.2E–02	3.1E–01	2.5E–01	3.0E+00	4.0	GSDmean	Site data FMLX	FMLX	Data from FM (n=1) and LX (n=1) do not overlap. GM and range from FM are more consistent with the CR value presented in ERICA, so it is considered more appropriate.
Am	La		7	1.2E–03	1.4E–02	1.5E–02	7.0E–01	4.4	GSD	Site data FMLX	FMLX	La is used as EA. ERICA used Th as analogue but we consider La as a better choice.
Ba			7	2.5E–02	2.4E–01	2.2E–01	2.4E+00	4.0	GSDmean	Site data FMLX	FMLX	
Ca			7	2.3E–02	2.7E–01	1.8E–01	3.0E+00	4.0	GSDmean	Site data FMLX	FMLX	FM and LX data overlap to a limited degree. LX range is small and values differ 4 times, so it is not considered an issue.
Cd			7	2.2E–02	2.1E–01	2.1E–01	2.1E+00	4.0	GSDmean	Site data FMLX	FMLX	
Cl			3	1.6E–01	1.1E+01	1.1E+01	2.6E+02	7.0	GSDmax	Site data FM	FM	
Cm	La		7	1.2E–03	1.4E–02	1.5E–02	7.0E–01	4.4	GSD	Site data FMLX	FMLX	La used as EA (site data are available).
Co			7	2.6E–03	3.2E–02	2.7E–02	1.0E+00	4.0	GSDmean	Site data FMLX	FMLX	
Cs			7	6.0E–03	9.3E–02	1.0E–01	3.2E+00	5.3	GSD	Site data FMLX	FMLX	Site data lower than literature data, yet it is considered valid since FM and LX data correlate.
Eu			7	5.6E–04	1.3E–02	1.2E–02	7.8E–01	5.2	GSD	Site data FMLX	FMLX	
Ho			7	9.2E–04	1.3E–02	1.2E–02	5.6E–01	4.1	GSD	Site data FMLX	FMLX	
I			3	2.7E–03	6.7E–02	6.7E–02	1.6E+00	7.0	GSDmax	Site data FM	FM	
Mo			7	3.2E–03	5.5E–02	6.3E–02	6.4E–01	4.0	GSDmean	Site data FMLX	FMLX	
Nb			7	2.1E–03	3.5E–02	3.9E–02	1.8E+00	4.8	GSD	Site data FMLX	FMLX	
Ni			7	4.8E–03	4.7E–02	4.5E–02	7.3E–01	4.0	GSDmean	Site data FMLX	FMLX	
Np	La		7	1.2E–03	1.4E–02	1.5E–02	7.0E–01	4.4	GSD	Site data FMLX	FMLX	La used as EA. ERICA used Th as analogue but we consider La as a better choice.
Pa	La		7	1.2E–03	1.4E–02	1.5E–02	7.0E–01	4.4	GSD	Site data FMLX	FMLX	La used as EA (site data are available).
Pb			7	1.2E–02	1.2E–01	1.2E–01	1.2E+00	4.0	GSDmean	Site data FMLX	FMLX	Site data lower than literature, yet it is considered valid since FM and LX data correlate.
Pd	Ni		7	4.8E–03	4.7E–02	4.5E–02	7.3E–01	4.0	GSDmean	Site data FMLX	FMLX	Ni used as EA (site data are available).
Po			12	5.7E–01	5.5E+00	5.5E+00	5.4E+01	4.0	GSDmean	ERICA	L1	
Pu	U		7	2.3E–04	2.5E–02	2.9E–02	7.6E+00	8.9	GSD	Site data FMLX	FMLX	U used as EA (site data are available).
Ra			1	1.3E–03	3.1E–02	3.1E–02	7.6E–01	7.0	GSDmax	Site data FM	FM	Ranges of FM and ERICA data are very narrow. Values differ 1 order of magnitude, which is realistic. Site data selected.
Se			2	4.2E–03	1.0E–01	1.0E–01	2.6E+00	7.0	GSDmax	Site data LX	LX	LX data lower than ERICA. The latter presents 1 value based on separate measurements of lichen and soil. LX data are from the area of interest and therefore considered more reliable.
Sm			7	9.7E–04	1.3E–02	1.3E–02	6.6E–01	4.7	GSD	Site data FMLX	FMLX	
Sn			6	8.7E–03	8.5E–02	8.6E–02	8.3E–01	4.0	GSDmean	Site data FMLX	FMLX	
Sr			7	2.8E–02	2.8E–01	2.5E–01	2.7E+00	4.0	GSDmean	Site data FMLX	FMLX	Site data lower than literature data,yet it is considered valid since FM and LX data correlate.
Tc			1	8.1E–01	2.0E+01	2.0E+01	4.9E+02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th			7	8.6E–04	1.5E–02	1.3E–02	5.9E–01	4.8	GSD	Site data FMLX	FMLX	Large variation in site data, which almost encloses the literature range. Site data selected.
U			7	2.3E–04	2.5E–02	2.9E–02	7.6E+00	8.9	GSD	Site data FMLX	FMLX	Large variations in U conc in soil samples gives large parameter range. No action taken.
Zr			7	6.4E–03	1.3E–01	1.3E–01	3.9E+00	4.4	GSD	Site data FMLX	FMLX	

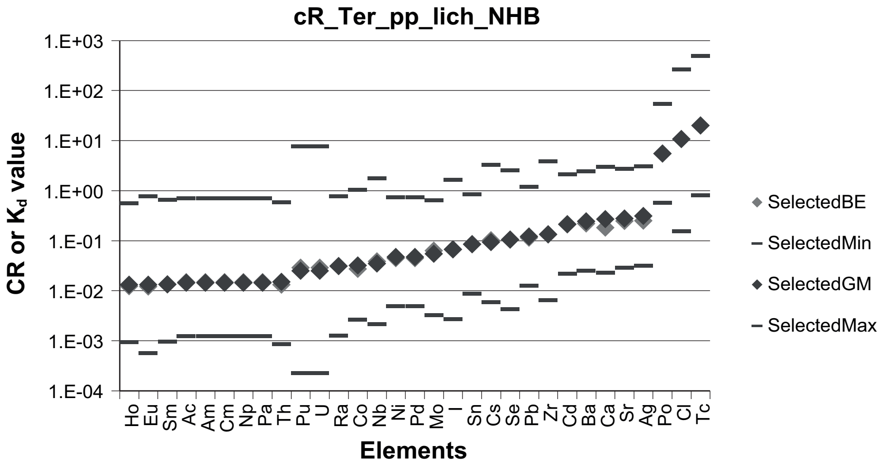

Figure 6-4. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value* (kg_{dw}/kg_{fw}).

6.2 cR_Ter_pp, cR_Ter_pp_grass_NHB, cR_Ter_pp_shrub_NHB, cR_Ter_pp_tree_NHB

The parameter cR_Ter_pp represents the uptake of elements from the soil compartment into terrestrial primary producers. The primary producers represent the green part of "natural" vegetation (not cultivated), as defined in the radionuclide model description (Saetre et al. 2013). Mosses and lichens are not included, see Section 6.1. The parameters cR_Ter_pp_grass_NHB, cR_Ter_pp_shrub_NHB and cR_Ter_pp_tree_NHB are used to describe the element uptake in terrestrial grasses and herbs, shrubs and trees, respectively, in dose estimates to these organism types. cR_Ter_pp is given in the unit kg_{dw}/kg_C whereas the others are given in the unit kg_{dw}/kg_{fw}.

Vegetation samples assessed to adequately represent primary producers (the parameter cR_Ter_pp) are the following samples from FM and LX: field layer green part samples including herbs, Bowle's golden sedge, stone bramble, small cow-wheat and may lily (*Carex elata*, *Rubus saxatilis, Melampyrum sylvaticum* and *Maianthemum bifolium*) from Grolander and Roos (2009), Hannu and Karlsson (2006), Roos et al. (2007), Engdahl et al. (2006), shrub layer green parts samples including bilberry (*Vaccinium myrtillus*) and small specimens of ash (*Fraxinus excelsior*) from Engdahl et al. (2006), Hannu and Karlsson (2006), Grolander and Roos (2009) and tree layer green part samples including spruce, alder and oak (*Picea abies, Alnus glutinosa* and *Quercus robur*) from Engdahl et al. (2006), Hannu and Karlsson (2006), Grolander and Roos (2009). It may be argued that the terrestrial vegetation should be divided into smaller entities in the radionuclide model as well (not only for the assessment to non-human biota) and, therefore, the variation in element concentration among green parts of field, shrub and tree layers are investigated. As can be seen in Figure 6-5, the variations are not very large (all elements except Na and Br varies within an order of magnitude) and thus it is appropriate to treat all vegetation samples as 1 set of data. Also for the 3 parameters utilised in the non-human biota assessment (cR_Ter_pp_grass_NHB, cR_Ter_pp_shrub_NHB and cR_Ter_pp_tree_NHB) the total data set of terrestrial primary producers are utilissed without further division (the same data are used for all three parameters).

The corresponding upper soil layer samples from FM and LX, assessed to adequately represent the parameter cR_Ter_pp are further described in Section 6. CRs are estimated from vegetation and soil concentration values paired from FM and LX, respectively.

The literature data assessed to adequately represent the parameter cR_Ter_pp are the following: Data concerning wild grasses, and more specifically their spikes (ICRP 2011) are categorised as L1 data. Data concerning grasses, and more specifically their stems and shoots, for all soils (see corresponding text in Section 6.8) from IAEA (2010) are categorised as L2 data. Data from ERICA (Beresford et al. 2008a) concerning grasses and herbs are categorised as L3 data (Table 6-4). Somewhat different literature sources and priorities are set for the CRs utilised for non-human biota calculations (cR_Ter_pp_grass_NHB, cR_Ter_pp_shrub_NHB, cR_Ter_pp_tree_NHB). For NHB biota parameters, it is considered most important to select data for the right kind of organism. Therefore, if e.g. tree data are available, these will be prioritised above other data of the parameter cR_Ter_pp_tree_NHB, as will grass data be prioritised above other data of the parameter cR_Ter_pp_grass_NHB. If data for a relevant organism are available from several literature sources, ICRP (2011) data are classified higher than ERICA data (Beresford et al. 2008). In effect, site data are utilised for all elements and no literature data are selected for parameterisation, although the available literature data sources for these 3 parameters are presented in separate tables, Table 6-5, Table 6-6 and Table 6-7).

Data for primary producers are available for nearly all the elements of interest. Site data are available for the following 20 elements: Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Ra, Sm, Sn, Sr, Th, U and Zr (Figure 6-8 and Table 6-4). In addition, literature data are available to varying degree. Literature data alone are available for Ag, Am, Cm, Np, Po, Pu, Se and Tc. Neither site nor literature data are available for Ac, Pa and Pd (Figure 6-8 and Table 6-4).

The results of various sense checks for the parameter cR_Ter_pp are shown in Table 6-4. When site data are compared to the total literature data range, the results indicate that site and literature data correlate for all elements except Cd. The site data are lower for Cd and show no overlap with the literature data range. The FM and LX data encompass the total literature data range for Ba. When the ranges from FM and LX are compared, overlaps are found for all elements, which indicates that the data from the two sites are consistent. Comparisons of literature data ranges are possible for 14 elements: Am, Cd, Cl, Cs, Ni, Pb, Po, Pu, Ra, Se, Sr, Tc, Th and U, and in all cases the ranges overlap, which indicates that the different data classes are consistent.

Literature data for the parameters cR_Ter_pp_grass_NHB, cR_Ter_pp_shrub_NHB and cR_Ter_pp_Tree_NHB are shown in Table 6-5, Table 6-6 and Table 6-7. The comparisons of literature data sources show that the different data classes are consistent in these cases as well. There is only 1 element and parameter (Am for the parameter cR_Ter_pp_shrub_NHB) where no overlap are found among the chosen literature data.

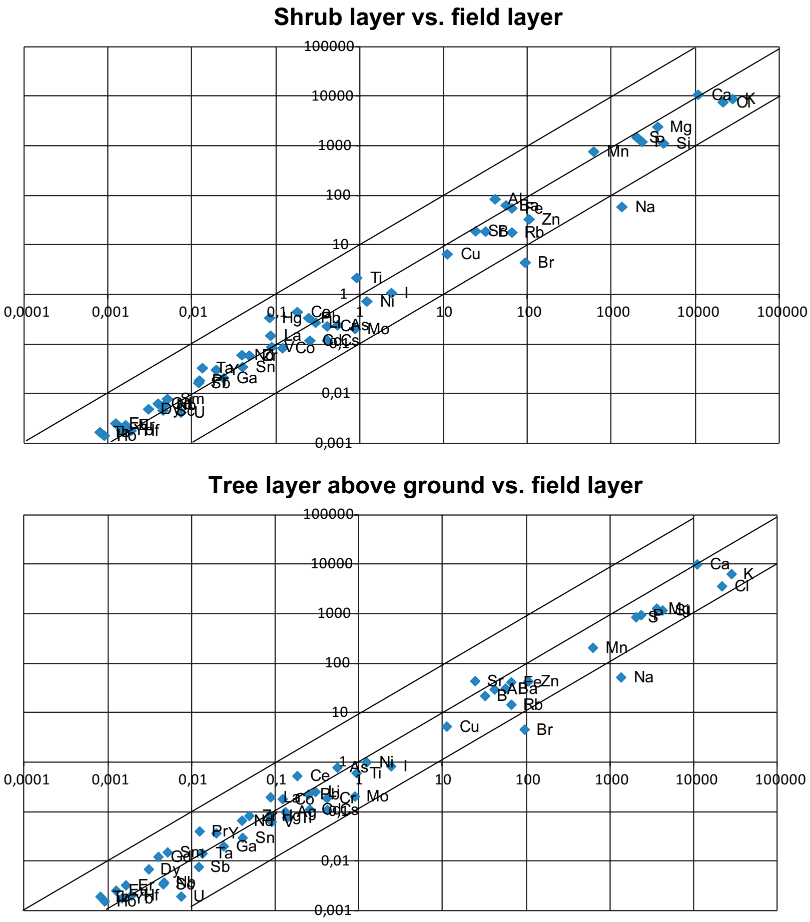

Figure 6-5. *Element concentrations in green parts of shrub layer samples compared to field layer samples (upper) and green part of tree layer samples compared to field layer samples (lower).*

The values selected for the parameter cR_Ter_pp are shown in Table 6-8 and Figure 6-9. As mentioned earlier, a good amount of relevant site data are available for many elements and, therefore, site data values are selected as parameter values for the parameter cR_Ter_pp in all of the element cases. The same parameterisation choices that are made for the parameter cR_Ter_pp are also made for the parameters cR_Ter_pp_grass_NHB, cR_Ter_pp_shrub_NHB and cR_Ter_pp_Tree_NHB. The selected values for the NHB parameters differ in unit from the cR_Ter_pp parameter and are shown in Table 6-9 to Table 6-11 and in Figure 6-10 to Figure 6-12. Element-specific site data are not available for Ac, Am, Cm, Np, Pa, Pd and Pu, although site data for relevant EAs are available and utilised for parameterisation (La, La, La, La, La, Ni and U, respectively). Cereal site data (Section 6.6) that are considered relevant PAs to primary producer data are selected for Ag, Po, Se and Tc. Element-specific cereal data are available for Ag and Se. In the case of Po and Tc, cereal site data for analogues Bi and Re, respectively, are selected for parameterisation.

A comparison of CRs for wild vegetation and cereals, based on site data (Figure 6-6), indicate a spread around the 1:1-line, although for most elements the divergence between the two data sources are within 1 order of magnitude. Comparisons of CRs based on site data for wild vegetation with literature data for grasses and shrubs (Figure 6-7), indicate that literature data for most elements have a higher CR and that the divergence can be more than 2 orders of magnitude. A variation in CR for Cl among plant species in the order of 3- to 6-fold are presented by Sheppard et al. (1999), who claims that this is comparable to other observations of the variation for a single plant species across many sites. The higher CR value for Cl in FM could be expected, as a result of sea spray in that coastal area. The CR values for P from ERICA are the same as for C, which were derived from specific activity models (Beresford et al. 2008a). For S, ERICA utilises a value from Copplestone et al. (2001). This value is used for the short-lived radionuclide S-35 (half-life of 87.4 days), which is taken up from air and the uptake is modelled with a specific activity model in that particular study. The CR is said to be a conservative CR, for leafy crops from Kluczewski et al. (1987).

The reasonable GSD range for parameter cR_Ter_pp value are assessed to span from 3 GSDmin to 7 GSDmax with a GSDmean value of 4 (Section 4.3). A GSDmin is appointed to 5 elements: Cd, Ni, Pb, Pd and Sr, a GSDmean to 5 elements: Cl, Eu, Ho, Ra and Sn, and a GSDmax to 8 elements: Ag, Np, Pa, Po, Pu, Se, Tc and Th. None of the selected data for cR_Ter_pp show GSD values above 7 (which is the GSDmax).

As in other terrestrial parameter cases (cR_agri_veg, cR_agri_cereal and cR_Ter_Mush), lanthanides (Sm, Eu and Ho) and actinides (U, Ac, Am, Cm, Pu, Th, Pa and Np) indicate low CR values that often are clustered since EAs are utilised for many of these elements (Figure 6-9). Po and Nb are among the low CR elements as well. Cl, Ca, Sr, Ba, Cd, Cs and Mo are the elements that indicate the highest CRs. These elements retain high-ranking values in nearly all other parameter cases (see respective figure for the other terrestrial CR parameters).

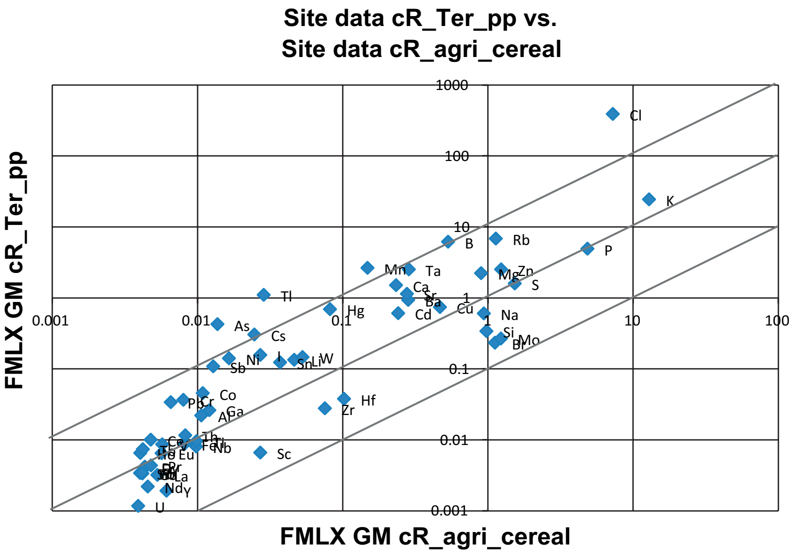

Figure 6-6. CR for wild vegetation compared to CR for cereals, based on site data.

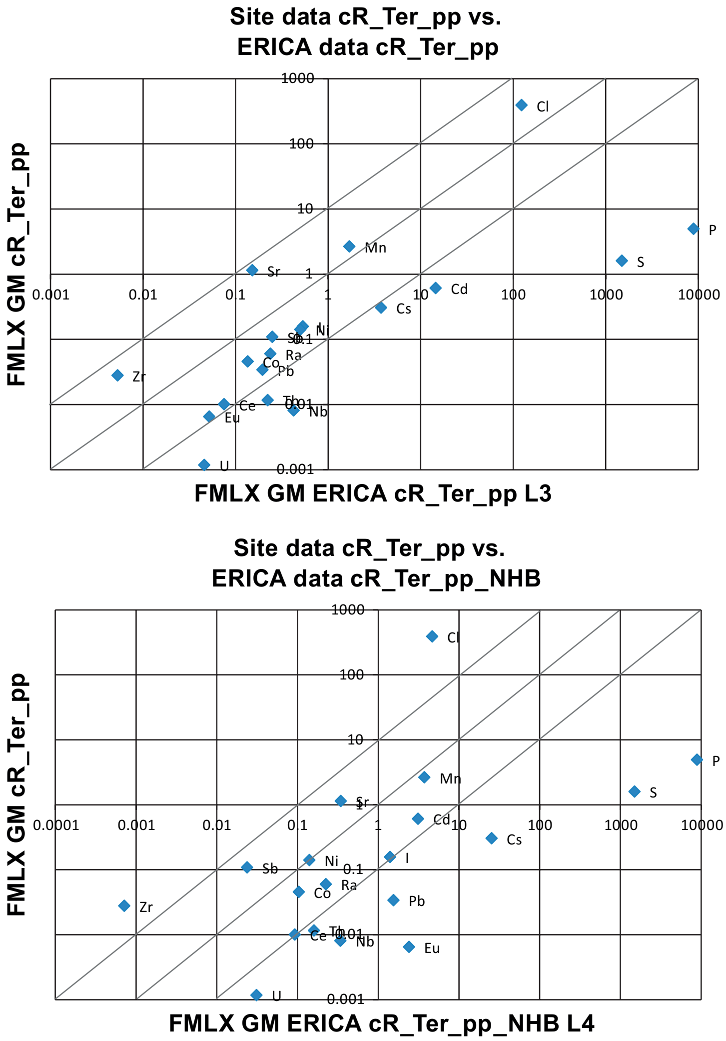

Figure 6-7. CR for wild vegetation (site data) compared to CR for grasses and herbs in ERICA (Beresford et al. 2008a) and CR for shrubs in ERICA (Beresford et al. 2008a).

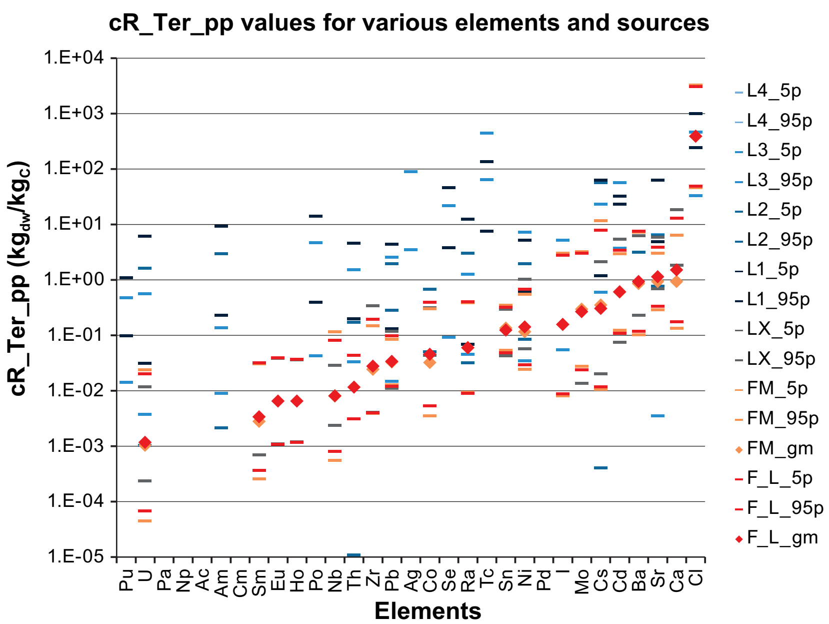

Figure 6-8. Total available data ranges for the parameter cR_Ter_pp for the elements of primary concern (kg_{dw}/kg_C).The elements are arranged in the same order as in Figure 6-9 showing selected parameter values.

Table 6-4. All available data for the parameter cR_Ter_pp (kg_{dw}/kg_C) for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ICRP 2011 Terrestrail Wild grass, L2 = IAEA 2010 Grasses All soils, L3 = ERICA (Beresford et al. 2008a) Terrestrial Grasses & Herbs.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag						13							2.7						1:0/0
Am				23	7	40					3.1	9.0	2.3						3:2/3
Ba	28/8	8/10	36/18		3			3.7	2.7	3.5		1.3			S2(L19%)	S2(L21%)	S3	S3	1:0/0
Ca	28/8	8/10	36/18					3.2	2.0	3.7								S2(L32%)	0:0/0
Cd	28/8	8/10	36/18	200		530		2.6	3.7	2.9	1.1		2.3		S4	S2(L8%)	S4	S1	2:1/1
Cl	25/8		25/8	8		22		3.7		3.5	1.5		2.2		S2(U72%)		S2(U72%)		2:1/1
Cm						20													1:0/0
Co	28/8	8/10	36/18		4	112		3.9	1.8	3.7		2.2			S2(L40%)	S2(L92%)	S2(L47%)	S2(L43%)	2:0/0
Cs	28/8	8/10	36/18	1,068	64	433		8.4	4.1	7.2	3.3	36.6	3.0		S1	S1	S1	S3	3:3/3
Eu		8/9	8/9			1			3.0	3.0									1:0/0
Ho		8/6	8/6						2.8	2.9									0:0/0
I	25/5		25/5			39		6.1		5.8			4.0		S2(L67%)		S2(L68%)		1:0/0
La	28/8	8/10	36/18		4			5.5	3.1	5.6		2.3			S2(U5%)	S4	S4	S2(L52%)	1:0/0
Mo	28/8	8/10	36/18					4.3	5.1	4.4								S2(U98%)	0:0/0
Nb	28/7	8/10	36/17			1		5.1	2.1	4.1								S3	1:0/0
Ni	28/8	8/10	36/18	58	38	111		2.6	2.4	2.6	1.9	2.6	5.1		S2(L88%)	S1	S2(L94%)	S2(L72%)	3:3/3
Np						20													1:0/0
Pa																			0:0/0
Pb	28/5	8/10	36/15	72	17	223		1.8	2.1	1.9	2.9	1.8	4.8		S2(L92%)	S2(L87%)	S2(L89%)	S1	3:3/3
Pd																			0:0/0
Po				22		34					3.0		4.2						2:1/1
Pu				5	2	73					2.1		2.9						3:1/1
Ra	25/6		25/6	168	62	32		3.1		3.2	4.8	4.0	2.7		S2(L66%)		S2(L66%)		3:3/3
Se				48		158					2.1		5.3						2:1/1
Sm	28/5	8/10	36/15					4.3	3.2	3.9								S2(L78%)	0:0/0
Sn	28/1	8/3	36/4					1.8	1.8	1.8								S2(U91%)	0:0/0
Sr	28/8	8/10	36/18	36	50	33		2.0	1.9	2.1	2.2	1.9	9.8		S1	S1	S1	S2(L62%)	3:3/3
Tc				6		18					2.4		1.8						2:1/1
Th		8/1	8/1	30	1	12			2.2	2.2	2.6	18.8	3.2			S1	S1		3:2/3
U	28/8	8/10	36/18	151	147	84		6.8	3.3	5.6	5.0	9.4	4.6		S2(L50%)	S2(L62%)	S2(L52%)	S3	3:3/3
Zr	28/6	8/10	36/16			1		3.0	3.8	3.3								S2(L99%)	1:0/0

Table 6-5. Available literature data for parameterisation of cR_Ter_pp_grass_NHB (kg_{dw}/kg_{fw}). The available site data are not included (see Table 6-4). L1 = ICRP 2011 Terrestrail Wild grass, L3 = ERICA (Beresford et al. 2008a) Terrestrial Grasses & Herbs. L4 = IAEA 2010 Grasses All soils.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					13							2.7							1:0/0
Am				23	40		7				3.1	2.3		9.0					3:2/3
Ba							3							1.3					1:0/0
Ca																			0:0/0
Cd				200	530						1.1	2.3							2:1/1
Cl				8	22						1.5	2.2							2:1/1
Cm					20														1:0/0
Co					112		4							2.2					2:0/0
Cs				1,068	433		64				3.3	3.0		36.6					3:3/3
Eu					1														1:0/0
Ho																			0:0/0
I					39							4.0							1:0/0
Mo																			0:0/0
Nb					1														1:0/0
Ni				58	111		38				1.9	5.1		2.6					3:3/3
Np					20	3							3.7						2:0/0
Pa																			0:0/0
Pb				72	223		17				2.9	4.8		1.8					3:3/3
Pd																			0:0/0
Po				22	34						3.0	4.2							2:1/1
Pu				5	73		2				2.1	2.9							3:1/1
Ra				168	32		62				4.8	2.7		4.0					3:3/3
Se				48	158						2.1	5.3							2:1/1
Sm																			0:0/0
Sn																			0:0/0
Sr				36	33		50				2.2	9.8		1.9					3:3/3
Tc				6	18						2.4	1.8							2:1/1
Th				30	12		1				2.6	3.2		18.8					3:2/3
U				151	84		147				5.0	4.6		9.4					3:3/3
Zr					1														1:0/0

Table 6-6. Available data for parameterisation of cR_Ter_pp_shrub_NHB (kg_{dw}/kg_{fw}). Available site data are not included (see Table 6-4). L2 = ERICA (Beresford et al. 2008a) Terrestrial Shrubs, L2 = ICRP 2011 Terrestrial Wild grass, L3 = ICRP 2011 Terrestrial Pine tree, L4 = ERICA (Beresford et al. 2008a) Terrestrial Grasses & Herbs.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				1			13							2.7					2:0/0
Am				1	23		40					3.1		2.3					3:0/1
Ba						3							1.8						1:0/0
Ca																			0:0/0
Cd				210	200		530				3.2	1.1		2.3					3:2/3
Cl				79	8	5	22				3.5	1.5	2.2	2.2					4:4/6
Cm				1			20												2:0/0
Co				11		3	112				18.6		1.9						3:1/1
Cs				196	1,068	235	433				2.6	3.3	3.2	3.0					4:5/6
Eu				12		2	1												3:0/0
Ho																			0:0/0
I				1			39							4.0					2:0/0
Mo																			0:0/0
Nb				1			1												2:0/0
Ni				64	58		111				3.8	1.9		5.1					3:3/3
Np				13			20				9.7								2:0/0
Pa																			0:0/0
Pb				120	72	10	223				3.2	2.9	1.7	4.8					4:6/6
Pd																			0:0/0
Po				14	22	10	34				1.8	3.0	1.7	4.2					4:6/6
Pu				1	5		73					2.1		2.9					3:1/1
Ra				10	168	10	32				1.4	4.8	2.4	2.7					4:3/6
Se				73	48		158				2.0	2.1		5.3					3:3/3
Sm						3							2.0						1:0/0
Sn																			0:0/0
Sr				175	36	77	33				2.3	2.2	4.1	9.8					4:5/6
Tc				1	6		18					2.4		1.8					3:1/1
Th				1	30	5	12					2.6	3.6	3.2					4:1/3
U				496	151	13	84				3.6	5.0	2.0	4.6					4:6/6
Zr				64			1				2.1								2:0/0

Table 6-7. Available data for parameterisation of cR_Ter_pp_tree_NHB. Available site data are not included (see Table 6-4). L1 = ICRP 2011 Terrestrial Pine tree, L2 = ERICA (Beresford et al. 2008a) Terrestrial Tree, L3 = ICRP 2011 Terrestrial Wild grass, L4 = ERICA (Beresford et al. 2008a) Terrestrial Shrub.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					1		1												2:0/0
Am					1	23	1						3.1						3:0/0
Ba				3							1.8								1:0/0
Ca																			0:0/0
Cd					228	200	210					3.3	1.1	3.2					3:2/3
Cl				5	11	8	79				2.2	2.1	1.5	3.5					4:3/6
Cm					2		1					2.5							2:0/0
Co				3	3		11				1.9	2.1		18.6					3:2/3
Cs				235	181	1,068	196				3.2	3.0	3.3	2.6					4:5/6
Eu				2	1		12												3:0/0
Ho																			0:0/0
I					1		1												2:0/0
Mo																			0:0/0
Nb					1		1												2:0/0
Ni					3	58	64					1.3	1.9	3.8					3:2/3
Np					1		13							9.7					2:0/0
Pa																			0:0/0
Pb				10	42	72	120				1.7	2.9	2.9	3.2					4:6/6
Pd																			0:0/0
Po				10	20	22	14				1.7	1.7	3.0	1.8					4:6/6
Pu					1	5	1						2.1						3:0/0
Ra				10	20	168	10				2.4	2.5	4.8	1.4					4:2/6
Se					1	48	73						2.1	2.0					3:1/1
Sm				3							2.0								1:0/0
Sn																			0:0/0
Sr				77	7	36	175				4.1	1.4	2.2	2.3					4:4/6
Tc					1	6	1						2.4						3:0/0
Th				5	83	30	1				3.6	2.3	2.6						4:1/3
U				13	521	151	496				2.0	3.6	5.0	3.6					4:6/6
Zr					1		64							2.1					2:0/0

Table 6-8. Selected data properties, references and comments for the parameter cR_Ter_pp (kg_{dw}/kg_C) for the elements of primary concern.

Ele-ment	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La		18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	5.6	GSD	Site data FMLX	FMLX	No site data available. Good amount of relevant FMLX data is available for La, which is assessed to be areasonable EA.
Ag		cR_agri_cereal	10	1.7E–03	4.2E–02	4.2E–02	1.0E+00	7.0	GSDmax	Site data FM	FM	Neither site nor literature data available. However, site data for Ag and cereals are available. cR_agri_cereal is assessed to be a relevant PA.
Am	La		18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	5.6	GSD	Site data FMLX	FMLX	No site data available. Good amount of relevant FMLX data is available for La, which is assessed to be areasonable EA.
Ba			18	5.5E–02	9.3E–01	8.6E–01	3.1E+01	3.5	GSD	Site data FMLX	FMLX	A good amount of FMLX data available.
Ca			18	8.8E–02	1.5E+00	9.3E–01	2.8E+01	3.7	GSD	Site data FMLX	FMLX	A good amount of FMLX data available.
Cd			18	4.4E–02	6.1E–01	6.0E–01	1.8E+01	3.0	GSDmin	Site data FMLX	FMLX	A good amount of FMLX data available.. The data variation has been adjusted to a reasonable GSDmin.
Cl			8	7.1E+00	3.9E+02	3.9E+02	7.1E+03	4.0	GSDmean	Site data FM	FM	A sufficient amount of relevant FM data available. The data variation has been adjusted to a reasonable GSDmean.
Cm	La		18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	5.6	GSD	Site data FMLX	FMLX	No site data available. Good amount of relevant FMLX data is available for La, which is assessed to be areasonable EA.
Co			18	2.1E–03	4.5E–02	3.2E–02	1.3E+00	3.7	GSD	Site data FMLX	FMLX	A good amount of FMLX data available.
Cs			18	9.0E–03	3.0E–01	3.5E–01	4.0E+01	7.2	GSD	Site data FMLX	FMLX	A good amount of FMLX data available.
Eu			8	6.1E–04	6.5E–03	6.5E–03	6.3E–02	4.0	GSDmean	Site data LX	LX	An sufficient amount of relevant LX data available. The data variation has been adjusted to a reasonable GSDmean.
Ho			6	6.7E–04	6.5E–03	6.5E–03	6.4E–02	4.0	GSDmean	Site data LX	LX	An sufficient amount of relevant LX data available. The data variation has been adjusted to a reasonable GSDmean.
I			5	6.7E–03	1.6E–01	1.6E–01	1.3E+01	5.8	GSD	Site data FM	FM	An sufficient amount of FM data available.
Mo			18	7.0E–03	2.7E–01	3.0E–01	7.0E+00	4.4	GSD	Site data FMLX	FMLX	A good amount of FMLX data available.
Nb			17	5.8E–04	8.1E–03	8.0E–03	4.9E–01	4.1	GSD	Site data FMLX	FMLX	A good amount of FMLX data available.
Ni			18	2.0E–02	1.4E–01	1.2E–01	2.5E+00	3.0	GSDmin	Site data FMLX	FMLX	A good amount of FMLX data available.. The data variation has been adjusted to a reasonable GSDmin.
Np	La		18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	5.6	GSD	Site data FMLX	FMLX	No site data available. Good amount of relevant FMLX data is available for La, which is assessed to be areasonable EA.
Pa	La		18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	5.6	GSD	Site data FMLX	FMLX	No site data available. Good amount of relevant FMLX data is available for La, which is assessed to be areasonable EA.
Pb			15	5.6E–03	3.4E–02	3.3E–02	2.1E–01	3.0	GSDmin	Site data FMLX	FMLX	A good amount of FMLX data available.. The data variation has been adjusted to a reasonable GSDmin.
Pd	Ni		18	2.0E–02	1.4E–01	1.2E–01	2.5E+00	3.0	GSDmin	Site data FMLX	FMLX	No site data for Pd available. However, site data are available for the relevant EA Ni.

Ele-ment	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Po	Bi	cR_agri_cereal	10	2.7E–04	6.5E–03	6.5E–03	1.6E–01	7.0	GSDmax	Site data FM	FM	No site data and no relevant EA available. For Bi that is assessed to be a relevant element analogue, cereal site data (cR_agri_cereal) are available.
Pu	U		18	1.9E–05	1.2E–03	1.0E–03	3.1E–01	5.6	GSD	Site data FMLX	FMLX	No site data available. Good amount of FMLX data available for U, which is assessed to be areasonable EA.
Ra			6	6.1E–03	6.0E–02	6.0E–02	9.8E–01	4.0	GSDmean	Site data FM	FM	A sufficient amount of FM data available. The data variation has been adjusted to a reasonable GSDmean.
Se		cR_agri_cereal	6	2.3E–03	5.6E–02	5.6E–02	1.4E+00	7.0	GSDmax	Site data FM	FM	No site data are available. No adequate EA data are available. However, Se site data for cereals (cR_agri_cereal) are available and have been assessed to be the best available parametrisation option.
Sm			15	2.8E–04	3.4E–03	2.8E–03	9.8E–02	3.9	GSD	Site data FMLX	FMLX	A good amount of FMLX data available.
Sn			4	1.3E–02	1.2E–01	1.4E–01	1.2E+00	4.0	GSDmean	Site data FMLX	FMLX	A sufficient amount of FMLX data available. The data variation has been adjusted to a reasonable GSDmean.
Sr			18	1.9E–01	1.1E+00	9.3E–01	9.7E+00	3.0	GSDmin	Site data FMLX	FMLX	A good amount of FMLX data available. The data variation has been adjusted to a reasonable GSDmin.
Tc	Re	cR_agri_cereal	9	9.0E–04	6.4E–02	6.4E–02	4.5E+00	7.0	GSDmax	Site data FM	FM	No site data and no relevant EA available. For Re that is assessed to be a relevant element analogue, cereal site data (cR_agri_cereal) are available.
Th			1	4.7E–04	1.2E–02	1.2E–02	2.9E–01	7.0	GSDmax	Site data LX	LX	An acceptable amount of LX data available. The data variation has been adjusted to a reasonable GSDmax.
U			18	1.9E–05	1.2E–03	1.0E–03	3.1E–01	5.6	GSD	Site data FMLX	FMLX	A good amount of FMLX data available.
Zr			16	2.5E–03	2.8E–02	2.4E–02	6.2E–01	3.3	GSD	Site data FMLX	FMLX	A good amount of FMLX data available.

Table 6-9. Selected data properties, references and comments for the parameter cR_Ter_pp_grass_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.

Ele-ment	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ag		cR_agri_cereal	10	1.9E–04	4.6E–03	4.6E–03	1.1E–01	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected.
Am	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ba		cR_Ter_pp_NHB	18	4.7E–03	1.1E–01	1.1E–01	3.7E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ca		cR_Ter_pp_NHB	18	7.5E–03	1.9E–01	1.2E–01	4.6E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cd		cR_Ter_pp_NHB	18	3.1E–03	7.5E–02	7.6E–02	1.9E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cl		cR_Ter_pp_NHB	8	1.0E+00	4.9E+01	4.9E+01	1.2E+03	7.0	GSDmax	Site data FM	FM	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cm	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Co		cR_Ter_pp_NHB	18	2.3E–04	5.6E–03	4.1E–03	1.7E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cs		cR_Ter_pp_NHB	18	1.1E–03	3.8E–02	4.4E–02	5.1E+00	7.2	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Eu		cR_Ter_pp_NHB	8	3.1E–05	7.6E–04	7.6E–04	1.9E–02	7.0	GSDmax	Site data LX	LX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ho		cR_Ter_pp_NHB	6	3.1E–05	7.7E–04	7.7E–04	1.9E–02	7.0	GSDmax	Site data LX	LX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
I		cR_Ter_pp_NHB	5	7.8E–04	1.9E–02	1.9E–02	1.5E+00	7.0	GSDmax	Site data FM	FM	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Mo		cR_Ter_pp_NHB	18	8.7E–04	3.3E–02	3.7E–02	8.1E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Nb		cR_Ter_pp_NHB	17	4.0E–05	9.9E–04	1.0E–03	5.4E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ni		cR_Ter_pp_NHB	18	7.1E–04	1.7E–02	1.5E–02	4.3E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Np	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	5.6	GSD	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Pa	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Pb		cR_Ter_pp_NHB	15	1.7E–04	4.1E–03	4.1E–03	1.0E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Pd	Ni	cR_Ter_pp_NHB	18	7.1E–04	1.7E–02	1.5E–02	4.3E–01	7.0	GSDmax	Site data FMLX	FMLX	Ni used as EA (site data are available).
Po	Bi	cR_agri_cereal	10	2.9E–05	7.2E–04	7.2E–04	1.8E–02	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected. Bi used as EA.
Pu	U	cR_Ter_pp	18	2.4E–06	1.4E–04	1.3E–04	3.4E–02	5.6	GSD	Site data FMLX	FMLX	U used as EA (site data are available)
Ra		cR_Ter_pp_NHB	6	2.8E–04	6.9E–03	6.9E–03	1.7E–01	7.0	GSDmax	Site data FM	FM	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Se		cR_agri_cereal	6	2.5E–04	6.2E–03	6.2E–03	1.5E–01	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected.
Sm		cR_Ter_pp_NHB	15	1.7E–05	4.1E–04	3.5E–04	1.1E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Sn		cR_Ter_pp_NHB	4	5.8E–04	1.4E–02	1.5E–02	3.5E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Sr		cR_Ter_pp_NHB	18	5.7E–03	1.4E–01	1.2E–01	3.4E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Tc	Re	cR_agri_cereal	9	1.0E–04	7.1E–03	7.1E–03	5.1E–01	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected. Re used as EA.
Th		cR_Ter_pp_NHB	1	5.6E–05	1.4E–03	1.4E–03	3.4E–02	7.0	GSDmax	Site data LX	LX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
U		cR_Ter_pp_NHB	18	2.4E–06	1.4E–04	1.3E–04	3.4E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Zr		cR_Ter_pp_NHB	16	1.4E–04	3.4E–03	3.0E–03	8.3E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.

Table 6-10. Selected data properties, references and comments for the parameter cR_Ter_pp_shrub_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ag		cR_agri_cereal	10	1.9E–04	4.6E–03	4.6E–03	1.1E–01	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected.
Am	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ba		cR_Ter_pp_NHB	18	4.7E–03	1.1E–01	1.1E–01	3.7E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ca		cR_Ter_pp_NHB	18	7.5E–03	1.9E–01	1.2E–01	4.6E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cd		cR_Ter_pp_NHB	18	3.1E–03	7.5E–02	7.6E–02	1.9E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cl		cR_Ter_pp_NHB	8	1.0E+00	4.9E+01	4.9E+01	1.2E+03	7.0	GSDmax	Site data FM	FM	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cm	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Co		cR_Ter_pp_NHB	18	2.3E–04	5.6E–03	4.1E–03	1.7E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cs		cR_Ter_pp_NHB	18	1.1E–03	3.8E–02	4.4E–02	5.1E+00	7.2	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Eu		cR_Ter_pp_NHB	8	3.1E–05	7.6E–04	7.6E–04	1.9E–02	7.0	GSDmax	Site data LX	LX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ho		cR_Ter_pp_NHB	6	3.1E–05	7.7E–04	7.7E–04	1.9E–02	7.0	GSDmax	Site data LX	LX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
I		cR_Ter_pp_NHB	5	7.8E–04	1.9E–02	1.9E–02	1.5E+00	7.0	GSDmax	Site data FM	FM	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Mo		cR_Ter_pp_NHB	18	8.7E–04	3.3E–02	3.7E–02	8.1E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Nb		cR_Ter_pp_NHB	17	4.0E–05	9.9E–04	1.0E–03	5.4E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ni		cR_Ter_pp_NHB	18	7.1E–04	1.7E–02	1.5E–02	4.3E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Np	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	5.6	GSD	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Pa	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Pb		cR_Ter_pp_NHB	15	1.7E–04	4.1E–03	4.1E–03	1.0E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Pd	Ni	cR_Ter_pp_NHB	18	7.1E–04	1.7E–02	1.5E–02	4.3E–01	7.0	GSDmax	Site data FMLX	FMLX	Ni used as EA (site data are available).
Po	Bi	cR_agri_cereal	10	2.9E–05	7.2E–04	7.2E–04	1.8E–02	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was used. Bi used as EA.
Pu	U	cR_Ter_pp	18	2.4E–06	1.4E–04	1.3E–04	3.4E–02	5.6	GSD	Site data FMLX	FMLX	U used as EA (site data are available).
Ra		cR_Ter_pp_NHB	6	2.8E–04	6.9E–03	6.9E–03	1.7E–01	7.0	GSDmax	Site data FM	FM	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Se		cR_agri_cereal	6	2.5E–04	6.2E–03	6.2E–03	1.5E–01	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected.
Sm		cR_Ter_pp_NHB	15	1.7E–05	4.1E–04	3.5E–04	1.1E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Sn		cR_Ter_pp_NHB	4	5.8E–04	1.4E–02	1.5E–02	3.5E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Sr		cR_Ter_pp_NHB	18	5.7E–03	1.4E–01	1.2E–01	3.4E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Tc	Re	cR_agri_cereal	9	1.0E–04	7.1E–03	7.1E–03	5.1E–01	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was used. Re used as EA.
Th		cR_Ter_pp_NHB	1	5.6E–05	1.4E–03	1.4E–03	3.4E–02	7.0	GSDmax	Site data LX	LX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
U		cR_Ter_pp_NHB	18	2.4E–06	1.4E–04	1.3E–04	3.4E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Zr		cR_Ter_pp_NHB	16	1.4E–04	3.4E–03	3.0E–03	8.3E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.

Table 6-11. Selected data properties, references and comments for the parameter cR_Ter_pp_tree_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ag		cR_agri_cereal	10	1.9E–04	4.6E–03	4.6E–03	1.1E–01	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected.
Am	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ba		cR_Ter_pp_NHB	18	4.7E–03	1.1E–01	1.1E–01	3.7E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ca		cR_Ter_pp_NHB	18	7.5E–03	1.9E–01	1.2E–01	4.6E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cd		cR_Ter_pp_NHB	18	3.1E–03	7.5E–02	7.6E–02	1.9E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cl		cR_Ter_pp_NHB	8	1.0E+00	4.9E+01	4.9E+01	1.2E+03	7.0	GSDmax	Site data FM	FM	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cm	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Co		cR_Ter_pp_NHB	18	2.3E–04	5.6E–03	4.1E–03	1.7E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Cs		cR_Ter_pp_NHB	18	1.1E–03	3.8E–02	4.4E–02	5.1E+00	7.2	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Eu		cR_Ter_pp_NHB	8	3.1E–05	7.6E–04	7.6E–04	1.9E–02	7.0	GSDmax	Site data LX	LX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ho		cR_Ter_pp_NHB	6	3.1E–05	7.7E–04	7.7E–04	1.9E–02	7.0	GSDmax	Site data LX	LX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
I		cR_Ter_pp_NHB	5	7.8E–04	1.9E–02	1.9E–02	1.5E+00	7.0	GSDmax	Site data FM	FM	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Mo		cR_Ter_pp_NHB	18	8.7E–04	3.3E–02	3.7E–02	8.1E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Nb		cR_Ter_pp_NHB	17	4.0E–05	9.9E–04	1.0E–03	5.4E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Ni		cR_Ter_pp_NHB	18	7.1E–04	1.7E–02	1.5E–02	4.3E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Np	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	5.6	GSD	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Pa	La	cR_Ter_pp_NHB	18	1.4E–05	3.9E–04	2.5E–04	1.6E–02	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data are available). All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Pb		cR_Ter_pp_NHB	15	1.7E–04	4.1E–03	4.1E–03	1.0E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Pd	Ni	cR_Ter_pp_NHB	18	7.1E–04	1.7E–02	1.5E–02	4.3E–01	7.0	GSDmax	Site data FMLX	FMLX	Ni used as EA (site data are available).
Po	Bi	cR_agri_cereal	10	2.9E–05	7.2E–04	7.2E–04	1.8E–02	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected. Bi used as EA.
Pu	U	cR_Ter_pp	18	2.4E–06	1.4E–04	1.3E–04	3.4E–02	5.6	GSD	Site data FMLX	FMLX	U used as EA (site data are available).
Ra		cR_Ter_pp_NHB	6	2.8E–04	6.9E–03	6.9E–03	1.7E–01	7.0	GSDmax	Site data FM	FM	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Se		cR_agri_cereal	6	2.5E–04	6.2E–03	6.2E–03	1.5E–01	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected.
Sm		cR_Ter_pp_NHB	15	1.7E–05	4.1E–04	3.5E–04	1.1E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Sn		cR_Ter_pp_NHB	4	5.8E–04	1.4E–02	1.5E–02	3.5E–01	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Sr		cR_Ter_pp_NHB	18	5.7E–03	1.4E–01	1.2E–01	3.4E+00	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Tc	Re	cR_agri_cereal	9	1.0E–04	7.1E–03	7.1E–03	5.1E–01	7.0	GSDmax	Site data FM	FM	No site data for wild vegetation available so site data for cereals was selected. Re used as EA.
Th		cR_Ter_pp_NHB	1	5.6E–05	1.4E–03	1.4E–03	3.4E–02	7.0	GSDmax	Site data LX	LX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
U		cR_Ter_pp_NHB	18	2.4E–06	1.4E–04	1.3E–04	3.4E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.
Zr		cR_Ter_pp_NHB	16	1.4E–04	3.4E–03	3.0E–03	8.3E–02	7.0	GSDmax	Site data FMLX	FMLX	All terrestrial primary producers, except mosses and lichens, treated as 1 group.

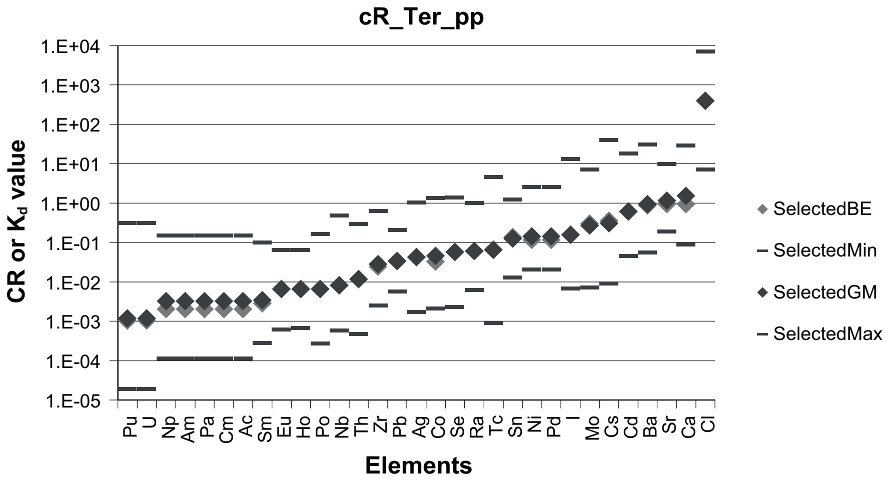

Figure 6-9. *Selected parameter values (best estimate, geometric mean, min and max values) for the parameter cR_Ter_pp arranged in ascending order based on the GM value (kg_{dw}/kg_C).*

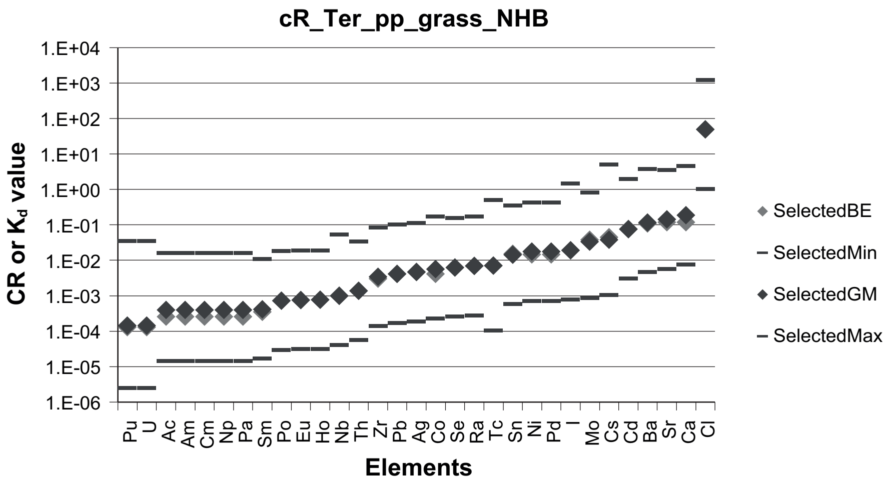

Figure 6-10. *Selected parameter values (best estimate, geometric mean, min and max values) for the parameter cR_Ter_pp_grass_NHB arranged in ascending order based on the GM value (kg_{dw}/kg_{fw}).*

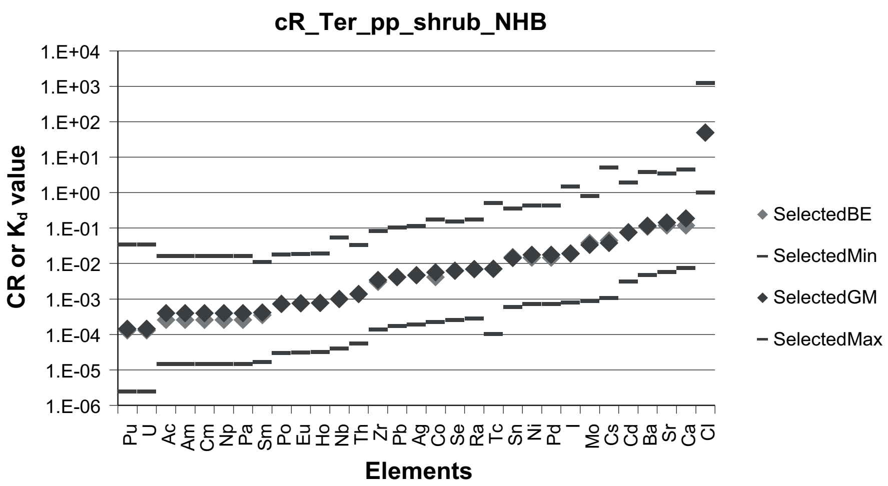

Figure 6-11. *Selected parameter values (best estimate, geometric mean, min and max values) for the parameter cR_Ter_pp_shrub_NHB arranged in ascending order based on the GM value (kg_{dw}/kg_{fw}).*

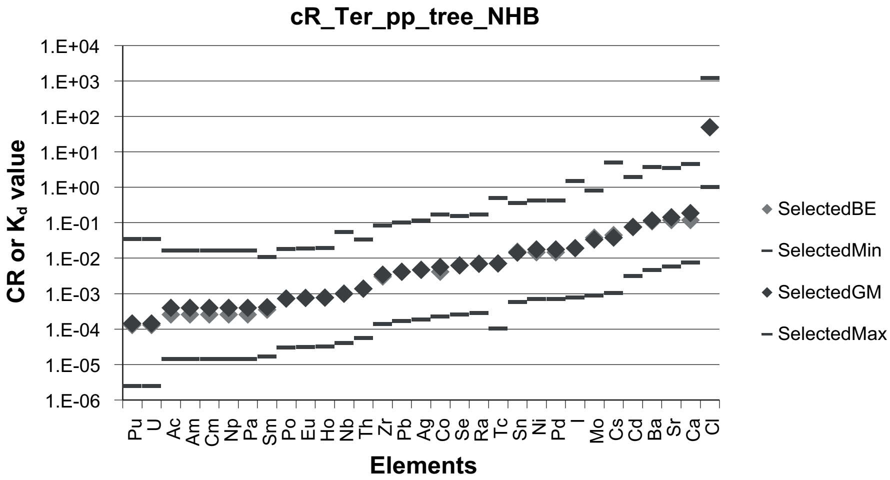

Figure 6-12. *Selected parameter values (best estimate, geometric mean, min and max values) for the parameter cR_Ter_pp_tree_NHB arranged in ascending order based on the GM value (kg_{dw}/kg_{fw}).*

6.3 cR_food_herbiv

The parameter cR_food_herbiv describes the uptake into terrestrial herbivores from the ingestion of terrestrial primary producers, as defined in the radionuclide model (Saetre et al. 2013). The parameter is presented in the unit of kg_C/kg_C, since it is a ratio of concentration in the primary producers and the meat of the terrestrial herbivores. It is the edible part of terrestrial herbivores that is of interest, i.e. the parameter represents the uptake into muscle tissue of herbivores consumed by humans (such as moose and roe deer).

Site data are available for Ba, Ca, Cd, Cl, Cs, I, La, Mo, Nb, Ni, Pb, Ra, Se, Sm, Sn, Sr, U and Zr. For I and Se, only FM data are available.

IAEA (2010) reports CR values for generic domestic animals based on data for cow, sheep and pig. Data are available for Ag, Ca, Cd, Cl, I, La, Mn, Mo, Nb Ni, Pb, Po, Pu, Ra, Se and U. Only arithmetic means are reported and information on sample numbers or variations are not available. These data are categorised L1 data.

When FM data are compared to LX data, a significant overlap is found for 12 elements: Ba, Ca, Cl, Cd, Cs, I, Mo, Nb, Sm, Sn, Sr, U and Zr. Pb, Ra and Ni show only a partial overlap, generally with higher values for FM data.

Since no variation is reported for data for generic domestic animals in IAEA (2010), comparisons of literature data and site data ranges cannot be made. IAEA (2010) reported ranges for some elements for cow, sheep and pig, though these data are limited and, therefore, not utilised. The GM for site data and literature data are plotted in Figure 6-13. In this comparison, it can be seen that the CR values reported for generic domestic animal meat by IAEA (2010) generally are lower than the site data for herbivore muscle tissue. For Nb and Th, the differences are several orders of magnitude. For Ra and U, the data are consistent. For the elements: Ca, Cd, Ni, Mo, Pb, Cl and Se, the difference is 1 order of magnitude. This concludes that utilising generic meat data probably underestimate the uptake in wild herbivores.

As can be seen in Table 6-12 data are missing for the elements: Ac, Am, Cm, Np, Pa, Pd and Tc, and EAs are utilised in these cases.

Data are missing for Am and Cm, and only 1 sample is reported from LX for Ho and Eu. For the analogue lanthanide series, site data are available for all elements except Pm, Tb and Lu. All reported GM fall between 0.1 and 1 kg_C/kg_C. FM data are in general higher than LX data. La data are selected for Am, Cm, Eu and Ho, while the reported Sm site data are utilised for Sm (n=8). La has the highest sample number among the lanthanides (n=30) and is therefore selected. La is also the element among the REEs that exists in the highest concentrations in the environment, thus minimizing data loss due to falling below reporting limits.

Data are missing for Np and Pa, and La is utilised as EA. As data are not available for Tc, site data for Zr are used as EA. Literature data (generic meat data from IAEA (2010)) are utilised for Ag, Po and Pu, The selected site data for Se and I are based on FM data alone. The selected data are presented in Table 6-13 and Figure 6-15. The selected GM span from 3.9E-5 kg_C/kg_C for Pu to 23.1 kg_C/kg_C for Cs.

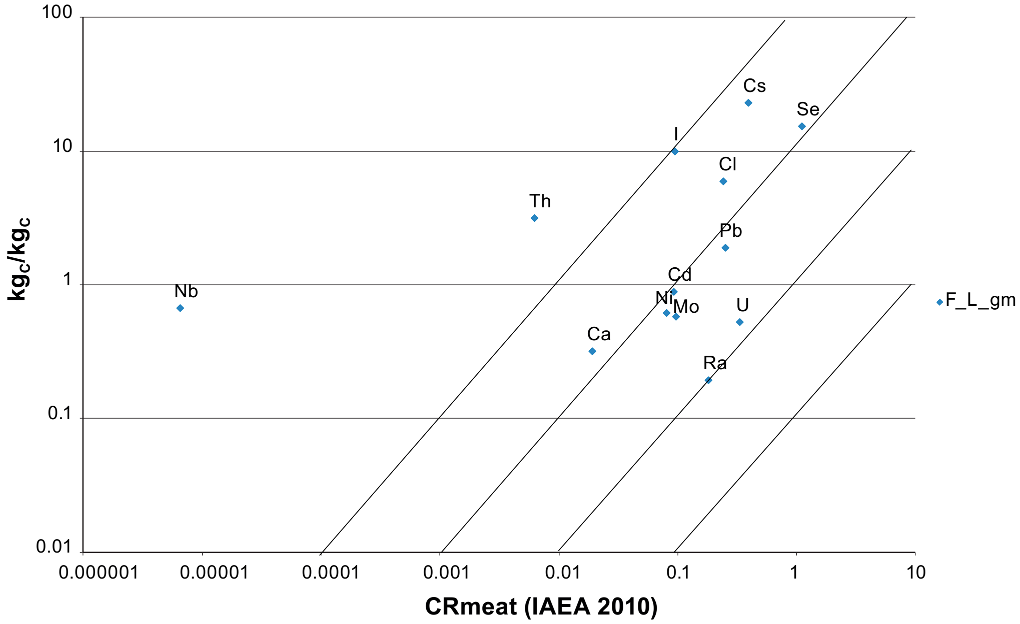

Figure 6-13. *GM for site data for herbivore muscle tissue versus reported GM for generic domestic animal meat (IAEA 2010) kg_C/kg_C.*

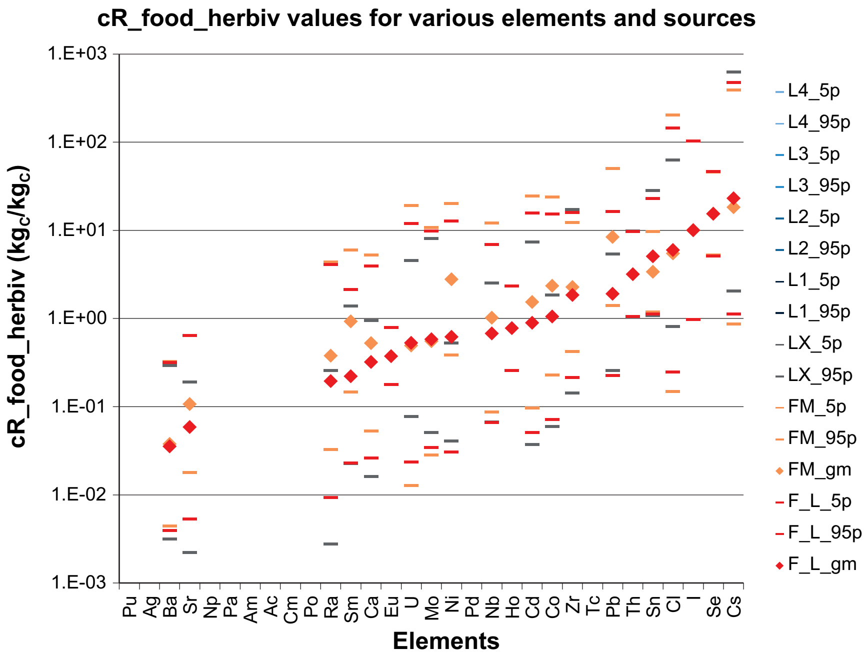

Figure 6-14. *Total available data ranges for the parameter cR_food_herbiv (kg_C/kg_C). The elements are arranged in the same order as in Figure 6-15 showing selected parameter values.*

Table 6-12. All available data for the parameter cR_food_herbiv for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010 generic meat.

Ele-ment	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba	21/18	13/12	34/30					3.7	4.0	3.8								S2(U97%)	0:0/0
Ca	21/18	13/15	34/33	1				4.0	3.4	4.6								S2(U62%)	1:0/0
Cd	18/10	13/14	31/24	1				5.4	5.0	5.7								S2(U78%)	1:0/0
Cl	21/18	13/15	34/33	1				9.0	3.8	6.9								S3	1:0/0
Cm																			0:0/0
Co	20/14	13/15	33/29	1				4.1	2.8	5.1								S2(U44%)	1:0/0
Cs	20/18	13/15	33/33	1				6.4	5.7	6.3								S2(L85%)	1:0/0
Eu		9/1	9/1						1.6	1.6									0:0/0
Ho		8/1	8/1						2.0	2.0									0:0/0
I	15/1		15/1	1				4.1		4.1									1:0/0
La	20/15	13/15	33/30	1				6.7	4.5	8.9								S2(U47%)	1:0/0
Mo	21/18	13/15	34/33	1				6.1	4.7	5.6								S3	1:0/0
Nb	18/13	13/15	31/28	1				4.5	3.0	4.1								S2(U68%)	1:0/0
Ni	20/5	13/8	33/13	1				3.3	2.2	6.2								S2(U7%)	1:0/0
Np																			0:0/0
Pa																			0:0/0
Pb	17/1	13/4	30/5	1				3.0	2.5	3.7								S2(U37%)	1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				1															1:0/0
Ra	6/2	2/2	8/4	1				4.4	4.0	6.3								S2(U42%)	1:0/0
Se	6/18		6/18	1				1.9		2.0									1:0/0
Sm	14/1	13/7	27/8					3.1	3.5	4.0								S2(U60%)	0:0/0
Sn	11/1	4/12	15/13					1.9	2.7	2.5								S1	0:0/0
Sr	21/14	13/13	34/27					3.0	3.9	4.3								S2(U66%)	0:0/0
Tc																			0:0/0
Th		1/5	1/5	1					2.0	2.0									1:0/0
U	18/11	13/10	31/21	1				9.2	3.4	6.6								S3	1:0/0
Zr	16/10	13/15	29/25					2.8	4.3	3.7								S1	0:0/0

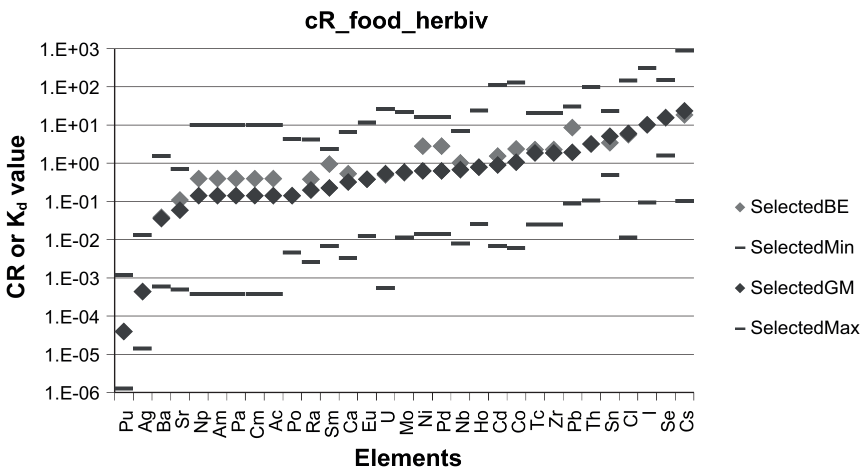

Figure 6-15. Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg_C/kg_C).

Table 6-13. Selected data properties, references and comments for the parameter cR_food_herbiv (kg_C/kg_C) for the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La		30	3.7E–04	1.4E–01	3.9E–01	1.0E+01	8.9	GSD	Site data FMLX	FMLX	Site data for La used as EA
Ag			1	1.4E–05	4.3E–04	4.3E–04	1.3E–02	8.0	GSDmax	IAEA 2010	L1	No site data available. Only 1 sample for generic meat reported by IAEA 2010 and this value is used in combination with GSDmax.
Am	La		30	3.7E–04	1.4E–01	3.9E–01	1.0E+01	8.9	GSD	Site data FMLX	FMLX	Site data for La used as analogue
Ba			30	5.9E–04	3.5E–02	3.8E–02	1.5E+00	3.8	GSD	Site data FMLX	FMLX	
Ca			33	3.2E–03	3.2E–01	5.2E–01	6.5E+00	4.6	GSD	Site data FMLX	FMLX	Ca data higher than Sr, Ba and Ra data
Cd			24	6.8E–03	8.9E–01	1.5E+00	1.1E+02	5.7	GSD	Site data FMLX	FMLX	
Cl			33	1.1E–02	6.0E+00	5.5E+00	1.4E+02	6.9	GSD	Site data FMLX	FMLX	Large range in site data.
Cm	La		30	3.7E–04	1.4E–01	3.9E–01	1.0E+01	8.9	GSD	Site data FMLX	FMLX	Site data for La used as EA
Co			29	6.0E–03	1.0E+00	2.3E+00	1.3E+02	5.1	GSD	Site data FMLX	FMLX	
Cs			33	1.0E–01	2.3E+01	1.8E+01	8.8E+02	6.3	GSD	Site data FMLX	FMLX	
Eu			1	1.2E–02	3.7E–01	3.7E–01	1.1E+01	8.0	GSDmax	Site data LX	LX	
Ho			1	2.5E–02	7.7E–01	7.7E–01	2.4E+01	8.0	GSDmax	Site data LX	LX	Site data for La used as EA
I			1	9.2E–02	1.0E+01	1.0E+01	3.1E+02	8.0	GSDmax	Site data FM	FM	Only 1 sample reported from FM. The value is orders of magnitude higher than the reported data for generic meat in IAEA 2010. FM data are used together with GSDmax.
Mo			33	1.1E–02	5.8E–01	5.5E–01	2.2E+01	5.6	GSD	Site data FMLX	FMLX	
Nb			28	8.0E–03	6.7E–01	1.0E+00	6.9E+00	4.1	GSD	Site data FMLX	FMLX	
Ni			13	1.4E–02	6.2E–01	2.8E+00	1.6E+01	6.2	GSD	Site data FMLX	FMLX	
Np	La		30	3.7E–04	1.4E–01	3.9E–01	1.0E+01	8.9	GSD	Site data FMLX	FMLX	Site data for La used as EA
Pa	La		30	3.7E–04	1.4E–01	3.9E–01	1.0E+01	8.9	GSD	Site data FMLX	FMLX	Site data for La used as EA
Pb			5	8.8E–02	1.9E+00	8.4E+00	3.0E+01	4.0	GSDmean	Site data FMLX	FMLX	
Pd	Ni		13	1.4E–02	6.2E–01	2.8E+00	1.6E+01	6.2	GSD	Site data FMLX	FMLX	Site data for Ni used as EA
Po			1	4.6E–03	1.4E–01	1.4E–01	4.3E+00	8.0	GSDmax	IAEA 2010	L1	1 sample for generic meat reported by IAEA 2010 and this value is used in combination with GSDmax.
Pu			1	1.3E–06	3.9E–05	3.9E–05	1.2E–03	8.0	GSDmax	IAEA 2010	L1	1 sample for generic meat reported by IAEA 2010 and this value is used in combination with GSDmax.
Ra			4	2.6E–03	1.9E–01	3.8E–01	4.1E+00	6.3	GSD	Site data FMLX	FMLX	
Se			6	1.6E+00	1.5E+01	1.5E+01	1.5E+02	4.0	GSDmean	Site data FM	FM	No Laxemar-Simpevarp data avalaiable. Forsmark data used.
Sm			8	6.7E–03	2.2E–01	9.3E–01	2.3E+00	4.0	GSDmean	Site data FMLX	FMLX	
Sn			13	4.8E–01	5.1E+00	3.4E+00	2.3E+01	2.5	GSD	Site data FMLX	FMLX	
Sr			27	4.9E–04	5.9E–02	1.1E–01	6.9E–01	4.3	GSD	Site data FMLX	FMLX	
Tc	Zr		25	2.4E–02	1.8E+00	2.3E+00	2.0E+01	3.7	GSD	Site data FMLX	FMLX	Zr used as EA
Th			1	1.0E–01	3.2E+00	3.2E+00	9.7E+01	8.0	GSDmax	Site data LX	LX	Only 1 sample from LX available.
U			21	5.4E–04	5.3E–01	4.9E–01	2.6E+01	6.6	GSD	Site data FMLX	FMLX	
Zr			25	2.4E–02	1.8E+00	2.3E+00	2.0E+01	3.7	GSD	Site data FMLX	FMLX	

6.4 TC_meat

The uptake of elements in cow meat is calculated by using transfer coefficients relating the uptake of elements in muscle tissue (meat) to the intake of food, water and soil by the cow, as described in Section 2.5 and Saetre et al. (2013).

Site data are not available. Transfer coefficients for meat are reported by IAEA (2010) for different domestic animals as cow, sheep and pig. Data for cow meat are reported for the elements: Am, Ba, Ca, Cd, Cl, Cs,La, Mn, Mo, Nb, Pb, Pu, Ra, Sr, Th, U, Zn and Zr. Only 1 sample is reported for Am, Cl, Mo, Nb, Ra and Zr, while 58 and 35 samples are available for Cs and Sr, respectively. Data checks could not be performed, since only 1 data source is available. Available data are presented in Table 6-14 and Figure 6-16.

Literature data reported for cow meat by IAEA (2010) are selected when available. Literature data are not available for Ac, Ag, Cm, Eu, Ho, Ni, Np, Pa, Po, Se, Sm, Sn and Tc, and EAs are utilised. La data are used as EA for Ac, Cm, Eu, Np, Pa and Sm. Zr is selected as EA for Tc and Sn, and Zn is used as EA for Ag and Ni. Te data are utilised as EA for Se. Selected data are presented in Table 6-15 and Figure 6-17.

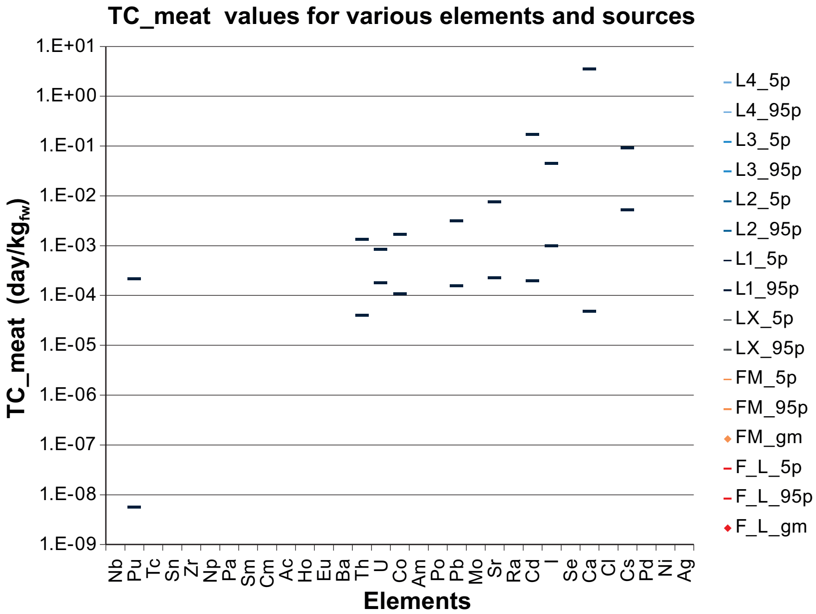

Figure 6-16. *Total available data ranges for the parameter TC_meat (day/kg$_{fw}$). The elements are arranged in the same order as in Figure 6-17 showing selected parameter values.*

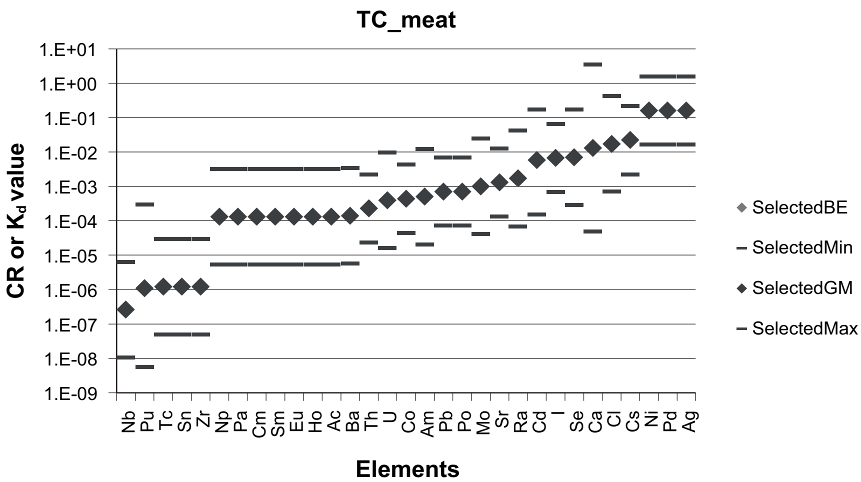

Figure 6-17. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (day/kg$_{fw}$)*.

Table 6-14. All available data for the parameter TC_meat for the elements of primary concern and selected EAs. L1 = IAEA 2010 cow meat.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag																			0:0/0
Am				1															1:0/0
Ba				2															1:0/0
Ca				3							30.0								1:0/0
Cd				8							7.8								1:0/0
Cl				1															1:0/0
Cm																			0:0/0
Co				4							2.3								1:0/0
Cs				58							2.4								1:0/0
Eu																			0:0/0
Ho																			0:0/0
I				5							3.2								1:0/0
La				3							1.2								1:0/0
Mo				1															1:0/0
Nb				1															1:0/0
Ni																			0:0/0
Np																			0:0/0
Pa																			0:0/0
Pb				5							2.5								1:0/0
Pd																			0:0/0
Po																			0:0/0
Pu				5							24.8								1:0/0
Ra				1															1:0/0
Se																			0:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				35							2.9								1:0/0
Tc																			0:0/0
Te				1															1:0/0
Th				6							2.9								1:0/0
U				3							1.6								1:0/0
Zn				6							3.2								1:0/0
Zr				1															1:0/0

Table 6-15. Selected data properties, references and comments for the parameter TC_meat (day/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La		3	5.3E–06	1.3E–04	1.3E–04	3.2E–03	7.0	GSDmax	IAEA 2010	L1	La used as analogue. GSD max assigned
Ag	Zn		6	1.6E–02	1.6E–01	1.6E–01	1.6E+00	4.0	GSDmean	IAEA 2010	L1	Zn used as analogue
Am			1	2.0E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	IAEA 2010	L1	
Ba			2	5.7E–06	1.4E–04	1.4E–04	3.4E–03	7.0	GSDmax	IAEA 2010	L1	
Ca			3	4.8E–05	1.3E–02	1.3E–02	3.5E+00	30.0	GSD	IAEA 2010	L1	
Cd			8	1.5E–04	5.8E–03	5.8E–03	1.7E–01	7.8	GSD	IAEA 2010	L1	
Cl			1	6.9E–04	1.7E–02	1.7E–02	4.2E–01	7.0	GSDmax	IAEA 2010	L1	
Cm	La		3	5.3E–06	1.3E–04	1.3E–04	3.2E–03	7.0	GSDmax	IAEA 2010	L1	La used as analogue. GSD max assigned
Co			4	4.4E–05	4.3E–04	4.3E–04	4.2E–03	4.0	GSDmean	IAEA 2010	L1	
Cs			58	2.2E–03	2.2E–02	2.2E–02	2.2E–01	4.0	GSDmean	IAEA 2010	L1	
Eu	La		3	5.3E–06	1.3E–04	1.3E–04	3.2E–03	7.0	GSDmax	IAEA 2010	L1	La used as analogue. GSD max assigned
Ho	La		3	5.3E–06	1.3E–04	1.3E–04	3.2E–03	7.0	GSDmax	IAEA 2010	L1	La used as analogue. GSD max assigned
I			5	6.8E–04	6.7E–03	6.7E–03	6.6E–02	4.0	GSDmean	IAEA 2010	L1	
Mo			1	4.1E–05	1.0E–03	1.0E–03	2.5E–02	7.0	GSDmax	IAEA 2010	L1	
Nb			1	1.1E–08	2.6E–07	2.6E–07	6.4E–06	7.0	GSDmax	IAEA 2010	L1	
Ni	Zn		6	1.6E–02	1.6E–01	1.6E–01	1.6E+00	4.0	GSDmean	IAEA 2010	L1	Zn used as analogue
Np	La		3	5.3E–06	1.3E–04	1.3E–04	3.2E–03	7.0	GSDmax	IAEA 2010	L1	La used as analogue. GSD max assigned
Pa	La		3	5.3E–06	1.3E–04	1.3E–04	3.2E–03	7.0	GSDmax	IAEA 2010	L1	La used as analogue. GSD max assigned
Pb			5	7.2E–05	7.0E–04	7.0E–04	6.8E–03	4.0	GSDmean	IAEA 2010	L1	
Pd	Zn		6	1.6E–02	1.6E–01	1.6E–01	1.6E+00	4.0	GSDmean	IAEA 2010	L1	The same EA as for Ni (Zn) is used as EA
Po	Pb		5	7.2E–05	7.0E–04	7.0E–04	6.8E–03	4.0	GSDmean	IAEA 2010	L1	Pb is used as EA
Pu			5	5.6E–09	1.1E–06	1.1E–06	3.0E–04	24.8	GSD	IAEA 2010	L1	
Ra			1	6.9E–05	1.7E–03	1.7E–03	4.2E–02	7.0	GSDmax	IAEA 2010	L1	
Se	Te		1	2.9E–04	7.0E–03	7.0E–03	1.7E–01	7.0	GSDmax	IAEA 2010	L1	Te used as analogue
Sm	La		3	5.3E–06	1.3E–04	1.3E–04	3.2E–03	7.0	GSDmax	IAEA 2010	L1	La used as analogue. GSD max assigned
Sn	Zr		1	4.9E–08	1.2E–06	1.2E–06	2.9E–05	7.0	GSDmax	IAEA 2010	L1	Zr is used as EA
Sr			35	1.3E–04	1.3E–03	1.3E–03	1.3E–02	4.0	GSDmean	IAEA 2010	L1	
Tc	Zr		1	4.9E–08	1.2E–06	1.2E–06	2.9E–05	7.0	GSDmax	IAEA 2010	L1	Zr used as analogue
Th			6	2.4E–05	2.3E–04	2.3E–04	2.2E–03	4.0	GSDmean	IAEA 2010	L1	
U			3	1.6E–05	3.9E–04	3.9E–04	9.6E–03	7.0	GSDmax	IAEA 2010	L1	
Zr			1	4.9E–08	1.2E–06	1.2E–06	2.9E–05	7.0	GSDmax	IAEA 2010	L1	

6.5 TC_milk

Transfer of elements into milk of animals is calculated by using transfer coefficients relating the concentration of elements in milk to the intake of food, water and soil by the animal.

Site data are not available. IAEA (2010) reports transfer coefficients for milk for the elements: Am, Ba, Ca, Cd, Cs, I, Mn, Mo, Nb, Ni, Pb, Po, Pu, Ra, Se, Sr, U, Zn and Zr. Only 1 sample is available or Am, Nb and Pu, while 104, 154 and 288 samples are available for I, Sr and Cs, respectively. Available data are presented in Table 6-16 and Figure 6-18. Data checks could not be performed, since only 1 data source is available.

For elements where IAEA (2010) data are available, these are selected. If the reported sample number is below 3, a GSDmax is assigned. Data are not available for Ac, Ag, Cl, Cm, Eu, Ho, Np, Pa, Sm, Sn, Tc and Th, EAs are used instead. Zn is selected as EA for Ag, whereas Am is selected for Ac, Cm, Eu, Ho, Pa, Np and Sm. Zr is utilised as EA for Sn, Tc and Th and I is used as EA for Cl. The selected data are presented in Table 6-17 and Figure 6-19.

The selected TC values for cow milk span from 4.1E-07 day/L to for Nb to 0.01 day/L for Ca.

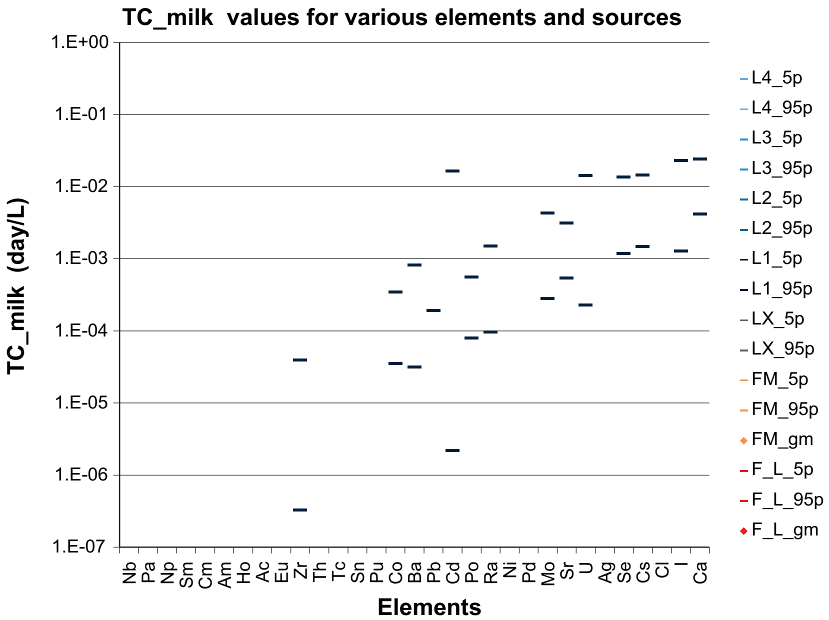

Figure 6-18. *Total available data ranges for the parameter TC_milk (day/L). The elements are arranged in the same order as in Figure 6-19 showing selected parameter values.*

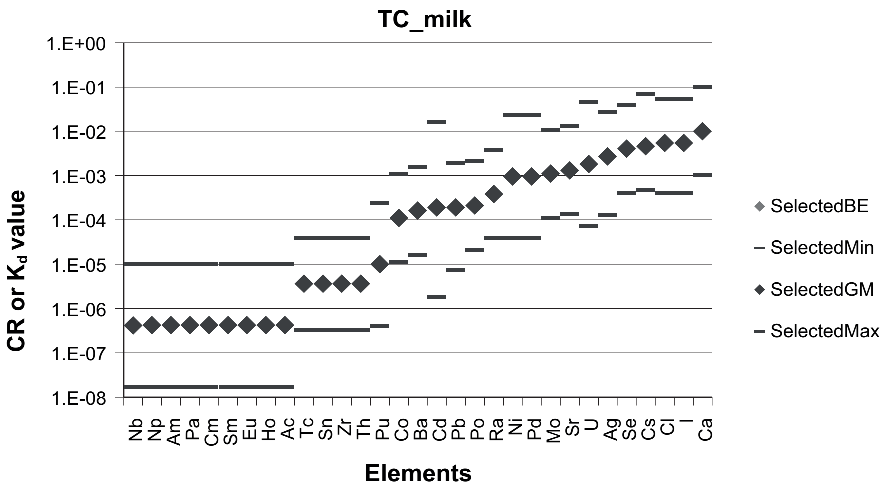

Figure 6-19. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (day/L)***.**

Table 6-16. All available data for the parameter TC_milk for the elements of primary concern and selected EAs. L1 = IAEA 2010 cow milk.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag																			0:0/0
Am				1															1:0/0
Ba				15							2.7								1:0/0
Ca				15							1.7								1:0/0
Cd				8							15.0								1:0/0
Cl																			0:0/0
Cm																			0:0/0
Co				4							2.0								1:0/0
Cs				288							2.0								1:0/0
Eu																			0:0/0
Ho																			0:0/0
I				104							2.4								1:0/0
Mo				7							2.3								1:0/0
Nb				1															1:0/0
Ni				2															1:0/0
Np																			0:0/0
Pa																			0:0/0
Pb				15							1.0								1:0/0
Pd																			0:0/0
Po				4							1.8								1:0/0
Pu				1															1:0/0
Ra				11							2.3								1:0/0
Se				12							2.1								1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				154							1.7								1:0/0
Tc																			0:0/0
Th																			0:0/0
U				3							3.5								1:0/0
Zn				8							3.9								1:0/0
Zr				6							4.3								1:0/0

Table 6-17. Selected data properties, references and comments for the parameter TC_milk (day/L) for the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Am		1	1.7E–08	4.2E–07	4.2E–07	1.0E–05	7.0	GSDmax	IAEA 2010	L1	Am used as EA. GSD max assigned
Ag	Zn		8	1.3E–04	2.7E–03	2.7E–03	2.6E–02	4.0	GSDmean	IAEA 2010	L1	Zn used as analogue
Am			1	1.7E–08	4.2E–07	4.2E–07	1.0E–05	7.0	GSDmax	IAEA 2010	L1	
Ba			15	1.6E–05	1.6E–04	1.6E–04	1.6E–03	4.0	GSDmean	IAEA 2010	L1	
Ca			15	1.0E–03	1.0E–02	1.0E–02	9.8E–02	4.0	GSDmean	IAEA 2010	L1	
Cd			8	1.8E–06	1.9E–04	1.9E–04	1.6E–02	15.0	GSD	IAEA 2010	L1	
Cl	I		104	4.0E–04	5.4E–03	5.4E–03	5.3E–02	4.0	GSDmean	IAEA 2010	L1	I used as analogue
Cm	Am		1	1.7E–08	4.2E–07	4.2E–07	1.0E–05	7.0	GSDmax	IAEA 2010	L1	Am used as EA. GSD max assigned
Co			4	1.1E–05	1.1E–04	1.1E–04	1.1E–03	4.0	GSDmean	IAEA 2010	L1	
Cs			288	4.7E–04	4.6E–03	4.6E–03	6.8E–02	4.0	GSDmean	IAEA 2010	L1	
Eu	Am		1	1.7E–08	4.2E–07	4.2E–07	1.0E–05	7.0	GSDmax	IAEA 2010	L1	Am used as EA. GSD max assigned
Ho	Am		1	1.7E–08	4.2E–07	4.2E–07	1.0E–05	7.0	GSDmax	IAEA 2010	L1	Am used as EA. GSD max assigned
I			104	4.0E–04	5.4E–03	5.4E–03	5.3E–02	4.0	GSDmean	IAEA 2010	L1	
Mo			7	1.1E–04	1.1E–03	1.1E–03	1.1E–02	4.0	GSDmean	IAEA 2010	L1	
Nb			1	1.7E–08	4.1E–07	4.1E–07	1.0E–05	7.0	GSDmax	IAEA 2010	L1	
Ni			2	3.9E–05	9.5E–04	9.5E–04	2.3E–02	7.0	GSDmax	IAEA 2010	L1	
Np	Am		1	1.7E–08	4.2E–07	4.2E–07	1.0E–05	7.0	GSDmax	IAEA 2010	L1	Am used as EA. GSD max assigned
Pa	Am		1	1.7E–08	4.2E–07	4.2E–07	1.0E–05	7.0	GSDmax	IAEA 2010	L1	Am used as EA. GSD max assigned
Pb			15	7.3E–06	1.9E–04	1.9E–04	1.9E–03	4.0	GSDmean	IAEA 2010	L1	
Pd	Ni		2	3.9E–05	9.5E–04	9.5E–04	2.3E–02	7.0	GSDmax	IAEA 2010	L1	Ni is used as EA
Po			4	2.1E–05	2.1E–04	2.1E–04	2.1E–03	4.0	GSDmean	IAEA 2010	L1	
Pu			1	4.1E–07	1.0E–05	1.0E–05	2.5E–04	7.0	GSDmax	IAEA 2010	L1	
Ra			11	3.9E–05	3.8E–04	3.8E–04	3.7E–03	4.0	GSDmean	IAEA 2010	L1	
Se			12	4.1E–04	4.0E–03	4.0E–03	3.9E–02	4.0	GSDmean	IAEA 2010	L1	
Sm	Am		1	1.7E–08	4.2E–07	4.2E–07	1.0E–05	7.0	GSDmax	IAEA 2010	L1	Am used as EA. GSD max assigned
Sn	Zr		6	3.3E–07	3.6E–06	3.6E–06	4.0E–05	4.3	GSD	IAEA 2010	L1	Zr is used as EA
Sr			154	1.3E–04	1.3E–03	1.3E–03	1.3E–02	4.0	GSDmean	IAEA 2010	L1	
Tc	Zr		6	3.3E–07	3.6E–06	3.6E–06	4.0E–05	4.3	GSD	IAEA 2010	L1	Zr used as analogue
Th	Zr		6	3.3E–07	3.6E–06	3.6E–06	4.0E–05	4.3	GSD	IAEA 2010	L1	Zr used as analogue
U			3	7.3E–05	1.8E–03	1.8E–03	4.4E–02	7.0	GSDmax	IAEA 2010	L1	
Zr			6	3.3E–07	3.6E–06	3.6E–06	4.0E–05	4.3	GSD	IAEA 2010	L1	

6.6 cR_agri_cereal

The parameter cR_agri_cereal represents the uptake of elements from the soil compartment into cereal grains growing in agricultural fields, as defined in the radionuclide model description (Saetre et al. 2013).

The vegetation samples assessed to adequately represent cereals (the parameter cR_agri_cereal) are crop grains and stems from wheat and barley (*Hordeum vulgare* and *Triticum aestivum*) collected in FM (Sheppard et al. 2011). The corresponding upper soil layer samples from FM and LX, selected to represent the parameter cR_agri_cereal are described in Section 6 (the same soil samples as for cR_Ter_pp, cR_Ter_lich_NHB are used).

Literature data assessed to adequately represent the parameter cR_agri_cereal are the following: CRs calculated for all soils and cereal grains presented by IAEA (2010) are categorised as L1 data, CRs for cereal stems and shoots for all soils (IAEA 2010) are categorised as L2 data (see corresponding text in Section 6.8).

Data for cereals are available for nearly all elements of interest (Figure 6-20 and Table 6-18). Site data are available for 21 elements: Ag, Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Sr, Th, U and Zr. In addition, literature data are available to varying degree. Literature data alone are available for Am, Cm, Np, Po, Pu, Ra and Tc. The data available Po and Tc are based on only 2 samples and lack a distribution measure. Neither site nor literature data are available for Ac, Pa and Pd (IAEA 2010).

The results of the various sense checks are shown in Table 6-18. Site data ranges can be compared to total literature ranges in 11 cases; Ca, Cd, Cl, Co, Cs, I, Ni, Pb, Sr, Th and U. In all cases except Ca and Cl, the ranges show some overlap. In the case of Am, Cd, Co, Cs, Pb, Pu, Ra, Sr, Th and U, the compared literature data ranges show overlaps. For Cl and I, no overlaps are found between L1 data (cereal grain) and L2 data (cereal stem and shoot).

The element-specific values selected to parameterise cR_agri_cereal are presented in Table 6-19 and Figure 6-21. Since site data are available in many element cases, these are selected as parameter values for all except 1 element. Relevant EA site-specific data are generally prioritised ahead of literature data. For Ac, Am, Cm, Np, Pa, Pd, Po, Pu and Tc, EA site-specific values are selected (La, La, La, La, La, Ni, Bi, U and Re, respectively). Ra is parameterised using L1 data.

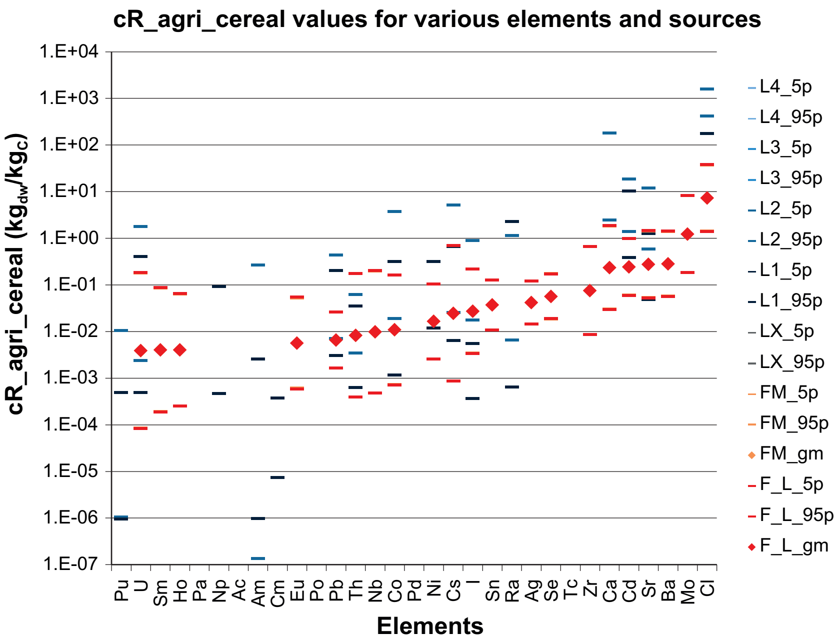

Figure 6-20. *Total available data ranges for the parameter cR_agri_cereal (kg$_{dw}$/kg$_C$). The elements are arranged in the same order as in Figure 6-21 showing selected parameter values.*

Table 6-18. All available data for the parameter cR_agri_cereal (kg_{dw}/kg_C) for the elements of primary concern and selected EAs. Sense check, with the corresponding results are also included. L1 = IAEA 2010 Cereal grains All soils. L2 = IAEA 2010 Cereal stems & shoots Alla soils.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag	26/10		26/10					1.9		1.9									0:0/0
Am				83	5						11.0	81.5							2:1/1
Ba	28/10		28/10	1				2.6		2.7									1:0/0
Bi	25/10		25/10					3.0		3.0									0:0/0
Ca	28/10		28/10		6			3.5		3.5		3.7			S4		S4		1:0/0
Cd	28/8		28/8	11	24			2.3		2.4	2.7	2.2			S2(L32%)		S2(L33%)		2:1/1
Cl	25/10		25/10	7	7			2.7		2.7	1.6	1.5			S4		S2(L0%)		2:0/1
Cm				67							3.3								1:0/0
Co	28/10		28/10	61	27			5.2		5.2	5.5	5.0			S2(L91%)		S2(L91%)		2:1/1
Cs	28/10		28/10	470	130			7.6		7.6	4.1	5.0			S2(L70%)		S2(L70%)		2:1/1
Eu	27/2		27/2					3.9		3.9									0:0/0
Ho	27/9		27/9					5.4		5.4									0:0/0
I	25/10		25/10	13	16			3.5		3.6	2.3	3.3			S1		S1		2:0/1
La	28/9		28/9	1				6.5		6.5									1:0/0
Mo	28/10		28/10	1				3.2		3.2									1:0/0
Nb	28/10		28/10	2				6.3		6.3									1:0/0
Ni	28/10		28/10	44				3.1		3.1	2.7				S2(L58%)		S2(L58%)		1:0/0
Np				85							5.0								1:0/0
Pa																			0:0/0
Pb	28/10		28/10	9	4			2.3		2.3	3.6	3.5			S2(L78%)		S2(L77%)		2:1/1
Pd																			0:0/0
Po				2															1:0/0
Pu				105	10						6.7	16.4							2:1/1
Ra				24	20						12.0	4.8							2:1/1
Re	28/9		28/9					5.1		5.1									0:0/0
Se	27/6		27/6					2.0		2.0									0:0/0
Sm	28/9		28/9					6.4		6.4									0:0/0
Sn	28/10		28/10					2.1		2.1									0:0/0
Sr	28/10		28/10	282	37			2.7		2.7	2.7	2.5			S1		S1		2:1/1
Tc				2															1:0/0
Th	28/10		28/10	36	28			6.4		6.4	3.4	2.4			S3		S3		2:1/1
U	28/10		28/10	59	55			10.3		10.4	7.7	7.5			S2(L77%)		S2(L77%)		2:1/1
Zr	28/10		28/10	1				3.8		3.7									1:0/0

Table 6-19. Selected parameter values properties, references and comments for the parameter cR_agri_cereal (kg_{dw}/kg_C) for the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La		9	2.0E–04	5.3E–03	5.3E–03	6.7E–01	6.5	GSD	Site data FM	FM	No site nor literature data available. Sufficient amount of FM data for La available, which is assessed to be a relevant EA to Ac.
Ag			10	6.3E–03	4.2E–02	4.2E–02	2.6E–01	3.0	GSDmin	Site data FM	FM	A good amount of FM data available. The data variability has been adjusted to a reasonable GSDmin.
Am	La		9	2.0E–04	5.3E–03	5.3E–03	6.7E–01	6.5	GSD	Site data FM	FM	o site data available. Good amount of FM data available for La, which is considered a valid EA.
Ba			10	3.6E–02	2.8E–01	2.8E–01	4.4E+00	3.0	GSDmin	Site data FM	FM	Good amount of FM data available. Data variability adjusted to a reasonable GSDmin
Ca			10	2.0E–02	2.3E–01	2.3E–01	5.0E+00	3.5	GSD	Site data FM	FM	Good amount of FM data available. FM data and available literature data show no overlap, still, FM data are considered the best parameterisation option.
Cd			8	2.5E–02	2.4E–01	2.4E–01	2.7E+00	4.0	GSDmean	Site data FM	FM	Good amount of FM data available. Data variability adjusted to a reasonable GSDmean.
Cl			10	2.7E–01	7.3E+00	7.3E+00	4.5E+01	3.0	GSDmin	Site data FM	FM	Good amount of FM data available. Data variability adjusted to a reasonable GSDmin.
Cm	La		9	2.0E–04	5.3E–03	5.3E–03	6.7E–01	6.5	GSD	Site data FM	FM	No site data are available. Good amount of FM data available for La, which is considered a valid EA
Co			10	3.2E–04	1.1E–02	1.1E–02	6.4E–01	5.2	GSD	Site data FM	FM	A good amount of FM data available.
Cs			10	8.8E–04	2.5E–02	2.5E–02	2.1E+00	7.6	GSD	Site data FM	FM	A good amount of FM data available.
Eu			2	2.3E–04	5.7E–03	5.7E–03	1.7E–01	7.0	GSDmax	Site data FM	FM	Barely acceptable amount of FM data available. Data variability therefore adjusted to a GSDmax.
Ho			9	2.5E–04	4.0E–03	4.0E–03	4.2E–01	5.4	GSD	Site data FM	FM	A sufficient amount of FM data available.
I			10	1.5E–03	2.7E–02	2.7E–02	6.6E–01	3.6	GSD	Site data FM	FM	A good amount of FM data available.
Mo			10	7.2E–02	1.2E+00	1.2E+00	1.3E+01	3.2	GSD	Site data FM	FM	A good amount of FM data available.
Nb			10	4.8E–04	9.8E–03	9.8E–03	1.9E+00	6.3	GSD	Site data FM	FM	A good amount of FM data available.
Ni			10	1.5E–03	1.6E–02	1.6E–02	5.2E–01	3.1	GSD	Site data FM	FM	A good amount of FM data available.
Np	La		9	2.0E–04	5.3E–03	5.3E–03	6.7E–01	6.5	GSD	Site data FM	FM	No site nor literature data available. A good amount of FM data for La available. La is assessed to be a relevant EA.
Pa	La		9	2.0E–04	5.3E–03	5.3E–03	6.7E–01	6.5	GSD	Site data FM	FM	No site nor literature data available. A good amount of FM data for La available. La is assessed to be a relevant EA.
Pb			10	9.9E–04	6.5E–03	6.5E–03	4.0E–02	3.0	GSDmin	Site data FM	FM	Good amount of FM data available. Data variability adjusted to a reasonable GSDmin.
Pd	Ni		10	1.5E–03	1.6E–02	1.6E–02	5.2E–01	3.1	GSD	Site data FM	FM	No site data available. Ni site data available and relevant as an EA.
Po	Bi		10	4.9E–04	6.5E–03	6.5E–03	7.0E–02	3.0	GSDmin	Site data FM	FM	No site data available. Good amount of FM data available for Bi, which is assessed to be a valid EA. Data variation adjusted to a GSDmin.
Pu	U		10	2.8E–05	3.9E–03	3.9E–03	1.9E+00	10.4	GSD	Site data FM	FM	No site data available. A good amount of FM data for U available. U is assessed to be a reasonable Pu EA.
Ra			24	1.8E–04	3.8E–02	3.8E–02	2.3E+00	12.0	GSD	IAEA 2010	L1	No site data available. Relevant literature data available and which is considered the best parameterisation option.
Se			6	5.8E–03	5.6E–02	5.6E–02	5.5E–01	4.0	GSDmean	Site data FM	FM	Good amount of relevant FM data available. Data variability adjusted to a reasonable GSDmean.
Sm			9	1.8E–04	4.0E–03	4.0E–03	4.4E–01	6.4	GSD	Site data FM	FM	Sufficient amount of FM data available.
Sn			10	5.4E–03	3.7E–02	3.7E–02	2.3E–01	3.0	GSDmin	Site data FM	FM	Good amount of FM data available. Data variability adjusted to a reasonable GSDmin.
Sr			10	3.4E–02	2.8E–01	2.8E–01	3.3E+00	3.0	GSDmin	Site data FM	FM	Good amount of FM data available. Data variability adjusted to a reasonable GSDmin.
Tc	Re		9	9.0E–04	6.4E–02	6.4E–02	4.5E+00	5.1	GSD	Site data FM	FM	No site data available. Sufficient amount of FM Re data available, which is assessed to be a valid EA
Th			10	3.9E–04	8.2E–03	8.2E–03	1.6E+00	6.4	GSD	Site data FM	FM	Good amount of FM data available.
U			10	2.8E–05	3.9E–03	3.9E–03	1.9E+00	10.4	GSD	Site data FM	FM	Good amount of FM data available. The data variability is very high.
Zr			10	7.3E–03	7.5E–02	7.5E–02	4.9E+00	3.7	GSD	Site data FM	FM	Good amount of FM data available.

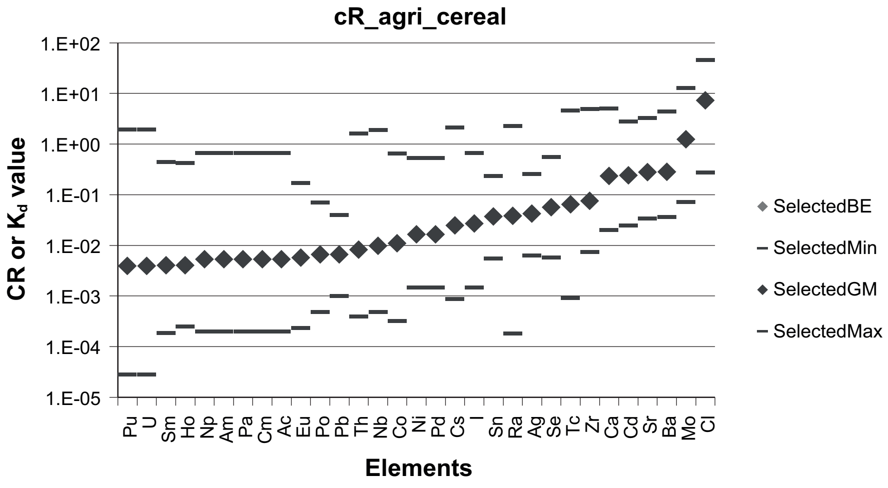

Figure 6-21. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (*kg_{dw}/kg_C*).*

The reasonable GSD range for parameter cR_agri_cereal values are assessed to span from 3 GSDmin to 7 GSDmax with a GSDmean value of 4 (Section 4.3). A GSDmin is appointed to 7 elements; Ag, Ba, Cl, Pb, Po, Sn and Sr, a GSDmean to Cd and Se, and a GSDmax to Eu. Selected data for Cs, Ra and U show notably high GSDs (8, 12 and 11, respectively).

As in most other terrestrial parameter cases, actinides (U, Am, Cm, Ac, Pu, Np, Pa and Th) and lanthanides (Ho, Sm, Eu) are the elements that indicate low CR values (Figure 6-21). The use of EAs for parameterisation is apparent with both actinides and lanthanides. Th data are selected to parameterise Np, and Pu and La data are utilised to parameterise Ac, Am, Cm and Pa. Pb and Po can also be found among the elements with low CRs. Pb shows relatively low CR in comparison to other terrestrial CR parameters and, as usual, Cl, Mo, Sr, Ba and Ca indicate relatively high values.

6.7 cR_agri_fodder

The parameter cR_agri_fodder represents uptake of elements from the soil compartment into pasture vegetation. Pasture is the vegetation that covers the grazing area of domestic animals, as defined in the radionuclide model description (Saetre et al. 2013). The site-specific vegetation and soil samples that are assessed to adequately represent the parameter cR_agri_fodder are the same as for the parameter cR_Ter_pp (see Section 6.2).

6.8 cR_agri_veg

The parameter cR_agri_veg represents the uptake of elements from the soil compartment into agricultural vegetables, i.e. cultivated vegetables as defined in the radionuclide model description (Saetre et al. 2013). Vegetables are defined as the edible parts of plants above ground, such as fruits, leafs and stems, and should be distinguished from tubers, whose uptake is represented by the parameter cR_agri_tuber (Section 6.9).

Vegetables have not been sampled in FM or LX.

Literature data assessed to best represent agricultural vegetables (the parameter cR_agri_veg) are the following: CRs calculated for leaves of leafy vegetables and various soil types presented by IAEA (2010) are categorised as L1 data. CRs calculated for non-leafy vegetables, such as fruits, heads, berries and buds of non-leafy vegetables and various soil types in IAEA (2010) are categorised as L2 data. CRs calculated for stem and shoot samples of non-leafy vegetables and different soil types in IAEA (2010) are categorised as L3 data. Agricultural concentration ratios are reported for several different soil types in IAEA (2010), however, to various extents for different elements and vegetation types. The soil types presented in IAEA (2010) are "sand", "loam", "clay" and "organic" soils. In addition, the group "all soils" is included, which is a fusion of all available soil types. This is the soil type available for most elements and vegetation types. The literature data from IAEA (2010) for "all soils" are chosen to represent the parameter cR_agri_veg. There are two fundamental reasons for this choice; organic soils are usually oxidised after a short time and thereafter, the mineral soil below the organic soil is used for cultivation. By using "all soils" data, the soil succession stages are accounted for and the largest amount of data are available for parametrisation. Literature data are available for 21 elements of interest: Ag, Am, Ba, Cl, Cm, Co, Cs, I, Mo, Nb, Np, Pb, Po, Pu, Ra, Sr, Tc, Th, U, Zn and Zr. For 4 of these elements, Ba, Mo, Nb and Zr, the available data are based on only 1 to 2 samples (N) and lack a distribution measure. Data are not available in IAEA (2010) for the remaining 11 elements: Ac, Ca, Cd, Eu, Ho, Ni, Pa, Pd, Se, Sm and Sn.

All the available data are shown in Figure 6-22 and Table 6-20. Table 6-20 shows the results of the various sense checks. Comparisons of site and literature data cannot be made as site data are not available. In the case of Ag, Am, Cm, Co, Cs, Np, Pb, Pu, Ra, Sr, Th, U and Zn, the compared literature data ranges show overlaps.

Element-specific values selected for the cR_agri_veg parameter are presented in Table 6-21 and Figure 6-23. In the case of Ag, Am, Cl, Cm, Co, Cs, I, Mo, Nb, Np, Pb, Po, Pu, Ra, Sr, Th, U and Zr, literature data are used for parameterisation of the cR_agri_veg parameter. For Ac, Ba, Ca, Cd, Eu, Ho, Pa, Sm and Sn, EA literature data (La, Ra, Sr, Zn, La, La, La, La and Th, respectively) are utilised to obtain parameter values. Primary producer site data, cR_Ter_pp as PA, is the best available parameterisation option for Ni. In the case of Se, cR_agri_cereal site data are used as PA. cR_Ter_pp site data for Ni are selected as a combined PA/EA for Pd, while cR_agri_cereal site data for Re is utilised as a combined PA/EA for Tc.

The reasonable GSD range for parameter cR_agri_veg values are assessed to span from 3 GSDmin to 7 GSDmax with a GSDmean value of 4 (Section 4.3). GSDmean is appointed to 11 elements: Ac, Ag, Am, Cd, Cl, Co, Eu, Ho, I, Np, Pu and La and GSDmax to 7 elements: Mo, Nb, Ni, Pd, Se, Tc and Zr (Table 6-21). The selected data for Pb show particularly high GSDs (13).

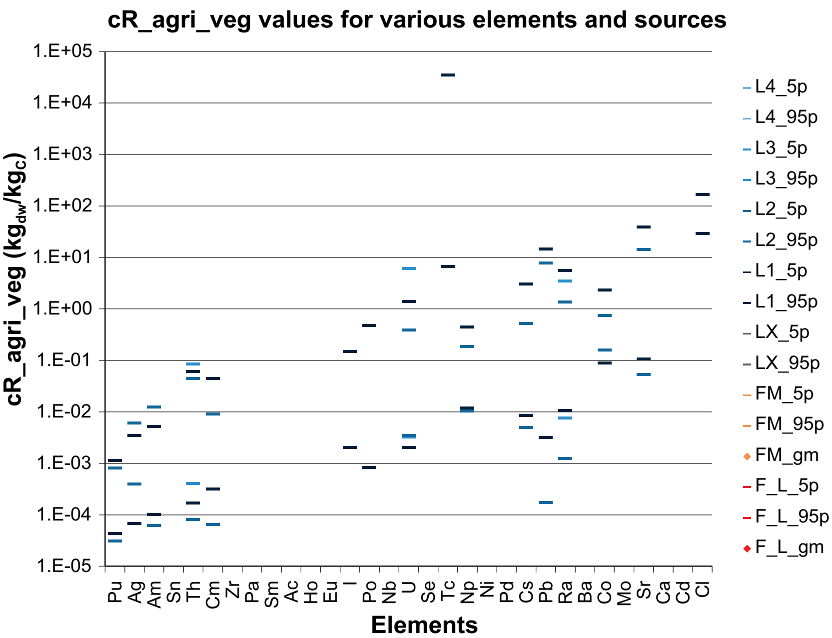

Figure 6-22. *Total available data ranges for the parameter cR_agri_veg (kg$_{dw}$/kg$_C$). The elements are arranged in the same order as in Figure 6-23 showing selected parameter values.*

The elements that show the lowest selected CRs are actinides (Pu, Am, Pa, Th, Cm and Ac), lanthanides (Sm, Eu and Ho) and the metals Ag and Zr (Figure 6-23). It is apparent that all lanthanides and Ac are parameterised using the same data, which is La data. Sn, Pa and Th are parameterised using Th data. Lanthanides and actinides are usually not very mobile in soils and, therefore, plant uptake of these elements are usually low (see respective figure for other terrestrial CR parameters). However, both Ag and Zr show low CR values in comparison to other parameters. In the case of mushroom data, i.e. cR_Ter_Mush, Ag shows one of the highest CR values. In contrast, U that usually shows distinctly low CR values when it comes to site data (see cR_agri_ceral, cR_Ter_Mush and cR_Ter_pp), is relatively mobile in this case. This is probably an effect of the high mobility of U in the alkaline soils in the FM area (cf. Chapter 5 on K_d values). Mo, Ca, Sr, Cd and Cl are the elements with the highest selected values, and it is common that they show high values in this assessment (see other parameters) in comparison to other elements.

Table 6-20. All available data for the parameter cR_agri_veg (kg_{dw}/kg_C) for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010 leavs of leafy vegetables All soils, L2 = IAEA 2010 fruits, heads, berries and buds for Nonleafy vegetables All soils.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				5	5						3.3	2.3							2:1/1
Am				10	9						3.3	5.0							2:1/1
Ba				1	1														2:0/0
Ca																			0:0/0
Cd																			0:0/0
Cl				6							1.7								1:0/0
Cm				7	8						4.5	4.5							2:1/1
Co				185	7						2.7	1.6							2:1/1
Cs				290	38						6.0	4.1							2:1/1
Eu																			0:0/0
Ho																			0:0/0
I				12							3.7								1:0/0
La				7	2						2.7								2:0/0
Mo				1															1:0/0
Nb				2	1														2:0/0
Ni																			0:0/0
Np				5	9						3.0	2.4							2:1/1
Pa																			0:0/0
Pb				31	5	2					13.0	26.0							3:1/1
Pd																			0:0/0
Po				12		2					6.9								2:0/0
Pu				13	9						2.7	2.7							2:1/1
Ra				77	44	13					6.7	8.4	6.4						3:3/3
Se																			0:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				217	19						6.0	5.5							2:1/1
Tc				10							13.5								1:0/0
Th				24	17	6					6.0	6.8	5.1						3:3/3
U				108	38	6					7.3	4.2	9.9						3:3/3
Zn				112	3						2.4	3.7							2:1/1
Zr				1	1														2:0/0

Table 6-21. Selected data properties, references and comments for the parameter cR_agri_veg (kg_{dw}/kg_{C}) for the elements of primary concern.

Ele-ment	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La		7	1.6E–03	1.5E–02	1.5E–02	1.5E–01	4.0	GSDmean	IAEA 2010	L1	No site or literature data available. Sufficient amount of literature data available for the EA La. La data variability adjusted to a reasonable GSDmean.
Ag			5	4.9E–05	4.8E–04	4.8E–04	4.7E–03	4.0	GSDmean	IAEA 2010	L1	No site data available. Sufficient amount of literature data available
Am			10	7.4E–05	7.2E–04	7.2E–04	7.0E–03	4.0	GSDmean	IAEA 2010	L1	No site data available. Sufficient amount of literature data available
Ba	Ra		77	4.8E–03	2.4E–01	2.4E–01	3.5E+02	6.7	GSD	IAEA 2010	L1	No site data available and literature data insufficient. Large amount of literature data available for the EA Ra
Ca	Sr		217	1.0E–02	2.0E+00	2.0E+00	3.9E+01	6.0	GSD	IAEA 2010	L1	No site data or literature data available. Large amount of literature data available for the EA Sr.
Cd	Zn		112	2.7E–01	6.4E+00	6.4E+00	6.3E+01	4.0	GSDmean	IAEA 2010	L1	No site data or literature data available. Large amount of literature data available for the EA Zn. Data variability adjusted to a reasonable GSDmean.
Cl			6	7.1E+00	6.9E+01	6.9E+01	6.8E+02	4.0	GSDmean	IAEA 2010	L1	No site data available. Sufficient amount of literature data available. Data variability adjusted to a reasonable GSDmean
Cm			7	3.1E–04	3.7E–03	3.7E–03	4.4E–02	4.5	GSD	IAEA 2010	L1	No site data available. Sufficient amount of literature data available.
Co			185	3.5E–02	4.5E–01	4.5E–01	4.4E+00	4.0	GSDmean	IAEA 2010	L1	No site data available. Large amount of literature data available. Data variability adjusted to a reasonable GSDmean
Cs			290	8.0E–04	1.6E–01	1.6E–01	3.0E+00	6.0	GSD	IAEA 2010	L1	No site data available. Large amount of literature data available..
Eu	La		7	1.6E–03	1.5E–02	1.5E–02	1.5E–01	4.0	GSDmean	IAEA 2010	L1	No site data or literature data available. Satisfying amount of literature data available for the EA La. La data variability adjusted to a reasonable GSDmean.
Ho	La		7	1.6E–03	1.5E–02	1.5E–02	1.5E–01	4.0	GSDmean	IAEA 2010	L1	No site data or literature data available. Satisfying amount of literature data available for the EA La . La data variability adjusted to a reasonable GSDmean.
I			12	1.8E–03	1.7E–02	1.7E–02	2.7E–01	4.0	GSDmean	IAEA 2010	L1	No site data available. Good amount of literature data available. Data variability adjusted to a reasonable GSDmean.
Mo			1	5.5E–02	1.4E+00	1.4E+00	3.3E+01	7.0	GSDmax	IAEA 2010	L1	No site data. 1 relevant literature data sample available with a GSDmin and GSDmax value reported, which is not reasonable. This information coupled to a reasonable
Nb			2	1.8E–03	4.5E–02	4.5E–02	1.1E+00	7.0	GSDmax	IAEA 2010	L1	No site data. Two relevant literature data samples available. This information coupled to a reasonable GSDmax is assessed the best available parameterisation solution.
Ni		cR_ter_pp	18	5.7E–03	1.4E–01	1.2E–01	3.5E+00	7.0	GSDmax	Site data FMLX	FMLX	Neither site nor literature data available. Good amount of relevant site data available for the parameter cR_Ter_pp, which is considered a valid PA.
Np			5	7.4E–03	7.2E–02	7.2E–02	7.0E–01	4.0	GSDmean	IAEA 2010	L1	No site data available. Sufficient amount of literature data available. Data variability adjusted to a reasonable GSDmean.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Pa	La		7	1.6E–03	1.5E–02	1.5E–02	1.5E–01	4.0	GSDmean	IAEA 2010	L1	No site nor literature data are available. Good amount of La literature data are available. La is assessed to be a reasonable EA to Pa.
Pb			31	3.1E–03	2.1E–01	2.1E–01	6.7E+01	13.0	GSD	IAEA 2010	L1	No site data available. Good amount of literature data available. Data show very large variation.
Pd	Ni	cR_ter_pp	18	5.7E–03	1.4E–01	1.2E–01	3.5E+00	7.0	GSDmax	Site data FMLX	FMLX	Neither site nor literature data are available. This is the case with Pd and Ni as well. Good amount of relevant Ni site data available for cR_Ter_pp, which is a valid PA.
Po			12	6.7E–04	2.0E–02	2.0E–02	4.7E–01	6.9	GSD	IAEA 2010	L1	No site data available. Sufficient amount of literature data available.
Pu			13	2.3E–05	2.2E–04	2.2E–04	2.2E–03	4.0	GSDmean	IAEA 2010	L1	No site data available. Good amount of literature data available. Data variability adjusted to a reasonable GSDmean.
Ra			77	4.8E–03	2.4E–01	2.4E–01	3.5E+02	6.7	GSD	IAEA 2010	L1	No site data available. Large amount of literature data available.
Se		cR_agri_cereal	6	2.3E–03	5.6E–02	5.6E–02	1.4E+00	7.0	GSDmax	Site data FM	FM	No site or literature data available. No adequate EA literature data available. Good amount of cereal FM data for Se available, which is assessed the best available parameterisation option.
Sm	La		7	1.6E–03	1.5E–02	1.5E–02	1.5E–01	4.0	GSDmean	IAEA 2010	L1	No site data or literature data available. Good amount of literature data available for the EA La. La data variability adjusted to a reasonable GSDmean.
Sn	Th		24	1.7E–04	3.2E–03	3.2E–03	5.6E–01	6.0	GSD	IAEA 2010	L1	No site data or literature data available. Good amount of data available for the EA Th.
Sr			217	1.0E–02	2.0E+00	2.0E+00	3.9E+01	6.0	GSD	IAEA 2010	L1	No site data available. Large amount of valid literature data available.
Tc	Re	cR_agri_cereal	9	9.0E–04	6.4E–02	6.4E–02	4.5E+00	7.0	GSDmax	Site data FM	FM	No site data available. Literature data are available, but show very large variation. Re is a valid EA and site data available for cereal data.
Th			24	1.7E–04	3.2E–03	3.2E–03	5.6E–01	6.0	GSD	IAEA 2010	L1	No site data. Good amount of literature data are available.
U			108	2.1E–04	5.3E–02	5.3E–02	2.3E+01	7.3	GSD	IAEA 2010	L1	No site data. Large amount of valid literature data available.
Zr			1	4.3E–04	1.1E–02	1.1E–02	2.6E–01	7.0	GSDmax	IAEA 2010	L1	No site data. 1 relevant literature data sample available. This coupled to a reasonable GSDmax is assessed the best available parameterisation option.

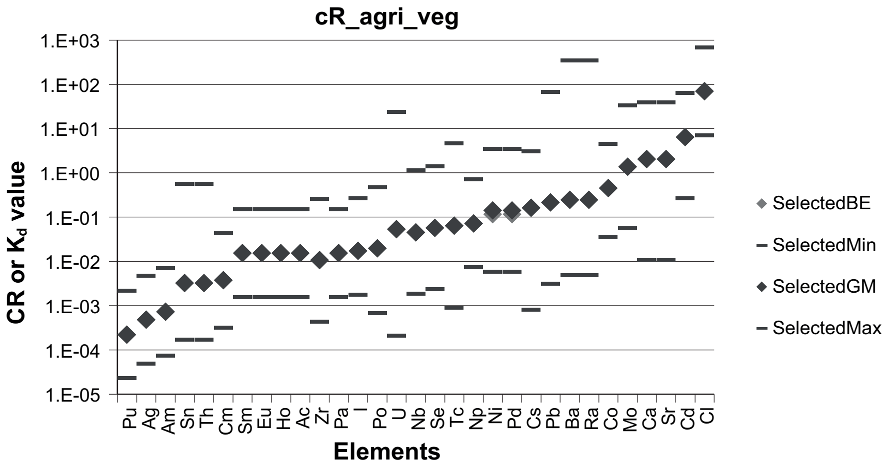

Figure 6-23. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (*kg_{dw}/kg_C*).*

6.9 cR_agri_tuber

The parameter cR_agri_tuber represents the uptake of elements into edible tubers from the soil compartment, as defined in the radionuclide model description (Saetre et al. 2013).

Tubers have not been sampled in FM and LX. The literature data assessed to adequately represent tubers (the parameter cR_agri_tuber) are available in IAEA (2010). CRs based on tuber data from temperate areas representing the soil category "all soils" (see corresponding text in Section 6.8) from IAEA (2010) are categorised as L1 data and CRs based on root crop data for all soils from IAEA (2010) that are categorised as L2 data. Reported values are in most cases based on relatively high sample numbers, compared to other parameters. Tubers, as defined by IAEA (2010) are samples of potato, yam, arrowhead and sweet potato. Root crops are samples of beet, beetroot, red beet/mangold, sugar beet, turnip, radish, carrot and manihot (cassava, yucca, tapioca) (IAEA 2010). Unfortunately, it is not clear which of the listed crops are included in the CR values for temperate environment. Manihot (e.g. cassava, yucca, turnip) are tropical crops and should not be included in the temperate CR values, though this cannot be concluded from the IAEA (2010) report. Both literature sources L1 and L2 are assessed to be relevant in regard to which vegetation types they are based on as well as their sample numbers. Many tubers have edible peel that contains higher concentrations of elements than the flesh. It is not clear if the CR values reported by IAEA (2010) are measured on peeled or unpeeled tubers and root crops.

Tuber data are available for 21 elements: Ag, Am, Ba, Cd, Cl, Cm, Co, Cs, I, Mo, Nb, Np, Pb, Po, Pu, Ra, Sr, Tc, Th, U and Zr (Figure 6-24 and Table 6-22). For Ba, Cd, Mo, Nb and Zr, the data available are based on only 1 to 3 samples (N) and lack a distribution measure. Site data are not available for any of the elements. Data are not available in the SKB database for 10 elements: Ac, Ca, Eu, Ho, Ni, Pa, Pd, Se, Sm and Sn.

The results of the sense checks are shown In Table 6-22. A comparison between site and literature data cannot be made, since site data are not available. Where a comparison between literature data ranges is possible, the compared data ranges show overlaps in all 12 cases: Am, Cm, Co, Cs, Np, Pb, Po, Pu, Ra, Sr, Th and U.

Since site data are not available for tuber values, the options are to choose either relevant literature data (which could include the use of EA literature data) or PA that results in element-specific site data. It was concluded that both literature data sources L1 and L2 for tuber values (as described earlier) are relevant and of sufficient quality. The literature data are considered a better approximation than element-specific site data for other types of vegetation (cereal, primary producer and to some extent mushroom data), since the element uptake processes in tubers are believed to differ from the uptake processes in the above-ground type vegetation.

All parameter value selections are presented in Table 6-23 and Figure 6-25. Literature data are utilised in 18 element cases: Ag, Am, Cl, Cm, Co, Cs, I, Mo, Nb, Np, Pb, Po, Pu, Ra, Sr, Tc, Th and U. Insufficient or no literature data are available in other element cases. For Ac, Ba, Ca, Cd, Eu, Ho, Pa, Sm and Sn,sufficient EA literature data are available and selected (La, Sr, Sr, Zn, La, La, La, La and Th, respectively). Suitable EA data are not available for Ni, Se, Pd and Zr. Site-specific data are obtained for cR_Ter_pp, which is used as a PA for Ni and Zr. cR_Ter_pp data for Ni are selected for Pd, and cR_agri_cereal element-specific data are selected for Se. cR_Ter_pp data are selected over cR_agri_cereal (or cR_Ter_Mush) data as PAs, since cR_Ter_pp is a more generic plant parameter in regards to plant composition.

The reasonable GSD range for parameter cR_agri_tuber values are assessed to span from 3 GSDmin to 7 GSDmax with a GSDmean value of 4 (Section 4.3). A GSDmean is appointed to 14 elements: Ac, Ag, Ba, Ca, Cd, Cm, Co, Cs, Eu, Ho, Np, Sm, Sr and Tc, and a GSDmax to 3 elements: Ni, Se and Zr. None of the selected data show exceptionally high GSDs.

Similar to other terrestrial CRs, lanthanides and actinides generally show the lowest CR values among the selected elements. The elements that indicates the highest values are Ca, Sr, Ba, Tc, Cd, Mo and Cl. These elements can have the highest CRs in other terrestrial CR parameter cases as well. In other words, elements evidently do not diverge from expected behaviour.

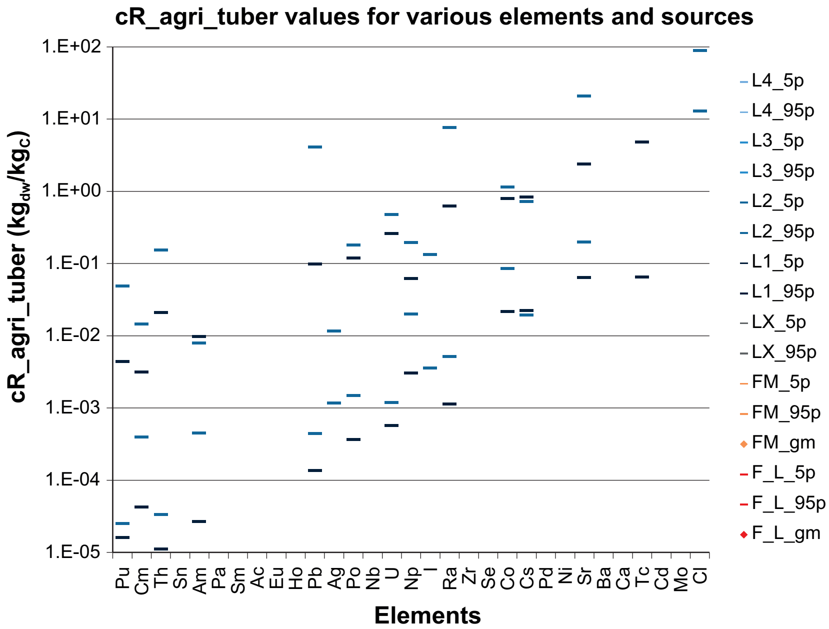

__Figure 6-24.__ Total available data ranges for the parameter cR_agri_tuber for the elements of primary concern. The elements are arranged in the same order as in Figure 6-25 showing selected parameter values.

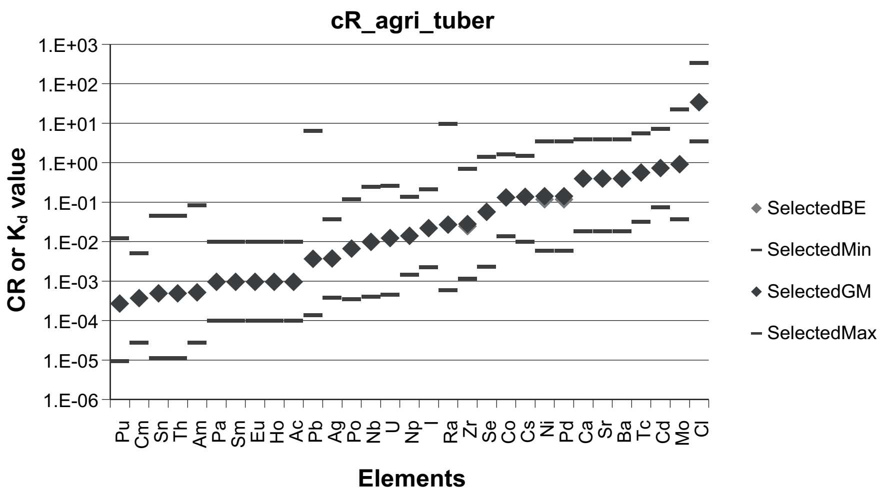

__Figure 6-25.__ Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg$_{dw}$/kg$_C$).

Table 6-22. All available data for the parameter cR_agri_tuber (kg_{dw}/kg_C) for the elements of primary concern and the selected EAs. Sense checks with corresponding results are also presented. L1 = IAEA 2010 Tubers All soils, L2 = IAEA 2010 Root crops all soils.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					6							2.0							1:0/0
Am				78	4						6.0	2.4							2:1/1
Ba				1	1														2:0/0
Ca																			0:0/0
Cd				1															1:0/0
Cl					14							1.8							1:0/0
Cm				66	6						3.7	3.0							2:1/1
Co				56	14						3.0	2.2							2:1/1
Cs				138	81						3.0	3.0							2:1/1
Eu																			0:0/0
Ho																			0:0/0
I				1	28							3.0							2:0/0
La				8	9						3.7	2.7							2:1/1
Mo					3														1:0/0
Nb				1	2														2:0/0
Ni																			0:0/0
Np				57	7						2.5	2.0							2:1/1
Pa																			0:0/0
Pb				30	27						7.4	16.0							2:1/1
Pd																			0:0/0
Po				9	10						5.8	4.3							2:1/1
Pu				87	5						5.5	10.0							2:1/1
Ra				45	60						6.8	9.2							2:1/1
Se																			0:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				106	56						3.0	4.1							2:1/1
Tc				8	2						3.7								2:0/0
Th				24	33						9.9	13.0							2:1/1
U				28	46						6.4	6.2							2:1/1
Zn				20							1.8								1:0/0
Zr				1	1														2:0/0

Table 6-23. Selected parameter values properties, references and comments for the parameter cR_agri_tuber (kg_{dw}/kg_{C}) for the elements of primary concern.

Ele-ment	EA	PA	N	Min	GM	BE	Max	GSD	GSD com-ment	Reference	Data Source	Comment
Ac	La		8	9.7E–05	9.5E–04	9.5E–04	9.7E–03	4.0	GSDmean	IAEA 2010	L1	Neither site nor literature data available. Good amount of relevant literature data available for the EA La.
Ag			6	3.8E–04	3.7E–03	3.7E–03	3.6E–02	4.0	GSDmean	IAEA 2010	L2	Site data not available. Acceptable amount of literature data available. Data variation adjusted to a reasonable GSDmean.
Am			78	2.7E–05	5.1E–04	5.1E–04	8.3E–02	6.0	GSD	IAEA 2010	L1	Site data not available. Good amount of literature data are available
Ba	Sr		106	1.8E–02	3.9E–01	3.9E–01	3.9E+00	4.0	GSDmean	IAEA 2010	L1	Neither site nor literature data available. Good amount of data available for the EA Sr. Data variation adjusted to a reasonable GSDmean.
Ca	Sr		106	1.8E–02	3.9E–01	3.9E–01	3.9E+00	4.0	GSDmean	IAEA 2010	L1	Neither site nor literature data available. Good amount of data available for the EA Sr. Data variation adjusted to a reasonable GSDmean.
Cd	Zn		20	7.4E–02	7.3E–01	7.3E–01	7.1E+00	4.0	GSDmean	IAEA 2010	L1	Neither site nor literature data available. Good amount of relevant data available for the EA Zn. Data variation adjusted to a reasonable GSDmean.
Cl			14	3.5E+00	3.4E+01	3.4E+01	3.3E+02	1.8	gsd	IAEA 2010	L2	Good amount of relevant literature data available.
Cm			66	2.7E–05	3.6E–04	3.6E–04	5.1E–03	4.0	GSDmean	IAEA 2010	L1	Good amount of literature data available. Data variation adjusted to a reason-able GSDmean.
Co			56	1.3E–02	1.3E–01	1.3E–01	1.6E+00	4.0	GSDmean	IAEA 2010	L1	Site data not available. Good amount of literature data available. Data varia-tion adjusted to a reasonable GSDmean
Cs			138	9.7E–03	1.4E–01	1.4E–01	1.5E+00	4.0	GSDmean	IAEA 2010	L1	Site data not available. Good amount of literature data available. Data varia-tion adjusted to a reasonable GSDmean.
Eu	La		8	9.7E–05	9.5E–04	9.5E–04	9.7E–03	4.0	GSDmean	IAEA 2010	L1	Neither site nor literature data available. Good amount of data available for the EA La. Data variation adjusted to a reasonable GSDmean.
Ho	La		8	9.7E–05	9.5E–04	9.5E–04	9.7E–03	4.0	GSDmean	IAEA 2010	L1	Neither site nor literature data available. Good amount of data available for the EA La. The data variation adjusted to a reasonable GSDmean.
I			28	2.2E–03	2.2E–02	2.2E–02	2.1E–01	3.0	gsd	IAEA 2010	L2	Site data not available. Good amount of literature data available.
Mo			3	3.7E–02	9.0E–01	9.0E–01	2.2E+01	7.0	GSDmax	IAEA 2010	L2	Site data not available. Literature data are available. GSDmax assiged.
Nb			1	4.0E–04	9.7E–03	9.7E–03	2.4E–01	7.0	GSDmax	IAEA 2010	L1	Site data not available. One sample reported by IAEA this value is used together with GSDmax
Ni		cR_Ter_pp	18	5.7E–03	1.4E–01	1.2E–01	3.5E+00	7.0	GSDmax	Site data FMLX	FMLX	Neither site nor literature data available. No relevant EA data available. cR_Ter_pp data for Ni selected.
Np			57	1.4E–03	1.4E–02	1.4E–02	1.4E–01	4.0	GSDmean	IAEA 2010	L1	Site data not available. Good amount of literature data available. Data varia-tion adjusted to a reasonable GSDmean.
Pa	La		8	9.7E–05	9.5E–04	9.5E–04	9.7E–03	4.0	GSDmean	IAEA 2010	L1	Neither site nor literature data are available. A good amount of data are available for La, which is assessed to be a reasonable EA.
Pb			30	1.4E–04	3.6E–03	3.6E–03	6.3E+00	7.4	GSD	IAEA 2010	L1	Site data not available. Good amount of literature data available

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Pd	Ni	cR_Ter_pp	18	5.7E–03	1.4E–01	1.2E–01	3.5E+00	7.0	GSDmax	Site data FMLX	FMLX	Neither site nor literature data available (neither for Pd or Ni, which would be a reasonable EA). Good amount of relevant Ni site data available for cR_Ter_pp, which is assessed to be a reasonable PA.
Po			9	3.4E–04	6.6E–03	6.6E–03	1.2E–01	5.8	GSD	IAEA 2010	L1	Site data not available. Good amount of literature data available.
Pu			87	9.2E–06	2.7E–04	2.7E–04	1.2E–02	5.5	GSD	IAEA 2010	L1	Site data not available. Good amount of literature data available.
Ra			45	5.8E–04	2.7E–02	2.7E–02	9.5E+00	6.8	GSD	IAEA 2010	L1	Site data not available. Good amount of literature data available.
Se		cR_agri_cereal	6	2.3E–03	5.6E–02	5.6E–02	1.4E+00	7.0	GSDmax	Site data FM	FM	No site or literature data available. No reasonable EA literature data available. Good amount of cereal FM data available.
Sm	La		8	9.7E–05	9.5E–04	9.5E–04	9.7E–03	4.0	GSDmean	IAEA 2010	L1	Neither site nor literature data available. Good amount of data available for the EA La.
Sn	Th		24	1.1E–05	4.9E–04	4.9E–04	4.4E–02	9.9	GSD	IAEA 2010	L1	Site data are not available. Literature data available scarce and insufficient. Literature data available for the EA Th
Sr			106	1.8E–02	3.9E–01	3.9E–01	3.9E+00	4.0	GSDmean	IAEA 2010	L1	Site data not available. A good amount of relevant literature data available. Data variation adjusted to a reasonable GSDmean.
Tc			8	3.2E–02	5.6E–01	5.6E–01	5.5E+00	4.0	GSDmean	IAEA 2010	L1	Site data not available. A good amount of relevant literature data available. Data variation adjusted to a reasonable GSDmean
Th			24	1.1E–05	4.9E–04	4.9E–04	4.4E–02	9.9	GSD	IAEA 2010	L1	Site data not available. A good amount of literature data available.
U			28	4.4E–04	1.2E–02	1.2E–02	2.6E–01	6.4	GSD	IAEA 2010	L1	Site data not available. A good amount of literature data available.
Zr		cR_Ter_pp	16	1.1E–03	2.8E–02	2.4E–02	6.8E–01	7.0	GSDmax	Site data FMLX	FMLX	Neither site nor literature data available. No relevant EA data available and therefore, the best parameterisation option is cR_Ter_pp data regarding Zr.

6.10 cR_Ter_Mush

The parameter cR_Ter_Mush represents the uptake of elements from the soil compartment into mushrooms that are part of the human diet, as defined in the radionuclide model description (Saetre et al. 2013).

The vegetation samples assessed to adequately represent mushrooms (the parameter cR_Ter_Mush) are fruit body samples of the following mushroom species collected in FM: *Boletus edulis*, *Cantharellus tubaeformis*, *Collybia peronata*, *Cortinarius armeniacus*, *Cortinarius odorifer*, *Cortinarius sp*. *Hypholoma capnoides*, *Lactarius deterrimus*, *Lactarius scrobiculatus*, *Lactarius trivialis*, *Sarcodon imbricatus*, *Suillus granulatus*, *Suillus variegates* and *Tricholoma equestre* (Johanson et al. 2004). These mushroom samples are coupled to upper layer soil samples from the same study (samples from the root zone bulk soil, the rhizosphere fraction of the soil and the soil-root interface fraction). All soil samples were extracted using a mixture of hydrogen peroxide (H_2O_2) and nitric acid (HNO_3). CRs are estimated from the paired vegetation and soil concentration values.

Available literature data are assessed to not adequately represent the cR_Ter_Mush parameter. Mushroom site data are available for the following 10 elements: Ca, Cd, Co, Cs, I, Ni, Pb, Sr, Th and U (Figure 6-26 and Table 6-24). Neither site nor literature data are available 21 of the elements: Ac, Ag, Am, Ba, Cl, Cm, Eu, Ho, Mo, Nb, Np, Pa, Pd, Po, Pu, Ra, Se, Sm, Sn, Tc and Zr. The results of the various sense checks are outlined in Table 6-24, Since literature data sources are not available, neither literature data comparisons nor comparisons between site and literature data could be performed.

The selected element-specific parameter values are presented in Table 6-25 and Figure 6-27. Element and parameter -specific site data are utilised when available. EAs, with site-specific mushroom data, are selected for parameterisation of Ag, Ba, Mo, Pd, Pu, Ra and Sn, utilising Cu, Sr, Cr, Ni, U, Sr and Th data, respectively. Element-specific PA values, alternatively a combination of an EA and PA are selected when relevant parameter -specific EAs are not available. cR_Ter_pp data are assessed to be the best available PA alternative for mushroom data and, therefore, Cl, Eu, Ho, Nb, Sm and Zr are parameterised using element -specific cR_Ter_pp site data. Se for the parameter cR_Ter_pp is parameterised using cR_agri_cereal data, which is the preferred option. Ac, Am and Cm, Np and Pa are parameterised using cR_Ter_pp as PA and La as EA. Po is parameterised using cR_agri_cereal data and Bi as EA, and Tc is parameterised using cR_agri_cereal data and Re as EA (the same solution as for the parameter cR_Ter_pp, respectively, see Section 6.2).

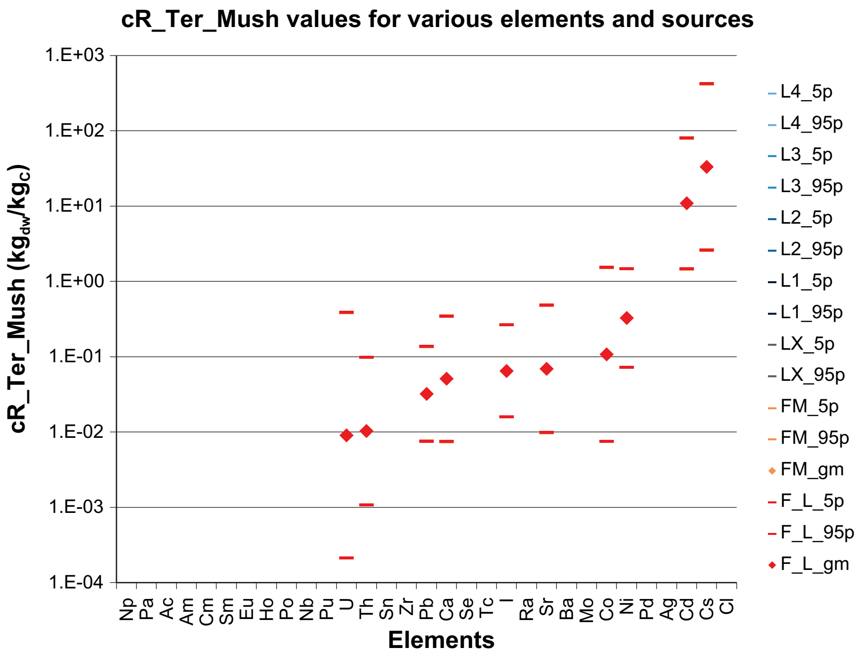

Figure 6-26. *Total available data ranges for the parameter cR_Ter_Mush (kg$_{dw}$/kg$_C$). The elements are arranged in the same order as in figure Figure 6-27 showing selected parameter values.*

The reasonable GSD range for parameter cR_agri_cereal values are assessed to span from 3 GSDmin to 7 GSDmax with a GSDmean value of 4 (see Section 4.3). A GSDmin is appointed to 5 elements: Ag, I, Ni, Pb and Pd and a GSDmax to 12 elements: Ac, Am, Cl, Cm, Eu, Ho, Nb, Po, Se, Sm, Tc and Zr (Table 6-25). Selected GSD data for U is exceptionally high (9.8).

Lanthanides and actinides display low CRs, as expected (Figure 6-27). It is apparent that many of them are parameterised using the same values; La cR_Ter_pp data in the case of Am, Cm and Ac, and Th data in the case of Pu, Sn, Np and Pa. Ag shows relatively high CR compared to other terrestrial vegetation and, as expected, Cl displays the highest values.

Table 6-24. All available data for the parameter cR_Ter_Mush (kg_{dw}/kg_C) for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			
Ag																			
Am																			
Ba																			
Ca	18/22		18/22					3.2		3.2									
Cd	21/22		21/22					3.4		3.4									
Cl																			
Cm																			
Co	21/22		21/22					5		5									
Cr	21/22		21/22					4.5		4.4									
Cs	21/22		21/22					4.7		4.7	1.9				S3		S3		
Cu	21/22		21/22					2.3		2.2									
Eu																			
Ho																			
I	21/22		21/22					2.4		2.3									
Mo																			
Nb																			
Ni	21/22		21/22					2.5		2.5									
Np																			
Pa																			
Pb	21/22		21/22					2.4		2.4	2				S4		S4		
Pd																			
Po											1.7								
Pu																			
Ra											1.3								
Se																			
Sm																			
Sn																			
Sr	21/22		21/22					3.3		3.2	2.2				S4		S4		
Tc																			
Th	21/22		21/22					3.9		3.9	1.8				S4		S4		
U	21/22		21/22					9.8		9.8									
Zr																			

Table 6-25. Selected parameter values properties, references and comments for the parameter cR_Ter_Mush (kg_{dw}/kg_{C}) for the elements of primary concern.

Ele-ment	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La	cR_Ter_pp	18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	7.0	GSDmax	Site data FMLX	FMLX	No site or literature data available. Good amount of data available for the EA La and cR_Ter_pp, which is considered the best PA.
Ag	Cu		21	4.5E–01	5.8E+00	5.8E+00	3.5E+01	3.0	GSDmin	Site data FM	FM	No site or literature data available. Good amount of FM data available for Cu, which is considered a relevant EA .
Am	La	cR_Ter_pp	18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	7.0	GSDmax	Site data FMLX	FMLX	No site or literature data available. Good amount of data available for the EA La and cR_Ter_pp, which is considered the best PA.
Ba	Sr		21	5.8E–03	6.9E–02	6.9E–02	1.5E+00	3.2	GSD	Site data FM	FM	No site or literature data available. Good amount of FM data available for Sr, which is considered a relevant EA.
Ca			18	2.5E–03	5.1E–02	5.1E–02	6.3E–01	3.2	GSD	Site data FM	FM	Good amount of FM data available
Cd			21	2.3E–01	1.1E+01	1.1E+01	2.2E+02	3.4	GSD	Site data FM	FM	Good amount of FM data available
Cl		cR_Ter_pp	8	7.1E+00	3.9E+02	3.9E+02	9.6E+03	7.0	GSDmax	Site data FM	FM	No site or literature data available. Good amount of relevant site data available for the parameter cR_Ter_pp, which is considered a valid PA.
Cm	La	cR_Ter_pp	18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	7.0	GSDmax	Site data FMLX	FMLX	No site or literature data available. Good amount of data available for the EA La and cR_Ter_pp, which is considered the best PA
Co			21	5.9E–03	1.1E–01	1.1E–01	7.0E+00	5.0	GSD	Site data FM	FM	Good amount of FM data available
Cs			21	2.3E–01	3.3E+01	3.3E+01	1.2E+03	4.7	GSD	Site data FM	FM	Good amount of FM data available
Eu		cR_Ter_pp	8	2.6E–04	6.5E–03	6.5E–03	1.6E–01	7.0	GSDmax	Site data LX	LX	No site or literature data available. Good amount of relevant site data available for the parameter cR_Ter_pp, which is considered a valid PA.
Ho		cR_Ter_pp	6	2.7E–04	6.5E–03	6.5E–03	1.6E–01	7.0	GSDmax	Site data LX	LX	No site or literature data available. Good amount of relevant site data available for the parameter cR_Ter_pp, which is considered a valid PA.
I			21	1.1E–02	6.5E–02	6.5E–02	3.0E+00	3.0	GSDmin	Site data FM	FM	Good amount of FM data available
Mo	Cr		21	6.4E–03	1.0E–01	1.0E–01	1.2E+01	4.4	GSD	Site data FM	FM	No site or literature data are available. Good amount of FM Cr data are available, which is considered a relevant EA.
Nb		cR_Ter_pp	17	3.3E–04	8.1E–03	8.0E–03	4.9E–01	7.0	GSDmax	Site data FMLX	FMLX	No site or literature data available. Good amount of relevant site data available for the parameter cR_Ter_pp, which is assessed to be a valid PA.
Ni			21	1.5E–02	3.3E–01	3.3E–01	3.4E+00	3.0	GSDmin	Site data FM	FM	Good amount of relevant FM data available
Np	La	cR_Ter_pp	18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	7.0	GSDmax	Site data FMLX	FMLX	No site or literature data available. Good amount of relevant FM data for cR_Ter_pp available for EA La
Pa	La	cR_Ter_pp	18	1.1E–04	3.2E–03	2.0E–03	1.5E–01	7.0	GSDmax	Site data FMLX	FMLX	No site or literature data available. Good amount of relevant FM data for cR_Ter_pp available for EA La
Pb			21	4.2E–03	3.2E–02	3.2E–02	3.4E–01	3.0	GSDmin	Site data FM	FM	Good amount of relevant FM data available
Pd	Ni		21	1.5E–02	3.3E–01	3.3E–01	3.4E+00	3.0	GSDmin	Site data FM	FM	No site data available. Ni site data available and considered a valid EA.
Po	Bi	cR_agri_cereal	10	2.7E–04	6.5E–03	6.5E–03	1.6E–01	7.0	GSDmax	Site data FM	FM	No site data available. Bi is a plausible EA. Site data aavailable for Bi in the case of cereal data.

Ele-ment	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Pu	U		21	1.2E–04	9.0E–03	9.0E–03	1.5E+01	9.8	GSD	Site data FM	FM	No site or literature data available. Good amount of FM data available for U, which is assessed to be a relevant EA.
Ra	Sr		21	5.8E–03	6.9E–02	6.9E–02	1.5E+00	3.2	GSD	Site data FM	FM	No site or literature data available. Good amount of FM data available for Sr, which is assessed to be a relevant EA.
Se		cR_agri_cereal	6	2.3E–03	5.6E–02	5.6E–02	1.4E+00	7.0	GSDmax	Site data FM	FM	No site data available. No adequate EA available. Se in the case of cR_Ter_pp data (which is assessed to be the best parameterisation option in many other cases) is parameterised using Se cR_agri_cereal site data.
Sm		cR_Ter_pp	15	1.4E–04	3.4E–03	2.8E–03	9.8E–02	7.0	GSDmax	Site data FMLX	FMLX	No site or literature data available. Good amount of data available for cR_Ter_pp, which is a reasonable PA.
Sn	Th		21	7.1E–04	1.0E–02	1.0E–02	6.1E–01	3.9	GSD	Site data FM	FM	No site data available. Good amount of FM data vailable for Th, which is considered a relevant EA.
Sr			21	5.8E–03	6.9E–02	6.9E–02	1.5E+00	3.2	GSD	Site data FM	FM	Good amount of relevant FM data available
Tc	Re	cR_agri_cereal	9	9.0E–04	6.4E–02	6.4E–02	4.5E+00	7.0	GSDmax	Site data FM	FM	No site data available. Re is a plausible EA, and site data are available for Re in the case of cereal data
Th			21	7.1E–04	1.0E–02	1.0E–02	6.1E–01	3.9	GSD	Site data FM	FM	Good amount of relevant FM data available
U			21	1.2E–04	9.0E–03	9.0E–03	1.5E+01	9.8	GSD	Site data FM	FM	Good amount of relevant FM data available
Zr		cR_Ter_pp	16	1.1E–03	2.8E–02	2.4E–02	6.8E–01	7.0	GSDmax	Site data FMLX	FMLX	No site or literature data available. Good amount of site data available for the parameter cR_Ter_pp, which is considered a reasonable analogue.

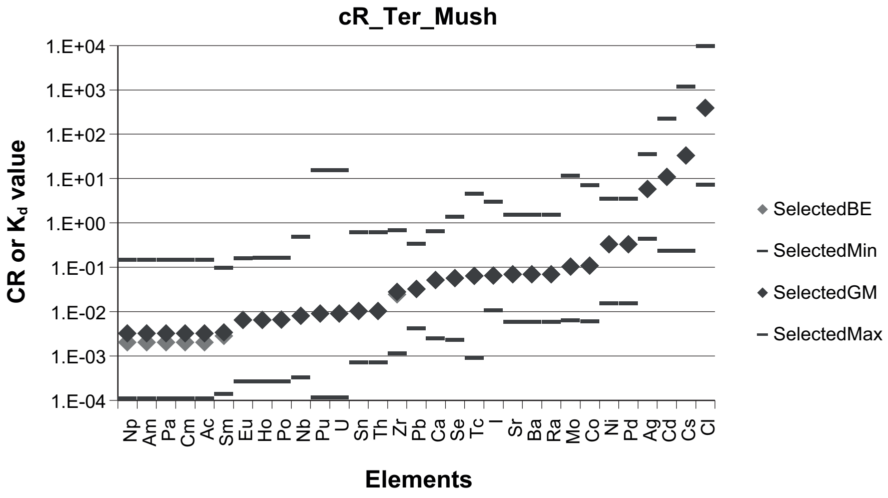

Figure 6-27. Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg_{dw}/kg_C).

6.11 cR_Ter_detr_inv_NHB

This parameter describes the element uptake in terrestrial detrivorous invertebrates for use in dose estimates to this organism type. Site data are not available for this organism type. Data for adult earthworm in ICRP (2011), categorised as L1 data, are available for a restricted number of elements; Am, Cd, Cl, Cs, Eu, I, Nb, Ni, Pb, Po, Se, Sr and U, and only 1 value without range is often presented. In such cases, literature data for detritivorous invertebrate invertebrates in ERICA (Beresford et al. 2008a), categorised as L2 data, are selected. In cases where data on detritivorous invertebrates are missing, data on soil invertebrates, gastropods or the maximum available value are utlised in ERICA (Beresford et al. 2008a). Since both references often lack ranges, sense checks of the parameter values are only possible for 5 elements: Cd, Cl, Cs, I and Pb. Data for these elements correlate, and the values are often very consistent in ICRP (2011) and ERICA (Beresford et al. 2008a). The available data are shown in Figure 6-28 and Table 6-26.

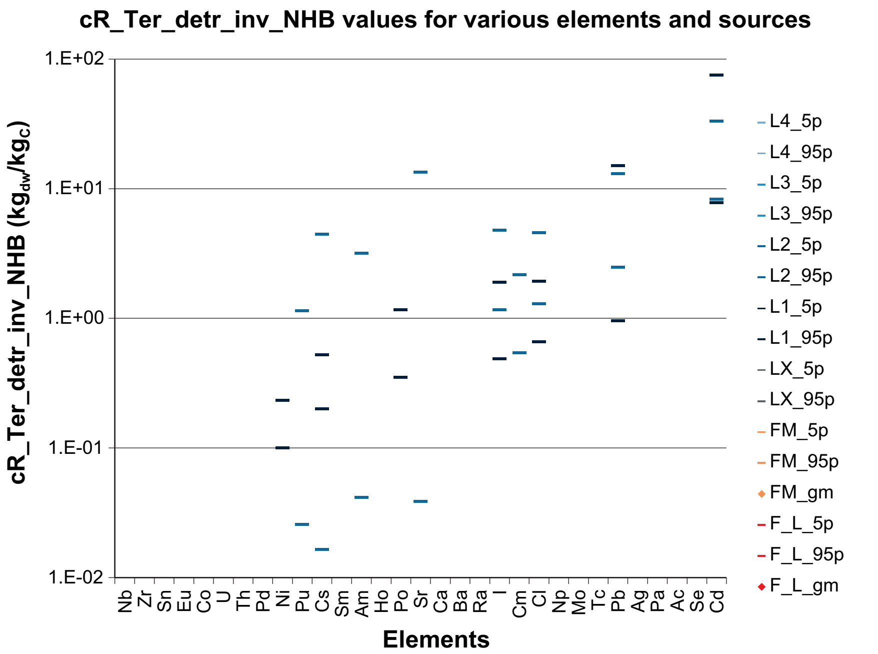

Figure 6-28. Total available data ranges for the parameter cR_Ter_detr_inv_NHB (kg_{dw}/kg_C). The elements are arranged in the same as in Figure 6-29 showing selected parameter values.

Data are missing for 9 elements: Ac, Ba, Ca, Ho, Mo, Pa, Pd, Sm and Sn. EAs are used in several cases. Am is used as EA for Ac, Ho, Pa and Sm. The choice is between Am, Cm and Eu. Am and Cm values are based on CR reviews and Am encompassed the higest number of observations (61). Sr is used as EA for Ba and Ca (see Section 2.7.1). Tc is utilised as EA for Mo in ERICA. Although this may not be the best EA, it is the highest value and, therefore, selected. Ni is used as EA for Pd.

Ranges are not available for Zr, Nb, Mo, Tc, Ag, Se, Sm, Eu, Ho, Ra, Th and U, and GSDmax (7) is assigned to these parameters. GSDmax is also assigned to elements where PAs are utilised. The presented GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean or GSDmax).

The selected CR values are presented in Table 6-27 and Figure 6-29.

Table 6-26. All available data for the parameter cR_Ter_detr_inv_NHB for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. ICRP 2011 Terrestrial Earth worm, ERICA (Beresford et al. 2008a) Terrestrail Detritivorous invertebrate.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am				1	61							3.7							2:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				398	411						2.0	1.5							2:1/1
Cl				17	31						1.4	1.5							2:1/1
Cm					2							1.5							1:0/0
Co					1														1:0/0
Cs				7	127						1.3	5.5							2:1/1
Eu				1	1														2:0/0
Ho																			0:0/0
I				10	32						1.5	1.5							2:1/1
Mo																			0:0/0
Nb				1	1														2:0/0
Ni				5	1						1.3								2:0/0
Np					1														1:0/0
Pa																			0:0/0
Pb				409	288						2.3	1.7							2:1/1
Pd																			0:0/0
Po				7	1						1.4								2:0/0
Pu					91							3.2							1:0/0
Ra					1														1:0/0
Se				1	1														2:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				1	31							5.9							2:0/0
Tc					1														1:0/0
Th					1														1:0/0
U				1	1														2:0/0
Zr					1														1:0/0

Table 6-27. **Selected data properties, references and comments for the parameter cR_Ter_detr_inv_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.**

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	Am		1	4.5E–02	1.1E+00	1.1E+00	2.7E+01	7.0	GSDmax	ICRP 2011	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am and Cm in ERICA are based on CR reviews and Am have have the largest number of observations (61).
Ag			1	2.9E–02	7.0E–01	7.0E–01	1.7E+01	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Am			61	1.3E–03	4.2E–02	4.2E–02	1.7E+00	3.7	gsd	ERICA	L2	ICRP 2011 presented 1 value without range, whereas ERICA presented a value and range based on 61 observations. The latter is selected, due to the large number of observations.
Ba	Sr		31	4.5E–03	8.4E–02	8.4E–02	1.9E+00	5.9	gsd	ERICA	L2	Sr used as EA. Data from ERICA chosen due to larger number of observations.
Ca	Sr		31	4.5E–03	8.4E–02	8.4E–02	1.9E+00	5.9	gsd	ERICA	L2	Sr used as EA. Data from ERICA chosen due to larger number of observations.
Cd			398	3.7E–01	3.6E+00	3.6E+00	3.5E+01	4.0	GSDmean	ICRP 2011	L1	
Cl			17	1.7E–02	1.7E–01	1.7E–01	1.7E+00	4.0	GSDmean	ICRP 2011	L1	
Cm			2	5.1E–03	1.3E–01	1.3E–01	3.1E+00	7.0	GSDmax	ERICA	L2	
Co			1	1.4E–04	3.5E–03	3.5E–03	8.6E–02	7.0	GSDmax	ERICA	L2	
Cs			7	4.9E–03	4.8E–02	4.8E–02	4.7E–01	4.0	GSDmean	ICRP 2011	L1	
Eu			1	3.2E–05	7.9E–04	7.9E–04	1.9E–02	7.0	GSDmax	ICRP 2011	L1	Validation not possible since both ERICA and ICRP 2011 presented only 1 value each without range, though the values correlate well. No range presented. GSDmax assigned.
Ho	Am		61	1.3E–03	4.2E–02	4.2E–02	1.7E+00	3.7	gsd	ERICA	L2	Am used as EA. The choice is between Am, Cm and Eu. Data for Am and Cm in ERICA are based on CR reviews and Am have have the largest number of observations (61).
I			10	1.5E–02	1.4E–01	1.4E–01	1.4E+00	4.0	GSDmean	ICRP 2011	L1	
Mo	Tc		1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L2	Tc used as EA. ERICA used maximum value for Tc in lack of other information. No range presented. GSDmax assigned.
Nb			1	2.1E–05	5.1E–04	5.1E–04	1.2E–02	7.0	GSDmax	ICRP 2011	L1	Both ERICA and ICRP 2011 presented only 1 value without range, though the values agree well. No range presented. GSDmax assigned.
Ni			5	2.3E–03	2.3E–02	2.3E–02	2.2E–01	4.0	GSDmean	ICRP 2011	L1	Validation not possible, since ERICA present only min and max values. Data from ICRP 2011 and ERICA correlate quite well.
Np	Am	cR_Ter_gastr_NHB	8	6.6E–03	1.6E–01	1.6E–01	4.0E+00	7.0	GSDmax	ERICA	L1	ERICA used the same value as for Am in gastropod.
Pa	Am		1	4.5E–02	1.1E+00	1.1E+00	2.7E+01	7.0	GSDmax	ICRP 2011	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am and Cm in ERICA are based on CR reviews and Am have have the largest number of observations (61).
Pb			409	2.3E–03	5.7E–01	5.7E–01	5.5E+00	4.0	GSDmean	ICRP 2011	L1	

Ele-ment	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pd	Ni		5	2.3E–03	2.3E–02	2.3E–02	2.2E–01	4.0	GSDmean	ICRP 2011	L1	Ni used as EA.
Po			7	9.8E–03	9.6E–02	9.6E–02	9.4E–01	4.0	GSDmean	ICRP 2011	L1	Validation not possible, since ERICA presented only 1 value without range.
Pu			91	4.2E–04	2.0E–02	2.0E–02	3.3E–01	4.0	GSDmean	ERICA	L2	
Ra			1	3.7E–03	9.0E–02	9.0E–02	2.2E+00	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Se			1	6.0E–02	1.5E+00	1.5E+00	3.6E+01	7.0	GSDmax	ICRP 2011	L1	Validation not possible since both ERICA and ICRP 2011 presented only 1 value each without range, though thr values correlate well. No range presented. GSDmax assigned.
Sm	Am		61	1.3E–03	4.2E–02	4.2E–02	1.7E+00	3.7	gsd	ERICA	L2	No data for Sm. Am was used as EA. The choice was between Am, Cm and Eu. Data for Am and Cm in ERICA was based on CR reviews, that for Am contained most observations (61) and was chosen.
Sn	Zr		1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L2	Zr used as EA. No range presented. GSDmax assigned.
Sr			31	4.5E–03	8.4E–02	8.4E–02	1.9E+00	5.9	gsd	ERICA	L2	Validation not possible since ICRP 2011 presented only 1 value without range. Data from ERICA are chosen due to larger number of observations.
Tc			1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Th			1	3.6E–04	8.8E–03	8.8E–03	2.2E–01	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
U			1	3.6E–04	8.8E–03	8.8E–03	2.2E–01	7.0	GSDmax	ERICA	L2	Validation not possible since both ERICA and ICRP 2011 presented only 1 value each without range, though the values correlate well. No range presented. GSDmax assigned.
Zr			1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.

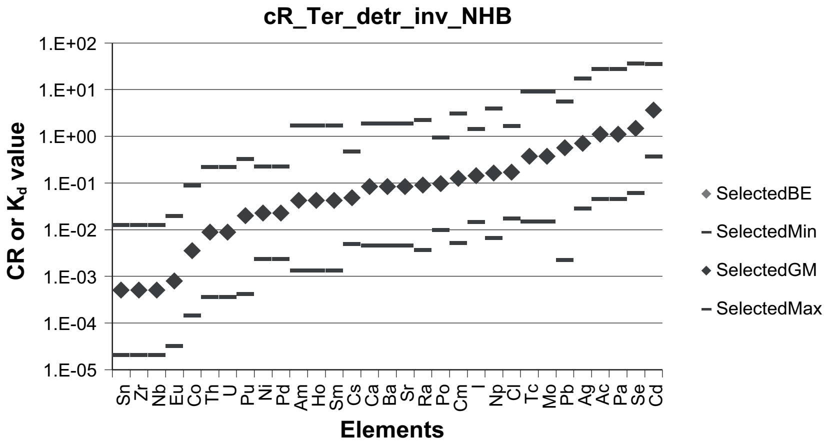

__Figure 6-29.__ Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM values (kg_{dw}/kg_{fw}).

6.12 cR_Ter_soil_inv_NHB

This parameter describes the element uptake in terrestrial soil invertebrates for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are available in ERICA (Beresford et al. 2008a) (see Figure 6-30 and Table 6-28) and in many cases the data are the same as data for flying insects or soil invertebrates. Most of the elements are lacking a range and GSDmax (7) is assigned for these parameters.

The maximum animal value for Po is selected in ERICA (Beresford et al. 2008a), due to lack of data. A higher CR value is presented for adult earthworm in ICRP (2011), and the latter is selected. There are no data in ERICA (Beresford et al. 2008a) for 9 elements: Ac, Ba, Ca, Ho, Mo, Pa, Pd, Sm and Sn, and EAs are utilised in these cases. Am is selected as EA for Ac, Ho, Pa and Sm. The choice is between Am, Cm and Eu. Am and Eu values are based on CR reviews and Am encompassed the highest number of observations. Zr is used as EA for Sn, whereas Sr is selected for Ca and Ba. Tc data are used for Mo and Ni data for Pd. The former is not the best EA, though this value is the maximum data in ERICA (Beresford et al. 2008a) due to the lack of other information.

GSDmax is assigned to elements where PAs are utilised. The presented GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean).

The selected CR values are presented in Table 6-29 and Figure 6-31.

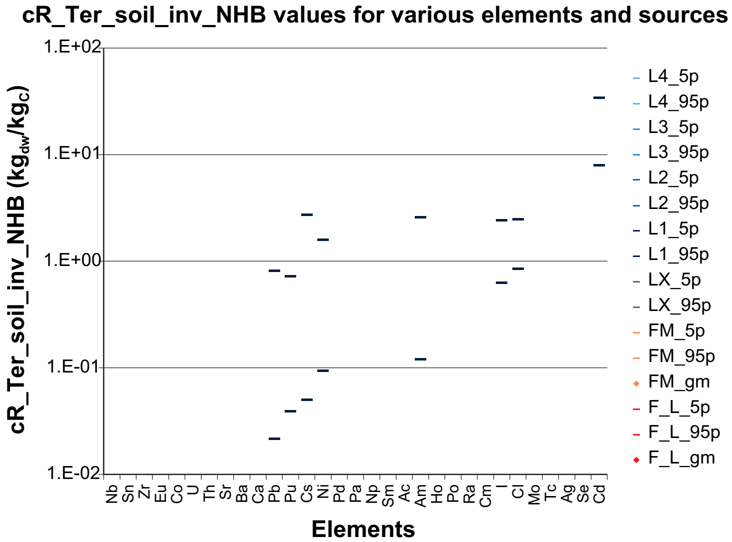

__Figure 6-30.__ Total available data ranges for the parameter cR_Ter_soil_inv_NHB (kg_{dw}/kg_C). The elements are arranged in the same order as in Figure 6-31 showing selected parameter values.

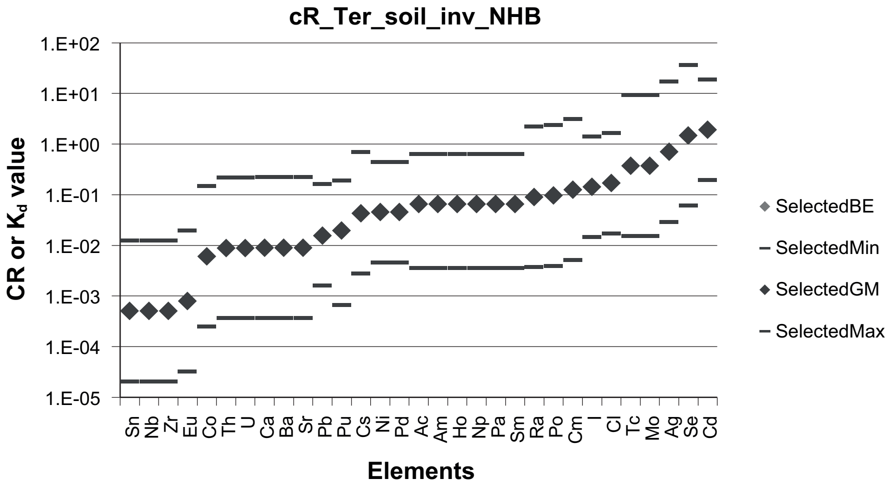

Figure 6-31. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg_{dw}/kg_{fw}).*

Table 6-28. **All available data for the parameter cR_Ter_soil_inv_NHB for the elements of primary concern and selected EAs. L1 = ERICA (Beresford et al. 2008a) Terrestrail Soil Invertebrate (worm).**

Ele-ment	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				12							2.5								1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				15							1.6								1:0/0
Cl				17							1.4								1:0/0
Cm				1															1:0/0
Co				1															1:0/0
Cs				19							3.4								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				10							1.5								1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				77							2.4								1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				264							3.0								1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				8							2.4								1:0/0
Ra				1															1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				1															1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

Table 6-29. **Selected data properties, references and comments for the parameter cR_Ter_soil_inv_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.**

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	Am		12	3.5E–03	6.5E–02	6.5E–02	6.3E–01	4.0	GSDmean	ERICA	L1	Am used as EA. Cm and Eu are also considered, though the element with largest number of observations is selected.
Ag			1	2.9E–02	7.0E–01	7.0E–01	1.7E+01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Am			12	3.5E–03	6.5E–02	6.5E–02	6.3E–01	4.0	GSDmean	ERICA	L1	
Ba	Sr		1	3.7E–04	9.0E–03	9.0E–03	2.2E–01	7.0	GSDmax	ERICA	L1	Sr used as EA. No range presented. GSDmax assigned.
Ca	Sr		1	3.7E–04	9.0E–03	9.0E–03	2.2E–01	7.0	GSDmax	ERICA	L1	Sr used as EA. No range presented. GSDmax assigned.
Cd			15	1.9E–01	1.9E+00	1.9E+00	1.9E+01	4.0	GSDmean	ERICA	L1	
Cl			17	1.7E–02	1.7E–01	1.7E–01	1.7E+00	4.0	GSDmean	ERICA	L1	
Cm		cR_Ter_detr_inv_NHB	2	5.1E–03	1.3E–01	1.3E–01	3.1E+00	7.0	GSDmax	ERICA	L2	ERICA used value for detrivorous invertebrate.
Co			1	2.5E–04	6.1E–03	6.1E–03	1.5E–01	7.0	GSDmax	ERICA	L1	
Cs			19	2.8E–03	4.3E–02	4.3E–02	6.9E–01	4.0	GSDmean	ERICA	L1	
Eu			1	3.2E–05	7.9E–04	7.9E–04	1.9E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Ho	Am		12	3.5E–03	6.5E–02	6.5E–02	6.3E–01	4.0	GSDmean	ERICA	L1	Am used as EA. Cm and Eu are also considered, though the element with largest number of observations is selected.
I			10	1.5E–02	1.4E–01	1.4E–01	1.4E+00	4.0	GSDmean	ERICA	L1	
Mo	Tc		1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L1	Tc used as EA. ERICA used maximum data in lack of other information. No range presented. GSDmax assigned.
Nb			1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Ni			77	4.6E–03	4.5E–02	4.5E–02	4.4E–01	4.0	GSDmean	ERICA	L1	
Np	Am		12	3.5E–03	6.5E–02	6.5E–02	6.3E–01	4.0	GSDmean	ERICA	L1	ERICA used same value as for Am.
Pa	Am		12	3.5E–03	6.5E–02	6.5E–02	6.3E–01	4.0	GSDmean	ERICA	L1	Am used as EA. Cm and Eu are also considered, though the element with largest number of observations is selected.
Pb			264	1.6E–03	1.5E–02	1.5E–02	1.6E–01	4.0	GSDmean	ERICA	L1	
Pd	Ni		77	4.6E–03	4.5E–02	4.5E–02	4.4E–01	4.0	GSDmean	ERICA	L1	Ni used as EA.
Po		cR_Ter_detr_inv_NHB	7	3.9E–03	9.6E–02	9.6E–02	2.4E+00	7.0	GSDmax	ICRP 2011	L1	ERICA used maximum available animal value, in lack of data. Higher value presented for adult earthworm in ICRP and the latter are selected.
Pu			8	6.6E–04	2.0E–02	2.0E–02	1.9E–01	4.0	GSDmean	ERICA	L1	
Ra			1	3.7E–03	9.0E–02	9.0E–02	2.2E+00	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Se			1	6.0E–02	1.5E+00	1.5E+00	3.6E+01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Sm	Am		12	3.5E–03	6.5E–02	6.5E–02	6.3E–01	4.0	GSDmean	ERICA	L1	Am used as EA. Cm and Eu are also considered, though the element with largest number of observations is selected.
Sn	Zr		1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L1	Zr is used as EA. No range presented. GSDmax assigned.
Sr			1	3.7E–04	9.0E–03	9.0E–03	2.2E–01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Tc			1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th			1	3.6E–04	8.8E–03	8.8E–03	2.2E–01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
U			1	3.6E–04	8.8E–03	8.8E–03	2.2E–01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Zr			1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.

6.13 cR_Ter_gastr_NHB

This parameter describes the element uptake in terrestrial gastropods for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are available in ERICA (Beresford et al. 2008a) (Table 6-30 and Figure 6-32) and data for 11 elements are available; Am, Cd, Cl, Cs, I, Ni, Pb, Pu, Ra, Se and Sr. For other elements detritivorous invertebrates, soil invertebrates or flying insects are utilised. Data are missing for 9 elements: Ac, Ba, Ca, Ho, Mo, Pa, Pd, Sm and Sn, and EAs are utilised.

Am is used as EA for Ac, Ho, Pa and Sm. The choice is between Am, Cm and Eu. The Am value is based on a CR review, whereas the other two are values for detritivorous invertebrates and for soil invertebrates, respectively. Sr is selected as EA for Ba and Ca (see Section 2.7.1). Tc are utilised as EA for Mo in ERICA. Although this may not be the best EA, it is the highest value for this parameter. Zr is utilised as EA for Sn, whereas Ni is used for Pd.

The maximum animal value for Po is selected in ERICA, due to lack of data. A higher CR value is presented for adult earthworm in ICRP (2011) and the latter is selected.

Ranges are not available for a number of elements and GSDmax (7) is assigned to these. GSDmax is also assigned to elements where PAs are utilised. The GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in 6.5.2 (GSDmean).

The selected CR values are presented in Table 6-31 and Figure 6-33.

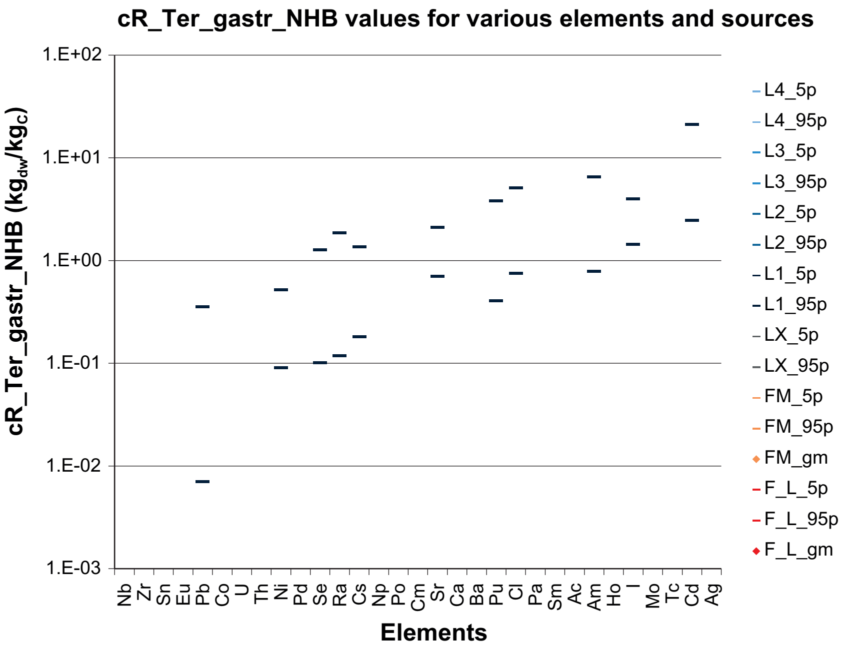

Figure 6-32. *Total available data ranges for the parameter cR_Ter_gastr_NHB (kg_{dw}/kg_C). The elements are arranged in the same order as in Figure 6-33 showing selected parameter values.*

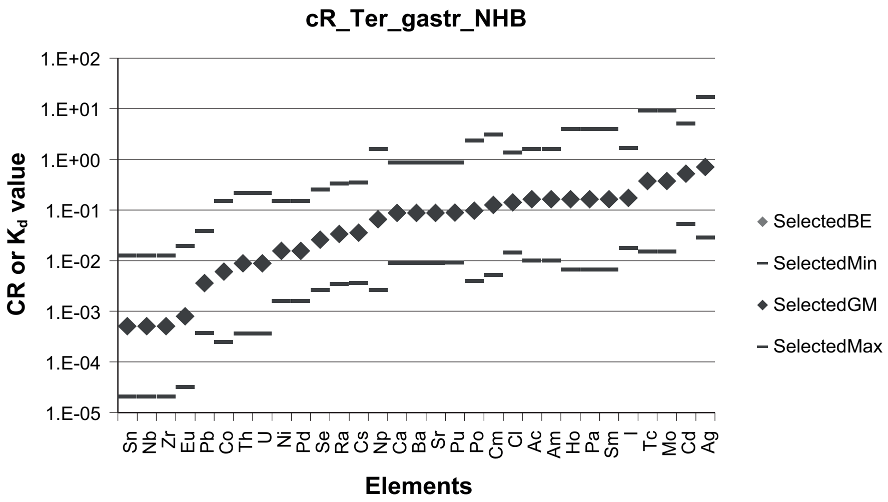

Figure 6-33. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg$_{dw}$/kg$_{fw}$).*

Table 6-30. All available data for the parameter cR_Ter_gastr_NHB for the elements of primary concern and selected EAs. L1 = ERICA (Beresford et al. 2008a) Terrestrial Gastropod.

Element	FM N (from/ to)	LX N (from/ to)	FMLX (from/ to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				8							1.9								1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				47							1.9								1:0/0
Cl				20							1.8								1:0/0
Cm				1															1:0/0
Co				1															1:0/0
Cs				18							1.8								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				12							1.4								1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				7							1.7								1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				47							3.3								1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				8							2.0								1:0/0
Ra				10							2.3								1:0/0
Se				7							2.2								1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				7							1.4								1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

Table 6-31. Selected data properties, references and comments for the parameter cR_Ter_gastr_NHB (kg_{dw}/kg_{fw}) for elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	Am		8	1.0E–02	1.6E–01	1.6E–01	1.6E+00	4.0	GSDmean	ERICA	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am were based on CR reviews whereas the others were PAs.
Ag			1	2.9E–02	7.0E–01	7.0E–01	1.7E+01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Am			8	1.0E–02	1.6E–01	1.6E–01	1.6E+00	4.0	GSDmean	ERICA	L1	
Ba	Sr		7	8.9E–03	8.7E–02	8.7E–02	8.6E–01	4.0	GSDmean	ERICA	L1	Sr used as EA.
Ca	Sr		7	8.9E–03	8.7E–02	8.7E–02	8.6E–01	4.0	GSDmean	ERICA	L1	Sr used as EA.
Cd			47	5.3E–02	5.2E–01	5.2E–01	5.1E+00	4.0	GSDmean	ERICA	L1	
Cl			20	1.4E–02	1.4E–01	1.4E–01	1.4E+00	4.0	GSDmean	ERICA	L1	
Cm		cR_Ter_detr_inv_NHB	2	5.1E–03	1.3E–01	1.3E–01	3.1E+00	7.0	GSDmax	ERICA	L2	ERICA used the same value as for detrivorous invertebrate.
Co			1	2.5E–04	6.1E–03	6.1E–03	1.5E–01	7.0	GSDmax	ERICA	L1	
Cs			18	3.6E–03	3.5E–02	3.5E–02	3.5E–01	4.0	GSDmean	ERICA	L1	
Eu			1	3.2E–05	7.9E–04	7.9E–04	1.9E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Ho	Am		8	6.6E–03	1.6E–01	1.6E–01	4.0E+00	7.0	GSDmax	ERICA	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am were based on CR reviews whereas the others were PAs.
I			12	1.8E–02	1.7E–01	1.7E–01	1.7E+00	4.0	GSDmean	ERICA	L1	
Mo	Tc		1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L1	Tc used as EA. ERICA used maximum value for Tc in lack of other information. No range presented. GSDmax assigned.
Nb			1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Ni			7	1.6E–03	1.5E–02	1.5E–02	1.5E–01	4.0	GSDmean	ERICA	L1	
Np	Am	cR_Ter_soil_inv_NHB	12	2.6E–03	6.5E–02	6.5E–02	1.6E+00	7.0	GSDmax	ERICA	L1	ERICA used value for Am in soil invertebrate.
Pa	Am		8	6.6E–03	1.6E–01	1.6E–01	4.0E+00	7.0	GSDmax	ERICA	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am were based on CR reviews whereas the others were PAs.
Pb			47	3.7E–04	3.6E–03	3.6E–03	3.8E–02	4.0	GSDmean	ERICA	L1	
Pd	Ni		7	1.6E–03	1.5E–02	1.5E–02	1.5E–01	4.0	GSDmean	ERICA	L1	Ni used as EA.
Po		cR_Ter_detr_inv_NHB	7	3.9E–03	9.6E–02	9.6E–02	2.4E+00	7.0	GSDmax	ICRP 2011	L1	ERICA used maximum available animal value in lack of data. Higher value presented for adult earthworm in ICRP and the latter is utilised.
Pu			8	9.1E–03	8.9E–02	8.9E–02	8.7E–01	4.0	GSDmean	ERICA	L1	
Ra			10	3.4E–03	3.4E–02	3.4E–02	3.3E–01	4.0	GSDmean	ERICA	L1	
Se			7	2.6E–03	2.6E–02	2.6E–02	2.5E–01	4.0	GSDmean	ERICA	L1	
Sm	Am		8	6.6E–03	1.6E–01	1.6E–01	4.0E+00	7.0	GSDmax	ERICA	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am were based on CR reviews whereas the others were PAs.
Sn	Zr		1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L1	Zr is used as EA. No range presented. GSDmax assigned.
Sr			7	8.9E–03	8.7E–02	8.7E–02	8.6E–01	4.0	GSDmean	ERICA	L1	
Tc			1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th			1	3.6E–04	8.8E–03	8.8E–03	2.2E–01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
U			1	3.6E–04	8.8E–03	8.8E–03	2.2E–01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Zr			1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.

6.14 cR_Ter_fl_ins_NHB

This parameter describes the element uptake in flying insects for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are available in ERICA (Beresford et al. 2008a) (Figure 6-34 and Table 6-32) and data for flying insects are presented for Am, Cd, Cs, Ni, Pb, Pu and Sr. For other elements, PAs such as detritivorous invertebrates or soil invertebrates, or estimates from un-paired concentrations are selected. ERICA (Beresford et al. 2008a) in some cases utilised a maximum value for terrestrial animals, due to lack of data.

One should suggest that the appropriate substrate used for a CR for this organism type would be air (as implied by the word "flying"). One may also argue that many flying insects have aquatic larval forms and, therefore, water (or sediment) would be a relevant medium as well. The medium utilised in the ERICA tool is soil and the organisms are considered to spend all their time on soil. Although this is a bit confusing, this concept is prescribed since our assessment is based on the method in the ERICA tool. The aquatic stage of insect larvae is treated separately by using the limnic reference organism "insect larvae", leaving the terrestrial stage of this organism type to be considered. The soils modelled in our assessment are always deposits derived from former aquatic stages and may have accumulated radionuclides in a previous stage. Therefore, it is more likely to have a higher radionuclide content than the surrounding air, making this a conservative approach (a higher exposure is expected).

Data presented in ERICA (Beresford et al. 2008a) are utilised when available. Data are missing for 9 elements: Ac, Ba, Ca, Ho, Mo, Pa, Pd, Sm and Sn and in these cases EAs are utilised. Am is selected as EA for Ac, Ho, Pa and Sm. The choice is between Am, Cm and Eu. The Am value is based on a CR review, whereas Cm and Eu are values for detritivorous invertebrates and for soil invertebrates, respectively. Sr is selected as EA for Ba and Ca (see Section 2.7.1). Tc is utilised as EA for Mo in ERICA. Although this may not be the best EA, it is the highest value and, therefore, selected. Zr is utilised as EA for Sn, whereas Ni is used for Pd.

The maximum animal value for Po is selected in ERICA, due to lack of data. A higher CR value is presented for adult earthworm in ICRP (2011), and the latter is selected. For Cl ERICA uses the same value as for detrivorous invertebrate. A value for adult earthworm is available in the higher ranked data source (ICRP 2011) and this was used.

Ranges are not available for a number of elements and GSDmax (7) is assigned to these elements.. GSDmax is also assigned to elements where PAs are used. The presented GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean or GSDmax).

The selected CR values are presented in Table 6-33 and Figure 6-35.

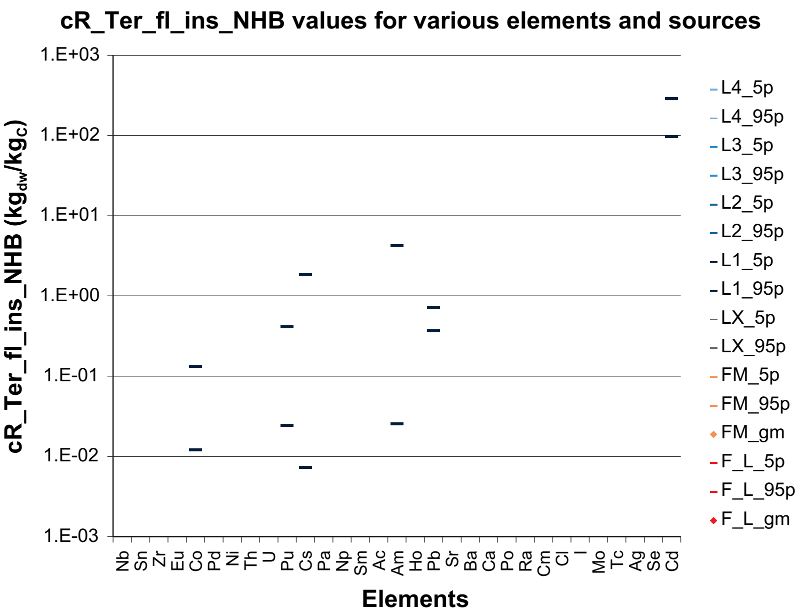

Figure 6-34. *Total available data ranges for the parameter cR_Ter_fl_ins_NHB (kg_{dw}/kg_C). The elements are arranged in the same order as in Figure 6-35 showing selected parameter values.*

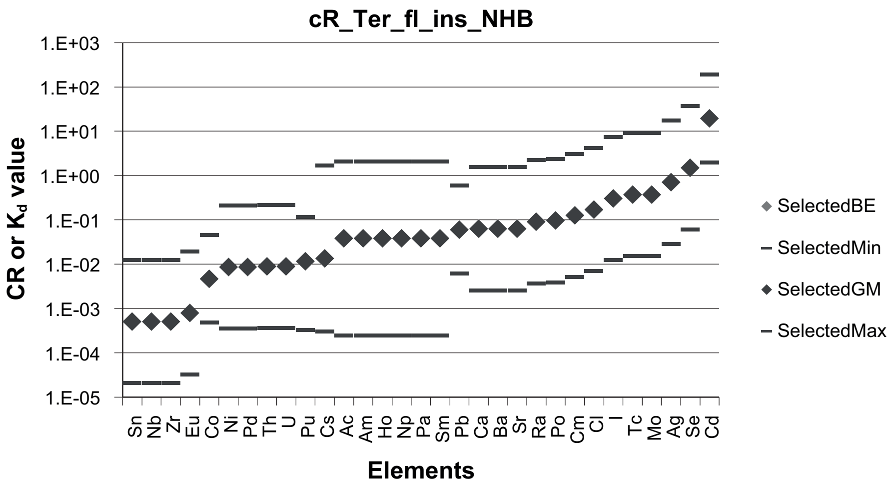

***Figure 6-35**. Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg_{dw}/kg_{fw}).*

Table 6-32. All available data for the parameter cR_Ter_fl_ins_NHB for the elements of primary concern and selected EAs. L1 = ERICA (Beresford et al. 2008a) Terrestrial Flying insects.

Ele-ment	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				25							4.7								1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				29							1.4								1:0/0
Cl				1															1:0/0
Cm				1															1:0/0
Co				17							2.1								1:0/0
Cs				67							5.4								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				1															1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				18							1.2								1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				25							2.4								1:0/0
Ra				1															1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				20															1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

Table 6-33. Selected data properties, references and comments for the parameter cR_Ter_fl_ins_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	Am		25	2.4E–04	3.8E–02	3.8E–02	2.0E+00	4.7	GSD	ERICA	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am were based on CR reviews whereas the others were PAs.
Ag			1	2.9E–02	7.0E–01	7.0E–01	1.7E+01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Am			25	2.4E–04	3.8E–02	3.8E–02	2.0E+00	4.7	GSD	ERICA	L1	
Ba	Sr		20	2.6E–03	6.3E–02	6.3E–02	1.6E+00	7.0	GSDmax	ERICA	L1	Sr used as EA. No range presented. GSDmax assigned.
Ca	Sr		20	2.6E–03	6.3E–02	6.3E–02	1.6E+00	7.0	GSDmax	ERICA	L1	Sr used as EA. No range presented. GSDmax assigned.
Cd			29	2.0E+00	1.9E+01	1.9E+01	1.9E+02	4.0	GSDmean	ERICA	L1	
Cl		cR_Ter_detr_inv_NHB	17	6.9E–03	1.7E–01	1.7E–01	4.1E+00	7.0	GSDmax	ICRP 2011	L1	ERICA used same value as for detrivorous invertebrate. Value for adult earthworm in ICRP 2011 is selected.
Cm		cR_Ter_detr_inv_NHB	2	5.1E–03	1.3E–01	1.3E–01	3.1E+00	7.0	GSDmax	ERICA	L2	ERICA used same value as for detrivorous invertrebrate.
Co			17	4.8E–04	4.7E–03	4.7E–03	4.6E–02	4.0	GSDmean	ERICA	L1	
Cs			67	3.0E–04	1.3E–02	1.3E–02	1.7E+00	5.4	GSD	ERICA	L1	
Eu			1	3.2E–05	7.9E–04	7.9E–04	1.9E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Ho	Am		25	2.4E–04	3.8E–02	3.8E–02	2.0E+00	4.7	GSD	ERICA	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am were based on CR reviews whereas the others were PAs.
I			1	1.2E–02	3.0E–01	3.0E–01	7.4E+00	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Mo	Tc		1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L1	Tc used as EA. ERICA used maximum value for Tc in lack of other information. No range presented. GSDmax assigned.
Nb			1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Ni			1	3.5E–04	8.6E–03	8.6E–03	2.1E–01	7.0	GSDmax	ERICA	L1	
Np	Am		25	2.4E–04	3.8E–02	3.8E–02	2.0E+00	4.7	GSD	ERICA	L1	ERICA used Am value.
Pa	Am		25	2.4E–04	3.8E–02	3.8E–02	2.0E+00	7.0	GSDmax	ERICA	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am were based on CR reviews whereas the others were PAs.
Pb			18	6.1E–03	6.0E–02	6.0E–02	5.8E–01	4.0	GSDmean	ERICA	L1	
Pd	Ni		1	3.5E–04	8.6E–03	8.6E–03	2.1E–01	7.0	GSDmax	ERICA	L1	Ni used as EA.
Po		cR_Ter_detr_inv_NHB	7	3.9E–03	9.6E–02	9.6E–02	2.4E+00	7.0	GSDmax	ICRP 2011	L1	ERICA used maximum available animal value in lack of data. Higher value presented for adult earthworm in ICRP and the latter is utilised.
Pu			25	3.2E–04	1.2E–02	1.2E–02	1.1E–01	4.0	GSDmean	ERICA	L1	
Ra			1	3.7E–03	9.0E–02	9.0E–02	2.2E+00	7.0	GSDmax	ERICA	L1	
Se			1	6.0E–02	1.5E+00	1.5E+00	3.6E+01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Sm	Am		25	2.4E–04	3.8E–02	3.8E–02	2.0E+00	4.7	GSD	ERICA	L1	Am used as EA. The choice is between Am, Cm and Eu. Data for Am were based on CR reviews whereas the others were PAs.
Sn	Zr		1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L1	Zr used as EA. No range presented. GSDmax assigned.
Sr			20	2.6E–03	6.3E–02	6.3E–02	1.6E+00	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Tc			1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th			1	3.6E–04	8.8E–03	8.8E–03	2.2E–01	7.0	GSDmax	ERICA	L1	
U			1	3.6E–04	8.8E–03	8.8E–03	2.2E–01	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Zr			1	2.1E–05	5.0E–04	5.0E–04	1.2E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.

6.15 cR_Ter_amph_NHB

This parameter describes the element uptake in terrestrial amphibians for use in dose estimates to this organism type. Amphibians spend their life in both aquatic (mostly freshwater) and terrestrial environments. The aquatic part is treated separately by using the limnic reference organisms "amphibian", which spend all their time in water (Section 7.11). The terrestrial amphibians spend all their time in the terrestrial environment (on soil). Combining the limnic and terrestial reference amphibians, using habitat preferences for relevant site species, will give a more accurate dose estimate.

Site data are not available. Literature data are available for adult frog in ICRP (2011), categorised as L1 data, and for amphibians in ERICA (Beresford et al. 2008a), categorised as L2 data, see Figure 6-36 and Table 6-34. Data are missing for Ac, Pa and Pd.

Sense checks of literature data are possible for 5 elements: Cd, Cs, Pb, Sr and Tc and all are consistent.

When data are missing, ERICA (Beresford et al. 2008a) often utilised mammal data and in a few cases bird data. Site data for mammals are available and selected as PA for Cl, Co, I, Nb, Ni, Ra, Se, Th, U and Zr. Mammal site data are also utilised for the elements Mo, Sm and Sn, that are not included in ERICA.

Site data for Eu and Ho are missing in mammals and data for La in mammals are selected (combined EA and PAs). La is also utilised as EA for Ac, Am, Cm, Np and Pa. Zr and Ni are selected as EAs for Pd. Site data for Ca and Ba in mammals are available, though much lower than literature data for Sr in adult frog. It is more relevant to use EA data for the right organism than to select site data for another organism, hence literature data for Sr are utilised (from ICRP 2011).

Ranges are not available for Ag and Pu in ERICA (Beresford et al. 2008a) and GSDmax (5) is assigned to these parameters. GSDmax is also assigned to elements where PAs are utilised. The presented GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean or GSDmax).

The selected CR values are presented in Table 6-35 and Figure 6-37.

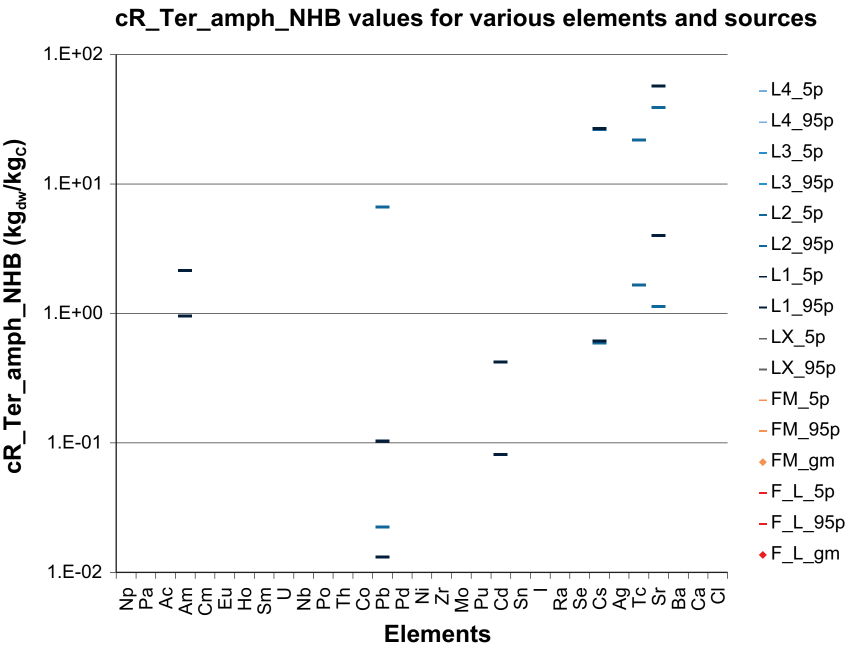

Figure 6-36. *Total available data ranges for the parameter cR_Ter_amph_NHB (kg$_{dw}$/kg$_C$). The elements are arranged in the same order as in Figure 6-37 showing selected parameter values.*

Table 6-34. **All available data for the parameter cR_Ter_amph_NHB for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ICRP 2011 Terrestrial Amphibian. L2 = ERICA (Beresford et al. 2008a) Terrestrial Amphibian.**

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am				7	1						1.3								2:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				5	5						1.7	1.7							2:1/1
Cl					1														1:0/0
Cm					1														1:0/0
Co					1														1:0/0
Cs				105	107						3.2	3.2							2:1/1
Eu					1														1:0/0
Ho																			0:0/0
I					1														1:0/0
Mo																			0:0/0
Nb					1														1:0/0
Ni					1														1:0/0
Np					1														1:0/0
Pa																			0:0/0
Pb				6	24						1.9	5.6							2:1/1
Pd																			0:0/0
Po					1														1:0/0
Pu					1														1:0/0
Ra					1														1:0/0
Se					1														1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				14	21						2.2	2.9							2:1/1
Tc					2							2.2							1:0/0
Th					1														1:0/0
U					1														1:0/0
Zr					1														1:0/0

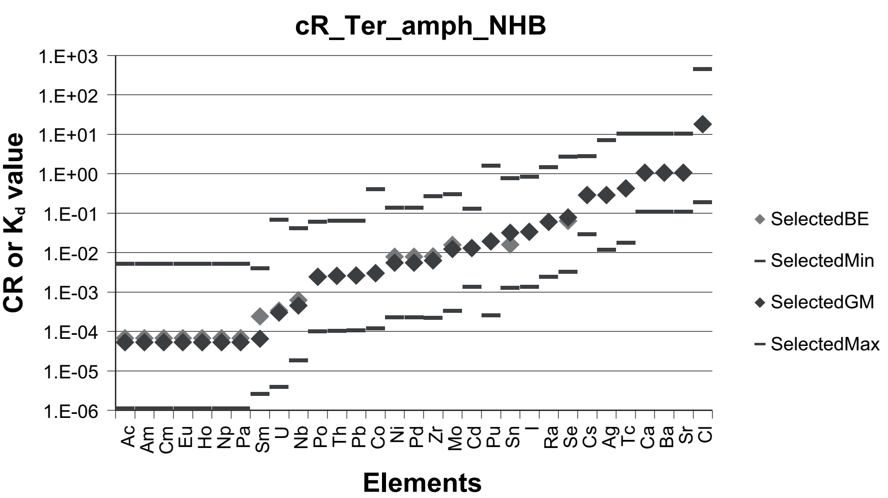

Figure 6-37*. Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg$_{dw}$/kg$_{fw}$)*.

Table 6-35. **Table showing selected data properties, references and comments for the parameter cR_Ter_amph_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.**

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Mammals used as PA. Site data for Ac in mammals is missing. La used as EA.
Ag			1	1.2E–02	2.9E–01	2.9E–01	7.0E+00	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Am	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Site data for La in mammals used (combined PA and EA).
Ba	Sr		14	1.1E–01	1.1E+00	1.1E+00	1.0E+01	4.0	GSDmean	ICRP 2011	L1	Site data for Ba in mammals available though much lower than literature data for Sr in adult frog. It is considered more relevant to use EA data for the right organism than to use site data for another organism, hence literature data for Sr are utilised.
Ca	Sr		14	1.1E–01	1.1E+00	1.1E+00	1.0E+01	4.0	GSDmean	ICRP 2011	L1	Site data for Ca in mammals available though much lower than literature data for Sr in adult frog. It is considered more relevant to use EA data for the right organism than to use site data for another organism, hence literature data for Sr are utilised.
Cd			5	1.3E–03	1.3E–02	1.3E–02	1.3E–01	4.0	GSDmean	ICRP 2011	L1	
Cl		cR_Ter_mammal_NHB	19	1.9E–01	1.8E+01	1.8E+01	4.4E+02	7.0	GSDmax	Site data FM	FM	ERICA used data for mammal. Site data for Cl in mammals available and utilised.
Cm	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Site data for La in mammals used (combined PA and EA).
Co		cR_Ter_mammal_NHB	33	1.2E–04	3.0E–03	3.0E–03	4.1E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for mammals utilised.
Cs			105	2.9E–02	2.8E–01	2.8E–01	2.8E+00	4.0	GSDmean	ICRP 2011	L1	
Eu	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Eu in mammals not available. Data for La in mammals used (combined PA and EA).
Ho	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Ho in mammals not available. Data for La in mammals used (combined PA and EA).
I		cR_Ter_mammal_NHB	1	1.4E–03	3.3E–02	3.3E–02	8.2E–01	7.0	GSDmax	Site data FM	FM	ERICA used mammal data. Site data for I in mammals available and utilised.
Mo		cR_Ter_mammal_NHB	36	3.3E–04	1.2E–02	1.5E–02	3.0E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used data from mammals and sometimes for birds, when data are missing. Site data available for Mo in mammal and assumed a reasonable analogue.
Nb		cR_Ter_mammal_NHB	32	1.8E–05	4.5E–04	6.2E–04	4.1E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Nb in mammals available and utilised.
Ni		cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Ni in mammals available and utilised.
Np	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Site data for La in mammals used (combined PA and EA).
Pa	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Mammals are used as PA. Site data for Pa in mammals missing. La used as EA.
Pb			6	1.1E–04	2.6E–03	2.6E–03	6.3E–02	7.0	GSDmax	ICRP 2011	L1	

Ele-ment	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pd	Ni	cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	Ni used as EA. ERICA used mammals as PA when data are missing. Site data for Ni in mammals available and utilised.
Po		cR_Ter_mammal_NHB	36	9.9E–05	2.4E–03	2.4E–03	5.9E–02	7.0	GSDmax	ERICA	L3	ERICA used same value as for mammals.
Pu		cR_Ter_mammal_NHB	27	2.6E–04	1.9E–02	1.9E–02	1.6E+00	7.0	GSDmax	ICRP 2011	L2	ERICA used same value as for mammals. The ICRP data with highest number of observations (rat) is selected.
Ra		cR_Ter_mammal_NHB	2	2.4E–03	5.9E–02	5.9E–02	1.5E+00	7.0	GSDmax	Site data FM	FM	Mammals used as PA.
Se		cR_Ter_mammal_NHB	35	3.2E–03	7.8E–02	6.3E–02	2.6E+00	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Se in mammals available and utilised.
Sm		cR_Ter_mammal_NHB	11	2.6E–06	6.5E–05	2.4E–04	4.0E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used data from mammals and sometimes for birds, when data are missing. Site data available for Sm in mammal and assumed a reasonable analogue.
Sn		cR_Ter_mammal_NHB	17	1.3E–03	3.1E–02	1.6E–02	7.7E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used data from mammals and sometimes for birds, when data are missing. Site data available for Sn in mammal and assumed a reasonable analogue.
Sr			14	1.1E–01	1.1E+00	1.1E+00	1.0E+01	4.0	GSDmean	ICRP 2011	L1	
Tc			2	1.7E–02	4.2E–01	4.2E–01	1.0E+01	7.0	GSDmax	ERICA	L2	
Th		cR_Ter_mammal_NHB	5	1.0E–04	2.6E–03	2.6E–03	6.3E–02	7.0	GSDmax	Site data LX	LX	Mammals used as PA. See comment for parameter cR_Ter_ mammal_NHB
U		cR_Ter_mammal_NHB	25	3.8E–06	3.0E–04	3.4E–04	6.6E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for U in mammals available and utilised.
Zr		cR_Ter_mammal_NHB	29	2.2E–04	6.2E–03	8.0E–03	2.7E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Zr in mammals available and utilised.

6.16 cR_Ter_rept_NHB

This parameter describes the element uptake in terrestrial reptiles for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are available in ERICA (Beresford et al. 2008a) (Figure 6-38 and Table 6-36) and in many cases the data are the same as data for mammals and in a few cases the same as for birds. Site data for mammals are available for 21 elements and are used as PA (see Section 6.19). Data for Ac, Pa and Pd are missing and a combination of PAs and EAs are utilised; site mammal data for La (EA for Ac and Pa) and for Ni (EA for Pd), respectively. La is also selected as EA for Am, Cm, Eu, Ho and Np.

Site data for mammals are missing for Ag, Po, Pu and Tc, and ERICA (Beresford et al. 2008a) utilised mammals as PA for these elements. Mammal data are available in ICRP (2011) for Po and Pu and this data source is generally ranked higher than ERICA (Beresford et al. 2008a), due to its more recent update. Mammal data are available for deer and rat, and the organism with the highest number of observations are utilised (rat for Pu (n=27)). For Po, data are not available for deer and the value for rat is based on a single observation in ICRP (2011), whereas ERICA data (Beresford et al. 2008a) are based on 36 observations and the latter is selected, due to the larger number of observations. For Ag and Tc, data from ERICA (Beresford et al. 2008a) are utilised (see parameter cR_Ter_mammal_NHB for details).

Ranges are not available for Tc and Ag in ERICA (Beresford et al. 2008a) and GSDmax (7) is assigned to these parameters. GSDmax is also assigned to elements where PAs are utilised.

The selected CR values are presented in Figure 6-39 and Table 6-37.

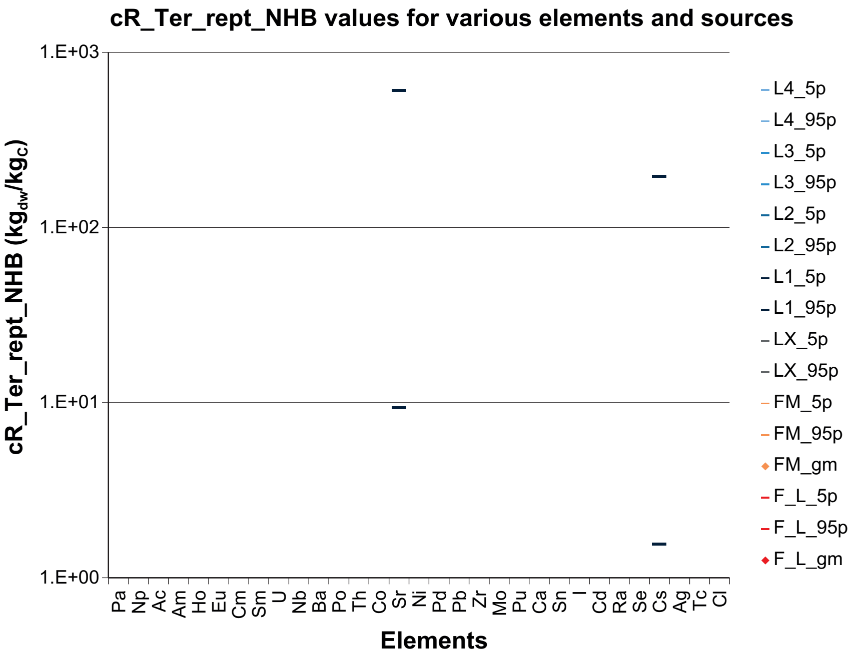

Figure 6-38. *Total available data ranges for the parameter cR_Ter_rept_NHB (kg_{dw}/kg_C). The elements are arranged in the same order as in Figure 6-39 showing selected parameter values.*

Table 6-36. **All available data for the parameter cR_Ter_rept_NHB for the elements of primary concern and selected EAs. L1 = ERICA (Beresford et al. 2008a) Terrestrial Reptile.**

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				1															1:0/0
Cl				1															1:0/0
Cm				1															1:0/0
Co				1															1:0/0
Cs				8							4.3								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				1															1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				1															1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				1															1:0/0
Ra				1															1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				4							3.6								1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

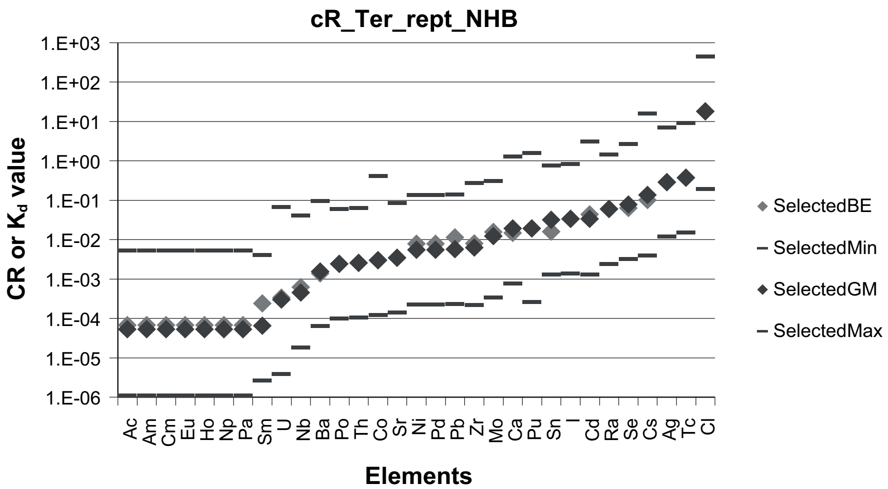

Figure 6-39. Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg_{dw}/kg_{fw}).

Table 6-37. **Selected data properties, references and comments for the parameter cR_Ter_rept_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.**

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. La used as EA (site data are available).
Ag			1	1.2E–02	2.9E–01	2.9E–01	7.0E+00	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Am	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. La used as EA (site data are available).
Ba		cR_Ter_mammal_NHB	31	6.3E–05	1.6E–03	1.4E–03	9.5E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Ba in mammals are available.
Ca		cR_Ter_mammal_NHB	36	7.7E–04	1.9E–02	1.5E–02	1.3E+00	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Ca in mammals are available.
Cd		cR_Ter_mammal_NHB	27	1.3E–03	3.4E–02	4.3E–02	3.0E+00	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Cd in mammals are available.
Cl		cR_Ter_mammal_NHB	19	1.9E–01	1.8E+01	1.8E+01	4.4E+02	7.0	GSDmax	Site data FM	FM	ERICA used mammal data as PA. Site data for Cl in mammals are available.
Cm	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA uses the same value as for mammals. Site data for Cm is missing so La was used as EA
Co		cR_Ter_mammal_NHB	33	1.2E–04	3.0E–03	3.0E–03	4.1E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Co in mammals are available.
Cs		cR_Ter_mammal_NHB	36	3.9E–03	1.4E–01	1.0E–01	1.6E+01	7.4	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Cs in mammals are available.
Eu	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. La used as EA (site data are available).
Ho	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. La used as EA (site data are available).
I		cR_Ter_mammal_NHB	1	1.4E–03	3.3E–02	3.3E–02	8.2E–01	7.0	GSDmax	Site data FM	FM	ERICA used mammal data as PA. Site data for I in mammals are available.
Mo		cR_Ter_mammal_NHB	36	3.3E–04	1.2E–02	1.5E–02	3.0E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Mo in mammals are available.
Nb		cR_Ter_mammal_NHB	32	1.8E–05	4.5E–04	6.2E–04	4.1E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Nb in mammals are available.
Ni		cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Ni in mammals are available.
Np	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. La used as EA (site data are available).
Pa	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. La used as EA (site data are available).
Pb		cR_Ter_mammal_NHB	7	2.3E–04	5.6E–03	1.1E–02	1.4E–01	7.0	GSDmax	Site data FMLX	FMLX	
Pd	Ni	cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Ni used as EA (site data are available).
Po		cR_Ter_mammal_NHB	36	9.9E–05	2.4E–03	2.4E–03	5.9E–02	7.0	GSDmax	ERICA	L3	ERICA used the same value as for mammals.
Pu		cR_Ter_mammal_NHB	27	2.6E–04	1.9E–02	1.9E–02	1.6E+00	7.0	GSDmax	ICRP 2011	L2	ERICA used the same value as for mammals. The ICRP data with highest number of observations (rat) is selected.
Ra		cR_Ter_mammal_NHB	2	2.4E–03	5.9E–02	5.9E–02	1.5E+00	7.0	GSDmax	Site data FM	FM	
Se		cR_Ter_mammal_NHB	35	3.2E–03	7.8E–02	6.3E–02	2.6E+00	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Se in mammals are available.
Sm		cR_Ter_mammal_NHB	11	2.6E–06	6.5E–05	2.4E–04	4.0E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Sm in mammals are available.
Sn		cR_Ter_mammal_NHB	17	1.3E–03	3.1E–02	1.6E–02	7.7E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Sn in mammals are available.
Sr		cR_Ter_mammal_NHB	31	1.4E–04	3.4E–03	3.4E–03	8.4E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Sr in mammals are available.
Tc			1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th		cR_Ter_mammal_NHB	5	1.0E–04	2.6E–03	2.6E–03	6.3E–02	7.0	GSDmax	Site data LX	LX	
U		cR_Ter_mammal_NHB	25	3.8E–06	3.0E–04	3.4E–04	6.6E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for U in mammals are available.
Zr		cR_Ter_mammal_NHB	29	2.2E–04	6.2E–03	8.0E–03	2.7E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data as PA. Site data for Zr in mammals are available.

6.17 cR_Ter_bird_NHB

This parameter describes the element uptake in terrestrial birds for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are available for adult domestic duck in ICRP (2011) and are categorised as L1 data and terrestrial birds in ERICA (Beresford et al. 2008a) are categorised as L2 data, see Table 6-38 and Figure 6-40.

Sense checks for literature data are only possible for Cs and Sr and both elements correlate.

Data pertaining to birds in the two references (with no PAs) are selected when available. If the literature sources utilised PAs (mainly mammals) and mammal site data are available for that element, the latter are selected. Also, mammal site data are selected for the elements that are not included in the literature. La is utilised as EA for Ac, Am, Cm, Eu, Ho, Np and Pa, whereas Ni is used as EA for Pd (combined EAs and PAs). Data for Ba and Ca are not included in the literature. Site data for these two elements in mammals are lower than the value used for the element analogue Sr in bird. It was considered better to use an EA for the right organism than to use Ba data for mammal.

The mammal data for Nb differ 3 orders of magnitude between site data (lower) and ERICA, hence the latter is utilised as a conservative approach. Choosing a higher CR will lead to a higher (modelled) organism concentration, in turn leading to higher dose estimate and a value that correlates better with Nb in bird eggs (see Section 6.18).

Ranges are not available for Ag, Nb, Tc, Th and U, and GSDmax (7) are assigned to these parameters. GSDmax are also assigned to elements where PAs are used. The GSD is considered too narrow for some elements and a more appropriate GSD is appointed using the conditions stated in 4.3.2 (GSDmean or GSDmax).

The selected CR values are presented in Table 6-39 and Figure 6-41.

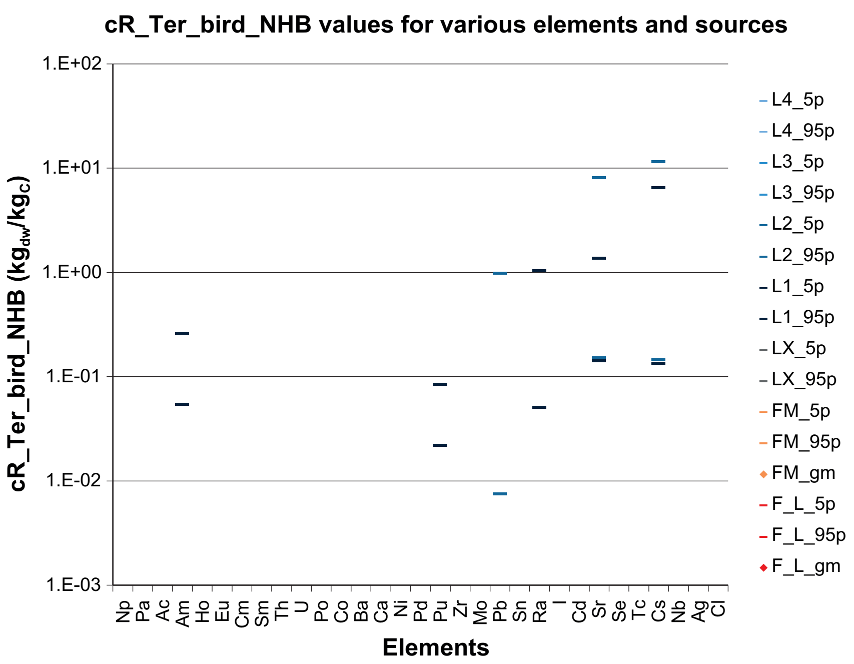

Figure 6-40. *Total available data ranges for the parameter cR_Ter_bird_NHB (kg_{dw}/kg_C). The elements are arranged in the order as in Figure 6-41 showing selected parameter values.*

Table 6-38. **All available data for the parameter cR_Ter_bird_NHB for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = Terrestrial Duck**

Ele-ment	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am				3	1						1.6								2:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd					1														1:0/0
Cl					1														1:0/0
Cm					1														1:0/0
Co					1														1:0/0
Cs				40	158						3.2	3.8							2:1/1
Eu					1														1:0/0
Ho																			0:0/0
I					1														1:0/0
Mo																			0:0/0
Nb					1														1:0/0
Ni					1														1:0/0
Np					1														1:0/0
Pa																			0:0/0
Pb					424							4.4							1:0/0
Pd																			0:0/0
Po					1														1:0/0
Pu				5	1						1.5								2:0/0
Ra				5	1						2.5								2:0/0
Se					1														1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				4	69						2.0	3.3							2:1/1
Tc				2	1														2:0/0
Th					1														1:0/0
U					1														1:0/0
Zr					1														1:0/0

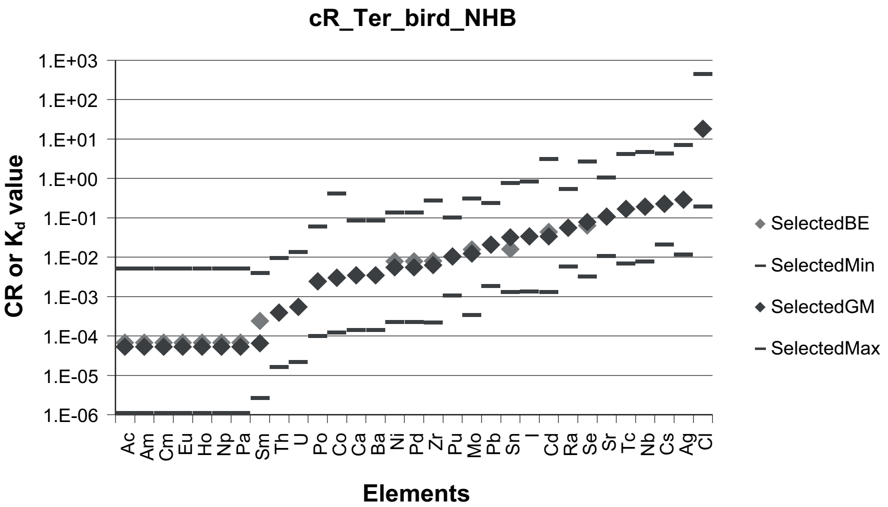

Figure 6-41. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg_{dw}/kg_{fw}).*

Table 6-39. **Selected data properties, references and comments for the parameter cR_Ter_bird_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.**

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Mammals used as PA. No site data for Ac in mammals available. La used as EA (combined PA and EA).
Ag		cR_Ter_mammal_NHB	1	1.2E–02	2.9E–01	2.9E–01	7.0E+00	7.0	GSDmax	ERICA	L3	ERICA used mammal data. No range presented. GSDmax assigned.
Am	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used value for mammals. Site data for mammals available. La used as EA.
Ba	Sr	cR_Ter_mammal_NHB	31	1.4E–04	3.4E–03	3.4E–03	8.4E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Ba in mammals are lower than the value used for Sr in birds. It is considered better to use an EA for the right organism than to use Ba data for mammals.
Ca	Sr	cR_Ter_mammal_NHB	31	1.4E–04	3.4E–03	3.4E–03	8.4E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Ca in mammals are lower than the value used for Sr in birds. It is considered better to use an EA for the right organism than to use Ca data for mammals.
Cd		cR_Ter_mammal_NHB	27	1.3E–03	3.4E–02	4.3E–02	3.0E+00	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Cd in mammals available and utilised.
Cl		cR_Ter_mammal_NHB	19	1.9E–01	1.8E+01	1.8E+01	4.4E+02	7.0	GSDmax	Site data FM	FM	ERICA used mammal data. Site data for Cl in mammals available and utilised.
Cm	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used Am data (for mammal). Site data for mammals available. La used as EA.
Co		cR_Ter_mammal_NHB	33	1.2E–04	3.0E–03	3.0E–03	4.1E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for mammals are selected.
Cs			40	2.1E–02	2.2E–01	2.2E–01	4.3E+00	4.0	GSDmean	ICRP 2011	L1	
Eu	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Mammals used as PA. No site data for Eu in mammals available. La used as EA (combined PA and EA).
Ho	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Mammals used as PA. No site data for Ho in mammals available. La used as EA (combined PA and EA).
I		cR_Ter_mammal_NHB	1	1.4E–03	3.3E–02	3.3E–02	8.2E–01	7.0	GSDmax	Site data FM	FM	ERICA used mammal data. Site data for mammals are selected.
Mo		cR_Ter_mammal_NHB	36	3.3E–04	1.2E–02	1.5E–02	3.0E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Mo in mammals available and utilised.
Nb		cR_Ter_mammal_NHB	1	7.8E–03	1.9E–01	1.9E–01	4.7E+00	7.0	GSDmax	ERICA	L3	ERICA used mammal data. Site data for Nb in mammals available, though 3 orders of magnitude lower than values in ERICA, which are used instead as a conservative approach.
Ni		cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Ni in mammals available and utilised.
Np	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used Am data for mammal. Site data for La in mammals is selected (combined PA and EA).

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pa	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Mammals was used as PA. Site data for Pa in mammals is missing so La was used as EA.
Pb			424	1.8E–03	2.1E–02	2.1E–02	2.3E–01	4.4	GSD	ERICA	L2	
Pd	Ni	cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. No site data for Pd in mammals available. Ni used as EA (combined PA and EA).
Po		cR_Ter_mammal_NHB	36	9.9E–05	2.4E–03	2.4E–03	5.9E–02	7.0	GSDmax	ERICA	L3	ERICA used mammal data.
Pu			5	1.1E–03	1.0E–02	1.0E–02	1.0E–01	4.0	GSDmean	ICRP 2011	L1	Validation not possible since ERICA presented only 1 value without range (for mammal). Values correlate.
Ra			5	5.6E–03	5.5E–02	5.5E–02	5.4E–01	4.0	GSDmean	ICRP 2011	L1	validation not possible since ERICA presented value with min and max. Data from ICRP 2011 and ERICA correlate well.
Se		cR_Ter_mammal_NHB	35	3.2E–03	7.8E–02	6.3E–02	2.6E+00	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Se in mammals available and utilised.
Sm		cR_Ter_mammal_NHB	11	2.6E–06	6.5E–05	2.4E–04	4.0E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Sm in mammals available and utilised.
Sn		cR_Ter_mammal_NHB	17	1.3E–03	3.1E–02	1.6E–02	7.7E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Sn in mammals available and utilised.
Sr			4	1.1E–02	1.1E–01	1.1E–01	1.0E+00	4.0	GSDmean	ICRP 2011	L1	
Tc			2	6.8E–03	1.7E–01	1.7E–01	4.1E+00	7.0	GSDmax	ICRP 2011	L1	Validation not possible, since both ICRP and ERICA presented only 1 value each without ranges. Values correlate. No range presented. GSDmax assigned.
Th			1	1.6E–05	3.9E–04	3.9E–04	9.5E–03	7.0	GSDmax	ERICA	L2	
U			1	2.2E–05	5.4E–04	5.4E–04	1.3E–02	7.0	GSDmax	ERICA	L2	
Zr		cR_Ter_mammal_NHB	29	2.2E–04	6.2E–03	8.0E–03	2.7E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Zr in mammals available and utilised.

6.18 cR_Ter_bird_egg_NHB

This parameter describes the element uptake in terrestrial bird eggs for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are available in ERICA (Table 6-40 and Figure 6-42) and the data utilised are mainly for birds or mammals. Bird data are considered a better analogue and are prioritised when available (in ERICA (Beresford et al. 2008a) or ICRP (2011)). In cases where mammal data are utilised as PAs in ERICA, site data for mammals are selected if available. The elements Ba, Ca, Ho, Mo and Sn, are not included in ERICA and in these cases site data for mammals are also utilised. In lack of site data for Eu and Ho in mammals, site data for La are preferred (combined EA and PA). La is also selected as EA for Ac, Am, Cm, Np and Pa, whereas Ni is utilised as EA for Pd.

Ranges are not available for Ag, Nb, Tc, Th, I and U, and GSDmax (7) is assigned to these parameters. GSDmax is also assigned to elements where PAs are utilised.

In ERICA (Beresford et al. 2008a), the data used are those mammals mulriplied 400 times for I, and multiplied with 3 for Nb. The site data value for I in mammals is somewhat lower than the literature value, hence the latter is utilised as a conservative approach. Choosing a higher CR will lead to a higher (modelled) uptake of the element/radionuclide in the organism, in turn leading to a higher estimated dose. Site data for Nb in mammal are several orders of magnitude lower than literature data and, therefore, ERICA data are selected. Site data for Ca and Ba in mammals are lower than the value utilised for Sr in bird eggs. This probably indicates the fact that Sr can substitute for Ca in eggshells. Considering the large differences, it is better to utilise an EA for the right organism than to use site data for mammals.

The selected CR values are presented in Table 6-41 and Figure 6-43.

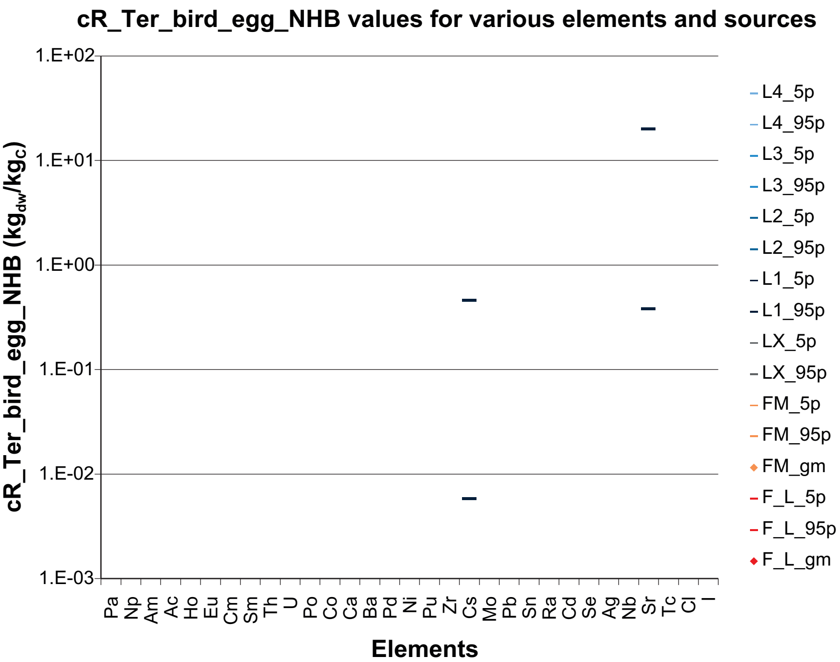

Figure 6-42. *Total available data ranges for the parameter cR_Ter_bird_egg_NHB (kg_{dw}/kg_C). The elements are arranged in the same order as in Figure 6-43 showing selected parameter values.*

Table 6-40. **All available data for the parameter cR_Ter_bird_egg_NHB for the elements of primary concern and selected EAs. L2 = ERICA (Beresford et al. 2008a) Terrestrail Bird egg.**

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				1															1:0/0
Cl				1															1:0/0
Cm				1															1:0/0
Co				1															1:0/0
Cs				1							3.8								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				1															1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				1															1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				1															1:0/0
Ra				1															1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				1							3.3								1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

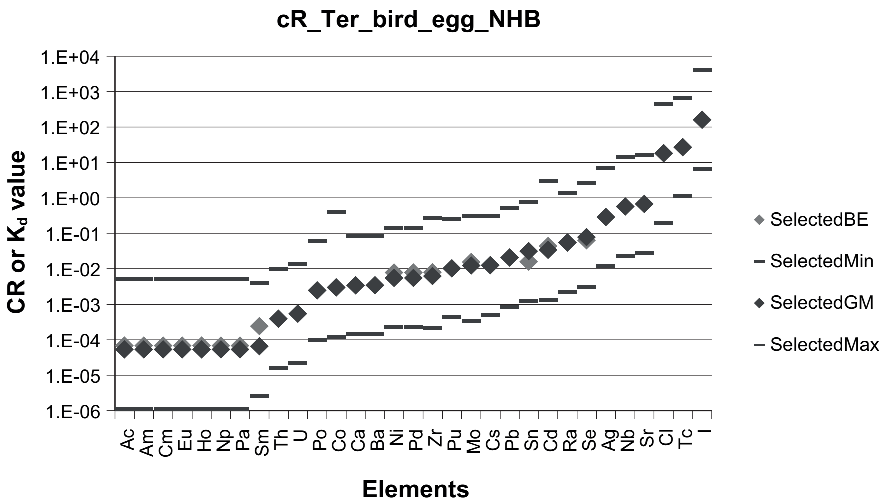

Figure 6-43. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (*kg_{dw}/kg_{fw}*).*

Table 6-41. **Selected data properties, references and comments for the parameter cR_Ter_bird_egg_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.**

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Mammals used as PA. No site data for Ac in mammals available. La used as EA (combined PA and EA).
Ag		cR_Ter_mammal_NHB	1	1.2E–02	2.9E–01	2.9E–01	7.0E+00	7.0	GSDmax	ERICA	L3	ERICA used mammal data.
Am	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used the same value for bird and bird egg (mammal data). Site data for mammals used as PA. La used as EA.
Ba	Sr	cR_Ter_mammal_NHB	31	1.4E–04	3.4E–03	3.4E–03	8.4E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Ba in mammals are lower than the value used for Sr in bird eggs. It is considered better to use an EA for the right organism than to use Ba data for mammal.
Ca	Sr	cR_Ter_mammal_NHB	31	1.4E–04	3.4E–03	3.4E–03	8.4E–02	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Ca in mammals are lower than the value used for Sr in bird eggs. It is considered better to use an EA for the right organism than to use Ca data for mammal.
Cd		cR_Ter_mammal_NHB	27	1.3E–03	3.4E–02	4.3E–02	3.0E+00	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Cd in mammals available and utilised.
Cl		cR_Ter_mammal_NHB	19	1.9E–01	1.8E+01	1.8E+01	4.4E+02	7.0	GSDmax	Site data FM	FM	ERICA used mammal data. Site data for Cl in mammals available and utilised.
Cm	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used Am data for mammal. Site data for La in mammals available and utilised as combined PA and EA.
Co		cR_Ter_mammal_NHB	33	1.2E–04	3.0E–03	3.0E–03	4.1E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for mammals selected.
Cs			1	5.1E–04	1.2E–02	1.2E–02	3.1E–01	7.0	GSDmax	ERICA	L1	
Eu	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. No site data for Eu in mammals available. La used as EA (combined PA and EA).
Ho	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. No site data for Ho in mammals available. La used as EA (combined PA and EA).
I			1	6.5E+00	1.6E+02	1.6E+02	3.9E+03	7.0	GSDmax	ERICA	L1	ERICA used mammal value*400. Site data value for I in mammals are somewhat lower than the literature value, hence the latter is used. No range presented. GSDmax assigned.
Mo		cR_Ter_mammal_NHB	36	3.3E–04	1.2E–02	1.5E–02	3.0E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Mo in mammals available and utilised.
Nb			1	2.3E–02	5.7E–01	5.7E–01	1.4E+01	7.0	GSDmax	ERICA	L1	ERICA used mammal value*3. Site data for Nb in mammals are several orders of magnitude lower than literature data, hence the latter are used as a conservative approach. No range presented. GSDmax assigned.
Ni		cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Ni in mammals available and utilised.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Np	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used Am data for mammal. We use site data for La in mammals as combined PA and EA
Pa	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	Mammals used as PA. No site data for Pa in mammals available. La used as EA (combined PA and EA).
Pb		cR_Ter_bird_NHB	424	8.4E–04	2.1E–02	2.1E–02	5.1E–01	7.0	GSDmax	ERICA	L2	ERICA used bird value.
Pd	Ni	cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. No site data for Pd in mammals available. Ni used as EA (combined Pa and EA).
Po		cR_Ter_mammal_NHB	36	9.9E–05	2.4E–03	2.4E–03	5.9E–02	7.0	GSDmax	ERICA	L3	ERICA used mammal value.
Pu		cR_Ter_bird_NHB	5	4.2E–04	1.0E–02	1.0E–02	2.5E–01	7.0	GSDmax	ICRP 2011	L1	ERICA used the same value as for birds (which is the same as for mammals). ICRP bird data are available and utilised.
Ra		cR_Ter_bird_NHB	5	2.2E–03	5.5E–02	5.5E–02	1.4E+00	7.0	GSDmax	ICRP 2011	L1	ERICA used bird value.
Se		cR_Ter_mammal_NHB	35	3.2E–03	7.8E–02	6.3E–02	2.6E+00	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Se in mammals available and utilised.
Sm		cR_Ter_mammal_NHB	11	2.6E–06	6.5E–05	2.4E–04	4.0E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Sm in mammals available and utilised.
Sn		cR_Ter_mammal_NHB	17	1.3E–03	3.1E–02	1.6E–02	7.7E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data or sometimes bird data when data are missing. Site data for Sn in mammals available and utilised.
Sr			1	2.7E–02	6.6E–01	6.6E–01	1.6E+01	7.0	GSDmax	ERICA	L1	
Tc			1	1.1E+00	2.7E+01	2.7E+01	6.6E+02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th		cR_Ter_bird_NHB	1	1.6E–05	3.9E–04	3.9E–04	9.5E–03	7.0	GSDmax	ERICA	L2	ERICA used bird value.
U			1	2.2E–05	5.4E–04	5.4E–04	1.3E–02	7.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Zr		cR_Ter_mammal_NHB	29	2.2E–04	6.2E–03	8.0E–03	2.7E–01	7.0	GSDmax	Site data FMLX	FMLX	ERICA used mammal data. Site data for Zr in mammals available and utilised.

6.19 cR_Ter_mammal_large_NHB and cR_Ter_mammal_small_NHB

These parameters describe the element uptake in terrestrial mammals for use in dose estimates to these organism types. Site data are available for small and large mammals and are also utilised for the parameter cR_food_herbiv (Section 6.3). Site data for small mammals consist of the following small rodents: shrew (*Sorex araneus*), yellow-necked mouse (*Apodemus flavicollis*), water vole (*Arvicola terrestris*), bank vole (*Clethrionomys glareolus*) and wood mouse (*Apodemus sylvaticus*), whereas large mammals are represented by: moose (*Alces alces*), roe deer (*Capreolus capreolus*) and fox (*Vulpes vulpes*). All these samples have been put together as discussed further below (mammal data from Hannu and Karlsson (2006) (FM), Roos et al. (2007) (both sites, radionuclides) and Engdahl et al. (2006) (LX)). The soil samples utilised for this parameter are presented in Section 6 (the same soil samples are used as for the parameters cR_Ter_pp, cR_Ter_lich_NHB and cR_agri_cereal). Site data are available for 20 elements. Only FM data are available for Cl, I and Ra whereas only LX data are available for Eu, Ho and Th. Literature data are available from ICRP (2011) and ERICA (Beresford et al. 2008a), which is the only data source for 7 elements. Data are missing for Ac, Pa and Pd. The available data are shown in Figure 6-44, Figure 6-45, Table 6-42 and Table 6-43.

All of the site data for terrestrial animal samples are very similar in elemental composition with minor differences within the animal group, as can be seen in Tröjbom and Nordén (2010). A clear separation between larger herbivores (roe deer and moose) and smaller herbivores (rodents) can be noted, when studying animal samples in detail. The carnivores group is in between these two extremes. Several elements occur in higher amounts in the muscle tissue of smaller herbivores compared to larger herbivores. This discrepancy could be methodological rather than real, due to difficulties in preparing pure muscle tissue in small animals. The larger variation among samples from small herbivores perhaps supports this hypothesis. According to Tröjbom and Nordén (2010), there is also a systematic difference between FM and LX since some elements, e.g. Cs, Rb, Cu and Se, occur at higher amounts in LX samples compared to FM samples. This pattern is evident for both small and large herbivores, and most probably reflects site-specific differences regarding the composition of the regolith. It is considered valid to use all mammal samples together instead of separating small and larger mammals separately. Technically this was performed by setting up the parameter cR_Ter_mammal_NHB which includes all site mammal data samples.

When site data are sense checked with literature data, it is consistent for all elements except Co, Sr and Th. Site data for Sr are lower than ICRP (2011) data. Although the latter is based on 58 observations, there are 31 site data observations where the FM and LX data are very consistent, hence site data are preferred. This is the case for Co as well, where site data (n=33) are lower than literature data (n=29). FM data are not available for Th, and the LX data (n=5) do not overlap with the range in ERICA (Beresford et al. 2008a) (n=18). The LX value is about 100 times higher. The minimum and maximum values overlap some, indicating that the LX values may be reasonable and, therefore, selected.

La is selected as EA for Ac, Am, Cm, Eu, Ho, Np and Pa (see Section 2.7). Zr is utilised as EA for Sn, whereas Ni is used for Pd.

For the remaining elements, literature data for large or small mammals are selected from ICRP (2011), categorised as L1 data, and ERICA (Beresford et al. 2008a), categorised as L2 data, respectively. For large mammals, data are available from both references for Am, Cs, Pu and Sr, enabling a sense check of data where all data correlates. For small mammals, sense checks are possible for Am, Cs, Pb, Pu, Ra and Sr. The data are consitent for all of the elements except Am, where the GMs deviate about two orders of magnitude.

For Po in small mammals, ICRP (2011) presented 1 value without a range, whereas ERICA data (Beresford et al. 2008a) are based on 36 observations. The ICRP value is just below the ERICA range. ERICA data (Beresford et al. 2008a) are chosen due to the larger number of observations.

The value for Ag in ERICA (Beresford et al. 2008a) is based on concentrations in humans and general soil concentrations. For Tc the ERICA value is some kind of predicted value. For Np, ERICA (Beresford et al. 2008a) utilised Am as EA. Am data for mammals are available in ICRP (2011) and these data are selected

Ranges are not available for Tc and Ag and GSDmax (7) is assigned to these parameters. GSDmax is also assigned to elements where PAs are utilised. The presented GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean or GSDmax).

In summary, the same values are used for small and large mammals for all elements except Pu. The reason for that is that most values are based on site data which has not separated information for mammals of different sizes. Literature data is used for Ag, Po, Tc and Pu and only for the latter element is different values presented in the data source used.

The selected CR values are presented in Table 6-44, Table 6-45, Figure 6-46 and Figure 6-47.

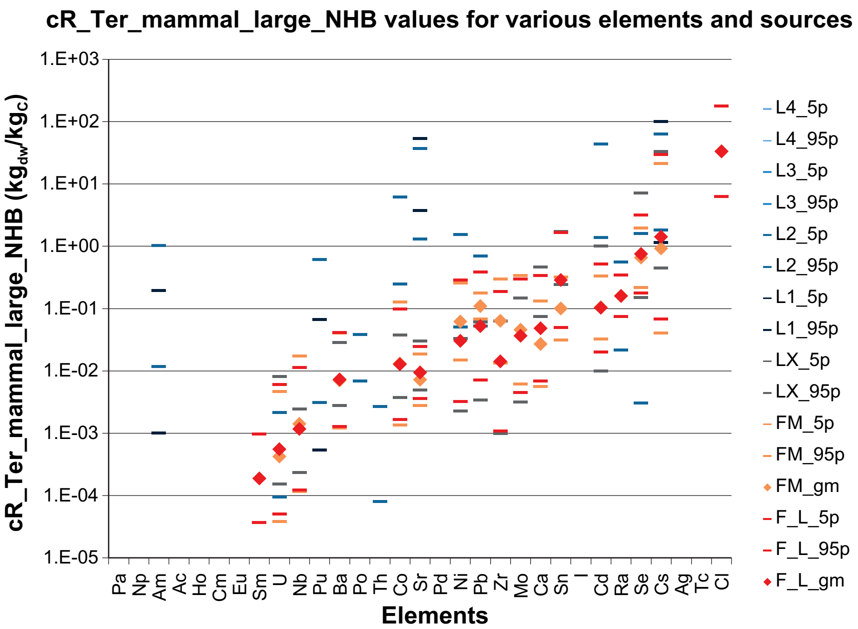

Figure 6-44. *Total available data ranges for the parameter cR_Ter_mammal_large_NHB (kg_{dw}/kg_C). The elements are arranged in the same order as in Figure 6-46 showing selected parameter values.*

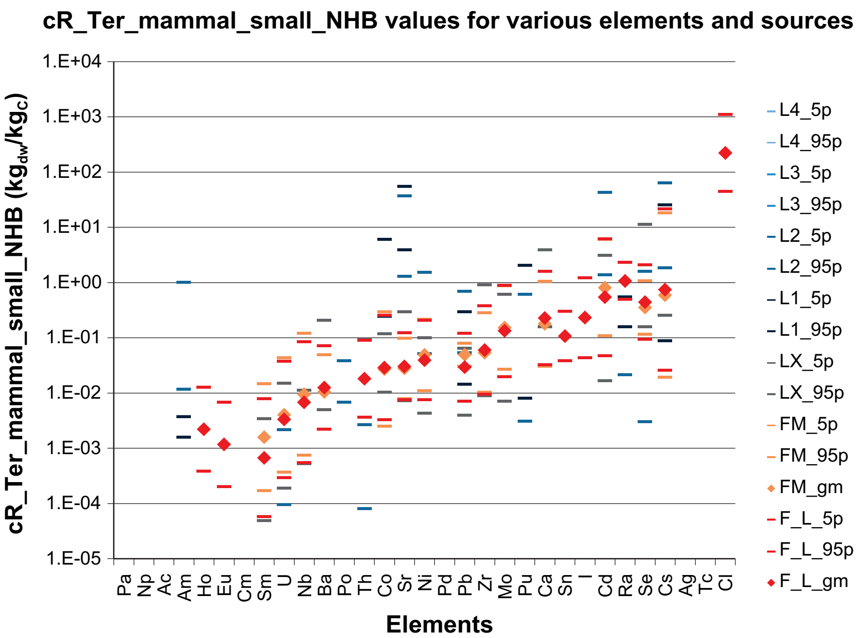

Figure 6-45. *Total available data ranges for the parameter cR_Ter_mammal_small_NHB (kg_{dw}/kg_C). The elements are arranged in the same order as in Figure 6-46 showing selected parameter values.*

Table 6-42. All available data for the parameter cR_Ter_mammal_large_NHB for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. Site data show small and large mammals together. L1 = ICRP 2011 Terrestrial Deer, L2 = ERICA (Beresford et al. 2008a) Terrestrial Mammal (Deer).

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am				13	121						4.9	3.9							2:1/1
Ba	28/6	8/3	36/9					2.9	2.0	2.9								S3	0:0/0
Ca	28/6	8/9	36/15					2.6	1.7	3.3								S2(L18%)	0:0/0
Cd	28/5	8/9	36/14		415			2.0	4.1	2.7		2.9			S4	S4	S4	S1	1:0/0
Cl	25/6		25/6		1			2.8		2.8									1:0/0
Cm					1														1:0/0
Co	28/6	8/9	36/15		29			4.0	2.0	3.4		2.7			S4	S4	S4	S3	1:0/0
Cs	28/6	8/9	36/15	1,745	1,784			6.7	3.7	6.3	3.9	2.9			S2(L46%)	S2(L77%)	S2(L53%)	S2(L61%)	2:1/1
Eu					1														1:0/0
Ho																			0:0/0
I					1														1:0/0
Mo	28/6	8/9	36/15					3.4	3.2	3.6								S2(U79%)	0:0/0
Nb	28/6	8/9	36/15		1			4.6	2.0	4.0								S3	1:0/0
Ni	28/1	8/2	36/3		2			2.4	2.3	3.9		2.8			S2(L56%)	S4	S2(L38%)	S2(U27%)	1:0/0
Np					1														1:0/0
Pa																			0:0/0
Pb	28/1	8/2	36/3		502			1.3	2.4	3.4		2.2			S1	S2(L4%)	S2(L49%)	S4	1:0/0
Pd																			0:0/0
Po					36							1.7							1:0/0
Pu				15	123						4.3	5.0							2:1/1
Ra	25/1		25/1		73			1.6		1.6		2.7			S1		S1		1:0/0
Se	27/6	8/9	35/15		12			2.0	3.2	2.4		6.7			S2(U90%)	S2(U60%)	S2(U75%)	S1	1:0/0
Sm		8/4	8/4						2.7	2.7									0:0/0
Sn	28/2	8/9	36/11					2.0	1.8	2.9								S2(L11%)	0:0/0
Sr	28/2	8/7	36/9	58	196			1.8	1.7	1.8	2.3	2.8			S4	S4	S4	S2(L69%)	2:1/1
Tc					1														1:0/0
Th					18							2.9							1:0/0
U	28/3	8/4	36/7		2			4.3	3.4	4.3		2.6			S3	S2(U66%)	S3	S2(L71%)	1:0/0
Zr	28/1	8/9	36/10		1			2.6	3.5	4.8								S2(U50%)	1:0/0

Table 6-43. All available data for the parameter cR_Ter_mammal_small_NHB for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. Site data show small and large mammals together. L1 = ICRP 2011 Terrestrial Rat, L2 = ERICA (Beresford et al. 2008a) Terrestrial Mammal (rat).

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am				9	121						1.3	3.9							2:0/1
Ba	28/13	8/9	36/22					2.6	3.1	2.9								S2(L73%)	0:0/0
Ca	28/13	8/9	36/22					2.9	2.6	3.3								S2(L53%)	0:0/0
Cd	28/5	8/8	36/13		415			3.4	4.9	4.4		2.9			S2(L36%)	S2(L15%)	S2(L30%)	S2(U83%)	1:0/0
Cl	25/13		25/13		1			2.6		2.6									1:0/0
Cm					1														1:0/0
Co	28/9	8/9	36/18	29	29			4.2	2.1	3.8	2.7	2.7			S2(L3%)	S4	S2(L0%)	S3	2:1/1
Cs	28/13	8/9	36/22	70	1,784			8.0	3.8	7.7	5.6	2.9			S2(L77%)	S1	S2(L81%)	S2(L62%)	2:1/1
Eu		8/1	8/1		1				2.9	2.9									1:0/0
Ho		8/1	8/1						2.9	2.9									0:0/0
I	25/1		25/1		1			2.7		2.7									1:0/0
Mo	28/13	8/9	36/22					2.9	3.9	3.2								S2(U89%)	0:0/0
Nb	28/8	8/9	36/17		1			4.7	2.5	4.6								S2(U53%)	1:0/0
Ni	28/5	8/6	36/11		2			2.5	2.6	2.7		2.8			S2(L48%)	S2(L21%)	S2(L42%)	S2(U74%)	1:0/0
Np					1														1:0/0
Pa																			0:0/0
Pb	28/1	8/3	36/4	36	502			1.3	2.3	2.4	2.5	2.2			S1	S2(L54%)	S2(L75%)	S2(U77%)	2:1/1
Pd																			0:0/0
Po				1	36							1.7							2:0/0
Pu				27	123						5.4	5.0							2:1/1
Ra	25/1		25/1	5	73			1.6		1.6	1.4	2.7			S2(U7%)		S2(U7%)		2:1/1
Se	27/13	8/9	35/22		12			2.0	3.7	2.6		6.7			S1	S2(U54%)	S2(U90%)	S2(L86%)	1:0/0
Sm	28/1	8/6	36/7					3.9	3.6	4.4								S2(U67%)	0:0/0
Sn		8/6	8/6						1.9	1.9									0:0/0
Sr	28/13	8/9	36/22	37	196			2.2	3.1	2.3	2.2	2.8			S4	S4	S4	S1	2:1/1
Tc					1														1:0/0
Th		8/5	8/5	1	18				2.7	2.7		2.9				S4	S4		2:0/0
U	28/9	8/9	36/18	1	2			4.3	3.8	4.4		2.6			S2(U36%)	S2(U55%)	S2(U41%)	S2(U77%)	2:0/0
Zr	28/10	8/9	36/19		1			2.7	4.1	3.0								S1	1:0/0

Table 6-44. **Selected data properties, references and comments for the parameter cR_Ter_mammal_large_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.**

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Ag			1	1.2E–02	2.9E–01	2.9E–01	7.0E+00	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Am	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Ba		cR_Ter_mammal_NHB	31	6.3E–05	1.6E–03	1.4E–03	9.5E–02	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Ca		cR_Ter_mammal_NHB	36	7.7E–04	1.9E–02	1.5E–02	1.3E+00	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Cd		cR_Ter_mammal_NHB	27	1.3E–03	3.4E–02	4.3E–02	3.0E+00	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Cl		cR_Ter_mammal_NHB	19	1.9E–01	1.8E+01	1.8E+01	4.4E+02	7.0	GSDmax	Site data FM	FM	All mammals (small and large) treated as 1 group. Validation impossible since ERICA presented only 1 value without range, though that value is within the range of site data.
Cm	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used Am value. La used as EA (site data available). All mammals (small and large) treated as 1 group.
Co		cR_Ter_mammal_NHB	33	1.2E–04	3.0E–03	3.0E–03	4.1E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Cs		cR_Ter_mammal_NHB	36	3.9E–03	1.4E–01	1.0E–01	1.6E+01	7.4	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Eu	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Ho	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
I		cR_Ter_mammal_NHB	1	1.4E–03	3.3E–02	3.3E–02	8.2E–01	7.0	GSDmax	Site data FM	FM	All mammals (small and large) treated as 1 group. Validation impossible since ERICA presented only 1 value without range. That value is somewhat higher than the maximum value for site data.
Mo		cR_Ter_mammal_NHB	36	3.3E–04	1.2E–02	1.5E–02	3.0E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Nb		cR_Ter_mammal_NHB	32	1.8E–05	4.5E–04	6.2E–04	4.1E–02	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Ni		cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Np	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	5.8	GSD	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Pa	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Pb		cR_Ter_mammal_NHB	7	2.3E–04	5.6E–03	1.1E–02	1.4E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Pd	Ni	cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	Ni used as EA (site data available).
Po			36	2.4E–04	2.4E–03	2.4E–03	2.4E–02	4.0	GSDmean	ERICA	L2	
Pu			15	8.0E–05	8.9E–04	8.9E–04	1.0E–02	4.3	GSD	ICRP 2011	L1	
Ra		cR_Ter_mammal_NHB	2	2.4E–03	5.9E–02	5.9E–02	1.5E+00	7.0	GSDmax	Site data FM	FM	All mammals (small and large) treated as 1 group.

Ele- ment	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD com- ment	Reference	Data- Source	Comment
Se		cR_Ter_mammal_NHB	35	3.2E–03	7.8E–02	6.3E–02	2.6E+00	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Sm		cR_Ter_mammal_NHB	11	2.6E–06	6.5E–05	2.4E–04	4.0E–03	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Sn		cR_Ter_mammal_NHB	17	1.3E–03	3.1E–02	1.6E–02	7.7E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Sr		cR_Ter_mammal_NHB	31	1.4E–04	3.4E–03	3.4E–03	8.4E–02	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Tc			1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Th		cR_Ter_mammal_NHB	5	1.0E–04	2.6E–03	2.6E–03	6.3E–02	7.0	GSDmax	Site data LX	LX	All mammals (small and large) treated as 1 group. LX data (n=5) do not overlap with literature range (n=18), LX value c 100 times higher. The min and max values do overlap somewhat though indicating that the LX values are reasonable. LX data seleted.
U		cR_Ter_mammal_NHB	25	3.8E–06	3.0E–04	3.4E–04	6.6E–02	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Zr		cR_Ter_mammal_NHB	29	2.2E–04	6.2E–03	8.0E–03	2.7E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.

Table 6-45. **Selected data properties, references and comments for the parameter cR_Ter_mammal_small_NHB (kg_{dw}/kg_{fw}) for the elements of primary concern.**

Ele-ment	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Ag			1	1.2E–02	2.9E–01	2.9E–01	7.0E+00	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Am	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Ba		cR_Ter_mammal_NHB	31	6.3E–05	1.6E–03	1.4E–03	9.5E–02	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Ca		cR_Ter_mammal_NHB	36	7.7E–04	1.9E–02	1.5E–02	1.3E+00	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Cd		cR_Ter_mammal_NHB	27	1.3E–03	3.4E–02	4.3E–02	3.0E+00	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Cl		cR_Ter_mammal_NHB	19	1.9E–01	1.8E+01	1.8E+01	4.4E+02	7.0	GSDmax	Site data FM	FM	All mammals (small and large) treated as 1 group.
Cm	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	ERICA used Am value. La used as EA (site data available). All mammals (small and large) treated as 1 group.
Co		cR_Ter_mammal_NHB	33	1.2E–04	3.0E–03	3.0E–03	4.1E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Cs		cR_Ter_mammal_NHB	36	3.9E–03	1.4E–01	1.0E–01	1.6E+01	7.4	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Eu	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Ho	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
I		cR_Ter_mammal_NHB	1	1.4E–03	3.3E–02	3.3E–02	8.2E–01	7.0	GSDmax	Site data FM	FM	All mammals (small and large) treated as 1 group.
Mo		cR_Ter_mammal_NHB	36	3.3E–04	1.2E–02	1.5E–02	3.0E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Nb		cR_Ter_mammal_NHB	32	1.8E–05	4.5E–04	6.2E–04	4.1E–02	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Ni		cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Np	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	5.8	GSD	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Pa	La	cR_Ter_mammal_NHB	34	1.1E–06	5.3E–05	6.7E–05	5.2E–03	7.0	GSDmax	Site data FMLX	FMLX	La used as EA (site data available). All mammals (small and large) treated as 1 group.
Pb		cR_Ter_mammal_NHB	7	2.3E–04	5.6E–03	1.1E–02	1.4E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Pd	Ni	cR_Ter_mammal_NHB	14	2.2E–04	5.5E–03	7.7E–03	1.3E–01	7.0	GSDmax	Site data FMLX	FMLX	Ni used as EA (site data available).
Po			36	2.4E–04	2.4E–03	2.4E–03	2.4E–02	1.7	gsd	ERICA	L2	ICRP presented 1 value without range whereas ERICA data are based on 36 observations. The ICRP value is just below the ERICA range. ERICA data chosen due to the larger number of observations.
Pu			27	2.6E–04	1.9E–02	1.9E–02	1.6E+00	5.4	GSD	ICRP 2011	L1	
Ra		cR_Ter_mammal_NHB	2	2.4E–03	5.9E–02	5.9E–02	1.5E+00	7.0	GSDmax	Site data FM	FM	All mammals (small and large) treated as 1 group.
Se		cR_Ter_mammal_NHB	35	3.2E–03	7.8E–02	6.3E–02	2.6E+00	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.

Ele-ment	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Sm		cR_Ter_mammal_NHB	11	2.6E–06	6.5E–05	2.4E–04	4.0E–03	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Sn		cR_Ter_mammal_NHB	17	1.3E–03	3.1E–02	1.6E–02	7.7E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Sr		cR_Ter_mammal_NHB	31	1.4E–04	3.4E–03	3.4E–03	8.4E–02	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Tc			1	1.5E–02	3.7E–01	3.7E–01	9.1E+00	7.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Th		cR_Ter_mammal_NHB	5	1.0E–04	2.6E–03	2.6E–03	6.3E–02	7.0	GSDmax	Site data LX	LX	All mammals (small and large) treated as 1 group. LX data (n=5) do not overlap with literature range (n=18), LX value c 100 times higher. The min and max values do overlap somewhat though indicating that the LX values are reasonable. LX data seleted.
U		cR_Ter_mammal_NHB	25	3.8E–06	3.0E–04	3.4E–04	6.6E–02	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.
Zr		cR_Ter_mammal_NHB	29	2.2E–04	6.2E–03	8.0E–03	2.7E–01	7.0	GSDmax	Site data FMLX	FMLX	All mammals (small and large) treated as 1 group.

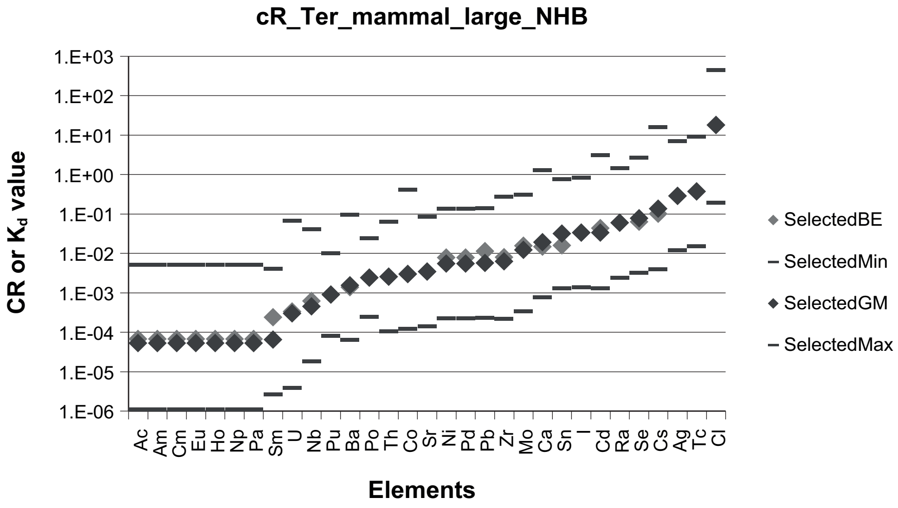

Figure 6-46. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg_{dw}/kg_{fw}).*

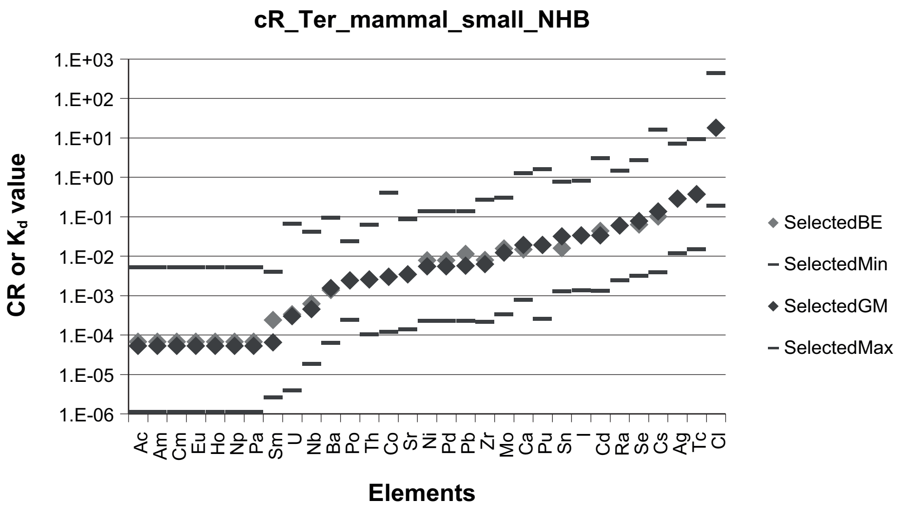

Figure 6-47*. Selected parameter values for cR_Ter_mammal_small_NHB (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (kg_{dw}/kg_{fw}).*

6.20 Evaluation of selected terrestrial CR data

There are eleven parameters for the terrestrial primary producers and thirteen for terrestrial consumers. In addition, there are two parameters representing the uptake in milk and meat of domestic animals (cows). For many terrestrial parameters, the selected CRs could be expected to correlate to some extent. This is investigated in Figure 6-48 to Figure 6-53 where these data are plotted.

In Figure 6-48 the CR for lichen and bryophytes (cR_Ter_pp_lich) are plotted against the CR for terrestrial vegetation (cR_Ter_pp). For cR_Ter_pp_lich, which is mainly based on data for bryophytes, the uptake is in general higher than for terrestrial primary producers. Element concentrations in mosses are compared with those of other terrestrial vegetation types (site data) in Section 6.1 and the same pattern is seen. Large deviations in CR are for example found for Tc, Ru, Te and Po. The reason for these large deviations are not known, but due to the differening uptake routes between higher plants and bryophytes (the latter has for example no root uptake), differences between these parameters could be expected. CR values for Po and Tc are based on ERICA data.

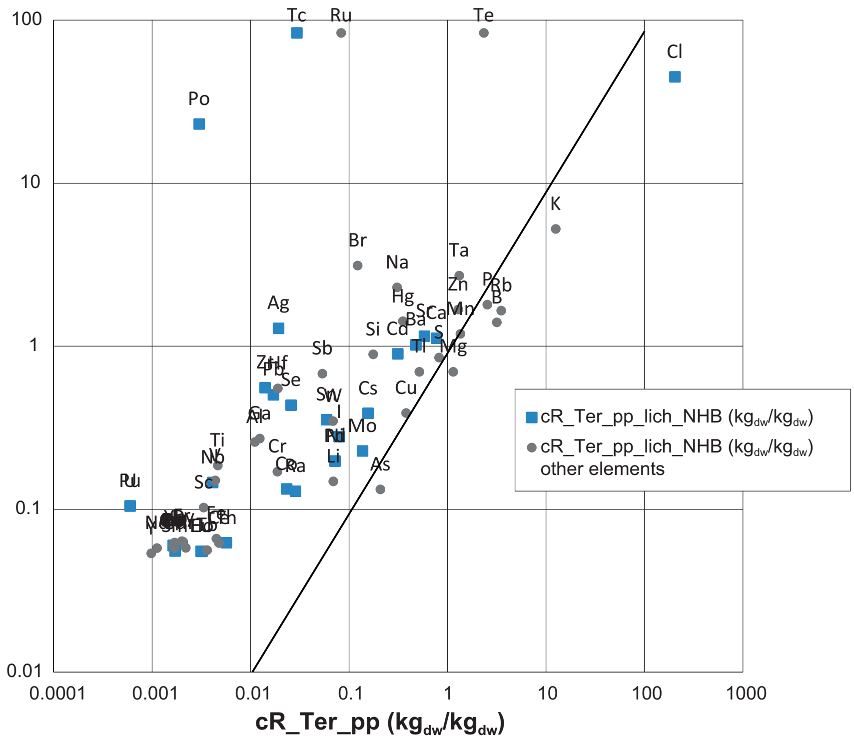

Figure 6-48. *GM of CR for lichen and bryophytes (cR_Ter_pp_lich_NHB) are plotted against the GM of CR for other natural terrestrial vegetation (cR_Ter_pp). Blue squares represent elements included in the safety assessments whereas grey dots represent other elements.*

The CR values for the different crops (cereals, vegetables and tubers) could be expected to correlate to each other to some extent. CR for natural vegetation can also be expected to correlate to the CRs for the crops. The CR for tubers, cereals, vegetables and natural vegetation are plotted in Figure 6-49. The CR among these parameters spread around one order of magnitude for most elements, no systematic difference between the CRs can be seen. For some elements the diffeences between the CR differs more than one order of magnitude, this is true for Pb, Ag, Sn, Cd, Cs, Co, Th, U and Cl. Due to lack of data, the same data are used for Se (site data for cereal) for all parameters. CR values for vegetables and tubers are based on literature data while cereal and natural vegetation are based on site data. The combination of site data and literature data sources could perhaps to some extent explain the poor correlations, but these differences could also be due to species-specific uptake processes.

When data for mushrooms are missing, data on terrestrial vegetation are used as PA. In Figure 6-50 the data for mushrooms are plotted against the CR values for natural vegetation (cR_Ter_pp). For many of the elements the selected data are identical for these two parameters when PAs are assigned. In cases were data are available for both mushrooms and terrestrial vegetation the agreement is poor, with generally higher CR values for mushrooms. This comparison indicates that the use of data for primary producers as PA for mushrooms could lead to underestimated CRs for mushrooms.

In Figure 6-51, the CR for uptake in herbivores (cR_food_herbiv) are plotted against the transfer coefficient for cow meat (TC_meat). These two parameters are not fully comparable since the transfer factor relates the food intake rate to the concentration in meat, while the cR_food_herbiv parameter relates the conentration in the food to the concentration in meat. It could, however, be expected that these parameters should be correlated, with generally higer values for cR_food_herbiv. The TC_meat values are generally lower than the cR_food_herbiv, but according to the figure the correlation between these two parameters is poor.

The transfer coefficients used to assess uptake in meat (TC_meat) and milk (TC_milk) are compared in Figure 6-52. The selected values (literature values) correlates well for some elements (Nb, Zr, Sn, Ba, Mo, Sr, Se, I and Ca) whereas higher values are selected for assimilation in meat for the lanthanides and Np, Th, Cd, Pd and Ag. Largest difference is seen for Am (three orders of magnitude). Differences are expected since elements behaves differently.

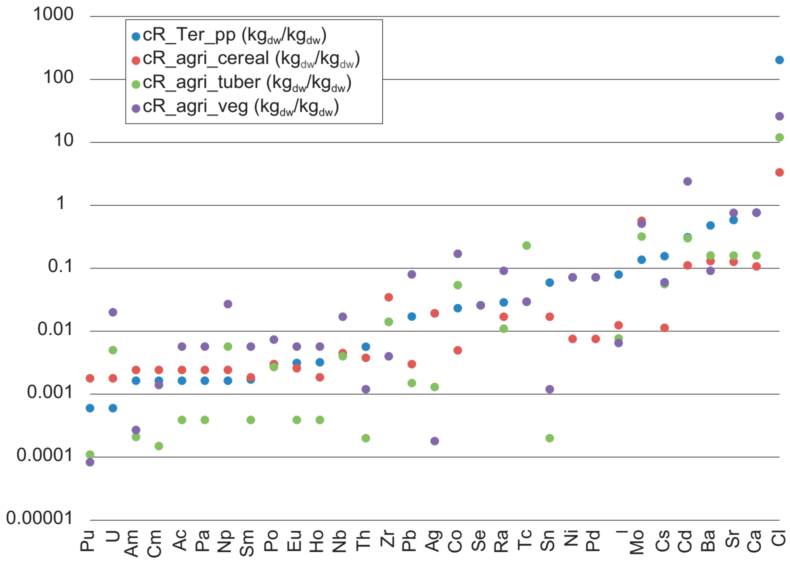

Figure 6-49. *GM of CR for tubers (cR_agri_tuber), CR for cereals (cR_agri_cereal) CR for vegetables (cR_agri_veg) and CR for natural vegetation (cR_Ter_pp) are compared.*

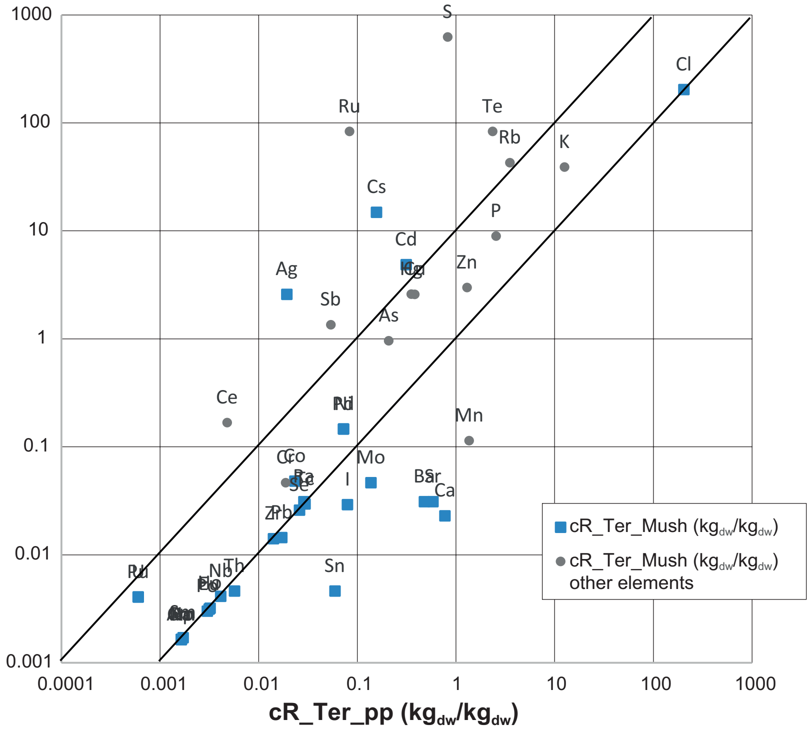

Figure 6-50. *GM of CR for mushrooms (cR_Ter_Mush) plotted against GM of CR for natural terrestrial vegetation (cR_Ter_pp). Data on terrestrial vegetation are used to parameterise mushrooms in several element cases. Blue squares represent elements included in the safety assessments whereas grey dots represent other elements.*

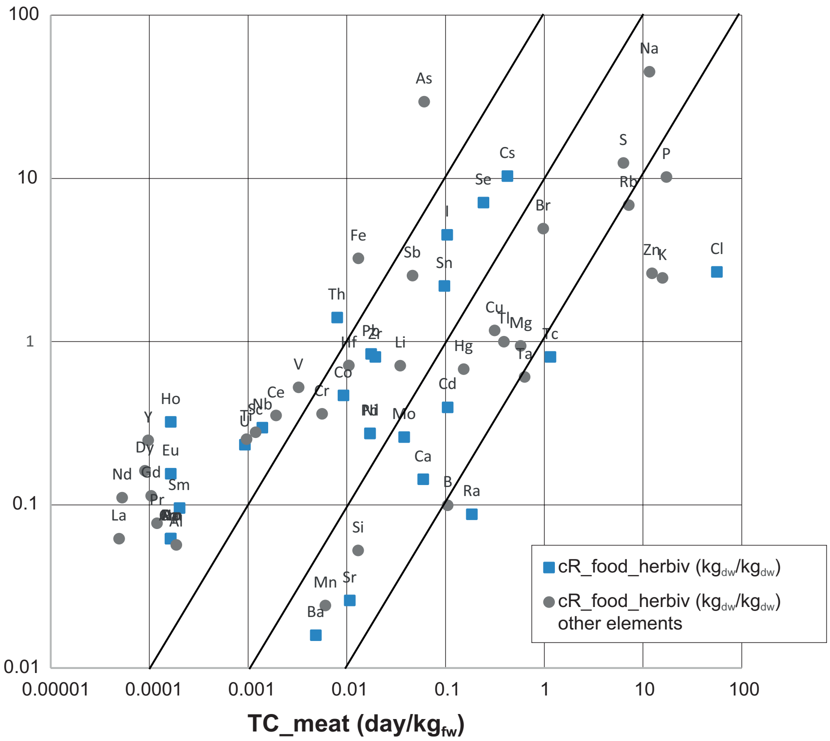

Figure 6-51. CR for food to herbivores plotted against the transfer factor for cow meat. Blue squares represent elements included in the safety assessments whereas grey dots represent other elements.

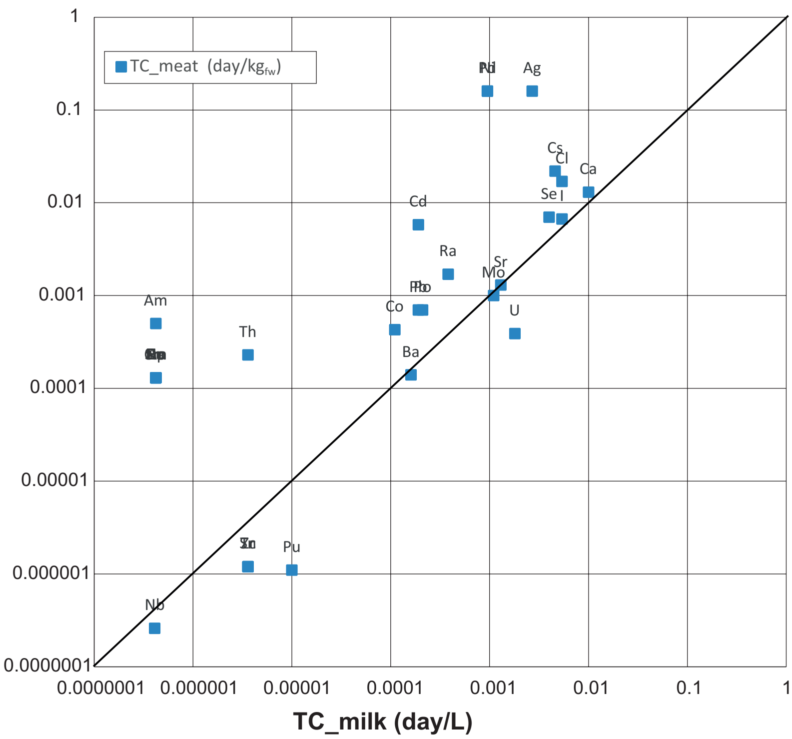

Figure 6-52. Transfer coefficients used to assess uptake in meat (TC_meat) and milk (TC_milk).

In Figure 6-53, CR for amphibians, reptiles, birds and bird eggs are plotted against the CR for mammals. In many cases the selected CRs are identical since mammal data are used as PA for amphibians, reptiles, birds and bird eggs. Mammal data has been considered a reasonalble PA for the other organisms in lack of other options. The relevance of this PA is hard to evaluate as data for all organism types from the same source (site) are not available so a relevant comparison can not be made. For elements where organism-specific literature data are used, large deviations can be seen for Tc, I, Sr and Nb for bird eggs and Ba, Sr, Ca for amphibians.

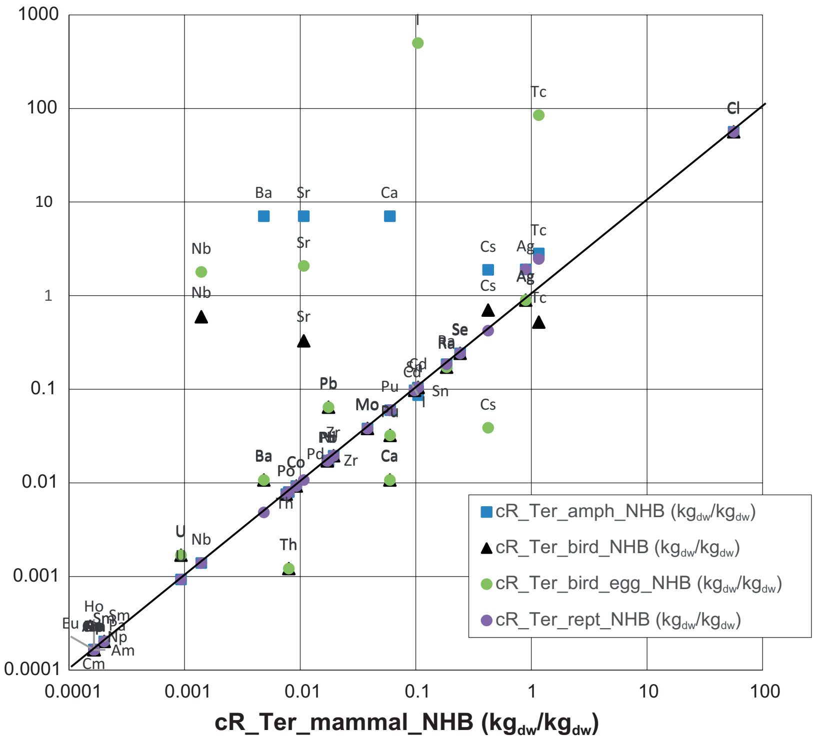

Figure 6-53. *GM for CR values for amphibians (cR_Ter_amph_NHB), birds (cR_Ter_bird_NHB), bird eggs (cR_Ter_bird_egg_NHB) and reptiles (cR_Ter_rept_NHB) plotted against GM of CR for terrestrial mammals (cR_Ter_mammal_NHB). Mammal site data are used as PA in many cases.*

7 Selected CR for the limnic ecosystem

The uptake in limnic biota is assessed using CR values, which relate concentrations in surrounding freshwater to concentrations in biota. The transport of radionuclides is related to the flow of carbon in the environment in this safety assessment and, therefore, CR values are based on carbon content and given in the unit of m^3/kg_C. Because of technical reasons, the CR values utilised for dose assessment to non-human biota are based on fresh weight concentrations and given in the unit m^3/kg_{fw}. Conversions between the different units are described in Section 4.3.

In the radionuclide model, limnic biota are divided into several compartments, representing both primary producers and consumers. The primary producers are divided into 3 functional groups: phytoplankton, microphytobenthos and macroalgae/macrophytes. The limnic consumers of interest are those that are expected to be a part of exposed humans' diet, which are limnic fish and limnic crustaceans.

For calcualtion of dose to non-human biota, the organism groups identified as reference organisms in ERICA (Brown et al. 2008) are utilised. For the limnic environment, phytoplankton and vascular plants are considered representative primary producers and the representative fauna encompass zooplankton, bivalves, gastropods, insect larvae, crustaceans, benthic and pelagic fish, amphibians, birds and mammals.

The main difference in CR values when estimating dose to humans or to non-human biota, is that the concentration in the edible part (muscle) is of interest for organisms seen as human food, whereas the whole body concentration is relevant when estimating dose to the organism itself. The limnic biota assumed to be consumed by humans in this safety assessment is limnic fish and crustaceans, and the element uptake in these two organism groups are calculated using CR values based on muscle tissue concentrations. For calculation of dose to limnic fish and crustacean itself, CR values based on whole body concentrations are utilised. Biota data from FM and LX are in most cases measured on muscle and when possible, a conversion of the data to whole body concentrations is accomplished by using the conversion factors in Yankovich et al. (2010).

Site-specific limnic CRs are calculated by combining biota data and lake water data from FM and LX. Biota and water samples from the same site are matched. The same set of water samples are used to calculate CRs for all limnic biota types. These samples are lake water concentration samples measured at FM and LX by Engdahl et al. (2008) and 3 samples are reported for each site. The samples were analysed after filtering, which makes them suitable for use in CR calculations as elements in particulate phase are considered to be unavailable for uptake in biota. In addition, a large data set of water concentration measurements is available from SKBs monitoring program and these data are utilised as supporting data. The data correlates well when the selected water samples are compared with the supporting data.

The available and selected CRs regarding limnic biota are presented and discussed in the following subsections.

Abbreviations used in the tables and figures in this chapter are explained in Table 7-1.

Table 7-1. Abbreviations used in the tables of this chapter.

Abbrevation	Description
FM N (from/to),	Number of samples in FM site data. Number of independent samples in denominator (from) and numerator (to) of the ratio
LX N (from/to)	Number of samples in LX site data. Number of independent samples in denominator (from) and numerator (to) of the ratio
FMLX (from/to)	Number of samples in FMLX site data. Number of independent samples in denominator (from) and numerator (to) of the ratio
L1 N, L2 N, L3 N, L4 N	Number of samples for literature source L1, L2, L3 and L4 respectively
FM GSD, LX GSD, FMLX GSD	Geometric standard deviation of site data from FM, LX and FMLX
L1 GSD, L2 GSD, L3 GSD, L4 GSD	Geometric standard deviation for literature source L1, L2, L3 and L4 respectively
SC FM	Sense check comparing ranges for FM site data and literature data
SC LX	Sense check comparing ranges for LX site data and literature data
SC FMLX	Sense check comparing ranges for FMLX site data and literature data
SC FMvsLX	Sense check comparing ranges for FM and LX data
SC Lit	Sense check comparing ranges for literature data sources

7.1 cR_lake_pp_macro, cR_Lake_pp_vasc_NHB

In the radionuclide model for the biosphere, the limnic macroalgae are defined as the macroalgea and macrophytes of the limnic ecosystem (Saetre et al. 2013). The parameter cR_Lake_pp_vasc_NHB describes the element uptake in limnic vascular plants utilised in dose estimates to this organism type. Since macroalgae are important primary producers in the lakes of FM (see below) and this organism type is not an identified reference organism in ERICA (Brown et al. 2008), it is assumed that the reference organism vascular plant to also can be used for macroalgae. The selected data for the two parameters (cR_lake_pp_macro and cR_Lake_pp_vasc_NHB) are identical, although the selected data for cR_lake_pp_macro are reported in m^3/kg_C while the data for cR_Lake_pp_vasc_NHB are reported in m^3/kg_{fw}.

Chara algae dominate the limnic macrovegetation of the FM area. The FM lakes are classified as oligotrophic hardwater lakes, due to their high calcium content (Andersson 2010). This specific chemical status of the lakes may alter in the future, due to landscape development and leaching of calcium. Therefore, the brown water lakes located in LX are representative for the lakes in the future landscape of FM. Consequently, the limnic primary producers found in the lakes of FM and LX are assumed to be representative for the limnic primary producers in the future FM lakes.

One sample of microphytobenthos and 4 samples of Stonewort (*Chara sp*.) are available from FM and 4 samples of Water lily (*Nymphaeaceae sp*) from LX. Just the samples of the green parts of the Water lily are utilised even though root samples are available. These samples are not included in the CR calculations since they are not representative for the modelled compartment and the risk of soil adhesion to root samples is high.

FMLX data are available for Ba, Ca, Cd, Cl, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sr, Th, U and Zr. Literature data for freshwater plants are reported for Am, Cd, Cm, Cs, I, Ni, Np, Pb, Pu, Ra, Se, Sr, Tc and U, in IAEA (2010). ERICA (Hosseini et al. 2008) reports freshwater vascular plant data for Ag, Am, Cd, Cl, Cm, Cs, Eu, I, Nb, Ni, Np, Pb, Po, Pu, Ra, Se, Sr, Tc, Th, U and Zr (see Figure 7-1). Data reported in IAEA (2010) are classified as L1 data and ERICA data (Hosseini et al. 2008) are classified as L2 data. Data for phytoplankton reported in ERICA (Hosseini et al. 2008) are less suitable than data for vascular plants and are not utilised.

When FM data are compared to LX data, the overlaps of the ranges show major discrepancies for most elements: Cl, Cd, Eu, Ho, Ni, Nb, Se, Sm, Sr, Pb and Zr. FM data are higher than LX data for all of these elements except Cl. When FM data are compared to the total range of reported literature data, the FM data are within the range of literature data for most elements. FM data for Cl are lower than literature data. The FM data range for Th is wider than the literature range in ERICA (Hosseini et al. 2008). The comparison of LX data and literature data correlates well for all elements except for U, Cd and Th, where LX data are lower than literature data. Data for Cl are within the literature range. When FMLX data are compared to literature data, the data correlates well for all elements except Cl. Literature ranges reported in IAEA (2010) and ERICA (Hosseini et al. 2008) for Am, Pu, Ra, Sr, I, Cs and U, overlap in all cases. The results of these sense checks are presented in Table 7-2.

Reported GSD values for U, Th and Mo are higher than GSDmax (5) in FM, while GSDs for LX data are within a reasonable range for all elements. Exceptionally high GSDs are reported for Cu, Ni and Cs (320, 130 and 76, respectively) in IAEA (2010). GSD values are also high for Pu and Cs (16 and 14, respectively), for an unknown reason. GSD values reported in ERICA (Hosseini et al. 2008) are between 1.7 and 3.0.

The selected data are presented in Table 7-3, Table 7-4, Figure 7-2 and Figure 7-3. For elements where site data are available or where site data for suitable EAs are available, these are selected. Site data are not available for Ra and Ba data are selected as EA. Ba site data overlap literature data for Ra, which supports the selection. Site data are not available for Ac, Am, Cm and Np. Literature data are available for Am and Cm. Site data are available for several lanthanides: Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Tb, Tm and Yb. The site data for various lanthanides are consistent with the reported literature data for Am and Cm, which supports the use of lanthanides as EA for Ac, Am, Cm and Np. La is utilised as EA for Ac, Am, Cm and Np, as it has the highest sample number.

Neither site data nor suitable EAs are available for Ag, Po, Np, Tc and Pu and, therefore, literature data are utilised for parameterisation. Neither site nor literature data are available for Pa and Sn. La site data are selected as EA for Pa and Zr site data are used as EA for Sn.

The selected data span over 3 orders of magnitude, from 0.13 m^3/kg_C for Cl to 645 m^3/kg_C for Pu. The uptake is low for Cl and Tc and high for Pu and Np. The CR values are within 1 order of magnitude for the remaining elements, from 1.9 to 32 m^3/kg_C.

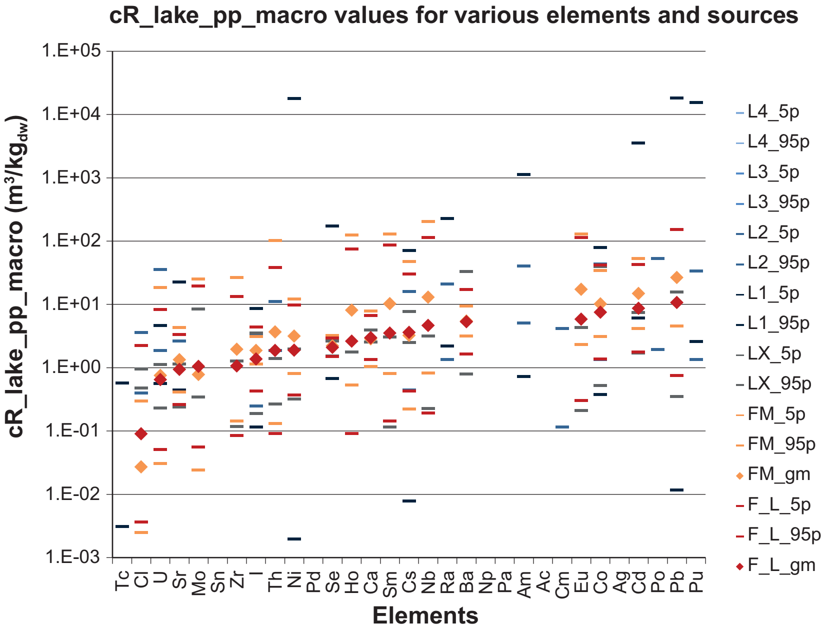

__Figure 7-1.__ Total available data ranges for the parameter cR_lake_pp_macro (m^3/kg_C). The elements are arranged in the same order as in Figure 7-2 showing selected parameter values.

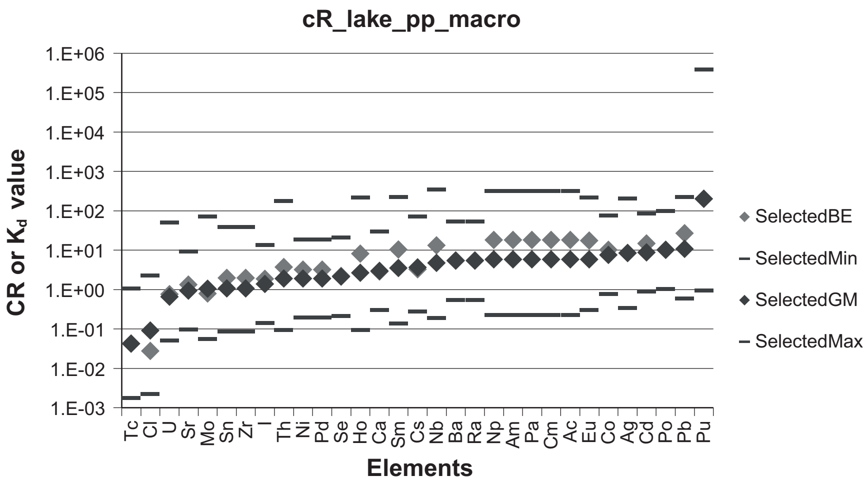

__Figure 7-2.__ Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_C).

Table 7-2. All available data for the parameters cR_lake_pp_macro and cR_Lake_pp_vasc_NHB for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010 Freshwater, Water plant, L2 = ERICA (Hosseini et al. 2008) Freshwater, Vascular plants. See Table 7-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am				16	5						9.3	1.9							2:1/1
Ba	3/5	3/3	6/8					1.5	3.1	2.0								S1	0:0/0
Ca	3/5	3/3	6/8					2.2	1.1	1.6								S3	0:0/0
Cd	3/5	3/3	6/8	5	2			1.9	1.6	2.6	6.9				S2(L97%)	S4	S2(L59%)	S4	2:0/0
Cl	3/5	3/3	6/8		6			4.5	1.2	7.1		2.0			S2(L3%)	S1	S2(L30%)	S4	1:0/0
Cm				1	3							3.0							2:0/0
Co	3/5	3/3	6/8	19	12			1.8	3.7	2.8	5.1	2.9			S1	S1	S1	S1	2:1/1
Cs	3/5	3/3	6/8	26	20			4.7	1.4	3.7	16.0	3.0			S1	S1	S1	S3	2:1/1
Eu	3/5	3/3	6/8		1			2.9	2.5	6.1								S2(U0%)	1:0/0
Ho	3/5	3/3	6/8					4.6	2.5	7.7								S2(U12%)	0:0/0
I	3/5	3/3	6/8	3	22			1.3	2.5	2.0	3.7	2.2			S1	S1	S1	S2(U79%)	2:1/1
La	3/5	3/3	6/8					3.6	2.5	6.9								S2(U5%)	0:0/0
Mo	3/5	3/3	6/8					7.0	2.6	6.0								S3	0:0/0
Nb	3/5	3/3	6/8		1			4.6	2.3	7.0								S2(U14%)	1:0/0
Ni	3/5	3/3	6/8	5	1			2.0	1.8	2.7	130.0				S1	S1	S1	S2(U12%)	2:0/0
Np				2	1														2:0/0
Pa																			0:0/0
Pb	3/5	3/3	6/8	5	1			2.5	3.2	5.0	76.0				S1	S1	S1	S2(U20%)	2:0/0
Pd																			0:0/0
Po					6							2.7							1:0/0
Pu				40	7						14.0	2.7							2:1/1
Ra				9	15						4.1	2.3							2:1/1
Se	3/3	3/3	6/6	31	1			1.1	1.2	1.2	5.4				S1	S1	S1	S4	2:0/0
Sm	3/5	3/3	6/8					4.1	2.7	7.0								S2(U15%)	0:0/0
Sn																			0:0/0
Sr	3/5	3/3	6/8	17	8			2.4	1.6	2.2	3.3	2.1			S1	S1	S1	S2(U31%)	2:1/1
Tc				9	1						4.9								2:0/0
Th	3/5	3/3	6/8		5			6.4	1.7	6.3		1.7			S3	S4	S3	S3	1:0/0
U	3/5	3/3	6/8	4	9			6.0	1.6	4.7	1.9	2.4			S2(L56%)	S2(L25%)	S2(L51%)	S3	2:1/1
Zr	3/5	3/3	6/8		2			4.1	2.1	4.6								S2(U33%)	1:0/0

Table 7-3. Selected data properties, references and comments for the parameter cR_lake_pp_macro (m^3/kg_C) for the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La		6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	6.9	GSD	Site data FMLX	FMLX	No site data avaliable, La used as EA.
Ag			1	8.1E–01	2.0E+01	2.0E+01	4.9E+02	7.0	GSDmax	ERICA	L2	No site data avaliable,ERICA data used
Am	La		6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	6.9	GSD	Site data FMLX	FMLX	Literature data reported by IAEA 2010 (n=16) and ERICA (n=5) overlap and are in the same order of magnitude as site data for the lanthanides. La site data used as EA.
Ba			6	1.7E+00	1.6E+01	1.9E+01	1.6E+02	4.0	GSDmean	Site data FMLX	FMLX	No literature data avaliablel FM and LX data overlap. Ba site data similar to Ca site data.
Ca			6	9.3E–01	9.1E+00	1.0E+01	8.9E+01	4.0	GSDmean	Site data FMLX	FMLX	No literature data avaliable. FM data consistent with LX data and FMLX data for Sr and Ba.
Cd			6	2.7E+00	2.6E+01	5.2E+01	2.6E+02	4.0	GSDmean	Site data FMLX	FMLX	FM data higher than LX data. Literature data high in comparison to site data. Site data selected.
Cl			6	8.9E–03	2.8E–01	9.5E–02	6.9E+00	7.1	GSD	Site data FMLX	FMLX	FM data lower than LX data and ERICA data. Site data selected. GSD high.
Cm	La		6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	6.9	GSD	Site data FMLX	FMLX	Reported data for Cm for Vascular plant in ERICA 1 order of magnitude lower than IAEA data and data reported for Am, Eu, Ho, and Sm. La site data used as analogue.
Co			6	2.4E+00	2.3E+01	3.6E+01	2.3E+02	4.0	GSDmean	Site data FMLX	FMLX	Site data selected.
Cs			6	1.1E+00	1.1E+01	1.1E+01	1.9E+02	4.0	GSDmean	Site data FMLX	FMLX	Large range in FM data, although IAEA 2010 also reported a large range for Cs. Site data selected
Eu			6	7.9E–01	1.8E+01	6.0E+01	5.7E+02	6.1	GSD	Site data FMLX	FMLX	Site data selected. Site data for lanthanides are similar.
Ho			6	2.2E–01	8.0E+00	2.8E+01	5.7E+02	7.7	GSD	Site data FMLX	FMLX	Site data selected. FM data higher than LX data. Site data for lanthanides are similar.
I			6	4.3E–01	4.2E+00	6.5E+00	4.1E+01	4.0	GSDmean	Site data FMLX	FMLX	Site data selected. FM, LX and literature data overlap.
Mo			6	1.7E–01	3.2E+00	2.7E+00	1.9E+02	6.0	GSD	Site data FMLX	FMLX	Reported FM data show a large range and LX a narrow range. No literature data available. Site data are selected.
Nb			6	5.9E–01	1.4E+01	4.6E+01	8.9E+02	7.0	GSD	Site data FMLX	FMLX	FM data higher than LX data. No literature data available. Site data are selected.
Ni			6	5.9E–01	5.7E+00	1.1E+01	5.6E+01	4.0	GSDmean	Site data FMLX	FMLX	FM data higher than LX data. Literature data overlapp.
Np	La		6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	6.9	GSD	Site data FMLX	FMLX	La used as EA
Pa	La		6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	6.9	GSD	Site data FMLX	FMLX	No data are available. La used as EA.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Pb			6	1.4E+00	3.3E+01	9.3E+01	5.8E+02	5.0	GSD	Site data FMLX	FMLX	FM data higher than LX data. IAEA 2010 reported a GSD of 76, which is considered unrealistic. Site data selected.
Pd	Ni		6	5.9E–01	5.7E+00	1.1E+01	5.6E+01	4.0	GSDmean	Site data FMLX	FMLX	No data avaliable. Ni used as EA.
Po			6	2.5E+00	2.4E+01	2.4E+01	2.4E+02	4.0	GSDmean	ERICA	L2	No site data avaliable. ERICA reported data n=6, these data are selected.
Pu			40	3.0E+00	6.5E+02	6.5E+02	1.2E+06	14.0	GSD	IAEA 2010	L1	IAEA 2010 reported 40 samples. Maximum value extreamly high and GSD high (14).
Ra	Ba		6	1.7E+00	1.6E+01	1.9E+01	1.6E+02	4.0	GSDmean	Site data FMLX	FMLX	No site data avaliable. Ba data used as analogue.
Se			6	6.4E–01	6.2E+00	8.0E+00	6.1E+01	4.0	GSDmean	Site data FMLX	FMLX	The range repored for both FM and LX are narrow and they do not overlap. Data reported in IAEA have a wide range (GSD=5.4). Site data selected.
Sm			6	3.3E–01	1.1E+01	3.6E+01	5.8E+02	7.0	GSD	Site data FMLX	FMLX	Site data selected. FM data higher than LX data. Site data for lanthanides similar.
Sn	Zr		6	2.6E–01	3.2E+00	6.8E+00	9.9E+01	4.6	GSD	Site data FMLX	FMLX	Zr data are used as EA.
Sr			6	2.9E–01	2.9E+00	4.7E+00	2.8E+01	4.0	GSDmean	Site data FMLX	FMLX	FM data are higher than LX data. Site data within the range of reported literature data.
Tc			9	5.6E–03	1.4E–01	1.4E–01	3.4E+00	7.0	GSDmax	IAEA 2010	L1	IAEA reports 9 samples. These data are selected.
Th			6	2.8E–01	5.7E+00	1.3E+01	4.6E+02	6.3	GSD	Site data FMLX	FMLX	FM data have a wide range that overlap LX and literature data. Site data selected. GSD higher than GSDmax.
U			6	1.5E–01	2.0E+00	2.6E+00	1.3E+02	4.7	GSD	Site data FMLX	FMLX	Data from FM and LX are low in comparison to IAEA data. GSD also small. Site data selected.
Zr			6	2.6E–01	3.2E+00	6.8E+00	9.9E+01	4.6	GSD	Site data FMLX	FMLX	FM data range high in comparison to LX. ERICA reported data n=2. Site data selected

Table 7-4. Selected data properties, references and comments for the parameter cR_Lake_pp_vasc_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Ac missing. La used as EA.
Ag			1	8.1E–02	2.0E+00	2.0E+00	4.9E+01	7.0	GSDmax	ERICA	L1	Validation not possible. No ranges presented.
Am	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Am missing. La used as EA.
Ba		cR_lake_pp_macro	6	5.2E–02	1.3E+00	1.3E+00	3.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Ca		cR_lake_pp_macro	6	2.9E–02	7.1E–01	6.9E–01	1.8E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Cd		cR_lake_pp_macro	6	8.5E–02	2.1E+00	3.6E+00	5.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Cl		cR_lake_pp_macro	6	5.3E–04	2.2E–02	6.5E–03	5.3E–01	7.1	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Cm	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Cm missing. La used as EA.
Co		cR_lake_pp_macro	6	7.4E–02	1.8E+00	2.4E+00	4.4E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Cs		cR_lake_pp_macro	6	3.5E–02	8.7E–01	7.8E–01	2.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Eu		cR_lake_pp_macro	6	5.7E–02	1.4E+00	4.1E+00	5.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Ho		cR_lake_pp_macro	6	2.3E–02	6.3E–01	1.9E+00	5.2E+01	7.7	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
I		cR_lake_pp_macro	6	1.3E–02	3.3E–01	4.5E–01	8.1E+00	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Mo		cR_lake_pp_macro	6	1.0E–02	2.5E–01	1.9E–01	1.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Nb		cR_lake_pp_macro	6	4.6E–02	1.1E+00	3.1E+00	8.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. The overlap between FM and LX data are restricted due to the small LX range.
Ni		cR_lake_pp_macro	6	1.8E–02	4.5E–01	7.6E–01	1.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Np	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Ac missing. La used as EA.

Ele-ment	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pa	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Pa missing. La used as EA.
Pb		cR_lake_pp_macro	6	1.0E–01	2.6E+00	6.4E+00	6.3E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Pd	Ni	cR_lake_pp_macro	6	1.8E–02	4.5E–01	7.6E–01	1.1E+01	7.0	GSDmax	Site data FMLX	FMLX	Ni used as EA. All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Po			6	2.5E–01	2.4E+00	2.4E+00	2.4E+01	4.0	GSDmean	ERICA	L1	Validation not relevant, due to different organims.
Pu			40	1.2E–01	2.6E+01	2.6E+01	4.9E+04	14.0	gsd	IAEA 2010	L2	Data from IAEA selected based on the larger number of observations.
Ra	Ba	cR_lake_pp_macro	6	5.2E–02	1.3E+00	1.3E+00	3.1E+01	7.0	GSDmax	Site data FMLX	FMLX	Ba used as EA. All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Se		cR_lake_pp_macro	6	2.0E–02	5.0E–01	5.3E–01	1.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Sm		cR_lake_pp_macro	6	3.3E–02	8.4E–01	2.5E+00	5.3E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Sn	Zr	cR_lake_pp_macro	6	1.0E–02	2.5E–01	4.7E–01	9.0E+00	7.0	GSDmax	Site data FMLX	FMLX	Zr used as EA. All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Sr		cR_lake_pp_macro	6	9.1E–03	2.2E–01	3.2E–01	5.5E+00	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Tc			9	2.9E–04	5.5E–03	5.5E–03	9.9E–02	4.9	gsd	IAEA 2010	L2	The ERICA value (n=1) higher than IAEA (n=9). The latter used, due to the larger number of observations.
Th		cR_lake_pp_macro	6	1.8E–02	4.5E–01	8.8E–01	4.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Range larger than GSDmax.
U		cR_lake_pp_macro	6	6.3E–03	1.6E–01	1.8E–01	1.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Zr		cR_lake_pp_macro	6	1.0E–02	2.5E–01	4.7E–01	9.0E+00	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.

7.2 cR_lake_pp_plank, cR_Lake_pp_plank_NHB

The cR_lake_pp_plank and cR_Lake_pp_plank_NHB parameters reflect the uptake of elements from water to phytoplankton in limnic ecosystem. The cR_Lake_pp_plank_NHB is utilised for dose calculation to limnic phytoplankton. The two parameters are identical though presented in different units, cR_lake_pp_plank is in m^3/kg_C while cR_Lake_pp_plank_NHB is in m^3/kg_{fw}.

Site data are not available for the phytoplankton and the reported literature data are limited. Data on limnic phytoplankton are available in ERICA (Hosseini et al. 2008). More than 2 observations are only available for Cs, I, Po, Pu, Ra and U, while 1 or 2 observations are reported for several elements. A comparison of literature data cannot be completed since only 1 source contained data on phytoplantkon. Literature data in ERICA (Hosseini et al. 2008) are compared to site data for limnic macroalgae/macrophytes in Figure 7-3. Phytoplankton data are higher than macroalgae data in all cases, which may be caused by the difference in specific surface area between phytoplankton and macroalgae/macrophytes. The large surface area to volume ratio, a requirement of passively floating pelagic organisms, is conducive to accumulate many elements and the adsorption could lead to higher uptake for phytoplankton.

For elements where site data for limnic macroalgae/macrophytes (cR_lake_pp_macro) are available, these data are utilised as PAs. The element uptake in phytoplankton is assumed to deviate from the uptake in limnic macroalgae, though since no other data are available, these data are used as PA in combination with GSDmax. When site data for macroalgae/macrophytes are not available for Ag, Po, Pu and Tc, and literature data on phytoplankton in ERICA (Hosseini et al. 2008) are utilised.

Selected data are presented in Table 7-6, Table 7-7 and Figure 7-5.

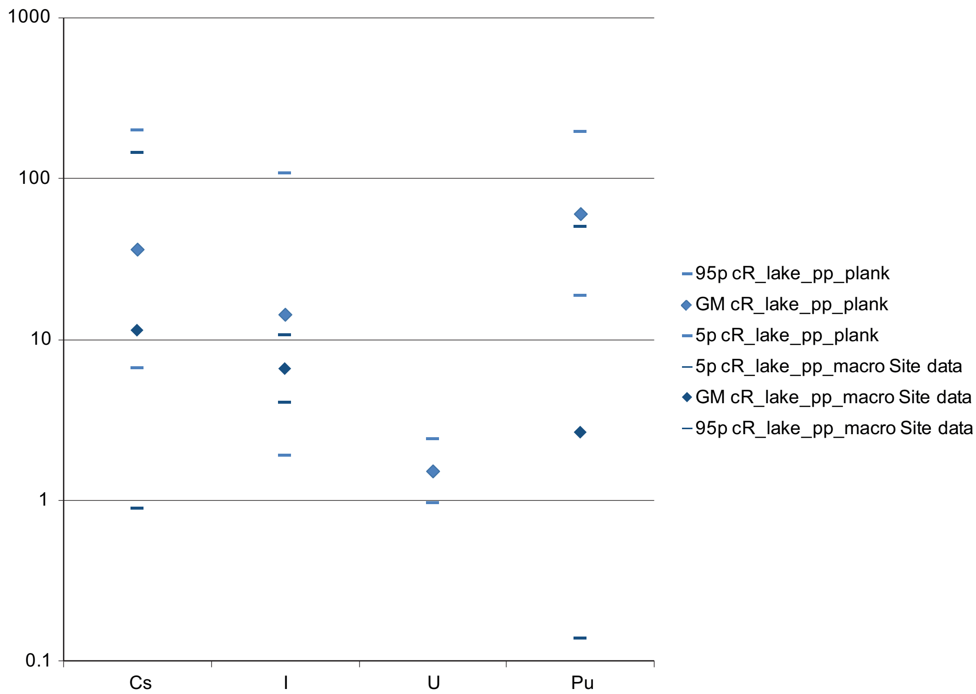

Figure 7-3. *Data on phytoplankton reported in ERICA (Hosseini et al. 2008) are higher than site data for macroalgae for Cs, I and Pu.*

Table 7-5. All available data for the parameters cR_lake_pp_plank and cR_Lake_pp_plank_NHB for the elements of primary concern and selected EAs. L1= ERICA (Hosseini et al. 2008) Freshwater, phytoplankton. See Table 7 1 for description of headings.

Ele-ment	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				1															1:0/0
Cl				1															1:0/0
Cm				2							1.0								1:0/0
Co				1															1:0/0
Cs				12							2.8								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				7							3.4								1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				1															1:0/0
Pd																			0:0/0
Po				7							1.2								1:0/0
Pu				7							2.0								1:0/0
Ra				8							1.9								1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				2							1.1								1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				3							1.3								1:0/0
Zr				1															1:0/0

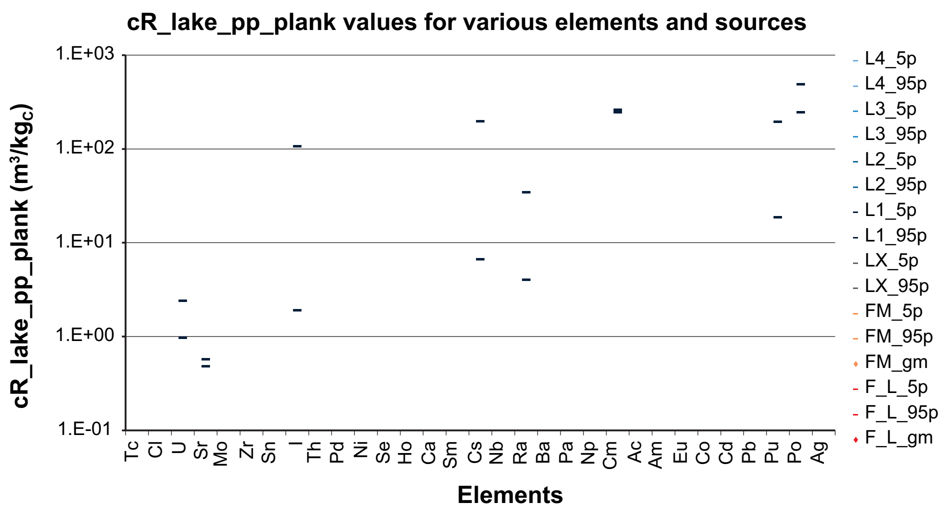

Figure 7-4. *Total available data ranges for the parameter cR_lake_pp_plank (m³/kgC). The elements are arranged in the same order as in Figure 7-5 showing selected parameter values.*

Table 7-6. Selected data properties, references and comments for the parameter cR_lake_pp_plank (m^3/kg_C) for the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La	cR_lake_pp_macro	6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA and La as EA
Ag			1	3.0E+01	7.4E+02	7.4E+02	1.8E+04	7.0	GSDmax	ERICA	L1	No site data available. ERICA reports n=1 for marine phytoplankton, this value is used in combination with GSDmax
Am	La	cR_lake_pp_macro	6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA and La as EA
Ba		cR_lake_pp_macro	6	6.6E–01	1.6E+01	1.9E+01	4.0E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Ca		cR_lake_pp_macro	6	3.7E–01	9.1E+00	1.0E+01	2.2E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Cd		cR_lake_pp_macro	6	1.1E+00	2.6E+01	5.2E+01	6.5E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Cl		cR_lake_pp_macro	6	8.9E–03	2.8E–01	9.5E–02	6.8E+00	7.1	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Cm	La	cR_lake_pp_macro	6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA and La as EA
Co		cR_lake_pp_macro	6	9.4E–01	2.3E+01	3.6E+01	5.7E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Cs		cR_lake_pp_macro	6	4.5E–01	1.1E+01	1.1E+01	2.7E+02	7.0	GSDmax	Site data FMLX	FMLX	ERICA reported 12 samples on phytoplankton. Site data for algea are used.
Eu		cR_lake_pp_macro	6	7.2E–01	1.8E+01	6.0E+01	5.7E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Ho		cR_lake_pp_macro	6	2.2E–01	8.0E+00	2.8E+01	5.7E+02	7.7	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
I		cR_lake_pp_macro	6	1.7E–01	4.2E+00	6.5E+00	1.0E+02	7.0	GSDmax	Site data FMLX	FMLX	ERICA reported 7 samples on phytoplankton. Site data fro macro algea are used.
Mo		cR_lake_pp_macro	6	1.3E–01	3.2E+00	2.7E+00	1.9E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Nb		cR_lake_pp_macro	6	5.8E–01	1.4E+01	4.6E+01	8.9E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Ni		cR_lake_pp_macro	6	2.3E–01	5.7E+00	1.1E+01	1.4E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Np	La	cR_lake_pp_macro	6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA and La as EA

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Pa	La	cR_lake_pp_macro	6	5.4E–01	1.8E+01	6.3E+01	8.4E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA and La as EA
Pb		cR_lake_pp_macro	6	1.3E+00	3.3E+01	9.3E+01	8.0E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Pd	NI	cR_lake_pp_macro	6	2.3E–01	5.7E+00	1.1E+01	1.4E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA and Ni as EA
Po			7	3.6E+01	3.5E+02	3.5E+02	3.4E+03	4.0	GSDmean	ERICA	L1	ERICA reported 7 samples on phytoplankton. These data was selected
Pu			7	6.2E+00	6.0E+01	6.0E+01	5.9E+02	4.0	GSDmean	ERICA	L1	ERICA reported 7 samples on phytoplankton. These data was selected
Ra	Ba	cR_lake_pp_macro	6	6.6E–01	1.6E+01	1.9E+01	4.0E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA and Ba as EA
Se		cR_lake_pp_macro	6	2.5E–01	6.2E+00	8.0E+00	1.5E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Sm		cR_lake_pp_macro	6	3.3E–01	1.1E+01	3.6E+01	5.8E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Sn	Zr	cR_lake_pp_macro	6	1.3E–01	3.2E+00	6.8E+00	9.9E+01	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA and Zr as EA
Sr		cR_lake_pp_macro	6	1.2E–01	2.9E+00	4.7E+00	7.0E+01	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
Tc			1	4.3E–03	1.1E–01	1.1E–01	2.6E+00	7.0	GSDmax	ERICA	L1	Phytoplankton data only from ERICA. Lower value than for water plants in ERICA but in the same magnitude as for water plants in IAEA. ERICA plankton data was used (most representative). GSDmax used.
Th		cR_lake_pp_macro	6	2.3E–01	5.7E+00	1.3E+01	4.6E+02	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA
U		cR_lake_pp_macro	6	8.1E–02	2.0E+00	2.6E+00	1.3E+02	7.0	GSDmax	Site data FMLX	FMLX	ERICA reported 3 samples on phytoplankton. Site data for macroalgea are used.
Zr		cR_lake_pp_macro	6	1.3E–01	3.2E+00	6.8E+00	9.9E+01	7.0	GSDmax	Site data FMLX	FMLX	No data available. cR_lake_pp_macro used as PA

Table 7-7. Selected data properties, references and comments for the parameter cR_lake_pp_macro_plank_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Ac missing. La used as EA.
Ag			1	2.3E+00	5.6E+01	5.6E+01	1.4E+03	7.0	GSDmax	ERICA	L1	No range presented so GSDmax was used
Am	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Am missing. La used as EA.
Ba		cR_lake_pp_macro	6	5.2E–02	1.3E+00	1.3E+00	3.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Ca		cR_lake_pp_macro	6	2.9E–02	7.1E–01	6.9E–01	1.8E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Cd		cR_lake_pp_macro	6	8.5E–02	2.1E+00	3.6E+00	5.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Cl		cR_lake_pp_macro	6	5.3E–04	2.2E–02	6.5E–03	5.3E–01	7.1	GSDmax	Site data FMLX	FMLX	Small overlap between FM and LX/ERICA. FM algea data (Chara=macroalgae and microphytobenthos), LX macrophyte (Nymphacea), ERICA vasc plants. FM considered more relevant.
Cm	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Cm missing. La used as EA.
Co		cR_lake_pp_macro	6	7.4E–02	1.8E+00	2.4E+00	4.4E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Cs		cR_lake_pp_macro	6	3.5E–02	8.7E–01	7.8E–01	2.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Eu		cR_lake_pp_macro	6	5.7E–02	1.4E+00	4.1E+00	5.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Ho		cR_lake_pp_macro	6	2.3E–02	6.3E–01	1.9E+00	5.2E+01	7.7	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
I		cR_lake_pp_macro	6	1.3E–02	3.3E–01	4.5E–01	8.1E+00	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Mo		cR_lake_pp_macro	6	1.0E–02	2.5E–01	1.9E–01	1.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Nb		cR_lake_pp_macro	6	4.6E–02	1.1E+00	3.1E+00	8.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Limited overlap between FM and LX data. ERICA value between those two, so both considered valid.
Ni		cR_lake_pp_macro	6	1.8E–02	4.5E–01	7.6E–01	1.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Np	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Ac missing. La used as EA.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pa	La	cR_lake_pp_macro	6	5.4E–02	1.4E+00	4.3E+00	7.7E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Pa missing. La used as EA.
Pb		cR_lake_pp_macro	6	1.0E–01	2.6E+00	6.4E+00	6.3E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Pd	Ni	cR_lake_pp_macro	6	1.8E–02	4.5E–01	7.6E–01	1.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Pd missing. Ni used as EA.
Po			7	2.7E+00	2.6E+01	2.6E+01	2.6E+02	4.0	GSDmean	ERICA	L1	Validation not relevant, due to different organims.
Pu			7	4.7E–01	4.6E+00	4.6E+00	4.5E+01	4.0	GSDmean	ERICA	L1	
Ra	Ba	cR_lake_pp_macro	6	5.2E–02	1.3E+00	1.3E+00	3.1E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Ba used as EA (site data available).
Se		cR_lake_pp_macro	6	2.0E–02	5.0E–01	5.3E–01	1.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Sm		cR_lake_pp_macro	6	3.3E–02	8.4E–01	2.5E+00	5.3E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Sn	Zr	cR_lake_pp_macro	6	1.0E–02	2.5E–01	4.7E–01	9.0E+00	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group. Site data for Sn missing. Zr used as EA.
Sr		cR_lake_pp_macro	6	9.1E–03	2.2E–01	3.2E–01	5.5E+00	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Tc			1	3.3E–04	8.0E–03	8.0E–03	2.0E–01	7.0	GSDmax	ERICA	L1	Phytoplankton data only from ERICA. Lower value than for water plants in ERICA but in the same magnitude as for water plants in IAEA. ERICA plankton data used (most representative). GSDmax assigned.
Th		cR_lake_pp_macro	6	1.8E–02	4.5E–01	8.8E–01	4.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1. Range larger than GSDmax.
U		cR_lake_pp_macro	6	6.3E–03	1.6E–01	1.8E–01	1.2E+01	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.
Zr		cR_lake_pp_macro	6	1.0E–02	2.5E–01	4.7E–01	9.0E+00	7.0	GSDmax	Site data FMLX	FMLX	All site data for limnic primary producers (macroalgae and microphytobenthos) merged to 1 group.

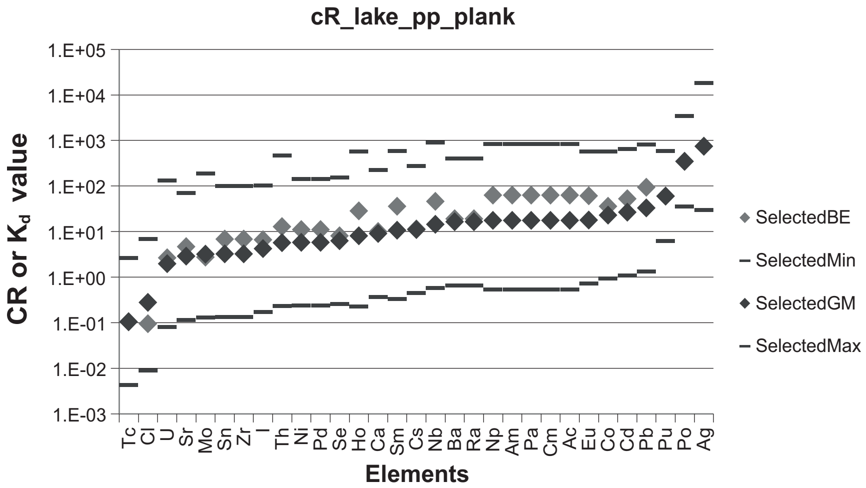

Figure 7-5. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_C).*

7.3 cR_lake_pp_micro

The cR_lake_pp_micro parameter represents the uptake of element in the microphytobenthos compartment in the model (Saetre et al. 2013).

Only 1 limnic microphytobenthos sample is available from FM and literature data on the uptake in microphytobenthos are not available. The single sample of microphytobentos is compared to concentrations measured in chara algae and it can be concluded that the concentration in microphytobenthos sample is higher for most of the elements. The single sample of microphytobenthos is insufficient for parameterisation. Instead, the parameter cR_lake_pp_macro is used as PA in combination with an assigned GSDmax for all elements (site data for this parameter includes the single microphytobenthos sample). The uptake of microphytobenthos is assumed to differ systematically from macroalgea uptake due to the difference in area to volume ratio between these organisms. A large area to volume ratio could facilitate a high uptake of elements associated to the surface of the organism. Though no other information on uptake in microphytobenthos is available, the data on uptake in macroalgae/macrophytes are considered the best data to utilise. The selected data for cR_lake_pp_macro are presented in Section 7.1.

7.4 cR_Lake_zoopl_NHB

cR_Lake_zoopl_NHB describes the element uptake in limnic zooplankton for use in dose estimates to this organism type. Site data are not available. The literature source available is ERICA (Hosseini et al. 2008) (Table 7-8 and Figure 7-6), where the same values as for limnic phytoplankton are utilised in many cases and data for marine zooplankton in some cases. Site data are available for marine zooplankton (marine zooplankton data from Kumblad and Bradshaw (2008) (FM), water data from Engdahl et al. (2008) (FMLX)), see parameter cR_Sea_zoopl_NHB.

When analogues or 1 value without range are presented in ERICA, an analogue using site data is preferred and site data for marine zooplankton are selected. Site data for marine zooplankton are also used, when available, for the 8 elements not included in ERICA. Site data for Ca in marine zooplankton are utilised for Sr. Nd data are used for Ac, Am, Cm, Np and Pa (combined PA and EA). Zr is utilised as EA for Sn, and Ni is used for Pd. For Co and Th the available site data for marine zooplankton are not used since it showed limited or no overlap with ERICA data which were based on a larger number of observations (site data contains only 1 sample, see Section 8.4 (cR_Sea_zoopl_NHB)).

For Cl and Nb, site data for limnic fish as well as for limnic primary producers are available. Fish data (see parameter cR_Lake_Fish_NHB in Section 7.10) is selected as it is considered more relevant. For Pb, site data for fish are not available, though site data for limnic primary producers are (phytoplankton not included). Literature data for fish is selected as PA for Pb in order to be more consistent. For Ra site data are missing for marine zooplankton, limnic fish and primary producers. ERICA (Hosseini et al. 2008) utilised the same value as for phytoplankton, though literature data for Ra in limnic fish (from ICRP 2011) are selected in order to be consistent with PAs for other elements.

Ranges are not presented for Tc and Ag, and GSDmax (5) is assigned to these parameters. The presented GSD is too narrow for some elements and a more appropriate GSD is set, in accordance with the statements in Section 4.3, (GSDmean or GSDmax). GSDmax is also assigned to elements where PAs are utilised.

The selected CR values are presented in Table 7-9 and Figure 7-7.

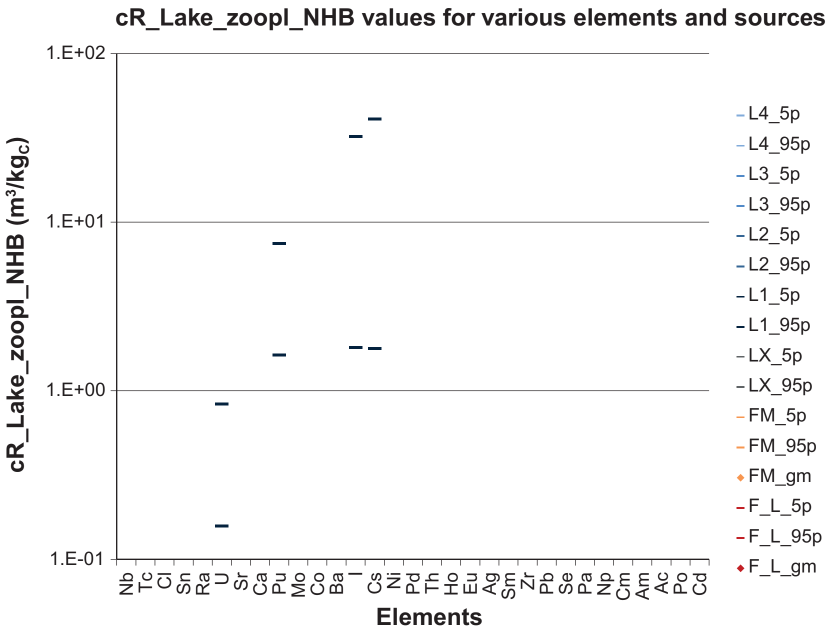

Figure 7-6. *Total available data ranges for the parameter cR_Lake_zoopl_NHB (m^3/kg_C). The elements are arranged in the same order as in Figure 7-7 showing selected parameter values.*

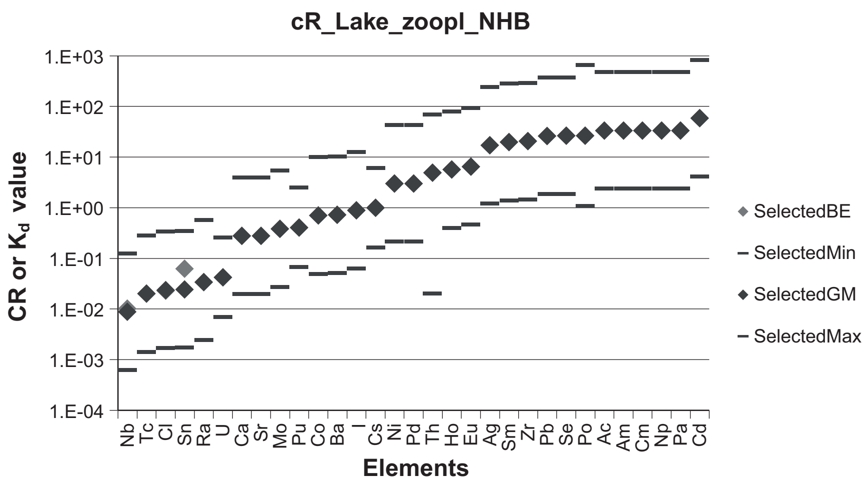

Figure 7-7. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

Table 7-8. All available data for the parameter cR_Lake_zoopl_NHB for the elements of primary concern and selected EAs. L1 = ERICA (Hosseini et al. 2008) Freshwater, Zooplankton. See Table 7-1 for description of headings.

Ele-ment	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				1															1:0/0
Cl				1															1:0/0
Cm				1															1:0/0
Co				1															1:0/0
Cs				4							2.6								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				3							2.4								1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				1															1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				5							1.6								1:0/0
Ra				1															1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				1															1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				4							1.7								1:0/0
Zr				1															1:0/0

Table 7-9. Selected data properties, references and comments for the parameter cR_Lake_zoopl_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	Nd	cR_Sea_zoopl_NHB	1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	Marine zooplankton used as PA. Nd used as EA.
Ag			1	1.2E+00	1.7E+01	1.7E+01	2.4E+02	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Am	Nd	cR_Sea_zoopl_NHB	1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	Marine zooplankton used as PA. Nd used as EA.
Ba		cR_Sea_zoopl_NHB	1	5.1E–02	7.2E–01	7.2E–01	1.0E+01	5.0	GSDmax	Site data FM	FM	Marine zooplankton used as PA. Site data available.
Ca		cR_Sea_zoopl_NHB	1	2.0E–02	2.8E–01	2.8E–01	3.9E+00	5.0	GSDmax	Site data FM	FM	Marine zooplankton used as PA. Site data available.
Cd		cR_Sea_zoopl_NHB	1	4.1E+00	5.8E+01	5.8E+01	8.2E+02	5.0	GSDmax	Site data FM	FM	ERICA utilised phytoplankton data. Value for marine zooplankton selected (site data available).
Cl		cR_Lake_Fish_NHB	6	1.7E–03	2.4E–02	2.3E–02	3.3E–01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised phytoplankton data. Limnic fish best analogue available (site data available).
Cm	Nd	cR_Sea_zoopl_NHB	1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	ERICA utilised phytoplankton data. Marine zooplankton selected as PA. Site data for Cm missing. Nd used as EA.
Co			1	5.0E–02	7.0E–01	7.0E–01	9.9E+00	5.0	GSDmax	ERICA	L1	Site data for marine zooplankton available but not used (see comment for cR_Sea_zoopl_NHB). ERICA data selected. No range presented. GSDmax assigned.
Cs			4	1.6E–01	9.9E–01	9.9E–01	6.0E+00	3.0	GSDmean	ERICA	L1	
Eu		cR_Sea_zoopl_NHB	1	4.6E–01	6.5E+00	6.5E+00	9.1E+01	5.0	GSDmax	Site data FM	FM	ERICA used AE (Ce). Value for marine zooplankton used (site data available).
Ho		cR_Sea_zoopl_NHB	1	4.0E–01	5.6E+00	5.6E+00	7.9E+01	5.0	GSDmax	Site data FM	FM	Value for marine zooplankton used (site data available).
I			3	6.3E–02	8.8E–01	8.8E–01	1.2E+01	5.0	GSDmax	ERICA	L1	
Mo		cR_Sea_zoopl_NHB	1	2.7E–02	3.8E–01	3.8E–01	5.4E+00	5.0	GSDmax	Site data FM	FM	Value for marine zooplankton used (site data available).
Nb		cR_Lake_Fish_NHB	6	6.2E–04	8.8E–03	1.0E–02	1.2E–01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised phytoplankton data. Limnic fish best analogue available (site data available).
Ni		cR_Sea_zoopl_NHB	1	2.1E–01	3.0E+00	3.0E+00	4.2E+01	5.0	GSDmax	Site data FM	FM	ERICA utilised phytoplankton data. Value for marine zooplankton selected (site data available).
Np	Nd	cR_Sea_zoopl_NHB	1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	Marine zooplankton used as PA. Nd used as EA.
Pa	Nd	cR_Sea_zoopl_NHB	1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	Marine zooplankton used as PA. Nd used as EA.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pb			1	1.8E+00	2.6E+01	2.6E+01	3.7E+02	5.0	GSDmax	ERICA	L1	
Pd	Ni	cR_Sea_zoopl_NHB	1	2.1E–01	3.0E+00	3.0E+00	4.2E+01	5.0	GSDmax	Site data FM	FM	Ni used as EA. Value for marine zooplankton used (site data available).
Po		cR_Lake_pp_plank_NHB	7	1.1E+00	2.6E+01	2.6E+01	6.5E+02	7.0	GSDmax	ERICA	L1	ERICA utilised phytoplankton data.
Pu			5	6.6E–02	4.0E–01	4.0E–01	2.5E+00	3.0	GSDmean	ERICA	L1	
Ra		cR_Lake_Fish_NHB	46	2.4E–03	3.4E–02	3.4E–02	5.6E–01	5.0	GSDmax	ICRP 2011	L1	ERICA utilised phytoplankton data. In order to be consequent fish data (ICRP 2011) is used as PA.
Se		cR_Sea_zoopl_NHB	1	1.9E+00	2.6E+01	2.6E+01	3.7E+02	5.0	GSDmax	Site data FM	FM	ERICA presented one value without range. Value for marine zooplankton used (site data available).
Sm		cR_Sea_zoopl_NHB	1	1.4E+00	2.0E+01	2.0E+01	2.8E+02	5.0	GSDmax	Site data FM	FM	Value for marine zooplankton used (site data available).
Sn	Zr	cR_Lake_Fish_NHB	4	1.7E–03	2.4E–02	6.3E–02	3.4E–01	5.0	GSDmax	Site data FMLX	FMLX	Limnic fish best available analogue. Zr used as EA.
Sr	Ca	cR_Sea_zoopl_NHB	1	2.0E–02	2.8E–01	2.8E–01	3.9E+00	5.0	GSDmax	Site data FM	FM	ERICA presented one value without range. Marine zooplankton used as PA. Ca used as EA. No range presented. GSDmax assigned.
Tc			1	1.4E–03	2.0E–02	2.0E–02	2.8E–01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th		cR_Sea_zoopl_NHB	4	2.0E–02	4.9E+00	4.9E+00	6.9E+01	5.0	GSDmax	ERICA	L1	Site data for marine zooplankton available but not used (see comment for cR_Sea_zoopl_NHB). ERICA data selected. No range presented. GSDmax assigned.
U			4	6.9E–03	4.2E–02	4.2E–02	2.6E–01	3.0	GSDmean	ERICA	L1	
Zr		cR_Sea_zoopl_NHB	1	1.5E+00	2.0E+01	2.0E+01	2.9E+02	5.0	GSDmax	Site data FM	FM	ERICA utilised phytoplankton data. Value for marine zooplankton selected (site data available).

7.5 cR_Lake_gastr_NHB

This parameter describes the element uptake in limnic gastropods for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are available for Am, Cm, Cs, Po, Pu, Ra, Tc, Th and U in ERICA (Hosseini et al. 2008), which in most cases only presented 1 value without range. For other elements, the values in ERICA (Hosseini et al. 2008) are the same as for bivalve molluscs (in the case of Cl the same as for crustaceans), see Table 7-10 and Figure 7-8. Site data are available for a number of elements in limnic mussels (20 elements, see parameter cR_Lake_bivalve_NHB) and these are utilised as PA. Data are missing for Ac, Pa, Pd and Sn, and a combination of PA and EAs are selected (mussel data for La, Zr, Ni and Zr, respectively, see Section 7.7). Site data for La in mussels are utilised as a combination of EA and PAs for Am, Cm and Np.

For the elements where site data for limnic mussels are not available (Po, Pu, Ra and Tc) data for limnic gastropods in ERICA (Hosseini et al. 2008) are utilised. Ranges are not available for Tc and Pu, and GSDmax (5) is assigned to these parameters. GSDmax is also assigned to elements where a PA is utilised, in accordance with the statements in Section 4.3.

The selected CR values are presented in Table 7-11 and Figure 7-9.

Table 7-10. All available data for the parameter cR_Lake_gastr_NHB for the elements of primary concern and selected EAs. L1 = ERICA (Hosseini et al. 2008) Freshwater, Gastropod. See Table 7-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				4							1.2								1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				1															1:0/0
Cl				1															1:0/0
Cm				1															1:0/0
Co				2							1.6								1:0/0
Cs				6							2.5								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				1															1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				1															1:0/0
Pd																			0:0/0
Po				2							2.6								1:0/0
Pu				1															1:0/0
Ra				2							2.3								1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				1															1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

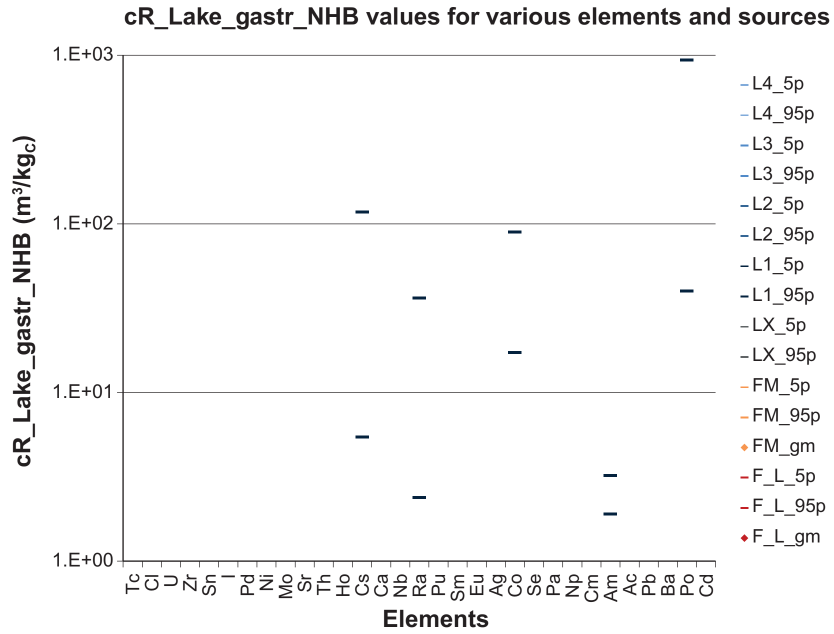

Figure 7-8. *Total available data ranges for the parameter cR_Lake_gastr_NHB (m^3/kg_C). The elements are arranged in the same order as in Figure 7-9 showing selected parameter values.*

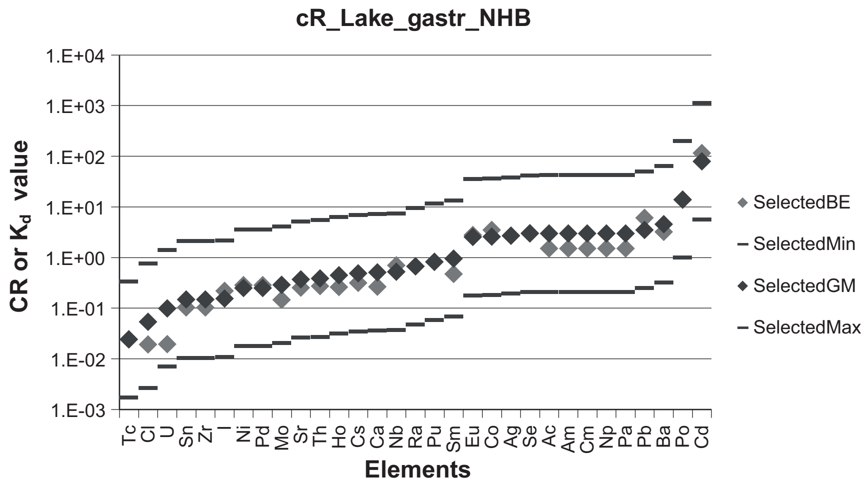

Figure 7-9. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

Table 7-11. Selected data properties, references and comments for the parameter cR_Lake_gastr_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA.
Ag		cR_Lake_bivalve_NHB	2	1.9E–01	2.7E+00	2.7E+00	3.8E+01	5.0	GSDmax	Site data LX	LX	Mussels utilised as PA as is often the case in ERICA. LX data available.
Am	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA.
Ba		cR_Lake_bivalve_NHB	6	3.2E–01	4.5E+00	3.2E+00	6.4E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Ca		cR_Lake_bivalve_NHB	6	3.6E–02	5.1E–01	2.6E–01	7.2E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cd		cR_Lake_bivalve_NHB	6	5.6E+00	7.9E+01	1.2E+02	1.1E+03	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cl		cR_Lake_bivalve_NHB	6	2.7E–03	5.4E–02	1.9E–02	7.6E–01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cm	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA.
Co		cR_Lake_bivalve_NHB	6	1.8E–01	2.6E+00	3.5E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cs		cR_Lake_bivalve_NHB	6	3.4E–02	4.8E–01	3.1E–01	6.8E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Eu		cR_Lake_bivalve_NHB	6	1.8E–01	2.5E+00	2.8E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Ho		cR_Lake_bivalve_NHB	6	3.1E–02	4.4E–01	2.6E–01	6.3E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
I		cR_Lake_bivalve_NHB	6	1.1E–02	1.5E–01	2.2E–01	2.2E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Mo		cR_Lake_bivalve_NHB	6	2.0E–02	2.9E–01	1.5E–01	4.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Nb		cR_Lake_bivalve_NHB	6	3.7E–02	5.2E–01	7.0E–01	7.4E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Ni		cR_Lake_bivalve_NHB	6	1.8E–02	2.5E–01	2.8E–01	3.5E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Np	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA.
Pa	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pb		cR_Lake_bivalve_NHB	6	2.5E–01	3.5E+00	6.1E+00	4.9E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Pd	Ni	cR_Lake_bivalve_NHB	6	1.8E–02	2.5E–01	2.8E–01	3.5E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA.
Po			2	9.8E–01	1.4E+01	1.4E+01	2.0E+02	5.0	GSDmax	ERICA	L1	
Pu			1	5.8E–02	8.2E–01	8.2E–01	1.2E+01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Ra			2	4.7E–02	6.7E–01	6.7E–01	9.4E+00	5.0	GSDmax	ERICA	L1	
Se		cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	3.0E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Sm		cR_Lake_bivalve_NHB	6	6.7E–02	9.5E–01	4.7E–01	1.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Sn	Zr	cR_Lake_bivalve_NHB	6	1.0E–02	1.5E–01	1.0E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Zr used as EA.
Sr		cR_Lake_bivalve_NHB	6	2.6E–02	3.7E–01	2.5E–01	5.2E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Tc			1	1.7E–03	2.4E–02	2.4E–02	3.4E–01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th		cR_Lake_bivalve_NHB	6	2.7E–02	3.9E–01	2.7E–01	5.4E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
U		cR_Lake_bivalve_NHB	6	7.0E–03	9.9E–02	1.9E–02	1.4E+00	5.6	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Zr		cR_Lake_bivalve_NHB	6	1.0E–02	1.5E–01	1.0E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.

7.6 cR_Lake_ins_larvae_NHB

cR_Lake_ins_larvae_NHB describes the element uptake in limnic insect larvae for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are available in ERICA (Hosseini et al. 2008), where 1 value without range is presented in most cases, see Table 7-12 and Figure 7-10. Commonly, the presented values are the same as for limnic crustaceans and in the remaining cases, the same as marine crustaceans. Site data for limnic crustaceans are not available and site data for limnic mussels are utilised as PA for this organism type. Data for crustaceans are utilised as PA for insect larvae in ERICA (Hosseini et al. 2008), hence site data for crustaceans (mussels) are assumed valid PAs for this organism. Another option is to utilise ERICA data for crustaceans and estimate a range. Since the FM lakes are quite unusual (calcareous clear-water lakes) it is considered better to prioritise site data. Data are missing for Ac, Pa, Pd and Sn, and a combination of PA and EAs are utilised in these cases (mussel data for La, Zr, Ni and Zr respectively, see Section 2.7). Site data for La in mussels are utilised as a combination of EA and PAs for Am, Cm and Np.

For elements where site data for limnic mussels are not available (Po, Pu, Ra and Tc), data for insect larvae in ERICA (Hosseini et al. 2008) are selected. ERICA (Hosseini et al. 2008) utilised the same values as for crustaceanss for Tc and Pu, and Am as EA for Np.

Ranges are not presented for Tc and Pu, and GSDmax (5) is assigned to these parameters. GSDmax is also assigned to elements where a PA is utilised, in accordance with the statements in Section 4.3.

The selected CR values are presented in Table 7-13 and Figure 7-11.

Table 7-12. All available data for the parameter cR_Lake_ins_larvae_NHB for the elements of primary concern and selected EAs. L1 = ERICA (Hosseini et al. 2008) Freshwater, Insect larvae. See Table 7-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				1															1:0/0
Cl				1															1:0/0
Cm				12							2.8								1:0/0
Co				1															1:0/0
Cs				1															1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				2															1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				1															1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				1															1:0/0
Ra				1															1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				1															1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

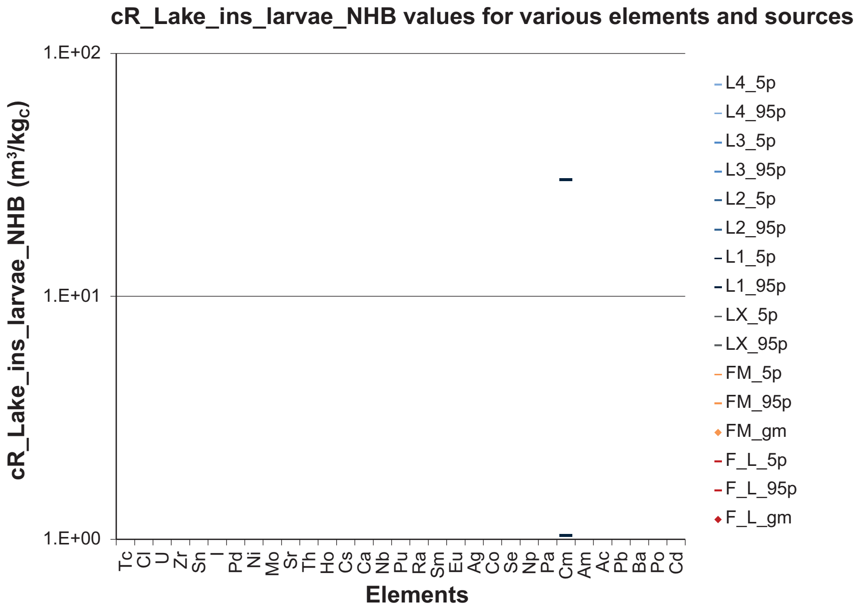

Figure 7-10. *Total available data ranges for the parameter cR_Lake_ins_larvae_NHB (m^3/kg_C). The elements are arranged in the same order as in Figure 7-11 showing selected parameter values.*

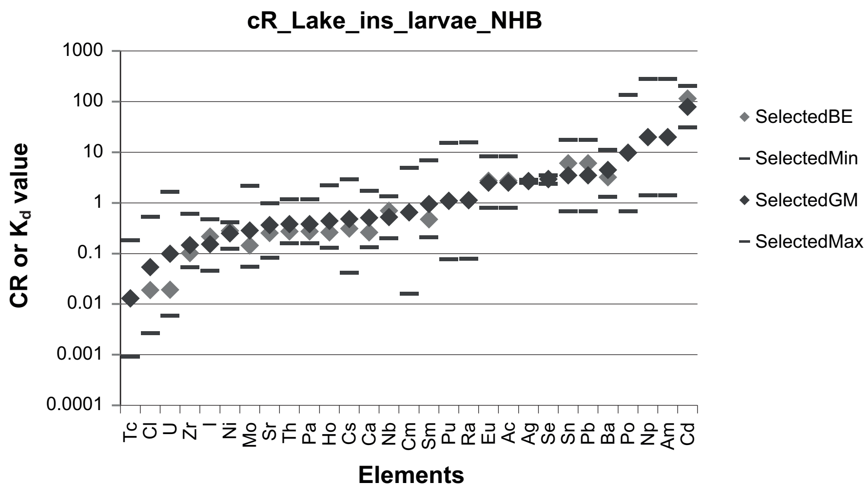

Figure 7-11. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

Table 7-13. Selected data properties, references and comments for the parameter cR_Lake_ins_larvae_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. La used as EA (site data available).
Ag		cR_Lake_bivalve_NHB	2	1.9E–01	2.7E+00	2.7E+00	3.8E+01	5.0	GSDmax	Site data LX	LX	Mussels utilised as PA. LX data available.
Am	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. La used as EA (site data available).
Ba		cR_Lake_bivalve_NHB	6	3.2E–01	4.5E+00	3.2E+00	6.4E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Ca		cR_Lake_bivalve_NHB	6	3.6E–02	5.1E–01	2.6E–01	7.2E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Cd		cR_Lake_bivalve_NHB	6	5.6E+00	7.9E+01	1.2E+02	1.1E+03	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Cl		cR_Lake_bivalve_NHB	6	2.7E–03	5.4E–02	1.9E–02	7.6E–01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Cm	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. La used as EA (site data available).
Co		cR_Lake_bivalve_NHB	6	1.8E–01	2.6E+00	3.5E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Cs		cR_Lake_bivalve_NHB	6	3.4E–02	4.8E–01	3.1E–01	6.8E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Eu		cR_Lake_bivalve_NHB	6	1.8E–01	2.5E+00	2.8E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Ho		cR_Lake_bivalve_NHB	6	3.1E–02	4.4E–01	2.6E–01	6.3E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
I		cR_Lake_bivalve_NHB	6	1.1E–02	1.5E–01	2.2E–01	2.2E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Mo		cR_Lake_bivalve_NHB	6	2.0E–02	2.9E–01	1.5E–01	4.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Nb		cR_Lake_bivalve_NHB	6	3.7E–02	5.2E–01	7.0E–01	7.4E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Ni		cR_Lake_bivalve_NHB	6	1.8E–02	2.5E–01	2.8E–01	3.5E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Np	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. La used as EA (site data available).
Pa	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. La used as EA (site data available).
Pb		cR_Lake_bivalve_NHB	6	2.5E–01	3.5E+00	6.1E+00	4.9E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Pd	Ni	cR_Lake_bivalve_NHB	6	1.8E–02	2.5E–01	2.8E–01	3.5E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Ni used as EA (site data available).
Po		cR_Lake_crust_NHB	2	6.9E–01	9.8E+00	9.8E+00	1.4E+02	5.0	GSDmax	ERICA	L1	ERICA used crustacean data.
Pu		cR_Lake_crust_NHB	3	7.3E–02	1.0E+00	1.0E+00	1.4E+01	5.0	GSDmax	ERICA	L1	ERICA used crustacean data.
Ra		cR_Lake_crust_NHB	5	8.0E–02	1.1E+00	1.1E+00	1.6E+01	5.0	GSDmax	ERICA	L1	ERICA used crustacean data.
Se		cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	3.0E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Sm		cR_Lake_bivalve_NHB	6	6.7E–02	9.5E–01	4.7E–01	1.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Sn	Zr	cR_Lake_bivalve_NHB	6	1.0E–02	1.5E–01	1.0E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Zr used as EA (site data available).
Sr		cR_Lake_bivalve_NHB	6	2.6E–02	3.7E–01	2.5E–01	5.2E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Tc			1	9.2E–04	1.3E–02	1.3E–02	1.8E–01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th		cR_Lake_bivalve_NHB	6	2.7E–02	3.9E–01	2.7E–01	5.4E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
U		cR_Lake_bivalve_NHB	6	7.0E–03	9.9E–02	1.9E–02	1.4E+00	5.6	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.
Zr		cR_Lake_bivalve_NHB	6	1.0E–02	1.5E–01	1.0E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA. Site data available.

7.7 cR_Lake_bivalve_NHB

This parameter describes the element uptake in limnic bivalves for use in dose estimates to this organism type. Site data are available for 20 elements: Ag, Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sr, Th, U and Zr (water data from Engdahl et al. (2008), see Section 7, and mussel data (2 samples each from FM and LX) from Hannu and Karlsson (2006) and Engdahl et al. (2006), respectively). LX site data are available for Ag alone. Literature data are available for Ag, Am, Cd, Cl, Cm, Cs, Eu, I, Nb, Ni, Np, Pb, Po, Pu, Ra, Se, Sr, Tc, Th, U and Zr for freshwater bivalve molluscs in ERICA (Hosseini et al. 2008) (categorised as L1 data) and for Ag, Am, Ba, Ca, Cd, Cl, Cm, Cs, Eu, I, Mo, Np, Pu, Pb, Ra, Se, Sm, Sr, Tc and U for invertebrates in IAEA (2010) (categorised as L2 data), see Table 7-14 and Figure 7-12. Literature data are the only data source for 7 elements: Am, Cm, Np, Po, Pu, Ra and Tc. Data are missing for Ac, Pa, Pd and Sn.

As discussed in Section 8.6 (Marine bentic moluscs) the shells of bivalves are rather thick and accumulate mass and radionuclides over time. The site data on limnic mussels are only sampled on muscle tissue and the selected literature data (see below) do not always state which tissue have been utilised for the reported CR, and when stated, it is soft tissues or muscle. Therefore, these CR may not represent the whole organisms, especially in the case of elements tending to accumulate in shell.

For Ag, site data are only available from LX (n=1). Literature data (L1 and L2), based on few observations, are available as well. None of the sources overlap. The value from LX is in between the literature values and deviates 10 times from both. LX data are used.

A comparison of FM data and LX data indicate consistency for all elements except for Ba, Ca, Cd, Cl and U. LX data are higher than FM data for Ba, Ca, Cl and U, while data for Cd are lower in LX.

Literature data in IAEA (2010) are compared to ERICA data (Hosseini et al. 2008) and data correlates well in all cases where a comparison is possible, i.e. for Am, Ra, I, Cs and Sr (GM and GSD are reported in both sources).

Site data are sense checked with literature data and major discrepancies are found for Ca, Cd, Mo, Nb and Pb. FM and LX data are higher than the reported literature range for all of these elements. Site data are consistent with the literature data range for Cs, I, Se, Sr and U.

The reported GSD in FM and LX data are low in many cases, while the GSD in IAEA (2010), are high for many elements (75 for Cs). The reason for the high GSD is unknown.

For elements where site data are available, these data are selected. Site data are missing for 10 elements: Ac, Am, Cm, Np, Pa, Pd, Po, Pu, Ra, Sn and Tc, and in those cases EAs with available site data are prioritised, while literature data are selected last. La is utilised as EA for Ac, Am, Cm and Pa. Zr is selected as EA for Sn and Ni is used for Pd (see Section 2.7). Ba site data are utilised as EA for Ra.

For Pu, data in ERICA (Hosseini et al. 2008) are within the large range of IAEA (2010) data. ERICA (Hosseini et al. 2008) is ranked higher of the 2 sources as it is considered to better represent non-human biota. For Cm and Np, both references are based on few observations (ERICA n=1, IAEA n=2). Data from ERICA (Hosseini et al. 2008) is utilised for Cm, whereas data from IAEA (2010) are selected for Np, since ERICA (Hosseini et al. 2008) utilised an EA in that element case. For Tc, IAEA (2010) reported a higher number of observations and were therfore selected (IAEA n=10, ERICA n=1).

GSDmax (5) is assigned to 8 elements, due to the low number of observations. GSDmean (3) is assigned to 18 elements according to the conditions stated in Section 4.3.

The selected CR values are presented in Table 7-15 and Figure 7-13.

Table 7-14. All available data for the parameter cR_Lake_bivalve_NHB for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ERICA (Hosseini et al. 2008) Freshwater, Bivalve mollusc, L2 = IAEA 2010 Freshwater, Invertebrate. See Table 7-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag		2/3	2/3	1	2				1.0	1.0									2:0/0
Am				3	17						2.4	7.0							2:1/1
Ba	3/3	3/3	6/6		2			1.8	1.3	1.7								S2 (L40%)	1:0/0
Ca	3/3	3/3	6/6		3			1.6	1.2	2.1		2.5			S4	S4	S4	S4	1:0/0
Cd	3/3	3/3	6/6	1	149			1.6	1.4	1.8		39.0			S4	S4	S4	S2 (U32%)	2:0/0
Cl	3/3	3/3	6/6	1	2			3.7	1.1	4.0								S2 (L9%)	2:0/0
Cm				1	2														2:0/0
Co	3/3	3/3	6/6	2	29			1.3	3.6	2.6	1.8	130.0			S1	S1	S1	S1	2:1/1
Cs	3/3	3/3	6/6	14	29			4.1	1.4	3.0	2.7	75.0			S1	S1	S1	S3	2:1/1
Eu	3/3	3/3	6/6	2	2			1.7	2.3	2.0								S1	2:0/0
Ho	3/3	3/3	6/6					1.2	2.0	2.1								S2 (L90%)	0:0/0
I	3/3	3/3	6/6	8	99			1.2	2.3	2.0	1.9	11.0			S1	S1	S1	S1	2:1/1
La	3/3	3/3	6/6		2			1.2	2.0	2.4								S2 (L40%)	1:0/0
Mo	3/3	3/3	6/6		33			1.6	2.6	2.7		13.0			S4	S4	S4	S2 (L70%)	1:0/0
Nb	3/3	3/3	6/6	2				1.1	2.0	1.8	1.3				S4	S3	S2 (U45%)	S1	1:0/0
Ni	3/3	3/3	6/6	1				1.2	1.5	1.4								S2 (U93%)	1:0/0
Np				1	2														2:0/0
Pa																			0:0/0
Pb	3/3	3/3	6/6	1	79			1.5	3.1	2.7		20.0			S4	S2 (U46%)	S2 (U27%)	S2 (U96%)	2:0/0
Pd																			0:0/0
Po				2							2.7								1:0/0
Pu				1	100							29.0							2:0/0
Ra				2	5						2.4	30.0							2:1/1
Se	3/3	3/3	6/6	1	16			1.1	1.1	1.1		15.0			S1	S1	S1	S2 (U85%)	2:0/0
Sm	3/3	3/3	6/6		2			1.1	2.3	2.5								S2 (L71%)	1:0/0
Sn																			0:0/0
Sr	3/3	3/3	6/6	6	5			1.9	1.3	1.8	1.4	3.2			S1	S1	S1	S3	2:1/1
Tc				1	10							9.9							2:0/0
Th	3/3	3/3	6/6	1	2			1.4	1.6	1.7								S2 (L63%)	2:0/0
U	3/3	3/3	6/6	1	9			1.6	1.3	5.6		19.0			S1	S1	S1	S4	2:0/0
Zr	3/3	3/3	6/6	2				1.3	1.9	1.8								S1	1:0/0

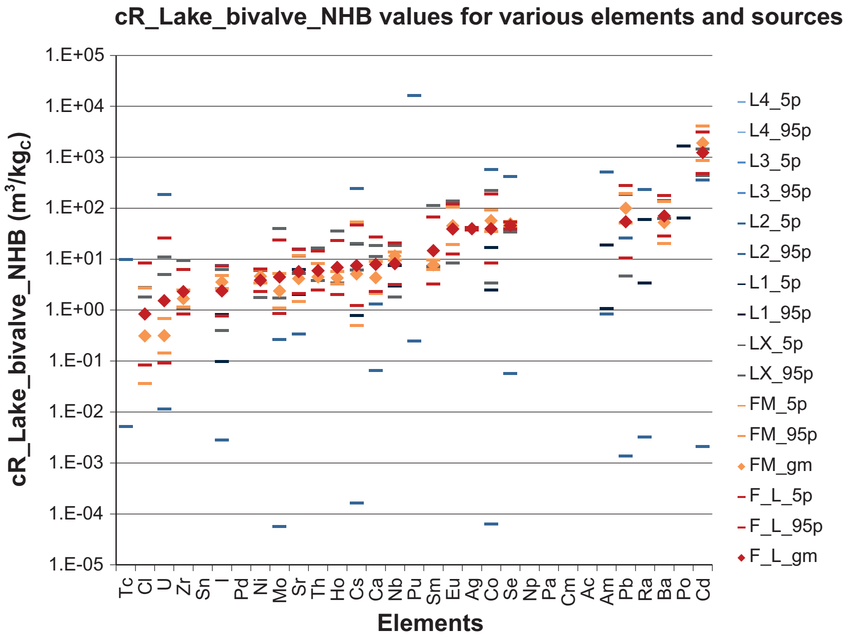

Figure 7-12. *Total available data ranges for the parameter cR_Lake_bivalve_NHB (m^3/kg_C). The elements are arranged in the same order as in Figure 7-13 showing selected parameter values.*

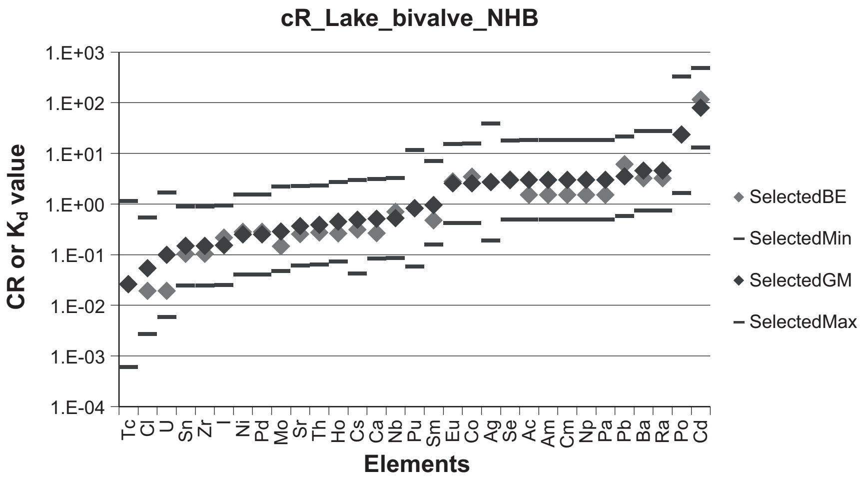

Figure 7-13. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

Table 7-15. Selected data properties, references and comments for the parameter cR_Lake_bivalve_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La		6	4.9E–01	3.0E+00	1.5E+00	1.8E+01	3.0	GSDmean	Site data FMLX	FMLX	La used as EA (site data available).
Ag			2	1.9E–01	2.7E+00	2.7E+00	3.8E+01	5.0	GSDmax	Site data LX	LX	Lx data do not overlap with literature and is 10 times higher. LX data chosen (conservative approach, higher CR means higher org. conc.).
Am	La		6	4.9E–01	3.0E+00	1.5E+00	1.8E+01	3.0	GSDmean	Site data FMLX	FMLX	La used as EA (site data available).
Ba			6	7.4E–01	4.5E+00	3.2E+00	2.8E+01	3.0	GSDmean	Site data FMLX	FMLX	Value and small range in IAEA 2010 lower than FM and LX data. The latter two agrees fairly well. FM data used.
Ca			6	8.4E–02	5.1E–01	2.6E–01	3.1E+00	3.0	GSDmean	Site data FMLX	FMLX	FM and LX data do not overlap, though FM within range of literature data (IAEA 2010). FM data used for BE and FMLX for GM and GSD. The latter is higher than litterature data.
Cd			6	1.3E+01	7.9E+01	1.2E+02	4.8E+02	3.0	GSDmean	Site data FMLX	FMLX	Value in IAEA 2010 lower than FM and LX data. The latter two agrees fairly well. FM data used.
Cl			6	2.7E–03	5.4E–02	1.9E–02	5.4E–01	4.0	GSD	Site data FMLX	FMLX	Small ranges for FM, LX and IAEA, data agrees fairly well. FM data used.
Cm	La		6	4.9E–01	3.0E+00	1.5E+00	1.8E+01	3.0	GSDmean	Site data FMLX	FMLX	La used as EA (site data available).
Co			6	4.2E–01	2.6E+00	3.5E+00	1.6E+01	3.0	GSDmean	Site data FMLX	FMLX	
Cs			6	4.2E–02	4.8E–01	3.1E–01	3.0E+00	3.0	GSD	Site data FMLX	FMLX	
Eu			6	4.2E–01	2.5E+00	2.8E+00	1.5E+01	3.0	GSDmean	Site data FMLX	FMLX	
Ho			6	7.3E–02	4.4E–01	2.6E–01	2.7E+00	3.0	GSDmean	Site data FMLX	FMLX	
I			6	2.5E–02	1.5E–01	2.2E–01	9.3E–01	3.0	GSDmean	Site data FMLX	FMLX	
Mo			6	4.7E–02	2.9E–01	1.5E–01	2.2E+00	3.0	GSDmean	Site data FMLX	FMLX	Literature data much lower. Site data (FMLX) used.
Nb			6	8.6E–02	5.2E–01	7.0E–01	3.2E+00	3.0	GSDmean	Site data FMLX	FMLX	FM and LX data have a somewhat larger range than literature,which is expected since it is based on larger number of observations.
Ni			6	4.1E–02	2.5E–01	2.8E–01	1.5E+00	3.0	GSDmean	Site data FMLX	FMLX	
Np	La		6	4.9E–01	3.0E+00	1.5E+00	1.8E+01	3.0	GSDmean	Site data FMLX	FMLX	La used as EA (site data available).
Pa	La		6	4.9E–01	3.0E+00	1.5E+00	1.8E+01	3.0	GSDmean	Site data FMLX	FMLX	La used as EA (site data available).
Pb			6	5.7E–01	3.5E+00	6.1E+00	2.1E+01	3.0	GSDmean	Site data FMLX	FMLX	Site data agrees with ERICA, though higher than IAEA 2010. Site data used.
Pd	Ni		6	4.1E–02	2.5E–01	2.8E–01	1.5E+00	3.0	GSDmean	Site data FMLX	FMLX	Ni used as EA (site data available).
Po			2	1.6E+00	2.3E+01	2.3E+01	3.3E+02	5.0	GSDmax	ERICA	L1	
Pu			1	5.8E–02	8.2E–01	8.2E–01	1.2E+01	5.0	GSDmax	ERICA	L1	ERICA data within the large range of IAEA 2010. The former is higher ranked (best representativity). GSDmax assigned.
Ra	Ba		6	7.4E–01	4.5E+00	3.2E+00	2.8E+01	3.0	GSDmean	Site data FMLX	FMLX	Ba used as EA (site data available).
Se			6	4.9E–01	3.0E+00	3.0E+00	1.8E+01	3.0	GSDmean	Site data FMLX	FMLX	
Sm			6	1.6E–01	9.5E–01	4.7E–01	7.0E+00	3.0	GSDmean	Site data FMLX	FMLX	
Sn	Zr		6	2.4E–02	1.5E–01	1.0E–01	9.0E–01	3.0	GSDmean	Site data FMLX	FMLX	Zr used as EA (site data available).
Sr			6	6.0E–02	3.7E–01	2.5E–01	2.2E+00	3.0	GSDmean	Site data FMLX	FMLX	
Tc			10	6.0E–04	2.6E–02	2.6E–02	1.1E+00	9.9	GSD	IAEA 2010	L2	GM for both references in agreement. IAEA 2010 selected due to larger N.
Th			6	6.3E–02	3.9E–01	2.7E–01	2.3E+00	3.0	GSDmean	Site data FMLX	FMLX	
U			6	5.8E–03	9.9E–02	1.9E–02	1.7E+00	5.6	GSD	Site data FMLX	FMLX	Data for FM (n=3) and LX (n=3) do not overlap, large GSD (>GSDmax). No obviuos errors found.
Zr			6	2.4E–02	1.5E–01	1.0E–01	9.0E–01	3.0	GSDmean	Site data FMLX	FMLX	

7.8 cR_Lake_crust_NHB, cR_Lake_Cray

The parameter cR_Lake_crust_NHB describes the element uptake in limnic crustaceans for use in dose estimates to this organism type. The parameter is also utilised as PA for limnic crayfish (parameter name cR_Lake_Cray) in the part of the radionuclide model used for dose assessments to humans. Site data are not available for this organism. Literature data are available for crustaceans in ERICA (Hosseini et al. 2008) and for invertebrates in IAEA (2010), see Table 7-16 and Figure 7-14. Sense checks of literature data are possible for 6 elements; Am, Cs, I, Pu, Ra and Sr, which correlate well.

Freshwater filter feeder data are recommended as PAs for crayfish (Tröjbom and Nordén 2010) and were also used as crayfish analogues in the previous safety assessment by SKB (Nordén et al. 2010). Available limnic filter feeder data (cR_Lake_bivalve_NHB) are presented in Section 7.7. This PA is often utilised in ERICA (Hosseini et al. 2008) when data are missing for this parameter. The filter feeder data are utilised as GMs for cR_Lake_Cray and cR_Lake_crust_NHB in cases when site data or suitable EA site data are available. In these cases, data are considered uncertain and GSDmax values are assigned.

Site data are not available for the elements Po, Pu, Ra and Tc, and ERICA data (Hosseini et al. 2008) (categorised as L1 data) are selected. IAEA (2010) data (categorised as L2 data) are available though not utilised. The range presented for Pu in ERICA (Hosseini et al. 2008) is considered too narrow and is replaced by a more reasonable GSD, according to Section 4.3 (GSDmax). For Tc, the ERICA value (Hosseini et al. 2008) is within the wide range of IAEA (2010). Site and literature data are missing for Ac, Pa, Pd, and Sn. Site data for La in mussels are utilised for Ac and Pa, while site data for Ni and Zr in mussels are used for Pd and Sn, respectively (combined EA and PAs), see Section 2.7. Combined EAs and PAs are also selected for Am, Cm and Np, for which site data for La in mussels are utilised. In these cases, a GSDmax is assigned.

The selected CR values are presented in Table 7-17 (unit m^3/kg_{fw}), Table 7-18 (m^3/kg_C) and Figure 7-15.

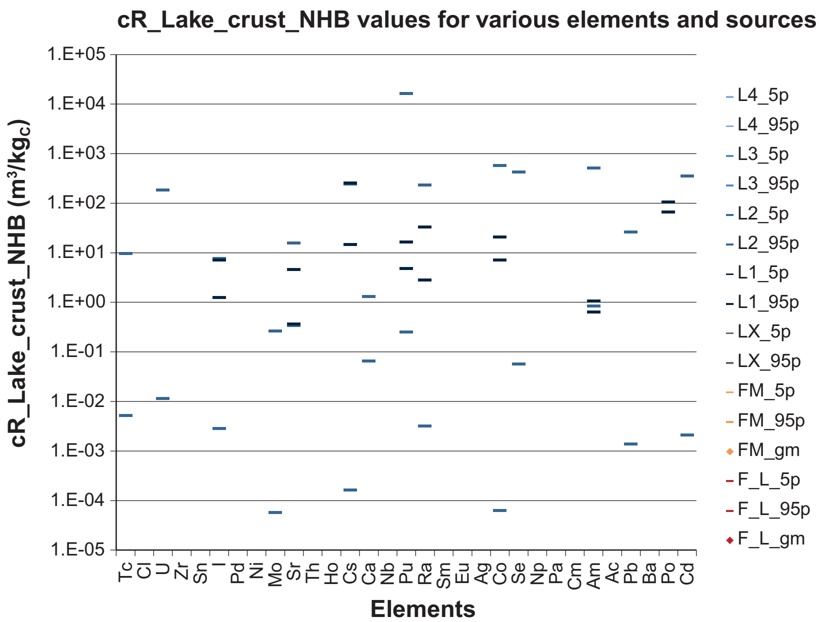

Figure 7-14. *Ttotal available data ranges for the parameters cR_Lake_crust_NHB and cR_Lake_Cray (m^3/kg_C). The elements are arranged in the same order as in Figure 7-15 showing selected parameter values.*

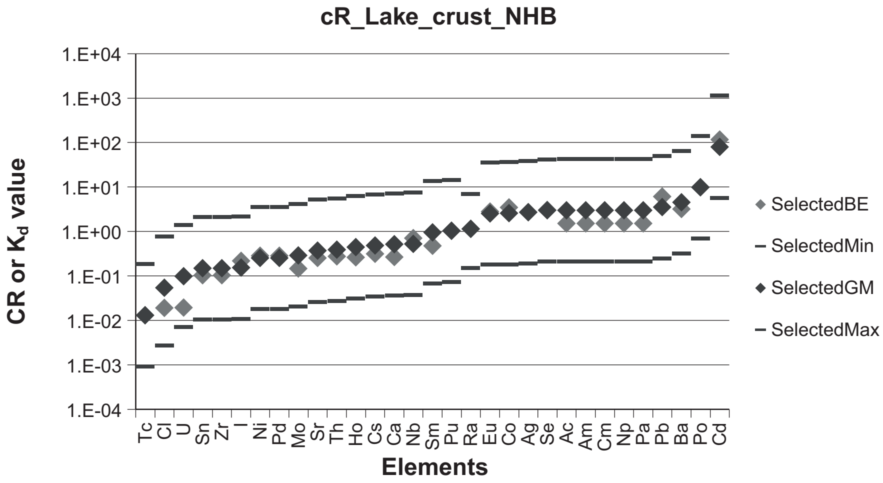

Figure 7-15. *Selected parameter values for cR_Lake_crust_NHB and cR_Lake_Cray (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

Table 7-16. All available data for the parameters cR_Lake_crust_NHB and cR_Lake_Cray for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also inlcuded. L1 = ERICA (Hosseini et al. 2008) Freshwater, Crustacean, L2 = IAEA 2010 Freshwater, Invertebrate. See Table 7-1 for description of headings.

Ele-ment	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				1	2														2:0/0
Am				4	17						1.2	7.0							2:1/1
Ba					2														1:0/0
Ca					3							2.5							1:0/0
Cd				1	149							39.0							2:0/0
Cl				2	2														2:0/0
Cm				1	2														2:0/0
Co				3	29						1.4	130.0							2:1/1
Cs				7	29						2.4	75.0							2:1/1
Eu				1	2														2:0/0
Ho																			0:0/0
I				3	99						1.7	11.0							2:1/1
Mo					33							13.0							1:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1	2														2:0/0
Pa																			0:0/0
Pb				1	79							20.0							2:0/0
Pd																			0:0/0
Po				2							1.2								1:0/0
Pu				3	100						1.5	29.0							2:1/1
Ra				5	5						2.1	30.0							2:1/1
Se				1	16							15.0							2:0/0
Sm					2														1:0/0
Sn																			0:0/0
Sr				3	5						2.2	3.2							2:1/1
Tc				1	10							9.9							2:0/0
Th				1	2														2:0/0
U				2	9							19.0							2:0/0
Zr				2															1:0/0

Table 7-17. Selected data properties, references and comments for the parameter cR_Lake_crust_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).
Ag		cR_Lake_bivalve_NHB	2	1.9E–01	2.7E+00	2.7E+00	3.8E+01	5.0	GSDmax	Site data LX	LX	Data for bivalves have been used as is often the case in ERICA. LX data available.
Am	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).
Ba		cR_Lake_bivalve_NHB	6	3.2E–01	4.5E+00	3.2E+00	6.4E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Ca		cR_Lake_bivalve_NHB	6	3.6E–02	5.1E–01	2.6E–01	7.2E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cd		cR_Lake_bivalve_NHB	6	5.6E+00	7.9E+01	1.2E+02	1.1E+03	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cl		cR_Lake_bivalve_NHB	6	2.7E–03	5.4E–02	1.9E–02	7.6E–01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cm	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).
Co		cR_Lake_bivalve_NHB	6	1.8E–01	2.6E+00	3.5E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cs		cR_Lake_bivalve_NHB	6	3.4E–02	4.8E–01	3.1E–01	6.8E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Eu		cR_Lake_bivalve_NHB	6	1.8E–01	2.5E+00	2.8E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Ho		cR_Lake_bivalve_NHB	6	3.1E–02	4.4E–01	2.6E–01	6.3E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
I		cR_Lake_bivalve_NHB	6	1.1E–02	1.5E–01	2.2E–01	2.2E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Mo		cR_Lake_bivalve_NHB	6	2.0E–02	2.9E–01	1.5E–01	4.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Nb		cR_Lake_bivalve_NHB	6	3.7E–02	5.2E–01	7.0E–01	7.4E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Ni		cR_Lake_bivalve_NHB	6	1.8E–02	2.5E–01	2.8E–01	3.5E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Np	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).
Pa	La	cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	1.5E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pb		cR_Lake_bivalve_NHB	6	2.5E–01	3.5E+00	6.1E+00	4.9E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Pd	Ni	cR_Lake_bivalve_NHB	6	1.8E–02	2.5E–01	2.8E–01	3.5E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Ni used as EA (site data available).
Po			2	6.9E–01	9.8E+00	9.8E+00	1.4E+02	5.0	GSDmax	ERICA	L1	
Pu			3	7.3E–02	1.0E+00	1.0E+00	1.4E+01	5.0	GSDmax	ERICA	L1	ERICA data within the large range of IAEA 2010. The former considered more relevant and utilised. The range too small, GSDmax assigned.
Ra			5	1.5E–01	1.1E+00	1.1E+00	6.9E+00	3.0	GSDmean	ERICA	L1	
Se		cR_Lake_bivalve_NHB	6	2.1E–01	3.0E+00	3.0E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Sm		cR_Lake_bivalve_NHB	6	6.7E–02	9.5E–01	4.7E–01	1.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Sn	Zr	cR_Lake_bivalve_NHB	6	1.0E–02	1.5E–01	1.0E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Zr used as EA (site data available).
Sr		cR_Lake_bivalve_NHB	6	2.6E–02	3.7E–01	2.5E–01	5.2E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Tc			1	9.2E–04	1.3E–02	1.3E–02	1.8E–01	5.0	GSDmax	ERICA	L1	The ERICA value is within the large range of IAEA 2010. No range in ERICA, GSDmax assigned.
Th		cR_Lake_bivalve_NHB	6	2.7E–02	3.9E–01	2.7E–01	5.4E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
U		cR_Lake_bivalve_NHB	6	7.0E–03	9.9E–02	1.9E–02	1.4E+00	5.6	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Zr		cR_Lake_bivalve_NHB	6	1.0E–02	1.5E–01	1.0E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.

Table 7-18. Selected data properties, references and comments for the parameter cR_Lake_Cray (m^3/kg_C) for the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La	cR_Lake_bivalve_NHB	6	3.3E+00	4.6E+01	2.5E+01	6.5E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).
Ag		cR_Lake_bivalve_NHB	2	2.8E+00	3.9E+01	3.9E+01	5.6E+02	5.0	GSDmax	Site data LX	LX	Data for bivalves have been used as is often the case in ERICA. LX data available.
Am	La	cR_Lake_bivalve_NHB	6	3.3E+00	4.6E+01	2.5E+01	6.5E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).
Ba		cR_Lake_bivalve_NHB	6	5.0E+00	7.0E+01	5.2E+01	9.9E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Ca		cR_Lake_bivalve_NHB	6	5.6E–01	7.9E+00	4.3E+00	1.1E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cd		cR_Lake_bivalve_NHB	6	8.7E+01	1.2E+03	1.9E+03	1.7E+04	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cl		cR_Lake_bivalve_NHB	6	4.4E–02	8.3E–01	3.1E–01	1.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cm	La	cR_Lake_bivalve_NHB	6	3.3E+00	4.6E+01	2.5E+01	6.5E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).
Co		cR_Lake_bivalve_NHB	6	2.8E+00	4.0E+01	5.7E+01	5.6E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Cs		cR_Lake_bivalve_NHB	6	5.3E–01	7.5E+00	5.1E+00	1.1E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Eu		cR_Lake_bivalve_NHB	6	2.8E+00	3.9E+01	4.5E+01	5.5E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Ho		cR_Lake_bivalve_NHB	6	4.9E–01	6.9E+00	4.3E+00	9.7E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
I		cR_Lake_bivalve_NHB	6	1.7E–01	2.4E+00	3.6E+00	3.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Mo		cR_Lake_bivalve_NHB	6	3.1E–01	4.4E+00	2.4E+00	6.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Nb		cR_Lake_bivalve_NHB	6	5.7E–01	8.1E+00	1.1E+01	1.1E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Ni		cR_Lake_bivalve_NHB	6	2.7E–01	3.9E+00	4.6E+00	5.5E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Np	La	cR_Lake_bivalve_NHB	6	3.3E+00	4.6E+01	2.5E+01	6.5E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).
Pa	La	cR_Lake_bivalve_NHB	6	3.3E+00	4.6E+01	2.5E+01	6.5E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. La used as EA (site data available).

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Pb		cR_Lake_bivalve_NHB	6	3.8E+00	5.4E+01	9.9E+01	7.6E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Pd	Ni	cR_Lake_bivalve_NHB	6	2.7E–01	3.9E+00	4.6E+00	5.5E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Ni used as EA (site data available).
Po			2	6.0E+00	8.4E+01	8.4E+01	1.2E+03	5.0	GSDmax	ERICA	L1	
Pu			3	6.2E–01	8.8E+00	8.8E+00	1.2E+02	5.0	GSDmax	ERICA	L1	ERICA range within the large range of IAEA 2010. The former reference considered more relevant and utilised. The range too small, GSDmin assigned.
Ra			5	1.3E+00	9.7E+00	9.7E+00	5.9E+01	3.0	GSDmean	ERICA	L1	
Se		cR_Lake_bivalve_NHB	6	3.2E+00	4.6E+01	4.9E+01	6.5E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Sm		cR_Lake_bivalve_NHB	6	1.0E+00	1.5E+01	7.7E+00	2.1E+02	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Sn	Zr	cR_Lake_bivalve_NHB	6	1.6E–01	2.3E+00	1.7E+00	3.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Sn used as EA (site data available).
Sr		cR_Lake_bivalve_NHB	6	4.0E–01	5.7E+00	4.1E+00	8.0E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Tc			1	7.9E–03	1.1E–01	1.1E–01	1.6E+00	5.0	GSDmax	ERICA	L1	The ERICA value is within the large range of IAEA 2010. No range in ERICA, GSDmax assigned.
Th		cR_Lake_bivalve_NHB	6	4.2E–01	6.0E+00	4.5E+00	8.4E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
U		cR_Lake_bivalve_NHB	6	1.1E–01	1.5E+00	3.2E–01	2.2E+01	5.6	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.
Zr		cR_Lake_bivalve_NHB	6	1.6E–01	2.3E+00	1.7E+00	3.2E+01	5.0	GSDmax	Site data FMLX	FMLX	Mussels utilised as PA as is often the case in ERICA. Site data available.

7.9 cR_Lake_Fish

The cR_Lake_Fish parameter reflects the uptake in edible parts of limnic fish. The concentration in edible parts of fish is of interest when assessing the dose contribution to humans from ingestion of fish. The cR_Lake_Fish_NHB parameter is utilised in dose calculation to limnic fish and the uptake in the whole fish is of interest. Since the data selection differs for these two parameters, the cR_Lake_Fish_NHB parameter is described separately in Section 7.10.

The dominating fish species in the future lakes of FM are assumed to be the same as the species existing at the site today. The fish species sampled at FM and LX are: *Esox lucius* (pike), *Gymnocephalus cernuus* (ruffe), *Rutilus rutilus* (roach), *Tinca tinca* (tench) and *Perca fluviatilis* (perch). The fish samples are coupled to the lake water samples (as described in Section 7) to calculate CR values. The fish and water samples are coupled per site, i.e. fish samples from FM are coupled with water samples from FM and fish samples from LX are coupled with water samples from LX. Site data are available for 15 elements: Ba, Ca, Cl, Co, Cs, Ho, I, Mo, Nb, Ni, Se, Sm, Sr, U and Zr.

CRs for both fish muscle tissue and whole body are available in IAEA (2010), while CRs for fish whole body alone are available in ERICA (Hosseini et al. 2008) and ICRP (2011). Since the parameters cR_Lake_Fish represent muscle tissue, the IAEA (2010) muscle tissue data are classified as L1 data, while data for whole fish presented in IAEA (2010) and ERICA (Hosseini et al. 2008) are classified as L2 data and L3 data, respectively.

The element-specific CR values are described in Table 7-19 and plotted in Figure 7-16. FM and LX data correlate well in the case of Ba, Cl, Co, I, Mo, Nb and Sr (see Table 7-19). For Zr, 1 FM sample is available and it is in the same order of magnitude as the maximum value reported from LX. For I, only 1 FM sample is available and it is within the range of corresponding LX data. The overlap between FM and LX data are less than 50% for Ca, Cs, Se and U, and the LX data are higher than FM data in all these cases.

Muscle tissue CRs from IAEA (2010) generally indicate lower values than whole body CRs from ERICA (Hosseini et al. 2008) and IAEA (2010). A possible explanation is that elements accumulate in the skeleton and other organs to a higher degree than in muscle tissues, however, this tendency is not evident for all elements. For Pu, muscle tissue data reported in IAEA (2010) are higher than whole body data in ERICA (Hosseini et al. 2008). Muscle tissue CRs for Ca, I, Pb, Ra, Th, Sr, Ba and Mo are more than 1 order of magnitude lower than the whole body CRs from the same source (IAEA 2010). The whole body data in ERICA (Hosseini et al. 2008) are generally higher, though in the same order of magnitude as the whole body data in IAEA (2010). A comparison of literature sources indicates a general consistency between the two sources. For Ba, Ca and Mo, muscle tissue and whole body data are available in IAEA (2010) and do not overlap. For I, whole body and muscle tissue data in IAEA (2010) do not overlap (muscle tissue data are lower), while whole body data in ERICA (Hosseini et al. 2008) overlap with both muscle tissue and whole body data in IAEA (2010).

When FMLX data are compared to the literature range, the data correlate well for the elements: Ba, Ca, Cl, Co, I, Mo, Ni, Sn, Sr, Zr and U. The range of FM data encompasses and is larger than the range of literature data for Cs. The range of FMLX data is lower than the available literature data range for Nb and Se.

Reported GSD values are low in many cases for both site and literature data. For U, GSD is higher than GSDmax for site data and IAEA (2010) muscle tissue data.

Selected data are presented in Table 7-20 and illustrated in Figure 7-18. For elements where site data are available, these are utilised. When site data are not available, suitable EAs are selected if possible. EAs are utilised for Ac, Am, Cm, Eu, Np, Pa, Pd, Ra and Sn. In the case of Ac, Am and Cm, data are scarce. For Am, 2 samples are reported in IAEA (2010) and for Cm, only 1 observation is found in ERICA (Hosseini et al. 2008). In addition to these data, site data are available for the analogue elements Dy, Er, Tm, Yb, Pr, Nd, Tb and La, and these data are plotted in Figure 7-17. Reported GMs for the lanthanides range over 2 orders of magnitude, which is not expected for these analogous elements. This is probably due to discrepancies between data from FM and LX, e.g. differences in chemistry for these elements between the sites or difficulties in measuring these elements at concentrations close to detection limits. Even though the data indicate an unexpectedly wide span in measured CRs, site data for La (highest reported sample numbers) are utilised to parameterise Ac, Am, Cm. and Np Site data are missing for Eu and La is selected as EA. For Sm and Ho, CRs are based on 1 fish sample from LX and these data are utilised in combination with GSDmax. For Pa, site data on La are utilised as EA, while Ba is used as EA for Ra. LX data on Ni are utilised for Pd, and Zr site data are used for Sn.

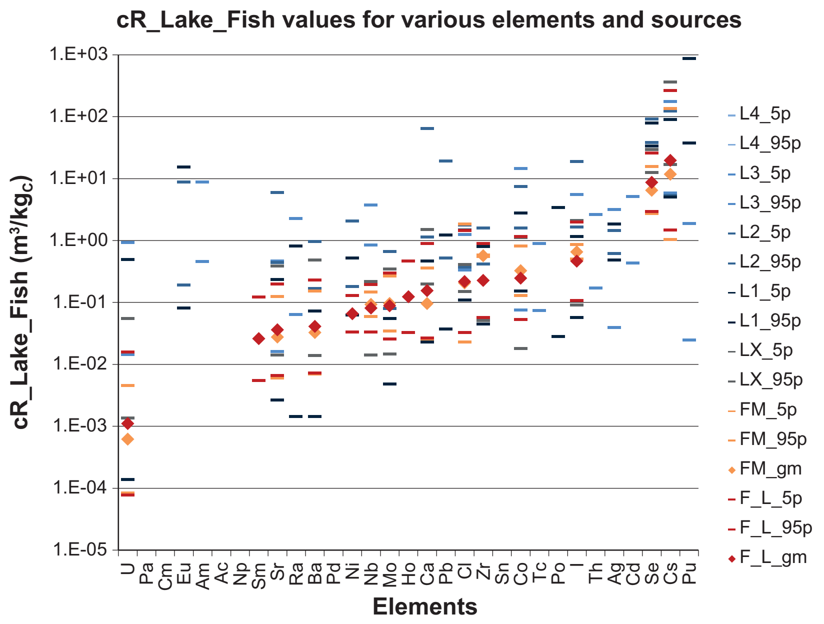

Figure 7-16. *Figure showing total available data ranges for the parameter cR_Lake_Fish (m^3/kg_C). The elements are arranged in the same order as in Figure 7-18 showing selected parameter values.*

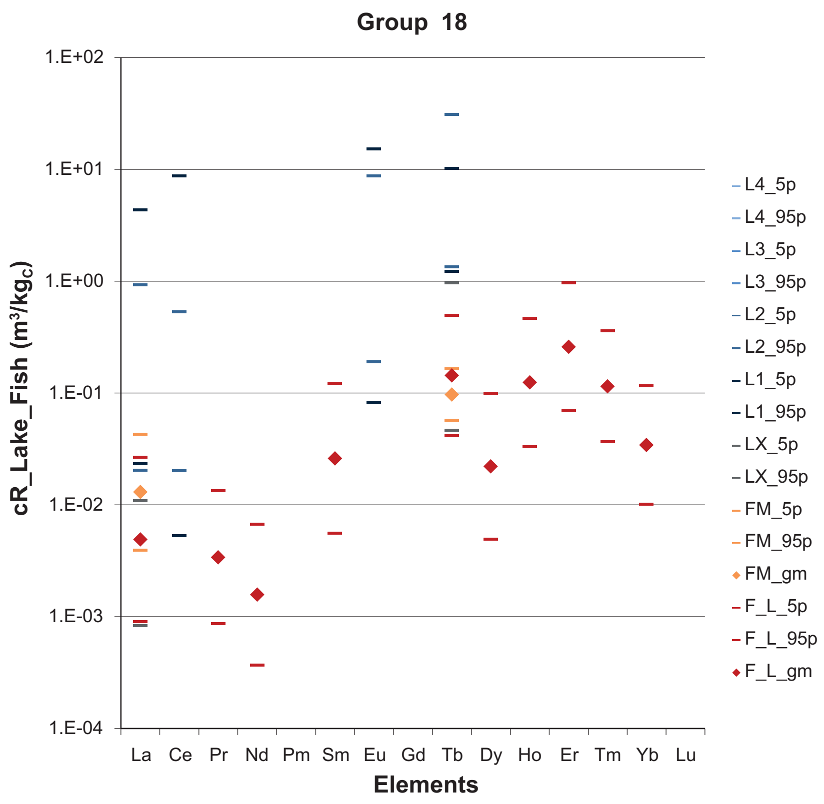

Figure 7-17. *Available data for lanthanides m^3/kg_C.*

In cases where neither site data nor suitable EAs are available, literature data are selected for parameterisation. IAEA (2010) data for muscle tissue are utilised for Ag, Pb, Po and Pu. ERICA (Hosseini et al. 2008) data on whole body are used for Cd, Tc and Th.

GSDmax is assigned to Ho, Ni, Pd, Pu, Sm and Tc, since the sample numbers are low (less than 3) for these elements. GSDmean is assigned to Ac, Ag, Am, Ba, Ca, Cd, Cm, Co, I, Mo, Nb, Np, Pb, Se, Sn, Sr and Zr (see Section 4.3).

The highest uptake is found for Pu and Cs. The GM value for Pu is 2540 m^3/kg_C, which is 1 order of magnitude higher than the GM for Cs. The lowest uptake is found for U, Pa and the actinides/lanthanides Ac, Am, Cm, Eu, Np and Sm. The uptake of Ra, Sr and Ba is also considered low.

Table 7-19. All available data for the parameter cR_Lake_Fish for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = IAEA 2010 Freshwater, Fish muscle, L2 = IAEA 2010 Freshwater, Fish Whole fish, L3 = ERICA (Hosseini et al. 2008) Freshwater, Benthic fish. See Table 7-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				27	23	5					1.5	1.3	3.8						3:3/3
Am				2		7							2.5						2:0/0
Ba	3/15	3/5	6/20	111	92			2.6	2.9	2.9	3.3	1.7			S1	S1	S1	S2 (L77%)	2:0/1
Ca	3/16	3/6	6/22	104	119			2.2	1.8	2.9	2.5	3.4			S1	S1	S1	S2 (L22%)	2:0/1
Cd						4							2.1						1:0/0
Cl	3/16	3/6	6/22	16	37	7		3.8	1.4	3.2	2.2	1.6	1.5		S3	S1	S2 (L68%)	S3	3:3/3
Cm						1													1:0/0
Co	3/12	3/6	6/18	65	119	29		1.7	3.5	2.6	2.4	1.6	4.9		S1	S2 (L65%)	S2 (L88%)	S1	3:3/3
Cs	3/16	3/6	6/22	106	145	100		4.4	2.5	4.9	2.4	2.6	2.8		S2 (L67%)	S2 (U75%)	S3	S2 (L42%)	3:3/3
Eu				24	53	3					4.9	3.2							3:1/1
Ho		3/1	3/1						2.2	2.2									0:0/0
I	3/1	3/6	6/7	50	94	10		1.2	2.6	2.4	2.5	2.1	3.5		S1	S1	S1	S1	3:2/3
La	3/3	3/6	6/9	74	102			2.1	2.2	2.8	4.9	3.2			S2 (L31%)	S4	S2 (L8%)	S2 (U42%)	2:1/1
Mo	3/14	3/6	6/20	64	91			1.9	2.6	2.1	2.1	1.9			S1	S1	S1	S1	2:0/1
Nb	3/11	3/4	6/15			3		1.3	2.3	1.7			1.6		S4	S4	S4	S1	1:0/0
Ni		3/1	3/1	5	24	3			1.5	1.5	1.9	2.1				S2 (L53%)	S2 (L53%)		3:1/1
Np						1													1:0/0
Pa																			0:0/0
Pb				39	92	1					2.9	3.0							3:1/1
Pd																			0:0/0
Po				5		1					4.3								2:0/0
Pu				3		45					2.6		3.7						2:0/1
Ra				21	2	17					6.9		3.0						3:1/1
Se	3/16	3/6	6/22	14	29	1		1.7	1.3	1.9	1.3	1.3			S4	S4	S4	S2 (L12%)	3:1/1
Sm		3/1	3/1						2.6	2.6									0:0/0
Sn																			0:0/0
Sr	3/16	3/6	6/22	99	116	14		2.5	2.7	2.8	3.9	2.2	2.8		S1	S1	S1	S2 (L71%)	3:2/3
Tc						3							2.1						1:0/0
Th				3	2	5							2.3						3:0/0
U	3/14	3/4	6/18	9	2	11		3.4	3.1	5.0	12.0		3.6		S2 (L87%)	S1	S2 (L89%)	S2 (L30%)	3:1/1
Zr	3/1	3/3	6/4	10	9	1		1.0	2.1	2.3	2.4	1.5			S1	S1	S1	S4	3:1/1

Table 7-20. Selected data properties, references and comments for the parameter cR_Lake_Fish (m^3/kg_C) for the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La		6	8.0E–04	4.9E–03	1.3E–02	3.6E–02	3.0	GSDmean	Site data FMLX	FMLX	La used as EA
Ag			27	1.5E–01	9.4E–01	9.4E–01	5.7E+00	3.0	GSDmean	IAEA 2010	L1	No site data avaliable. Literature data in IAEA 2010 for fish muscle tissue (n=27) selected.
Am	La		6	8.0E–04	4.9E–03	1.3E–02	3.6E–02	3.0	GSDmean	Site data FMLX	FMLX	La used as EA
Ba			6	6.7E–03	4.1E–02	3.3E–02	2.6E–01	3.0	GSDmean	Site data FMLX	FMLX	Site data selected. FM and LX data within literature data range. Data for whole body higher than muscle tissue, probably due to accumulation of Ba in skeleton.
Ca			6	2.5E–02	1.5E–01	9.6E–02	1.0E+00	3.0	GSDmean	Site data FMLX	FMLX	Site data selected. FM and LX data did not overlap. LX data higher. Though site data are within the large literature range. Data for whole body higher than muscle tissue, probably due to accumulation of Ca in skeleton.
Cd			4	1.7E–01	1.5E+00	1.5E+00	9.1E+00	3.0	GSDmean	ERICA	L3	No data avaliable. Erica data avaliable
Cl			6	2.2E–02	2.2E–01	2.1E–01	2.0E+00	3.2	GSD	Site data FMLX	FMLX	Site data selected. FM and LX data range larger than literature range.
Cm	La		6	8.0E–04	4.9E–03	1.3E–02	3.6E–02	3.0	GSDmean	Site data FMLX	FMLX	La used as EA
Co			6	3.6E–02	2.5E–01	3.2E–01	1.8E+00	3.0	GSDmean	Site data FMLX	FMLX	
Cs			6	5.4E–01	2.0E+01	1.2E+01	3.1E+02	4.9	GSD	Site data FMLX	FMLX	Site data selected. FM and LX data overlap less than 50%. Literature data overlap both FM and LX data.
Eu	La		6	8.0E–04	4.9E–03	1.3E–02	3.6E–02	3.0	GSDmean	Site data FMLX	FMLX	La used as EA
Ho			1	8.8E–03	1.2E–01	1.2E–01	1.7E+00	5.0	GSDmax	Site data LX	LX	One sample reported from LX used in combination with GSDmax.
I			6	7.6E–02	4.6E–01	6.6E–01	2.8E+00	3.0	GSDmean	Site data FMLX	FMLX	Site data selected. FM data, LX data and literature data overlap. Data on whole body higher than mussle tissue.
Mo			6	1.4E–02	8.8E–02	9.6E–02	5.3E–01	3.0	GSDmean	Site data FMLX	FMLX	Site data selected. FM data, LX data and literature data overlap. Data on whole body higher than mussle tissue.
Nb			6	1.3E–02	8.1E–02	9.3E–02	4.9E–01	3.0	GSDmean	Site data FMLX	FMLX	Site data selected. FM and LX data overlap. No data avaliable in IAEA 2010. Data on whole body available in ERICA based on data presented in IAEA2004. These data was for some reason excluded in the IAEA 2010 compilation
Ni			1	4.6E–03	6.5E–02	6.5E–02	9.2E–01	5.0	GSDmax	Site data LX	LX	No FM data avaliable. 1 sample reported in LX. ERICA data overlap with IAEA 2010 data. LX data used in combination with GSDmax.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Np	La	cR_Lake_Fish_NHB	6	6.6E–04	9.3E–03	2.5E–02	1.3E–01	5.0	GSDmax	Site data FMLX	FMLX	La data used as EA.
Pa	La		6	8.0E–04	4.9E–03	1.3E–02	3.6E–02	3.0	GSDmean	Site data FMLX	FMLX	No data avalibale. La data used.
Pb			39	8.6E–04	2.1E–01	2.1E–01	2.3E+00	3.0	GSDmean	IAEA 2010	L1	No site data avaliable. IAEA muscle tissue data used.
Pd	Ni		1	4.6E–03	6.5E–02	6.5E–02	9.2E–01	5.0	GSDmax	Site data LX	LX	Ni used as EA
Po			5	2.8E–02	3.1E–01	3.1E–01	3.4E+00	4.3	GSD	IAEA 2010	L1	No site data avaliable. IAEA muscle tissue data used.
Pu			3	1.3E+01	1.8E+02	1.8E+02	2.5E+03	5.0	GSDmax	IAEA 2010	L1	No site data available. IAEA 2010 reported 3 samples for muscle tissues, these data are much higher than the data for whole body reported in ERICA. The data reported in IAEA 2010 selected.
Ra	Ba		6	6.7E–03	4.1E–02	3.3E–02	2.6E–01	3.0	GSDmean	Site data FMLX	FMLX	No site data avaliable. Ba site data are used as EA.
Se			6	1.4E+00	8.7E+00	6.5E+00	5.3E+01	3.0	GSDmean	Site data FMLX	FMLX	FM data low in comparison to LX data. Literature data and site data do not overlap. Site data for Se consistent with site data for the analogue S. Se data selected.
Sm			1	1.8E–03	2.6E–02	2.6E–02	3.7E–01	5.0	GSDmax	Site data LX	LX	One sample reported from LX used in combination with GSDmax.
Sn	Zr		4	3.7E–02	2.3E–01	5.7E–01	1.4E+00	3.0	GSDmean	Site data FMLX	FMLX	No site or literature data avaliable. Zr used as EA.
Sr			6	3.1E–03	3.6E–02	2.8E–02	2.2E–01	3.0	GSDmean	Site data FMLX	FMLX	Site data selected. FM data, LX data and literature data overlap.
Tc			3	1.8E–02	2.6E–01	2.6E–01	3.6E+00	5.0	GSDmax	ERICA	L3	Only literature data presented for whole body in ERICA avaliable
Th			5	1.1E–01	6.7E–01	6.7E–01	4.8E+00	2.3	gsd	ERICA	L3	IAEA 2010 did not report GSD. ERICA data selected.
U			6	5.9E–05	1.1E–03	6.2E–04	2.9E–02	5.0	GSD	Site data FMLX	FMLX	Site data selected. The FM data low in comparison to LX and literature data.
Zr			4	3.7E–02	2.3E–01	5.7E–01	1.4E+00	3.0	GSDmean	Site data FMLX	FMLX	Only 1 sample from FM are available. FMLX data used. FMLX data and literature data in IAEA 2010 overlap.

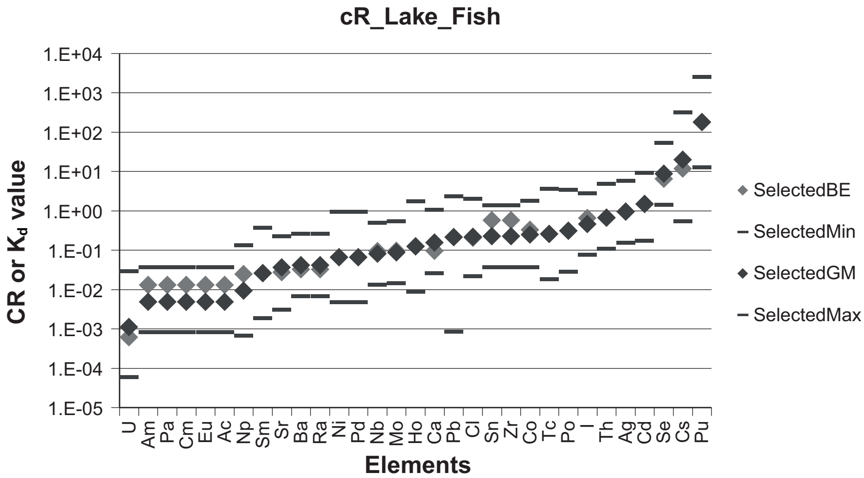

Figure 7-18. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_C).*

7.10 cR_Lake_Fish_NHB, cR_Lake_bent_Fish_NHB, cR_Lake_pel_Fish_NHB

The cR_Lake_Fish_NHB parameter describes the element uptake in limnic fish from lake water, utilised in dose estimates to this organism type. In the radionuclide model, limnic fish is represented by benthic and pelagic fish species (parameters cR_Lake_bent_fish_NHB and cR_Lake_pel_fish_NHB). The same CR values are utilised for these two organism types and site data for all limnic fish, both benthic and pelagic species are merged together and are used for both parameters (fish data from Hannu and Karlsson (2006) (FM) and Engdahl et al. (2006) (LX)), see Section 7.9. Benthic species may be more prone to accumulate e.g. heavy metals from contaminated sediment but these are relocated to separate tissues (liver) which has not been analyzed in site data. Site data are measured on fish muscle and, when possible, conversion to whole body concentrations are accomplished by using conversion factors in Yankovich et al. (2010). A comparison of data for muscle and whole body measurements is presented in Section 7.9.

Water data are available from both sites (Engdahl et al. 2008) and are further treated in Section 7. Site data are available for 15 elements. LX site data alone are available for Ho, Ni and Sm. Site data are described further in the section for parameter cR_Lake_Fish (Section 7.9). Available literature data from ICRP (2011) are categorised as L1 data, ERICA (Hosseini et al. 2008) as L2 data and IAEA (2010) as L3 data. Literature data are the only data source for 12 elements: Ag, Am, Cd, Cm, Eu, Np, Pb, Po, Pu, Ra, Tc and Th. Data are missing for Ac, Pa, Pd and Sn. All available data are presented in Table 7-21 and Figure 7-19.

Some elements for which site data are utilised, did not match literature data when the sense check were performed. For Se, FM and LX data overlap to some extent and are lower than data from ICRP (2011) and IAEA (2010) (FM about 10 times lower than IAEA). The ranges are small and the lower site value (n=6) does not seem unrealistic, hence site data are utilised. For U, FM data are lower than LX and literature data though some overlap occur. The FM value is approximately 10 times lower than LX and approximately 50 times lower than the value in ICRP (2011). Combined site data are utilised. For Nb and Zr, site data are lower than literature data, though as FM and LX values are consitent, the data are considered valid. Although FM and LX data do not entirely overlap for Ca, the site data completely overlap literature data. Both ranges are small, though not considered an issue and site data are utilised.

Site data for Eu are missing and La data are utilised as EA. La is also selected as EA for Ac, Am, Cm, Np and Pa, since no site data for relevant actinides are available. Zr is utilised as EA for Sn, Ni is used for Pd and Ba is selected for Ra.

A comparison of literature data indicates consistency for all elements except I. For this element, the data range in IAEA (2010) is higher than the ranges in ICRP (2011) and ERICA (Hosseini et al. 2008). All three ranges are 1 order of magnitude.

Literature data are utilised in cases where site data are missing: Ag, Cd, Pb, Po, Pu, Tc and Th. For Cd, a comparison of literature data cannot be completed since only 1 source presented data (ERICA; benthic or pelagic fish). For the elements Ag, Pb, Po, Pu, Ra, Tc and Th, sense checks indicate that data correlates well.

For Pb, only 1 value without range is presented in ERICA (Hosseini et al. 2008), while ICRP (2011) data are based on 22 observations and have a large range (almost 3 orders of magnitude) and IAEA (2010) data are based on 92 observations and are mainly within ICRP range. The minimum value in IAEA is about 10 times higher than the minimum value in ICRP, while the GMs deviate about 4 times. IAEA (2010) data are selected due to the larger number of observations.

Due to the restricted number of observations, GSDmax (5) is assigned to 7 elements and GSDmean to 14 elements (see Section 4.3 for details).

The selected CR values are presented in Table 7-22 and Figure 7-20.

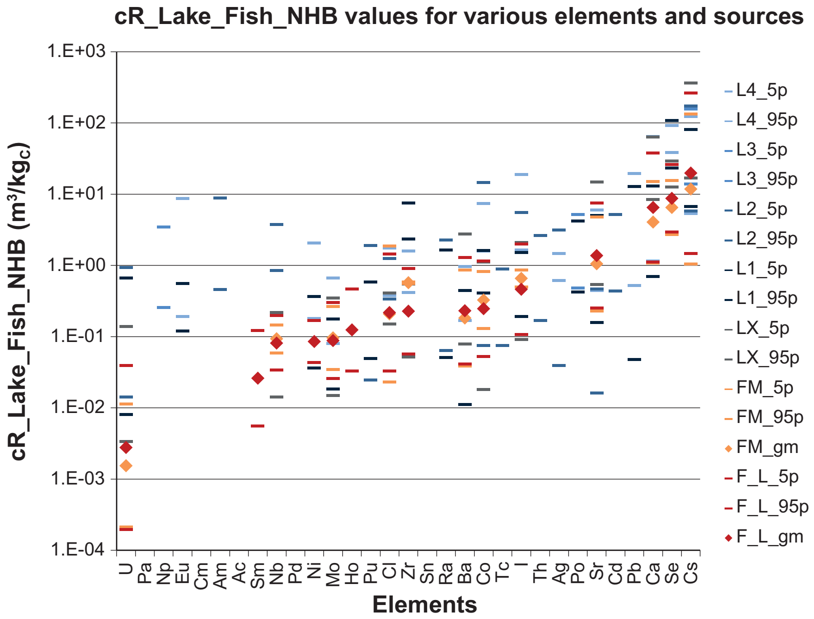

Figure 7-19. *Total available data ranges for the parameter cR_Lake_Fish_NHB (m^3/kg_C). The elements are arranged in the same order as in Figure 7-20 selected parameter values. Available site data are not included (see Table 7-18 for the parameter cR_Lake_Fish).*

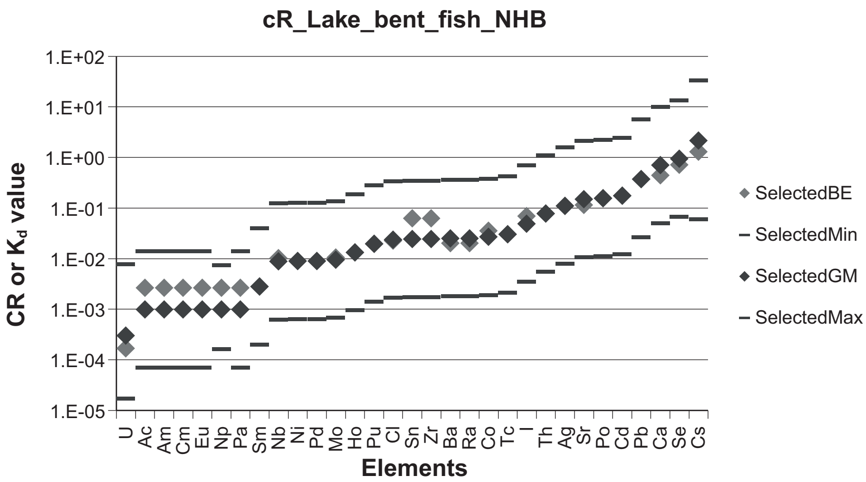

Figure 7-20. *Selected parameter values for cR_Lake_bent_Fish_NHB and cR_Lake_pel_Fish_NHB (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

Table 7-21. Available data for parameterisation of limnic fish. Available site data are not included (see Table 7-19 for the parameter cR_Lake_Fish). L1 = ICRP 2011 Freshwater, Salmonid, L2 = ERICA (Hosseini et al. 2008) Freshwater, Benthic fish, L3 = ERICA (Hosseini et al. 2008) Freshwater, Pelagic fish, L4 = IAEA 2010 Freshwater, Fish. See Table 7-1 for description of headings.

Element	L1 N	L2 N	L3 N	L4 N	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC Lit
Ac									0:0/0
Ag		5	1	23		3.8		1.3	3:1/1
Am		7	1			2.5			2:0/0
Ba	87			92	3.1			1.7	2:1/1
Ca	124			119	2.4			3.4	2:1/1
Cd		4	1			2.1			2:0/0
Cl		7	1	37		1.5		1.6	3:1/1
Cm		1	2						2:0/0
Co	56	29	29	119	1.5	4.9	4.9	1.6	4:6/6
Cs	118	100	13	145	2.1	2.8	2.1	2.6	4:6/6
Eu	18	3	1	53	1.6			3.2	4:1/1
Ho									0:0/0
I	17	10	10	94	1.9	3.5	3.5	2.1	4:5/6
La	60			102	2.5			3.2	2:1/1
Mo	90			91	2.0			1.9	2:1/1
Nb		3	3			1.6	1.6		2:1/1
Ni	15	3	3	24	2.0			2.1	4:1/1
Np		1	2				2.2		2:0/0
Pa									0:0/0
Pb	22	1	1	92	5.5			3.0	4:1/1
Pd									0:0/0
Po	10	1	13		2.0		2.1		3:1/1
Pu	5	45	45		2.1	3.7	3.7		3:3/3
Ra	46	17	17	2	2.9	3.0	3.0		4:3/3
Se	15	1	1	29	1.6			1.3	4:1/1
Sm									0:0/0
Sn									0:0/0
Sr	129	14	14	116	2.9	2.8	2.8	2.2	4:6/6
Tc		3	3			2.1	2.1		2:1/1
Th		5	5	2		2.3	2.3		3:1/1
U	36	11	11	2	3.8	3.6	3.6		4:3/3
Zr	4	1	1	9	1.4			1.5	4:0/1

Table 7-22. Selected data properties, references and comments for the parameters cR_Lake_bent_Fish_NHB and the cR_Lake_pel_Fish_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group. La used as EA (site data available).
Ag		cR_Lake_Fish_NHB	23	7.8E–03	1.1E–01	1.1E–01	1.6E+00	5.0	GSDmax	IAEA 2010	L4	ERICA gives only one value without range. The GM correlates with data in IAEA 2010 (n=23) which includes a range. The latter was utilised.
Am	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group. La used as EA (site data available).
Ba		cR_Lake_Fish_NHB	6	1.8E–03	2.5E–02	2.0E–02	3.5E–01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Ca		cR_Lake_Fish_NHB	6	5.0E–02	7.1E–01	4.4E–01	1.0E+01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Cd		cR_Lake_Fish_NHB	4	1.2E–02	1.7E–01	1.7E–01	2.5E+00	5.0	GSDmax	ERICA	L2	Validation not possible since only one value without range is given in one of the references.
Cl		cR_Lake_Fish_NHB	6	1.7E–03	2.4E–02	2.3E–02	3.3E–01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Cm	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group. La used as EA (site data available).
Co		cR_Lake_Fish_NHB	6	1.9E–03	2.7E–02	3.6E–02	3.8E–01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Cs		cR_Lake_Fish_NHB	6	6.0E–02	2.1E+00	1.3E+00	3.3E+01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Eu	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group. La used as EA (site data available).
Ho		cR_Lake_Fish_NHB	1	9.4E–04	1.3E–02	1.3E–02	1.9E–01	5.0	GSDmax	Site data LX	LX	All fish (pelagic and benthic) are merged into 1 group.
I		cR_Lake_Fish_NHB	6	3.5E–03	4.9E–02	6.9E–02	6.9E–01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Mo		cR_Lake_Fish_NHB	6	6.7E–04	9.5E–03	1.0E–02	1.3E–01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Nb		cR_Lake_Fish_NHB	6	6.2E–04	8.8E–03	1.0E–02	1.2E–01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Ni		cR_Lake_Fish_NHB	1	6.3E–04	8.9E–03	8.9E–03	1.3E–01	5.0	GSDmax	Site data LX	LX	All fish (pelagic and benthic) are merged into 1 group.
Np	La	cR_Lake_Fish_NHB	6	1.6E–04	9.9E–04	2.6E–03	7.4E–03	3.0	GSDmean	Site data FMLX	FMLX	La used as chemical analogue (site data available).

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pa	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group. La used as EA (site data available).
Pb		cR_Lake_Fish_NHB	92	2.6E–02	3.7E–01	3.7E–01	5.7E+00	5.0	GSDmax	IAEA 2010	L4	Range of IAEA 2010 (n=94) within that of ICRP 2011 (n=22). The GM deviates with a factor of 4. IAEA data chosen (larger N).
Pd	Ni	cR_Lake_Fish_NHB	1	6.3E–04	8.9E–03	8.9E–03	1.3E–01	5.0	GSDmax	Site data LX	LX	All fish (pelagic and benthic) are merged into 1 group. Ni used as EA (LX data available).
Po		cR_Lake_Fish_NHB	10	1.1E–02	1.6E–01	1.6E–01	2.2E+00	5.0	GSDmax	ICRP 2011	L1	Value and range in ICRP and ERICA correlate very well.
Pu		cR_Lake_Fish_NHB	5	1.4E–03	2.0E–02	2.0E–02	2.8E–01	5.0	GSDmax	ICRP 2011	L1	
Ra	Ba	cR_Lake_Fish_NHB	6	1.8E–03	2.5E–02	2.0E–02	3.5E–01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group. Ba used as EA (site data available).
Se		cR_Lake_Fish_NHB	6	6.7E–02	9.5E–01	7.1E–01	1.3E+01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Sm		cR_Lake_Fish_NHB	1	2.0E–04	2.8E–03	2.8E–03	3.9E–02	5.0	GSDmax	Site data LX	LX	All fish (pelagic and benthic) are merged into 1 group.
Sn	Zr	cR_Lake_Fish_NHB	4	1.7E–03	2.4E–02	6.3E–02	3.4E–01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group. Zr used as EA (site data available).
Sr		cR_Lake_Fish_NHB	6	1.1E–02	1.5E–01	1.1E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Tc		cR_Lake_Fish_NHB	3	2.1E–03	3.0E–02	3.0E–02	4.3E–01	5.0	GSDmax	ERICA	L2	
Th		cR_Lake_Fish_NHB	5	5.5E–03	7.8E–02	7.8E–02	1.1E+00	5.0	GSDmax	ERICA	L2	Validation not possible since only min and max are given in IAEA 2010.
U		cR_Lake_Fish_NHB	6	1.7E–05	3.0E–04	1.7E–04	7.8E–03	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.
Zr		cR_Lake_Fish_NHB	4	1.7E–03	2.4E–02	6.3E–02	3.4E–01	5.0	GSDmax	Site data FMLX	FMLX	All fish (pelagic and benthic) are merged into 1 group.

7.11 cR_Lake_amph_NHB

cR_Lake_amph_NHB describes the element uptake in limnic amphibians for use in dose estimates to this organism type. Amphibians utilises both aquatic and terrestrial habitats. This parameter is used for dose stimates in the aquatic habitat. Site data are not available for this organism. Literature data are available for adult frog in ICRP (2011) and for amphibians in ERICA (Hosseini et al. 2008), see Table 7-23 and Figure 7-21. Data pertaining to the same element are only available in both references for Pb. Sense checks of data are not relevant since ranges are not available in ERICA (Hosseini et al. 2008). The presented values differs about 2 orders of magnitude.

The data in ICRP (2011) (categorised as L1 data) are for a restricted number of elements and only two of these (Ca and Pb) are of interrest here. For those two elements this data source was used. In ERICA, data for amphibians are usually the same as for fish (except for Am (bird data) and Pu (mammal data)). Therefore, for the 14 elements where site data for limnic fish are available, these data are selected (see parameter cR_Lake_Fish_NHB in Section 7.10). EAs are utilised for Ac, Am, Cm, Eu, Np, Pa, Pd, Ra and Sn (combined EAs and PAs).

Site data for limnic fish are missing for Ag, Cd, Pb, Po, Pu, Tc, and Th. In these cases, data given for amphibians in ERICA (categorised as L2 data) are selected. ERICA utilised mammal data for Pu. In order to be consistent, fish is selected as PA.

In summary, the only values differing from those used for limnic fish are the values for Ca and Pb.

A range is not presented for Pb (ICRP 2011) and GSDmax (5) is assigned to this parameter, see Section 4.3. GSDmax is assigned to all of the elements except 1, since both site and literature data are PAs (in accordance with the conditions stated in Section 4.3).

The selected CR values are presented in Table 7-22 and Figure 7-22.

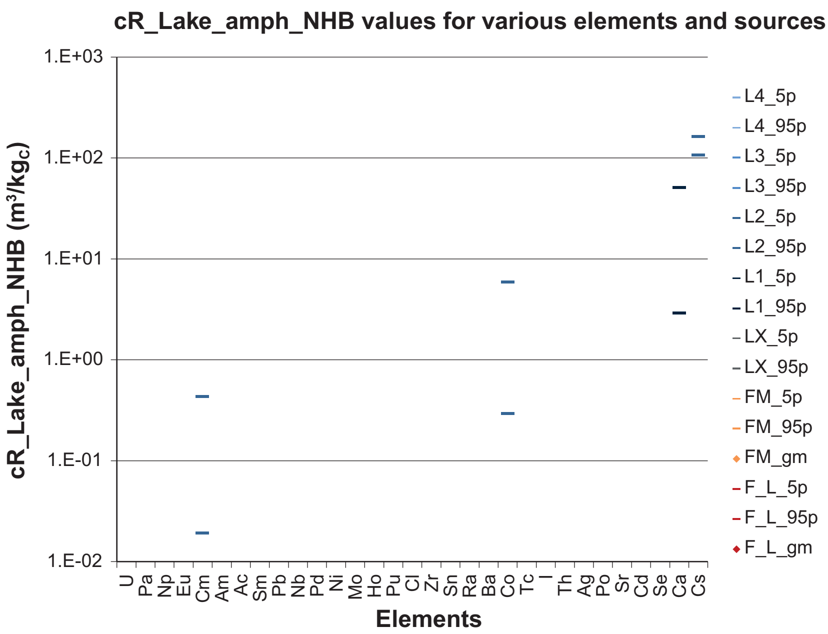

Figure 7-21. *Available data for parameterisation of cR_Lake_amph_NHB (m^3/kg_C), arranged in ascending order as in Figure 7-22. Elements not included in this figure, as data source contain no relevant information (GSD or 5/95 percentiles), are presented in Table 7-23.*

Table 7-23. All available data for the parameter cR_Lake_amph_NHB for the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ICRP 2011 Freshwater, Frog, L2 = ERICA (Hosseini et al. 2008) Freshwater, Amphibian. See Table 7-1 for description of headings.

Ele-ment	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am					1														1:0/0
Ba																			0:0/0
Ca				8							2.4								1:0/0
Cd					1														1:0/0
Cl					1														1:0/0
Cm					8							2.6							1:0/0
Co					2							2.5							1:0/0
Cs					3							1.1							1:0/0
Eu					1														1:0/0
Ho																			0:0/0
I					2														1:0/0
Mo																			0:0/0
Nb					1														1:0/0
Ni					1														1:0/0
Np					1														1:0/0
Pa																			0:0/0
Pb				2	1														2:0/0
Pd																			0:0/0
Po					1														1:0/0
Pu					1														1:0/0
Ra					1														1:0/0
Se					1														1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr					1														1:0/0
Tc					1														1:0/0
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U					1														1:0/0
Zr					1														1:0/0

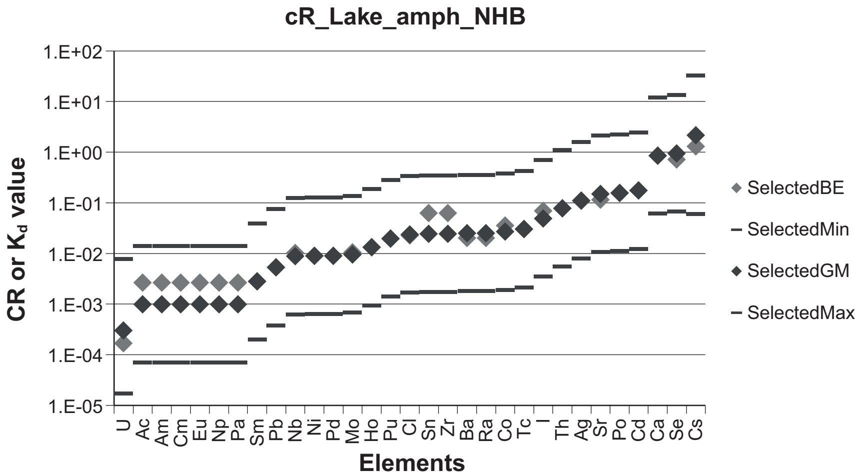


Figure 7-22. Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).

Table 7-24. Selected data properties, references and comments for the parameter cR_Lake_amph_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Data for lantanides in fish available. La used as EA.
Ag		cR_Lake_Fish_NHB	23	7.8E–03	1.1E–01	1.1E–01	1.6E+00	5.0	GSDmax	IAEA 2010	L4	Fish data utilised in ERICA.
Am	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Data for lantanides in fish available. La used as EA.
Ba		cR_Lake_Fish_NHB	6	1.8E–03	2.5E–02	2.0E–02	3.5E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Ca			8	6.0E–02	8.5E–01	8.5E–01	1.2E+01	5.0	GSDmax	ICRP 2011	L1	
Cd		cR_Lake_Fish_NHB	4	1.2E–02	1.7E–01	1.7E–01	2.5E+00	5.0	GSDmax	ERICA	L2	Fish data utilised in ERICA.
Cl		cR_Lake_Fish_NHB	6	1.7E–03	2.4E–02	2.3E–02	3.3E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Cm	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Data for lantanides in fish available. La used as EA.
Co		cR_Lake_Fish_NHB	6	1.9E–03	2.7E–02	3.6E–02	3.8E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Cs		cR_Lake_Fish_NHB	6	6.0E–02	2.1E+00	1.3E+00	3.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Eu	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Data for lantanides in fish available. La used as EA.
Ho		cR_Lake_Fish_NHB	1	9.4E–04	1.3E–02	1.3E–02	1.9E–01	5.0	GSDmax	Site data LX	LX	Fish data often utilised in ERICA. LX data available and utilised.
I		cR_Lake_Fish_NHB	6	3.5E–03	4.9E–02	6.9E–02	6.9E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Mo		cR_Lake_Fish_NHB	6	6.7E–04	9.5E–03	1.0E–02	1.3E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Nb		cR_Lake_Fish_NHB	6	6.2E–04	8.8E–03	1.0E–02	1.2E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Ni		cR_Lake_Fish_NHB	1	6.3E–04	8.9E–03	8.9E–03	1.3E–01	5.0	GSDmax	Site data LX	LX	Fish data often utilised in ERICA. LX data available and utilised.
Np	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Data for lantanides in fish available. La used as EA.
Pa	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Data for lantanides in fish available. La used as EA.
Pb			2	3.8E–04	5.3E–03	5.3E–03	7.5E–02	5.0	GSDmax	ICRP 2011	L1	Validation not possible since ERICA only presented 1 value without range. The range in ICRP 2011 considered too narrow. GSDmax assigned.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pd	Ni	cR_Lake_Fish_NHB	1	6.3E–04	8.9E–03	8.9E–03	1.3E–01	5.0	GSDmax	Site data LX	LX	Fish data often utilised in ERICA. Ni used as EA (LX data available).
Po		cR_Lake_Fish_NHB	10	1.1E–02	1.6E–01	1.6E–01	2.2E+00	5.0	GSDmax	ICRP 2011	L1	Pelagic fish data utilised in ERICA. The value used for fish (from ICRP 2011) selected.
Pu		cR_Lake_Fish_NHB	5	1.4E–03	2.0E–02	2.0E–02	2.8E–01	5.0	GSDmax	ICRP 2011	L1	ERICA used data for mammals. For all other elements, fish data used as PA when needed. Fish data for Pu (from ICRP) utilised.
Ra	Ba	cR_Lake_Fish_NHB	6	1.8E–03	2.5E–02	2.0E–02	3.5E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Ba used as EA (site data available).
Se		cR_Lake_Fish_NHB	6	6.7E–02	9.5E–01	7.1E–01	1.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Sm		cR_Lake_Fish_NHB	1	2.0E–04	2.8E–03	2.8E–03	3.9E–02	5.0	GSDmax	Site data LX	LX	Fish data often utilised in ERICA. Site data available and utilised.
Sn	Zr	cR_Lake_Fish_NHB	4	1.7E–03	2.4E–02	6.3E–02	3.4E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Sr		cR_Lake_Fish_NHB	6	1.1E–02	1.5E–01	1.1E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Tc		cR_Lake_Fish_NHB	3	2.1E–03	3.0E–02	3.0E–02	4.3E–01	5.0	GSDmax	ERICA	L2	Fish data utilised in ERICA.
Th		cR_Lake_Fish_NHB	5	5.5E–03	7.8E–02	7.8E–02	1.1E+00	5.0	GSDmax	ERICA	L2	Fish data utilised in ERICA.
U		cR_Lake_Fish_NHB	6	1.7E–05	3.0E–04	1.7E–04	7.8E–03	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.
Zr		cR_Lake_Fish_NHB	4	1.7E–03	2.4E–02	6.3E–02	3.4E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data often utilised in ERICA. Site data available and utilised.

7.12 cR_Lake_bird_NHB

cR_Lake_bird_NHB describes the element uptake in limnic birds for use in dose estimates to this organism type. Site data are not available for this organism. Literature data are available in ERICA (Hosseini et al. 2008), where 1 value without range is presented, see Table 7-25 (hence figure not available).

Data for birds are usually the same as for fish in ERICA (Hosseini et al. 2008). For 14 elements where site data for fish are available, these are utilised (see parameter cR_Lake_Fish_NHB in Section 7.10). EAs are utilised for Ac, Am, Cm, Eu, Np, Pa, Pd, Ra and Sn (combined EA and PAs).

When site data for limnic fish are missing, data from ERICA (Hosseini et al. 2008) are selected. No other literature data are available for comparison. Pu and Am are the only elements where data in ERICA is not the same as for fish. Notes concerning PA are not presented for these two elements. For elements where neither site data for fish nor literature data for birds are available (Ag, Cd, Pb, Po, Tc and Th), the parameter analogue cR_Lake_Fish_NHB is utilised. Therefore, the parameter values for cR_Lake_bird_NHB are the same as for cR_Lake_Fish_NHB for all of the elements except Pu.

A range is not presented for Pu in ERICA and GSDmax is assigned to this parameter (5), see Section 4.3. GSDmax is assigned to all of the elements, since both site and literature data are PAs.

The selected CR values are presented in Table 7-26 and Figure 7-23.

Table 7-25. All available data for the parameter cR_Lake_bird_NHB for the elements of primary concern and selected EAs. L1– L2 = ERICA (Hosseini et al. 2008) Freshwater, Bird. See Table 7-1 for description of headings.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am					1														1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd					1														1:0/0
Cl					1														1:0/0
Cm					1														1:0/0
Co					1														1:0/0
Cs					1														1:0/0
Eu					1														1:0/0
Ho																			0:0/0
I					1														1:0/0
Mo																			0:0/0
Nb					1														1:0/0
Ni					1														1:0/0
Np					1														1:0/0
Pa																			0:0/0
Pb					1														1:0/0
Pd																			0:0/0
Po					1														1:0/0
Pu					1														1:0/0
Ra					1														1:0/0
Se					1														1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr					1														1:0/0
Tc					1														1:0/0
Th					1														1:0/0
U					1														1:0/0
Zr					1														1:0/0

Table 7-26. Selected data properties, references and comments for the parameter cR_Lake_bird_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. La used as EA (site data available).
Ag		cR_Lake_Fish_NHB	23	7.8E–03	1.1E–01	1.1E–01	1.6E+00	5.0	GSDmax	IAEA 2010	L4	Fish data utilised in ERICA.
Am	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. La used as EA (site data available).
Ba		cR_Lake_Fish_NHB	6	1.8E–03	2.5E–02	2.0E–02	3.5E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Ca		cR_Lake_Fish_NHB	6	5.0E–02	7.1E–01	4.4E–01	1.0E+01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Cd		cR_Lake_Fish_NHB	4	1.2E–02	1.7E–01	1.7E–01	2.5E+00	5.0	GSDmax	ERICA	L2	Fish data utilised in ERICA.
Cl		cR_Lake_Fish_NHB	6	1.7E–03	2.4E–02	2.3E–02	3.3E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Cm	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. La used as EA (site data available).
Co		cR_Lake_Fish_NHB	6	1.9E–03	2.7E–02	3.6E–02	3.8E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Cs		cR_Lake_Fish_NHB	6	6.0E–02	2.1E+00	1.3E+00	3.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Eu	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. La used as EA (site data available).
Ho		cR_Lake_Fish_NHB	1	9.4E–04	1.3E–02	1.3E–02	1.9E–01	5.0	GSDmax	Site data LX	LX	Fish data utilised as PA as is often the case in ERICA. LX data available.
I		cR_Lake_Fish_NHB	6	3.5E–03	4.9E–02	6.9E–02	6.9E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Mo		cR_Lake_Fish_NHB	6	6.7E–04	9.5E–03	1.0E–02	1.3E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Nb		cR_Lake_Fish_NHB	6	6.2E–04	8.8E–03	1.0E–02	1.2E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Ni		cR_Lake_Fish_NHB	1	6.3E–04	8.9E–03	8.9E–03	1.3E–01	5.0	GSDmax	Site data LX	LX	Fish data utilised as PA as is often the case in ERICA. LX data available.
Np	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. La used as EA (site data available).

Pa	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. La used as EA (site data available).
Pb		cR_Lake_Fish_NHB	92	2.6E–02	3.7E–01	3.7E–01	5.7E+00	5.0	GSDmax	IAEA 2010	L4	Fish data utilised in ERICA. Value used for fish (from IAEA 2010) selected. See comment for cR_Lake_bent_fish_NHB.
Pd	Ni	cR_Lake_Fish_NHB	1	6.3E–04	8.9E–03	8.9E–03	1.3E–01	5.0	GSDmax	Site data LX	LX	Fish data utilised as PA as is often the case in ERICA. Ni used as EA (LX data available).
Po		cR_Lake_Fish_NHB	10	1.1E–02	1.6E–01	1.6E–01	2.2E+00	5.0	GSDmax	ICRP 2011	L1	Fish data utilised in ERICA. Value used for fish (from ICRP 2011) selected. See comment for cR_Lake_bent_fish_NHB.
Pu			1	1.4E–04	2.0E–03	2.0E–03	2.8E–02	5.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Ra	Ba	cR_Lake_Fish_NHB	6	1.8E–03	2.5E–02	2.0E–02	3.5E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Ba used as EA (site data available).
Se		cR_Lake_Fish_NHB	6	6.7E–02	9.5E–01	7.1E–01	1.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Sm		cR_Lake_Fish_NHB	1	2.0E–04	2.8E–03	2.8E–03	3.9E–02	5.0	GSDmax	Site data LX	LX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Sn	Zr	cR_Lake_Fish_NHB	4	1.7E–03	2.4E–02	6.3E–02	3.4E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Zr used as EA (site data available).
Sr		cR_Lake_Fish_NHB	6	1.1E–02	1.5E–01	1.1E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Tc		cR_Lake_Fish_NHB	3	2.1E–03	3.0E–02	3.0E–02	4.3E–01	5.0	GSDmax	ERICA	L2	Fish data utilised in ERICA.
Th		cR_Lake_Fish_NHB	5	5.5E–03	7.8E–02	7.8E–02	1.1E+00	5.0	GSDmax	ERICA	L2	Fish data utilised in ERICA. Value used for fish (from ERICA) selected. See comment for cR_Lake_bent_fish_NHB.
U		cR_Lake_Fish_NHB	6	1.7E–05	3.0E–04	1.7E–04	7.8E–03	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Zr		cR_Lake_Fish_NHB	4	1.7E–03	2.4E–02	6.3E–02	3.4E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.

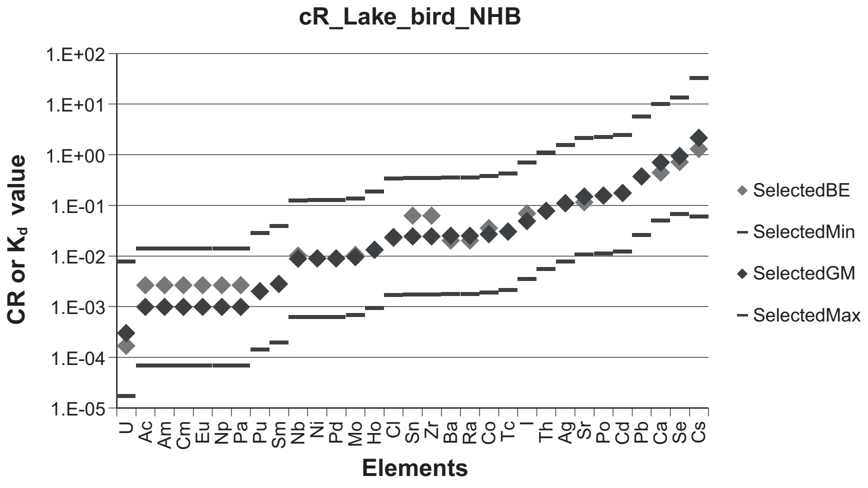


Figure 7-23. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

7.13 cR_Lake_mammal_NHB

cR_Lake_mammal_NHB describes the element uptake in limnic mammals for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are only available in ERICA (Hosseini et al. 2008), where 1 value without range is presented, see Table 7-27 (hence figure not available). With the exception of Pu, ERICA utilises fish data, amphibian data (2 cases) and bird data (1 case) to parametrise limnic mammals. Site data for fish are utilised as PA when available, see parameter cR_Lake_Fish_NHB in Section 7.10. Neither site nor literature data are available for Ac, Pa, Pd and Sn, and a combination of PA and EAs are utilised (fish data for La, Zr, Ni and Zr respectively). Site data for La in fish are utilised as a combination of EA and PAs for Am, Cm and Np whereas site data for Ba in fish is used for Ra.

Values for limnic mammals in ERICA (Hosseini et al. 2008) are utilised for elements lacking site data (same value as for fish for Tc and Ag, same as for bird for Cd). Fish data are also utilised for Pb and Po in ERICA (Hosseini et al. 2008), though ICRP (2011) values for fish are selected here for these 2 elements. As a result, the parameter values for cR_Lake_mammal_NHB are the same as for cR_Lake_Fish_NHB for all of the elements except for Cd and Pu.

GSDmax (5) is assigned to all elements, due to the low number of observations or use of PAs. The selected CR values are presented in Table 7-28 and Figure 7-24.

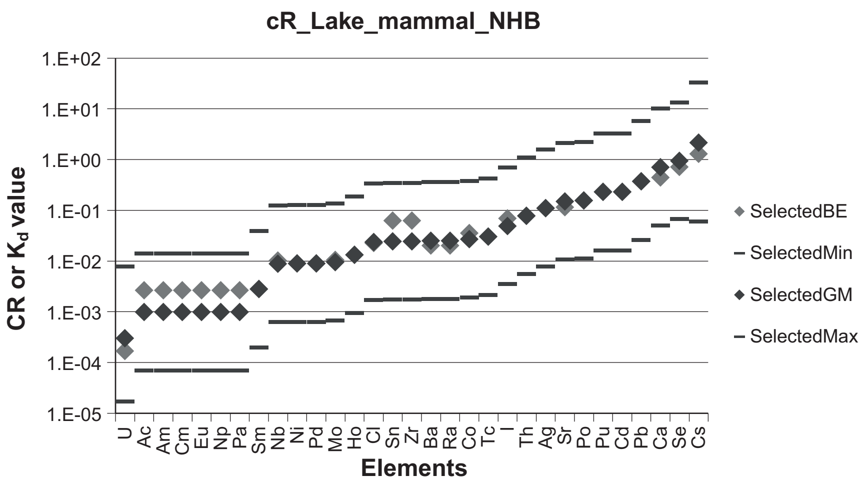


Figure 7-24. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

Table 7-27. All available data for the parameter cR_Lake_mammal_NHB for the elements of primary concern and selected EAs. L1 = ERICA (Hosseini et al. 2008) Freshwater, Mammal. See Table 7-1 for description of headings.

Ele-ment	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				1															1:0/0
Cl				1															1:0/0
Cm				1															1:0/0
Co				1															1:0/0
Cs				1															1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				1															1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				1															1:0/0
Pd																			0:0/0
Po				1															1:0/0
Pu				1															1:0/0
Ra				1															1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				1															1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

Table 7-28. Selected data properties, references and comments for the parameter cR_Lake_mammal_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Ac	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Limnic fish used as PA. La used as EA (site data available).
Ag		cR_Lake_Fish_NHB	23	7.8E–03	1.1E–01	1.1E–01	1.6E+00	5.0	GSDmax	IAEA 2010	L4	Fish data utilised in ERICA.
Am	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Bird data utilised in ERICA. Fish used as PA and La as EA (site data available).
Ba		cR_Lake_Fish_NHB	6	1.8E–03	2.5E–02	2.0E–02	3.5E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Ca		cR_Lake_Fish_NHB	6	5.0E–02	7.1E–01	4.4E–01	1.0E+01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Cd		cR_Lake_bird_NHB	1	1.6E–02	2.3E–01	2.3E–01	3.2E+00	5.0	GSDmax	ERICA	L2	Bird data utilised in ERICA.
Cl		cR_Lake_Fish_NHB	6	1.7E–03	2.4E–02	2.3E–02	3.3E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Cm	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Limnic fish used as PA. La used as EA (site data available).
Co		cR_Lake_Fish_NHB	6	1.9E–03	2.7E–02	3.6E–02	3.8E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Cs		cR_Lake_Fish_NHB	6	6.0E–02	2.1E+00	1.3E+00	3.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Eu	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Limnic fish used as PA. La used as EA (site data available).
Ho		cR_Lake_Fish_NHB	1	9.4E–04	1.3E–02	1.3E–02	1.9E–01	5.0	GSDmax	Site data LX	LX	Limnic fish used as PA. La used as EA (LX data available).
I		cR_Lake_Fish_NHB	6	3.5E–03	4.9E–02	6.9E–02	6.9E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Mo		cR_Lake_Fish_NHB	6	6.7E–04	9.5E–03	1.0E–02	1.3E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Nb		cR_Lake_Fish_NHB	6	6.2E–04	8.8E–03	1.0E–02	1.2E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Ni		cR_Lake_Fish_NHB	1	6.3E–04	8.9E–03	8.9E–03	1.3E–01	5.0	GSDmax	Site data LX	LX	Limnic fish used as PA. La used as EA (LX data available).
Np	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Limnic fish used as PA. La used as EA (site data available).
Pa	La	cR_Lake_Fish_NHB	6	7.0E–05	9.9E–04	2.6E–03	1.4E–02	5.0	GSDmax	Site data FMLX	FMLX	Limnic fish used as PA. La used as EA (site data available).

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data-Source	Comment
Pb		cR_Lake_Fish_NHB	92	2.6E–02	3.7E–01	3.7E–01	5.7E+00	5.0	GSDmax	IAEA 2010	L4	Fish data utilised in ERICA. Fish data from ICRP 2011 selected.
Pd	Ni	cR_Lake_Fish_NHB	1	6.3E–04	8.9E–03	8.9E–03	1.3E–01	5.0	GSDmax	Site data LX	LX	Limnic fish used as PA. Ni used as EA (LX data available).
Po		cR_Lake_Fish_NHB	10	1.1E–02	1.6E–01	1.6E–01	2.2E+00	5.0	GSDmax	ICRP 2011	L1	Pelagic fish data utilised in ERICA.Value for fish (from ICRP 2011) selected.
Pu			1	1.6E–02	2.3E–01	2.3E–01	3.2E+00	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Ra	Ba	cR_Lake_Fish_NHB	6	1.8E–03	2.5E–02	2.0E–02	3.5E–01	5.0	GSDmax	Site data FMLX	FMLX	Pelagic fish data utilised in ERICA. Ba used as EA (site data available).
Se		cR_Lake_Fish_NHB	6	6.7E–02	9.5E–01	7.1E–01	1.3E+01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Sm		cR_Lake_Fish_NHB	1	2.0E–04	2.8E–03	2.8E–03	3.9E–02	5.0	GSDmax	Site data LX	LX	Fish data utilised as PA as is often the case in ERICA. LX data available.
Sn	Zr	cR_Lake_Fish_NHB	4	1.7E–03	2.4E–02	6.3E–02	3.4E–01	5.0	GSDmax	Site data FMLX	FMLX	Limnic fish used as PA. Zr used as EA (site data available).
Sr		cR_Lake_Fish_NHB	6	1.1E–02	1.5E–01	1.1E–01	2.1E+00	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Tc		cR_Lake_Fish_NHB	3	2.1E–03	3.0E–02	3.0E–02	4.3E–01	5.0	GSDmax	ERICA	L2	Fish data utilised in ERICA.
Th		cR_Lake_Fish_NHB	5	5.5E–03	7.8E–02	7.8E–02	1.1E+00	5.0	GSDmax	ERICA	L2	Fish data utilised in ERICA.
U		cR_Lake_Fish_NHB	6	1.7E–05	3.0E–04	1.7E–04	7.8E–03	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.
Zr		cR_Lake_Fish_NHB	4	1.7E–03	2.4E–02	6.3E–02	3.4E–01	5.0	GSDmax	Site data FMLX	FMLX	Fish data utilised as PA as is often the case in ERICA. Site data available.

7.14 Evaluation of selected limnic CR data

There are five parameters for limnic primary producers and thirteen parameters for limnic consumers used within this study. As stated in Section 2.6.2, the approach used is to utilise site data whenever possible. Due to the restricted amount of site data for these specific parameters PAs are used in many cases. The limnic parameters with unique site data are limited to fish, filter feeders and primary producers. These parameters are used as PAs for others where site data are lacking.

In order to examine the relations between data representing limnic consumers, the data for limnic filter feeders and fishes are plotted in Figure 7-25. The correlation between these two parameters is poor, in general uptake is higher in filter feeders than in fish. This poor correlation indicate that species specific processes governs the uptake in these two animal types. The differences could possibly be due to the fact that fishes are higher in the nutrition chain and therefore the uptake is not directly proportional to water concentrations rather should be proportional to the concentrations in the biota consumed by fishes. Due to the difference between these two limnic consumers it could also be assumed that difference could exist between other consumers that are assumed to be analogues. Due to lack of data this cannot be investigated.

In Figure 7-26 and Figure 7-27 it can be seen that the uptake in primary producers correlates with the uptake in filter feeders to a higher degree than to uptake in fish. The correlation between filter feeders and primary producers is better than the correlation between fish and filter feeders. This is expected since filter feeders and aquatic plants are considered to better mirror the element concentrations of water than fish (which may be better correlated to concentrations within its food).

In Figure 7-28 the selected GM for limnic parameters are plotted and sorted by increasing CR for filter feeders. It can be seen that the CRs for filter feeders and primary producers in most element cases are similar while the CR for fish deviate in many cases. For U, Pa, Eu, Am, Ac, Cm, Po and Cd the CRs are lower for fishes than for filter feeders and primary consumers. The reason for this is not understod. Data for Pa, Eu, Am, Ac and Cm are missing so these elements are parameterised using La data as EA. When looking at the data for lanthanides an unexpected large range could be seen, (see Section 7.9). This means that the CR values for these elements are associated to a larger uncertainty and the deviating patterns seen in this figure could be due to poor data quality.

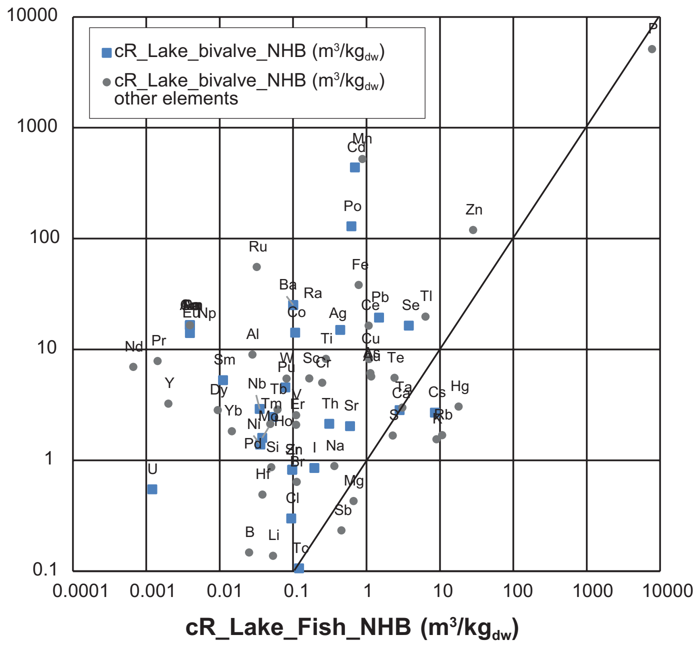


Figure 7-25. Selected GM of CR for bilvalve mollsucs (cR_Lake_Bivalve_NHB) (m^3/kg_{dw}) *plotted against the selected GM of CR for fish (cR_Lake_Fish_NHB)* (m^3/kg_{dw})*. The CR values are generally higher for the filter feeder than for fish. Blue squares represent elements included in the safety assessment whereas gray dots represent other elements.*

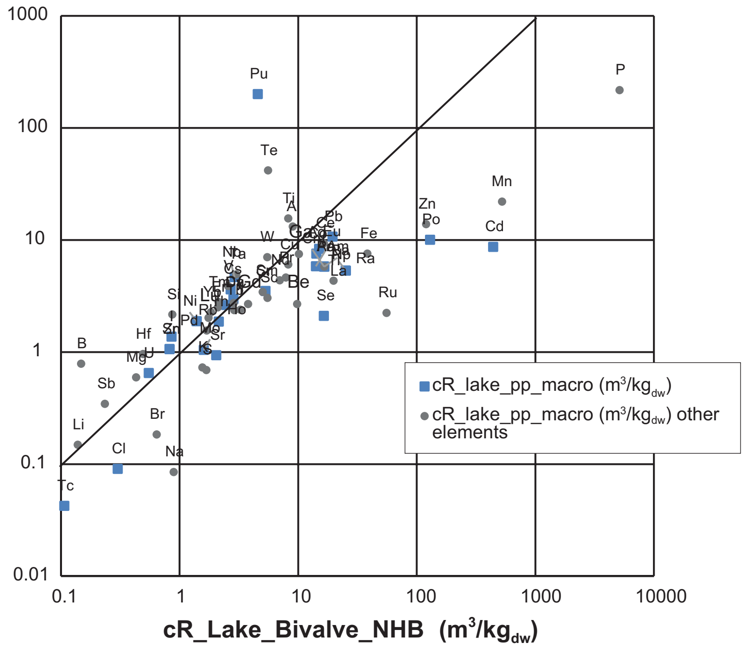


Figure 7-26. *The selected GM of CR for limnic primary producers (cR_lake_pp_macro) (m^3/kg_{dw}) plotted against the GM of CR for limnic filter feeders (cR_Lake_Bivalve_NHB) (m^3/kg_{dw}) show good correlation for most of the elements. Blue squares represent elements included in the safety assessment whereas gray dots represent other elements.*

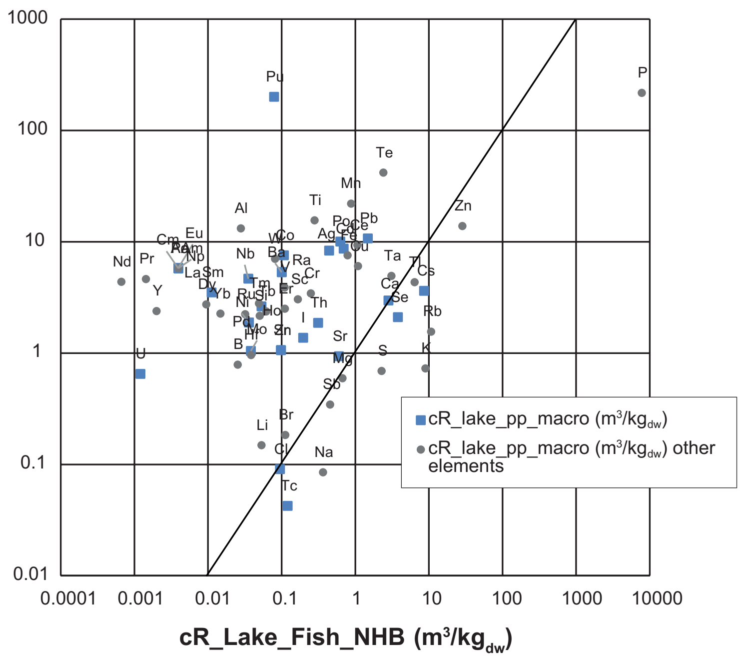


Figure 7-27. *Selected GM of CR for limnic primary producers (cR_Lakr_pp) (m^3/kg_{dw}) plotted against the selected GM of CR for limnic fish (cR_Lake_Fish_NHB) (m^3/kg_{dw}). The CR values are in general higher in the limnic primary producers. Blue squares represent elements included in the safety assessment whereas gray dots represent other elements.*

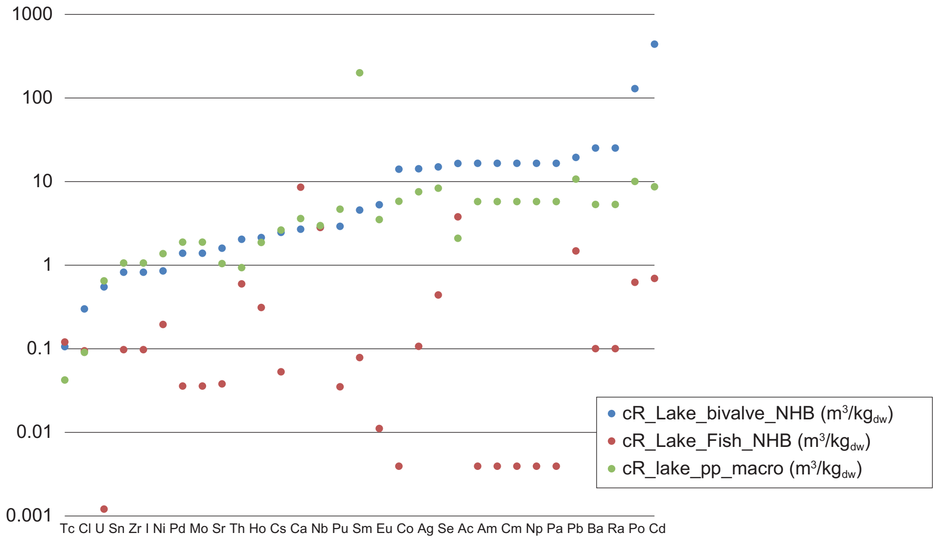


Figure 7-28. *CR for limnic primary producers (cR_lake_pp_macro), filter feeders (cR_Lake_bivalve_NHB) and fish (cR_Lake_Fish_NHB) sorted by uptake in filter feeders. The CR for fish differs from primary producers and filter feeders in general and in particular for U, Pa, Ac, Am and Cm.*

8 Selected CR for the marine ecosystem

This chapter comprise the selected parameter values utilised to parameterise marine biota in the radionuclide dose model, together with the considerations and assumptions behind the selections. The uptake in the marine biota is assessed by using CR values, which relate concentrations in surrounding sea water to concentrations in biota. The transport of radionuclides is related to the flow of carbon in the environment in this safety assessment and, therefore, the CR values are based on carbon content and given in the unit of m^3/kg_C. Because of technical reasons, the CR values utilised for dose assessment to non-human biota are based on fresh weight concentrations and are given in the unit m^3/kg_{fw}. Conversions between the different units are described in Section 4.2.3.

In the radionuclide model, the marine biota are divided into several compartments, representing both primary producers and consumers. The primary producers are divided into 3 functional groups: phytoplankton, microphytobenthos and macroalgae/macrophytes

For calculation of dose to non-human biota, the organism groups identified as reference organisms in the ERICA tool (Beresford et al. 2007) are utilised. For the marine environment, phytoplankton, macroalgae and vascular plants are considered representative primary producers, and the representative fauna encompass zooplankton, benthic molluscs, polychaete worms, crustaceans, benthic and pelagic fish, birds and mammals.

The only marine biota assumed to be consumed by humans in this safety assessment is marine fish and the element uptake in marine fish is calculated by using CR values based on muscle tissue concentrations (edible part). For estimation of dose to marine fish it self, CR values based on whole body concentrations are utilised.

Biota data from FM and LX are coupled with sea water samples from the corresponding sites. The same set of water samples are utilised to calculate CRs for all marine biota types. Therefore, these samples are presented here, while the various marine biota samples are described in more detail in the respective subsections that follow. Sea water concentrations have been measured at FM and LX on two occasions (Engdahl et al. 2008, Kumblad and Bradshaw 2008). There are 3 samples each from FM and LX reported in Engdahl et al. (2008) while an additional 6 FM samples are reported in Kumblad and Bradshaw (2008). Of the latter samples, 3 indicate unrealistic concentrations for several elements and are considered artefacts and therefore excluded from the dataset. The selected samples have been analysed after filtering, which makes them suitable for use in CR calculations as elements associated to the particulate phase are not considered available for uptake in biota. In addition to these samples, a large number of samples are available from SKB's monitoring program. These samples are not utilised, since all elements of interest were not analysed in the monitoring program. The monitoring data are used as supporting data and a comparison of the selected water samples and the monitoring show that data are consistent.

Available and selected CR data for marine biota are presented and discussed in following subsections.

Abbreviations used in the tables and figures in this chapter are explained in Table 8-1.

Table 8-1. Abbreviations used in the tables of this chapter.

Abbrevation	Description
FM N (from/to)	Number of samples in FM site data. Number of independent samples in denominator (from) and numerator (to) of the ratio.
LX N (from/to)	Number of samples in LX site data. Number of independent samples in denominator (from) and numerator (to) of the ratio.
FMLX (from/to)	Number of samples in FMLX site data. Number of independent samples in denominator (from) and numerator (to) of the ratio.
L1 N, L2 N, L3 N, L4 N	Number of samples for literature source L1, L2, L3, L4, respectively.
FM GSD, LX GSD, FMLX GSD	Geometric standard deviation of site data from FM, LX and FMLX.
L1 GSD, L2 GSD, L3 GSD, L4 GSD	Geometric standard deviation for literature source L1, L2, L3 and L4.
SC FM	Sense check comparing ranges for FM site data and literature data.
SC LX	Sense check comparing ranges for LX site data and literature data.
SC FMLX	Sense check comparing ranges for FMLX site data and literature data.
SC FMvsLX	Sense check comparing ranges for FM and LX data.
SC Lit	Sense check comparing ranges for literature data sources.

8.1 cR_sea_pp_macro, cR_Sea_pp_macro_NHB, cR_Sea_pp_vasc_NHB

The cR_sea_pp_macro parameter reflects the net uptake of elements from sea water in marine primary producers as defined in the radionuclide model (Saetre et al. 2013). The cR_Sea_pp_macro_NHB and cR_Sea_pp_vasc_NHB are utilised for dose calculation to marine macroalgae and vascular plants, respectively.

The marine macroalgae and vascular plants in the future ecosystem of FM are assumed to be similar to the population existing in the present day FM and LX areas. The selected site data for marine macroalgae and vascular plants are from a wide variety of marine primary producers: *Chara sp*. (stonewort), filamentous green algae, *Fucus vesiculosus* (bladder wrack), microphytobenthos, phytoplankton, *Pilayella littoralis* (sea felt), *Potamogeton pectinatus* (fennel pondweed) from both LX and FM area. The samples represent different functional groups, though merged into 1 group to calculate CRs for marine primary producers in order to gain a larger number of samples. These marine primary producer samples are combined with the selected sea water samples, which are utilised for calculating of all marine CR. Site data are available for Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Sr, Th, U and Zr.

The average element concentrations in marine primary producers sampled from FM and LX are displayed in Figure 8-1. The concentrations ranges between spieces are one order of magnitude in most element cases, spanning up to 3 orders of magnitude at most. The range is especially high for the elements with low concentrations, especially the group of lanthanides. The measured lanthanide concentrations are higher in LM samples and a large difference between LM spices can be seen for these elements. For elements with high concentration the opposite pattern can be seen, with low concentrations for LM samples. The reasons for these patterns are not understood. No strict pattern concerning species with generally higher or lower concentrations is noticed. The number of samples for each species is very low (n=2–4), hence it was considered insufficient to separate the data in to smaller units. All site data concerning marine primary producers are utilised together in the parameterisation, leading to generally large ranges in calculated CRs (see text below).

There are a few sources of representative literature data: CR data for brown seaweed are reported for Ag, Am, Cd, Cm, Co, Cs, Nb, Ni, Np, Pb, Pu, Sr, Tc, U and Zr in ICRP (2011), and data for macroalgae are reported for Ag, Am, Cd, Cl, Co, Cs, Eu, I, Nb, Ni, Np, Pb, Pd, Po, Pu, Ra, Se, Sr, Tc, Th, U and Zr in ERICA (Hosseini et al. 2008). ERICA (Hosseini et al. 2008) also reported data on marine vascular plants, though these data are in most cases identical to the data for macroalgae and, therefore, not an additional literature source. Data for brown seaweed in ICRP (2011) are classified as L1 data, while data in ERICA (Hosseini et al. 2008) are classified as L2 data.

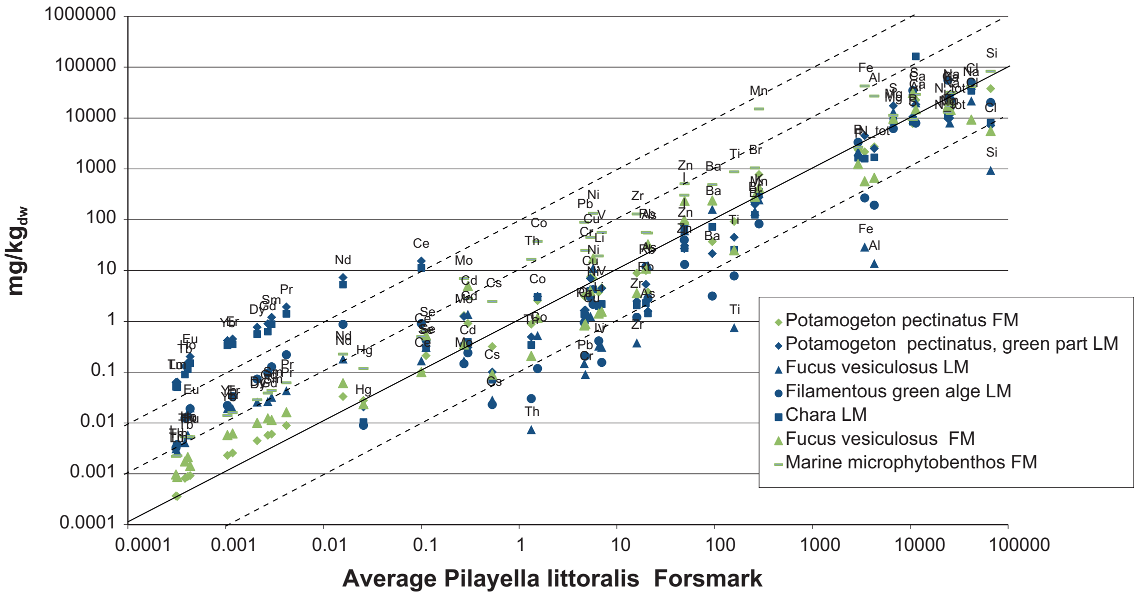


Figure 8-1. *Element concentration in marine primary producers sampled in FM and LX. Average concentration per species plotted against the concentration for Pilayella littoralis FM.*

The same data sets are utilised for the 3 parameters: cR_sea_pp_macro, cR_Sea_pp_macro_NHB and cR_Sea_pp_vasc_NHB, and the available data are plotted in Figure 8-2 and listed in Table 8-2. In cases where both FM and LX data are available, the data correlate well (more than 50% overlap) for the elements: Ba, Ca, Cd, Cl, Co, I, Mo, Pb, Se and Sm. The overlap is less than 50% for Cs, Eu, Ho, Ni, Th and Zr. In cases where FM data and literature data are available (Cd, Cl, Co, Cs, Eu, I, Ni, Pb, Se, Th and Zr) the compared data sets do not correlate well for all elements except for I (Table 8-2). For Pb, where a large GSD (13) is reported for FM data, the range includes the literature range. When LX data are compared to literature data, they correlate better though still poor for the elements Cd, Cl, Nb, and Se. For Th, U and Zr, the reported range of LX data are wider than the literature data range. When FMLX data are compared with literature data, the data show overlap for I, Pb, Sr, U and Eu. For Cl, Se, Cd, Co, Zr, Th, Cs, Co, Nb and Ni, FMLX data deviate from literature data and the former are higher than the literature data range. When data are available in both ICRP (2011) and ERICA (Hosseini et al. 2008), the literature data are consistent in all cases (see Table 8-2).

Reported GSDs are low (less than 2) for the elements U, Zr, Np, Pb, Sr in ICRP (2011) and Cl, Ra, Np, Tc, Eu in ERICA (Hosseini et al. 2008), while reported FM and LX GSDs are generally higher. The GSDs are especially high in some cases. ICRP (2011) and ERICA (Hosseini et al. 2008) reported high GSD values for Cs and site data GSD values are high for Co, Eu, Ho, Sm, Pb, Th and Zr.

Literature data as well as FM and LX data are not consistent for many of the modelled elements, which indicates that element uptake by marine primary producers is not represented well by the available data. The available data are based on different types of marine primary producers. The data are from the brackish Baltic Sea as well as from other, more saline waters, and therefore, an inconsistency between data sources can be expected.

As seen in Figure 8-2, the CR values are low for elements existing in high concentrations in sea water. The CR values are high for elements such as Zr and Hf, and these elements are known to be immobile and found associated to colloids and organic matter. They are not expected to be taken up by primary producers; the high CR values are probably an indication of adsorption (i.e. adhesion of colloids on the surface of the primary producers) rather than an uptake into the cells of the algae/vascular plant. The adsorption may contribute to human uptake and to dose to non-human biota.

The selected data for cR_sea_pp_macro are listed in Table 8-3 and plotted in Figure 8-3. The selected data for cR_Sea_pp_macro_NHB and cR_Sea_pp_vasc_NHB are presented in Table 8-4 and these data are identical to the data in Table 8-3 though they are presented in the unit of m^3/kg_{fw}.

Site data are selected for the elements: Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Th, U and Zr. (LX data alone are selected for Nb, Sn, Sr and U). In some cases, site data are insufficient and suitable EAs are selected. PAs are not utilised for this parameter. Ac data are missing though data on Am and Cm are reported in ICRP (2011) and ERICA (Hosseini et al. 2008). Site data for the lanthanides are suitable for parameterisation, as the lanthanides are assumed to be analogues to these elements (see Section 2.7) FMLX data are available for Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Tb, Tm and Yb. Nd is selected as EA for Ac, Am and Cm, since Nd is the lanthanide with the highest number of reported observations. FMLX data for Nd are 1 order of magnitude higher than literature data for Am, while the reported literature data for Cm are 1 order of magnitude higher than for Am.

Data are not available for Pa and FMLX data for Nd are utilised as EA (see Section 2.7). Data on Nd are also uses as EA for Np since no site data are available. Data are not available for Pd and FMLX data for Ni are selected. ERICA (Hosseini et al. 2008) reports 7 observations for Ra. Ba is assumed to be a suitable EA for Ra in marine environments (see Section 2.7), and FMLX data for Ba are utilised. The literature data for Ra are within the range of Ba FMLX data, which supports the use of Ba.

Literature data are utilised for elements where neither site data nor suitable EA site data are available. Data from ICRP (2011) are utilised for Ag, Pu and Tc, and ERICA (Hosseini et al. 2008) data are selected for Po.

The selected GMs span over 4 orders of magnitude, from 0.04 m^3/kg_C for Cl to 487 m^3/kg_C for Tc. A relatively high element uptake is indicated for Pb, Cd, Co, Zr, Pa, Th and Tc, while a relatively low uptake is indicated for Cl, Ca and Np.

The reported sample number for Sr, Sn, Nb and U are low (n=3) and GSDmax is assigned to these parameters. The reported GSDs are less than GSDmean (3) for Cl, Ca, Po, I, Se, Pu and Tc, and a more appropriate GSD (GSDmean) is set, using the conditions stated in Section 4.3.

The selected GM is lower (less than 50%) than the selected BE for Ho, Sm, Eu, Ac, Np and Am and higher (higher than 50%) for Ba, Ra, Co, Cs, Zr, Pa and Th. The difference between GM and BE is small (less than 50%) for Cd, Pb, Cl, Mo, I, Ni, Pd, Ca and Se. The selected BE and GM are identical for Ag, Nb, Po, Pu, Sn, Sr Tc and U.

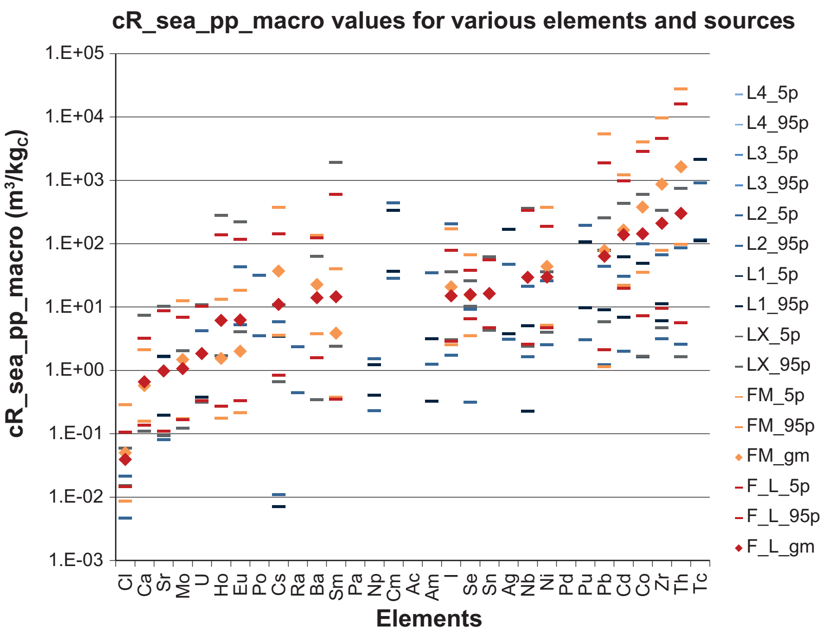


Figure 8-2. *Total available data ranges for the parameter cR_sea_pp_macro (m^3/kg_C). The elements are arranged in the same order as elements in figure Figure 8-3 showing selected parameter values.*

Table 8-2. All available data for the parameters cR_sea_pp_macro, cR_Sea_pp_macro_NHB and cR_Sea_pp_vasc_NHB, the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ICRP 2011 brown Seaweed Sea water, L2 = ERICA Macroalgea Seawater.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				10	16						3.2	2.3							2:1/1
Am				33	15						2.0	2.7							2:1/1
Ba	6/14	3/12	9/26					3.0	4.9	3.8								S2(U78%)	0:0/0
Ca	6/14	3/12	9/26					2.2	3.6	2.6								S1	0:0/0
Cd	6/14	3/12	9/26	6	63			3.4	2.5	3.3	2.0	2.3			S2(U26%)	S2(U36%)	S2(U29%)	S2(U74%)	2:1/1
Cl	5/8	3/12	8/20		35			2.9	1.5	1.8		1.6			S2(U25%)	S2(U24%)	S2(U18%)	S3	1:0/0
Cm				13	23						2.0	2.3							2:1/1
Co	4/14	3/12	7/26	62	72			4.2	6.0	6.1	2.8	3.4			S2(U21%)	S2(U69%)	S2(U43%)	S2(U60%)	2:1/1
Cs	3/14	3/12	6/26	410	579			4.1	2.3	4.8	6.6	6.8			S2(U10%)	S2(U78%)	S2(U37%)	S2(U23%)	2:1/1
Eu	3/11	2/12	5/23		4			3.9	3.4	6.0		1.9			S2(L28%)	S3	S3	S2(L34%)	1:0/0
Ho	3/11	3/12	6/23					3.7	4.7	6.7								S2(L47%)	0:0/0
I	5/8	3/12	8/20		62			3.6	2.1	2.7		4.3			S1	S1	S1	S3	1:0/0
Mo	6/14	3/12	9/26					3.7	2.4	3.1								S2(U57%)	0:0/0
Nb		3/12	3/12	3	20				4.6	4.4	2.6	2.2				S2(U43%)	S2(U43%)		2:1/1
Nd	6/14	3/12	9/26					4.2	7.7	7.4								S2(L68%)	0:0/0
Ni	6/14	3/12	9/26	2	14			3.7	2.0	3.1		2.0			S2(U37%)	S2(U85%)	S2(U46%)	S2(U45%)	2:0/0
Np				47	52						1.4	1.8							2:1/1
Pa																			0:0/0
Pb	6/14	3/12	9/26	5	54			13.0	3.1	7.9	1.9	3.0			S3	S2(U68%)	S2(U53%)	S3	2:1/1
Pd																			0:0/0
Po					13							2.0							1:0/0
Pu				146	225						2.1	3.5							2:1/1
Ra					7							1.7							1:0/0
Se	4/12	3/12	7/24		35			2.5	1.3	1.7		2.8			S2(U32%)	S4	S2(U19%)	S3	1:0/0
Sm	3/14	3/12	6/26					4.1	7.6	9.6								S2(L60%)	0:0/0
Sn		3/11	3/11						2.3	2.1									0:0/0
Sr		3/12	3/12	40	97				4.2	3.8	1.9	2.5				S2(U61%)	S2(U62%)		2:1/1
Tc				166	124						2.5	1.9							2:1/1
Th	3/14	3/11	6/25		6			5.6	6.4	11.3		2.9			S4	S3	S2(U34%)	S2(U35%)	1:0/0
U		3/12	3/12	17	33				2.9	2.8	1.0	2.2				S3	S2(U74%)		2:1/1
Zr	3/14	3/12	6/26	3	44			4.3	3.7	6.5	1.2	2.5			S4	S2(U62%)	S2(U31%)	S2(U30%)	2:1/1

Table 8-3. Selected data properties, references and comments for the parameter cR_sea_pp_macro (m^3/kg_C) for the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Nd		9	5.4E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSD	Site data FMLX	FMLX	Nd used as analogue.
Ag			10	3.8E+00	2.5E+01	2.5E+01	2.0E+02	3.2	GSD	ICRP 2011	L1	No site data available. ICRP reported (n=10) a wider range of data than ERICA (n=16). ICRP is the latest updated literature source so these data are selected.
Am	Nd		9	5.4E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSD	Site data FMLX	FMLX	Nd used as analogue.
Ba			9	3.2E–01	1.4E+01	2.3E+01	2.3E+02	3.8	GSD	Site data FMLX	FMLX	FM and LX data overlap.
Ca			9	1.1E–01	6.6E–01	5.8E–01	9.3E+00	3.0	GSDmean	Site data FMLX	FMLX	FM and LX data overlap. Ba data are much higher than Ca data.
Cd			9	2.0E+01	1.4E+02	1.6E+02	1.5E+03	3.3	GSD	Site data FMLX	FMLX	FM and LX data overlap. Reported literature data ICRP (n=6) and ERICA (n=63) lower than site data. Site data selected.
Cl			8	6.5E–03	3.9E–02	5.0E–02	2.4E–01	3.0	GSDmean	Site data FMLX	FMLX	The range of LX data falls within the range of FM data. ERICA presented data that were derived using general seawater concentrations, these data are not considered reliable. Site data selected.
Cm	Nd		9	5.4E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSD	Site data FMLX	FMLX	Nd used as analogue.
Co			7	1.4E+00	1.4E+02	3.8E+02	1.6E+04	6.1	GSD	Site data FMLX	FMLX	FM and LX data consistent.
Cs			6	5.0E–01	1.1E+01	3.7E+01	5.0E+02	4.8	GSD	Site data FMLX	FMLX	FM data have a wide range in comparison to LX data. Literature data on Cs reported by ICRP and ERICA (n=410 and n=579), respectively. Literature data and site data overlap. Site data selected.
Eu			5	2.3E–01	6.2E+00	2.0E+00	1.6E+02	6.0	GSD	Site data FMLX	FMLX	FM data higher than LX data. Eu correlates well with Ho and Sm site data.
Ho			6	2.2E–01	6.1E+00	1.5E+00	2.4E+02	6.7	GSD	Site data FMLX	FMLX	FM data higher than LX data. Ho correlates well with Eu and Sm site data.
I			8	1.9E+00	1.5E+01	2.1E+01	2.5E+02	3.0	GSDmean	Site data FMLX	FMLX	FM data and LX data similar. Data reported by ERICA (n=62) have a wide range. Site data selected.
Mo			9	1.7E–01	1.1E+00	1.5E+00	4.1E+01	3.1	GSD	Site data FMLX	FMLX	FM data and LX data similar.
Nb			3	1.9E+00	2.9E+01	2.9E+01	4.1E+02	5.0	GSDmax	Site data LX	LX	No FM data available. LX data range wide and overlap the literature range. LX data selected.
Ni			9	3.7E+00	3.0E+01	4.4E+01	1.4E+03	3.1	GSD	Site data FMLX	FMLX	FM data range higher than LX data and literature data ranges. Site data selected.
Np	Nd		9	5.4E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSD	Site data FMLX	FMLX	Nd used as analogue.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Pa	Nd		9	5.4E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSD	Site data FMLX	FMLX	Nd used as analogue.
Pb			9	3.7E–01	6.3E+01	7.8E+01	3.2E+04	7.9	GSD	Site data FMLX	FMLX	The FM data range is wide and both LX and literature data are within this range. Site data.
Pd	Ni		9	3.7E+00	3.0E+01	4.4E+01	1.4E+03	3.1	GSD	Site data FMLX	FMLX	Ni used as EA.
Po			13	9.2E–01	1.1E+01	1.1E+01	6.4E+01	3.0	GSDmean	ERICA	L2	ERICA reports (n=13) data on marine macroalgae.
Pu			146	4.3E+00	3.2E+01	3.2E+01	2.0E+02	3.0	GSDmean	ICRP 2011	L1	A large number of observations reported in ICRP (n=146) and ERICA (n=225). The data overlap. ICRP 2011 selected.
Ra	Ba		9	3.2E–01	1.4E+01	2.3E+01	2.3E+02	3.8	GSD	Site data FMLX	FMLX	Ba used as analogue.
Se			7	2.6E+00	1.6E+01	1.5E+01	9.6E+01	3.0	GSDmean	Site data FMLX	FMLX	FM data overlap with LX and literature data. ERICA data (n=35) lower than site data. Site data selected.
Sm			6	3.5E–01	1.5E+01	3.9E+00	2.8E+03	9.6	GSD	Site data FMLX	FMLX	FM data higher than LX data. Sm correlate well with Eu and Ho site data.
Sn			3	1.2E+00	1.6E+01	1.6E+01	2.3E+02	5.0	GSDmax	Site data LX	LX	Only LX data available. LX data selected.
Sr			3	6.9E–02	9.8E–01	9.8E–01	1.4E+01	5.0	GSDmax	Site data LX	LX	No FM data available. The range for LX data wider than ICRP data (n=40) and narrower than ERICA data (n=97).
Tc			166	8.0E+01	4.9E+02	4.9E+02	5.6E+03	3.0	GSDmean	ICRP 2011	L1	High value. Tc is known to accumulate in brown algae but not in green and red. Data from brown seaweed reported by ICRP (n=166) are utilized.
Th			6	1.4E+00	3.0E+02	1.6E+03	8.5E+04	11.3	GSD	Site data FMLX	FMLX	FM data high in comparison to ERICA and LX data (no overlap). LX data range overlap ERICA data range. Site data selected. GSD exceeds GSDmax.
U			3	1.3E–01	1.8E+00	1.8E+00	2.6E+01	5.0	GSDmax	Site data LX	LX	No FM data available. Data reported by ICRP (n=17) and ERICA (n=33) overlap. LX data overlap the whole range of literature data. LX data selected.
Zr			6	2.8E+00	2.1E+02	8.6E+02	1.7E+04	6.5	GSD	Site data FMLX	FMLX	FM data do not overlap with LX data or literature data. LX data overlap literature data range. Site data selected.

Table 8-4. Selected data properties, references and comments for the parameters cR_Sea_pp_macro_NHB and cR_Sea_pp_vasc_NHB (m^3/kg_{fw}) and the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Ag			10	2.9E–01	1.9E+00	1.9E+00	1.5E+01	3.2	GSD	ICRP 2011	L1	Data for macroalgae lower than phytoplankton data. The former are considered more relevant for this parameter. Data from ICRP have a wider range and are utilised.
Am	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Ba		cR_sea_pp_macro	9	1.7E–02	6.1E–01	9.3E–01	8.6E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Ca		cR_sea_pp_macro	9	2.0E–03	2.9E–02	2.4E–02	4.1E–01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Cd		cR_sea_pp_macro	9	4.3E–01	6.0E+00	6.7E+00	8.5E+01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Cl		cR_sea_pp_macro	8	1.2E–04	1.7E–03	1.8E–03	2.3E–02	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Cm	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Co		cR_sea_pp_macro	7	6.9E–02	6.4E+00	1.6E+01	4.3E+02	6.1	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Cs		cR_sea_pp_macro	6	2.6E–02	4.9E–01	1.5E+00	1.1E+01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Eu		cR_sea_pp_macro	5	1.1E–02	3.0E–01	9.2E–02	8.7E+00	6.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. FM data higher than LX data. Eu correlates well with Ho and Sm site data.
Ho		cR_sea_pp_macro	6	1.0E–02	2.9E–01	7.1E–02	1.3E+01	6.7	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
I		cR_sea_pp_macro	8	4.5E–02	6.3E–01	7.6E–01	8.9E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Mo		cR_sea_pp_macro	9	3.3E–03	4.7E–02	6.1E–02	1.1E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Nb		cR_sea_pp_macro	3	1.0E–01	1.5E+00	1.5E+00	2.1E+01	5.0	GSDmax	Site data LX	LX	All marine primary producers merged into 1 group.
Ni		cR_sea_pp_macro	9	9.2E–02	1.3E+00	1.8E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.

Ele-ment	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Np	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSD	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Pa	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Pb		cR_sea_pp_macro	9	2.2E–02	2.8E+00	3.2E+00	8.5E+02	7.9	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. GSD exceeds GSDmax. Large variation in water concentration. No obvious errors found.
Pd	Ni	cR_sea_pp_macro	9	9.2E–02	1.3E+00	1.8E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Ni used as EA (site data available).
Po			13	7.0E–02	8.0E–01	8.0E–01	4.9E+00	3.0	GSDmean	ERICA	L2	Validation not relevant, due to different organisms.
Pu			146	3.3E–01	2.4E+00	2.4E+00	1.5E+01	3.0	GSDmean	ICRP 2011	L1	Data from different sources defer, phytoplankton data much higher. ICRP data for sea weed are considered more relevant since it is the latest updated data source.
Ra	Ba	cR_sea_pp_macro	9	1.7E–02	6.1E–01	9.3E–01	8.6E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Ba used as EA (site data available).
Se		cR_sea_pp_macro	7	4.9E–02	6.9E–01	6.2E–01	9.8E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Sm		cR_sea_pp_macro	6	1.6E–02	6.5E–01	1.6E–01	1.5E+02	9.6	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.FM data higher than LX data. Sm correlates well with Eu and Ho site data. The higher values in LX data are probably due to poor detection limits in the analysis conducted.
Sn		cR_sea_pp_macro	3	5.7E–02	8.1E–01	8.1E–01	1.1E+01	5.0	GSDmax	Site data LX	LX	All marine primary producers merged into 1 group.
Sr		cR_sea_pp_macro	3	3.4E–03	4.8E–02	4.8E–02	6.8E–01	5.0	GSDmax	Site data LX	LX	All marine primary producers merged into 1 group.
Tc			166	6.1E+00	3.7E+01	3.7E+01	4.3E+02	3.0	GSDmean	ICRP 2011	L1	Data from different sources defer, phytoplankton data much lower. ICRP data for sea weed was considered more relevant since it is the latest updated data.
Th		cR_sea_pp_macro	6	7.7E–02	1.3E+01	6.8E+01	1.7E+03	11.3	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. The GSD of site data exceeds GSDmax due to pooling of FM and LX data.
U		cR_sea_pp_macro	3	6.5E–03	9.1E–02	9.1E–02	1.3E+00	5.0	GSDmax	Site data LX	LX	All marine primary producers merged into 1 group.
Zr		cR_sea_pp_macro	6	1.5E–01	9.4E+00	3.6E+01	3.9E+02	6.5	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.

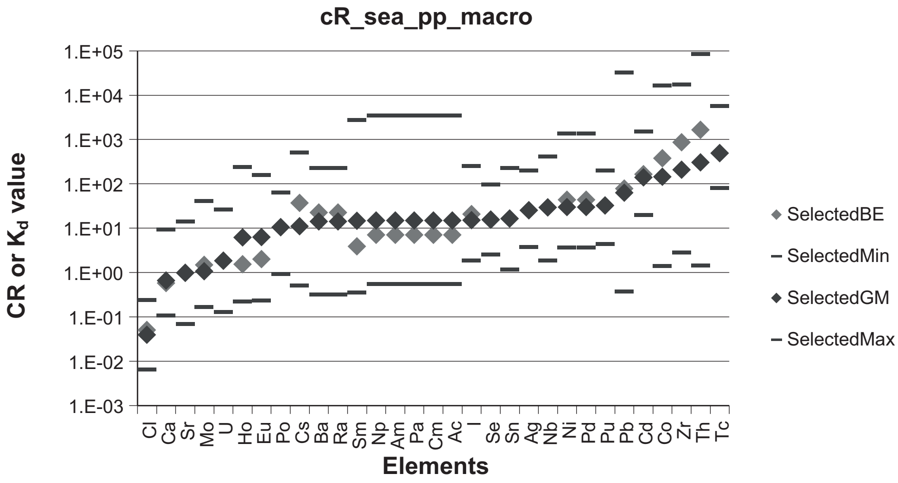


Figure 8-3. Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_C).

8.2 cR_sea_pp_plank, cR_Sea_pp_plank_NHB

The compartment representing the marine phytoplankton is assumed to consist of pelagic phytoplankton (Saetre et al. 2013). The parameters cR_sea_pp_plank and cR_Sea_pp_plank_NHB are identical. The cR_Sea_pp_plank_NHB is utilised for dose calculation to phytoplankton.

FM data on phytoplankton are available for some elements though the reported sample number is small (2 or 3), hence, these data are not considered usable for parameterisation. The phytoplankton samples are included in the site data set utilised for cR_sea_pp_macro, together with samples of marine macroalgae, macrophytes, vascular plants and microphytobenthos. In addition to site data, ERICA (Hosseini et al. 2008) reported data on marine phytoplankton for Ag, Am, Cd, Cl, Cm, Cs, Eu, I, Nb, Ni, Np, Pb, Po, Pu, Ra, Se, Sr, Tc, Th, U and Zr. The number of observations varies from 1 (Cl, Eu, I, Nb and Ni) to 94 (Se). The available data are presented in Table 8-5 and in Figure 8-4.

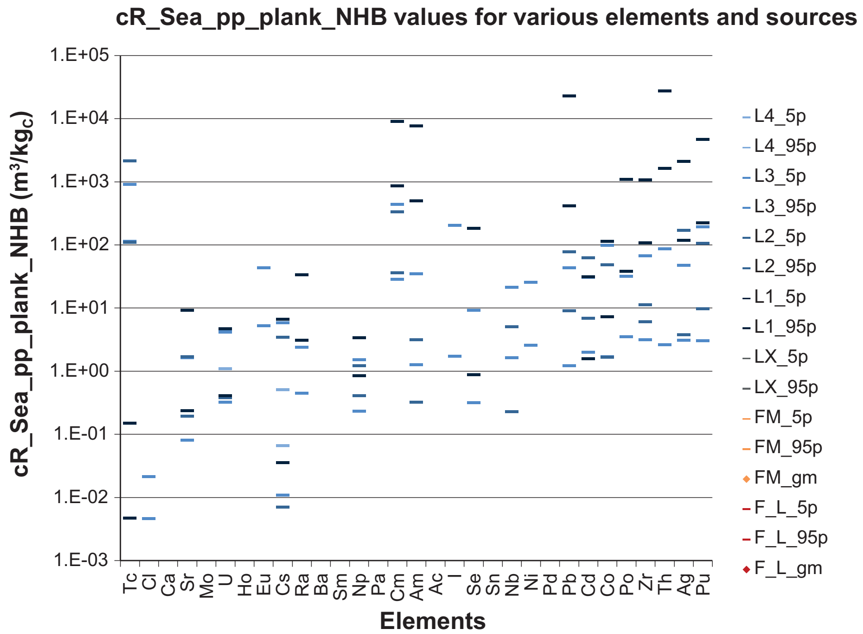


Figure 8-4. Total available data ranges for the parameter cR_Sea_pp_plank_NHB (m^3/kg_C). The elements are arranged in the same order as in Figure 8-5 showing selected parameter values.

A comparison of data cannot be made since only one source contained data on phytoplankton. When site data for macroalgae/macrophytes are compared to literature data for phytoplankton, most of the elements show major discrepancies. There are substantial variations of element concentrations in different marine primary producers from FM and LX, though a pattern is not clear. Due to the small number of samples for each functional group, it is considered better to use all site data together rather than to divide it into smaller entities, see Section 8.1.

The selected data for cR_sea_pp_plank are presented in Table 8-6 and for cR_Sea_pp_plank_NHB in Table 8-7. The selected data for these two parameters are identical, though cR_Sea_pp_plank_NHB data are presented in the unit m^3/kg_{fw} and cR_sea_pp_plank data are presented in m^3/kg_C. For elements where site data for marine primary producers are available or suitable EAs with site data are available, these data are selected. For elements where neither site data nor suitable EAs are available, phytoplankton data in ERICA (Hosseini et al. 2008) are utilised. The selected data for phytoplankton are in most cases identical to the data used for marine macroalgea/macrophytes (cR_sea_pp_macro), except for Ag, Po, Pu and Tc, where the selected data for phytoplankton differ. In all these cases, site data are not available and ERICA data for phytoplankton are utilised.

Table 8-5. Available data for marine phytoplankton. Site data are available for marine macroalgae/macrophytes and for LI = ERICA marine phytoplankton.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				8							2.4								1:0/0
Am				15							2.3								1:0/0
Ba	6/3		6/3					1.2		1.2									0:0/0
Ca	6/3		6/3					1.1		1.1									0:0/0
Cd	6/3		6/3	56				1.3		1.3	2.5				S4		S4		1:0/0
Cl	5/2		5/2	1				1.0		1.0									1:0/0
Cm				5							2.0								1:0/0
Co	4/3		4/3	22				1.4		1.4	2.3				S4		S4		1:0/0
Cs	3/3		3/3	21				1.3		1.3	4.9				S4		S4		1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I	5/2		5/2	1				1.6		1.6									1:0/0
Mo	6/3		6/3					1.1		1.1									0:0/0
Nb				1															1:0/0
Ni	6/3		6/3	1				1.4		1.3									1:0/0
Np				12							1.5								1:0/0
Pa																			0:0/0
Pb	6/3		6/3	35				6.7		6.7	3.4				S2 (L42%)		S2 (L42%)		1:0/0
Pd																			0:0/0
Po				18							2.8								1:0/0
Pu				52							2.5								1:0/0
Ra				10							2.1								1:0/0
Se	4/3		4/3	94				1.4		1.4	5.1				S1		S1		1:0/0
Sm	3/3		3/3					1.4		1.4									0:0/0
Sn																			0:0/0
Sr				27							3.1								1:0/0
Tc				14							2.9								1:0/0
Th	3/3		3/3	25				1.3		1.3	2.4				S1		S1		1:0/0
U				8							2.1								1:0/0
Zr	3/3		3/3	4				1.1		1.1	2.0				S4		S4		1:0/0

Table 8-6. Selected data properties, references and comments for the parameter cR_sea_pp_plank (m^3/kg_C) and the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Nd	cR_sea_pp_macro	9	6.3E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSDmax	Site data FMLX	FMLX	Nd data for cR_sea_pp_macro used as Ea and PA.
Ag			8	8.2E+01	5.0E+02	5.0E+02	3.1E+03	3.0	GSDmean	ERICA	L1	ERICA data used.
Am	Nd	cR_sea_pp_macro	9	6.3E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSDmax	Site data FMLX	FMLX	Nd for cR_sea_pp_macro used as analogue.
Ba		cR_sea_pp_macro	9	3.2E–01	1.4E+01	2.3E+01	2.3E+02	5.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Ca		cR_sea_pp_macro	9	4.7E–02	6.6E–01	5.8E–01	9.3E+00	5.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Cd		cR_sea_pp_macro	9	9.8E+00	1.4E+02	1.6E+02	2.0E+03	5.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Cl		cR_sea_pp_macro	8	2.8E–03	3.9E–02	5.0E–02	5.6E–01	5.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Cm	Nd	cR_sea_pp_macro	9	6.3E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSDmax	Site data FMLX	FMLX	Nd for cR_sea_pp_macro used as analogue.
Co		cR_sea_pp_macro	7	1.4E+00	1.4E+02	3.8E+02	1.6E+04	6.1	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Cs		cR_sea_pp_macro	6	5.0E–01	1.1E+01	3.7E+01	5.0E+02	5.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Eu		cR_sea_pp_macro	5	2.3E–01	6.2E+00	2.0E+00	1.6E+02	6.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Ho		cR_sea_pp_macro	6	2.2E–01	6.1E+00	1.5E+00	2.4E+02	6.7	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
I		cR_sea_pp_macro	8	1.1E+00	1.5E+01	2.1E+01	2.5E+02	5.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Mo		cR_sea_pp_macro	9	7.6E–02	1.1E+00	1.5E+00	4.1E+01	5.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Nb		cR_sea_pp_macro	3	1.9E+00	2.9E+01	2.9E+01	4.1E+02	5.0	GSDmax	Site data LX	LX	cR_sea_pp_macro used as analogue.
Ni		cR_sea_pp_macro	9	2.1E+00	3.0E+01	4.4E+01	1.4E+03	5.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Np	Nd	cR_sea_pp_macro	9	6.3E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSDmax	Site data FMLX	FMLX	Nd data for cR_sea_pp_macro used as Ea and PA.
Pa	Nd	cR_sea_pp_macro	9	6.3E–01	1.5E+01	7.0E+00	3.4E+03	7.4	GSDmax	Site data FMLX	FMLX	Nd data for cR_sea_pp_macro used as analogue.
Pb		cR_sea_pp_macro	9	3.7E–01	6.3E+01	7.8E+01	3.2E+04	7.9	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Pd	NI	cR_sea_pp_macro	9	2.1E+00	3.0E+01	4.4E+01	1.4E+03	5.0	GSDmax	Site data FMLX	FMLX	Ni data for cR_sea_pp_macro used.
Po			18	3.3E+01	2.0E+02	2.0E+02	1.6E+03	3.0	GSDmean	ERICA	L1	ERICA data used.
Pu			52	5.3E+00	1.0E+03	1.0E+03	8.3E+03	3.0	GSDmean	ERICA	L1	ERICA data used.
Ra	Ba	cR_sea_pp_macro	9	3.2E–01	1.4E+01	2.3E+01	2.3E+02	5.0	GSDmax	Site data FMLX	FMLX	Ba data for cR_sea_pp_macro used as analogue.
Se		cR_sea_pp_macro	7	1.1E+00	1.6E+01	1.5E+01	2.2E+02	5.0	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Sm		cR_sea_pp_macro	6	5.5E–01	1.5E+01	3.9E+00	2.8E+03	9.6	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
Sn		cR_sea_pp_macro	3	1.2E+00	1.6E+01	1.6E+01	2.3E+02	5.0	GSDmax	Site data LX	LX	cR_sea_pp_macro used as analogue.
Sr		cR_sea_pp_macro	3	6.9E–02	9.8E–01	9.8E–01	1.4E+01	5.0	GSDmax	Site data LX	LX	cR_sea_pp_macro used as analogue.
Tc			14	0.0E+00	2.6E–02	2.6E–02	2.2E–01	3.0	GSDmean	ERICA	L1	ERICA data used.
Th		cR_sea_pp_macro	6	1.4E+00	3.0E+02	1.6E+03	8.5E+04	11.3	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.
U		cR_sea_pp_macro	3	1.3E–01	1.8E+00	1.8E+00	2.6E+01	5.0	GSDmax	Site data LX	LX	cR_sea_pp_macro used as analogue.
Zr		cR_sea_pp_macro	6	2.8E+00	2.1E+02	8.6E+02	1.7E+04	6.5	GSDmax	Site data FMLX	FMLX	cR_sea_pp_macro used as analogue.

Table 8-7. Selected data properties, references and comments for the parameter cR_Sea_pp_plank_NHB (m^3/kg_{fw}) and the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Ag			8	6.3E+00	3.8E+01	3.8E+01	2.3E+02	3.0	GSDmean	ERICA	L1	Data for phytoplankton lower than macroalgae data. The former considered more relevant.
Am	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Ba		cR_sea_pp_macro	9	1.7E–02	6.1E–01	9.3E–01	8.6E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Ca		cR_sea_pp_macro	9	2.0E–03	2.9E–02	2.4E–02	4.1E–01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Cd		cR_sea_pp_macro	9	4.3E–01	6.0E+00	6.7E+00	8.5E+01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Cl		cR_sea_pp_macro	8	1.2E–04	1.7E–03	1.8E–03	2.3E–02	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Cm	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Co		cR_sea_pp_macro	7	6.9E–02	6.4E+00	1.6E+01	4.3E+02	6.1	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Cs		cR_sea_pp_macro	6	2.6E–02	4.9E–01	1.5E+00	1.1E+01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Eu		cR_sea_pp_macro	5	1.1E–02	3.0E–01	9.2E–02	8.7E+00	6.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. FM data higher than LX data. Eu correlates well with Ho and Sm site data.
Ho		cR_sea_pp_macro	6	1.0E–02	2.9E–01	7.1E–02	1.3E+01	6.7	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
I		cR_sea_pp_macro	8	4.5E–02	6.3E–01	7.6E–01	8.9E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Mo		cR_sea_pp_macro	9	3.3E–03	4.7E–02	6.1E–02	1.1E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Nb		cR_sea_pp_macro	3	1.0E–01	1.5E+00	1.5E+00	2.1E+01	5.0	GSDmax	Site data LX	LX	All marine primary producers merged into 1 group.
Ni		cR_sea_pp_macro	9	9.2E–02	1.3E+00	1.8E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Np	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Pa	Nd	cR_sea_pp_macro	9	1.8E–02	6.4E–01	2.9E–01	1.9E+02	7.4	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Nd used as EA (site data available).
Pb		cR_sea_pp_macro	9	2.2E–02	2.8E+00	3.2E+00	8.5E+02	7.9	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. GSD exceeds GSDmax. Large variation in water concentration. No obvious errors found.
Pd	Ni	cR_sea_pp_macro	9	9.2E–02	1.3E+00	1.8E+00	3.6E+01	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Ni used as EA (site data available).
Po			18	2.5E+00	1.6E+01	1.6E+01	1.2E+02	3.0	GSDmean	ERICA	L1	Validation not relevant, due to different organisms.
Pu			52	4.0E–01	7.8E+01	7.8E+01	6.3E+02	3.0	GSDmean	ERICA	L1	Data for phytoplankton lower than macroalgae data. The former considered more relevant.
Ra	Ba	cR_sea_pp_macro	9	1.7E–02	6.1E–01	9.3E–01	8.6E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. Ba used as EA (site data available).
Se		cR_sea_pp_macro	7	4.9E–02	6.9E–01	6.2E–01	9.8E+00	5.0	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.
Sm		cR_sea_pp_macro	6	1.6E–02	6.5E–01	1.6E–01	1.5E+02	9.6	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.FM data higher than LX data. Sm correlates well with Eu and Ho site data. The higher values in LX data are probably due to poor detection limits in the analysis conducted.
Sn		cR_sea_pp_macro	3	5.7E–02	8.1E–01	8.1E–01	1.1E+01	5.0	GSDmax	Site data LX	LX	All marine primary producers merged into 1 group.
Sr		cR_sea_pp_macro	3	3.4E–03	4.8E–02	4.8E–02	6.8E–01	5.0	GSDmax	Site data LX	LX	All marine primary producers merged into 1 group.
Tc			14	0.0E+00	2.0E–03	2.0E–03	1.7E–02	3.0	GSDmean	ERICA	L1	Data for phytoplankton lower than macroalgae data. The former considered more relevant.
Th		cR_sea_pp_macro	6	7.7E–02	1.3E+01	6.8E+01	1.7E+03	11.3	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group. The GSD of site data exceeds GSDmax due to pooling of FM and LX data.
U		cR_sea_pp_macro	3	6.5E–03	9.1E–02	9.1E–02	1.3E+00	5.0	GSDmax	Site data LX	LX	All marine primary producers merged into 1 group.
Zr		cR_sea_pp_macro	6	1.5E–01	9.4E+00	3.6E+01	3.9E+02	6.5	GSDmax	Site data FMLX	FMLX	All marine primary producers merged into 1 group.

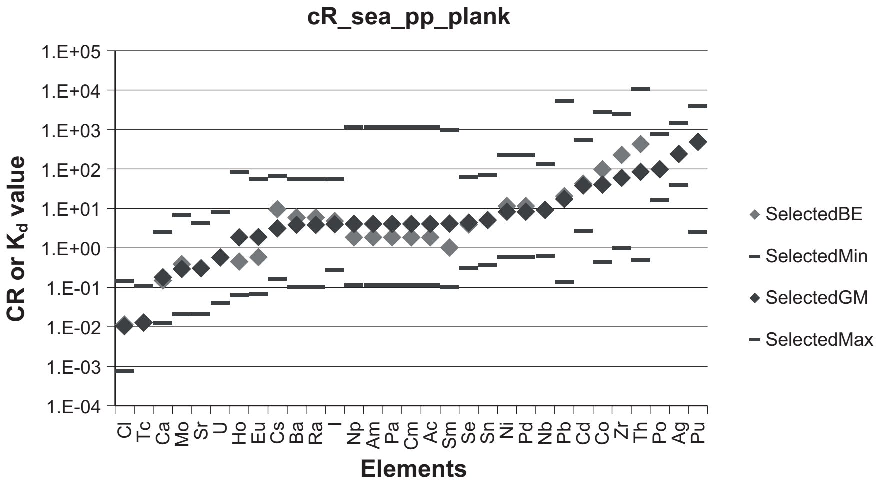


Figure 8-5. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_C).*

8.3 cR_sea_pp_micro

The cR_sea_pp_micro parameter reflects the net uptake of elements from sea water to the microphytobenthos compartment in the radionuclide model.

cR_sea_pp_micro is parameterised using the same data as the cR_sea_pp_macro parameter, due to the small amount of data for microphytobenthos. Only 2 samples are available from FM, one of these samples are used to measure radionuclides only, meaning that there is only one sample with element concentrations. One sample is not enough to parameterise the microphytobenthos. Therefore, the analogous parameter cR_sea_pp_macro (including data for the microphytobenthos sample) is utilised in all cases and GSDmax is assigned, since PAs are utilised.

The element concentrations in microphytobentho are compared to concentrations in other marine samples from FM and LX in Figure 8-1. Some elements show the highest concentrations in the microphytobenthos samples, whereas for other elements (e.g. the lanthanides) the concentrations are in the middle of the estimated range for marine primary producers. Some of the elements with higher concentrations are metals utilised in steel alloys, e.g. Fe, V, Co, Ni, Mn and Mo, which could be an indication of contamination during sampling (Tröjbom and Nordén 2010). Additionally, geogenic elements indicating mineral contamination, e.g. Al, Ti, and Zr, are enriched in the microphyte samples.

8.4 cR_Sea_Zoopl_NHB

cR_Sea_Zoopl_NHB describes the element uptake in marine zooplankton for use in dose estimates to this organism type. Site data are available for Ba, Ca, Cd, Co, Cs, Eu, Ho, I, Mo, Ni, Pb, Se, Sm, Th and Zr, from 1 zooplankton sample (Kumblad and Bradshaw 2008, FM), which is described further below, and water data from Engdahl et al. (2008) and Kumblad and Bradshaw (2008) (FM), which is further treated in Section 8. Literature data are only available in ERICA (Hosseini et al. 2008), which is the only data source for 12 of the elements. Site data are available for 15 elements and data are missing for Ac, Pa, Pd and Sn. The available data are presented in Table 8-8 and Figure 8-8.

The single zooplankton sample from FM is considered an outlier in Tröjbom and Nordén (2010) as it indicates more than a magnitude higher element concentrations compared to the average concentration in fish (Figure 8-6). The high concentrations are discussed in the original study (Kumblad and Bradshaw 2008) though no reasonable explanation is presented. Instead, the authors state that the sample is representative, as the C:N:P-ratio of the sample is close to the Redfield ratio and the CNP content is in the same range as the other organisms sampled in the study. Since high element concentrations in zooplankton samples give a higher uptake and lead to a higher dose estimate when estimating CR, it was considered more conservative to use site data for zooplankton than for fish.

A comparison of element concentrations in marine zooplankton and phytoplankton (data from Kumblad and Bradshaw 2008) displays a heterogeneous pattern, see Figure 8-7. Concentrations of rare earth elements as well as of e.g. Se, Ca and Cd are higher in zooplankton, whereas the concentrations of e.g. Li, Si, Fe, Al and Ti are higher in phytoplankton. The latter are main components in rocks, which may indicate contamination of the samples. Due to this uncertain pattern, phytoplankton data are not considered a proper PA.

Comparisons between site data and literature data for marine zooplankton could only be performed for a limited number of elements (6). For Cs and Th, FM data (n=1) do not overlap with ERICA (Hosseini et al. 2008) data (n=29 and 4 for Cs and Th, respectively) and the overlap is limited for Co (n=24). ERICA data are selected for these elements, due to the larger number of observations. For Zr and I, site data are within the literature range, whereas the literature range for Pb is within that of site data, and site data are utilised for these 3 elements.

GSD exceeds GSDmax (5) for Pb, due to large variations in water concentrations (circa 100 times) in underlying data. No obvious errors are found and no action is taken.

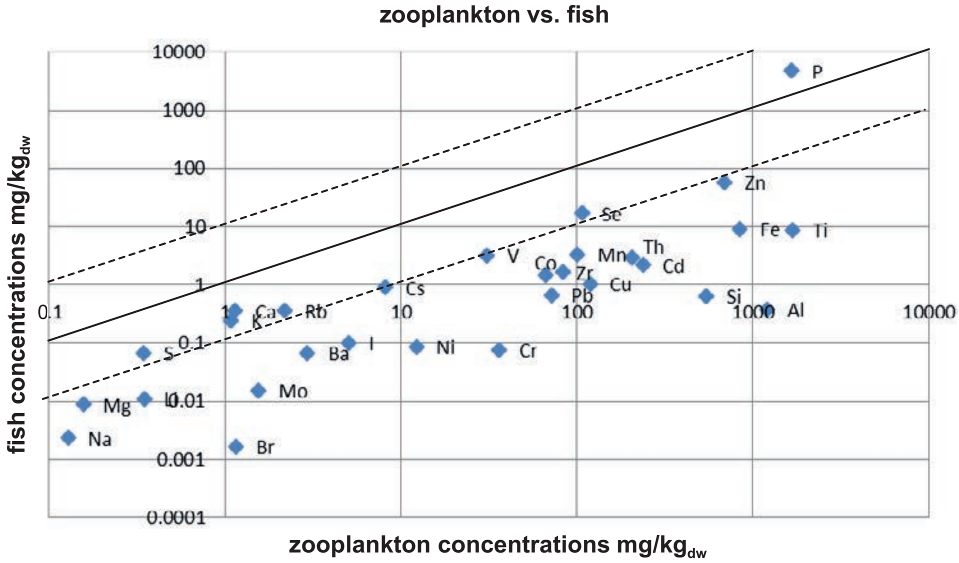


Figure 8-6. Zooplankton (n=1) versus fish (n between 1 and 9) concentrations (mg/kg$_{dw}$) from marine environments in FM. (From Tröjbom and Nordén 2010.)

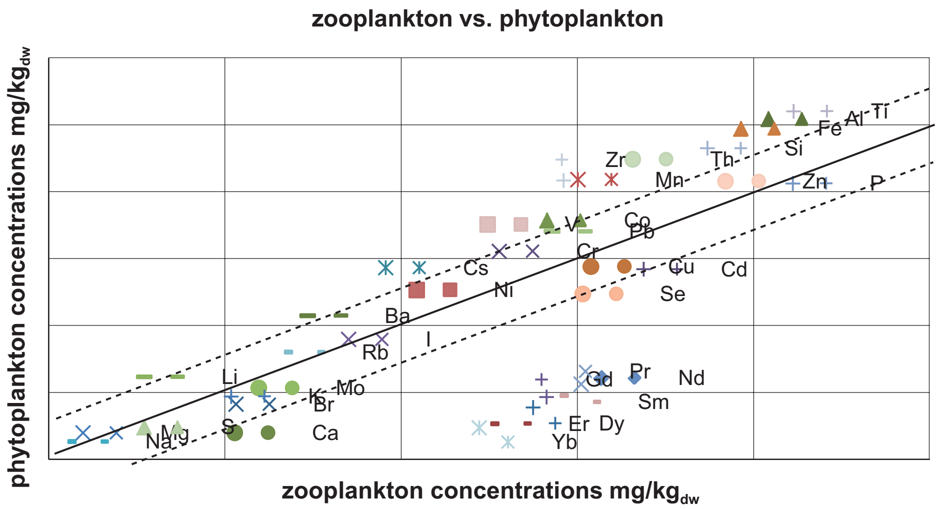


Figure 8-7. Zooplankton (n=1) versus phytoplankton (n=2 or 3) concentrations (mg/kg$_{dw}$) from marine environments in FM.

Nd is utilised as EA for Ac, Am, Cm and Np. Zr is selected as EA for Pa and Sn, while Ni is used for Pd. Site data for Sr are not available and literature data are much lower than Ca and Ba site data, hence Ca site data are selected.

Site data are not available for the elements: Ag, Cl, Np, Po, Pu, Ra, Tc and U, and literature data for marine zooplankton are utilised. Ranges are not available for Tc, Ag, Cl, Th and U, and GSDmax is assigned to these parameters. The presented GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean or GSDmax).

The selected CR values are presented in Table 8-9 and in Figure 8-9.

Table 8-8. All available data for the parameter cR_Sea_Zoopl_NHB, the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ERICA (Hosseini et al. 2008) Zooplankton Sea water.

Element	FM N (from/to)	LX N (from/to)	FMLX N (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba	6/1		6/1					1.0		1.0									0:0/0
Ca	6/1		6/1					1.0		1.0									0:0/0
Cd	6/1		6/1	1				1.2		1.2									1:0/0
Cl				1															1:0/0
Cm				1															1:0/0
Co	4/1		4/1	24				1.3		1.3	2.7				S2 (U26%)		S2 (U26%)		1:0/0
Cs	3/1		3/1	29				1.0		1.0	3.3				S4		S4		1:0/0
Eu	3/1		3/1	1				1.7		1.7									1:0/0
Ho	3/1		3/1					1.3		1.3									0:0/0
I	5/1		5/1	2				1.6		1.6	3.3				S1		S1		1:0/0
Mo	6/1		6/1					1.0		1.0									0:0/0
Nb				1															1:0/0
Nd	6/1		6/1					1.4		1.4									0:0/0
Ni	6/1		6/1	1				1.1		1.1									1:0/0
Np				2							1.3								1:0/0
Pa																			0:0/0
Pb	6/1		6/1	12				7.5		7.5	2.5				S3		S3		1:0/0
Pd																			0:0/0
Po				36							2.5								1:0/0
Pu				5							2.8								1:0/0
Ra				5							1.6								1:0/0
Se	4/1		4/1	1				1.4		1.4									1:0/0
Sm	3/1		3/1					1.1		1.1									0:0/0
Sn																			0:0/0
Sr				12							2.0								1:0/0
Tc				1															1:0/0
Th	3/1		3/1	4				1.3		1.3	2.5				S4		S4		1:0/0
U				1															1:0/0
Zr	3/1		3/1	3				1.1		1.1	1.1				S1		S1		1:0/0

Table 8-9. Selected data properties, references and comments for the parameter cR_Sea_zoopl_NHB (m^3/kg_{fw}) and the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Ac	Nd		1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	Nd used as EA (site data available).
Ag			1	1.2E+00	1.7E+01	1.7E+01	2.4E+02	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Am	Nd		1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	Nd used as EA (site data available).
Ba			1	5.1E–02	7.2E–01	7.2E–01	1.0E+01	5.0	GSDmax	Site data FM	FM	
Ca			1	2.0E–02	2.8E–01	2.8E–01	3.9E+00	5.0	GSDmax	Site data FM	FM	
Cd			1	4.1E+00	5.8E+01	5.8E+01	8.2E+02	5.0	GSDmax	Site data FM	FM	
Cl			1	7.1E–05	1.0E–03	1.0E–03	1.4E–02	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Cm	Nd		1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	ERICA utilised data for Pu. Nd used as EA (site data available).
Co			24	7.0E–02	2.9E+00	2.9E+00	2.6E+01	2.7	GSD	ERICA	L1	FM data (n=1) show limited overlap with ERICA data (n=24). ERICA data selected due to the number of observations.
Cs			29	3.0E–03	5.3E–02	5.3E–02	9.9E–01	3.3	GSD	ERICA	L1	FM data (n=1) do not overlap with ERICA data (n=29). ERICA data selected due to the number of observations.
Eu			1	4.6E–01	6.5E+00	6.5E+00	9.1E+01	5.0	GSDmax	Site data FM	FM	
Ho			1	4.0E–01	5.6E+00	5.6E+00	7.9E+01	5.0	GSDmax	Site data FM	FM	
I			1	8.7E–02	1.2E+00	1.2E+00	1.7E+01	5.0	GSDmax	Site data FM	FM	GM for FM and ERICA data correlates very well.
Mo			1	2.7E–02	3.8E–01	3.8E–01	5.4E+00	5.0	GSDmax	Site data FM	FM	
Nb	Zr		1	1.5E+00	2.0E+01	2.0E+01	2.9E+02	5.0	GSDmax	Site data FM	FM	ERICA utilised data for Zr.
Ni			1	2.1E–01	3.0E+00	3.0E+00	4.2E+01	5.0	GSDmax	Site data FM	FM	
Np	Nd		1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	Nd used as EA (site data available).
Pa	Nd		1	2.4E+00	3.3E+01	3.3E+01	4.7E+02	5.0	GSDmax	Site data FM	FM	Nd used as EA (site data available).
Pb			1	6.4E–01	1.8E+01	1.8E+01	4.8E+02	7.5	GSD	Site data FM	FM	Max GSD exceeded due to large range in water conc. No obvius errors found.
Pd	Ni		1	2.1E–01	3.0E+00	3.0E+00	4.2E+01	5.0	GSDmax	Site data FM	FM	Ni used as EA (site data available).
Po			36	6.0E–01	5.1E+01	5.1E+01	3.3E+02	3.0	GSDmean	ERICA	L1	
Pu			5	7.4E–01	4.5E+00	4.5E+00	2.8E+01	3.0	GSDmean	ERICA	L1	
Ra			5	5.0E–03	7.2E–02	7.2E–02	4.4E–01	3.0	GSDmean	ERICA	L1	
Se			1	1.9E+00	2.6E+01	2.6E+01	3.7E+02	5.0	GSDmax	Site data FM	FM	
Sm			1	1.4E+00	2.0E+01	2.0E+01	2.8E+02	5.0	GSDmax	Site data FM	FM	
Sn	Zr		1	1.5E+00	2.0E+01	2.0E+01	2.9E+02	5.0	GSDmax	Site data FM	FM	Zr used as EA (site data available).
Sr	Ca		1	2.0E–02	2.8E–01	2.8E–01	3.9E+00	5.0	GSDmax	Site data FM	FM	Site data for Sr not available and literature data are much lower than site data for Ca and Ba. Site data for Ca used.
Tc			1	7.1E–03	1.0E–01	1.0E–01	1.4E+00	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th			4	2.0E–02	4.9E+00	4.9E+00	3.0E+01	2.5	GSD	ERICA	L1	Site data (n=1) do not overlap with ERICA data (n=4). ERICA data selected due to the number of observations.
U			1	2.1E–03	3.0E–02	3.0E–02	4.2E–01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Zr			1	1.5E+00	2.0E+01	2.0E+01	2.9E+02	5.0	GSDmax	Site data FM	FM	Both FM and ERICA data are based on small sample numbers (1 and 3 respectively). The values do not differ, site data used.

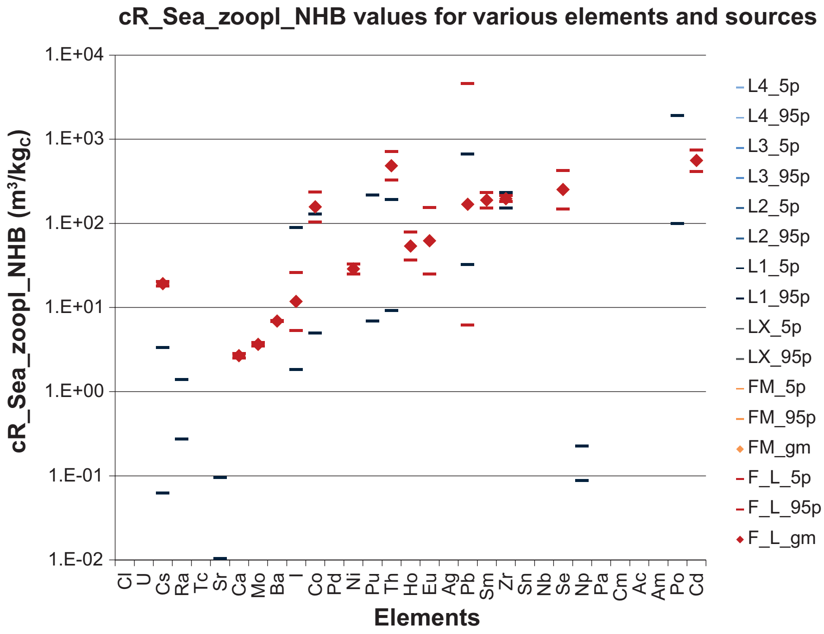


Figure 8-8. *Total available data ranges for the parameter cR_Sea_zoopl_NHB (m³/kg$_C$). The elements are in the same order as in figure Figure 8-9 showing selected parameter values.*

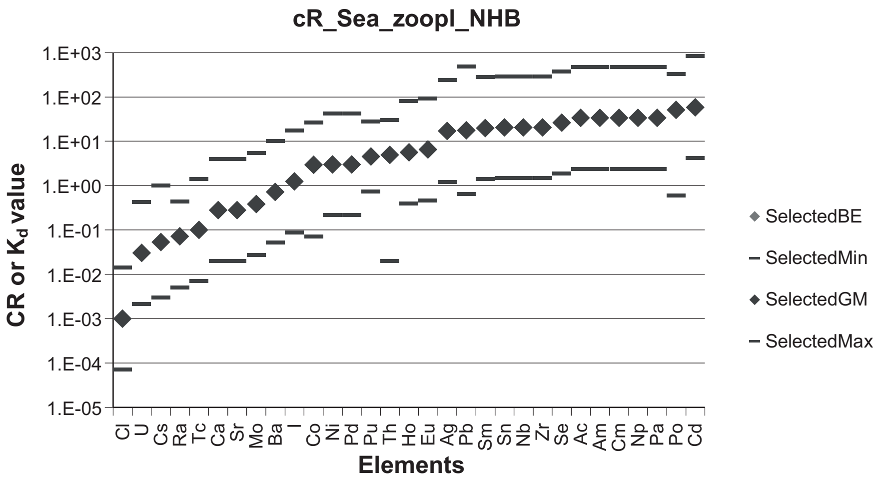


Figure 8-9. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m³/kg$_{fw}$).*

8.5 cR_Sea_polych_NHB

cR_Sea_polych_NHB describes the element uptake in marine polychaete worms for use in dose estimates to this organism type. Site data are not available for this organism type. Literature data are only available in ERICA (Hosseini et al. 2008), see Table 8-10 and Figure 8-10. In the cases of: Am, Cl, Eu, I, Nb, Np, Th, U and Zr, ERICA utilised data for marine molluscs for this parameter. Data for marine crustacean were selected for Tc, Ra and Pb. Site data are available for both marine molluscs and marine crustacean (see parameters cR_Sea_bent_moll_NBH and cR_Sea_crust_NHB, respectively). Data for marine molluscs are available from FM and LX, whereas data for crustacean are only available from FM. It is better to use mollusc data as PAs, since the data may encompass potential differences pertaining to the two sites. Site data for marine benthic molluscs are used as PAs for the elements: Ba, Ca, Cl, Ho, Mo, Pb, Sm and Th, which were either not included in ERICA (Hosseini et al. 2008) or an analogue was utilised for them in ERICA. Nd is selected as EA for Ac, Am, Cm, Eu and Np (combined EA and PAs). Zr is utilised as EA for Pa and Sn, while Ni and Ca are used for Pd and Sr, respectively.

Ranges are not available for Ni, Ag, Cd and Se, and GSDmax (5) is assigned to these parameters. GSDmax is also assigned to elements where PAs are utilised. The presented GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean or GSDmax).

The selected CR values are presented in Table 8-11 and Figure 8-11.

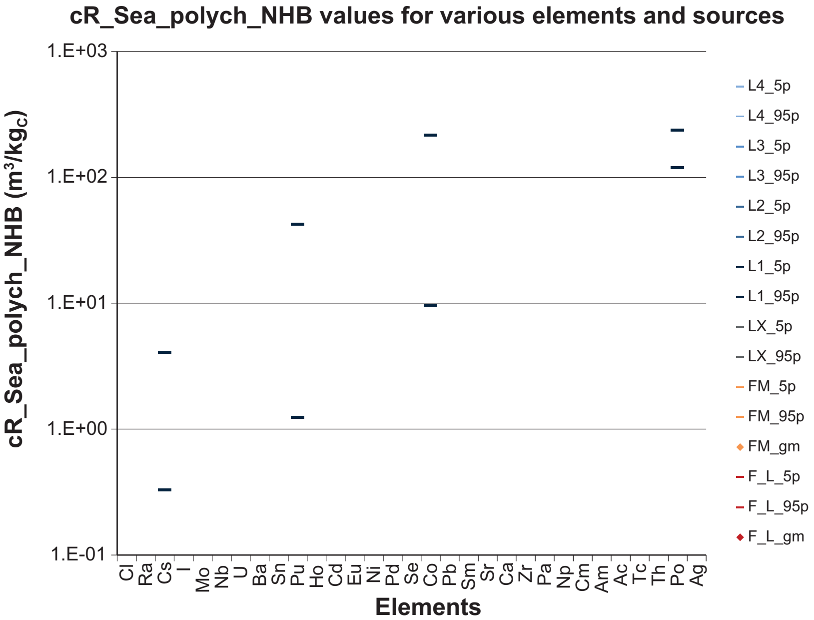


__Figure 8-10.__ Total available data ranges for the parameter cR_Sea_polych_NHB (m^3/kg_{fw}). The elements are arranged in the same order as in Figure 8-11 showing selected parameter values.

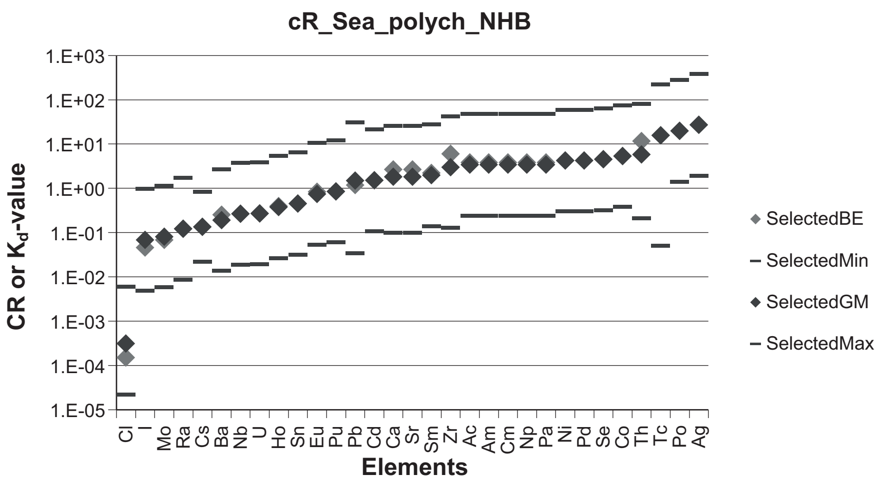


__Figure 8-11.__ Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).

Table 8-10. All available data for the parameter cR_Sea_polych_NHB, the elements of primary concern and selected EAs. L1 = ERICA Polychaete worm, Sea water.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag				1															1:0/0
Am				1															1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				1															1:0/0
Cl				1															1:0/0
Cm				1															1:0/0
Co				3							2.6								1:0/0
Cs				40							2.1								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				1															1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				1															1:0/0
Pd																			0:0/0
Po				2							1.2								1:0/0
Pu				3							2.9								1:0/0
Ra				1															1:0/0
Se				1															1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				1															1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

Table 8-11. Selected data properties, references and comments for the parameter cR_Sea_polych_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Ac	Nd	cR_Sea_bent_moll_NHB	9	2.4E–01	3.4E+00	3.8E+00	4.8E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Site data for Ac missing. Nd data for benthic molluscs used as combined EA and PA.
Ag			1	1.9E+00	2.7E+01	2.7E+01	3.8E+02	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Am	Nd	cR_Sea_bent_moll_NHB	9	2.4E–01	3.4E+00	3.8E+00	4.8E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs. Nd used as EA. Site data for Nd in both crustaceans (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
Ba		cR_Sea_bent_moll_NHB	9	1.4E–02	1.9E–01	2.5E–01	2.7E+00	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Site data for Ba in both crustacean (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
Ca		cR_Sea_bent_moll_NHB	9	1.0E–01	1.8E+00	2.6E+00	2.6E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Site data for Ca in both crustacean (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
Cd			1	1.1E–01	1.5E+00	1.5E+00	2.1E+01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Cl		cR_Sea_bent_moll_NHB	6	2.2E–05	3.1E–04	1.5E–04	5.9E–03	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for crustacean. Site data for benthic molluscs available and utilised.
Cm	Nd	cR_Sea_bent_moll_NHB	9	2.4E–01	3.4E+00	3.8E+00	4.8E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA used Pu as EA. Nd used as EA. Site data for both crustaceans (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
Co			3	3.8E–01	5.3E+00	5.3E+00	7.5E+01	5.0	GSDmax	ERICA	L1	
Cs			40	2.2E–02	1.3E–01	1.3E–01	8.2E–01	3.0	GSDmean	ERICA	L1	
Eu		cR_Sea_bent_moll_NHB	5	5.3E–02	7.4E–01	8.3E–01	1.0E+01	5.0	GSDmax	Site data FMLX	FMLX	Site data for both crustacean (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
Ho		cR_Sea_bent_moll_NHB	6	2.7E–02	3.8E–01	3.9E–01	5.3E+00	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Site data for Ho in both crustacean (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
I		cR_Sea_bent_moll_NHB	6	4.8E–03	6.8E–02	4.6E–02	9.6E–01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs.
Mo		cR_Sea_bent_moll_NHB	9	5.7E–03	8.1E–02	6.8E–02	1.1E+00	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Site data for Mo in both crustacean (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
Nb		cR_Sea_bent_moll_NHB	2	1.9E–02	2.7E–01	2.7E–01	3.8E+00	5.0	GSDmax	Site data LX	LX	ERICA utilised data for molluscs.
Ni			1	3.0E–01	4.2E+00	4.2E+00	5.9E+01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Np	Nd	cR_Sea_bent_moll_NHB	9	2.4E–01	3.4E+00	3.8E+00	4.8E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Site data for Np missing. Nd data for benthic molluscs used as combined EA and PA.
Pa	Nd	cR_Sea_bent_moll_NHB	9	2.4E–01	3.4E+00	3.8E+00	4.8E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Nd data for benthic molluscs used as combined EA and PA.
Pb		cR_Sea_bent_moll_NHB	9	3.4E–02	1.5E+00	1.2E+00	3.0E+01	7.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Site data for Pb in both crustaceans (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
Pd	Ni		1	3.0E–01	4.2E+00	4.2E+00	5.9E+01	5.0	GSDmax	ERICA	L1	Ni used as EA. No range presented. GSDmax assigned.
Po			2	1.4E+00	2.0E+01	2.0E+01	2.8E+02	5.0	GSDmax	ERICA	L1	
Pu			3	6.0E–02	8.5E–01	8.5E–01	1.2E+01	5.0	GSDmax	ERICA	L1	
Ra		cR_Sea_crust_NHB	7	8.6E–03	1.2E–01	1.2E–01	1.7E+00	5.0	GSDmax	ERICA	L2	ERICA utilised data for crustaceans.
Se			1	3.2E–01	4.5E+00	4.5E+00	6.4E+01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Sm		cR_Sea_bent_moll_NHB	6	1.4E–01	2.0E+00	2.2E+00	2.8E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Site data for Sm in both crustacean (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
Sn		cR_Sea_bent_moll_NHB	2	3.2E–02	4.5E–01	4.5E–01	6.4E+00	5.0	GSDmax	Site data LX	LX	Data for benthic molluscs utilised (LX data available).
Sr	Ca	cR_Sea_bent_moll_NHB	9	1.0E–01	1.8E+00	2.6E+00	2.6E+01	5.0	GSDmax	Site data FMLX	FMLX	The value for polycheate is much lower than the value used for Ca and Ba. For these two site data for benthic molluscs are utilised. Site data for Ca used (combined parameter and chemical analogue).
Tc		cR_Sea_crust_NHB	121	5.0E–02	1.6E+01	1.6E+01	2.2E+02	5.0	GSDmax	ERICA	L2	ERICA utilised data for crustaceans.
Th		cR_Sea_bent_moll_NHB	6	2.1E–01	5.8E+00	1.2E+01	8.1E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs or crustaceans when data are missing. Site data for Th in both crustacean (FM) and benthic molluscs (FMLX). The latter is used (data from both sites considered better).
U		cR_Sea_bent_moll_NHB	2	1.9E–02	2.7E–01	2.7E–01	3.8E+00	5.0	GSDmax	Site data LX	LX	ERICA utilised data for molluscs.
Zr		cR_Sea_bent_moll_NHB	6	1.3E–01	3.0E+00	6.0E+00	4.2E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for molluscs.

8.6 cR_Sea_bent_moll_NHB

This parameter cR_Sea_bent_moll_NHB describes the element uptake in marine benthic molluscs for use in dose estimates to this organism type. Site data for benthic molluscs from FM and LX are available for 20 elements: Ba, Ca, Cd, Cl, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Sr, Th, U and Zr (water data from Engdahl et al. (2008) (FMLX), further treated in Section 8, data for benthic molluscs from Kumblad and Bradshaw (2008) (FM) and Engdahl et al. (2006) (LX) described further below). Data for Nb, Sn, Sr and U are only available from LX. Literature data are available from ERICA (Hosseini et al. 2008), which is the only data source for 8 elements: Ag, Am, Cm, Np, Po, Pu, Ra and Tc. Data are missing for Ac, Pa and Pd. The available data are shown in Figure 8–12 and Table 8-12.

The shell of molluscs is more massive than that of crustaceans. Since molluscs do not moult, their shell will accumulate mass and radionuclides during their whole life (several years).

Site data are available for parameterisation of this parameter for: whole individuals of the mussels *Cerastoderma glaucum* and *Macoma baltica,* the snail *Theodoxus fluviatilis* from FM (Kumblad and Bradshaw 2008), and muscle as well as shell from the mussel *Mytilus edulis* from LX (Engdahl et al. 2006). The shell samples were not included in the data set used for this parameter. The samples are not completely comparable due to the different contents and a discrepancy in concentrations between the two studies is expected.

As can be seen in Figure 8-12, most CR values are between 1 and 100, while Cl and Sr CR values are below 1. The highest values are for Cd, Th and Zr. A comparison among the elements where both site and literature data (Hosseini et al. 2008) are available reveals no clear pattern. The elements Cs, Pb, Th and U show higher CR for site than for literature data, whereas the opposite is the case for Nb, Ni. Site data are prioritised when available.

There are some discrepancies between data sets. There is no overlap between FM and LX data ranges for 9 elements: Ba, Ca, Cd, Cl, Cs, Mo, Se, Th and Zr. The samples include 4 different species with relatively few samples and a somewhat narrow range for each sampling site. Extending the ranges gives a reasonable overlap and, therefore, not considered an issue. For Th, FM data do not overlap with LX or ERICA (Hosseini et al. 2008) data, though the latter two correlate very well. The GM for FM data is approximately 60 times higher and the minimum value near 10 times higher than the maximum value in ERICA (Hosseini et al. 2008). The reason is unclear and site data are selected.

For Nb and U, FM data are not available and LX and ERICA (Hosseini et al. 2008) data ranges are very narrow. The GM values are consistent for Nb, whereas the ERICA (Hosseini et al. 2008) value for U is about 10 times lower than the LX value. LX data are utilised for both elements.

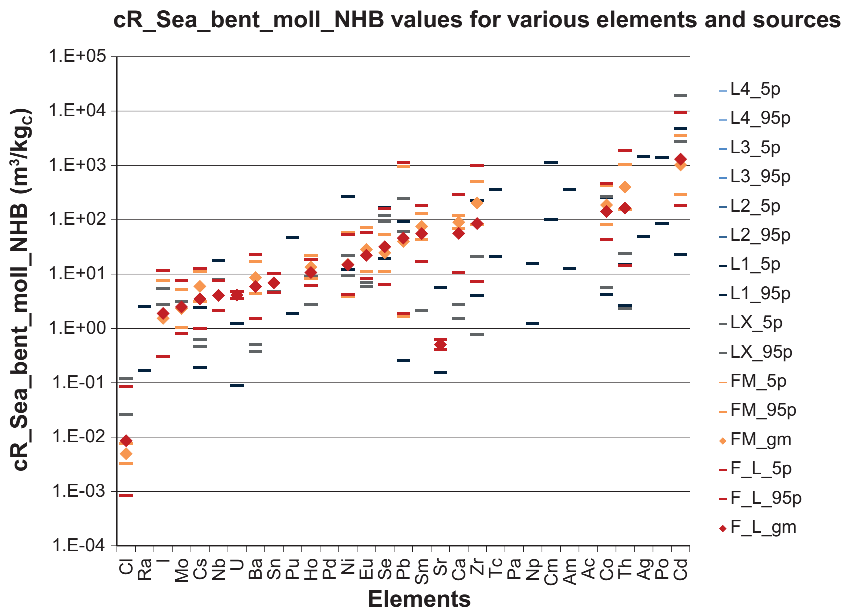


Figure 8-12. *Total available data ranges for the parameter cR_Sea_bent_moll_NHB (m*^{3}*/kg*$_C$*). The elements are arranged in the same order as in Figure 8-13 showing selected parameter values.*

Forsmark data are also missing for Sr and the value based on LX data are much smaller than the values used for the EAs Ca and Ba. Ca has therefore been used as EA for Sr.

For Pb, the site data have a GSD larger than GSDmax (5). This is due to a large water concentration range. No obvious errors are found in the underlying data and no action is taken. Nd is utilised as EA for Ac, Am, Cm and Np (see Section 2.7). Zr is selected as EA for Pa and Ni for Pd. Literature data from ERICA (Hosseini et al. 2008) are utilised for the elements: Ag, Pu, Po, Ra and Tc. No other literature data are available for comparison.

The selected CR values are presented in Table 8-13 and Figure 8-13.

Table 8-12. All available data for the parameter cR_Sea_bent_moll_NHB, the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ERICA (Hosseini et al. 2008) Benthic mollusc Sea water.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				15							2.8								1:0/0
Am				28							2.8								1:0/0
Ba	6/7	3/2	9/9					1.5	1.1	2.3								S4	0:0/0
Ca	6/7	3/2	9/9					1.2	1.2	2.7								S4	0:0/0
Cd	6/7	3/2	9/9	80				2.1	1.8	3.3	5.1				S1	S2 (U28%)	S2 (U83%)	S2 (L9%)	1:0/0
Cl	5/4	3/2	8/6	1				1.3	1.6	4.1								S4	1:0/0
Cm				10							2.1								1:0/0
Co	4/7	3/2	7/9	42				1.6	3.2	2.1	3.5				S2 (U69%)	S2 (U98%)	S2 (U74%)	S2 (U71%)	1:0/0
Cs	3/7	3/2	6/9	172				1.5	1.1	2.2	2.2				S4	S1	S2 (U35%)	S4	1:0/0
Eu	3/7	2/2	5/9	1				1.8	1.1	1.8								S4	1:0/0
Ho	3/7	3/2	6/9					1.4	1.4	1.4								S2 (U9%)	0:0/0
I	5/4	3/2	8/6	1				2.7	1.2	3.0								S3	1:0/0
Mo	6/7	3/2	9/9					1.7	1.2	2.0								S3	0:0/0
Nb		3/2	3/2	2					1.5	1.5	1.3					S2 (L3%)	S2 (L2%)		1:0/0
Nd	6/7	3/2	9/9					1.6	3.9	2.1								S2 (U79%)	0:0/0
Ni	6/7	3/2	9/9	12				2.3	1.3	2.2	2.6				S2 (L58%)	S2 (L68%)	S2 (L58%)	S3	1:0/0
Np				12							2.2								1:0/0
Pa																			0:0/0
Pb	6/7	3/2	9/9	57				7.0	1.5	7.0	5.9				S2 (U62%)	S2 (U28%)	S2 (U60%)	S3	1:0/0
Pd																			0:0/0
Po				70							2.3								1:0/0
Pu				159							2.7								1:0/0
Ra				20							2.3								1:0/0
Se	4/7	3/2	7/9	3				1.6	1.1	2.7	1.9				S2 (L66%)	S1	S2 (L66%)	S4	1:0/0
Sm	3/7	3/2	6/9					1.4	3.9	2.0								S1	0:0/0
Sn		3/2	3/2						1.3	1.3									0:0/0
Sr		3/2	3/2	8					1.1	1.1	3.0					S1	S1		1:0/0
Tc				58							2.3								1:0/0
Th	3/7	3/2	6/9	4				1.8	2.0	4.4	1.7				S4	S3	S2 (U0%)	S4	1:0/0
U		3/2	3/2	22					1.1	1.1	2.2					S4	S4		1:0/0
Zr	3/7	3/2	6/9	5				1.7	2.7	4.4	3.4				S2 (U56%)	S2 (L50%)	S2 (U70%)	S4	1:0/0

Table 8-13. Selected data properties, references and comments for the parameter cR_Sea_bent_moll_NHB (m^3/kg_{fw}) and the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Ac	Nd		9	4.9E–01	3.4E+00	3.8E+00	2.1E+01	3.0	GSDmean	Site data FMLX	FMLX	Nd used as EA (site data available).
Ag			15	1.0E–01	1.9E+01	1.9E+01	2.0E+02	3.0	GSDmean	ERICA	L1	
Am	Nd		9	4.9E–01	3.4E+00	3.8E+00	2.1E+01	3.0	GSDmean	Site data FMLX	FMLX	Nd used as EA (site data available).
Ba			9	2.5E–02	1.9E–01	2.5E–01	1.2E+00	3.0	GSDmean	Site data FMLX	FMLX	Data from FM (n=6) and LX (n=2) do not overlap. FM data selected due to more observations and a reasonable range.
Ca			9	1.0E–01	1.8E+00	2.6E+00	1.1E+01	3.0	GSDmean	Site data FMLX	FMLX	FM (n=6) and LX (n=2) data do not overlap. Both have very narrow ranges. FM considered valid, due to larger sample number.
Cd			9	6.0E+00	4.2E+01	3.0E+01	1.1E+03	3.3	GSD	Site data FMLX	FMLX	FM data totally overlap with ERICA. LX higher and do not correlate well.
Cl			6	3.1E–05	3.1E–04	1.5E–04	5.9E–03	4.1	GSD	Site data FMLX	FMLX	Data from FM (n=4) and LX (n=2) do not overlap, deviates about 1 order of magnitude (FM lower value).
Cm	Nd		9	4.9E–01	3.4E+00	3.8E+00	2.1E+01	3.0	GSDmean	Site data FMLX	FMLX	Nd used as EA (site data available).
Co			7	7.9E–01	4.8E+00	5.5E+00	2.9E+01	3.0	GSDmean	Site data FMLX	FMLX	
Cs			6	2.0E–02	1.2E–01	1.7E–01	7.5E–01	3.0	GSDmean	Site data FMLX	FMLX	FM data (n=3) do not overlap with LX (n=2) or ERICA. FM GM is just above the max value in ERICA and not considered unrealistic. Site data is utilised, not to underestimate the uptake.
Eu			5	1.2E–01	7.4E–01	8.3E–01	4.5E+00	3.0	GSDmean	Site data FMLX	FMLX	FM (n=3) and LX (n=2) data do not overlap. LX very narrow range and about 5 times lower than values from FM. FM data used due to a more reasonable range.
Ho			6	6.2E–02	3.8E–01	3.9E–01	2.3E+00	3.0	GSDmean	Site data FMLX	FMLX	FM and LX overlap very little and no literature available for comparison. The ranges very small and the values differ less than 3 times so this is not seen as an issue.
I			6	9.0E–03	6.8E–02	4.6E–02	4.2E–01	3.0	GSD	Site data FMLX	FMLX	
Mo			9	1.3E–02	8.1E–02	6.8E–02	4.9E–01	3.0	GSDmean	Site data FMLX	FMLX	
Nb			2	1.9E–02	2.7E–01	2.7E–01	3.8E+00	5.0	GSDmax	Site data LX	LX	Small overlap between LX data and literature. Very narrow ranges though. LX data used.
Ni			9	8.0E–02	4.8E–01	4.4E–01	3.0E+00	3.0	GSDmean	Site data FMLX	FMLX	
Np	Nd		9	4.9E–01	3.4E+00	3.8E+00	2.1E+01	3.0	GSDmean	Site data FMLX	FMLX	Nd used as EA (site data available).

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Pa	Nd		9	4.9E–01	3.4E+00	3.8E+00	2.1E+01	3.0	GSDmean	Site data FMLX	FMLX	Nd used as EA (site data available).
Pb			9	3.4E–02	1.5E+00	1.2E+00	3.6E+01	7.0	GSD	Site data FMLX	FMLX	GSD exceeded GSDmax, due to large deviations in water concentrations (c 100 times). No obvius errors found, no action taken.
Pd	Ni		9	8.0E–02	4.8E–01	4.4E–01	3.0E+00	3.0	GSDmean	Site data FMLX	FMLX	Ni used as EA (site data available).
Po			70	1.7E+00	2.4E+01	2.4E+01	1.7E+02	3.0	GSDmean	ERICA	L1	
Pu			159	2.0E–03	6.8E–01	6.8E–01	9.2E+00	3.0	GSDmean	ERICA	L1	
Ra			20	2.0E–03	4.7E–02	4.7E–02	2.8E–01	3.0	GSDmean	ERICA	L1	
Se			7	1.8E–01	1.1E+00	7.2E–01	7.4E+00	3.0	GSDmean	Site data FMLX	FMLX	Data from FM and LX do not overlap, though ranges are within or close to the range in ERICA.
Sm			6	3.2E–01	2.0E+00	2.2E+00	1.2E+01	3.0	GSDmean	Site data FMLX	FMLX	
Sn			2	3.2E–02	4.5E–01	4.5E–01	6.4E+00	5.0	GSDmax	Site data LX	LX	
Sr	Ca		9	1.0E–01	1.8E+00	2.6E+00	1.1E+01	3.0	GSDmean	Site data FMLX	FMLX	Sr value for benthic molluscs much lower than the value used for Ca and Ba. FMLX data used for Ca and Ba whereas Sr is LX data only. Ca used as EA.
Tc			58	1.5E–01	6.2E+00	6.2E+00	3.8E+01	3.0	GSDmean	ERICA	L1	
Th			6	2.1E–01	5.8E+00	1.2E+01	6.6E+01	4.4	GSD	Site data FMLX	FMLX	FM data (n=3) do not overlap with LX (n=2) or ERICA (n=4). FM GM about 60 times higher and FM min 10 times higher than ERICA max. LX and ERICA very consistent. FM data utilised, not to underestimate the uptake.
U			2	1.9E–02	2.7E–01	2.7E–01	3.8E+00	5.0	GSDmax	Site data LX	LX	LX data range very narrow and do not overlap with the range in ERICA. Since LX data are higher, it is a conservative approach (higher CR means higher org concentrations) and therefore selected.
Zr			6	1.3E–01	3.0E+00	6.0E+00	3.4E+01	4.4	GSD	Site data FMLX	FMLX	Data from Forsmark and Laxemar do not overlap, though ranges are well within the range in ERICA.

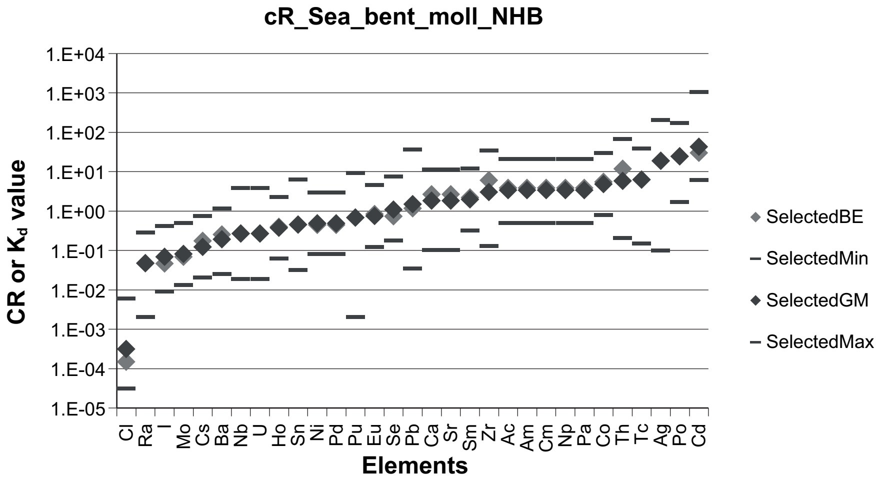


Figure 8-13. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

8.7 cR_Sea_crust_NHB

cR_Sea_crust_NHB describes the element uptake in marine crustaceans for use in dose estimates to this organism type. Site data from FM are available for 13 elements (water data from Engdahl et al. (2008) and Kumblad and Bradshaw (2008), further treated in Section 8, and data for marine crustaceans from Kumblad and Bradshaw (2008) which are described further below). Literature data are available for adult crab in ICRP (2011) for some elements and for crustacean in ERICA (Hosseini et al. 2008), and these are the only data sources for 11 elements. Data for Ac, Pa, Pd and Sn are missing. The available data are shown in Table 8-14 and in Figure 8-14.

Sense checks of literature data are performed on 4 elements, which correlate well for Cd, Cs and Sr, whereas literature data for Tc deviate somewhat. The GMs differ about 2 orders of magnitude and the ranges overlap to a limited degree.

Crustacean exoskeleton (shell) is a vital part of the organism and according to ICRP (2009), many radionuclides will adsorb on to it, in the short term and relative to processes involving uptake and depuration. This may be an important source of radiation exposure for radionuclides emitting beta and low-energy gamma radiations, although the shell will effectively shield the living organism from low-energy radiation emissions. Crustaceans moult, i.e. shed their shells, regularly and radionuclides present in the shell will therefore not be part of the organism forever. This radionuclide "reserve" can therefore be seen as temporal.

FM data contain 2 observations for the small crustacean *Idothea spp* (whole organisms) whereas ICRP (2011) data are for adult crab. According to ICRP (2009), their empirical database includes few data on the assimilation of radionuclides by crab shell and the majority of their data are derived from muscle tissue and hepatopancreas. ERICA (Hosseini et al. 2008) presented no information on which organism types are analysed, though tissue information is included in some cases (soft tissue, whole or unspecified). When site are compared to literature data, the CR values differ for 5 elements; Cd, Co, Cs, Zr and Ni. Site data are prioritised since they represent the organisms of interest better. Site data for Sr are not available and literature values are 2 orders of magnitude lower than site data for Ca and Ba. Ca site data are selected as EA. Nd is utilised as EA for Ac, Am, Cm and Np (see Section 2.7). Zr is selected as EA for Pa and Ni for Pd.

GSD exceeds GSDmax (5) for Pb, due to large variations in water concentrations (circa 100 times) in the underlying data. No obvious errors are found and no action is taken.

Data for Sn in marine crustacean are missing and data for marine fish are selected, which is common when data for this parameter are missing in ERICA. LX data for Sn in fish are available.

Literature data from ICRP (2011), categorised as L1 data, or ERICA (Hosseini et al. 2008), categorised as L2 data, are utilised when site data are not available. As stated earlier, Tc data from ICRP (2011) overlap to a limited degree with data from ERICA. The former are based on 17 observations for adult crab, whereas the latter are based on 121 observations without organism information. ERICA data are selected since crab is not the organism of interest (absent in brackish environments)

Ranges are not available for the elements Ag, Cl, I and U, and GSDmax is assigned to these parameters. The presented GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean or GSDmax).

The selected CR values are presented in Table 8-15 and in Figure 8-15.

Table 8-14. All available data for the parameter cR_Sea_crust_NHB, the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ICRP 2011 Crab Sea water, ERICA (Hosseini et al. 2008) Crustacean Sea water.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am					20							2.4							1:0/0
Ba	6/2		6/2					1.1		1.1									0:0/0
Ca	6/2		6/2					1.0		1.0									0:0/0
Cd	6/2		6/2	4	4			1.2		1.2	1.1	3.5			S4		S4		2:1/1
Cl					1														1:0/0
Cm					1														1:0/0
Co	4/2		4/2		18			1.3		1.3		2.4			S4		S4		1:0/0
Cs	3/2		3/2	66	279			1.1		1.1	1.9	3.6			S4		S4		2:1/1
Eu	3/2		3/2		1			1.7		1.7									1:0/0
Ho	3/2		3/2					1.3		1.3									0:0/0
I					1														1:0/0
Mo	6/2		6/2					1.1		1.1									0:0/0
Nb					3							1.0							1:0/0
Nd	6/2		6/2					1.5		1.5									0:0/0
Ni	6/2		6/2		2			1.3		1.2		2.5			S4		S4		1:0/0
Np					1														1:0/0
Pa																			0:0/0
Pb	6/2		6/2		7			6.8		6.8		4.1			S3		S3		1:0/0
Pd																			0:0/0
Po					9							2.2							1:0/0
Pu				1	48							2.1							2:0/0
Ra					7							1.9							1:0/0
Se	4/2		4/2		4			1.3		1.3		1.8			S2 (L43%)		S2 (L43%)		1:0/0
Sm	3/2		3/2					1.2		1.2									0:0/0
Sn																			0:0/0
Sr				4	20						1.2	2.2							2:1/1
Tc				17	121						1.6	2.3							2:0/1
Th	3/2		3/2		1			1.2		1.2									1:0/0
U					1														1:0/0
Zr	3/2		3/2		7			1.1		1.1		2.4			S4		S4		1:0/0

Table 8-15. Selected data properties, references and comments for the parameter cR_Sea_crust_NHB (m^3/kg_{fw}) and the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Ac	Nd		2	5.8E–01	8.2E+00	8.2E+00	1.2E+02	5.0	GSDmax	Site data FM	FM	Nd used as EA (site data available).
Ag			1	1.1E+00	1.6E+01	1.6E+01	2.3E+02	5.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Am	Nd		2	5.8E–01	8.2E+00	8.2E+00	1.2E+02	5.0	GSDmax	Site data FM	FM	Nd used as EA (site data available).
Ba			2	8.3E–02	1.2E+00	1.2E+00	1.6E+01	5.0	GSDmax	Site data FM	FM	
Ca			2	2.7E–01	3.8E+00	3.8E+00	5.4E+01	5.0	GSDmax	Site data FM	FM	
Cd			2	2.3E+01	3.3E+02	3.3E+02	4.7E+03	5.0	GSDmax	Site data FM	FM	FM data (n=2, Idothea spp) and literature data (ICRP 2011 (n=4, adult crab) and ERICA (n=4, no species info)) do not overlap. FM data have the highest value and represent the organisms of interest best.
Cl			1	4.2E–06	6.0E–05	6.0E–05	8.5E–04	5.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Cm	Nd		2	5.8E–01	8.2E+00	8.2E+00	1.2E+02	5.0	GSDmax	Site data FM	FM	Nd used as EA (site data available).
Co			2	4.1E+00	5.8E+01	5.8E+01	8.2E+02	5.0	GSDmax	Site data FM	FM	FM data (n=2, Idothea spp) and literature data (ERICA (n=18, no species info)) do not overlap. FM data have the highest value and is utilised.
Cs			2	4.2E–02	5.9E–01	5.9E–01	8.3E+00	5.0	GSDmax	Site data FM	FM	FM (n=2, Idothea spp) and literature data (ICRP 2011 (n=66, adult crab) and ERICA (n=279, no species info)) do not overlap. FM data represent the organisms of interest best.
Eu			2	4.7E–02	6.6E–01	6.6E–01	9.4E+00	5.0	GSDmax	Site data FM	FM	
Ho			2	9.3E–02	1.3E+00	1.3E+00	1.9E+01	5.0	GSDmax	Site data FM	FM	
I			1	2.5E–04	3.6E–03	3.6E–03	5.1E–02	5.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Mo			2	1.4E–02	1.9E–01	1.9E–01	2.7E+00	5.0	GSDmax	Site data FM	FM	
Nb			3	7.1E–03	1.0E–01	1.0E–01	1.4E+00	5.0	GSDmax	ERICA	L2	
Ni			2	4.0E–01	5.7E+00	5.7E+00	8.1E+01	5.0	GSDmax	Site data FM	FM	Ranges of FM (n=2) and ERICA (n=2) data do not overlap. Considering the few observations and the highest value, FM data are selected.
Np	Nd		2	5.8E–01	8.2E+00	8.2E+00	1.2E+02	5.0	GSDmax	Site data FM	FM	Nd used as EA (site data available).
Pa	Nd		2	5.8E–01	8.2E+00	8.2E+00	1.2E+02	5.0	GSDmax	Site data FM	FM	Nd used as EA (site data available).
Pb			2	2.2E–01	5.2E+00	5.2E+00	1.2E+02	6.8	GSD	Site data FM	FM	GSD exceed GSDmax, due to large deviations in water concentrations (c 100 times). No obviuos errors found, no action taken.
Pd	Ni		2	4.0E–01	5.7E+00	5.7E+00	8.1E+01	5.0	GSDmax	Site data FM	FM	Ni used as EA (site data available).
Po			9	7.3E+00	4.5E+01	4.5E+01	2.7E+02	3.0	GSDmean	ERICA	L2	

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Pu			48	2.0E–02	1.2E–01	1.2E–01	7.3E–01	2.1	GSD	ERICA	L2	ICRP only have 1 value. Data from ERICA selected. ICRP value within the 5–95 percentile of ERICA data.
Ra			7	2.0E–02	1.2E–01	1.2E–01	7.4E–01	3.0	GSDmean	ERICA	L2	
Se			2	1.1E–01	1.5E+00	1.5E+00	2.2E+01	5.0	GSDmax	Site data FM	FM	FM (n=2) and ERICA (n=4) data overlap to a limited degree but both ranges very small. The values differ about 3 times and not considered an issue. FM data used.
Sm			2	1.4E–01	2.0E+00	2.0E+00	2.8E+01	5.0	GSDmax	Site data FM	FM	
Sn		cR_Sea_Fish_NHB	3	3.2E–02	4.5E–01	4.5E–01	6.3E+00	5.0	GSDmax	Site data LX	LX	Fish data (site data) used (often the case in ERICA). LX data available.
Sr	Ca		2	2.7E–01	3.8E+00	3.8E+00	5.4E+01	5.0	GSDmax	Site data FM	FM	Literature data much lower than site data for Ca and Ba. Site data for Ca used.
Tc			121	5.0E–02	1.6E+01	1.6E+01	1.8E+02	2.3	GSD	ERICA	L2	ICRP 2011 (n=17, adult crab) and ERICA (n=121, no species information) do not overlap. Crab is not an organism of interest and ERICA GM 2 orders of magnitude higher than ICRP. ERICA data used.
Th			2	1.6E+00	2.3E+01	2.3E+01	3.2E+02	5.0	GSDmax	Site data FM	FM	
U			1	7.1E–04	1.0E–02	1.0E–02	1.4E–01	5.0	GSDmax	ERICA	L2	No range presented. GSDmax assigned.
Zr			2	7.6E–01	1.1E+01	1.1E+01	1.5E+02	5.0	GSDmax	Site data FM	FM	FM (n=2, Idothea spp) and ERICA (n=7, no species info) data do not overlap. FM value about 2 orders of magnitude higher. FM data selected.

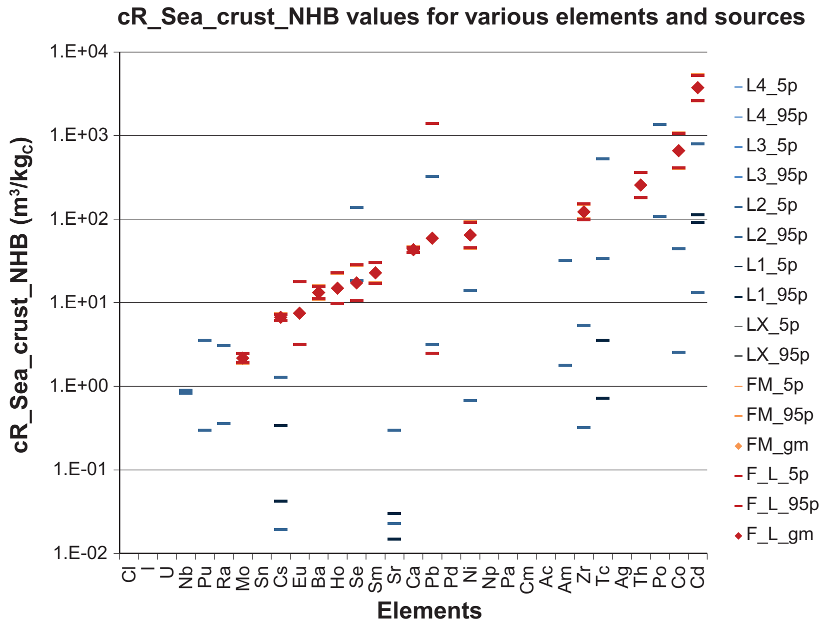


Figure 8-14. *Total available data ranges for the parameter cR_Sea_crust_NHB (m³/kg$_C$). The elements are arranged in the same order as in Figure 8-15 showing selected parameter values.*

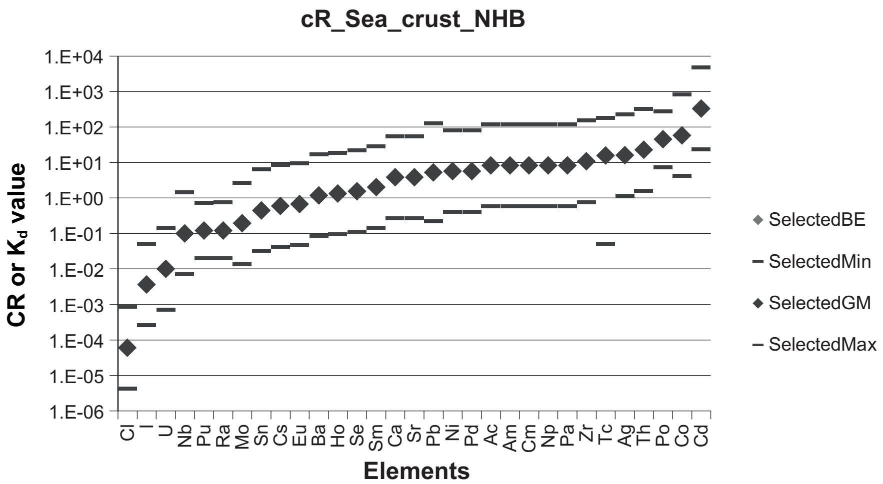


Figure 8-15. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m³/kg$_{fw}$).*

8.8 cR_Sea_Fish, cR_Sea_Fish_NHB, cR_Sea_bent_Fish_NHB, cR_Sea_pel_Fish_NHB

The cR_Sea_Fish parameter reflects the uptake of elements from sea water to the edible parts of marine fish, as defined in the radionuclide model (Saetre et al. 2013). The cR_Sea_Fish_NHB parameter is utilised as PA for marine benthic and pelagic fish (parameter names cR_Sea_bent_Fish_NHB and cR_Sea_pel_Fish_NHB), which are used for dose estimates to these two organism types. The difference between the two parameters is that the uptake in the edible part of the fish is of interest in the case of cR_Sea_Fish parameter, while the uptake in the whole fish is of interest for the cR_Sea_Fish_NHB parameter.

It is assumed that the marine fish species in the future ecosystem of FM are similar to the species found at FM and LX today. Site data for the parameterisation of cR_Sea_Fish are fish samples from the marine (brackish) areas of FM and LX, consisting of 8 species: *Abramis brama* (bream), *Alburnus alburnus* (bleak), *Clupea harengus* (herring), *Osmerus eperlanus* (smelt), *Platichthys* *flesus* (flounder), *Perca fluviatilis* (perch), *Rutilus rutilus* (roach) and *Gymnocephalus cernuus* (ruffe), sampled by Kumblad and Bradshaw (2008) in FM and Engdahl et al. (2008) in LX. It is evident that this is a brackish environment as some species are limnic instead of marine.

The sampled fish were treated differently in the study conducted in FM (Kumblad and Bradshaw 2008) compared to LX (Engdahl et al. 2008). In the study conducted in FM, the intestines were removed from the fish samples and the concentration measurements were done on slices of the remaining fish. These samples included bones and muscle tissue. The fish samples collected in LX were rinsed and the concentrations measurements were performed on muscle tissue alone. Consequently, the samples are not fully comparable and a difference in concentrations between the two studies is expected. According to the analysis presented in Tröjbom and Nordén (2010), marine fish from FM contain more Ca, P, Ba and several metals compared to marine fish from LX and limnic fish samples from FMLX (see Figure 8-16). Skeleton tissue is high in Ca (and P), which influences the total Ca contents considerably. It is unclear if the elevated contents of other elements originate from skeleton tissue or other tissues in the (almost) whole fish samples.

Biota data from FM and LX are measured on parts of the fish and when possible, a conversion of the data to whole body concentrations is accomplished by using the conversion factors in Yankovich et al. (2010). The whole body values are presented in ERICA (Hosseini et al. 2008) and ICRP (2011), hence conversions are not necessary for literature data.

Site data are available for the following 18 elements: Ba, Ca, Cd, Cl, Co, Cs, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Sr, Th, U and Zr.

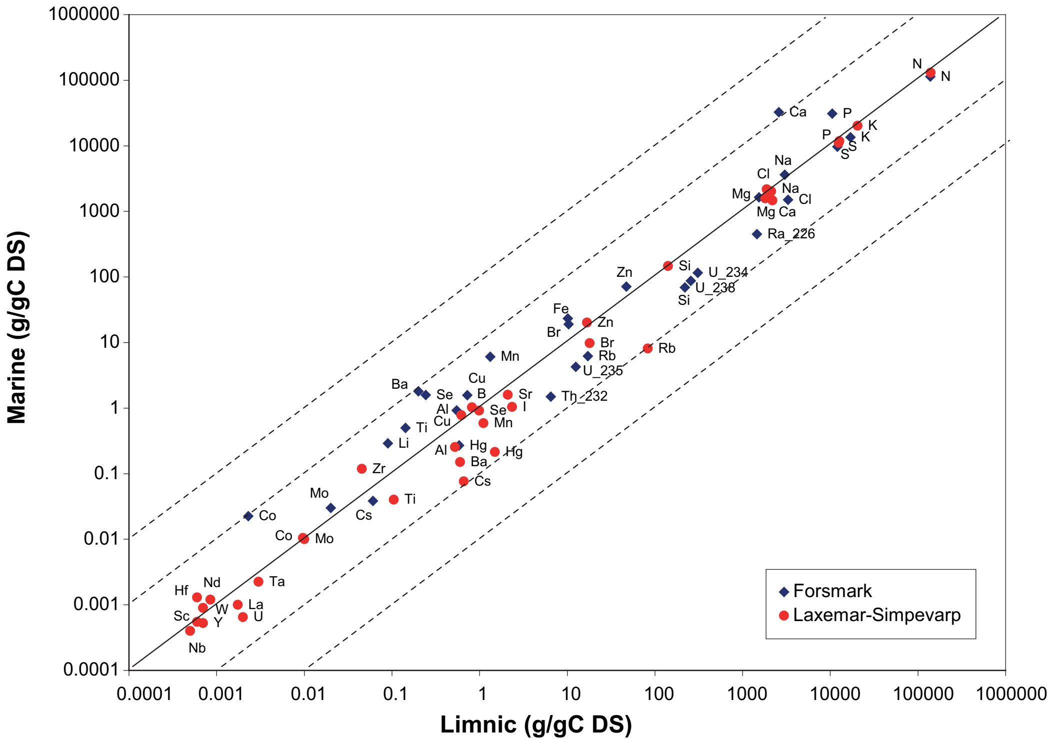
Representative literature data consists of CR values for whole body of adult salmonid fish and adult flatfish for 8 elements: Am, Ca, Co, Cs, Ni, Pb, Pu, Sr and Zr, reported in ICRP (2011). The data for the 2 fish types are identical. The number of observations reported in ICRP (2011) varies from 315 (for Cs) to 5 (for Ni), while only 1 sample is reported for Zr and Ca. Data from ICRP (2011) are prioritised and classified as L1 data. In ERICA (Hosseini et al. 2008), identical CR values for both benthic and pelagic fish are reported for 21 elements and these data are classified as L2 data. IAEA (2004) reported recommended mean values for marine fish without describing the variation or range, hence these data are not included. CRs for marine fish are not reported in IAEA (2010).

Available data for the parameter cR_Sea_Fish are plotted in Figure 8-17 and listed in Table 8-16. The ranges for FM and LX data overlap for all the elements except for Ba and Ca (see Table 8-16). In the case of Mo, the overlap is only 25% and LX data generally indicate lower values. When FM data are compared to available literature data (see Table 8-16) consistency between the data sets are shown for Cs, Co, Ni, Se and Zr. The overlap is less than 50% for Cd and Pb, and FM data indicate an overlap with the lower range of reported literature data. When LX data are compared to literature data, major discrepancies are found (see Table 8-16). The LX data range are lower than the reported literature data range for Cd, Co, Ni, Pb, Se, Sr and U, while it is higher for Cs. The LX data for Zr indicates a wide range, which encompasses the whole range of literature data. When ICRP (2011) data are compared to ERICA (Hosseini et al. 2008) data (see Table 8-16), an overlap is found for Cs, Co, Ni, Am, Pu and Sr. For Zr and Pb, data from the two literature sources do not indicate any overlap.

Based on the comparisons described above, it can be concluded that literature data, FM and LX data are inconsistent for many of the elements. An explanation for the discrepancies can be that the compared CR values are based on different parts of the fish samples. The utilised literature data are based on measurements of the whole fish, while FM and LX samples are only parts, therefore the data sets are not equivalent and some discrepancies are expected.

In many cases, reported GSD values for FM and LX data are lower than GSDmin (2) (see Table 8-16). The reported GSDs from various literature sources are also low in many cases. Reported GSDs are high for Pb FM data (6.6) and Zr LX data (6.0).

The selected data for cR_Sea_fish are listed in Table 8-17 and plotted in Figure 8-18. FM and LX data are available and utilised for Ba, Ca, Cd, Cl, Co, Cs, I, Mo, Ni, Pb, Se, Th and Zr, and LX data are available for Nb, Sn, Sr and U. Suitable EAs are available for the elements missing site data. PAs are not utilised for this parameter. Ni data are selected for Pd (see Section 2.7 for discussion on this EA). Ba is utilised as EA for Ra (literature data on Ra are consistent with the selected Ba site data).



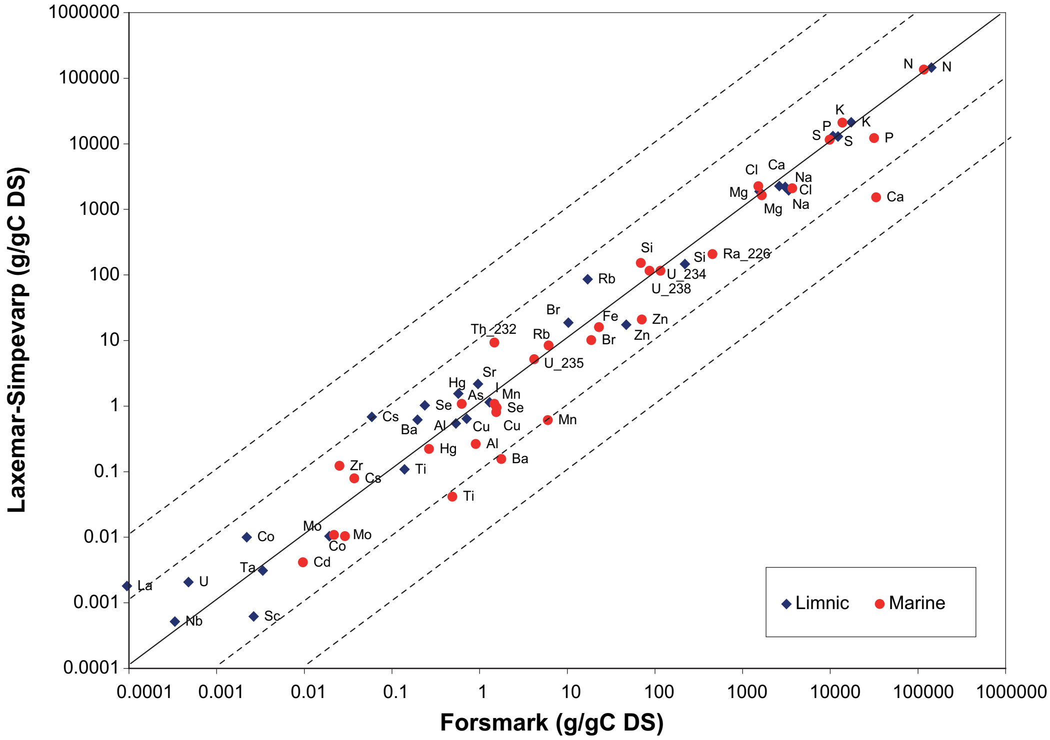


Figure 8-16. *Comparison between element composition of fish samples from FM and LX (marine and limnic ecosystems. These figures are based on median values of available fish samples. Dotted lines mark 10-fold deviations from the 1:1-relationship (the solid line). (Part of a figure from Tröjbom and Nordén 2010.)*

Data regarding Ac, Am, Cm, Eu, Ho, Np, Pa and Sm are limited and site data are not available, except for Sm where 1 sample is reported from LX. In the case of Am, 23 samples on marine fish are reported in ICRP (2011) and 33 samples in ERICA (Hosseini et al. 2008). ERICA reported 3 samples for Eu, while no literature data are available for Ho and Ac. For Np 1 sample is reported by ERICA (Hosseini et al. 2008). Site data are available for the analogous elements Dy, Gd, La, Nd and Pr. LX data for La (n=9) are used as EA for Am, Cm, Ac, Ho, Eu Np and Pa. Only 1 sample of Sm data is reported from LX, which is utilised for Sm.

Literature data are utilised for the elements Ag, Po, Pu and Tc, where neither site data nor site data for suitable EAs are available. ICRP (2011) data are selected for Pu and ERICA (Hosseini et al. 2008) data are used for Ag, Po, and Tc. Neither site nor literature data are available for Pa, instead, La site data are utilised as EA.

GSDmean is assigned to Ag, Cd, Cl, Cs, I, Mo, Ni, Pa. Po, Se and Th. GSDmax is assigned to Ac, Am, Cm, Eu, Ho, Nb, Np, Sm, Sn, Sr and U (Section 4.3).

In some cases BE and GM differs, as BE is based on FM data and the GM is based on FMLX data. The BE is more than 50% higher than the GM for Ca, Co, Th, Ba and Mo. In all other cases, the differences are considered small.

The selected data for cR_Sea_Fish_NHB are presented in Table 8-18. The data are similar to cR_Sea_Fish, described above, although presented in the unit m^3/kg_{fw}. The parameter cR_Sea_fish_NHB is utilised in dose calculation to fish and, therefore, the CR value for whole body is of interest. Since the site data are based on measurements from fish muscle (LX) or muscle and skeleton (FM), the CR data are converted to represent whole body measurement by using the conversion factors reported in Yankovich et al. (2010). This conversion is carried out on Cd, Co, Pb, Sr and Zr, hence the data utilised for these elements differ from the data used for the parameter cR_Sea_fish.

In Figure 8-18 elements are arranged in ascending order based on the selected GM values for cR_Sea_Fish. The selected GMs range over 5 orders of magnitude, from 1.25×10^{-3} m^3/kg_C for Cl to 116 m^3/kg_C for Po. Particularly high uptake is indicated for Po and Se, as well as the metals Ag and Sn. Low uptake is indicated for site data for Cl, U and the lanthanides. The GM for cR_Sea_Fish_NHB are higher for the elements where a conversion to whole body are performed.

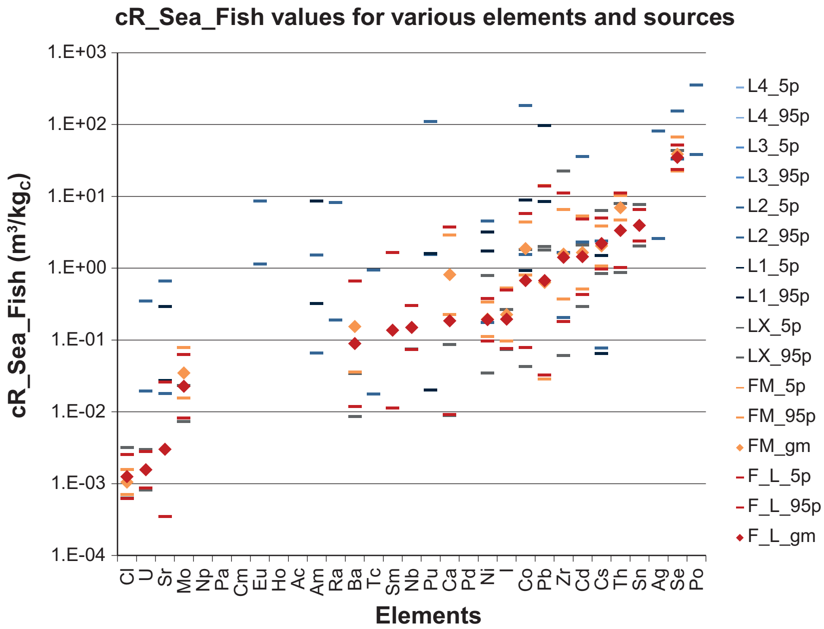


Figure 8-17. Total available data ranges for the parameter cR_Sea_Fish (m^3/kg_C). The elements are arranged in the same order as in Figure 8-18 showing selected parameter values.

Table 8-16. All available data for the parameter cR_Sea_Fish and cR_Sea_Fish_NHB, the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ICRP 2011 Flat fish Sea water, L2 = ERICA Benthic fish Sea water.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					4							2.9							1:0/0
Am				23	33						2.7	2.6							2:1/1
Ba	6/9	3/6	9/15					2.4	1.5	3.4								S4	0:0/0
Ca	6/9	3/14	9/23	1				2.2	2.0	6.2								S4	1:0/0
Cd	6/9	3/4	9/13		5			2.0	1.8	2.1		2.3			S2 (L35%)	S4	S2 (L30%)	S2 (U60%)	1:0/0
Cl	5/6	3/14	8/20		1			1.3	1.6	1.5								S1	1:0/0
Cm					1														1:0/0
Co	4/9	3/14	7/23	6	99			1.7	3.1	3.7	2.0	4.3			S2 (L91%)	S2 (L17%)	S2 (L42%)	S2 (U48%)	2:1/1
Cs	3/9	3/14	6/23	315	1,773			1.5	1.8	1.6	2.6	2.8			S2 (U61%)	S2 (U51%)	S2 (U54%)	S1	2:1/1
Eu					3							1.9							1:0/0
Ho																			0:0/0
I	5/4	3/3	8/7		1			1.7	1.5	1.8								S2 (U59%)	1:0/0
La		3/9	3/9						4.9	4.7									0:0/0
Mo	6/9	3/14	9/23					1.6	1.4	1.9								S2 (U25%)	0:0/0
Nb		3/7	3/7		1				1.5	1.5									1:0/0
Ni	6/9	3/2	9/11	5	7			1.4	2.6	1.5	1.2	2.7			S2 (L59%)	S2 (L48%)	S2 (L56%)	S1	2:1/1
Np					1														1:0/0
Pa																			0:0/0
Pb	6/9	3/1	9/10	5	1			6.6	1.0	6.3	2.1				S2 (L8%)	S4	S2 (L8%)	S3	2:0/0
Pd																			0:0/0
Po					16							2.0							1:0/0
Pu				25	110						3.8	3.7							2:1/1
Ra					29							3.1							1:0/0
Se	4/9	3/14	7/23		3			1.4	1.2	1.3		1.6			S2 (L64%)	S2 (L43%)	S2 (L56%)	S3	1:0/0
Sm		3/1	3/1						4.5	4.5									0:0/0
Sn		3/9	3/9						1.5	1.4									0:0/0
Sr		3/14	3/14	12	103				3.7	3.7	2.1	3.0				S2 (L8%)	S2 (L8%)		2:1/1
Tc					92							3.3							1:0/0
Th	3/1	3/3	6/4		1			1.3	2.0	2.1								S2 (U67%)	1:0/0
U		3/11	3/11		25				1.5	1.4		2.4				S4	S4		1:0/0
Zr	3/9	3/5	6/14	1	7			2.4	6.0	3.5		1.9			S2 (U51%)	S3	S3	S1	2:0/0

Table 8-17. Selected data properties, references and comments for the parameter cR_Sea_Fish (m^3/kg_C) and the elements of primary concern.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Ac	La		3	1.9E–03	2.6E–02	2.6E–02	9.9E–01	5.0	GSDmax	Site data LX	LX	La is used as EA.
Ag			4	2.4E+00	1.4E+01	1.4E+01	8.7E+01	3.0	GSDmean	ERICA	L2	No site data available. ERICA reported the same data for benthic and pelagic fish (n=4), which are selected.
Am	La		3	1.9E–03	2.6E–02	2.6E–02	9.9E–01	5.0	GSDmax	Site data LX	LX	La is used as EA.
Ba			9	1.1E–02	8.9E–02	1.5E–01	6.6E–01	3.4	GSD	Site data FMLX	FMLX	FM data are higher than LX data.
Ca			9	8.4E–03	1.8E–01	8.1E–01	3.7E+00	6.2	GSD	Site data FMLX	FMLX	FM data higher than LX data. The GSD for FMLX data higher than GSDmax.
Cd			9	2.4E–01	1.4E+00	1.6E+00	8.8E+00	3.0	GSDmean	Site data FMLX	FMLX	FM data and LX data overlap. ERICA reported a wide range (n=5) that overlap site data.
Cl			8	2.0E–04	1.2E–03	1.0E–03	7.6E–03	3.0	GSDmean	Site data FMLX	FMLX	FM data and LX data overlap. ERICA reported 1 sample.
Cm	La		3	1.9E–03	2.6E–02	2.6E–02	9.9E–01	5.0	GSDmax	Site data LX	LX	La is used as EA.
Co			7	5.0E–02	6.7E–01	1.9E+00	5.8E+00	3.7	GSD	Site data FMLX	FMLX	FM data agrees well with literature while LX data are lower than both FM and literature data range.
Cs			6	3.6E–01	2.2E+00	2.0E+00	1.3E+01	3.0	GSDmean	Site data FMLX	FMLX	Many samples reported in both ICRP and ERICA (n=315 and n=1,773 respectively). These data overlap with site data. GSD for site data low and GSDmean assigned instead.
Eu	La		3	1.9E–03	2.6E–02	2.6E–02	9.9E–01	5.0	GSDmax	Site data LX	LX	La is used as EA.
Ho	La		3	1.9E–03	2.6E–02	2.6E–02	9.9E–01	5.0	GSDmax	Site data LX	LX	La is used as EA.
I			7	3.2E–02	1.9E–01	2.2E–01	1.2E+00	3.0	GSDmean	Site data FMLX	FMLX	FM data and LX data overlap. Only 1 sample reported by ERICA. Site data selected.
Mo			9	3.7E–03	2.3E–02	3.5E–02	1.4E–01	3.0	GSDmean	Site data FMLX	FMLX	FM and LX data overlap less than 50%. No literature data available. Site data selected.
Nb			3	1.1E–02	1.5E–01	1.5E–01	2.1E+00	5.0	GSDmax	Site data LX	LX	No FM data available. LX data (n=3) are selected. No literature data available.
Ni			9	3.1E–02	1.9E–01	1.9E–01	1.2E+00	3.0	GSDmean	Site data FMLX	FMLX	FM and LX data overlap. ICRP reports a narrow range with higher values for Ni (n=5), which do not overlap with site data, while ERICA (n=7) data show a wider range that overlap with site data.
Np	La		3	1.9E–03	2.6E–02	2.6E–02	9.9E–01	5.0	GSDmax	Site data LX	LX	La is used as EA.
Pa	La		3	1.9E–03	2.6E–02	2.6E–02	9.9E–01	5.0	GSDmax	Site data LX	LX	La used as analogue.
Pb			9	2.4E–02	6.7E–01	6.3E–01	1.4E+01	6.3	GSD	Site data FMLX	FMLX	FM data show a wide range and LX data a small range. Literature data higher than site data. Site data selected.

Element	EA	PA	N	Min	GM	BE	Max	GSD	GSD comment	Reference	Data Source	Comment
Pd	Ni		9	3.1E–02	1.9E–01	1.9E–01	1.2E+00	3.0	GSDmean	Site data FMLX	FMLX	Ni is used as EA.
Po			16	1.2E+01	1.2E+02	1.2E+02	7.0E+02	3.0	GSDmean	ERICA	L2	ERICA data corrected from muscle tissue to whole body using a factor of 8.
Pu			25	1.7E–02	1.8E–01	1.8E–01	3.3E+00	3.8	GSD	ICRP 2011	L1	(ICRP 2011) reported (n=25) while ERICA reported n=110. (ICRP 2011) is the latest and most reliable literature source, hence these data are selected.
Ra	Ba		9	1.1E–02	8.9E–02	1.5E–01	6.6E–01	3.4	GSD	Site data FMLX	FMLX	Ba is used as EA.
Se			7	5.7E+00	3.5E+01	3.9E+01	2.1E+02	3.0	GSDmean	Site data FMLX	FMLX	FM and LX data overlap. Literature data reported by ERICA show an overlap with site data. Site data selected.
Sm			1	9.7E–03	1.4E–01	1.4E–01	1.9E+00	5.0	GSDmax	Site data LX	LX	LX data used.
Sn			3	2.8E–01	3.9E+00	3.9E+00	5.6E+01	5.0	GSDmax	Site data LX	LX	No FM data available. LX data n=3 are selected. No literature data are available.
Sr			3	2.1E–04	3.0E–03	3.0E–03	4.2E–02	5.0	GSDmax	Site data LX	LX	Sr data from LX lower than data for Ba and Ca.
Tc			92	1.8E–02	1.3E–01	1.3E–01	3.4E+00	3.3	GSD	ERICA	L2	ERICA data selected (n=92).
Th			4	5.5E–01	3.3E+00	6.9E+00	2.0E+01	3.0	GSDmean	Site data FMLX	FMLX	Site data used.
U			3	1.1E–04	1.6E–03	1.6E–03	2.2E–02	5.0	GSDmax	Site data LX	LX	No FM data available. LX data (n=3) are selected. ERICA reported a wide range (n=25) that do not overlap LX data.
Zr			6	9.8E–02	1.4E+00	1.6E+00	2.7E+01	3.5	GSD	Site data FMLX	FMLX	FM data and LX data have a wider range than ERICA data.

Table 8-18. Selected data for cR_Sea_Fish_NHB m^3/kg_{fw}. Data are converted to whole body for the elements Co, Cd, Pb, Sr and Zr, and differ from the data used for cR_Sea_Fish.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Ac	La		3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	Site data for Ac is missing. Relevant data is La which was used as EA.
Ag			4	2.7E–01	1.7E+00	1.7E+00	1.0E+01	3.0	GSDmean	ERICA	L3	
Am	La		3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	Site data for Am missing. Relevant data is La which was used as EA.
Ba			9	1.2E–03	9.7E–03	1.7E–02	7.2E–02	3.4	GSD	Site data FMLX	FMLX	FM (n=6) and LX (n=3) data do not overlap. No literature data available. FM data are about 10 times higher than LX data. Relatively narrow ranges, data OK.
Ca			9	9.2E–04	2.0E–02	8.9E–02	4.1E–01	6.2	GSD	Site data FMLX	FMLX	FM data (n=6) higher than LX (n=3) and ICRP 2011 (n=1). Due to larger number of observations, site data considered valid.
Cd			9	7.8E–02	4.7E–01	5.4E–01	2.9E+00	3.0	GSDmean	Site data FMLX	FMLX	
Cl			8	2.3E–05	1.4E–04	1.2E–04	8.4E–04	3.0	GSDmean	Site data FMLX	FMLX	
Cm	La		3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	Site data for Cm is missing. Relevant data is La which was used as EA.
Co			7	9.8E–03	1.3E–01	3.7E–01	1.1E+00	3.7	GSD	Site data FMLX	FMLX	
Cs			6	4.0E–02	2.4E–01	2.2E–01	1.5E+00	3.0	GSDmean	Site data FMLX	FMLX	
Eu	La		3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	La is used as chemcial analogue. Site data available.
Ho	La		3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	La is used as chemcial analogue. Site data available.
I			7	3.5E–03	2.1E–02	2.5E–02	1.3E–01	3.0	GSDmean	Site data FMLX	FMLX	
Mo			9	4.1E–04	2.5E–03	3.8E–03	1.5E–02	3.0	GSDmean	Site data FMLX	FMLX	FM and LX data overlap to a limited degree. Both ranges very small, values differ less than 3 times, so this was not considered an issue.
Nb			3	1.1E–03	1.6E–02	1.6E–02	2.3E–01	5.0	GSDmax	Site data LX	LX	
Ni			9	3.4E–03	2.1E–02	2.1E–02	1.3E–01	3.0	GSDmean	Site data FMLX	FMLX	
Np	La		3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	Site data for Np is missing. Relevant data is La which was used as EA.
Pa	La		3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	La was used as EA. Site data available.
Pb			9	7.0E–03	1.8E–01	1.7E–01	3.7E+00	6.3	GSD	Site data FMLX	FMLX	GSDmax exceeded due to large range in water concentration. No obvius errors found, no action taken.
Pd	Ni		9	3.4E–03	2.1E–02	2.1E–02	1.3E–01	3.0	GSDmean	Site data FMLX	FMLX	Ni used as EA.
Po			16	1.4E+00	1.4E+01	1.4E+01	8.2E+01	3.0	GSDmean	ERICA	L3	

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Pu			25	2.0E–03	2.1E–02	2.1E–02	3.9E–01	3.8	GSD	ICRP 2011	L2	
Ra	Ba		9	1.2E–03	9.7E–03	1.7E–02	7.2E–02	3.4	GSD	Site data FMLX	FMLX	Ba used as element analogue (site data available).
Se			7	6.3E–01	3.9E+00	4.2E+00	2.3E+01	3.0	GSDmean	Site data FMLX	FMLX	Site data somewhat lower than literature data. FM and LX data consistent and considered valid.
Sm			1	1.1E–03	1.5E–02	1.5E–02	2.2E–01	5.0	GSDmax	Site data LX	LX	
Sn			3	3.2E–02	4.5E–01	4.5E–01	6.3E+00	5.0	GSDmax	Site data LX	LX	
Sr			3	7.3E–05	1.0E–03	1.0E–03	1.5E–02	5.0	GSDmax	Site data LX	LX	
Tc			92	2.1E–03	1.5E–02	1.5E–02	4.0E–01	3.3	GSD	ERICA	L3	
Th			4	5.8E–02	3.5E–01	7.3E–01	2.2E+00	3.0	GSDmean	Site data FMLX	FMLX	
U			3	1.2E–05	1.8E–04	1.8E–04	2.5E–03	5.0	GSDmax	Site data LX	LX	LX data 50 times lower than ERICA data, which is based on a larger number of observations (n=25 vs 3). A reason may be the low salinity of the Baltic Sea, hence data from LX is selected.
Zr			6	2.6E–02	3.7E–01	4.1E–01	6.7E+00	3.5	GSD	Site data FMLX	FMLX	Site data somewhat higher than literature data. Due to the agreement between FM and LX site data was considered valid.

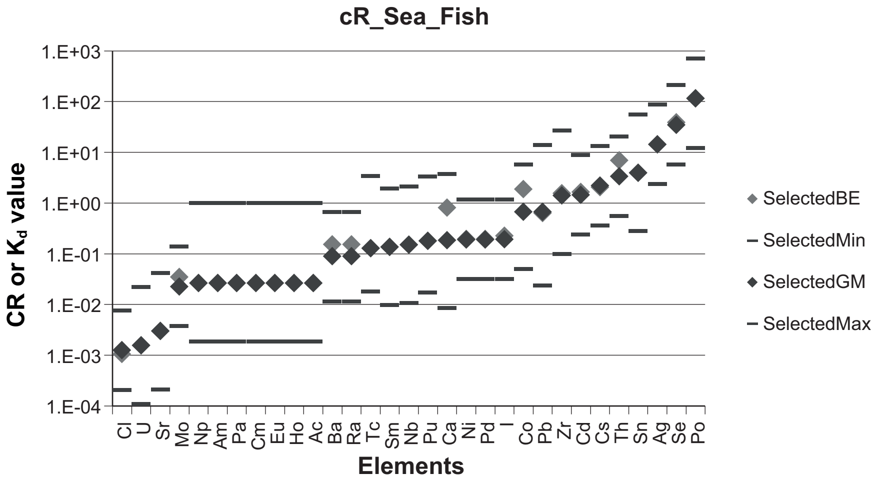


Figure 8-18. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_C).*

8.9 cR_Sea_bird_NHB

This parameter describes the element uptake in marine birds for use in dose estimates to this organism type. Site data for marine birds are not available. Literature data are available for 2 elements for adult duck in ICRP (2011) (categorised as L1 data) and for wading bird in ERICA (Hosseini et al. 2008) (categorised as L2 data), see Table 8-19 and Figure 8-19. Sense checks of data could not be completed as data from both literature sources are only available for the elements Pb and Po, which are presented without ranges. The values deviate by several orders of magnitude (approximately 2 for Pb and 9 for Po).

Data for vertebrates, often mammals though sometimes fish, are utilised as PA in ERICA (Hosseini et al. 2008). Site data for marine fish are available and are selected as PA for the elements: Ba, Ca, Cd, Cl, Co, Cs, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Sr, Tc, Th, U and Zr (see parameter cR_Sea_Fish in Section 8.8). Site data for fish are not available for Eu and Ho, and La data are used (combined PA and EA). Fish data for La are also selected for Ac, Am, Cm, Np and Pa. Ni is utilised as EA for Pd (see Section 2.7).

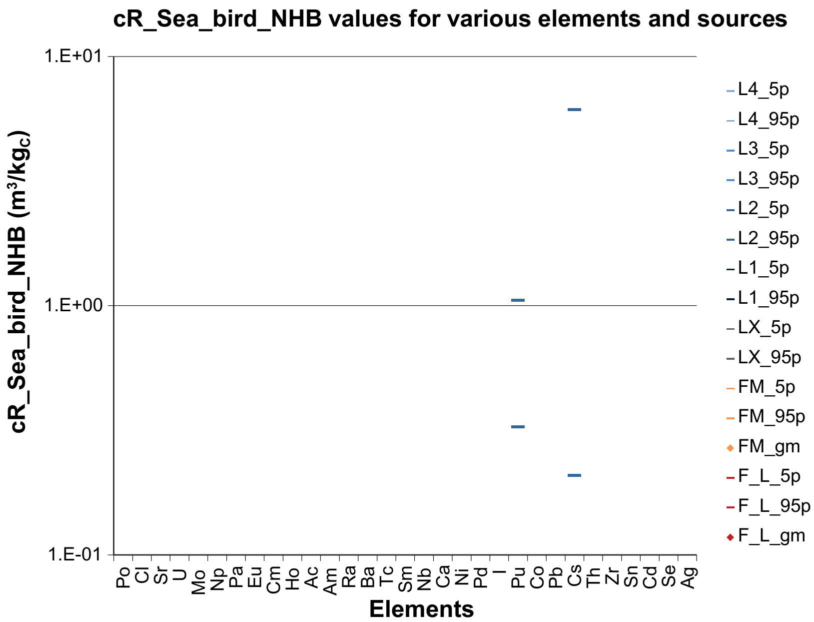


Figure 8-19. *Total available data ranges for the parameter cR_Sea_bird_NHB (m^3/kg_{fw}). The elements are arranged in the same order as in Figure 8-20 showing selected parameter values.*

Literature data from ICRP (2011) and ERICA (Hosseini et al. 2008) are selected for Ag, Po, Pu, Ra and Tc. Bird data are only available for Po (ICRP 2011) and Pu (ERICA (Hosseini et al. 2008)). The same data as for marine fish are used for Ra and Tc. Data utilised for marine birds in ERICA are selected for Ag and U. For Ag, the data is the same as for mammals and for U the data are based on a biokinetic model.

For Po, the values presented in ICRP (2011) and ERICA (Hosseini et al. 2008) differ with several (9) orders of magnitude. The former is considered a better representative (value for adult duck in estuarine environment vs. value for mammal) and this value is utilised. GSDmax (5) is assigned to this parameter as well as Tc and Ag, since ranges are not available. GSDmax is also assigned to elements where PAs are utilised.

The selected CR values are presented in Table 8-20 and in Figure 8-20.

Table 8-19. All available data for the parameter cR_Sea_bird_NHB, the elements of primary concern and selected EAs. L2 = ERICA (Hosseini et al. 2008) Wading bird Sea water.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvsLX	SC Lit
Ac																			0:0/0
Ag					1														1:0/0
Am					1														1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd					1														1:0/0
Cl					1														1:0/0
Cm					1														1:0/0
Co					1														1:0/0
Cs					70							2.8							1:0/0
Eu					1														1:0/0
Ho																			0:0/0
I					1														1:0/0
Mo																			0:0/0
Nb					1														1:0/0
Ni					1														1:0/0
Np					1														1:0/0
Pa																			0:0/0
Pb				1	1														2:0/0
Pd																			0:0/0
Po				1	1														2:0/0
Pu					6							1.4							1:0/0
Ra					1														1:0/0
Se					1														1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr					1														1:0/0
Tc					1														1:0/0
Th					1														1:0/0
U					1														1:0/0
Zr					1														1:0/0

Table 8-20. Selected data properties, references and comments for the parameter cR_Sea_bird_NHB (m^3/kg_{fw}) for the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Ac	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	ERICA utilised data for fish or mammals when data are missing. Site data for La in fish used (combined EA and PA).
Ag			1	1.6E+00	2.2E+01	2.2E+01	3.1E+02	5.0	GSDmax	ERICA	L2	ERICA utilised data for fish or mammals when data are missing. Site data for Ag in fish not available. Literature data used. No range presented. GSDmax assigned. Validation not possible.
Am	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	ERICA utilsed Pu as EA. Lantanides considered better analogues. Fish data for La available and used.
Ba		cR_Sea_Fish_NHB	9	6.9E–04	9.7E–03	1.7E–02	1.4E–01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Ca		cR_Sea_Fish_NHB	9	9.2E–04	2.0E–02	8.9E–02	3.0E–01	6.2	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Cd		cR_Sea_Fish_NHB	9	3.4E–02	4.7E–01	5.4E–01	6.7E+00	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Cl		cR_Sea_Fish_NHB	8	9.8E–06	1.4E–04	1.2E–04	2.0E–03	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Cm	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	ERICA utilsed Pu as EA. Lantanides considered better analogues. Fish data for La available and used.
Co		cR_Sea_Fish_NHB	7	9.4E–03	1.3E–01	3.7E–01	1.9E+00	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Cs		cR_Sea_Fish_NHB	6	1.7E–02	2.4E–01	2.2E–01	3.4E+00	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Eu	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	ERICA utilised data for fish or mammals when data are missing. Site data for La in fish used (combined EA and PA).
Ho	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	ERICA utilised data for fish or mammals when data are missing. Site data for La in fish used (combined EA and PA).
I		cR_Sea_Fish_NHB	7	1.5E–03	2.1E–02	2.5E–02	3.0E–01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Mo		cR_Sea_Fish_NHB	9	1.8E–04	2.5E–03	3.8E–03	3.5E–02	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Nb		cR_Sea_Fish_NHB	3	1.1E–03	1.6E–02	1.6E–02	2.3E–01	5.0	GSDmax	Site data LX	LX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Ni		cR_Sea_Fish_NHB	9	1.5E–03	2.1E–02	2.1E–02	3.0E–01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Np	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	ERICA utilised data for fish or mammals when data are missing. Site data for La in fish used (combined EA and PA).

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Pa	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	ERICA utilised data for fish or mammals when data are missing. Site data for La in fish used (combined EA and PA).
Pb		cR_Sea_Fish_NHB	9	7.0E–03	1.8E–01	1.7E–01	2.7E+00	6.3	GSDmax	Site data FMLX	FMLX	
Pd	Ni	cR_Sea_Fish_NHB	9	1.5E–03	2.1E–02	2.1E–02	3.0E–01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for Ni in fish used (combined EA and PA).
Po			1	7.1E–09	1.0E–07	1.0E–07	1.4E–06	5.0	GSDmax	ICRP 2011	L1	Very large difference between ICRP 2011 and ERICA. The former considered a better representative (duck vs mammal and later update) and selected.
Pu			6	2.3E–02	1.4E–01	1.4E–01	8.6E–01	3.0	GSDmean	ERICA	L2	ERICA utilsed data for fish or mammals when data are missing. Site data for Pu in fish not available. Literature data used. Validation not possible.
Ra	Ba	cR_Sea_Fish_NHB	9	6.9E–04	9.7E–03	1.7E–02	1.4E–01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish. Ba used as EA (site data available).
Se		cR_Sea_Fish_NHB	7	2.7E–01	3.9E+00	4.2E+00	5.4E+01	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Sm		cR_Sea_Fish_NHB	1	1.1E–03	1.5E–02	1.5E–02	2.2E–01	5.0	GSDmax	Site data LX	LX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Sn		cR_Sea_Fish_NHB	3	3.2E–02	4.5E–01	4.5E–01	6.3E+00	5.0	GSDmax	Site data LX	LX	ERICA utilised data for fish or mammals when data are missing. LX data for fish available and utilised.
Sr		cR_Sea_Fish_NHB	3	7.3E–05	1.0E–03	1.0E–03	1.5E–02	5.0	GSDmax	Site data LX	LX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
Tc		cR_Sea_Fish_NHB	92	1.1E–03	1.5E–02	1.5E–02	4.0E–01	5.0	GSDmax	ERICA	L3	ERICA utilised data for fish. Site data for Tc in fish not available, literature data used. No range presented. GSDmax assigned.
Th		cR_Sea_Fish_NHB	4	2.5E–02	3.5E–01	7.3E–01	5.0E+00	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised.
U			1	2.8E–04	4.0E–03	4.0E–03	5.6E–02	5.0	GSDmax	ERICA	L2	LX data for fish available though not used for the parameter cR_Sea_Fish_NHB. ERICA data for bird used. No range presented. GSDmax assigned.
Zr		cR_Sea_Fish_NHB	6	2.6E–02	3.7E–01	4.1E–01	6.7E+00	5.0	GSDmax	Site data FMLX	FMLX	ERICA utilised data for fish or mammals when data are missing. Site data for fish available and utilised. GSD exceeds max, no obvius errors found, no action taken.

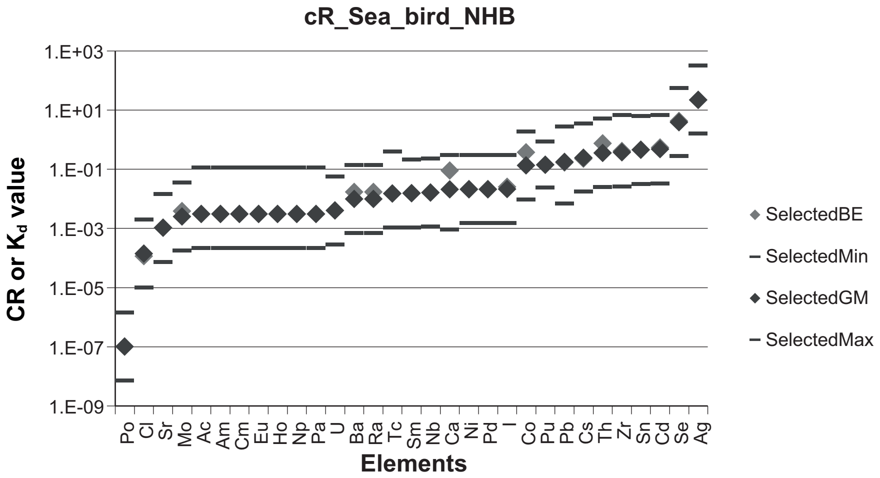


Figure 8-20. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

8.10 cR_Sea_mammal_NHB

This parameter describes the element uptake in marine mammals for use in dose estimates to this organism type. Site data on marine mammals are not available. Literature data are available in ERICA (Hosseini et al. 2008), see Table 8-21 and Figure 8-21, and data for fish and sometimes humans are utilised when data are missing. Literature data alone are available for Ag, Eu, Np, Po, Pu, Ra and Tc. Data are missing for Ac, Ho, Pa and Pd.

Marine fish is the only marine vertebrate organisms where site data are available and the data are utilised for following elements: Ba, Ca, Cd, Cl, Co, Cs, I, Mo, Nb, Ni, Pb, Se, Sm, Sn, Sr, Tc, Th, Zr. Site data are missing for Eu and Ho, and La is selected as EA (combined PA and EAs). La data are also utilised for Ac, Am, Cm and Np (see Section 2.7). Zr data are used for Pa and Ni for Pd.

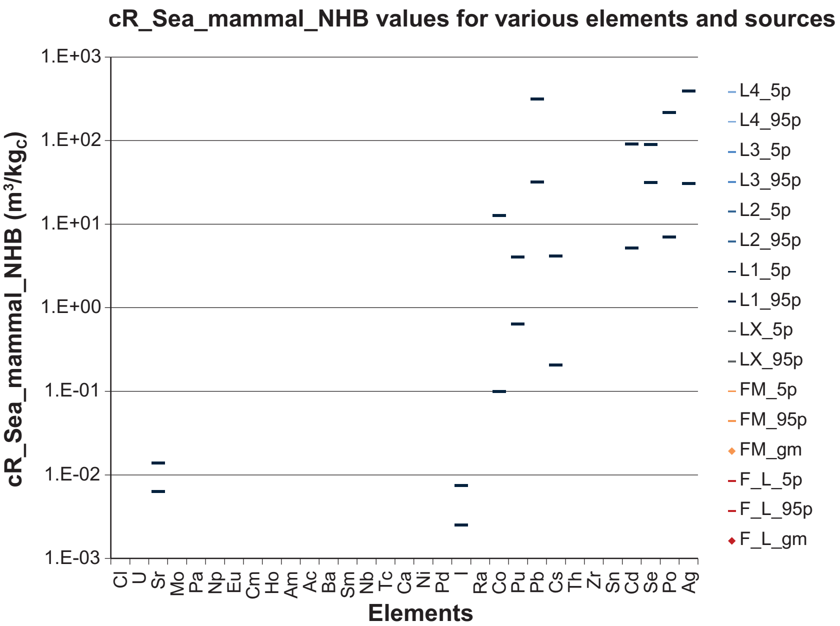


Figure 8-21. *Total available data ranges for the parameter cR_Sea_mammal_NHB (m^3/kg_C). The elements are arranged in the same order as in figure Figure 8-22 showing selected parameter values.*

Data for marine mammals in ERICA (Hosseini et al. 2008) are utilised for the elements: Ag, Np, Po, Pu, Ra, Tc and U. For Ra, Tc and U, a biokinetic model is used to derive the data. No other literature source is available, hence sense checks could not be completed. Ranges are not available for Tc, Cl, Ra and U and GSDmax (5) is assigned to these parameters. GSDmax is also assigned to elements where PAs are utilised. The presented GSD is considered too narrow for some elements and a more appropriate GSD is set, using the conditions stated in Section 4.3 (GSDmean or GSDmax).

The selected CR values are presented in Table 8-22 and Figure 8-22.

Table 8-21. All available data for the parameter cR_Sea_mammal_NHB, the elements of primary concern and selected EAs. Sense checks with the corresponding results are also included. L1 = ERIC (Hosseini et al. 2008) Mammal Sea water.

Element	FM N (from/to)	LX N (from/to)	FMLX (from/to)	L1 N	L2 N	L3 N	L4 N	FM GSD	LX GSD	FMLX GSD	L1 GSD	L2 GSD	L3 GSD	L4 GSD	SC FM	SC LX	SC FMLX	SC FMvs LX	SC Lit
Ac																			0:0/0
Ag				10							2.2								1:0/0
Am				1															1:0/0
Ba																			0:0/0
Ca																			0:0/0
Cd				529							2.4								1:0/0
Cl				1															1:0/0
Cm				1															1:0/0
Co				10							4.4								1:0/0
Cs				744							2.5								1:0/0
Eu				1															1:0/0
Ho																			0:0/0
I				8							1.4								1:0/0
Mo																			0:0/0
Nb				1															1:0/0
Ni				1															1:0/0
Np				1															1:0/0
Pa																			0:0/0
Pb				452							2.0								1:0/0
Pd																			0:0/0
Po				2							2.8								1:0/0
Pu				8							1.8								1:0/0
Ra				1															1:0/0
Se				720							1.4								1:0/0
Sm																			0:0/0
Sn																			0:0/0
Sr				10							1.3								1:0/0
Tc				1															1:0/0
Th				1															1:0/0
U				1															1:0/0
Zr				1															1:0/0

Table 8-22. Selected data properties, references and comments for the parameter cR_Sea_mammal_NHB (m^3/kg_{fw}) and the elements of primary concern.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Ac	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	Marine fish data used as PA (only marine vertebrate for which site data are available). La used as EA.
Ag			10	2.7E+00	1.6E+01	1.6E+01	1.1E+03	3.0	GSDmean	ERICA	L1	
Am	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	ERICA utilsed Pu as EA. Marine fish data used as PA (only marine vertebrate for which site data are available). La used as EA.
Ba		cR_Sea_Fish_NHB	9	6.9E–04	9.7E–03	1.7E–02	1.4E–01	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Ca		cR_Sea_Fish_NHB	9	9.2E–04	2.0E–02	8.9E–02	3.0E–01	6.2	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Cd		cR_Sea_Fish_NHB	9	3.4E–02	4.7E–01	5.4E–01	6.7E+00	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Cl		cR_Sea_Fish_NHB	8	9.8E–06	1.4E–04	1.2E–04	2.0E–03	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Cm	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	ERICA utilsed Pu as EA. Marine fish data used as PA (only marine vertebrate for which site data are available). La used as EA.
Co		cR_Sea_Fish_NHB	7	9.4E–03	1.3E–01	3.7E–01	1.9E+00	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Cs		cR_Sea_Fish_NHB	6	1.7E–02	2.4E–01	2.2E–01	3.4E+00	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Eu	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	Marine fish data used as PA (only marine vertebrate for which site data are available). La used as EA.
Ho	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	Marine fish data used as PA (only marine vertebrate for which site data are available). La used as EA.
I		cR_Sea_Fish_NHB	7	1.5E–03	2.1E–02	2.5E–02	3.0E–01	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Mo		cR_Sea_Fish_NHB	9	1.8E–04	2.5E–03	3.8E–03	3.5E–02	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Nb		cR_Sea_Fish_NHB	3	1.1E–03	1.6E–02	1.6E–02	2.3E–01	5.0	GSDmax	Site data LX	LX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Ni		cR_Sea_Fish_NHB	9	1.5E–03	2.1E–02	2.1E–02	3.0E–01	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Np	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	Marine fish data used as PA (only marine vertebrate for which site data are available). La used as EA.
Pa	La	cR_Sea_Fish_NHB	3	2.1E–04	3.0E–03	3.0E–03	1.1E–01	5.0	GSDmax	Site data LX	LX	Marine fish data used as PA (only marine vertebrate for which site data are available). La used as EA.

Element	EA	PA	N	Min_fw	GM_fw	BE_fw	Max_fw	GSD	GSD comment	Reference	Data Source	Comment
Pb		cR_Sea_Fish_NHB	9	7.0E–03	1.8E–01	1.7E–01	2.7E+00	6.3	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Pd	Ni	cR_Sea_Fish_NHB	9	1.5E–03	2.1E–02	2.1E–02	3.0E–01	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available). Ni used as EA.
Po			2	4.1E–01	5.8E+00	5.8E+00	8.2E+01	5.0	GSDmax	ERICA	L1	
Pu			8	3.9E–02	2.4E–01	2.4E–01	1.5E+00	3.0	GSDmean	ERICA	L1	
Ra			1	4.2E–03	6.0E–02	6.0E–02	8.5E–01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Se		cR_Sea_Fish_NHB	7	2.7E–01	3.9E+00	4.2E+00	5.4E+01	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
Sm		cR_Sea_Fish_NHB	1	1.1E–03	1.5E–02	1.5E–02	2.2E–01	5.0	GSDmax	Site data LX	LX	Marine fish data used as PA (only marine vertebrate for which site data are available). LX data available.
Sn		cR_Sea_Fish_NHB	3	3.2E–02	4.5E–01	4.5E–01	6.3E+00	5.0	GSDmax	Site data LX	LX	Marine fish data used as PA (only marine vertebrate for which site data are available). LX data available.
Sr		cR_Sea_Fish_NHB	3	7.3E–05	1.0E–03	1.0E–03	1.5E–02	5.0	GSDmax	Site data LX	LX	Marine fish data used as PA (only marine vertebrate for which site data are available). LX data available.
Tc			1	1.7E–03	2.4E–02	2.4E–02	3.4E–01	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Th		cR_Sea_Fish_NHB	4	2.5E–02	3.5E–01	7.3E–01	5.0E+00	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).
U			1	2.8E–05	4.0E–04	4.0E–04	5.6E–03	5.0	GSDmax	ERICA	L1	No range presented. GSDmax assigned.
Zr		cR_Sea_Fish_NHB	6	2.6E–02	3.7E–01	4.1E–01	6.7E+00	5.0	GSDmax	Site data FMLX	FMLX	Marine fish data used as PA (only marine vertebrate for which site data are available).

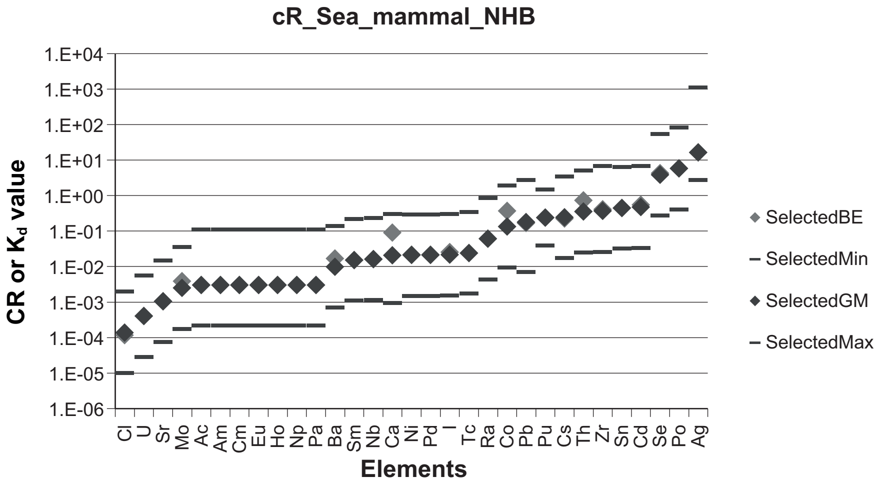


Figure 8-22. *Selected parameter values (best estimate, geometric mean, min and max values) arranged in ascending order based on the GM value (m^3/kg_{fw}).*

8.11 Evaluation of selected marine CR data

There are five parameters for marine primary producers and ten parameters for marine consumers used within this study. Due to lack of data for these specific parameters PAs are used in many cases. This means that the parameters with unique data are limited to marine fishes, filter feeders, crustaceans, zooplankton and primary producers. In order to examine the relations between these unique data sets representing marine biota, the data are plotted in Figure 8-23 to Figure 8-29. From these figures it can be concluded that the uptake in general is higher in filter feeders, crustaceans and in primary producers than in fish.

In Figure 8-23 the CR values for marine crustaceans are plotted against the CR values for marine fishes. It can be concluded that in general the correlation between the parameters are fairly good even if the CRs are higher for crustaceans for most elements. For essential elements as P, S, K, Cl and beneficial elements as Zn, I and Se the GM are equal for both parameters.

In Figure 8-24 the CR for marine mussels are plotted against CR for marine fishes. The correlation between these parameters are good for some elements Cl, Mg, Li, Na and for Hf, Cs, Sn, Te, Se, Zn and Po. Essential elements as P, S, K and Rb has tenfold lower uptake in marine mussles than in fish. For other elements the correlation is poor with higher values for marine mussles.

In Figure 8-25 CR values for mussles and crustaceans are compared, the two parameters correlates well.

CR values for marine fishes and bentic molluscs are plooted against the CR for marine primary producers in Figure 8-26. The uptake in marine primary producers are in general higher than the uptake in fish, the CR values for bentic molluscs also show poor correlation to the marine primary producers.

The CR values for marine zooplankton ae plotted against the CR value for marine bentic molluscs in Figure 8-27. The CR values for zooplankton are in general higher, a fairly good correlation can be seen between the parameters.

In Figure 8-28 and Figure 8-29 the limnic CR values for fish and primary producers are plotted against the corresponding CR values from the marine ecosystem. The CR values show poos correlations. The average concentration of elements in fish and primary producers from marine and limnic environments has been compared, and it could be concluded that there are small differences in biota concentrations between the ecosystems. This means that the differences in CR values to a large extent is caused by differences in water concentrations. Average sea water concentrations are ten fold higher for Cl, B, Br, Sr, Na and Mg, the CR values for limnic fish and primary producers can therefore be expected to be higher than for marine fishes and primary producers. This pattern can be seen in Figure 8-28 and Figure 8-29.

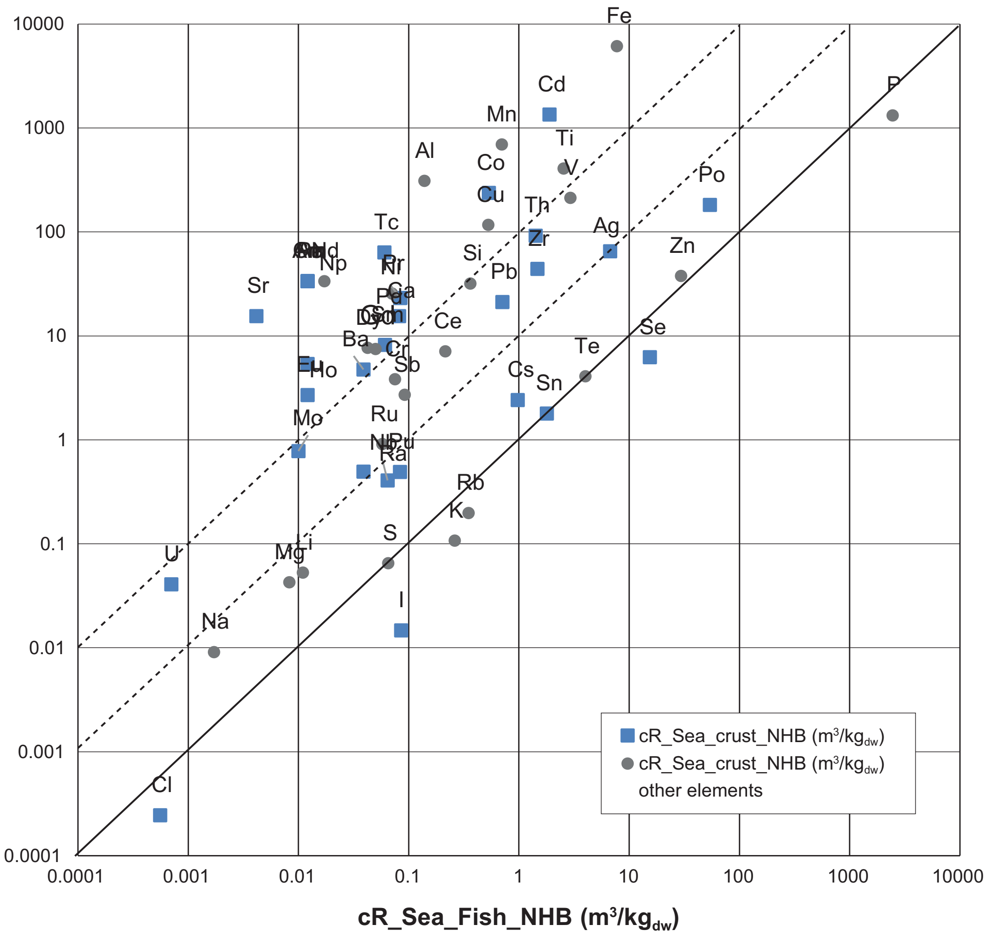


Figure 8-23. *GM of CR for crustaceans (cR_Sea_crust_NHB) plotted against the GM of CR for fish (cR_Sea_Fish_NHB) indicates that the uptake is in general higher in crustaceans than in fish. Blue squares represent elements included in the safety assessment whereas gray dots represent other elements.*

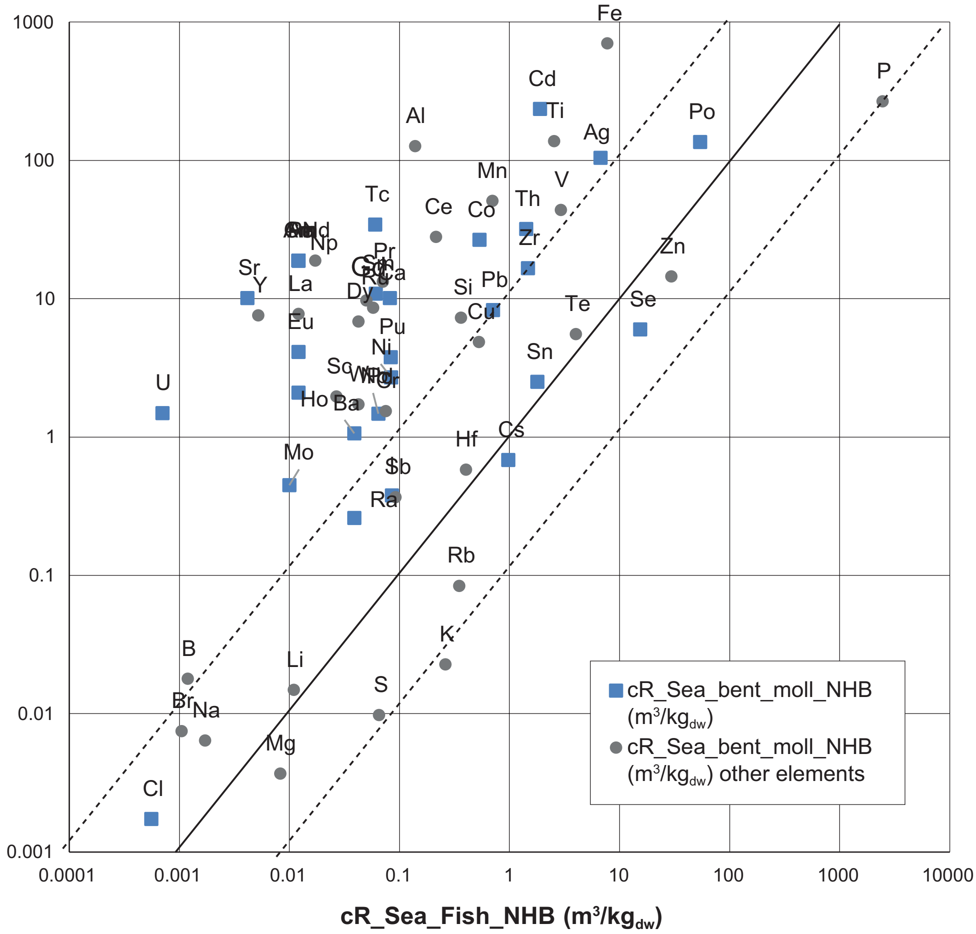


Figure 8-24. *GM of CR for benthic molluscs (cR_Sea_bent_moll_NHB) plotted against GM of CR for fish (cR_Sea_Fish_NHB) indicates that the uptake is in general higher in benthic molluscs than in fish. Blue squares represent elements included in the safety assessment whereas gray dots represent other elements.*

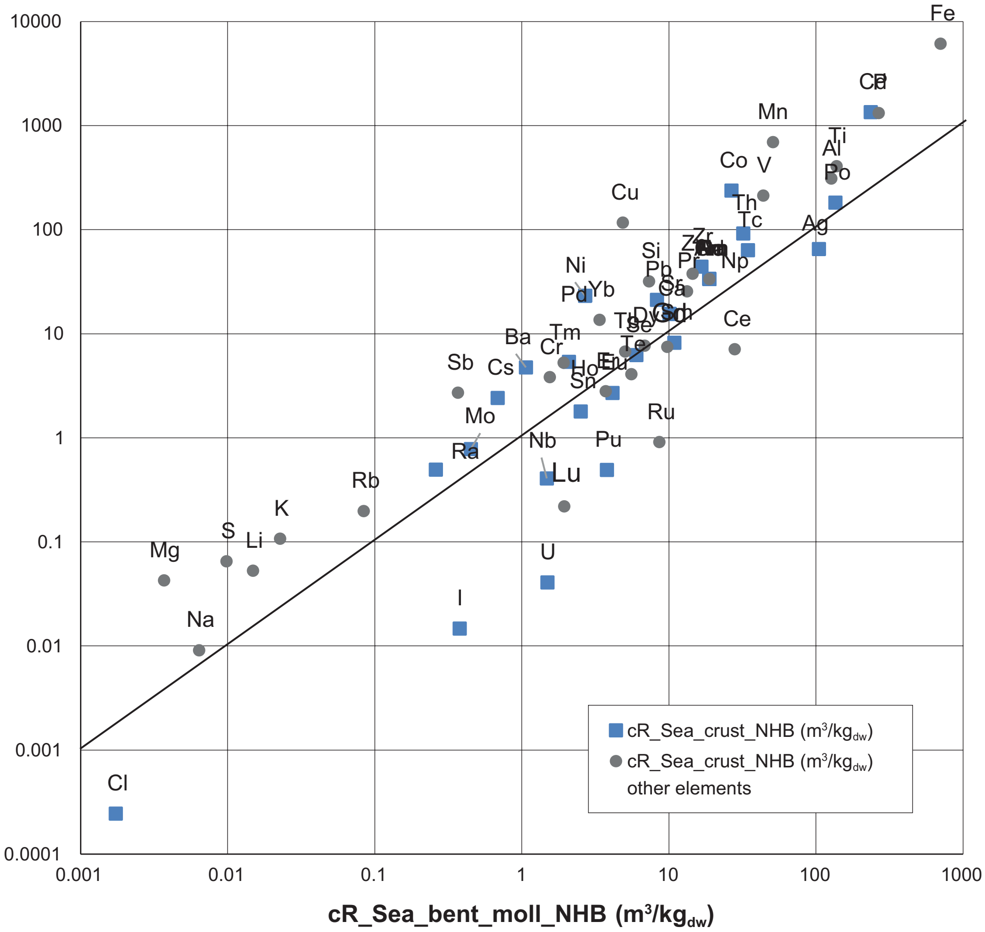


Figure 8-25. GM of CR for crustaceans (cR_Sea_crust_NHB) plotted against GM of CR for benthic molluscs (cR_Sea_bent_moll_NHB) correlates well. Blue squares represent elements included in the safety assessment whereas gray dots represent other elements.

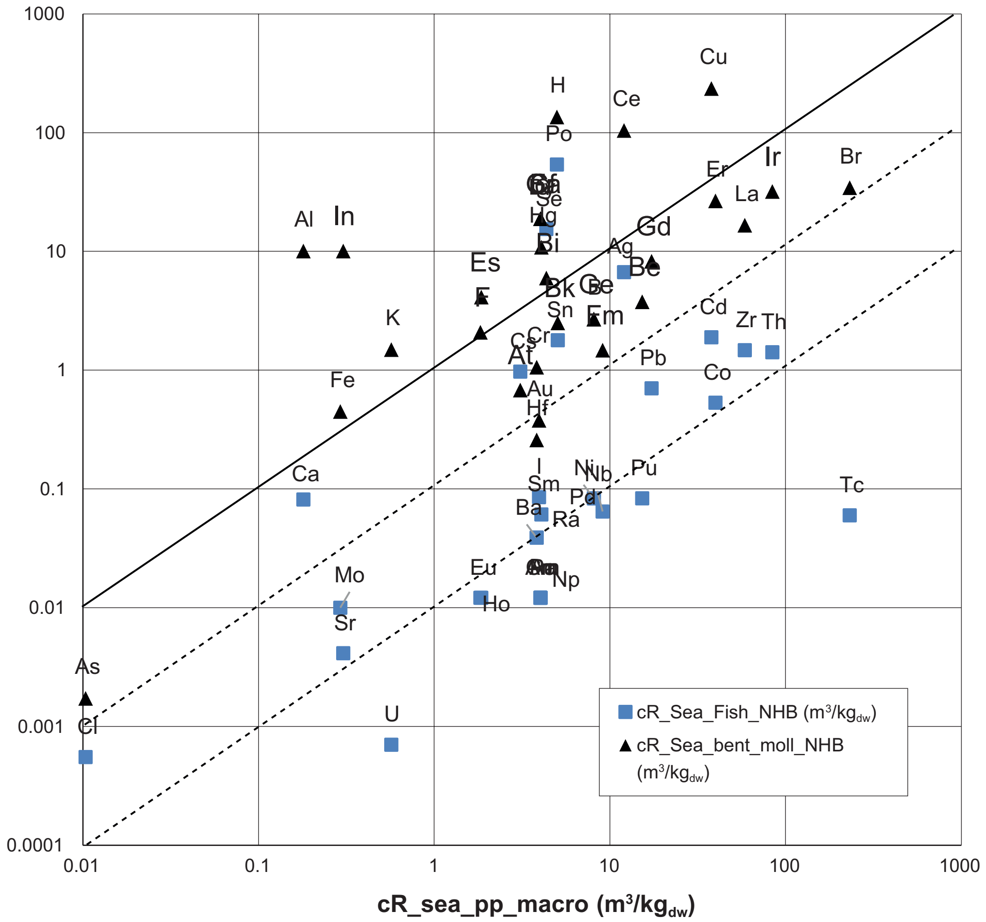


Figure 8-26. *GM of CR for fish (cR_Sea_Fish_NHB) and GM of CR for benthic molluscs (cR_Sea_bent_moll_NHB) plotted against the GM of CR for primary producers (cR_sea_pp_macro) indicates that the uptake is in general higher in primary producers than in fish and that the correlations is in general poor between the marine primary producers and the marine consumers.*

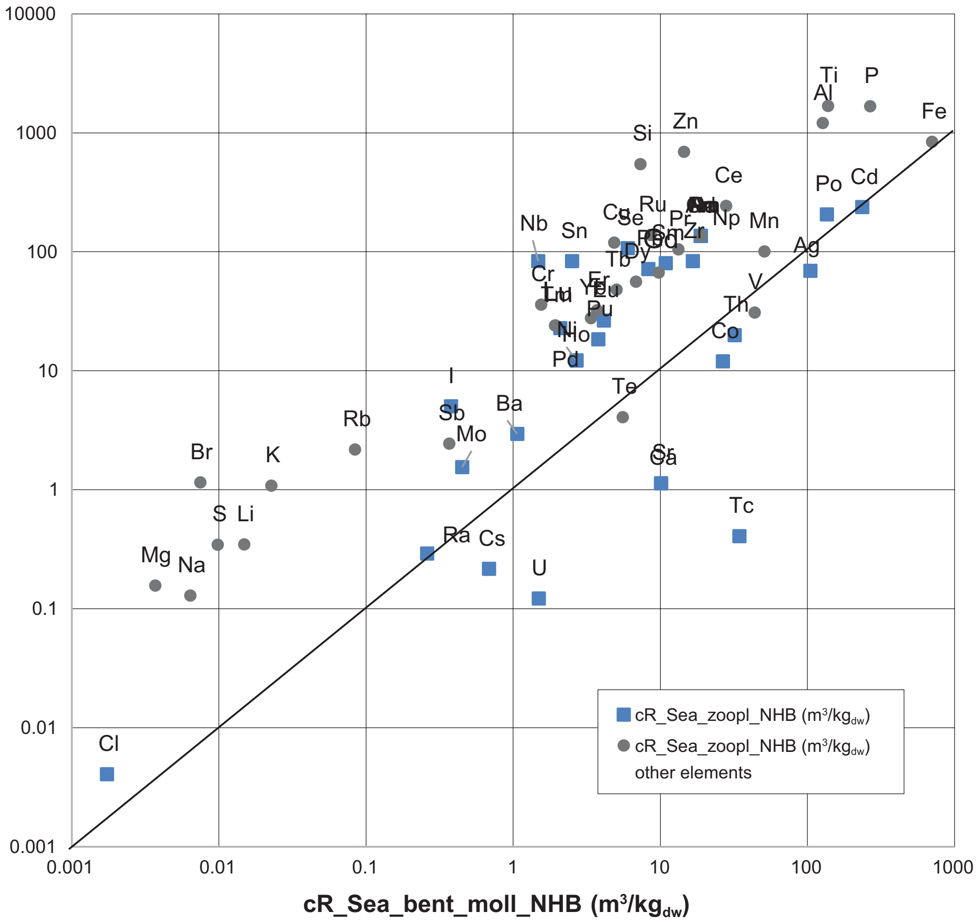


Figure 8-27. *GM of CR for zooplankton (cR_Sea_zoopl_NHB) plotted against GM of CR for benthic molluscs (cR_Sea_bent_moll_NHB) indicated a higher uptake in zooplankton. Blue squares represent elements included in the safety assessment whereas gray dots represent other elements.*

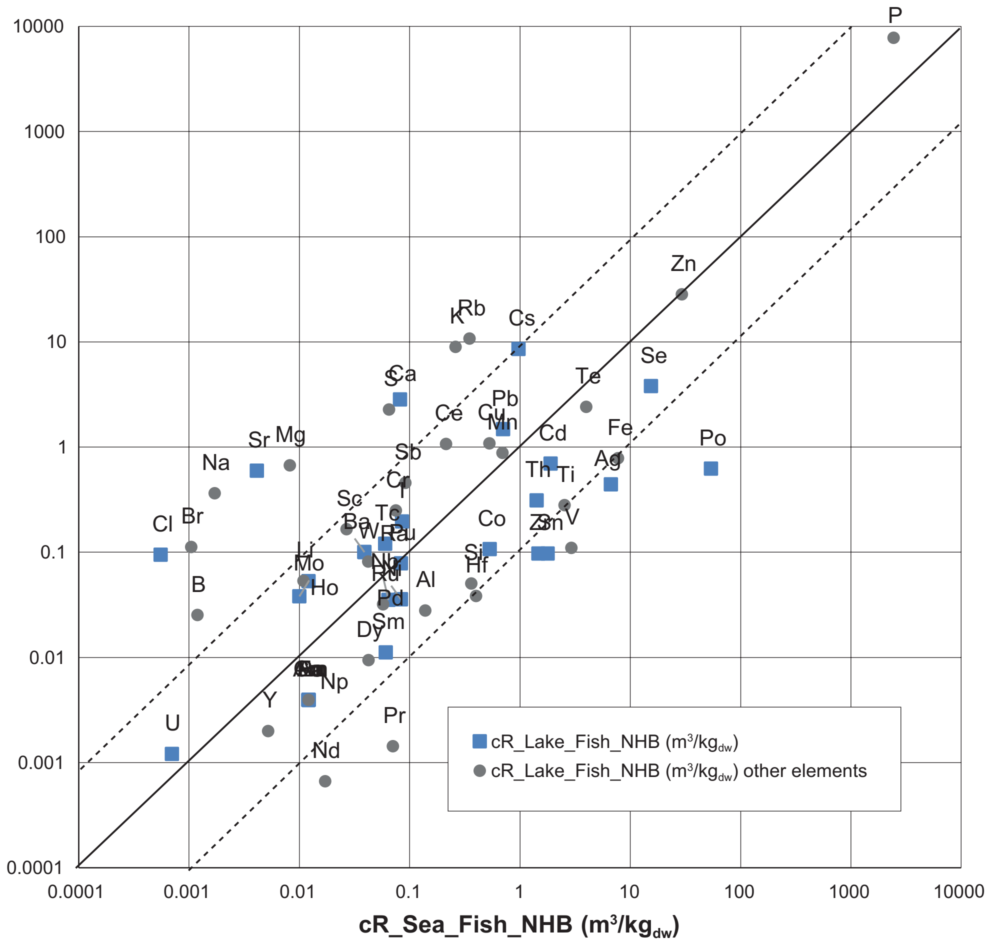


Figure 8-28. *GM of CR for limnic fish (cR_Lake_Fish_NHB) are plotted against GM of CR for marine fishes (cR_Sea_Fish_NHB). Blue squares represent elements included in the safety assessment whereas gray dots represent other elements.*

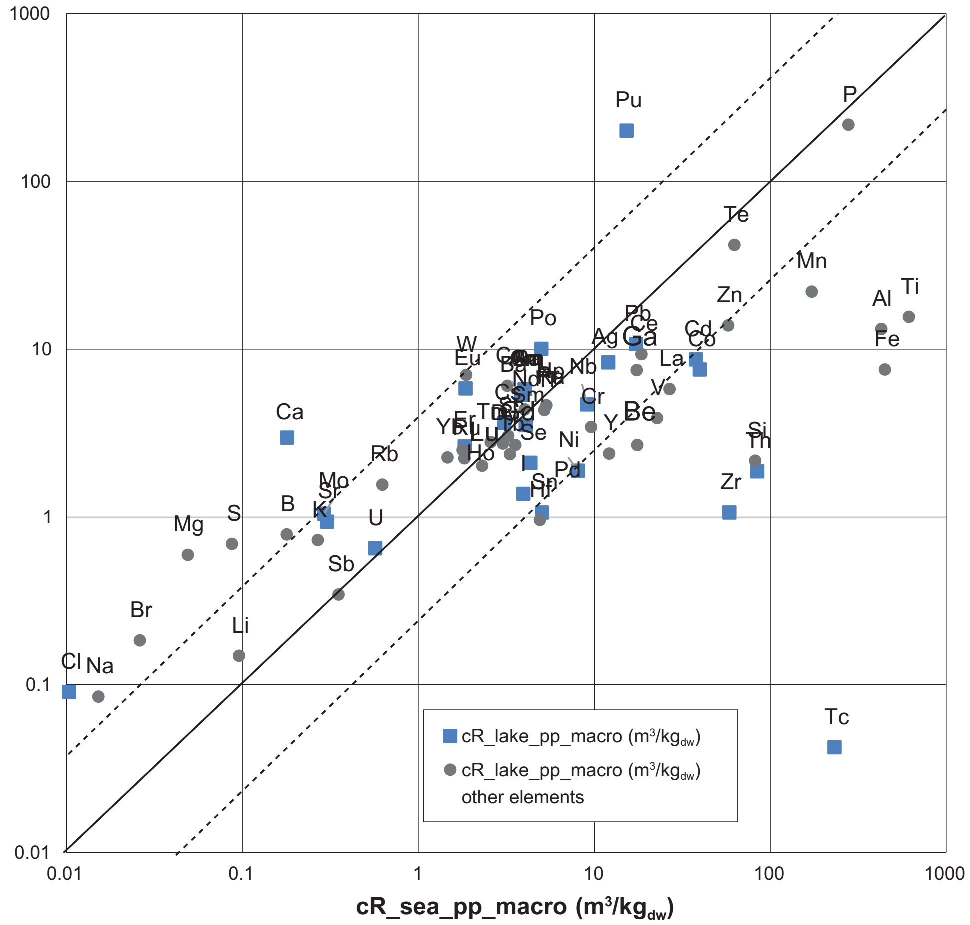


Figure 8-29. *GM of CR for limnic primary producers (cR_lake_pp_macro) plotted against GM of CR for marine primary producers (cR_sea_pp_macro) indicates higher CRs for marine ions as Cl, Na, Mg and Ca. Blue squares represent elements included in the safety assessment whereas gray dots represent other elements.*

9 Uncertainties and confidence in selected parameter values and comparison with previous safety assessments

Parameter values are presented for 70 parameters and 31 elements in this safety assessment. Many different data sources are utilised for the parameterisation and the confidence in the underlying data varies between the different parameters and elements. In addition, data are missing in many cases and different gap filling methods are utilised to assign parameter values, for example different types of analogues. In other cases, the parameter variation is increased based on assumptions and patterns in variation of a larger group of elements.

Data on all available elements are included in this work, though they are given different priority in the parameterisation process. Elements that are included in the radionuclide inventory or part of decay chains of these elements are prioritised, of which elements with radionuclides contributing significantly to radiological dose in previous safety assessments are of highest priority. The lowest priority is given to all other elements that may be utilised as supporting data in the manual data selection process or are selected as element analogues.

Since CR and K_d values are affected by chemical, physical and biological factors in the local environment, the parameter values are relevant for the conditions prevailing at the measured site. The parameters values assigned utilising site data are therefore associated with higher accuracy than those parameterised with literature data. Site data can also differ in quality, due to the varying numbers of samples as well as the degree of representativity. Literature data are always associated with a higher degree of uncertainty since the measured conditions might differ from the conditions on the site and the analytical and sampling methods used are often unknown. Literature data from compendiums, such as IAEA (2010), are commonly based on many different studies and combining data from a large number of environments.

It is important to consider the data quality when assessing the result of the radionuclide transport and dose calculation in the safety assessment, since the results are associated with different levels of uncertainty depending on the confidence of the input data. In this chapter, uncertainties and confidence of the selected K_d and CR parameter values are discussed based on a number of examples and summaries of site and literature data. In addition, this Chapter also includes a comparison to K_d and CR values used in earlier safety assessments and reasoning behind the updated values when differences to previous assessments are large.

To facilitate the evaluation of the confidence of specific parameter values a guide into the report is provided in Appendix G.

9.1 Conceptual and methodological uncertainties

This section contains discussion of a number of aspects that might be important for the overall confidence of the selected K_d and CR parameters. There are several types of uncertainties associated with the parameter values assigned in this study. The following estimations should be seen as examples of to what extent and in which direction parameter values might be affected by different factors. This is not a complete quantification of uncertainties but exemplify major aspects and factors that might have an influence on the confidence of the selected parameter values.

Conceptual uncertainties are associated with the assumptions made when utilising the simplified K_d and CR models to predict sorption and uptake. Other uncertainties are associated with assumptions made in the radionuclide model, for example the assumption of well-mixed soil compartments and selection of modelled times steps (see Section 9.1.1). The methods for combining site data in order to estimated K_d and CR parameters are associated to uncertainties discussed in Section 9.1.2. There are also uncertainties associated with analysis and sampling as discussed in Section 9.1.3.

9.1.1 Uncertainties related to representativity of data and parameters

In the Radionuclide Model for the Biosphere, the functional units of the landscape are divided in uniform, well-mixed compartments, which implicates that transport processes within a compartment are assumed to occur within a time step of the model (year). This modelling approach also postulates that the partitioning coefficients assigned are representative for the entire compartment on average (so-called effective K_d). If the retention processes take place in for example 10% of the actual compartment volume, the effective K_d for the whole compartment will be 1/10 of the original K_d value. In practice, this could be the case if there are significant fractions of coarse materials in the soil not accounted for when K_d is estimated for a fine grained soil sample (US EPA 1999). In addition, transport via heterogeneous layers of higher conductivity can lead to similar results where the effective K_d, valid for the whole compartment on average, needs to be corrected for the non-sorptive volumes.

In this safety assessment, it is assumed that the selected site-specific measurements are representative for the model compartments on average and no attempts are undertaken to adjust partitioning coefficients into effective K_ds. This means that the retention is potentially overestimated in the model, if the soil in fact contains coarse materials (boulders) or if the actual transport mainly takes place along conductive routes not representative for the whole compartment. For example, if the conductive volumes that have the properties of sandy till instead of clayey till comprise 10% of the total compartment volume, the adjusted effective K_d might be only 1/100 of K_d for clayey till interacting with the whole compartment. This hypothetical example is based on the assumption that the different grain sizes affect the nominal K_d value at least one order of magnitude in combination with 10% active volume. This implies that the deterministic calculation based on BE might be significantly biased if the actual conditions differ from the average conditions reflected by the sampled sites. The PDFs, that reflect the variation within the site, account for this variation to some extent in the probabilistic calculations. Extreme cases that violate the model assumptions, such as the example above, might fall outside the variation range of the PDFs and need to be handled in alternative model scenarios. K_d_regoLow have for example a GSD of 3 for most elements according to Table 9-6, which means that a 100-fold decrease in the example above is not included in the PDF.

If the partitioning coefficient reflects the net effects of reactions integrated over long time-spans compared to the temporal resolution of the model, e.g. precipitation reactions, sorption might be overestimated compared to what is possible during a time step in the model. In such case, flushing of radionuclides out of the system by advection might be underestimated, while the inventory of radionuclides sorbed to the solid phase might be overestimated. If the sorbed fraction includes minerals that have been deposited during long time spans, it may lead to an overestimation of K_d values and consequently an incorrect modelling of the transport dynamics in the landscape (cf. Section 9.1.3).

For CR parameters, the difficulties in representativity relate to assigning data corresponding to the modelled biota type (or part of the biota) defined in the radionuclide model. CR parameters utilised for dose calculations to humans pertains to uptake into edible parts of the biota, e.g. the muscle tissue of the fish. If available data correspond to measurements done on the whole fish body the CR is not fully representative for the modelling situation. In the case of dose calculations to biota (non-human biota assessment), the uptake to the whole fish body is of interest and CR data measured on muscle tissues would not be fully representative. Site data usually represent the edible parts of fish and these data are used in the parameterisation for the dose to human assessment. In case of non-huma biota parameters, these data are converted to whole body CR using generic conversion factors. Depending on element, differences in CR between whole body and muscle tissue might be up to 100 times, according to the compilation of generic factors in Appendix C. Another issue arises due to the fact that the parameters used in the radionuclide model by definition could include a wide range of species representing a functional unit of the ecosystem. If CR measurements are done on some of these species, the measured CR may not be representative for all species included in the functional unit. In the case of fish, only one sample of benthic fish has been analysed and all the other samples are pelagic species, hence the measured CRs are not fully representative for the parameter as defined in the model. In other cases, the definition of the parameters includes a narrower range of species than the data utilised for parameterisation. One example is the functional group of grasses and herbs, for which data is rather limited. In this case data for all terrestrial primary producers have been combined in order to parameterise grass as well as other terrestrial primary producers. Therefore, the selected data for the parameter may not be fully representative for the parameter definition, as a wider range of primary producers are included in the selected data.

There are also issues when data for several functional groups are totally missing as is the case for lower fauna (both aquatic and terrestrial) as well as birds and aquatic mammals. In such cases the use of parameter analogues has been considered which is further discussed in Section 9.2.5.

9.1.2 Uncertainties related to sample matching

In order to estimate K_d and CR from site data, individual samples have to be matched as described in Section 4.2.1.

In the case of K_d, corresponding samples of soil and pore water are determined from individual soil samples taken at specific geographical locations and depths. In a few cases when replicates of soil samples are available, these are combined in all possible combinations per location and depth. This might overestimate the variation as non-paired soil and pore water data are combined. Compared to other sources of variation, this contribution to the uncertainty in K_d is judged to be insignificant.

In the case of CR, corresponding measurements are usually unavailable and all possible combinations among data selected as representative for a parameter are combined for FM and LX, respectively. This presents a risk that unrelated data are combined leading to increased variation in the estimated parameter PDFs. The rationale for this approach is that as many combinations as possible are tested and that as much site data as possible is included in the material. The separate handling of site data from FM and LX, however, insures that the data from the two chemically different sites are not combined. This is especially important for CR that includes soil samples and lake water samples. The large variation in site data indicated by many CR parameters confirms that these ratios describe a broad range of processes and conditions (cf. Section 4.3).

When the parameter estimations are based on combined FM and LX data, no attention is paid to the number of samples of the FM and LX sites respectively. Thus the PDFs might be skewed depending on the relative contribution of FM and LX data. BEs are not affected as they are based on FM data alone, if available. Within the each site, BE might be biased depending on the actual samples included and, thus, the relative contribution of different sub populations of data might effect to a specific parameter. Ideally, the parameter values should reflect the average conditions of the ecosystem compartment, though there is no attempt to make such weighting in this work. Large bias in BE and increased variation is expected to occur when non-representative data are combined with all other data. The thorough evaluation of concentration data conducted prior to the selection of representative samples, have the purpose of reducing the risk of influence from artefacts and non-representative data (cf. Section 4.2.1). Discarded samples are compiled and justified in Appendix E.

9.1.3 Uncertainties related to analysis and sampling

There are several uncertainties in K_d and CR associated to sampling, sample preparation and analysis. A few factors that might be of importance to the uncertainties in the final parameter values are discussed in this section and, when possible, the effects of these factors are quantified.

When the concentrations of the dissolved and sorbed fractions are compared, the dissolved fraction seems to vary more than the sorbed fraction. This could be an indication that there are significant sources of error behind the estimations of the dissolved fraction. The sorbed and dissolved concentrations of soil samples of inorganic soils from FM are compared in Figure 9-1.

Several factors might contribute to this pattern. In Sheppard et al. (2009, 2011) the soil samples were restored to operational field capacity with distilled water followed by incubation and equilibration at the laboratory for one week. If there is true equilibrium in the sample, K_d values will not be affected by varying dilution. The discrepancy between the campaigns could consequently be explained by varying degrees of equilibration in the samples. Another more probable explanation, commonly referred to as the "colloid issue", implies that colloidal matter or elements sorbed to colloidal matter is included in the dissolved fraction, which is overestimated because of the colloids. This leads to underestimated K_d values. In Figure 9-1, elements usually associated with minerals of low solubility, e.g. Ga, Ti, Zr, Hf and Cr, show significantly higher dissolved concentrations in Sheppard et al. (2009), although the sorbed fractions are similar. This discrepancy could be explained by an inclusion of more colloidal matter in Sheppard et al. (2009) compared to Sheppard et al. (2011). Metals that usually are strongly sorbed to particulate matter, e.g. Cd and Pb, also show higher dissolved concentrations in Sheppard et al. (2009). If the discrepancies in Figure 9-1 are representative, it can be concluded that the inclusion of colloids in the dissolved phase might lower K_d one to two orders of magnitude for some elements.

The incubation of the soil samples might also lead to changes in the chemical environment compared to the in situ conditions. Altered redox conditions might change the mobility or sorption properties of elements, which could impact both the dissolved and sorbed phases when the equilibrium between the phases is changed. This might affect K_d in both directions.

When the sorbed fraction is estimated, evaporation of pore water remaining on the solids might overestimate the sorbed fractions. This might be of importance for elements with relatively low K_d values, where the K_d is in the same order of magnitude as the remaining soil moisture content after centrifugation. In this case, the correction for pore water is made according to the equation $K_d = C_s/C_w – MC$, where C_s is the sorbed concentration (mg/kg_{dw}), C_w the pore water concentration (mg/m^3) and MC the moisture content expressed in m^3/kg_{dw} (Sheppard et al. 2011). When corrected and uncorrected K_d values are compared for individual samples from Sheppard et al. (2011) in Figure 9-2, it could be concluded that K_d values lower than 0.01 are affected up to two orders of magnitude, here represented by the elements Ca, Na and Cl. Among the selected parameters in this report, the geometric mean (GM) might only be marginally affected for Cl and Ca when using uncorrected values (these K_d values are slightly overestimated when not corrected).

Another methodological issue that might be important, is the choice of solvent for estimation of the exchangeable, sorbed fraction. Aqua regia is commonly utilised for partial extraction of the sorbed phase, which means that non-reactive silicates are not included in the K_d calculation. If the sorbed fraction is overestimated due to inclusion of minerals that not take part in the sorption processes modelled, K_d values are overestimated. Different extraction methods have been used on the same SKB data samples, which give the opportunity to estimate the effects of different solvents. Two samples from Sheppard et al. (2011) were both completely digested and partially extracted by aqua regia (Figure 9-3) and from this, it can be concluded that the amount extracted by aqua regia varies over a broad range depending on the element. Elements located to the left in the figure are less soluble by aqua regia compared to the total digestion, e.g. Ta, Zr, Hf and Si, which could be interpreted as if they mainly are incorporated in non-reactive minerals in the solid matrix. Several metals reside at the other end of the scale, which could be interpreted as if they are almost completely extracted by aqua regia and that they probably do not occur in the mineral matrix to any large extent.

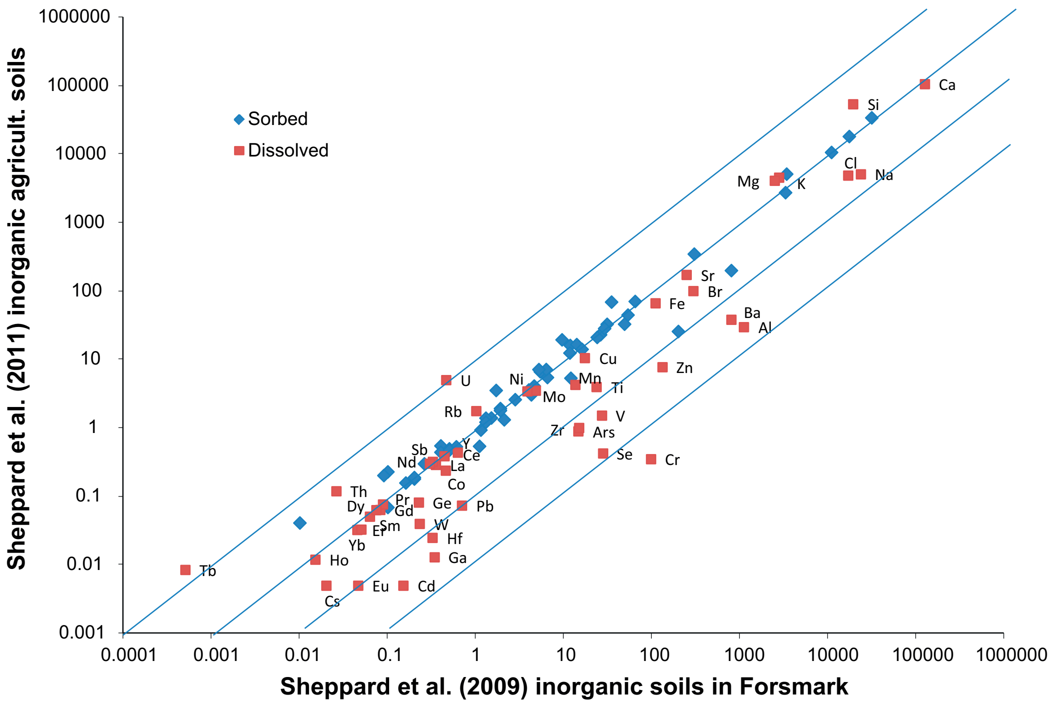


Figure 9-1. Comparisons among concentrations for dissolved (µg/L) and sorbed phases (mg/kg_{dw}) from two studies of inorganic soils in FM (Sheppard et al. 2009, 2011).

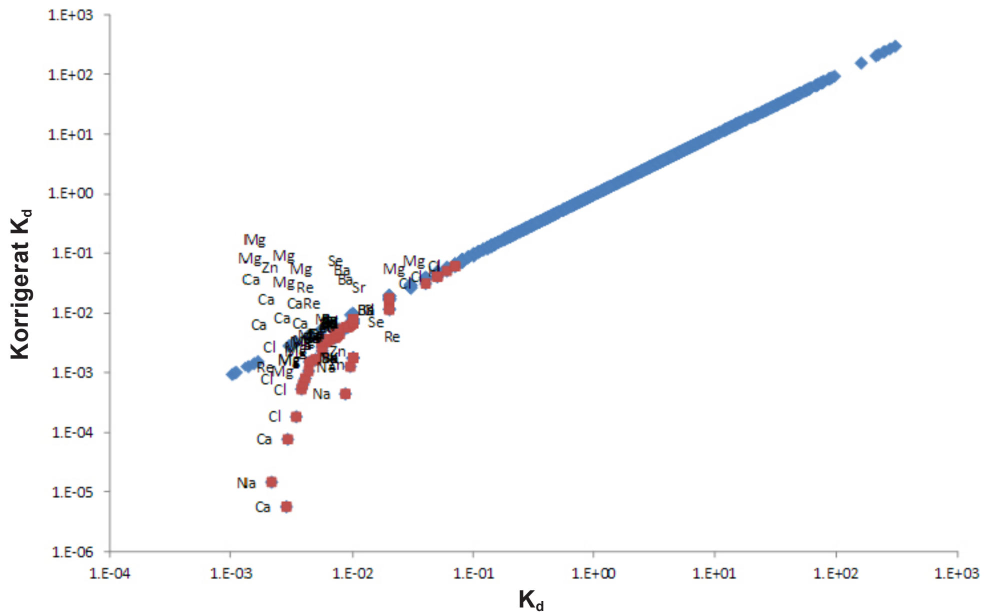


Figure 9-2. *Comparison between K_d values corrected for evaporated pore water included in the sorbed fraction. Uncorrected values on the x-axis and corrected at the y-axis. The red dots represent corrected values that differ from the blue dots representing the 1:1 line for uncorrected values.*

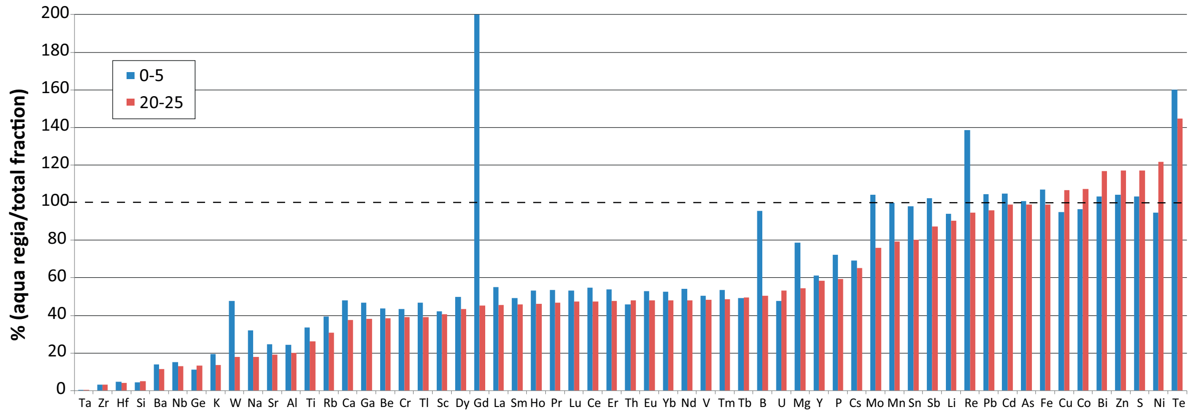


Figure 9-3. *Fraction extracted (%) by aqua regia of total digestion for two FM soil samples taken at two different depths in the soil profile (0–5 cm and 20–25 cm).*

The investigation of Engdahl et al. (2006), which also includes extraction with two weaker solvents, show similar results in Figure 9-4. When dithionite-citrate is used as a solvent, the amounts extracted are comparable to aqua regia extraction. The difference is accentuated when the weaker solvent ammonium acetate is utilised, especially for elements abundant in the mineral matrix, e.g. Zr, Ti Al and Si. The extraction with ammonium acetate is usually regarded to reflect the fraction easily available for plant uptake in soils. If the extraction by ammonium acetate is more valid for some elements than the estimation of the sorbed fraction by aqua regia, K_ds might be overestimated several orders of magnitude, according to this comparison. However, aqua regia is supposed to best represent the sorption processes at the modelled time scales.

It can be concluded from these examples, that methodological factors might affect the nominal K_d values measured from site data significantly, sometimes several orders of magnitude. Different elements are affected by different factors to varying degree. There are indications that the selected K_d might be underestimated one or two orders of magnitude for elements of low solubility, e.g. Zr, or elements strongly associated to particles, e.g. Cd, Pb, depending on colloids included in the dissolved fraction. Soluble elements, such as Cl, might be affected by pore water dried onto the solids and, thus, overestimating K_d. Comparisons of K_d for particulate matter in limnic and marine environments indicate that inclusion of sea water and total digestion of particles have a large influence on the estimated values (cf. Section 5.11.5).

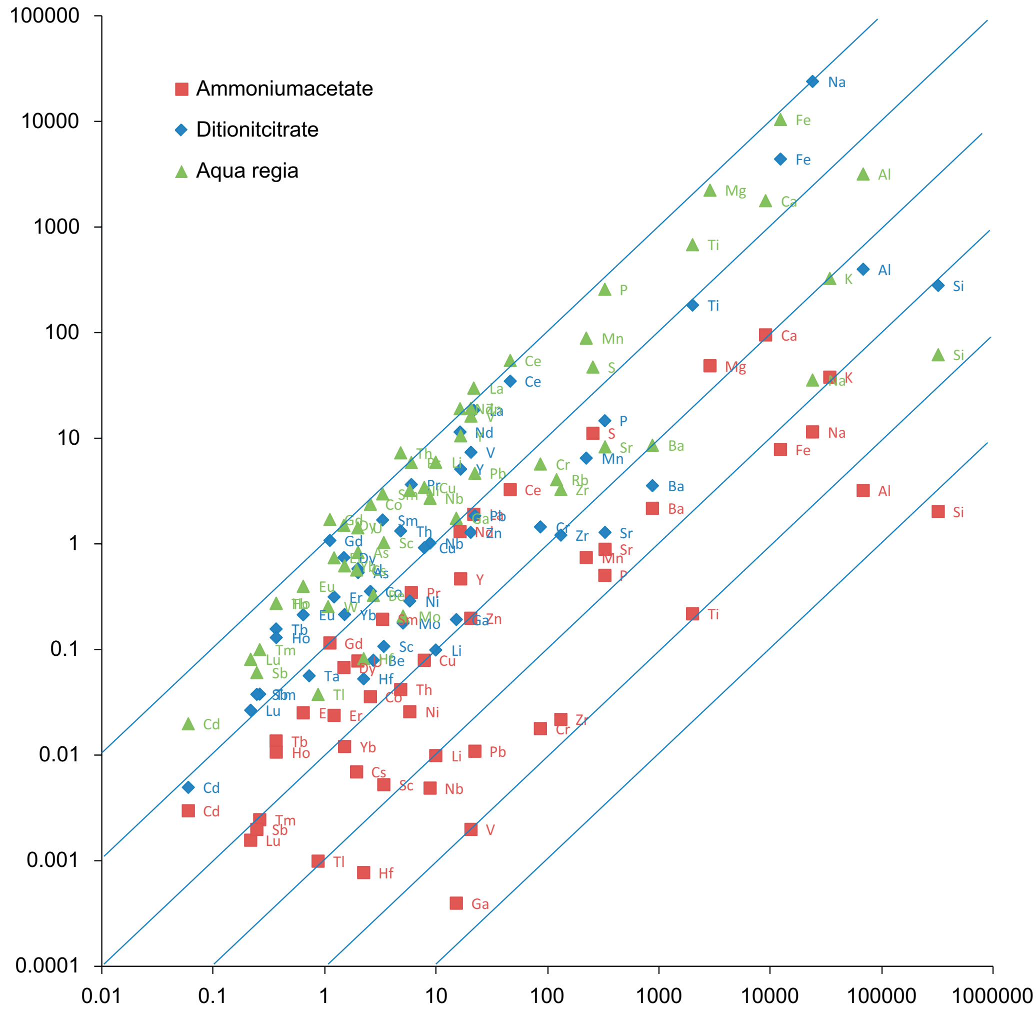


Figure 9-4. *Comparisons among different extraction methods for a soil profile (ASM001426) in the LX area. Total digestion on the horizontal axis (sample digested using a mixture of nitric/hydrochloric/hydrofluoric acids followed by $LiBO_3$ melting) of mineral bulk soil (mg/kg$_{dw}$). Partial extractions by ammonium acetate, dithionite-citrate and aqua regia at the vertical axis (mg/kg$_{dw}$).*

When analysing CR for aquatic organisms inclusion of particular matter in the organism fraction by adhesion of elements to the outer cuticle can be a cause for uncertainty in the values. When CR for marine organisms are evaluated in Section 8.11, bivalves, crustaceans and fish differ regarding elements associated to particulate matter. These elements seem to be included in the organism fraction of mussels and crustaceans, whereas fish (muscle tissue) deviate by showing lower uptake (CR). This might be explained by bivalves filtering particles from water and crustaceans living close to, or within the sediments. CR for primary producers show a pattern similar to bivalves and crustaceans, which could be explained by particulate matter adhered to the outer cuticle and, thus, included in the organism fraction. The general differences seen among these organisms are therefore plausible and CRs probably reflect relevant uptake routes for elements of different behaviour. However, when data for fish are utilised as parameter analogue (PA) for other organisms, the specific uptake characteristics of fish could have implications on the selected CRs, which might be underestimated. Conversely, if the inclusion of particulate matter in the organism fraction is not desirable, CR might be overestimated. This will affect elements such as REE (and actinides that utilise REE as EA) and metals associated to particulate matter, e.g. Cd, Pb. Deviations among these organism groups indicate that the differences might be up to two orders of magnitude.

9.1.4 Uncertainties related to the conversion of data

Conversion factors are utilised to convert literature data into different units, site data to carbon normalised and fresh weight units, and muscle data to whole body data (cf. Section 4.2.3).

In the case of site data, sample specific dry weight and carbon content data are normally utilised before the statistical handling of data (see exception for NHB parameters below). When site specific carbon and dry weight data are lacking, generic data are utilised from IAEA (2010) (Appendix F). This only concerns a few samples and according to the comparison below, uncertainties due to differences between site data and generic data are insignificant compared to other uncertainties.

For non-human biota (NHB) CR for dose calculations are expressed per fresh weight, compared to per dry weight and per carbon weight for the human dose parameters. For the NHB-parameters, all calculations are made per dry weight and in a posterior step converted to fresh weight by the use of generic conversion factors from IAEA (2010). For some parameters and elements, a conversion from muscle tissue to whole body values are also conducted, according to the factors listed in Appendix C. A comparison between the site-specific and generic dry matter and carbon content data in IAEA (2010) reveals only minor differences (maximum divergence of approximately 15%) compared to the large ranges presented for CR values:

- IAEA (2010) presents a dry matter content (DMC) of 25% for fish. This correlates to FM and LX data, which have mean values of 21 and 23% for freshwater and marine fish, respectively (ranges: 17–29%; 20–30%).
- DMC in site-specific data for mussels (5 and 7% for freshwater and marine, respectively) differs somewhat from that presented for corresponding organisms in IAEA (2010) (benthic molluscs, bivalves, filter feeders and mussels: DMC=18%).
- Site-specific DMC values for freshwater plants (water lily) varies between 9–16%, which correlates to the values presented for (freshwater and marine) water plants in IAEA (2010) (13%). The site specific marine data for macrophytes correlate (DMC 9–15%) with DMC for marine algae, which vary between 8–27% (IAEA 2010).
- IAEA (2010) presents a DMC of 32% for small and large mammals and the site-specific DMC data vary between 23–45%. The mean values for carnivores, large herbivores and small rodents are 26, 28 and 25%, respectively, which corresponds well with the values from IAEA (2010).
- IAEA (2010) presents an equivalent DMC value (24%) for a large range of natural terrestrial vegetation (including e.g. both foliage and wood from trees). The corresponding mean values for the site-specific data (green parts) are; shrub 38%, field layer 25% and trees 37%.

The overall conclusion is that the conversion factors does not lead to uncertainties in selected parameter values to. The conversion of muscle tissue to whole body values is only performed for a few elements, and the relative uncertainties in parameter values related to this conversion are probably to be of minor importance.

9.2 Confidence in selected parameter values

The overall confidence in selected parameter values is dependent on several factors. In this section, a number of comparisons are made among underlying data sources in order to assess the relative confidence in the parameter values. Different literature sources are compared in Section 9.2.1, site data are compared to literature data in Section 9.2.2. Confidence in selected data are also dependent on the number of available samples as discussed in Section 9.2.3, and if significant fractions of values fall below reporting limits (Section 9.2.4). The need for utilising element and parameter analogues varies among elements and parameters, and these substitutes are associated with decreasing confidence, as discussed in Section 9.2.5. In addition, comparisons are made between BE and GM in Section 9.2.6, expected correlations between K_d and CR are evaluated in Section 9.2.7 and, finally, an overview is given in Section 9.2.8.

9.2.1 Comparisons among literature data sources

Literature data are mainly utilised as supporting data in this parameterisation, through comparisons of site data and literature data intervals. Comparisons are made among literature sources when more than one literature source is available, in order to reveal confidence in literature data. When site data are unavailable for an element and there are no suitable analogue, literature data are utilised as the primary data source for the parameterisation (cf. Section 4.4).

Table 9-1 illustrates the agreement among available literature sources, for parameter and element combinations where literature data is selected in the parameterisation. The figures represent the fraction of overlapping, two by two combinations compared to the total number of possible comparisons among the literature data sources. A value of 1.0 implies a god agreement among all literature sources, whereas a value of 0 indicates no match between the literature data ranges. Detailed listings of the amount of available literature sources are found in Appendix B, together with a compilation that includes all parameter and element combinations. These figures are not fully comparable as they represent samples from a varying number of investigations and the literature data sources are not completely independent as the same underlying references may have been included in several of the literature compilations (i.e. different literature data sources can be sub-set of each other).

Table 9-1. Comparisons among literature data sources associated to each parameter and element combination where literature data are utilised as the data source (combinations where elements analogues are selected might be included in the table, cf. Section 9.2.5). A value of 1.0 represents overlap among all possible combinations of the literature sources, whereas lower numbers represent the fraction of overlapping combination compared to the total number of possible combinations. X denotes combinations where literature data are used for the parameterisation and where only one literature data source is available.

Parameter	Ac	Ag	Am	Ba	Ca	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_Lake_amph_NHB		1.0			X	X													X		1.0	1.0						1.0	1.0		
cR_Lake_bent_fish_NHB		1.0				X													1.0		1.0	1.0						1.0	1.0		
cR_Lake_bird_NHB		1.0				X													1.0		1.0	X						1.0	1.0		
cR_Lake_bivalve_NHB																					X	X						X			
cR_Lake_Cray																					X	X	X					X			
cR_Lake_crust_NHB																					X	1.0	1.0					X			
cR_Lake_Fish		1.0				X													1.0		X	0.0						X	X		
cR_Lake_Fish_NHB		1.0				X													1.0		1.0	1.0						1.0	1.0		
cR_Lake_gastr_NHB																					X	X	X					X			
cR_Lake_ins_larvae_NHB																					X	1.0	1.0					X			
cR_Lake_mammal_NHB		1.0				X													1.0		1.0	X						1.0	1.0		
cR_Lake_pel_fish_NHB		1.0				X													1.0		1.0	1.0						1.0	1.0		
cR_lake_pp_macro		X																			X	1.0						X			
cR_lake_pp_micro		X																			X	1.0						X			
cR_lake_pp_plank		X																			X	X						X			
cR_Lake_pp_plank_NHB		X																			0.0	1.0						X			
cR_Lake_pp_vasc_NHB		X																			0.0	1.0						X			
cR_Lake_zoopl_NHB		X							X	X			X						X		0.0	X	1.0					X	X	X	
cR_Sea_bent_fish_NHB		1.0																			1.0	1.0						1.0			
cR_Sea_bent_moll_NHB		X																			X	X	X					X			
cR_Sea_bird_NHB		X																			X	X						1.0		X	
cR_Sea_crust_NHB		X					X						X		X						X	X	X					0.0		X	
cR_Sea_Fish		X																			X	1.0						X			
cR_Sea_Fish_NHB		1.0																			1.0	1.0						1.0			
cR_Sea_mammal_NHB		X																			X	X	X					X		X	
cR_Sea_pel_fish_NHB		1.0																			1.0	1.0						1.0			
cR_Sea_polych_NHB		X				X			X	X						X				X	X	X	X	X				0.0			
cR_sea_pp_macro		1.0																			X	1.0						1.0			
cR_sea_pp_micro		1.0																			X	1.0						1.0			
cR_Sea_pp_macro_NHB		0.7																			0.0	0.3						0.3			
cR_sea_pp_plank		X																			X	X						X			
cR_Sea_pp_plank_NHB		0.7																			0.0	0.3						0.3			
cR_Sea_pp_vasc_NHB		0.7																			0.0	0.3						0.3			
cR_Sea_zoopl_NHB		X					X		X	X											X	X	X					X	X	X	
cR_agri_cereal																							1.0								
cR_agri_tuber	1.0	X	1.0	1.0	1.0	X	X	1.0	1.0	1.0	1.0	1.0	X	X	X		1.0	1.0	1.0		1.0	1.0	1.0		1.0	1.0	1.0	X	1.0	1.0	
cR_agri_veg	X	1.0	1.0	1.0	1.0	1.0	X	1.0	1.0	1.0	X	X	X	X	X		1.0	X	1.0		X	1.0	1.0		X	1.0	1.0		1.0	1.0	X
cR_Ter_amph_NHB		X		1.0	1.0	1.0				1.0									1.0		1.0	1.0					1.0	X			
cR_Ter_bird_egg_NHB		X								X			X		X				X		1.0	X	X				X	X	X	X	
cR_Ter_bird_NHB		X								1.0					X				X		1.0	X	X				1.0	X	X	X	
cR_Ter_detr_inv_NHB	X	X	X	X	X	1.0	1.0	X	X	1.0	X	X	1.0	X	X	X	X	X	1.0	X	X	X	X	X	X	X	X	X	X	X	X
cR_Ter_fl_ins_NHB	X	X	X	X	X	X	1.0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
cR_Ter_gastr_NHB	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
cR_Ter_mammal_large_NHB		X																			X	1.0						X			
cR_Ter_mammal_small_NHB		X																			X	1.0						X			
cR_Ter_pp_lich_NHB																					X							X			
cR_Ter_pp_NHB		X																				1.0		1.0							
cR_Ter_rept_NHB		X																			1.0	1.0						X			
cR_Ter_soil_inv_NHB	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TC_meat	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TC_milk	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

The compilation indicates that the available literature sources correlate well, when literature data is selected for parameterisation. Disagreements are mainly found for three elements, Po, Pu and Tc, where no or small overlap are seen among the available literature data sources. In this case, the 5^{th} or 95^{th} percentiles of the distributions do not overlap. Thus, parameter values for Po, Pu and Tc that are based on literature data might be less confident.

The total number of underlying samples from the highest ranked literature data sources (L1) is presented in Table 9-2. This compilation indicates that the number of samples varies extensively among elements and parameters and, thus, varies the confidence among parameters. Generally N for K_d parameters are high indicating high confidence whereas N for some NHB parameters are lower indicating higher uncertainties for these parameters. Cs stands out by showing a very large number of underlying samples.

Table 9-2. The number of samples for the highest ranked literature source for each element. This compilation shows all available literature data without any influence from analogue assumptions. The colour coding ranges from few sources (red) to several sources (green).

Parameter	Ac	Ag	Am	Ba	Bi	Br	Ca	Cd	Cl	Cm	Co	Cr	Cs	Cu	Eu	Ho	I	La	Mn	Mo	Nb	Nd	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Re	Se	Sm	Sn	Sr	Tc	Te	Th	U	Zn	Zr
cR_Lake_amph_NHB		1	1				8	1	1	8	2	2	3		1		2		1		1		1	1		2		1	1	1		1			1	1	1	1	1	2	1
cR_Lake_bird_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Lake_bivalve_NHB		1	3	2		2	3	1	1	1	2	2	14	92	2		8	2	2	33	2		1	1		1		2	1	2		1	2		6	1	1	1	1	92	2
cR_Lake_Cray		1	4					1	2	1	3		7		1		3		1		1		1	1		1		2	3	5		1			3	1	1	1	2		2
cR_Lake_crust_NHB		1	4	2		2	3	1	2	1	3	2	7	92	1		3	2	1	33	1		1	1		1		2	3	5		1	2		3	1	1	1	2	92	2
cR_Lake_Fish		27	2	111		15	104	4	16	1	65	57	106	96	24		50	74	97	64	3		5	1		39		5	3	21		14			99	3	3	3	9	96	10
cR_Lake_Fish_NHB		5	7	87			124	4	7	1	56	66	118	101	18		17	60	126	90	3		15	1		22		10	5	46		15			129	3	2	5	36	100	4
cR_Lake_gastr_NHB		1	4					1	1	1	2		6		1		1		2		1		1	1		1		2	1	2		1			1	1	1	1	1		1
cR_Lake_ins_larvae_NHB		1	1					1	1	12	1		1		1		2		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Lake_mammal_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_lake_pp_macro		1	16					5	6	1	19		26	5	1		3		6		1		5	2		5		6	40	9		31			17	9	1	5	4	5	2
cR_lake_pp_micro																																									
cR_lake_pp_plank		1	1					1	1	2	1		12		1		7		1		1		1	1		1		7	7	8		1			2	1	1	1	3		1
cR_Lake_pp_plank_NHB		1	1					1	1	2	1		12	5	1		7		1		1		1	1		1		7	7	8		1			2	1	1	1	3	5	1
cR_Lake_pp_vasc_NHB		1	5					2	6	3	12		20	5	1		22		3		1		1	1		1		6	7	15		1			8	1	1	5	9	5	2
cR_Lake_zoopl_NHB		1	1					1	1	1	1		4		1		3		1		1		1	1		1		1	5	1		1			1	1	1	1	4		1
cR_Sea_bent_moll_NHB		15	28					80	1	10	42		172		1		1		43		2		12	12		57		70	159	20		3			8	58	1	4	22		5
cR_Sea_bird_NHB		1	1					1	1	1	1		70		1		1		1		1		1	1		1		1	6	1		1			1	1	1	1	1		1
cR_Sea_crust_NHB		1	20					4	1	1	18		66		1		1		12		3		2	1		7		9	1	7		4			4	17	1	1	1		7
cR_Sea_Fish		4	23				1	5	1	1	6		315	5	3		1		6		1		5	1		5		16	25	29		3			12	92	1	1	25	5	1
cR_Sea_Fish_NHB		4	23				1	5	1	1	11		12	5	3		1		6		1		5	1		5		16	25	7		3			12	92	1	1	25	5	1
cR_Sea_mammal_NHB		10	1					529	1	1	10		744		1		8		10		1		1	1		452		2	8	1		720			10	1	1	1	1		1
cR_Sea_polych_NHB		1	1					1	1	1	3		40		1		1		1		1		1	1		1		2	3	1		1			1	1	1	1	1		1
cR_sea_pp_macro		10	33					6	35	13	62		410		4		62		10		3		2	47		5		13	146	7		35			40	166	1	6	17		3
cR_Sea_pp_macro_NHB		10	33					6	35	13	62		410		4		62		10		3		2	47		5		13	146	7		35			40	166	1	6	17		3
cR_sea_pp_micro																																									
cR_sea_pp_plank		8	15					56	1	5	22		21		1		1		6		1		1	12		35		18	52	10		94			27	14	12	25	8		4
cR_Sea_pp_plank_NHB		8	15					56	1	5	22		21		1		1		6		1		1	12		35		18	52	10		94			27	14	12	25	8		4
cR_Sea_pp_vasc_NHB		1	1					1	1	1	1		9		1		1		2		1		1	1		1		1	1	1		1			1	1	1	1	2		1
cR_Sea_zoopl_NHB		1	1					1	1	1	24		29		1		2		18		1		1	2		12		36	5	5		1			12	1	1	4	1		3
cR_agri_cereal			83	1			6	11	7	67	61	1	470				13	1	78	1	2		44	85		9		2	105	24					282	2	1	36	59	86	1
cR_agri_fodder			27	3						17	88	1	401				12	1	83	1	1		38	16		34		10	22	42					172	18	1	64	53	73	1
cR_agri_tuber		6	78	1				1	14	66	56	1	138				1	8	23	3	1			57		30		9	87	45					106	8	1	24	28	20	1
cR_agri_veg		5	10	1					6	7	185	1	290				12	7	103	1	2			5		31		12	13	77					217	10	1	24	108	112	1
cR_food_herbiv																																									
cR_Ter_amph_NHB		1	7					5	1	1	1		105		1		1		1		1		1	1		6		1	1	1		1			14	2	1	1	1		1
cR_Ter_bird_egg_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Ter_bird_NHB		1	3					1	1	1	1		40		1		1		1		1		1	1		424		1	5	5		1			4	2	1	1	1		1
cR_Ter_detr_inv_NHB		1	1					398	17	2	1		7	383	1		10		5		1		5	1		409		7	91	1		1			1	1	1	1	1	383	1
cR_Ter_fl_ins_NHB		1	25					29	1	1	17		67		1		1		1		1		1	1		18		1	25	1		1			20	1	1	1	1		1
cR_Ter_gastr_NHB		1	8					47	20	1	1		18		1		12		7		1		7	1		47		1	8	10		7			7	1	1	1	1		1
cR_Ter_mammal_large_NHB		1	13					415	1	1	29		1745		1		1		4		1		2	1		502		36	15	73		12			58	1	1	18	2		1
cR_Ter_mammal_small_NHB		1	9					415	1	1	29		70		1		1		4		1		2	1		36		1	27	5		12			37	1	1	1	1		1
cR_Ter_Mush		1	1					1	1	1	1		51		1		1		1		1		1	1		98		12	1	15		1			55	1	1	18	1		1
cR_Ter_pp		13	23	3				200	8	20	4		1068		1		39	4	100		1		58	20		72		22	5	168		48			36	6	1	30	151	6	1
cR_Ter_pp_grass_NHB		13	23					200	8	20	112		1068		1		39		100		1		58	20		72		22	5	168		48			36	6	1	30	151	6	1
cR_Ter_pp_lich_NHB		1	1					1	1	1	1		51		1		1		1		1		1	1		98		12	1	15		1			55	1	1	18	1		1
cR_Ter_pp_NHB		13	23	3		3		200	5	20	3	3	235		2		39	3	100		1		58	20		10		10	5	10		48	3		77	6	1	5	13	3	1
cR_Ter_pp_shrub_NHB		1	1	3		3		210	79	1	11	3	196		12		1	3	64		1		64	13		120		14	1	10		73	3		175	1	1	1	496	6	64
cR_Ter_pp_tree_NHB		1	1	3		3		228	5	2	3	3	235		2		1	3	3		1		3	1		10		10	1	10		1	3		77	1	1	5	13	3	1
cR_Ter_rept_NHB		1	1					1	1	1	1		8		1		1		1		1		1	1		1		1	1	1		1			4	1	1	1	1		1
cR_Ter_soil_inv_NHB		1	12					15	17	1	1		19		1		10		5		1		77	1		264		1	8	1		1			1	1	1	1	1		1
K_d_PM_lake		1	42	49				1	1	1	29		219		1		124		17		1		1	1		1		1	79	75		1			13	1	1	63	1		1
K_d_PM_sea		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
K_d_regoGL	3	5	17	1	4	3	33	39	22	18	118	23	114	11		3	196	1	79	9	2		64	22	3	9	4	43	11	51		15	3	4	65	22	2	25	146	17	4
K_d_regoLow	3	5	17	1	4	3	33	39	22	18	118	23	114	11		3	196	1	79	9	2		64	22	3	9	4	43	11	51		15	3	4	65	22	2	25	146	17	4
K_d_regoPeat	1	2	13	1	1	1	1	13	22	18	17	6	108	4		1	11	1	3	9	1		64	4	1	5	1	1	6	2		2	1	1	255	11	2	5	9	12	2
K_d_regoPG	4	9	32	1	6	4	34	61	22	18	89	31	227	3		4	250	1	83	9	8		40	26	4	7	6	44	37	39		134	4	12	255	33	2	46	178	56	4
K_d_regoUp_aqu		1	42	49				1	1	1	29		219		1		124		17		1		1	1		1		1	79	75		1			13	1	1	63	1		1
K_d_regoUp_drain	1	2	13	1	1	1	1	13	22	18	17	6	108	4		1	11	1	3	9	1		64	4	1	5	1	1	6	2		2	1	1	255	11	2	5	9	12	2
K_d_regoUp_garden	3	5	17	1	4	3	33	39	22	18	118	23	114	11		3	196	1	79	9	2		64	22	3	9	4	43	11	51		15	3	4	65	22	2	25	146	17	4
K_d_regoUp_io	3	5	17	1	4	3	33	39	22	18	118	23	114	11		3	196	1	79	9	2		64	22	3	9	4	43	11	51		15	3	4	65	22	2	25	146	17	4
K_d_regoUp_ter	1	2	13	1	1	1	1	13	22	18	17	6	108	4		1	11	1	3	9	1		64	4	1	5	1	1	6	2		2	1	1	255	11	2	5	9	12	2
TC_meat			1	2			3	8	1		4		58				5	3	2	1	1					5			5	1					35		1	6	3	6	1
TC_milk			1	15			15	8			4	3	288				104		4	7	1		2			15		4	1	11		12			154		11		3	8	6

9.2.2 Comparisons between site data and literature data sources

This section contains a discussion on confidence and uncertainties in site data based on comparisons between site data and literature data intervals, and between site data from FM and LX, for parameter and element combinations where site data are utilised for parameterisation. These comparisons, which show how well different data sources correlate, might give indications of the confidence in selected site data. Good correlation between site data and literature data, and between site data from FM and LX support that the selected site data are confident. The opposite might indicate that site data is less representative. These comparisons are further commented under each parameter section in Chapters 5-8.

Four generalised overlap situations based on the 5- and 95-percentiles of the theoretical distributions are presented in Table 9-3: S1, where the site data range lies within the literature data range; S2, where there is a partial overlap between the site data range and the literature data range; S3, where the literature data range lies within the site data range; and S4, where there is no overlap between the site data range and the literature data range (cf. Section 4.5).

The comparison shows that the majority of site data are included in or partially overlaps literature data ranges (S1-green or S2-yellow). Site data show wider ranges than literature data in a few cases (S3-orange). There is no overlap between site data and literature data for some parameters or elements, indicating that site data might be less reliable, or that available literature data is not representative for the site (S4-red). As many parameters are based on element and parameter analogues, the amount of unique combinations in the table is lower (cf. Section 9.2.5 for information of which elements). For example is the distinguishing pattern for K_d_regoGL to a large extent explained by the use of Sm as parameter analogue (PA) for the elements Ac, Am, Cm, Pa and Pu.

Data ranges for site data from FM and site data from LX are compared in Table 9-4. S1 indicates that the entire FM range is within the LX range, and S3 that the entire LX range is within the FM range. S2 indicates a partial overlap, whereas S4 indicates that there is no overlap between FM and LX data (cf. Section 4.5). Most comparisons indicate overlaps between the FM and LX site data ranges. A few elements stands out as no overlap occur between FM and LX ranges (S4-red). Some of these discrepancies can be explained by systematic differences in methods and/or samples, and other by probable element specific differences. For example differ concentrations of REE in several aspects between the sites, which both could be attributed to site specific differences and possible methodological inconsistencies. Another example are fish where different tissues are included in the samples (see each parameter section in Chapter 5-8 for detailed descriptions). As many parameters are based on element and parameter analogues, the amount of unique combinations in the table is lower (cf. Section 9.2.5 for information of which elements).

From this comparison could be concluded that independent site data from FM and LX agree in most cases which increases overall confidence in data. Most of the discrepancies identified could be explained by methodological or site specific differences between the sites. No relevant comparisons could be made for K_d data due to lack of comparable data from LX.

9.2.3 Comparisons of sample number N and selected GSD

For site data, the critical N is the major selection criteria determining to what extent GSD will be expanded around GM. For site data, the critical N represents the lowest number of unique samples in either the numerator or the denominator data selections. For literature data, N represents the total number of samples of each literature data source (cf. Section 4.2.1). Low critical N implies high uncertainty in the estimation of the variation, as well as the GM. Therefore, the critical N information might be important in order to identify parameters with potentially relatively lower confidence compared to other parameters.

Table 9-5, show critical N for all parameter and element combinations where site data are utilised in either form (directly, EA and/or PA). Critical N for literature data are excluded from the table as they are not directly comparable to site data (cf. Section 9.2.1). From this table could be concluded that for most parameter and element combinations critical N is generally low, i.e. below 10, limiting the possibilities of a confident statistical characterisation. The variation among parameters is mainly determined by the number of suitable samples available for that category, whereas the variation among elements is mainly determined by the fraction of values falling below reporting limits (cf. Section 9.2.4).

Table 9-3. Comparisons between site data and literature data where site data are utilised for the parameterisation. S1 to S4 denotes overlap situations for SC FMLX, as defined in Section 4.5. "n" denotes combinations lacking literature data.

Parameter	Ac	Ag	Am	Ba	Ca	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_Lake_amph_NHB	S2		S2	S2			S2	S2	S2	S3	S2	n	S1	S1	S4	S1	S2	S2		S1			S2	S2	n	S2	S2			S2	S2
cR_Lake_bent_fish_NHB	S2		S2	S2	S1		S2	S2	S2	S3	S2	n	S1	S1	S4	S1	S2	S2		S1			S2	S2	n	S2	S2			S2	S2
cR_Lake_bird_NHB	S2		S2	S2	S1		S2	S2	S2	S3	S2	n	S1	S1	S4	S1	S2	S2		S1			S2	S2	n	S2	S2			S2	S2
cR_Lake_bivalve_NHB	n	n	n	n	S4	S4	n	n	S1	S1	n	n	S1	S4	S3	n	n	n	S2	n			n	S1	n	n	S1		n	S1	n
cR_Lake_Cray	n	n	n	n	S4	S4	n	n	S1	S1	n	n	S1	S4	S3	n	n	n	S2	n				S1	n	n	S1		n	S1	n
cR_Lake_crust_NHB	n	n	n	n	S4	S4	n	n	S1	S1	n	n	S1	S4	S3	n	n	n	S2	n				S1	n	n	S1		n	S1	n
cR_Lake_Fish	S2		S2	S1	S1		S2	S2	S2	S3	S2	n	S1	S1	S4	S2	S2	S2		S2			S1	S4	n	S1	S1			S2	S1
cR_Lake_Fish_NHB	S2		S2	S2	S1		S2	S2	S2	S3	S2	n	S1	S1	S4	S1	S2	S2		S1			S2	S2	n	S2	S2			S2	S2
cR_Lake_gastr_NHB	n	n	n	n	S4	S4	n	n	S1	S1	n	n	S1	S4	S3	n	n	n	S2	n				S1	n	n	S1		n	S1	n
cR_Lake_ins_larvae_NHB	n	n	n	n	S4	S4	n	n	S1	S1	n	n	S1	S4	S3	n	n	n	S2	n				S1	n	n	S1		n	S1	n
cR_Lake_mammal_NHB	S2		S2	S2	S1		S2	S2	S2	S3	S2	n	S1	S1	S4	S1	S2	S2		S1			S2	S2	n	S2	S2			S2	S2
cR_Lake_pel_fish_NHB	S2		S2	S2	S1		S2	S2	S2	S3	S2	n	S1	S1	S4	S1	S2	S2		S1			S2	S2	n	S2	S2			S2	S2
cR_lake_pp_macro	n		n	n	n	S2	S2	n	S1	S1	n	n	S1	n	n	S1	n	n	S1	S1			n	S1	n	n	S1		S3	S2	n
cR_lake_pp_micro	n		n	n	n	S2	S2	n	S1	S1	n	n	S1	n	n	S1	n	n	S1	S1			n	S1	n	n	S1		S3	S2	n
cR_lake_pp_plank	n		n	n	n	S2	S2	n	S1	S1	n	n	S1	n	n	S1	n	n	S1	S1			n	S1	n	n	S1		S3	S2	n
cR_Lake_pp_plank_NHB	n		n	n	n	S2	S2	n	S1	S1	n	n	S1	n	n	S1	n	n	S1	S1			n	S1	n	n	S1		S3	S2	n
cR_Lake_pp_vasc_NHB	n		n	n	n	S2	S2	n	S1	S1	n	n	S1	n	n	S1	n	n	S1	S1			n	S1	n	n	S1		S3	S2	n
cR_Lake_zoopl_NHB	n		n	n	n	n	S2	n			n	n		n	S4	n	n	n		n				n	n	S2	n				S1
cR_Sea_bent_fish_NHB	n		n	n	n	S2	n	n	S2	S2	n	n	n	n	n	S2	n	n	S2	S2			n	S2	n	n	S2		n	S4	S2
cR_Sea_bent_moll_NHB	n		n	n	n	S1	n	n	S1	S2	n	n	n	n	S4	S2	n	n	S2	S2				S2	n	n	n		S2	S4	S3
cR_Sea_bird_NHB	n		n	n	n	S2	n	n	S2	S2	n	n	n	n	n	S2	n	n	S2	S2			n	S2	n	n	S2		n		S2
cR_Sea_crust_NHB	n		n	n	n	S4		n	S4	S4	n	n		n		S4	n	n	S3	S4				S2	n	n	n		n		S4
cR_Sea_Fish	n		n	n	n	S2	n	n	S2	S2	n	n	n	n	n	S2	n	n	S2	S2			n	S2	n	n	S2		n	S4	S3
cR_Sea_Fish_NHB	n		n	n	n	S2	n	n	S2	S2	n	n	n	n	n	S2	n	n	S2	S2			n	S2	n	n	S2		n	S4	S2
cR_Sea_mammal_NHB	n		n	n	n	S2	n	n	S2	S2	n	n	n	n	n	S2	n	n	S2	S2				S2	n	n	S2		n		S2
cR_Sea_pel_fish_NHB	n		n	n	n	S2	n	n	S2	S2	n	n	n	n	n	S2	n	n	S2	S2			n	S2	n	n	S2		n	S4	S2
cR_Sea_polych_NHB	n		n	n	n		n	n			n	n	n	n	S4		n	n	S2						n	n	n		S2	S4	S3
cR_sea_pp_macro	n		n	n	n	S2	S2	n	S2	S2	S3	n	S2	n	S2	S2	n	n	S3	S2			n	S2	n	n	S3		S2	S3	S2
cR_Sea_pp_macro_NHB	n		n	n	n	S2	S2	n	S2	S2	S3	n	S2	n	S2	S2	n	n	S3	S2			n	S2	n	n	S3		S2	S3	S2
cR_sea_pp_micro	n		n	n	n	S2	S2	n	S2	S2	S3	n	S2	n	S2	S2	n	n	S3	S2			n	S2	n	n	S3		S2	S3	S2
cR_sea_pp_plank	n		n	n	n	S2	S2	n	S2	S2	S3	n	S2	n	S2	S2	n	n	S3	S2			n	S2	n	n	S3		S2	S3	S2
cR_Sea_pp_plank_NHB	n		n	n	n	S2	S2	n	S2	S2	S3	n	S2	n	S2	S2	n	n	S3	S2			n	S2	n	n	S3		S2	S3	S2
cR_Sea_pp_vasc_NHB	n		n	n	n	S2	S2	n	S2	S2	S3	n	S2	n	S2	S2	n	n	S3	S2			n	S2	n	n	S3		S2	S3	S2
cR_Sea_zoopl_NHB	n		n	n	n	n		n			n	n	S1	n	S1	n	n	n	S3	n				n	n	S1	n				S1
cR_agri_cereal	n	n	n	n	S4	S2	S2	n	S2	S2	n	n	S1	n	n	S2	n	n	S2	S2	n	S2		n	n	n	S1	n	S3	S2	n
cR_agri_fodder	S4	n	S4	S3	n	S2	S2	S4	S2	S1	n	n	S2	n	n	S1	S4	S4	S2	S1	n	S2	S2	n	n	n	S1	n	S1	S2	n
cR_agri_tuber																S1				S1				n							n
cR_agri_veg																S1				S1				n				n			
cR_food_herbiv	n		n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n			n	n	n	n	n	n	n	n	n
cR_Ter_amph_NHB	n		n				n	n	S4		n	n	n	n	n	S2	n	n		S2			S2	S2	n	n			S4	S2	n
cR_Ter_bird_egg_NHB	n		n	S4	S4	S2	n	n	S4		n	n		n		S2	n	n		S2				S2	n	n					n
cR_Ter_bird_NHB	n		n	S4	S4	S2	n	n	S4		n	n	n	n		S2	n	n		S2				S2	n	n					n
cR_Ter_mammal_large_NHB	n		n	n	n	S2	n	n	S4	S2	n	n	n	n	n	S2	n	n	S2	S2			S2	S2	n	n	S4		S4	S2	n
cR_Ter_mammal_small_NHB	n		n	n	n	S2	n	n	S4	S2	n	n	n	n	n	S2	n	n	S2	S2			S2	S2	n	n	S4		S4	S2	n
cR_Ter_Mush	S4	n	S4	S4	n	n	S2	S4	n	S3	n	n	n	n	n	n	S4	S4	S4	n	n	n	S4	n	n	S4	S4	n	S4	n	n
cR_Ter_pp	S4	n	S4	S3	n	S2	S2	S4	S2	S1	n	n	S2	n	n	S1	S4	S4	S2	S1	n	S2	S2	n	n	n	S1	n	S1	S2	n
cR_Ter_pp_grass_NHB	S2	n	S2	S3	n	S2	S2	S2	S1	S2	n	n	S2	n	n	S1	S2	S2	S2	S1	n	S2	S1	n	S2	n	S1	n	S1	S2	S4
cR_Ter_pp_lich_NHB	n	n	n	n	n	n	n	n	n	S4	n	n	n	n	n	n	n	n	S4	n		n	S4	n	n	n	S4		S2	n	n
cR_Ter_pp_NHB	S2		S2	S3	n	S2	S2	S2	S1	S2	n	n	S2	n	n	S1	S2	S2	S2	S1	n		S1		S2	n	S1	n	S1	S2	S4
cR_Ter_pp_shrub_NHB	S2	n	S2	S3	n	S2	S2	S2	S1	S2	n	n	S2	n	n	S1	S2	S2	S2	S1	n	S2	S1	n	S2	n	S1	n	S1	S2	S4
cR_Ter_pp_tree_NHB	S2	n	S2	S3	n	S2	S2	S2	S1	S2	n	n	S2	n	n	S1	S2	S2	S2	S1	n	S2	S1	n	S2	n	S1	n	S1	S2	S4
cR_Ter_rept_NHB	n		n	n	n	S2	n	n	S4	S2	n	n	n	n	n	S2	n	n	S2	S2			S2	S2	n	n	S4		S4	S2	n
K_d_PM_lake	n	S2	n	S2	n	n	n	n	S2	S2	n	n	S1	n	n	n	n	n	n	n	n	n	S2	n	n	n	S1	n	S1	n	n
K_d_PM_sea	n	S2	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
K_d_regoGL	S4	S1	S4	n	S4	S1	S4	S4	S2	S4	n	S4	S2	S2	S4	S4	S2	S4	S2	S4	S4	S4	S1	S2	S4	S1	S1	S2	S2	S2	S2
K_d_regoLow	S2	S1	S2	n	S4	S2	S2	S2	S1	S2	n	S2	S1	S2	S2	S1	S1	S2	S1	S1	S2	S2	S1	S1	S2	S1	S1	S1	S1	S1	S1
K_d_regoPeat	S2	S1	S2	n	S4	S2	S4	S2	S1	S1	n	S2	S2	S4	S2	S1	S1	S2	S2	n	S4	S2	S1	n	S2	S2	S1	S1	S1	S2	S1
K_d_regoPG	S2	S2	S2	n	S2	S1	S2	S2	S1	S2	n	S2	S4	S2	S2	S1	S1	S2	S1	S1	S4	S2	S1	S2	S2	S2	S1	S1	S1	S2	S1
K_d_regoUp_aqu	n	S3	n	S2	n	n	n	n	S2	S1	n	n	S1	n	n	n	n	n	n	n	n	n	S2	n	n	n	S2	n	S1	n	n
K_d_regoUp_drain	S2	S2	S2	n	S2	S2	S4	S2	S1	S2	n	S2	S2	S2	S2	S1	S2	S2	S1	S2	S2	S2	S1	S2	S2	S1	S1	n	S1	S2	S1
K_d_regoUp_garden	S2	S1	S2	n	S2	S2	S4	S2	S2	S2	n	S2	S2	S2	S2	S1	S2	S2	S2	n	S4	S1	S1	S2	S2	S1	S1	n	S2	S1	S1
K_d_regoUp_io	S2	S1	S2	n	S2	S2	S4	S2	S2	S2	n	S2	S2	S2	S2	S1	S2	S2	S2	n	S4	S1	S1	S2	S2	S1	S1	n	S2	S1	S1
K_d_regoUp_ter	S2	S2	S2	n	S4	S2	S4	S2	S1	S1	n	S2	S2	S4	S2	S1	S2	S2	S2	S1	S4	S2	S1	S2	S2	S2	S2	n	S1	S2	S1

Table 9-4. Comparisons between site data from FM and LX when site data are utilised for the parameterisation. S1 to S4 denotes overlap situations for SC FMvsLX, as defined in Section 4.5 ”n” denotes combinations lacking FM or LX data.

Parameter	Ac	Ag	Am	Ba	Ca	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_Lake_amph_NHB	S2		S2	S2			S3	S2	S1	S2	S2	n	S1	S1	S1	n	S2	S2		n			S2	S2	n	S4	S2			S2	S4
cR_Lake_bent_fish_NHB	S2		S2	S2	S2		S3	S2	S1	S2	S2	n	S1	S1	S1	n	S2	S2		n			S2	S2	n	S4	S2			S2	S4
cR_Lake_bird_NHB	S2		S2	S2	S2		S3	S2	S1	S2	S2	n	S1	S1	S1	n	S2	S2		n			S2	S2	n	S4	S2			S2	S4
cR_Lake_bivalve_NHB	S2	n	S2	S2	S4	S2	S2	S2	S1	S3	S1	S2	S1	S2	S1	S1	S2	S2	S1	S1			S2	S1	S2	S2	S2		S2	S4	S2
cR_Lake_Cray	S2	n	S2	S2	S4	S2	S2	S2	S1	S3	S1	S2	S1	S2	S1	S1	S2	S2	S1	S1				S1	S2	S2	S2		S2	S4	S2
cR_Lake_crust_NHB	S2	n	S2	S2	S4	S2	S2	S2	S1	S3	S1	S2	S1	S2	S1	S1	S2	S2	S1	S1				S1	S2	S2	S2		S2	S4	S2
cR_Lake_Fish	S2		S2	S2	S2		S3	S2	S1	S2	S2	n	S1	S1	S1	n	S2	S2		n			S2	S2	n	S4	S2			S2	S4
cR_Lake_Fish_NHB	S2		S2	S2	S2		S3	S2	S1	S2	S2	n	S1	S1	S1	n	S2	S2		n			S2	S2	n	S4	S2			S2	S4
cR_Lake_gastr_NHB	S2	n	S2	S2	S4	S2	S2	S2	S1	S3	S1	S2	S1	S2	S1	S1	S2	S2	S1	S1				S1	S2	S2	S2		S2	S4	S2
cR_Lake_ins_larvae_NHB	S2	n	S2	S2	S4	S2	S2	S2	S1	S3	S1	S2	S1	S2	S1	S1	S2	S2	S1	S1				S1	S2	S2	S2		S2	S4	S2
cR_Lake_mammal_NHB	S2		S2	S2	S2		S3	S2	S1	S2	S2	n	S1	S1	S1	n	S2	S2		n			S2	S2	n	S4	S2			S2	S4
cR_Lake_pel_fish_NHB	S2		S2	S2	S2		S3	S2	S1	S2	S2	n	S1	S1	S1	n	S2	S2		n			S2	S2	n	S4	S2			S2	S4
cR_lake_pp_macro	S2		S2	S1	S3	S2	S4	S2	S1	S3	S2	S2	S1	S3	S2	S2	S2	S2	S2	S2			S1	S3	S2	S2	S2		S3	S3	S2
cR_lake_pp_micro	S2		S2	S1	S3	S2	S4	S2	S1	S3	S2	S2	S1	S3	S2	S2	S2	S2	S2	S2			S1	S3	S2	S2	S2		S3	S3	S2
cR_lake_pp_plank	S2		S2	S1	S3	S2	S4	S2	S1	S3	S2	S2	S1	S3	S2	S2	S2	S2	S2	S2			S1	S3	S2	S2	S2		S3	S3	S2
cR_Lake_pp_plank_NHB	S2		S2	S1	S3	S2	S4	S2	S1	S3	S2	S2	S1	S3	S2	S2	S2	S2	S2	S2			S1	S3	S2	S2	S2		S3	S3	S2
cR_Lake_pp_vasc_NHB	S2		S2	S1	S3	S2	S4	S2	S1	S3	S2	S2	S1	S3	S2	S2	S2	S2	S2	S2			S1	S3	S2	S2	S2		S3	S3	S2
cR_Lake_zoopl_NHB	n		n	n	n	n	S3	n			n	n		n	S1	n	n	n		n				n	n	S4	n				n
cR_Sea_bent_fish_NHB	n		n	S4	S4	S2	S1	n	S2	S1	n	n	S2	S2	n	S1	n	n	S3	S1			S4	S3	n	n	n		S2	n	S1
cR_Sea_bent_moll_NHB	S1		S1	S4	S4	S4	S4	S1	S1	S4	S3	S2	S2	S4	n	S3	S1	S1	S3	S3				S4	S1	n	S4		S4	n	S4
cR_Sea_bird_NHB	n		n	S4	S4	S2	S1	n	S2	S1	n	n	S2	S2	n	S1	n	n	S3	S1			S4	S3	n	n	n		S2		S1
cR_Sea_crust_NHB	n		n	n	n	n		n	n	n	n	n		n		n	n	n	n	n				n	n	n	n		n		n
cR_Sea_Fish	n		n	S4	S4	S2	S1	n	S2	S1	n	n	S2	S2	n	S1	n	n	S3	S1			S4	S3	n	n	n		S2	n	S1
cR_Sea_Fish_NHB	n		n	S4	S4	S2	S1	n	S2	S1	n	n	S2	S2	n	S1	n	n	S3	S1			S4	S3	n	n	n		S2	n	S1
cR_Sea_mammal_NHB	n		n	S4	S4	S2	S1	n	S2	S1	n	n	S2	S2	n	S1	n	n	S3	S1				S3	n	n	n		S2		S1
cR_Sea_pel_fish_NHB	n		n	S4	S4	S2	S1	n	S2	S1	n	n	S2	S2	n	S1	n	n	S3	S1			S4	S3	n	n	n		S2	n	S1
cR_Sea_polych_NHB	S1		S1	S4	S4		S4	S1			S3	S2	S2	S4	n		S1	S1	S3						S1	n	S4		S4	n	S4
cR_sea_pp_macro	S2		S2	S2	S2	S3	S3	S2	S2	S2	S2	S2	S3	S2	n	S2	S2	S2	S3	S2			S2	S3	S2	n	n		S2	n	S2
cR_Sea_pp_macro_NHB	S2		S2	S2	S2	S3	S3	S2	S2	S2	S2	S2	S3	S2	n	S2	S2	S2	S3	S2			S2	S3	S2	n	n		S2	n	S2
cR_sea_pp_micro	S2		S2	S2	S2	S3	S3	S2	S2	S2	S2	S2	S3	S2	n	S2	S2	S2	S3	S2			S2	S3	S2	n	n		S2	n	S2
cR_sea_pp_plank	S2		S2	S2	S2	S3	S3	S2	S2	S2	S2	S2	S3	S2	n	S2	S2	S2	S3	S2			S2	S3	S2	n	n		S2	n	S2
cR_Sea_pp_plank_NHB	S2		S2	S2	S2	S3	S3	S2	S2	S2	S2	S2	S3	S2	n	S2	S2	S2	S3	S2			S2	S3	S2	n	n		S2	n	S2
cR_Sea_pp_vasc_NHB	S2		S2	S2	S2	S3	S3	S2	S2	S2	S2	S2	S3	S2	n	S2	S2	S2	S3	S2			S2	S3	S2	n	n		S2	n	S2
cR_Sea_zoopl_NHB	n		n	n	n	n		n			n	n	n	n	n	n	n	n	n	n				n	n	n	n				n
cR_agri_cereal	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n		n	n	n	n	n	n	n	n
cR_agri_fodder	S2	n	S2	S3	S2	S1	n	S2	S2	S3	n	n	n	S2	S3	S2	S2	S2	S1	S2	n	S3	n	n	S2	S2	S2	n	n	S3	S1
cR_agri_tuber																S2				S2				n							S1
cR_agri_veg																S2				S2				n				n			
cR_food_herbiv	S2		S2	S2	S2	S2	S3	S2	S2	S2	n	n	n	S3	S2	S2	S2	S2	S2	S2			S2	n	S2	S1	S2	S1	n	S3	S1
cR_Ter_amph_NHB	S2		S2				n	S2	S3		S2	S2	n	S2	S3	S2	S2	S2		S2			n	S2	S2	S2			n	S3	S1
cR_Ter_bird_egg_NHB	S2		S2	S1	S1	S2	n	S2	S3		S2	S2		S2		S2	S2	S2		S2				S2	S2	S2					S1
cR_Ter_bird_NHB	S2		S2	S1	S1	S2	n	S2	S3		S2	S2	n	S2		S2	S2	S2		S2				S2	S2	S2					S1
cR_Ter_mammal_large_NHB	S2		S2	S2	S2	S2	n	S2	S3	S2	S2	S2	n	S2	S3	S2	S2	S2	S2	S2			n	S2	S2	S2	S1		n	S3	S1
cR_Ter_mammal_small_NHB	S2		S2	S2	S2	S2	n	S2	S3	S2	S2	S2	n	S2	S3	S2	S2	S2	S2	S2			n	S2	S2	S2	S1		n	S3	S1
cR_Ter_Mush	S2	n	S2	n	n	n	n	S2	n	n	n	n	n	n	S3	n	S2	S2	n	n	n	n	n	n	S2	n	n	n	n	n	S1
cR_Ter_pp	S2	n	S2	S3	S2	S1	n	S2	S2	S3	n	n	n	S2	S3	S2	S2	S2	S1	S2	n	S3	n	n	S2	S2	S2	n	n	S3	S1
cR_Ter_pp_grass_NHB	S2	n	S2	S3	S2	S1	n	S2	S2	S3	n	n	n	S2	S3	S2	S2	S2	S1	S2	n	S3	n	n	S2	S2	S2	n	n	S3	S1
cR_Ter_pp_lich_NHB	S3	S4	S3	S2	S2	S1	n	S3	S3	S3	S3	S3	n	S2	S3	S2	S3	S3	S1	S2		S3	n	n	S3	S1	S2		S3	S3	S1
cR_Ter_pp_NHB	S2		S2	S3	S2	S1	n	S2	S2	S3	n	n	n	S2	S3	S2	S2	S2	S1	S2	n		n		S2	S2	S2	n	n	S3	S1
cR_Ter_pp_shrub_NHB	S2	n	S2	S3	S2	S1	n	S2	S2	S3	n	n	n	S2	S3	S2	S2	S2	S1	S2	n	S3	n	n	S2	S2	S2	n	n	S3	S1
cR_Ter_pp_tree_NHB	S2	n	S2	S3	S2	S1	n	S2	S2	S3	n	n	n	S2	S3	S2	S2	S2	S1	S2	n	S3	n	n	S2	S2	S2	n	n	S3	S1
cR_Ter_rept_NHB	S2		S2	S2	S2	S2	n	S2	S3	S2	S2	S2	n	S2	S3	S2	S2	S2	S2	S2			n	S2	S2	S2	S1		n	S3	S1
K_d_PM_lake	S3	n	S3	S2	S3	S1	S2	S3	S1	S2	S2	S2	S2	S3	S2	S2	S3	S3	S1	S2	n	S4	S2	S3	S3	S2	S3	S2	S2	S4	S2
K_d_PM_sea	S4	n	S4	S2	S2	S3	n	S4	S2	S4	S2	S1	S1	S2	S4	S2	S4	S4	S3	S2	S2	S1	S2	S4	S4	n	S1	S1	S4	S1	S4
K_d_regoGL	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
K_d_regoLow	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
K_d_regoPeat	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
K_d_regoPG	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
K_d_regoUp_aqu	S2	S2	S2	S3	S3	S2	S3	S2	S3	S3	S2	S2	S3	S2	S1	S3	S2	S2	S3	S3	S2	S1	S3	S3	S2	S3	S2	n	S2	S1	S2
K_d_regoUp_drain	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
K_d_regoUp_garden	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
K_d_regoUp_io	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
K_d_regoUp_ter	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n

Table 9-5. Critical N for site data utilised in the parameterisation. Parameter and element combinations without information are based on literature data. The colour coding reflects the critical N limits N<=3 (red), 4<N<10 (yellow) and >=10 (green).

Parameter	Ac	Ag	Am	Ba	Ca	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_Lake_amph_NHB	6		6	6			6	6	6	6	6	1	6	6	6	1	6	6		1			6	6	1	4	6			6	4
cR_Lake_bent_fish_NHB	6		6	6	6		6	6	6	6	6	1	6	6	6	1	6	6		1			6	6	1	4	6			6	4
cR_Lake_bird_NHB	6		6	6	6		6	6	6	6	6	1	6	6	6	1	6	6		1			6	6	1	4	6			6	4
cR_Lake_bivalve_NHB	6	2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			6	6	6	6	6		6	6	6
cR_Lake_Cray	6	2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6				6	6	6	6		6	6	6
cR_Lake_crust_NHB	6	2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6				6	6	6	6		6	6	6
cR_Lake_Fish	6		6	6	6		6	6	6	6	6	1	6	6	6	1	6	6		1			6	6	1	4	6			6	4
cR_Lake_Fish_NHB	6		6	6	6		6	6	6	6	6	1	6	6	6	1	6	6		1			6	6	1	4	6			6	4
cR_Lake_gastr_NHB	6	2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6				6	6	6	6		6	6	6
cR_Lake_ins_larvae_NHB	6	2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6				6	6	6	6		6	6	6
cR_Lake_mammal_NHB	6		6	6	6		6	6	6	6	6	1	6	6	6	1	6	6		1			6	6	1	4	6			6	4
cR_Lake_pel_fish_NHB	6		6	6	6		6	6	6	6	6	1	6	6	6	1	6	6		1			6	6	1	4	6			6	4
cR_lake_pp_macro	6		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			6	6	6	6	6		6	6	6
cR_lake_pp_micro	6		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			6	6	6	6	6		6	6	6
cR_lake_pp_plank	6		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			6	6	6	6	6		6	6	6
cR_Lake_pp_plank_NHB	6		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			6	6	6	6	6		6	6	6
cR_Lake_pp_vasc_NHB	6		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6			6	6	6	6	6		6	6	6
cR_Lake_zoopl_NHB	1		1	1	1	1	6	1			1	1		1	6	1	1	1		1				1	1	4	1				1
cR_Sea_bent_fish_NHB	3		3	9	9	9	8	3	7	6	3	3	7	9	3	9	3	3	9	9			9	7	1	3	3		4	3	6
cR_Sea_bent_moll_NHB	9		9	9	9	9	6	9	7	6	5	6	6	9	2	9	9	9	9	9				7	6	2	9		6	2	6
cR_Sea_bird_NHB	3		3	9	9	9	8	3	7	6	3	3	7	9	3	9	3	3	9	9			9	7	1	3	3		4		6
cR_Sea_crust_NHB	2		2	2	2	2		2	2	2	2	2		2		2	2	2	2	2				2	2	3	2		2		2
cR_Sea_Fish	3		3	9	9	9	8	3	7	6	3	3	7	9	3	9	3	3	9	9			9	7	1	3	3		4	3	6
cR_Sea_Fish_NHB	3		3	9	9	9	8	3	7	6	3	3	7	9	3	9	3	3	9	9			9	7	1	3	3		4	3	6
cR_Sea_mammal_NHB	3		3	9	9	9	8	3	7	6	3	3	7	9	3	9	3	3	9	9				7	1	3	3		4		6
cR_Sea_pel_fish_NHB	3		3	9	9	9	8	3	7	6	3	3	7	9	3	9	3	3	9	9			9	7	1	3	3		4	3	6
cR_Sea_polych_NHB	9		9	9	9		6	9			5	6	6	9	2		9	9	9						6	2	9		6	2	6
cR_sea_pp_macro	9		9	9	9	9	8	9	7	6	5	6	8	9	3	9	9	9	9	9			9	7	6	3	3		6	3	6
cR_Sea_pp_macro_NHB	9		9	9	9	9	8	9	7	6	5	6	8	9	3	9	9	9	9	9			9	7	6	3	3		6	3	6
cR_sea_pp_micro	9		9	9	9	9	8	9	7	6	5	6	8	9	3	9	9	9	9	9			9	7	6	3	3		6	3	6
cR_sea_pp_plank	9		9	9	9	9	8	9	7	6	5	6	8	9	3	9	9	9	9	9			9	7	6	3	3		6	3	6
cR_Sea_pp_plank_NHB	9		9	9	9	9	8	9	7	6	5	6	8	9	3	9	9	9	9	9			9	7	6	3	3		6	3	6
cR_Sea_pp_vasc_NHB	9		9	9	9	9	8	9	7	6	5	6	8	9	3	9	9	9	9	9			9	7	6	3	3		6	3	6
cR_Sea_zoopl_NHB	1		1	1	1	1		1			1	1	1	1	1	1	1	1	1	1				1	1	1	1				1
cR_agri_cereal	9	10	9	10	10	8	10	9	10	10	2	9	10	10	10	10	9	9	10	10	10	10		6	9	10	10	9	10	10	10
cR_agri_fodder	18	10	18	18	18	18	8	18	18	18	8	6	5	18	17	18	18	18	15	18	10	18	6	6	15	4	18	9	1	18	16
cR_agri_tuber																18				18				6							16
cR_agri_veg																18				18				6				9			
cR_food_herbiv	30		30	30	33	24	33	30	29	33	1	1	1	33	28	13	30	30	5	13			4	6	8	13	27	25	1	21	25
cR_Ter_amph_NHB	34		34				19	34	33		34	34	1	36	32	14	34	34		14			2	35	11	17			5	25	29
cR_Ter_bird_egg_NHB	34		34	31	31	27	19	34	33		34	34		36		14	34	34		14				35	11	17					29
cR_Ter_bird_NHB	34		34	31	31	27	19	34	33		34	34	1	36		14	34	34		14				35	11	17					29
cR_Ter_detr_inv_NHB																															
cR_Ter_fl_ins_NHB																															
cR_Ter_gastr_NHB																															
cR_Ter_mammal_large_NHB	34		34	31	36	27	19	34	33	36	34	34	1	36	32	14	34	34	7	14			2	35	11	17	31		5	25	29
cR_Ter_mammal_small_NHB	34		34	31	36	27	19	34	33	36	34	34	1	36	32	14	34	34	7	14			2	35	11	17	31		5	25	29
cR_Ter_Mush	18	21	18	21	18	21	8	18	21	21	8	6	21	21	17	21	18	18	21	21	10	21	21	6	15	21	21	9	21	21	16
cR_Ter_pp	18	10	18	18	18	18	8	18	18	18	8	6	5	18	17	18	18	18	15	18	10	18	6	6	15	4	18	9	1	18	16
cR_Ter_pp_grass_NHB	18	10	18	18	18	18	8	18	18	18	8	6	5	18	17	18	18	18	15	18	10	18	6	6	15	4	18	9	1	18	16
cR_Ter_pp_lich_NHB	7	4	7	7	7	7	3	7	7	7	7	7	3	7	7	7	7	7	7	7		7	1	2	7	6	7		7	7	7
cR_Ter_pp_NHB	18		18	18	18	18	8	18	18	18	8	6	5	18	17	18	18	18	15	18	10		6		15	4	18	9	1	18	16
cR_Ter_pp_shrub_NHB	18	10	18	18	18	18	8	18	18	18	8	6	5	18	17	18	18	18	15	18	10	18	6	6	15	4	18	9	1	18	16
cR_Ter_pp_tree_NHB	18	10	18	18	18	18	8	18	18	18	8	6	5	18	17	18	18	18	15	18	10	18	6	6	15	4	18	9	1	18	16
cR_Ter_rept_NHB	34		34	31	36	27	19	34	33	36	34	34	1	36	32	14	34	34	7	14			2	35	11	17	31		5	25	29
cR_Ter_soil_inv_NHB																															
K_d_PM_lake	6	2	6	6	6	5	6	6	6	6	6	6	5	6	6	6	6	6	6	6	3	6	6	6	6	6	6	5	6	6	6
K_d_PM_sea	5	2	5	8	8	8	1	5	6	5	4	5	5	8	5	8	5	5	8	8	5	5	8	5	5	3	5	5	5	5	5
K_d_regoGL	5	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	5	5	5	5	5	4	2	5	5	5	5	5	5	5
K_d_regoLow	7	7	7	7	7	2	7	7	7	7	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
K_d_regoPeat	6	5	6	6	5	6	5	6	6	5	2	5	5	6	5	5	6	6	6	1	5	6	5	1	6	5	6	6	6	6	6
K_d_regoPG	8	5	8	8	8	7	5	8	8	7	8	8	5	8	7	8	8	8	8	8	5	8	5	5	8	5	8	8	8	8	8
K_d_regoUp_aqu	9	7	9	9	9	8	7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	1	9	9	9
K_d_regoUp_drain	10	10	10	10	10	10	10	10	10	10	6	10	10	10	10	10	10	10	10	2	10	10	10	6	10	10	10	10	10	10	10
K_d_regoUp_garden	11	10	11	11	11	8	10	11	11	11	8	11	10	11	11	11	11	11	11	1	10	11	9	8	11	10	11	10	11	11	11
K_d_regoUp_io	11	10	11	11	11	8	10	11	11	11	8	11	10	11	11	11	11	11	11	1	10	11	9	8	11	10	11	10	11	11	11
K_d_regoUp_ter	5	5	5	5	5	4	5	5	5	5	1	5	5	5	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	5
TC_meat																															
TC_milk																															

The selected GSDs, resulting from estimated variation in site data or derived from literature data, adjusted according to the critical N criteria are compiled in Table 9-6. There is a large variation in selected GSD. Differences among parameter groups (e.g. terrestrial CR, limnic CR and K_d parameter) mainly reflect the critical N criteria and GSD adjustments according to the rules described in Section 4.3.

Table 9-6. Selected GSD for all parameter and element combinations. The colour coding ranges from blue-yellow-red corresponding to increasing GSD.

Parameter	Ac	Ag	Am	Ba	Ca	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_Lake_amph_NHB	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
cR_Lake_bent_fish_NHB	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5
cR_Lake_bird_NHB	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
cR_Lake_bivalve_NHB	3	5	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	3	3	3	3	3	10	3	6	3
cR_Lake_Cray	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	6	5
cR_Lake_crust_NHB	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	6	5
cR_Lake_Fish	3	3	3	3	3	3	3	3	3	5	3	5	3	3	3	5	5	3	3	5	4	5	3	3	5	3	3	5	2	5	3
cR_Lake_Fish_NHB	3	1	3	3	3	3	3	5	3	5	3	5	3	3	3	5	3	3	3	5	3	3	3	3	5	3	3	5	3	5	3
cR_Lake_gastr_NHB	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5
cR_Lake_ins_larvae_NHB	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5
cR_Lake_mammal_NHB	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
cR_Lake_pel_fish_NHB	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5
cR_lake_pp_macro	7	7	7	4	4	4	7	7	4	4	6	8	4	6	7	4	7	7	5	4	4	14	4	4	7	5	4	7	6	5	5
cR_lake_pp_micro	7	7	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	7	14	7	7	7	7	7	7	7	7	7
cR_lake_pp_plank	7	7	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	4	4	7	7	7	7	7	7	7	7	7
cR_Lake_pp_plank_NHB	7	7	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	4	4	7	7	7	7	7	7	7	7	7
cR_Lake_pp_vasc_NHB	7	7	7	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	7	7	4	14	7	7	7	7	7	5	7	7	7
cR_Lake_zoopl_NHB	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	5	5	5	5	7	3	5	5	5	5	5	5	5	3	5
cR_Sea_bent_fish_NHB	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5
cR_Sea_bent_moll_NHB	3	3	3	3	3	3	4	3	3	3	3	3	3	3	5	3	3	3	7	3	3	3	3	3	3	5	3	3	4	5	4
cR_Sea_bird_NHB	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	3	5	5	5	5	5	5	5	5	5
cR_Sea_crust_NHB	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	7	5	3	2	3	5	5	5	5	2	5	5	5
cR_Sea_Fish	5	3	5	3	6	3	3	5	4	3	5	5	3	3	5	3	5	5	6	3	3	4	3	3	5	5	5	3	3	5	3
cR_Sea_Fish_NHB	5	3	5	3	6	3	3	5	4	3	5	5	3	3	5	3	5	5	6	3	3	4	3	3	5	5	5	3	3	5	3
cR_Sea_mammal_NHB	5	3	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	3	5	5	5	5	5	5	5	5	5
cR_Sea_pel_fish_NHB	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5
cR_Sea_polych_NHB	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	5	5	7	5	5	5	5	5	5	5	5	5	5	5	5
cR_sea_pp_macro	7	3	7	4	3	3	3	7	6	5	6	7	3	3	5	3	7	7	8	3	3	3	4	3	10	5	5	3	11	5	7
cR_Sea_pp_macro_NHB	7	3	7	5	5	5	5	7	6	5	6	7	5	5	5	5	7	7	8	5	3	3	5	5	10	5	5	3	11	5	7
cR_sea_pp_micro	7	5	7	5	5	5	5	7	6	5	6	7	5	5	5	5	7	7	8	5	5	5	5	5	10	5	5	5	11	5	7
cR_sea_pp_plank	7	3	7	5	5	5	5	7	6	5	6	7	5	5	5	5	7	7	8	5	3	3	5	5	10	5	5	3	11	5	7
cR_Sea_pp_plank_NHB	7	3	7	5	5	5	5	7	6	5	6	7	5	5	5	5	7	7	8	5	3	3	5	5	10	5	5	3	11	5	7
cR_Sea_pp_vasc_NHB	7	5	7	5	5	5	5	7	6	5	6	7	5	5	5	5	7	7	8	5	5	5	5	5	10	5	5	5	11	5	7
cR_Sea_zoopl_NHB	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	7	5	3	3	3	5	5	5	5	5	3	5	5
cR_agri_cereal	7	3	7	3	4	4	3	7	5	8	7	5	4	3	6	3	7	7	3	3	3	10	12	4	6	3	3	5	6	10	4
cR_agri_fodder	6	3	6	4	4	3	4	6	4	7	4	4	6	4	4	3	6	6	3	3	3	6	4	4	4	4	3	5	7	6	3
cR_agri_tuber	4	4	6	4	4	4	2	4	4	4	4	4	3	7	7	7	4	4	7	7	6	6	7	7	4	10	4	4	10	6	7
cR_agri_veg	4	4	4	7	6	4	4	5	4	6	4	4	4	7	7	7	4	4	13	7	7	4	7	7	4	6	6	7	6	7	7
cR_food_herbiv	9	8	9	4	5	6	7	9	5	6	8	8	8	6	4	6	9	9	4	6	8	8	6	4	4	3	4	4	8	7	4
cR_Ter_amph_NHB	7	7	7	4	4	4	7	7	7	4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	4	7	7	7	7
cR_Ter_bird_egg_NHB	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
cR_Ter_bird_NHB	7	7	7	7	7	7	7	7	7	4	7	7	7	7	7	7	7	7	4	7	7	4	4	7	7	7	4	7	7	7	7
cR_Ter_detr_inv_NHB	7	7	4	6	6	4	4	7	7	4	7	4	4	7	7	4	7	7	4	4	4	4	7	7	4	7	6	7	7	7	7
cR_Ter_fl_ins_NHB	5	7	5	7	7	4	7	7	4	5	7	5	7	7	7	7	5	7	4	7	7	4	7	7	5	7	7	7	7	7	7
cR_Ter_gastr_NHB	4	7	4	4	4	4	4	7	7	4	7	7	4	7	7	4	7	7	4	4	7	4	4	4	7	7	4	7	7	7	7
cR_Ter_mammal_large_NHB	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	7	4	4	7	7	7	7	7	7	7	7	7
cR_Ter_mammal_small_NHB	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	7	2	5	7	7	7	7	7	7	7	7	7
cR_Ter_Mush	7	3	7	3	3	3	7	7	5	5	7	7	3	4	7	3	7	7	3	3	7	10	3	7	7	4	3	7	4	10	7
cR_Ter_pp	6	7	6	4	4	3	4	6	4	7	4	4	6	4	4	3	6	6	3	3	7	6	4	7	4	4	3	7	7	6	3
cR_Ter_pp_grass_NHB	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	7	7	6	7	7	7	7	7	7	7	7	7
cR_Ter_pp_lich_NHB	4	4	4	4	4	4	7	4	4	5	5	4	7	4	5	4	4	4	4	4	4	9	7	7	5	4	4	7	5	9	4
cR_Ter_pp_NHB	6	4	6	4	4	3	4	6	4	7	4	4	6	4	4	3	6	6	3	3	7	4	4	4	4	4	3	7	7	6	3
cR_Ter_pp_shrub_NHB	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	7	7	6	7	7	7	7	7	7	7	7	7
cR_Ter_pp_tree_NHB	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	7	7	6	7	7	7	7	7	7	7	7	7
cR_Ter_rept_NHB	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
cR_Ter_soil_inv_NHB	4	7	4	7	7	4	4	7	7	4	7	4	4	7	7	4	4	4	4	4	7	4	7	7	4	7	7	7	7	7	7
K_d_PM_lake	3	5	3	3	3	3	4	3	4	3	3	3	3	3	3	3	3	3	3	3	5	7	3	3	3	3	3	3	3	7	3
K_d_PM_sea	3	5	3	48	10	8	5	3	3	4	3	3	3	10	3	3	5	3	3	3	3	5	48	3	3	5	3	3	3	3	3
K_d_regoGL	3	3	3	3	3	3	3	3	3	3	6	3	3	5	3	3	3	3	3	3	3	3	3	6	3	3	3	3	3	8	3
K_d_regoLow	3	3	3	3	3	8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3
K_d_regoPeat	3	3	3	5	3	7	4	3	3	3	6	3	3	3	3	3	3	3	3	6	3	3	3	6	3	4	3	3	3	3	3
K_d_regoPG	3	4	3	12	3	3	3	3	4	3	3	3	3	5	3	3	3	3	3	3	3	3	3	4	3	10	3	4	3	3	4
K_d_regoUp_aqu	3	3	3	3	3	3	4	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	6	3	3	4
K_d_regoUp_drain	3	3	3	2	3	7	3	3	2	4	4	4	3	3	3	3	3	3	4	6	3	3	2	3	3	2	3	7	3	3	4
K_d_regoUp_garden	4	2	4	3	2	6	2	4	3	5	5	4	2	2	4	2	4	4	7	6	5	2	3	3	4	2	2	2	5	2	3
K_d_regoUp_io	4	2	4	3	2	6	2	4	3	5	5	4	2	2	4	2	4	4	7	6	5	2	3	3	4	2	2	2	5	2	3
K_d_regoUp_ter	3	3	3	3	3	6	3	3	3	3	6	3	3	3	3	3	3	3	3	3	3	3	3	6	3	4	3	3	3	3	3
TC_meat	7	4	7	7	30	8	7	7	4	4	7	7	4	7	7	4	7	7	4	4	4	25	7	7	7	7	4	7	4	7	7
TC_milk	7	4	7	4	4	15	4	7	4	4	7	7	4	4	7	7	7	7	4	7	4	7	4	4	7	4	4	4	4	7	4

Generally, GSDs are not lowered in this study even if selected data results in very high estimated GSDs. During the iterative parameterisation procedure, high GSDs caused by artefacts in data have been eliminated by exclusion of individual samples in the primary data selection (cf. Section 4.3). The remaining high GSDs, due to high GSD in the literature data source or large variation in site data, are left even though they are unrealistic. For example, the GSD of 48 for K_d_PM_sea of Ba (also is utilised as PA for Ra) is caused by large variation in site data, although it is impossible to determine which data are correct. GMs are more or less influenced if non-representative or erroneous data are included. GSDs around realistic GMs lead to wide ranges tested in the probabilistic calculations. Thus, the whole range from mobile to immobile, or from low to high uptake, will be tested for these parameter and element combinations where uncertainties are large.

Variation in terrestrial CR values are generally larger than in aquatic CR values. The large variation in terrestrial CR values reflects the combined overall variation in soil and organism properties. The lower variation in the aquatic systems is probably due to more homogenous conditions in the aqueous media. Variation in K_d, is low mainly due to fully synchronised samples in sorbed and pore water fractions.

9.2.4 The fraction of values falling below reporting limits

Concentration measurements that fall below reporting limits have been omitted in the statistical handling in this report. Instead, the fractions of omitted values due to the reporting limits are revealed and implications are discussed in this conclusion of uncertainties and confidence in the selected parameter values (cf. Section 4.2.1).

In Table 9-7, the maximum fraction of omitted values per parameter and element combination, due to values below reporting limits, are displayed for either the denominator or numerator data in the K_d and CR ratios. The fractions of omitted values per denominator and numerator selections are found in Appendix A. It can be concluded from this compilation that some elements and parameters are subject for larger fractions of values below reporting limits and, thus, subject for less confidence in final parameter values. Note that this compilation show the fraction of values below reporting limits in selected site data before any manual element analogue selections have been made, i.e. these combinations are not necessarily utilised in the final parameter selection. The following major conclusions could be drawn from this compilation:

- Ag: Value below reporting limits (RL) mainly in water samples and, thus, lower confidence.
- Bi: cR_Lake samples not utilised in parameterisation. Lower confidence in K_d_PM_lake where Bi is used as EA for Po. Risk of underestimating K_d_PM_lake.
- Cd: Several values below RL in pore water ustilied for K_d estimations. Lower confidence and risk for underestimating K_d for Cd in many soils. Risk of overestimating CR in cR_Sea_Fish.
- Cr: The low confident Cr data are not utilised in parameterisation.
- Cs: Lower confidence for cR_Sea parameters due to values below RL in sea water samples. Risk of underestimating CR.
- REE (Eu, Ho, La, Nd and Sm): Varying fractions of values below RL depending on element. La usually prioritised as EA. Comparisons are made among all REE during the manual evaluation step. Higher uncertainty regarding Eu for many parameters.
- I, Nb and Ni: Lower confidence in fish and mammal parameters due to many values below RL in biota samples. Risk of overestimating CR.
- Pb: The low confident Pb data are not utilised in parameterisation.
- Pd: Low confidence for K_d data due to many values below RL, both in sorbed and dissolved phase. Risk for over- and underestimating K_d values. Ni data usually utilised as EA when data availability is limited.
- Re: utilised as EA for Tc. Risk of overestimating K_d for Tc in K_d_regoUp_aqu when Re is used as EA.

- Se: Many denominator values fall below RL for marine fish parameters, cR_lake_pp_macro and cR_food_herbiv, leading to a risk of underestimating these CRs. For cR_Ter_pp_lich_NHB, many values fall below RL in the numerator, leading to a risk of overestimating this CR.
- Sn: Many values fall below RL in the denominator samples for cR_Sea_fish parameters and K_d_PM_sea. Risk of underestimating CR. Mammal parameters and terrestrial primary producers show large proportion of values below RL in the numerator, leading to risk of overestimating cR_food_herbiv, cR_Ter_mammal_NHB parameters and cR_Ter_pp.
- Te: The low confident Te data are not utilised in parameterisation.
- Th and Zr: For mammals, fish and primary producers, many values fall below RL, which in combination with data below RL in sea water samples makes them less confident, especially cR_Sea_fish. In the case of cR_Ter_pp (mainly for Zr) and cR_food_herbiv, there is a risk for overestimating CR due to missing data in the vegetation fraction (numerator).
- U: Samples below RL in mammal and fish samples, indicating that there is a risk of overestimating CR.

9.2.5 The use of element and parameter analogues

When data are limited or unavailable, element and/or parameter analogues can be assigned to fill in the gaps. Suitable element analogues are proposed in Section 2.7, based on generic information and chemical modelling. The outcomes of these selections are discussed in general terms over elements and parameters in this section. The use of different types of analogues is usually associated with different levels of uncertainty.

Table 9-7. Maximum fraction (%) values below reporting limits in either the denominator or numerator of the K_d or CR ratio based on site data for parameters, elements and element analogues included in the parameterisation. This compilation include the fraction of values below reporting limits in selected site data before any manual element analogue selections have been made, i.e. all these combinations are not utilised in the final parameter selection.

Parameter	Ag	Ba	Bi	Br	Ca	Cd	Cl	Co	Cr	Cs	Cu	Eu	Ho	I	La	Mn	Mo	Nb	Nd	Ni	Pb	Pd	Re	Se	Sm	Sn	Sr	Te	Th	U	Zn	Zr
cR_food_herbiv	59					27		12	70	2.9		97	97	97	9.1			15	24	61	85		10	80	76	61		67	85	36		24
cR_Lake_bivalve_NHB	67		50																									83				
cR_Lake_Fish	67		50					18	95				95	68	59		4.76	32	73	95					95			83		18		82
cR_Lake_Fish_NHB	67		50					18	95				95	68	59		4.76	32	73	95					95			83		18		82
cR_lake_pp_macro	86		50																					14				83				
cR_lake_pp_micro	75		50																					25				83				
cR_Sea_bent_moll_NHB								22		33		44	33											22	33	50			33			33
cR_Sea_crust_NHB								22		33		44	33											22	33	50			33			33
cR_Sea_Fish						43		22	96	33		44	33	65	36			50	74	52	57			22	96	50			83	21		39
cR_Sea_Fish_NHB						43		22	96	33		44	33	65	36			50	74	52	57			22	96	50			83	21		39
cR_sea_pp_micro	83							22		33		44	33											22	33	50			33			33
cR_sea_pp_plank								22		33		44	33											22	33	50			33			33
cR_Sea_zoopl_NHB								22		33		44	33											22	33	50			33			33
cR_agri_cereal	16		22			20						78	2.8									32	10	2.8				67				
cR_Ter_mammal_large_NHB	16		22			6.7			80			2.8	2.8		6.7				33	80	80	32	6.3	2.8	73	27		22		53		33
cR_Ter_mammal_small_NHB	16		22			41		18	59			95	95	95	9.1			23	14	50	82	32	6.3	2.8	68	73		22	77	18		14
cR_Ter_Mush																																
cR_Ter_pp	16		22									50	67	17				5.6			17	32	6.3	2.8	17	78		22	94			11
cR_Ter_pp_lich_NHB	43		22									2.8	2.8									32	6.3	71		14		22				
K_d_PM_lake	67		50			14			14					14									14			14		83				
K_d_PM_sea				38			50	22		33		44	33	38										38	33	50			33			33
K_d_regoGL						48						40										92										
K_d_regoLow						71						14											14					29				
K_d_regoPeat	17		17		3.6	43				3.6		36	17	7.1				11		3.6		89	7.1	17		11		17				
K_d_regoPG	33		33			30				3.6		39	1.8	14				1.8	1.8			85	11	8.3	1.8	7.3		33	1.8			1.8
K_d_regoUp_aqu	22					8.3	18					17	25									90	80	7.7				22	25			17
K_d_regoUp_drain						16						44										88										
K_d_regoUp_garden	15		23			14				3.4		38		3.4				3.4				79	7.7			14		23				
K_d_regoUp_io	15		23			14				3.4		38		3.4				3.4				79	7.7			14		23				
K_d_regoUp_ter						16						44										88										

Table 9-8, show the selected EA and the number of parameters for which EAs have been assigned for each element in the parameterisation. This compilation concludes that the use of EAs is extensive for Ac, Am, Cm, Pa and Pd, where EAs are selected for almost all 69 parameters. For Eu, Ho, Np, Po, Pu, Ra, Sn and Tc, EAs are assigned to 19–43 of the 69 parameters. The use of EA for Eu, Ho and Sm is of minor importance for the parameter confidence, due to the very similar behaviour of all lanthanides (the need for EAs for Eu and Ho is due to a large fraction of values below reporting limits, (cf. Section 9.2.4). For other elements, the use of EAs are associated with large uncertainties, for example due to the varying speciation at different redox conditions (e.g. Np, Pa, Pu and Tc). In the cases of the trivalent actinides Ac, Am and Cm, site data for trivalent lanthanides are selected as EA. Since the behaviour of these trivalent elements are well known and expected to be similar, the EAs can be considered to be associated to relatively lower uncertainties. This can be compared to the EA utilised for Sn, which is associated with higher degree of uncertainty since the behaviour of Sn are less investigated in literature. For elements where EAs are assigned only in a few cases, the use of EAs might of course have a significant influence on the confidence for and the selected parameter values (e.g. Ag, Ba, Ca, Cd, Cl, Mo, Nb, Ni, Se, Sm, Sr and Th). Table 9-9 shows the specific selection per parameter and element combination. As stated in Section 2.6.5, the use of suitable site specific elements analogues are preferred prior to literature data that often represent different, or not specified, conditions.

The use of parameter analogues, PAs, is also associated with different levels of uncertainty. Table 9-10 show the number of elements per parameter for which PAs have been assigned. This compilation reveals that CR for a smaller number of organisms are utilised as PAs for many CR parameters; especially among the non-human biota parameters (_NHB suffix). The specific selection of PAs per parameter and element combination are shown in Table 9-11.

Table 9-8. The number of parameters for which EAs have been assigned for each element in the parameterisation, with a total of 69 parameters.

	Element analogue																						
Element	**Am**	**Ba**	**Bi**	**Br**	**Ca**	**Cr**	**Cu**	**I**	**La**	**Nd**	**NI**	**Pb**	**Ra**	**Re**	**Sm**	**Sr**	**Tc**	**Te**	**Th**	**U**	**Zn**	**Zr**	**Total**
Ac	5								42	11					11								69
Ag							1														2		3
Am									39	11					11								61
Ba													1			9							10
Ca																9							9
Cd																					3		3
Cl				1				1															2
Cm	1								40	11					11								63
Eu	1								22														23
Ho	5								15														20
Mo						1											4						5
Nb																						1	1
Ni																					1		1
Np	5								40	11					7				4				67
Pa	5								42	11					11								69
Pd											64										1		65
Po			19									1											20
Pu															4					15			19
Ra		27														1							28
Se																		1					1
Sm	5								3														8
Sn																			3			26	29
Sr					5																		5
Tc														16								7	23
Th																						1	1

Table 9-9. Selected EAs per parameter and element combination.

Parameter	Ac	Ag	Am	Ba	Ca	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_Lake_amph_NHB	La		La					La			La						La	La		Ni			Ba			Zr					
cR_Lake_bent_fish_NHB	La		La					La			La						La	La		Ni			Ba			Zr					
cR_Lake_bird_NHB	La		La					La			La						La	La		Ni			Ba			Zr					
cR_Lake_bivalve_NHB	La		La					La									La	La		Ni			Ba			Zr					
cR_Lake_Cray	La		La					La									La	La		Ni						Zr					
cR_Lake_crust_NHB	La		La					La									La	La		Ni						Zr					
cR_Lake_Fish	La		La					La			La						La	La		Ni			Ba			Zr					
cR_Lake_Fish_NHB	La		La					La			La						La	La		Ni			Ba			Zr					
cR_Lake_gastr_NHB	La		La					La									La	La		Ni						Zr					
cR_Lake_ins_larvae_NHB	La		La					La									La	La		Ni						Zr					
cR_Lake_mammal_NHB	La		La					La			La						La	La		Ni			Ba			Zr					
cR_Lake_pel_fish_NHB	La		La					La			La						La	La		Ni			Ba			Zr					
cR_lake_pp_macro	La		La					La									La	La		Ni			Ba			Zr					
cR_lake_pp_micro	La		La					La									La	La		Ni			Ba			Zr					
cR_lake_pp_plank	La		La					La									La	La		NI			Ba			Zr					
cR_Lake_pp_plank_NHB	La		La					La									La	La		Ni			Ba			Zr					
cR_Lake_pp_vasc_NHB	La		La					La									La	La		Ni			Ba			Zr					
cR_Lake_zoopl_NHB	Nd		Nd					Nd									Nd	Nd		Ni						Zr	Ca				
cR_Sea_bent_fish_NHB	La		La					La			La	La					La	La		Ni			Ba								
cR_Sea_bent_moll_NHB	Nd		Nd					Nd									Nd	Nd		Ni							Ca				
cR_Sea_bird_NHB	La		La					La			La	La					La	La		Ni			Ba								
cR_Sea_crust_NHB	Nd		Nd					Nd									Nd	Nd		Ni							Ca				
cR_Sea_Fish	La		La					La			La	La					La	La		Ni			Ba								
cR_Sea_Fish_NHB	La		La					La			La	La					La	La		Ni			Ba								
cR_Sea_mammal_NHB	La		La					La			La	La					La	La		Ni											
cR_Sea_pel_fish_NHB	La		La					La			La	La					La	La		Ni			Ba								
cR_Sea_polych_NHB	Nd		Nd					Nd									Nd	Nd		Ni							Ca				
cR_sea_pp_macro	Nd		Nd					Nd									Nd	Nd		Ni			Ba								
cR_Sea_pp_macro_NHB	Nd		Nd					Nd									Nd	Nd		Ni			Ba								
cR_sea_pp_micro	Nd		Nd					Nd									Nd	Nd		Ni			Ba								
cR_sea_pp_plank	Nd		Nd					Nd									Nd	Nd		NI			Ba								
cR_Sea_pp_plank_NHB	Nd		Nd					Nd									Nd	Nd		Ni			Ba								
cR_Sea_pp_vasc_NHB	Nd		Nd					Nd									Nd	Nd		Ni			Ba								
cR_Sea_zoopl_NHB	Nd		Nd					Nd							Zr		Nd	Nd		Ni						Zr	Ca				
cR_agri_cereal	La		La					La									La	La		Ni	Bi	U						Re			
cR_agri_fodder	La		La					La									La	La		Ni	Bi	U						Re			
cR_agri_tuber	La			Sr	Sr	Zn					La	La						La		Ni					La	Th					
cR_agri_veg	La			Ra	Sr	Zn					La	La						La		Ni					La	Th		Re			
cR_food_herbiv	La		La					La									La	La		Ni								Zr			
cR_Ter_amph_NHB	La		La	Sr	Sr			La			La	La					La	La		Ni											
cR_Ter_bird_egg_NHB	La		La	Sr	Sr			La			La	La					La	La		Ni											
cR_Ter_bird_NHB	La		La	Sr	Sr			La			La	La					La	La		Ni											
cR_Ter_detr_inv_NHB	Am			Sr	Sr							Am		Tc			Am	Am		Ni					Am	Zr					
cR_Ter_fl_ins_NHB	Am			Sr	Sr							Am		Tc			Am	Am		Ni					Am	Zr					
cR_Ter_gastr_NHB	Am			Sr	Sr							Am		Tc			Am	Am		Ni					Am	Zr					
cR_Ter_mammal_large_NHB	La		La					La			La	La					La	La		Ni											
cR_Ter_mammal_small_NHB	La		La					La			La	La					La	La		Ni											
cR_Ter_Mush	La	Cu	La	Sr				La						Cr			La	La		Ni	Bi	U	Sr			Th		Re			
cR_Ter_pp	La		La					La									La	La		Ni	Bi	U						Re			
cR_Ter_pp_grass_NHB	La		La					La									La	La		Ni	Bi	U						Re			
cR_Ter_pp_lich_NHB	La		La					La									La	La		Ni		U									
cR_Ter_pp_NHB	La		La					La									La	La		Ni	Bi							Re			
cR_Ter_pp_shrub_NHB	La		La					La									La	La		Ni	Bi	U						Re			
cR_Ter_pp_tree_NHB	La		La					La									La	La		Ni	Bi	U						Re			
cR_Ter_rept_NHB	La		La					La			La	La					La	La		Ni											
cR_Ter_soil_inv_NHB	Am			Sr	Sr							Am		Tc			Am	Am		Ni					Am	Zr					
K_d_PM_lake	Sm		Sm				Br	Sm									Sm	Sm		Ni	Bi	U	Ba			Zr		Re			
K_d_PM_sea	Sm		Sm					Sm									Sm	Sm		Ni	Bi	U	Ba					Re			
K_d_regoGL	Sm		Sm			Zn		Sm									Th	Sm		Ni	Bi	Sm						Zr			
K_d_regoLow	Sm		Sm					Sm									Th	Sm		Ni	Bi	Sm						Zr			
K_d_regoPeat	Sm		Sm					Sm									Th	Sm			Bi	Sm						Zr			
K_d_regoPG	Sm		Sm					Sm									Th	Sm		Ni	Bi	Sm						Zr			
K_d_regoUp_aqu	Sm		Sm					Sm									Sm	Sm		Ni	Bi	U	Ba					Re			
K_d_regoUp_drain	Sm		Sm					Sm									Sm	Sm			Bi	U						Re			
K_d_regoUp_garden	Sm		Sm					Sm									Sm	Sm			Bi	U						Re			
K_d_regoUp_io	Sm		Sm					Sm									Sm	Sm			Bi	U						Re			
K_d_regoUp_ter	Sm		Sm					Sm									Sm	Sm		Ni	Bi	U						Re			
TC_meat	La	Zn						La			La	La				Zn	La	La		Zn	Pb			Te	La	Zr		Zr			
TC_milk	Am	Zn					I	Am			Am	Am					Am	Am		Ni					Am	Zr		Zr	Zr		

Table 9-10. The number of elements for which PAs have been assigned for each parameter in this parameterisation, with a total of 31 elements.

	Parameter analogue																				
Parameter	cR_Lake_bird_NHB	cR_Lake_bivalve_NHB	cR_Lake_crust_NHB	cR_Lake_Fish_NHB	cR_lake_pp_macro	cR_Lake_pp_plank_NHB	cR_Sea_bent_moll_NHB	cR_Sea_crust_NHB	cR_Sea_Fish_NHB	cR_sea_pp_macro	cR_Sea_pp_macro_NHB	cR_Sea_zoopl_NHB	cR_Ter_bird_NHB	cR_agri_cereal	cR_Ter_detr_inv_NHB	cR_Ter_gastr_NHB	cR_Ter_mammal_NHB	cR_Ter_pp	cR_Ter_pp_NHB	cR_Ter_soil_inv_NHB	K_d_PM_lake
cR_Lake_amph_NHB				29																	
cR_Lake_bent_fish_NHB				31																	
cR_Lake_bird_NHB				30																	
cR_Lake_Cray		27																			
cR_Lake_crust_NHB		27																			
cR_Lake_Fish				1																	
cR_Lake_gastr_NHB		27																			
cR_Lake_ins_larvae_NHB		27	3																		
cR_Lake_mammal_NHB	1			29																	
cR_Lake_pel_fish_NHB				31																	
cR_lake_pp_micro					31																
cR_lake_pp_plank					27																
cR_Lake_pp_plank_NHB					27																
cR_Lake_pp_vasc_NHB					27																
cR_Lake_zoopl_NHB				4		1						18									
cR_Sea_bent_fish_NHB									31												
cR_Sea_bird_NHB									27												
cR_Sea_crust_NHB									1												
cR_Sea_mammal_NHB									25												
cR_Sea_pel_fish_NHB									31												
cR_Sea_polych_NHB							20	2													
cR_Sea_pp_macro_NHB										27											
cR_sea_pp_plank										27											
cR_Sea_pp_plank_NHB										27											
cR_Sea_pp_vasc_NHB										27	4										
cR_agri_fodder														4				27			
cR_agri_tuber														1				3			
cR_agri_veg														2				2			
cR_Ter_amph_NHB																	23				
cR_Ter_bird_egg_NHB													4				21				
cR_Ter_bird_NHB																	23				
cR_Ter_detr_inv_NHB																1					
cR_Ter_fl_ins_NHB															3						
cR_Ter_gastr_NHB															2					1	
cR_Ter_mammal_large_NHB																	27				
cR_Ter_mammal_small_NHB																	27				
cR_Ter_Mush														3				11			
cR_Ter_pp														4							
cR_Ter_pp_grass_NHB														4				1	26		
cR_Ter_pp_NHB														2							
cR_Ter_pp_shrub_NHB														4				1	26		
cR_Ter_pp_tree_NHB														4				1	26		
cR_Ter_rept_NHB																	29				
cR_Ter_soil_inv_NHB															2						
K_d_PM_sea																					1

Table 9-11. Selected PAs per parameter and element combination. The numbers refer to the parameter IDs listed in table foot.

Parameter	Ac	Ag	Am	Ba	Ca	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_Lake_amph_NHB	44	44	44	44		44	44	44	44	44	44	44	44	44	44	44	44	44		44	44	44	44	44	44	44	44	44	44	44	44
cR_Lake_bent_fish_NHB	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
cR_Lake_bird_NHB	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44		44	44	44	44	44	44	44	44	44
cR_Lake_bivalve_NHB																															
cR_Lake_Cray	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42				42	42	42	42		42	42	42
cR_Lake_crust_NHB	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42				42	42	42	42		42	42	42
cR_Lake_Fish																	44														
cR_Lake_Fish_NHB																															
cR_Lake_gastr_NHB	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42				42	42	42	42		42	42	42
cR_Lake_ins_larvae_NHB	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	43	43	43	42	42	42	42		42	42	42
cR_Lake_mammal_NHB	44	44	44	44	44	41	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44		44	44	44	44	44	44	44	44	44
cR_Lake_pel_fish_NHB	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
cR_lake_pp_macro																															
cR_lake_pp_micro	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
cR_lake_pp_plank	8		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8			8	8	8	8	8		8	8	8
cR_Lake_pp_plank_NHB	8		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8			8	8	8	8	8		8	8	8
cR_Lake_pp_vasc_NHB	8		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8			8	8	8	8	8		8	8	8
cR_Lake_zoopl_NHB	63		63	63	63	63	44	63			63	63		63	44	63	63	63		63	49		44	63	63	44	63		63		63
cR_Sea_bent_fish_NHB	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
cR_Sea_bent_moll_NHB																															
cR_Sea_bird_NHB	56		56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56			56	56	56	56	56	56	56		56
cR_Sea_crust_NHB																										56					
cR_Sea_Fish																															
cR_Sea_Fish_NHB																															
cR_Sea_mammal_NHB	56		56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56				56	56	56	56		56		56
cR_Sea_pel_fish_NHB	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
cR_Sea_polych_NHB	53		53	53	53		53	53			53	53	53	53	53		53	53	53				55		53	53	53	55	53	53	53
cR_sea_pp_macro																															
cR_Sea_pp_macro_NHB	14		14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14			14	14	14	14	14		14	14	14
cR_sea_pp_micro	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
cR_sea_pp_plank	14		14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14			14	14	14	14	14		14	14	14
cR_Sea_pp_plank_NHB	14		14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14			14	14	14	14	14		14	14	14
cR_Sea_pp_vasc_NHB	14	60	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	60	60	14	14	14	14	14	60	14	14	14
cR_Sea_zoopl_NHB																															
cR_agri_cereal																															
cR_agri_fodder	12	1	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	1	12	12	1	12	12	12	1	12	12	12
cR_agri_tuber																12				12				1							12
cR_agri_veg																12				12				1				1			
cR_food_herbiv																															
cR_Ter_amph_NHB	71		71				71	71	71		71	71	71	71	71	71	71	71		71	71	71	71	71	71	71			71	71	71
cR_Ter_bird_egg_NHB	71	71	71	71	71	71	71	71	71		71	71		71		71	71	71	66	71	71	66	66	71	71	71			66		71
cR_Ter_bird_NHB	71	71	71	71	71	71	71	71	71		71	71	71	71	71	71	71	71		71	71			71	71	71					71
cR_Ter_detr_inv_NHB																	69														
cR_Ter_fl_ins_NHB							67	67													67										
cR_Ter_gastr_NHB								67									79				67										
cR_Ter_mammal_large_NHB	71		71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71			71	71	71	71	71		71	71	71
cR_Ter_mammal_small_NHB	71		71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71			71	71	71	71	71		71	71	71
cR_Ter_Mush	12		12				12	12			12	12			12		12	12			1			1	12			1			12
cR_Ter_pp		1																			1			1				1			
cR_Ter_pp_grass_NHB	75	1	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	1	12	75	1	75	75	75	1	75	75	75
cR_Ter_pp_lich_NHB																															
cR_Ter_pp_NHB																					1							1			
cR_Ter_pp_shrub_NHB	75	1	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	1	12	75	1	75	75	75	1	75	75	75
cR_Ter_pp_tree_NHB	75	1	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	1	12	75	1	75	75	75	1	75	75	75
cR_Ter_rept_NHB	71		71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71		71	71	71
cR_Ter_soil_inv_NHB								67													67										
K_d_PM_lake																															
K_d_PM_sea		17																													
K_d_regoGL																															
K_d_regoLow																															
K_d_regoPeat																															
K_d_regoPG																															
K_d_regoUp_aqu																															
K_d_regoUp_drain																															
K_d_regoUp_garden																															
K_d_regoUp_io																															
K_d_regoUp_ter																															
TC_meat																															
TC_milk																															

1: cR_agri_cereal, 8:cR_lake_pp_macro, 12:cR_Ter_pp, 14:cR_sea_pp_macro, 17:K_d_PM_lake, 41:cR_Lake_bird_NHB, 42:cR_Lake_bivalve_NHB, 43:cR_Lake_crust_NHB, 44:cR_Lake_Fish_NHB, 49:cR_Lake_pp_plank_NHB, 53:cR_Sea_bent_moll_NHB, 55:cR_Sea_crust_NHB, 56:cR_Sea_Fish_NHB, 60:cR_Sea_pp_macro_NHB, 63:cR_Sea_zoopl_NHB, 66:cR_Ter_bird_NHB, 67:cR_Ter_detr_inv_NHB, 69:cR_Ter_gastr_NHB, 71:cR_Ter_mammal_NHB, 75:cR_Ter_pp_NHB, 79:cR_Ter_soil_inv_NHB.

In some cases, as for example the use of cR_Ter_pp as a PA for shrubs, threes, grass and pasture can be considered to be a PA with lower uncertainty than the use of data on terrestrial mammals for bird eggs. There are no data to support the assumption that the uptake in bird eggs would be similar to the uptake in mammals. Even if the similarities between selected PAs are hard to evaluate due to lack of data, the PAs used can be discussed based on similarities in habitat and feeding strategies of the organisms. In general, "higher" organisms have a more specialised element uptake than lower ones. For instance, the element uptake in vascular plants mainly takes place via specialised organs (roots), whereas uptake in plankton and macro algae takes place through the whole organism surface.

The habitat and the food intake of different organisms can affect the uptake of elements. Data for limnic filter feeders are utilised as PA for crustaceans, gastropods and insect larvae. These are all lower fauna that are present on (or in) sediment or vegetation in the lakes. Some insect larvae may be present in the water column as well. Some crustaceans, gastropods and insect larvae spend a restricted part of their lives in the limnic environment since only the larval stage is aquatic, unlike filter feeders. The food intake varies among the different organism types; i.e. filter feeder accumulates elements from the surrounding via filtering whereas gastropods feed on algae growing on hard substrates or vegetation. Despite these differences, the data for limnic filter feeders are assumed to best represent these organisms of the available site data sets. Site data for marine filter feeders, crustaceans and fish are compared in Tröjbom and Nordén (2010), revealing that the filter feeders, crustaceans form a loose group deviating from marine fish. A deviation is also found between filter feeders and fish from limnic environments. Hence, it has been assumed that limnic crustaceans are more similar to limnic filter feeder than to limnic fish.

Fish data are utilised as PA for limnic mammals and birds in many element cases where representative data are missing. Since higher animals are expected to differ from lower forms, birds and mammals are considered more similar to fish than to filter feeders. The main food source is fish for many of the relevant species, although some bird or mammal species eat aquatic vegetation or filter feeders.

9.2.6 Comparisons of Best estimates and Geometric mean

The main purpose with this section is to show for which parameters and elements BE deviates from GM. This might have implications for the interpretation of the deterministic calculations based on BE, and the probabilistic calculations based on GM.

According to the assumptions listed in Section 2.6, best estimates (BE) are determined from FM site data when available, whereas geometric means (GM) are based on all available site data (FM and LX data). Depending on available data sources this might lead to difference between BE and GM. In Table 9-12, the ratio between BE and GM are illustrated as 10-logarithms of these ratios, i.e. a tenfold difference is shown as 1 if BE is larger than GM, or –1 if BE is lower than GM.

The differences between BE and GM are generally less than factor 3. Limnic CRs differ the most, which is mainly explained by the very different types of lakes in FM and LX. This implicates that BE (and thus the deterministic calculations) are biased towards the conditions in present FM. The presumed future conditions at FM (represented by the present conditions at LX today) are, however, covered by the PDFs and thus included in the probabilistic calculations.

For marine CR, there are general deviations for a few elements even if data from FM and LX for cR_sea_pp_macro represent similar marine environments. This difference in not fully understood, but might be an effect of sampling methods in combination with limited sample numbers (cf. Chapter 8). cR_sea_pp_macro is utilised as PA for the cR_Sea_pp_macro, cR_sea_pp_plank and cR_Sea_pp_vasc_NHB parameters.

The difference for K_d_PM_sea for Ba and Ra relates to deviating Ba data, which leads to almost a tenfold difference between BE and GM for this parameter.

Table 9-12. Ratio between the best estimates, BE, and the geometric means, GM expressed as log(BE/GM). The figures thus represent differences at the order of magnitudes, i.e. 0 represents no difference and 1 represents a 10-fold difference with higher BE than GM, –1 represents a 10-fold difference with lower BE than GM. The colour coding range from blue-yellow-red corresponding to an increasing BE/GM ratio.

Parameter	Ac	Ag	Am	Ba	Ca	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_Lake_amph_NHB	0.4	0.0	0.4	-0.1	0.0	0.0	0.0	0.4	0.1	-0.2	0.4	0.0	0.1	0.0	0.1	0.0	0.4	0.4	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.4	-0.1	0.0	0.0	-0.3	0.4
cR_Lake_bent_fish_NHB	0.4	0.0	0.4	-0.1	-0.2	0.0	0.0	0.4	0.1	-0.2	0.4	0.0	0.1	0.0	0.1	0.0	0.4	0.4	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.4	-0.1	0.0	0.0	-0.3	0.4
cR_Lake_bird_NHB	0.4	0.0	0.4	-0.1	-0.2	0.0	0.0	0.4	0.1	-0.2	0.4	0.0	0.1	0.0	0.1	0.0	0.4	0.4	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.4	-0.1	0.0	0.0	-0.3	0.4
cR_Lake_bivalve_NHB	-0.3	0.0	-0.3	-0.1	-0.3	0.2	-0.5	-0.3	0.1	-0.2	0.0	-0.2	0.2	-0.3	0.1	0.1	-0.3	-0.3	0.2	0.1	0.0	0.0	-0.1	0.0	-0.3	-0.2	-0.2	0.0	-0.1	-0.7	-0.2
cR_Lake_Cray	-0.3	0.0	-0.3	-0.1	-0.3	0.2	-0.5	-0.3	0.1	-0.2	0.0	-0.2	0.2	-0.3	0.1	0.1	-0.3	-0.3	0.2	0.1	0.0	0.0	0.0	0.0	-0.3	-0.2	-0.2	0.0	-0.1	-0.7	-0.2
cR_Lake_crust_NHB	-0.3	0.0	-0.3	-0.1	-0.3	0.2	-0.5	-0.3	0.1	-0.2	0.0	-0.2	0.2	-0.3	0.1	0.1	-0.3	-0.3	0.2	0.1	0.0	0.0	0.0	0.0	-0.3	-0.2	-0.2	0.0	-0.1	-0.7	-0.2
cR_Lake_Fish	0.4	0.0	0.4	-0.1	-0.2	0.0	0.0	0.4	0.1	-0.2	0.4	0.0	0.1	0.0	0.1	0.0	0.4	0.4	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.4	-0.1	0.0	0.0	-0.3	0.4
cR_Lake_Fish_NHB	0.4	0.0	0.4	-0.1	-0.2	0.0	0.0	0.4	0.1	-0.2	0.4	0.0	0.1	0.0	0.1	0.0	0.4	0.4	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.4	-0.1	0.0	0.0	-0.3	0.4
cR_Lake_gastr_NHB	-0.3	0.0	-0.3	-0.1	-0.3	0.2	-0.5	-0.3	0.1	-0.2	0.0	-0.2	0.2	-0.3	0.1	0.1	-0.3	-0.3	0.2	0.1	0.0	0.0	0.0	0.0	-0.3	-0.2	-0.2	0.0	-0.1	-0.7	-0.2
cR_Lake_ins_larvae_NHB	-0.3	0.0	-0.3	-0.1	-0.3	0.2	-0.5	-0.3	0.1	-0.2	0.0	-0.2	0.2	-0.3	0.1	0.1	-0.3	-0.3	0.2	0.1	0.0	0.0	0.0	0.0	-0.3	-0.2	-0.2	0.0	-0.1	-0.7	-0.2
cR_Lake_mammal_NHB	0.4	0.0	0.4	-0.1	-0.2	0.0	0.0	0.4	0.1	-0.2	0.4	0.0	0.1	0.0	0.1	0.0	0.4	0.4	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.4	-0.1	0.0	0.0	-0.3	0.4
cR_Lake_pel_fish_NHB	0.4	0.0	0.4	-0.1	-0.2	0.0	0.0	0.4	0.1	-0.2	0.4	0.0	0.1	0.0	0.1	0.0	0.4	0.4	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0	0.4	-0.1	0.0	0.0	-0.3	0.4
cR_lake_pp_macro	0.5	0.0	0.5	0.0	0.0	0.2	-0.5	0.5	0.1	0.0	0.5	0.5	0.1	-0.1	0.4	0.2	0.5	0.5	0.4	0.2	0.0	0.0	0.0	0.0	0.5	0.3	0.2	0.0	0.3	0.1	0.3
cR_lake_pp_micro	0.5	0.0	0.5	0.0	0.0	0.2	-0.5	0.5	0.1	0.0	0.5	0.5	0.1	-0.1	0.4	0.2	0.5	0.5	0.4	0.2	0.0	0.0	0.0	0.0	0.5	0.3	0.2	0.0	0.3	0.1	0.3
cR_lake_pp_plank	0.5	0.0	0.5	0.0	0.0	0.2	-0.5	0.5	0.1	0.0	0.5	0.5	0.1	-0.1	0.4	0.2	0.5	0.5	0.4	0.2	0.0	0.0	0.0	0.0	0.5	0.3	0.2	0.0	0.3	0.1	0.3
cR_Lake_pp_plank_NHB	0.5	0.0	0.5	0.0	0.0	0.2	-0.5	0.5	0.1	0.0	0.5	0.5	0.1	-0.1	0.4	0.2	0.5	0.5	0.4	0.2	0.0	0.0	0.0	0.0	0.5	0.3	0.2	0.0	0.3	0.1	0.3
cR_Lake_pp_vasc_NHB	0.5	0.0	0.5	0.0	0.0	0.2	-0.5	0.5	0.1	0.0	0.5	0.5	0.1	-0.1	0.4	0.2	0.5	0.5	0.4	0.2	0.0	0.0	0.0	0.0	0.5	0.3	0.2	0.0	0.3	0.1	0.3
cR_Lake_zoopl_NHB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
cR_Sea_bent_fish_NHB	0.0	0.0	0.0	0.2	0.6	0.1	-0.1	0.0	0.4	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
cR_Sea_bent_moll_NHB	0.1	0.0	0.1	0.1	0.2	-0.2	-0.3	0.1	0.1	0.2	0.0	0.0	-0.2	-0.1	0.0	0.0	0.1	0.1	-0.1	0.0	0.0	0.0	0.0	-0.2	0.1	0.0	0.2	0.0	0.3	0.0	0.3
cR_Sea_bird_NHB	0.0	0.0	0.0	0.2	0.6	0.1	-0.1	0.0	0.4	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
cR_Sea_crust_NHB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cR_Sea_Fish	0.0	0.0	0.0	0.2	0.6	0.1	-0.1	0.0	0.4	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
cR_Sea_Fish_NHB	0.0	0.0	0.0	0.2	0.6	0.1	-0.1	0.0	0.4	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
cR_Sea_mammal_NHB	0.0	0.0	0.0	0.2	0.6	0.1	-0.1	0.0	0.4	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
cR_Sea_pel_fish_NHB	0.0	0.0	0.0	0.2	0.6	0.1	-0.1	0.0	0.4	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
cR_Sea_polych_NHB	0.1	0.0	0.1	0.1	0.2	0.0	-0.3	0.1	0.0	0.0	0.0	0.0	-0.2	-0.1	0.0	0.0	0.1	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.3	0.0	0.3
cR_sea_pp_macro	-0.3	0.0	-0.3	0.2	-0.1	0.0	0.0	-0.3	0.4	0.5	-0.5	-0.6	0.1	0.1	0.0	0.1	-0.3	-0.3	0.1	0.1	0.0	0.0	0.2	0.0	-0.6	0.0	0.0	0.0	0.7	0.0	0.6
cR_Sea_pp_macro_NHB	-0.3	0.0	-0.3	0.2	-0.1	0.0	0.0	-0.3	0.4	0.5	-0.5	-0.6	0.1	0.1	0.0	0.1	-0.3	-0.3	0.1	0.1	0.0	0.0	0.2	0.0	-0.6	0.0	0.0	0.0	0.7	0.0	0.6
cR_sea_pp_micro	-0.3	0.0	-0.3	0.2	-0.1	0.0	0.0	-0.3	0.4	0.5	-0.5	-0.6	0.1	0.1	0.0	0.1	-0.3	-0.3	0.1	0.1	0.0	0.0	0.2	0.0	-0.6	0.0	0.0	0.0	0.7	0.0	0.6
cR_sea_pp_plank	-0.3	0.0	-0.3	0.2	-0.1	0.0	0.0	-0.3	0.4	0.5	-0.5	-0.6	0.1	0.1	0.0	0.1	-0.3	-0.3	0.1	0.1	0.0	0.0	0.2	0.0	-0.6	0.0	0.0	0.0	0.7	0.0	0.6
cR_Sea_pp_plank_NHB	-0.3	0.0	-0.3	0.2	-0.1	0.0	0.0	-0.3	0.4	0.5	-0.5	-0.6	0.1	0.1	0.0	0.1	-0.3	-0.3	0.1	0.1	0.0	0.0	0.2	0.0	-0.6	0.0	0.0	0.0	0.7	0.0	0.6
cR_Sea_pp_vasc_NHB	-0.3	0.0	-0.3	0.2	-0.1	0.0	0.0	-0.3	0.4	0.5	-0.5	-0.6	0.1	0.1	0.0	0.1	-0.3	-0.3	0.1	0.1	0.0	0.0	0.2	0.0	-0.6	0.0	0.0	0.0	0.7	0.0	0.6
cR_Sea_zoopl_NHB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cR_agri_cereal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cR_agri_fodder	-0.2	0.0	-0.2	0.0	-0.2	0.0	0.0	-0.2	-0.1	0.1	0.0	0.0	0.0	0.1	0.0	-0.1	-0.2	-0.2	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0
cR_agri_tuber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cR_agri_veg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cR_food_herbiv	0.5	0.0	0.5	0.0	0.2	0.3	0.0	0.5	0.4	-0.1	0.0	0.0	0.0	0.0	0.2	0.7	0.5	0.5	0.7	0.7	0.0	0.0	0.3	0.0	0.7	-0.1	0.3	0.1	0.0	0.0	0.1
cR_Ter_amph_NHB	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	-0.1	0.6	-0.3	0.0	0.0	0.0	0.1	0.1
cR_Ter_bird_egg_NHB	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	-0.1	0.6	-0.3	0.0	0.0	0.0	0.0	0.1
cR_Ter_bird_NHB	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	-0.1	0.6	-0.3	0.0	0.0	0.0	0.0	0.1
cR_Ter_detr_inv_NHB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cR_Ter_fl_ins_NHB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cR_Ter_gastr_NHB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cR_Ter_mammal_large_NHB	0.1	0.0	0.1	-0.1	-0.1	0.1	0.0	0.1	0.0	-0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.0	0.0	0.0	-0.1	0.6	-0.3	0.0	0.0	0.0	0.1	0.1
cR_Ter_mammal_small_NHB	0.1	0.0	0.1	-0.1	-0.1	0.1	0.0	0.1	0.0	-0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.0	0.0	0.0	-0.1	0.6	-0.3	0.0	0.0	0.0	0.1	0.1
cR_Ter_Mush	-0.2	0.0	-0.2	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
cR_Ter_pp	-0.2	0.0	-0.2	0.0	-0.2	0.0	0.0	-0.2	-0.1	0.1	0.0	0.0	0.0	0.1	0.0	-0.1	-0.2	-0.2	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0
cR_Ter_pp_grass_NHB	-0.2	0.0	-0.2	0.0	-0.2	0.0	0.0	-0.2	-0.1	0.1	0.0	0.0	0.0	0.1	0.0	-0.1	-0.2	-0.2	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0
cR_Ter_pp_lich_NHB	0.0	-0.1	0.0	0.0	-0.2	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.1	0.0
cR_Ter_pp_NHB	-0.2	0.0	-0.2	0.0	-0.2	0.0	0.0	-0.2	-0.1	0.1	0.0	0.0	0.0	0.1	0.0	-0.1	-0.2	-0.2	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0
cR_Ter_pp_shrub_NHB	-0.2	0.0	-0.2	0.0	-0.2	0.0	0.0	-0.2	-0.1	0.1	0.0	0.0	0.0	0.1	0.0	-0.1	-0.2	-0.2	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0
cR_Ter_pp_tree_NHB	-0.2	0.0	-0.2	0.0	-0.2	0.0	0.0	-0.2	-0.1	0.1	0.0	0.0	0.0	0.1	0.0	-0.1	-0.2	-0.2	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0
cR_Ter_rept_NHB	0.1	0.0	0.1	-0.1	-0.1	0.1	0.0	0.1	0.0	-0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.0	0.0	0.0	-0.1	0.6	-0.3	0.0	0.0	0.0	0.1	0.1
cR_Ter_soil_inv_NHB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kd_PM_lake	-0.1	0.0	-0.1	-0.3	-0.1	0.1	0.4	-0.1	-0.1	-0.2	-0.2	-0.2	0.2	0.0	-0.2	0.2	-0.1	-0.1	0.1	0.2	0.6	-0.8	-0.3	-0.1	-0.1	-0.2	-0.2	0.2	-0.1	-0.8	-0.2
Kd_PM_sea	0.2	0.0	0.2	0.9	0.5	0.3	0.0	0.2	0.3	0.6	0.1	0.2	0.0	0.4	0.5	0.0	0.2	0.2	-0.1	0.0	0.3	0.2	0.9	-0.2	0.2	0.0	0.0	0.0	0.5	0.2	0.5
Kd_regoGL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kd_regoLow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kd_regoPeat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kd_regoPG	-0.1	0.0	-0.1	0.7	0.0	-0.1	0.0	-0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	-0.1	-0.1	0.1	0.0	-0.1	0.0	0.6	-0.1	0.0	0.0	0.3	0.0	-0.2	0.3
Kd_regoUp_aqu	0.2	-0.3	0.2	-0.1	0.0	-0.4	0.1	0.2	0.0	0.1	0.2	0.1	0.0	-0.2	0.1	0.0	0.2	0.2	-0.1	0.0	0.1	-0.1	-0.1	0.0	0.2	0.0	-0.1	0.0	0.2	-0.1	0.0
Kd_regoUp_drain	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kd_regoUp_garden	0.1	0.0	0.1	0.1	-0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	-0.1	0.0	0.2	0.1	0.0	-0.1	0.0	0.1	-0.1	0.1
Kd_regoUp_io	0.1	0.0	0.1	0.1	-0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	-0.1	0.0	0.2	0.1	0.0	-0.1	0.0	0.1	-0.1	0.1
Kd_regoUp_ter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TC_meat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TC_milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

9.2.7 Correlations between K_d and CR in selected values

On theoretical grounds, there should be a negatively correlated relationship between CR soil-to-plant and K_d in soil for elements that are subject to the same uptake mechanisms. A significant fraction of the variation in terrestrial CR among elements could be explained by the underlying variation in sorption properties (K_d). If CR soil-to-plant and K_d are determined from different data sources, the use of different inherent K_d values could perhaps increase uncertainties in the model results.

In Figure 9-5, CR for terrestrial vegetation and for cereals are compared to K_d for natural and agricultural soils, respectively. The correlations show negative relationships between the CRs for both natural terrestrial vegetation and agricultural crops, and K_d for soils. The variation in the direction of the arrow represent different degrees of enhanced uptake, on the scale from passive to active uptake.

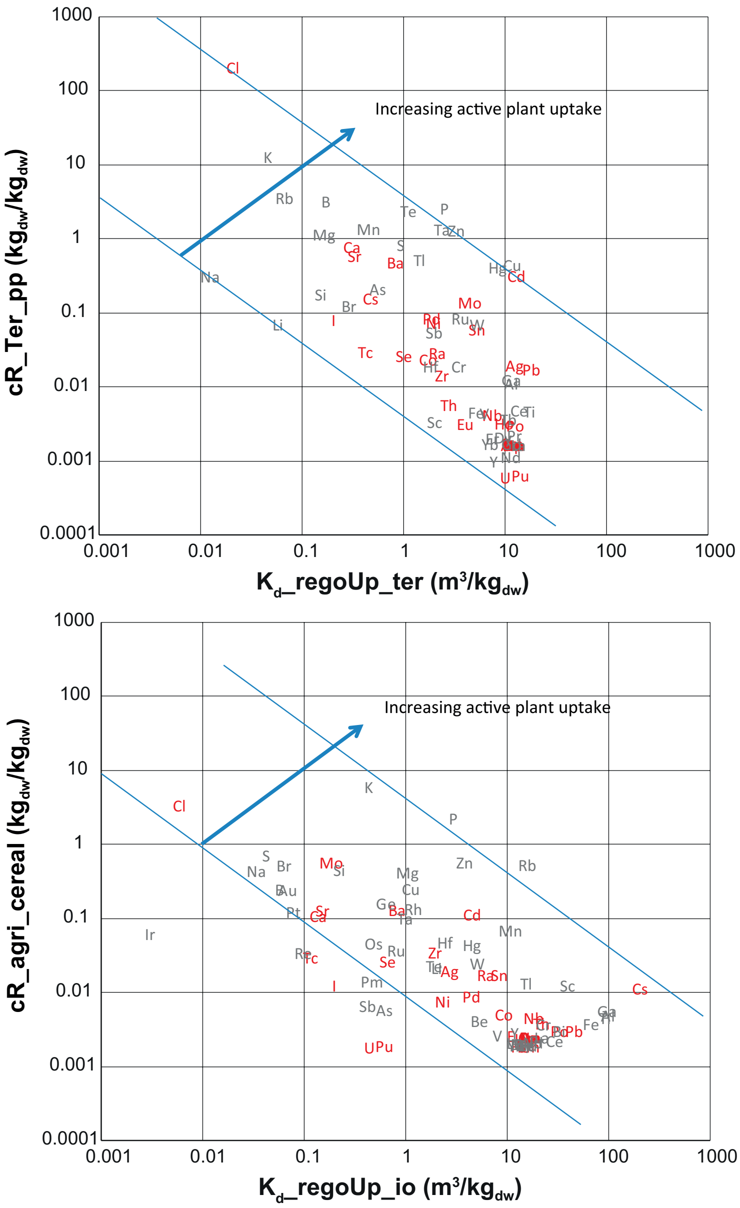


Figure 9-5. *Correlation between K_d and CR for natural vegetation (upper plot) and cereals in agricultural soils (lower plot). Red figures indicate elements parameterised in SR-PSU and grey figures indicate supporting information of elements not included in the safety assessment. In the upper plot, the lower straight line connects elements taken up passively by plants, e.g. Na, where plant concentrations per fresh weight are comparable with pore water concentrations in soil. In the lower plot, this line marks the location of Na. The dashed lines mark elements probably taken up by active processes, for example P and Zn.*

The lower straight line in the upper panel probably represents the conditions when plant concentrations per fresh weight are in approximately equilibrium with pore water concentrations and the uptake is mainly driven by diffusion, exemplified by cations such as Na and Li. The upper dashed line marks elements taken up actively by plants, for example P and Zn. Known analogues with respect to plant uptake, such as K, Rb and Cs, also plot along these lines indicating similar plant uptake properties, though differing in mobility in soil (K_d).

The presence of expected correlations within element groups showing similar uptake properties but different mobility in soil increases the confidence in selected data.

9.2.8 Overview of confidence in selected parameter values

The confidence in a single parameter value depends on several factors that contribute to the overall uncertainty. No attempt has been made to create a single index describing the overall uncertainty of a parameter, due to the difficulties in determining the relative importance of different contributing factors. However, the origin of the data, the results of the sense checks (see Section 4.5), in combination with the assumptions made on analogues are compiled in a single table (Table 9-14). This compilation might give a first perception of the relative confidence in the selected parameter values. In preceding sections, uncertainties are discussed separately in combination with various comparisons that might contribute to the understanding of the overall confidence of the parameters.

The different classifications used in Table 9-14 are explained in Table 9-13. According to the assumptions in Section 2.6, site data are generally more confident than literature data. The level of confidence increases if literature data supports site data (class SO), if site data deviates from comparable literature data (class SV) the uncertainty increases and also if no literature data are available the confidence of selected data decreases (class SX). Considerable variation in site data can also be an indication that the uncertainties are elevated (class SM). The use of analogues is associated with increased uncertainties (class EA, PA and EP, confidence in descending order). If literature data are used (class LO, LV, LX) the confidence in selected data is lower in comparison to cases where site data are used, especially if the selected literature data deviate from data from other literature sources (class LV) or if no other comparable literature data are available for comparison (class LX). The categories listed in Table 9-13 are arranged in decreasing order after the relative confidence according to these coarse guidelines.

The overall pattern of Table 9-14 indicates that some parameters and elements are associated with higher uncertainty than others. Many of the non-human biota parameters (with the suffix _NHB) are based on parameter analogues (PA or EP) and thus less confident according to the classification described above. It is evident from the table that the parameterisation of some elements is mainly based on element analogues (EA). Literature data are mainly utilised to fill occasional data gaps, with the exception of a few parameters (cR_Ter_fl_ins_NHB, cR_Ter_gastr_NHB, cR_Ter_soil_inv_NHB, TC_milk and TC_meat). When site data are utilised for the parameterisation, comparisons with literature data show varying degrees of agreement between the sources (SO, SV and SX). In addition, there are a few cases where site data are utilised for the parameterisation, but where these data show excessive variation compared to other elements (SM). In these cases, comparisons with literature data might be less informative, and the increased uncertainty leads to lower confidence in parameter values.

Table 9-13. The different classifications utilised in Table 9-14 describing the relative confidence in parameter values based on the origin of data, results of sense checks and analogue assumptions.

SO	Site data used, > 50% overlap with literature data
SV	Site data used, < 50% overlap with literature data
SX	Site data used, no comparisons with literature data possible
SM	Site data used, variation > GSDmax
EA	Element analogue is used
PA	Parameter analogue is used
EP	Element and parameter analogue is used
LO	Literature data are used, overlap with other literature data
LV	Literature data are used, no overlap with other literature data
LX	Literature data are used, no comparisons with other literature data possible
OV	Manual override

Table 9-14. Classification of data according to the origin of the data source, results of sense checks and the corresponding analogue assumptions. The categories are described in Table 9-13.

Parameter	Ac	Ag	Am	Ba	Ca	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_Lake_amph_NHB	EP	OV	EP	PA	LX	PA	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	EP	EP	LV	EP	PA	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA
cR_Lake_bent_fish_NHB	EP	OV	EP	PA	PA	PA	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	EP	EP	OV	EP	PA	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA
cR_Lake_bird_NHB	EP	OV	EP	PA	PA	PA	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	EP	EP	OV	EP	PA	LX	EP	PA	PA	EP	PA	PA	PA	PA	PA
cR_Lake_bivalve_NHB	EA	SX	EA	SX	SV	SV	SX	EA	SO	SO	SX	SX	SO	SV	SV	SX	EA	EA	SV	EA	LX	LV	EA	SO	SX	EA	SO	OV	SX	SM	SX
cR_Lake_Cray	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	LX	LX	LX	PA	PA	EP	PA	LX	PA	PA	PA
cR_Lake_crust_NHB	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	LX	LO	LO	PA	PA	EP	PA	LV	PA	PA	PA
cR_Lake_Fish	EA	LO	EA	SO	SO	LX	SO	EA	SO	SV	EA	SX	SO	SO	SV	SV	EP	EA	LO	EA	LV	LV	EA	SV	SX	EA	SO	LX	OV	SM	SO
cR_Lake_Fish_NHB	EA	OV	EA	SO	SO	LV	SV	EA	SO	SV	EA	SX	SO	SO	SV	SO	EA	EA	OV	EA	LO	LO	EA	SV	SX	EA	SO	LO	LO	SM	SV
cR_Lake_gastr_NHB	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	LX	LX	LX	PA	PA	EP	PA	LX	PA	PA	PA
cR_Lake_ins_larvae_NHB	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	PA	PA	PA	PA	PA	EP	PA	LX	PA	PA	PA
cR_Lake_mammal_NHB	EP	OV	EP	PA	PA	PA	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	EP	EP	OV	EP	PA	LX	EP	PA	PA	EP	PA	PA	PA	PA	PA
cR_Lake_pel_fish_NHB	EP	OV	EP	PA	PA	PA	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	EP	EP	OV	EP	PA	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA
cR_lake_pp_macro	EA	LX	EA	SX	SX	SO	SM	EA	SO	SO	SX	SM	SO	SX	SX	SO	EA	EA	SO	EA	LX	LO	EA	SO	SX	EA	SO	LV	SV	SO	SX
cR_lake_pp_micro	PA	PA	PA	PA	PA	PA	PA	EP	PA	EP	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	EP	EP	PA	EP	PA	EP	PA	PA	PA	PA	PA
cR_lake_pp_plank	EP	LX	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	LX	LX	EP	PA	PA	EP	PA	LX	PA	PA	PA
cR_Lake_pp_plank_NHB	EP	LV	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	LV	LO	EP	PA	PA	EP	PA	LV	PA	PA	PA
cR_Lake_pp_vasc_NHB	EP	LV	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	LV	OV	EP	PA	PA	EP	PA	OV	PA	PA	PA
cR_Lake_zoopl_NHB	EP	LX	EP	PA	PA	PA	PA	EP	LX	LX	PA	PA	LX	PA	PA	PA	EP	EP	LX	EP	PA	LX	PA	PA	PA	EP	EP	LX	OV	LX	PA
cR_Sea_bent_fish_NHB	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	EP	EP	PA	PA	PA	PA	EP	EP	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA
cR_Sea_bent_moll_NHB	EA	LX	EA	SX	SX	SO	SX	EA	SO	SO	SX	SX	SX	SX	SV	SV	EA	EA	SM	EA	LX	LX	LX	SV	SX	SX	EA	LX	SV	SV	SV
cR_Sea_bird_NHB	EP	LX	EP	PA	PA	PA	PA	EP	PA	PA	EP	EP	PA	PA	PA	PA	EP	EP	PA	EP	LV	LX	EP	PA	PA	PA	PA	PA	PA	LX	PA
cR_Sea_crust_NHB	EA	LX	EA	SX	SX	SV	LX	EA	SV	SV	SX	SX	LX	SX	LX	SV	EA	EA	SM	EA	LX	OV	LX	SV	SX	PA	EA	OV	SX	LX	SV
cR_Sea_Fish	EA	LX	EA	SX	SM	SV	SX	EA	SV	SO	EA	EA	SX	SX	SX	SV	EA	EA	SM	EA	LX	LO	EA	SV	SX	SX	SV	LX	SX	SV	SV
cR_Sea_Fish_NHB	EA	LO	EA	SX	SM	SO	SX	EA	SO	SO	EA	EA	SX	SX	SX	SV	EA	EA	SM	EA	LO	LO	EA	SV	SX	SX	SV	LO	SX	SV	SV
cR_Sea_mammal_NHB	EP	LX	EP	PA	PA	PA	PA	EP	PA	PA	EP	EP	PA	PA	PA	PA	EP	EP	PA	EP	LX	LX	LX	PA	PA	PA	PA	LX	PA	LX	PA
cR_Sea_pel_fish_NHB	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	EP	EP	PA	PA	PA	PA	EP	EP	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA
cR_Sea_polych_NHB	EP	LX	EP	PA	PA	LX	PA	EP	LX	LX	PA	PA	PA	PA	PA	LX	EP	EP	PA	EA	LX	LX	PA	LX	PA	PA	EP	OV	PA	PA	PA
cR_sea_pp_macro	EA	LO	EA	SX	SX	SV	SV	EA	SM	SV	SM	SM	SO	SX	SO	SO	EA	EA	SM	EA	LX	LO	EA	SV	SM	SX	SV	LO	SM	SV	SM
cR_Sea_pp_macro_NHB	EP	LO	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	LV	LV	EP	PA	PA	PA	PA	LV	PA	PA	PA
cR_sea_pp_micro	PA	PA	PA	PA	PA	PA	PA	PA	PA	EP	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	EP	EP	PA	EP	PA	EP	PA	PA	PA	PA	PA
cR_sea_pp_plank	EP	LX	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	LX	LX	EP	PA	PA	PA	PA	LX	PA	PA	PA
cR_Sea_pp_plank_NHB	EP	LO	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	LV	LV	EP	PA	PA	PA	PA	LV	PA	PA	PA
cR_Sea_pp_vasc_NHB	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA
cR_Sea_zoopl_NHB	EA	LX	EA	SX	SX	SX	LX	EA	OV	OV	SX	SX	SV	SX	EA	SX	EA	EA	SM	EA	LX	LX	LX	SX	SX	EA	EA	LX	OV	LX	SV
cR_agri_cereal	EA	SX	EA	SX	SV	SV	SV	EA	SO	SM	SX	SX	SO	SX	SX	SO	EA	EA	SO	EA	EA	EA	LO	SX	SX	SX	SO	EA	SV	SM	SX
cR_agri_fodder	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	EP	EP	PA	PA	PA	PA	PA	EP	PA	PA	PA
cR_agri_tuber	EA	OV	LO	EA	EA	EA	OV	LO	LO	LO	EA	EA	OV	OV	LV	PA	LO	EA	LO	EP	LO	LO	LO	PA	EA	EA	LO	LV	LO	LO	PA
cR_agri_veg	EA	LO	LO	EA	EA	EA	LX	LO	LO	LO	EA	EA	LX	LX	LV	PA	LO	EA	LO	EP	LV	LO	LO	PA	EA	EA	LO	EP	LO	LO	LV
cR_food_herbiv	EA	LX	EA	SX	SX	SX	SX	EA	SX	SX	SX	SX	SM	SX	SX	SX	EA	EA	SX	EA	LX	LX	SX	SX	SX	SX	SX	EA	SX	SX	SX
cR_Ter_amph_NHB	EP	LX	EP	EA	EA	LO	PA	EP	PA	LO	EP	EP	PA	PA	PA	PA	EP	EP	LO	EP	OV	OV	PA	PA	PA	PA	LO	LX	PA	PA	PA
cR_Ter_bird_egg_NHB	EP	PA	EP	EP	EP	PA	PA	EP	PA	LX	EP	EP	LX	PA	LX	PA	EP	EP	PA	EP	OV	PA	PA	PA	PA	PA	LX	LX	PA	LX	PA
cR_Ter_bird_NHB	EP	PA	EP	EP	EP	PA	PA	EP	PA	LO	EP	EP	PA	PA	OV	PA	EP	EP	LX	EP	OV	LV	LV	PA	PA	PA	LO	LV	LX	LX	PA
cR_Ter_detr_inv_NHB	OV	LX	OV	OV	OV	LO	LO	LX	LX	LO	LV	OV	LO	EA	LV	LV	EP	EA	LO	EA	LV	LX	LX	LV	OV	EA	OV	LX	LX	OV	LX
cR_Ter_fl_ins_NHB	EA	LX	LX	EA	EA	LX	PA	PA	LX	LX	LX	EA	LX	EA	LX	LX	EA	EA	LX	EA	PA	LX	LX	LX	EA	EA	LX	LX	LX	LX	LX
cR_Ter_gastr_NHB	EA	LX	LX	EA	EA	LX	LX	PA	LX	LX	LX	EA	LX	EA	LX	LX	EP	EA	LX	EA	PA	LX	LX	LX	EA	EA	LX	LX	LX	LX	LX
cR_Ter_mammal_large_NHB	EP	LX	EP	PA	PA	PA	PA	EP	PA	PA	EP	EP	PA	PA	PA	PA	EP	EP	PA	EP	LX	LO	PA	PA	PA	PA	PA	LX	PA	PA	PA
cR_Ter_mammal_small_NHB	EP	LX	EP	PA	PA	PA	PA	EP	PA	PA	EP	EP	PA	PA	PA	PA	EP	EP	PA	EP	OV	LO	PA	PA	PA	PA	PA	LX	PA	PA	PA
cR_Ter_Mush	EP	EA	EP	EA	SX	SX	PA	EP	SX	SV	PA	PA	SX	EA	PA	SX	EP	EP	SV	EA	EP	EA	EA	PA	PA	EA	SV	EP	SV	SM	PA
cR_Ter_pp	EA	PA	EA	SV	SX	SV	SO	EA	SO	SM	SX	SX	SO	SX	SX	SO	EA	EA	SO	EA	EP	EA	SO	PA	SX	SX	SO	EP	SO	SO	SX
cR_Ter_pp_grass_NHB	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	EP	EP	PA	PA	PA	PA	PA	EP	PA	PA	PA
cR_Ter_pp_lich_NHB	EA	SX	EA	SX	SX	SX	SX	EA	SX	SV	SX	SX	SX	SX	SX	SX	EA	EA	SV	EA	LX	EA	SV	SX	SX	SX	SV	LX	SV	SM	SX
cR_Ter_pp_NHB	EA	LV	EA	SV	SX	SO	SO	EA	SO	SM	SX	SX	SO	SX	SX	SO	EA	EA	SO	EA	EP	LO	SO	LO	SV	SX	SO	EP	SO	SV	SV
cR_Ter_pp_shrub_NHB	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	EP	EP	PA	PA	PA	PA	PA	EP	PA	PA	PA
cR_Ter_pp_tree_NHB	EP	PA	EP	PA	PA	PA	PA	EP	PA	PA	PA	PA	PA	PA	PA	PA	EP	EP	PA	EP	EP	EP	PA	PA	PA	PA	PA	EP	PA	PA	PA
cR_Ter_rept_NHB	EP	LX	EP	PA	PA	PA	PA	EP	PA	PA	EP	EP	PA	PA	PA	PA	EP	EP	PA	EP	OV	OV	PA	PA	PA	PA	PA	LX	PA	PA	PA
cR_Ter_soil_inv_NHB	EA	LX	LX	EA	EA	LX	LX	PA	LX	LX	LX	EA	LX	EA	LX	LX	EA	EA	LX	EA	PA	LX	LX	LX	EA	EA	LX	LX	LX	LX	LX
K_d_PM_lake	EA	SV	EA	SO	SX	SX	EA	EA	SO	SO	SX	SX	SO	SX	SX	SX	EA	EA	SX	EA	EA	EA	EA	SX	SX	EA	SV	EA	SO	SM	SX
K_d_PM_sea	EA	PA	EA	SM	SM	SM	SM	EA	SX	SX	SX	SX	SX	SM	SX	SX	EA	EA	SX	EA	EA	EA	EA	SX	SX	SX	SX	EA	SX	SX	SX
K_d_regoGL	EA	SO	EA	SX	SV	EA	SV	EA	SV	SV	SX	SV	SV	SV	SV	SV	EA	EA	SV	EA	EA	EA	SO	SO	SV	SO	SO	EA	SO	SM	SO
K_d_regoLow	EA	SO	EA	SX	SV	SM	SO	EA	SO	SO	SX	SV	SO	SO	SV	SO	EA	EA	SO	EA	EA	EA	SO	SO	SV	SO	SO	EA	SO	SO	SO
K_d_regoPeat	EA	SO	EA	SX	SV	SM	SV	EA	SO	SO	SX	SV	SV	SV	SO	SO	EA	EA	SO	SV	EA	EA	SO	SM	SV	SO	SO	EA	SO	SO	SO
K_d_regoPG	EA	SO	EA	SM	SO	SO	SV	EA	SO	SV	SX	SO	SV	SV	SV	SO	EA	EA	SO	EA	EA	EA	SO	SO	SO	SM	SO	EA	SO	SO	SO
K_d_regoUp_aqu	EA	SV	EA	SO	SX	SX	SX	EA	SO	SO	SX	SX	SO	SX	SX	SX	EA	EA	SX	EA	EA	EA	EA	SX	SX	SX	SV	EA	SO	SX	SX
K_d_regoUp_drain	EA	SO	EA	SX	SV	SM	SV	EA	SO	SO	SX	SO	SO	SV	SO	SO	EA	EA	SO	SV	EA	EA	SO	SO	SV	SO	SO	EA	SO	SO	SO
K_d_regoUp_garden	EA	SO	EA	SX	SV	SO	SV	EA	SO	SV	SX	SV	SV	SO	SV	SO	EA	EA	SM	SV	EA	EA	SO	SO	SV	SO	SO	EA	SO	SO	SO
K_d_regoUp_io	EA	SO	EA	SX	SV	SO	SV	EA	SO	SV	SX	SV	SV	SO	SV	SO	EA	EA	SM	SV	EA	EA	SO	SO	SV	SO	SO	EA	SO	SO	SO
K_d_regoUp_ter	EA	SV	EA	SX	SV	SV	SV	EA	SO	SO	SX	SV	SO	SV	SO	SO	EA	EA	SO	EA	EA	EA	SO	SO	SV	SO	SO	EA	SO	SO	SO
TC_meat	EA	EA	LX	LX	LX	LX	LX	EA	LX	LX	EA	EA	LX	LX	LX	EA	EA	EA	LX	EA	EA	LX	LX	EA	EA	EA	LX	EA	LX	LX	LX
TC_milk	EA	EA	LX	LX	LX	LX	EA	EA	LX	LX	EA	EA	LX	LX	LX	LX	EA	EA	LX	EA	LX	LX	LX	LX	EA	EA	LX	EA	EA	LX	LX

9.3 Comparisons with previous safety assessments

K_d and CR data have been utilised in several safety assessments conducted by SKB. This section serves as a comparison between parameter values used in the present SR-PSU assessment and the previous SR-Site and the SAR-08 and SAFE assessments. The SR-Site safety assessment dealt with long term safety of the deep repository for spent nuclear fuel, whereas SAR-08 and SAFE dealt with the long term safety of SKB's final repository for radioactive operational waste, SFR 1. SAR-08 is an updated version of SAFE.

In this comparison, data from Karlsson and Bergström (2002) are utilised for comparisons with the previous safety assessments for SFR-1, whereas data from Nordén et al. (2010) are used for comparisons with the SR-Site safety assessment.

9.3.1 Comparisons with data used in SR-Site safety assessment

In Table 9-15, the ratio between GMs utilised in SR-PSU and SR-site are compiled for comparable parameters. Since fewer parameters were used in SR-Site, some SR-Site parameters are compared to several SR-PSU parameters, according to the parameter columns in the table.

The differences between SR-PSU and SR-Site parameter values are generally small. The yellow colouring in the table represents deviations up to approximately two times in either direction (the figures in the table represent ratios between SR-PSU and SR-Site on 10-log scale, i.e. one represents a difference of order of magnitude with higher value for SR-PSU). Green colour represents comparisons where the SR-PSU parameter value is lower than the corresponding SR-site value, whereas red colour marks the opposite.

A few parameter alues show deviations between GMs of several orders of magnitude. The most pronounced differences are for Tc, where the SR-PSU value for K_d_regoLow is five orders of magnitude higher than the corresponding value used in SR-site (the difference is even larger for K_d_regoGL, though this is mainly due to the physical differences of soils, cf. Section 5.11). This deviation is mainly caused by the use of element analogues in order to reflect varying redox conditions in SR-PSU, and the use of literature data representing only oxic conditions in SR-Site. Accordingly, most deviations are caused by additional site data, often in combination with assumptions of element analogues that are thought to better represent the conditions at the site.

When GSDs are compared between SR-PSU and SR-site in Table 9-16, the 10-logarithm of the ratios are usually close to zero, indicating that the differences between the GSDs are usually less than a factor 2.

Table 9-15. The 10-logarithm of GM ratio between SR-PSU and SR-Site for corresponding parameters. The figures represent differences at the order of magnitudes, i.e. 0 represents no difference and 1 represents a 10-fold difference with higher values in SR-PSU than SR-site. The colour coding range from green (lowest ratio), to yellow (small difference), to red (large ratio). The logarithmic scale is mainly utilised to achieve a symmetric colour coding of the ratios.

SR-PSU	SR-Site	Ac	Ag	Am	Ca	Cd	Cl	Cm	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_lake_crust_NHB	cR_watToCray_lake	0.6	0.2	0.2	0.5	0.0	0.0	-0.4	0.1	0.3	0.0	0.1	0.2	0.0	0.1	0.5	1.6	0.1	0.0	-0.2	-0.2	-0.1	0.0	-0.1	-0.5	0.2	-0.5	-0.3	0.0	0.1
cR_lake_fish	cR_watToFish_lake	-2.0	-0.1	-2.6	0.1	0.1	-0.2	-2.4	-0.1	-2.5	-0.4	0.2	0.6	-0.4	-0.5	-2.1	-1.4	-0.1	-1.2	-0.8	2.8	-0.7	-0.6	-1.1	-2.2	0.0	-0.1	-0.1	-0.3	0.2
cR_lake_pp_macro	Lake_cR_pp_macro	0.0	0.4	-0.5	0.0	-0.4	-0.7	1.0	0.0	0.0	0.0	0.1	-0.1	-0.3	0.0	-0.7	2.3	-0.1	-0.6	-0.1	0.3	-0.2	0.0	-0.3	0.3	-0.2	-2.1	-0.3	-0.1	-0.4
cR_lake_pp_plank	Lake_cR_pp_macro	0.0	2.0	-0.5	0.0	-0.4	-0.7	1.0	0.0	0.0	0.0	0.1	-0.1	-0.3	0.0	-0.7	2.3	-0.1	-0.6	1.0	-0.8	-0.2	0.0	-0.3	0.3	-0.2	-2.2	-0.3	-0.1	-0.4
cR_Sea_fish	cR_watToFish_Sea	-1.2	-0.1	-1.1	-0.1	-0.1	-0.1	-1.6	0.0	-1.6	-1.1	0.3	0.0	-0.1	-0.1	0.4	-0.6	0.2	0.3	0.8	-0.5	-0.9	-0.1	-0.2	0.0	-0.4	-0.1	0.5	-0.1	0.4
cR_sea_pp_macro	Sea_cR_pp_macro	0.0	0.2	0.3	-0.1	1.0	0.1	-1.0	0.3	-0.2	0.0	0.1	0.2	0.4	0.2	1.3	2.2	0.8	0.1	-0.1	0.0	1.1	0.1	-0.7	0.1	0.3	0.1	0.7	-0.1	0.9
cR_sea_pp_plank	Sea_cR_pp_macro	0.0	1.5	0.3	-0.1	1.0	0.1	-1.0	0.3	-0.2	0.0	0.1	0.2	0.4	0.2	1.3	2.2	0.8	0.1	1.2	1.5	1.1	0.1	-0.7	0.1	0.3	-4.2	0.7	-0.1	0.9
cR_food_herbiv	cR_food_herbiv	0.5	-4.1	1.3	0.3	0.7	0.7	0.8	1.0	0.0	0.1	0.8	0.2	0.1	0.7	0.6	0.8	1.3	0.1	-2.5	-2.0	-0.7	-0.5	0.3	0.3	0.4	1.2	0.6	0.2	0.1
cR_agri_cereal	cR_soilToCereal	1.3	-1.3	2.0	0.0	-0.9	-1.0	2.0	-0.4	1.0	1.2	-1.0	-0.2	-0.2	-0.6	-0.1	-0.2	-0.6	-0.7	1.1	2.3	0.0	-2.4	1.2	-0.8	0.1	-1.7	0.2	-0.5	1.5
cR_agri_fodder	Ter_cR_pp	0.5	-1.4	0.0	-0.1	-0.1	0.9	0.2	0.2	0.2	0.4	-0.7	0.1	0.3	-0.1	-1.6	-0.3	0.2	-0.5	-1.6	0.0	-0.4	-2.3	0.1	0.4	-0.3	-3.4	-1.2	-0.2	1.7
cR_agri_tuber	cR_soilToTuber	-0.7	-2.6	0.1	0.1	-0.6	-0.3	0.1	0.1	0.2	0.0	-1.0	-0.3	0.1	-0.4	0.1	-0.8	0.1	-0.4	0.1	0.1	0.1	-2.3	0.4	-3.3	0.1	0.1	0.1	0.1	0.8
cR_Ter_mush	cR_soilToMush	0.5	0.8	0.0	-0.1	1.1	0.9	0.2	0.0	0.2	0.4	0.0	-0.3	0.3	0.0	-1.7	-0.3	0.1	-0.1	-1.6	0.3	-1.9	-2.3	0.1	-0.7	-0.1	-1.5	0.1	-0.1	1.7
cR_Ter_pp	Ter_cR_pp	0.5	-1.4	0.0	-0.1	-0.1	0.9	0.2	0.2	0.2	0.4	-0.7	0.1	0.3	-0.1	-1.6	-0.3	0.2	-0.5	-1.6	0.0	-0.4	-2.3	0.1	0.4	-0.3	-3.4	-1.2	-0.2	1.7
K_d_PM_lake	Lake_K_d_PM	1.0	-0.4	-0.1	0.2	0.5	1.4	1.3	0.0	0.1	-0.3	0.2	0.2	0.1	0.0	4.0	0.0	0.0	1.1	1.5	-1.5	0.2	0.1	-0.2	0.4	0.1	1.9	-0.2	0.1	0.2
K_d_PM_sea	Sea_K_d_PM	1.7	0.6	-0.6	0.0	0.4	-0.2	-0.6	0.2	0.1	0.5	0.2	1.1	0.3	0.0	2.7	-0.4	0.0	0.1	-2.8	-3.0	1.3	0.4	0.0	0.0	0.7	0.1	-0.1	0.0	0.1
K_d_regoGL	K_d_regoLow	2.0	0.4	1.6	1.4	1.9	1.1	1.1	1.0	0.9	1.2	1.5	0.2	1.9	1.7	3.7	1.9	1.4	2.1	2.8	2.1	0.6	1.6	1.3	1.7	0.3	6.0	0.5	-0.5	2.1
K_d_regoLow	K_d_regoLow	1.0	0.9	0.6	0.9	0.7	0.1	0.1	-0.5	-0.1	0.0	0.3	-0.9	1.2	0.4	3.1	0.9	0.3	0.8	1.8	1.2	-0.3	0.8	0.3	1.6	-0.5	4.8	-0.1	-1.8	0.9
K_d_regoPeat	Ter_K_d_regoUp	0.8	-1.4	0.6	0.8	0.6	0.4	0.0	-1.7	0.2	0.0	0.0	0.5	-0.5	-0.1	0.6	0.7	-0.5	1.4	0.4	1.1	-0.1	-0.1	0.0	0.1	0.5	2.9	-1.1	0.3	-0.3
K_d_regoPG	kD_regoLow	0.5	1.5	0.2	0.1	-0.4	1.3	-0.4	0.0	-0.5	-0.2	1.8	1.3	1.1	0.4	2.8	0.5	0.1	0.8	2.2	0.7	0.0	1.2	-0.1	2.0	-0.7	4.6	-0.4	0.6	0.7
K_d_regoUp_aqu	Ter_K_d_regoUp	1.5	0.0	1.4	0.4	1.5	-0.2	0.8	0.1	0.8	0.6	-0.4	-0.1	0.5	0.6	1.9	1.5	0.6	1.9	0.8	0.9	0.2	0.9	0.7	0.1	0.1	1.8	0.5	-0.1	1.2
K_d_regoUp_ter	Ter_K_d_regoUp	0.8	-0.7	0.7	0.7	0.5	0.3	0.1	-1.7	-0.3	-0.1	-0.5	0.6	-0.7	-0.2	1.2	0.8	-0.4	1.0	0.3	1.1	-0.1	0.3	0.0	-0.2	0.4	2.1	-1.2	0.2	-0.4
TC_meat	TC_meat	0.8	1.7	0.0	0.0	1.2	0.0	0.8	0.0	-1.7	-1.6	0.0	0.0	0.0	1.5	-0.9	1.1	0.0	2.2	-0.4	0.0	0.0	0.7	-1.6	-3.9	0.0	-1.9	0.0	0.0	0.0
TC_milk	TC_milk	-0.7	1.7	0.0	0.0	0.3	-0.5	-1.7	0.0	-1.7	-0.9	0.0	-0.3	0.0	0.0	-1.1	-1.4	0.0	0.0	0.0	0.0	0.0	0.0	-1.7	-2.4	0.0	-1.4	0.1	0.0	0.0

Table 9-16. The 10-logarithm GSD ratio between SR-PSU and SR-Site for corresponding parameters. The 0 represents no difference, whereas 1 represents a ratio between GSD of 10, with higher GSD for SR-PSU. The logarithmic scale is mainly utilised to achieve a symmetric colour coding of the ratios.

SR-PSU	SR-Site	Ac	Ag	Am	Ca	Cd	Cl	Cm	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_lake_crust_NHB	cR_watToCray_lake	0.2	-0.7	-0.1	-0.1	0.3	-0.1	0.7	0.0	-0.3	-0.1	0.2	0.1	0.3	0.3	0.7	0.2	0.0	0.2	0.6	0.5	0.3	0.6	-0.3	0.6	0.2	-0.3	0.0	0.1	0.1
cR_lake_fish	cR_watToFish_lake	0.1	-0.4	-0.4	0.1	-0.4	-0.1	-0.4	0.3	-0.2	0.2	0.0	0.1	-0.4	0.4	-0.2	0.0	0.0	0.2	0.3	0.1	-0.3	0.0	0.2	0.0	-0.2	-0.2	0.0	-0.1	-0.1
cR_lake_pp_macro	Lake_cR_pp_macro	0.3	0.8	-0.1	0.0	-0.2	0.0	0.4	-0.1	0.0	0.2	0.1	0.2	0.3	0.1	0.8	0.3	0.0	0.2	0.2	0.0	-0.1	0.4	0.0	0.2	0.0	0.2	0.1	0.2	0.1
cR_lake_pp_plank	Lake_cR_pp_macro	0.3	0.8	-0.1	0.3	0.0	0.0	0.4	0.1	0.1	0.2	0.3	0.3	0.3	0.4	0.8	0.3	0.1	0.4	0.2	-0.5	0.2	0.7	0.0	0.3	0.3	0.2	0.2	0.4	0.3
cR_sea_fish	cR_watToFish_Sea	0.4	0.0	0.3	0.3	-0.3	0.2	-0.1	0.2	0.2	0.2	0.2	0.2	0.4	-0.2	-0.1	0.2	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.3	0.2	0.0	0.0	0.4	-0.1
cR_sea_pp_macro	Sea_cR_pp_macro	0.4	0.1	0.4	0.0	0.0	0.2	0.5	0.0	-0.2	-0.2	0.2	0.1	0.2	0.2	0.6	0.4	0.3	0.1	0.2	-0.1	0.4	0.2	0.3	0.1	0.3	0.2	0.2	0.4	0.3
cR_sea_pp_plank	Sea_cR_pp_macro	0.4	0.1	0.4	0.2	0.2	0.4	0.5	0.1	-0.2	-0.2	0.4	0.3	0.2	0.4	0.6	0.4	0.3	0.3	0.2	-0.1	0.5	0.4	0.3	0.1	0.3	0.2	0.2	0.4	0.3
cR_food_herbiv	cR_food_herbiv	0.9	0.9	0.8	0.2	0.2	0.3	0.8	0.2	0.2	0.2	0.8	0.3	0.1	0.2	0.8	0.8	-0.1	0.8	0.9	0.7	0.8	0.5	-0.1	-0.2	0.2	0.3	0.5	0.3	0.0
cR_agri_cereal	cR_soilToCereal	0.3	0.0	-0.2	0.1	0.2	0.3	0.3	0.3	0.3	0.2	0.0	-0.6	0.5	0.1	0.1	0.3	-0.1	0.0	0.5	0.2	0.0	0.2	0.3	0.0	0.0	0.2	0.3	0.1	-0.6
cR_agri_fodder	Ter_cR_pp	0.1	0.0	0.1	0.1	-0.1	0.0	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.3	0.2	0.1	0.0	-0.1	0.3	-0.1	0.2	-0.1	0.3	0.1	0.2	0.1	0.1	0.0
cR_agri_tuber	cR_soilToTuber	-0.1	0.2	0.0	0.1	-0.5	0.0	0.0	0.1	0.1	0.1	-0.7	0.3	-0.3	0.3	0.2	0.1	0.0	0.3	0.0	0.0	0.0	0.5	0.1	0.5	0.1	0.0	0.0	0.0	-0.3
cR_ter_Mush	cR_soilToMush	0.2	0.0	0.2	0.0	0.0	0.3	0.5	-0.1	0.4	0.4	0.1	0.1	0.3	0.1	0.4	0.3	0.1	0.0	0.2	0.5	-0.2	0.5	0.2	0.3	0.0	0.4	0.1	0.0	0.3
cR_ter_pp	Ter_cR_pp	0.1	0.4	0.1	0.1	-0.1	0.0	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.3	0.2	0.1	0.0	0.2	0.3	-0.1	0.5	-0.1	0.3	0.1	0.4	0.1	0.1	0.0
K_d_PM_lake	Lake_K_d_PM	0.0	0.3	-0.3	0.0	-0.1	-0.8	-0.5	0.0	0.0	0.1	-0.1	-0.2	0.0	0.1	-0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.2	-0.1	0.2	0.0	-0.2	-0.2	-0.1	-0.2
K_d_PM_sea	Sea_K_d_PM	0.0	0.3	-0.3	0.1	-0.1	-0.7	-0.5	-0.2	0.1	-0.2	0.2	-0.2	-0.2	0.3	0.0	0.0	0.0	0.0	0.0	-0.7	1.2	-0.7	0.1	0.3	-0.8	-0.2	-0.2	0.0	-0.2
K_d_regoGL	K_d_regoLow	0.2	0.0	-0.3	0.3	-0.4	-0.2	-0.1	-0.1	0.0	-0.5	-0.2	0.1	-0.2	-0.1	-0.1	0.2	-0.3	0.2	-0.2	-0.1	-0.6	0.4	-0.6	0.2	0.0	-0.1	-0.7	0.4	0.3
K_d_regoLow	K_d_regoLow	0.2	0.0	-0.3	0.3	0.0	-0.2	-0.1	-0.1	-0.3	-0.5	-0.2	0.0	-0.2	-0.1	-0.1	0.2	-0.3	0.2	-0.1	-0.1	-0.6	0.1	-0.6	0.2	0.0	-0.1	-0.7	0.0	0.3
K_d_regoPeat	Ter_K_d_regoUp	0.0	-0.1	-0.2	-0.2	-0.4	0.0	-0.1	0.1	0.0	-0.2	-0.4	-0.5	-0.1	-0.2	0.4	0.0	-0.3	0.5	-0.2	-0.1	-0.6	0.2	-0.2	0.0	0.1	0.0	0.0	-0.1	-0.7
K_d_regoPG	K_d_regoLow	0.2	0.2	-0.3	0.3	-0.4	-0.2	-0.1	-0.1	-0.2	-0.5	-0.2	0.2	-0.2	-0.1	-0.1	0.2	-0.3	0.2	-0.2	-0.1	-0.6	0.2	-0.6	0.7	0.0	0.0	-0.7	0.0	0.4
K_d_regoUp_aqu	Ter_K_d_regoUp	0.0	-0.1	-0.2	-0.2	-0.7	0.0	-0.1	0.1	-0.3	-0.2	-0.4	-0.5	-0.1	-0.2	0.4	0.0	-0.3	0.2	-0.2	-0.1	-0.6	0.0	-0.2	-0.1	0.1	0.3	-0.1	-0.1	-0.6
K_d_regoUp_ter	Ter_K_d_regoUp	0.0	-0.1	-0.2	-0.2	-0.5	-0.1	-0.1	0.1	0.0	-0.2	-0.4	-0.5	-0.1	-0.2	0.4	0.0	-0.3	0.2	-0.2	-0.1	-0.6	0.2	-0.2	0.0	0.1	0.0	-0.1	-0.1	-0.7
TC_meat	TC_meat	0.3	0.5	-0.1	0.8	0.4	-0.1	0.3	0.3	0.3	0.3	0.3	0.3	-0.1	0.1	0.3	0.3	0.4	0.1	0.4	0.5	-0.1	0.3	0.3	0.3	0.2	0.3	0.2	0.7	-0.1
TC_milk	TC_milk	0.3	0.1	0.1	0.4	0.7	0.6	0.3	0.1	0.3	0.3	0.1	0.1	0.1	0.1	0.3	0.3	0.0	0.3	0.5	0.1	0.3	0.3	0.3	0.1	0.3	0.1	-0.1	0.6	0.3

There is a general pattern of lower GSDs (marked green in the table) among the K_d parameters with significantly lower GSD in SR-PSU compared to SR-Site. The main explanation for this pattern is that additional site data are utilised in SR-PSU, replacing the literature data with large variation utilised in SR-site. For cR_food_herbiv, the higher GSDs in SR-PSU are mainly explained by the use of site data in combination with analogue assumptions, compared to the use of a kinetic allometric model in SR-Site.

9.3.2 Comparisons with SAR-08 and SAFE safety assessments

When parameter values used in SR-PSU are compared to previous SFR safety assessments SAR-08 and SAFE, fewer comparisons are possible due to the lower number of parameters used in previous assessments. The SR-PSU parameters are compared to data from used in SAFE/SAR-08 in Table 9-18, according to the matching of the SR-PSU parameters to the corresponding data categories in Karlsson and Bergström (2002) in Table 9-17.

It can be concluded from these comparisons that deviations are up to four orders of magnitude in both directions, depending on parameter. For Cd, Mo, Pb and Tc, K_d parameter values are significantly higher in SR-PSU compared to SAR-08. For CR parameters, Ag, Se, Sn and Tc deviate in the opposite direction showing significantly lower values in SR-PSU compared to SAR-08. These large discrepancies mainly reflect the improvements in data over ten years time, where generic data used in the previous SFR-1 safety assessments have been replaced by site specific data.

Table 9-17. Matching of SR-PSU parameters to the corresponding data categories in Karlsson and Bergström (2002). The comparisons in Table 9-18 are based on these combinations.

Parameter in SR-PSU	Corresponding data categories in Karlsson and Bergström (2002)		
cR_agri_cereal	n	n	Cereals
cR_agri_fodder	n	n	Pasture
cR_agri_tuber	n	n	Root crops
cR_agri_veg	n	n	Vegetables
K_d_regoUp_ter	Peat	n	n
K_d_regoLow	Soil	n	n
K_d_PM_lake	Suspended matter	Freshwater	n
K_d_PM_sea	Suspended matter	Sea water	n

Table 9-18. The 10-logarithm of GM ratio between SR-PSU and SAR-08/SAFE/SR97 for corresponding parameters and data categories according to Table 9-17. The figures represent differences at the order of magnitudes, i.e. 0 represents no difference and 1 represents a 10-fold difference with higher values in SR-PSU than SAR-08. The colour coding range from green (lowest ratio), to yellow (small difference), to red (large ratio).

Parameter	Ac	Ag	Am	Cd	Cl	Cm	Co	Cs	Eu	Ho	I	Mo	Nb	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Se	Sm	Sn	Sr	Tc	Th	U	Zr
cR_agri_cereal	0.7	-1.4	2.0	-1.7	-1.0	2.0	-1.4	-0.3	1.1	1.2	-1.0	-0.1	0.0	-0.7	0.0	-0.1	-0.2	-0.7	0.4	2.4	1.2	-2.9	1.2	-1.4	-0.3	-1.4	-0.5	0.2	1.5
cR_agri_fodder	0.5	-1.4	0.2	-1.2	0.8	0.2	-0.6	-0.1	-0.5	0.5	-0.9	-0.8	-0.1	-0.4	-1.6	-0.3	1.2	-0.4	-1.2	0.2	-0.4	-2.9	-0.8	-0.2	-0.2	-2.4	-0.2	-1.5	1.1
cR_agri_tuber	0.0	-3.1	-0.2	-1.4	-0.6	-0.2	-0.2	-0.4	-0.1	-0.2	-1.0	-0.7	-0.3	-0.6	-0.4	-1.1	-1.3	-0.6	-1.1	-0.3	-0.4	-3.1	0.1	-3.4	-0.5	-0.2	0.4	-0.7	1.0
cR_agri_veg	-0.9	-3.8	-0.5	-0.4	-0.2	0.1	0.1	-0.6	-0.8	-0.8	-1.8	-0.3	0.4	-0.5	-0.3	0.2	0.8	-0.5	-0.2	-0.5	0.2	-3.0	-0.8	-2.7	-0.7	-3.9	-0.3	0.2	0.5
K_d_PM_lake	1.0	1.3	1.3	3.4	0.4	1.3	1.2	1.0	2.2	2.4	1.7	4.1	1.4	0.4	1.0	0.0	4.0	1.1	1.5	-1.1	0.1	0.3	1.3	0.2	0.1	0.6	0.3	-0.1	1.9
K_d_PM_sea	1.7	1.6	1.7	1.6	-0.2	-0.3	-0.2	0.3	1.4	3.2	1.2	3.4	1.6	0.1	1.7	0.7	3.7	0.1	-2.8	-1.9	0.9	0.2	0.7	0.0	0.0	0.1	0.9	-0.9	0.8
K_d_regoLow	1.0	1.1	0.7	1.0	-0.3	0.0	0.4	1.1	-1.3	0.8	-1.3	-0.7	1.8	0.2	2.4	0.0	2.2	0.6	1.5	0.3	0.4	1.1	1.0	2.0	1.0	2.9	0.4	-0.7	0.6
K_d_regoUp_ter	0.4	-0.2	-0.9	1.2	0.3	0.1	0.2	0.2	0.6	0.5	0.8	2.2	0.6	0.3	1.1	0.2	-0.1	0.4	0.2	0.7	0.0	-0.3	0.6	0.4	0.2	2.3	-1.5	1.4	-0.5

10 Conclusions

Values for approximately 2,000 element-specific K_d and CR parameters are presented in this report. This has been achieved by compiling an extensive data set, comprising of site-specific measurements and literature data, through a transparent and fully traceable parameterisation process that is described in this report.

The basis for this unique parameter data set are the extensive site-specific measurements available that to a high degree reflects site-specific conditions. This is an important improvement from the earlier safety assessments SAR-08/SAFE, where only literature data were used (see Section 9.3). Site-specific data are of particular importance for K_d and CR since these parameters are highly affected by the local biogeochemical environment. These parameters are correlated to some extent, and measurements in the same site enable such correlations to be captured. Reducing uncertainties in hese parameters by using site-specific data is particularly relevant, since the confidence in K_d and CR values directly affect the certitude in the resulting dose calculations (see e.g. Avila et al. 2010, Smith et al. 2010, Beresford et al. 2008b, c).

The manual evaluation performed for each element- and parameter-specific case ensures a concurrent parameter set with as few contradictions as possible. This labor-intensive part of the parameterisation is not limited to the prioritised elements, though includes element- and parameter analogues among site data as well as literature data. All of the approximately 2,000 specific cases have been handled similarly to ensure that all parameters attain a similar level of confidence.

Gap-filling methods have been applied, in case of missing or scarce data. The implementation of element analogues, for parameterisation and as supporting data, are more frequent in this work compared to previous safety assessments (e.g. Nordén et al. 2010). The use of analogues is, in many cases, a logical consequence due to prioritisation of site data.

When site data are limited, the natural variation might not be correctly represented. In such cases variation estimations based on groups of elements and parameters are adopted, which reduces the risk of underestimating the variation. These methods lead to increased confidence in the parameter estimates, especially where previous safety assessments have depended on literature data sources.

The compilation of site data and literature data, for a very large number of elements and from several sources, has made systematic comparisons and evaluations of data from different sources possible.

This has brought forth an increased understanding of the data quality and has revealed some uncertainties in the underlying data sources. The parameter values in this report should be regarded as the most probable values selected among the included data sources. The uncertainty discussion in chapter 9, however, indicates that the relative uncertainties might be substantial for some parameters, which is reflected by the broad parameter ranges.

Even if the available site data is extensive, still there are large data gaps and site data could be improved. Site data are absent for some parameters, e.g. CR for crops such as vegetables and tubers or lower organisms such as invertebrates, and additional site measurements could increase certitude of these parameters that currently are represented by parameter analogues. Some parameter estimations are based on a limited number of observations and additional site measurements could capture that the natural variation. The long time scale modelled in this safety assessments requires that data represent the changing chemical conditions of the ecosystems in a simulated future, stressing the importance of measuring K_d and CR in the whole range of possible chemical environments, in order to ensure that the temporal and spatial variations are captured.

Increasing the understanding of how processes and environmental factors, e.g. pH, redox and clay content, affect sorption and uptake, might improve the evaluation of the selected data. Furthermore, it would make it possible to assess changes in the parameter values over time and to assign alternative parameter sets that reflect different chemical environments.

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Values below reporting limits

Table A-1. Fraction of values below reporting limits in the denominator data (FROM) of K_d and CR ratios. It should be noted that this compilation show the fraction of values below reporting limits in selected site data before any manual element analogue selections have been made, i.e. all these combinations are not utilised in the final parameter selection.

FROM	Ag	Ba	Bi	Br	Ca	Cd	Cl	Co	Cr	Cs	Cu	Eu	Ho	I	La	Mn	Mo	Nb	Nd	Ni	Pb	Pd	Re	Se	Sm	Sn	Sr	Te	Th	U	Zn	Zr
cR_agri_cereal	16	0	22	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	32	6	3	0	0	0	22	0	0	0	0
cR_food_herbiv	59	0	0	0	0	9	0	3	12	3	0	67	48	26	0	0	0	9	0	3	12		10	80	18	56	0	67	68	9	0	15
cR_Lake_bivalve_NHB	67	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0		0	83	0	0	0	0
cR_Lake_Fish	67	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0		0	83	0	0	0	0
cR_Lake_Fish_NHB	67	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0		0	83	0	0	0	0
cR_lake_pp_macro	67	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0		0	83	0	0	0	0
cR_lake_pp_micro	67	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0		0	83	0	0	0	0
cR_Sea_bent_moll_NHB		0	0	0	0	0	0	22	0	33	0	44	33	0	0	0	0	0	0	0	0		0	22	33	50	0	0	33	0	0	33
cR_Sea_crust_NHB		0	0	0	0	0	0	22	0	33	0	44	33	0	0	0	0	0	0	0	0		0	22	33	50	0	0	33	0	0	33
cR_Sea_Fish		0	0	0	0	0	0	22	0	33	0	44	33	0	0	0	0	0	0	0	0		0	22	33	50	0	0	33	0	0	33
cR_Sea_Fish_NHB		0	0	0	0	0	0	22	0	33	0	44	33	0	0	0	0	0	0	0	0		0	22	33	50	0	0	33	0	0	33
cR_sea_pp_macro		0	0	0	0	0	0	22	0	33	0	44	33	0	0	0	0	0	0	0	0		0	22	33	50	0	0	33	0	0	33
cR_sea_pp_micro		0	0	0	0	0	0	22	0	33	0	44	33	0	0	0	0	0	0	0	0		0	22	33	50	0	0	33	0	0	33
cR_sea_pp_plank		0	0	0	0	0	0	22	0	33	0	44	33	0	0	0	0	0	0	0	0		0	22	33	50	0	0	33	0	0	33
cR_Sea_zoopl_NHB		0	0	0	0	0	0	22	0	33	0	44	33	0	0	0	0	0	0	0	0		0	22	33	50	0	0	33	0	0	33
cR_Ter_mammal_large_NHB	16	0	22	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	32	6	3	0	0	0	22	0	0	0	0
cR_Ter_mammal_NHB	16	0	22	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	32	6	3	0	0	0	22	0	0	0	0
cR_Ter_mammal_small_NHB	16	0	22	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	32	6	3	0	0	0	22	0	0	0	0
cR_Ter_Mush					0	0		0	0	0	0			0		0				0	0						0		0	0	0	
cR_Ter_pp	16	0	22	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	32	6	3	0	0	0	22	0	0	0	0
cR_Ter_pp_lich_NHB	16	0	22	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	32	6	3	0	0	0	22	0	0	0	0
K_d_PM_lake	67	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0		0	83	0	0	0	0
K_d_PM_sea		0	0	0	0	0	0	22	0	33	0	44	33	0	0	0	0	0	0	0	0		0	22	33	50	0	0	33	0	0	33
K_d_regoGL	0	0	0	0	0	48	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	92	0	0	0	0	0	0	0	0	0	0
K_d_regoLow	0	0	0	0	0	71	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0		0	0	0	0	0	29	0	0	0	0
K_d_regoPeat	11	0	11	0	4	43	0	0	0	4	0	36	4	7	0	0	0	11	0	4	0	89	7	0	0	11	0	11	0	0	0	0
K_d_regoPG	7	0	7	0	0	30	0	0	0	4	0	39	2	2	0	0	0	2	2	0	0	85	0	0	2	7	0	7	2	0	0	2
K_d_regoUp_aqu	22	0	0	0	0	8	0	0	0	0	0	17	25	0	0	0	0	0	0	0	0		0	0	0	0	0	22	25	0	0	17
K_d_regoUp_drain	0	0	0	0	0	16	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	88	0	0	0	0	0	0	0	0	0	0
K_d_regoUp_garden	14	0	14	0	0	14	0	0	0	3	0	38	0	3	0	0	0	3	0	0	0	79	0	0	0	14	0	14	0	0	0	0
K_d_regoUp_io	14	0	14	0	0	14	0	0	0	3	0	38	0	3	0	0	0	3	0	0	0	79	0	0	0	14	0	14	0	0	0	0
K_d_regoUp_ter	0	0	0	0	0	16	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	88	0	0	0	0	0	0	0	0	0	0

Table A-2. Fraction of values below reporting limits in the numerator data (TO) of K_d and CR ratios. It should be noted that this compilation show the fraction of values below reporting limits in selected site data before any manual element analogue selections have been made, i.e. all these combinations are not utilised in the final parameter selection.

TO	Ag	Ba	Bi	Br	Ca	Cd	Cl	Co	Cr	Cs	Cu	Eu	Ho	I	La	Mn	Mo	Nb	Nd	Ni	Pb	Pd	Re	Se	Sm	Sn	Sr	Te	Th	U	Zn	Zr
cR_agri_cereal	0	0	0	0	0	20	0	0	0	0	0	78	0	0	0	0	0	0	0	0	0		10	0	0	0	0	67	0	0	0	0
cR_food_herbiv		0		0	0	27	0	12	70	0	0	97	97	97	9	0	0	15	24	61	85			0	76	61	0		85	36	0	24
cR_Lake_bivalve_NHB	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0	0	0	0		0	0	0	0
cR_Lake_Fish		0		0	0		0	18	95	0	0		95	68	59	0	5	32	73	95				0	95		0			18	0	82
cR_Lake_Fish_NHB		0		0	0		0	18	95	0	0		95	68	59	0	5	32	73	95				0	95		0			18	0	82
cR_lake_pp_macro	75	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			25	0	0	0		0	0	0	0
cR_lake_pp_micro	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0	0	0		0	0	0	0
cR_Sea_bent_moll_NHB	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0	0	0	0		0	0	0	0
cR_Sea_crust_NHB		0			0	0		0	0	0	0	0	0			0	0		0	0	0			0	0				0		0	0
cR_Sea_Fish		0		0	0	43	0	0	96	0	0			65	36	0	0	50	74	52	57			0	96	36	0		83	21	0	39
cR_Sea_Fish_NHB		0		0	0	43	0	0	96	0	0			65	36	0	0	50	74	52	57			0	96	36	0		83	21	0	39
cR_sea_pp_macro	83	0		0	0	0	0	0	0	0	0	12	12	0	0	0	0	0	0	0	0			8	0	8	0		4	0	0	0
cR_sea_pp_micro		0		0	0	0	0	0	0	0	0	0	0	0		0	0		0	0	0			0	0				0		0	0
cR_sea_pp_plank		0		0	0	0	0	0	0	0	0			0		0	0		0	0	0			0	0				0		0	0
cR_Sea_zoopl_NHB		0		0	0	0		0	0	0	0	0	0	0		0	0		0	0	0			0	0				0		0	0
cR_Ter_mammal_large_NHB		0		0	0	7	0	0	80	0	0				7	0	0	0	33	80	80			0	73	27	0			53	0	33
cR_Ter_mammal_NHB		0		0	0	27	0	11	68	0	0	97	97	97	8	0	0	14	22	62	81			0	70	54	0		86	32	0	22
cR_Ter_mammal_small_NHB		0		0	0	41	0	18	59	0	0	95	95	95	9	0	0	23	14	50	82			0	68	73	0		77	18	0	14
cR_Ter_Mush					0	0		0	0	0	0			0		0				0	0						0		0	0	0	
cR_Ter_pp		0		0	0	0	0	0	0	0	0	50	67	17	0	0	0	6	0	0	17				17	78	0		94	0	0	11
cR_Ter_pp_lich_NHB	43	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			71	0	14	0		0	0	0	0
K_d_PM_lake	0	0	0	0	0	14		0	14	0	0	0	0	14	0	0	0	0	0	0	0		14	0	0	14	0	0	0	0	0	0
K_d_PM_sea	0	0	0	38	0	0	50	0	0	0	0	38	0	38	0	0	0	0	0	0	0		0	38	0	0	0	0	0	0	0	0
K_d_regoGL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0
K_d_regoLow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0
K_d_regoPeat	17	0	17	0	0	0	0	0	0	0	0	17	17	0	0	0	0	0	0	0	0	40	0	17	0	0	0	17	0	0	0	0
K_d_regoPG	33	0	33	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	17	11	8	0	0	0	33	0	0	0	0
K_d_regoUp_aqu	10	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	80	8	0	0	0	0	0	0	0	0
K_d_regoUp_drain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0
K_d_regoUp_garden	15	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	8	0	0	0	0	23	0	0	0	0
K_d_regoUp_io	15	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	8	0	0	0	0	23	0	0	0	0
K_d_regoUp_ter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	0	0	0	0	0	0	0	0	0	0

Sample number of literature sources

Table B-1. Compilation of the sample number of literature sources coupled to each parameter and element combination. The colour coding range from yellow (one source) to red (four sources) representing the number of sources.

Parameter	Ac	Ag	Am	Ba	Bi	Br	Ca	Cd	Cl	Cm	Co	Cr	Cs	Cu	Eu	Ho	I	La	Mn	Mo	Nb	Nd	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Re	Se	Sm	Sn	Sr	Tc	Te	Th	U	Zn	Zr
cR_Lake_amph_NHB		1	1				1	1	1	1	1	1	1		1		1		1		1		1	1		2		1	1	1		1			1	1	1	1	1	1	1
cR_Lake_bent_fish_NHB																																									
cR_Lake_bird_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Lake_bivalve_NHB		2	2	1		1	1	2	2	2	2	1	2	1	2		2	1	2	1	1		1	2		2		1	2	2		2	1		2	2	1	2	2	1	1
cR_Lake_Cray		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Lake_crust_NHB		2	2	1		1	1	2	2	2	2	1	2	1	2		2	1	2	1	1		1	2		2		1	2	2		2	1		2	2	1	2	2	1	1
cR_Lake_Fish		3	2	2		2	2	1	3	1	3	2	3	2	3		3	2	3	2	1		3	1		3		2	2	3		3			3	1	3	3	3	2	3
cR_Lake_Fish_NHB		3	2	2		1	2	2	3	2	4	2	4	2	4		4	2	4	2	2		4	2		4		3	3	4		4			4	2	3	3	4	2	4
cR_Lake_gastr_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Lake_ins_larvae_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Lake_mammal_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Lake_pel_fish_NHB																																									
cR_lake_pp_macro		1	2					2	1	2	2		2	1	1		2		2		1		2	2		2		1	2	2		2			2	2	1	1	2	1	1
cR_lake_pp_micro																																									
cR_Lake_pp_plank		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Lake_pp_plank_NHB		2	3					3	2	3	3		3	1	2		3		3		2		3	3		3		2	3	3		3			3	3	2	2	3	1	2
cR_Lake_pp_vasc_NHB		2	3					3	2	3	3		3	1	2		3		3		2		3	3		3		2	3	3		3			3	3	2	2	3	1	2
cR_Lake_zoopl_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Sea_bent_fish_NHB																																									
cR_Sea_bent_moll_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Sea_bird_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		2		2	1	1		1			1	1	1	1	1		1
cR_Sea_crust_NHB		1	1					2	1	1	1		2		1		1		1		1		1	1		1		1	2	1		1			2	2	1	1	1		1
cR_Sea_Fish		1	2				1	1	1	1	2		2	1	1		1		2		1		2	1		2		1	2	1		1			2	1	1	1	1	1	2
cR_Sea_Fish_NHB		2	3				1	2	2	2	4		4	1	2		2		3		2		3	2		3		2	3	3		2			3	2	2	2	2	1	3
cR_Sea_mammal_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Sea_pel_fish_NHB																																									
cR_Sea_polych_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_sea_pp_macro		2	2					2	1	2	2		2		1		1		2		2		2	2		2		1	2	1		1			2	2	1	1	2		2
cR_Sea_pp_macro_NHB		4	4					4	3	4	4		4		3		3		4		4		4	4		4		3	4	3		3			4	4	3	3	4		4
cR_sea_pp_micro																																									
cR_sea_pp_plank		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Sea_pp_plank_NHB		4	4					4	3	4	4		4		3		3		4		4		4	4		4		3	4	3		3			4	4	3	3	4		4
cR_Sea_pp_vasc_NHB		4	4					4	3	4	4		4		3		3		4		4		4	4		4		3	4	3		3			4	4	3	3	4		4
cR_Sea_zoopl_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_agri_cereal			2	1			1	2	2	1	2	1	2				2	1	2	1	1		1	1		2		1	2	2					2	1	1	2	2	2	1
cR_agri_fodder			3	2						1	3	1	3				1	2	2	1	1		2	2		3		2	3	3					3	1	1	3	3	1	1
cR_agri_tuber		1	2	2				1	1	2	2	2	2				2	2	2	1	2			2		2		2	2	2					2	2	2	2	2	1	2
cR_agri_veg		2	2	2					1	2	2	2	2				1	2	2	1	2			2		3		2	2	3					2	1	2	3	3	2	2
cR_food_herbiv																																									
cR_Ter_amph_NHB		1	2					2	1	1	1		2		1		1		1		1		1	1		2		1	1	1		1			2	1	1	1	1		1
cR_Ter_bird_egg_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Ter_bird_NHB		1	2					1	1	1	1		2		1		1		1		1		1	1		1		1	2	2		1			2	2	1	1	1		1
cR_Ter_detr_inv_NHB		1	2					2	2	1	1		2	1	2		2		2		2		2	1		2		2	1	1		2			2	1	1	1	2	1	1
cR_Ter_fl_ins_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Ter_gastr_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Ter_mammal_large_NHB		1	2					1	1	1	1		2		1		1		1		1		1	1		1		1	2	1		1			2	1	1	1	1		1
cR_Ter_mammal_NHB		2	4					2	2	2	3		4		2		2		2		2		2	2		3		3	4	3		2			4	2	2	3	3		2
cR_Ter_mammal_small_NHB		1	2					1	1	1	2		2		1		1		1		1		1	1		2		2	2	2		1			2	1	1	2	2		1
cR_Ter_Mush		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Ter_pp		1	3	1				2	2	1	2		3		1		1	1	1		1		3	1		3		2	3	3		2			3	2	1	3	3	1	1
cR_Ter_pp_grass_NHB		1	3	1				2	2	1	2		3		1		1	1	1		1		3	2		3		2	3	3		2			3	2	1	3	3	1	1
cR_Ter_pp_lich_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Ter_pp_NHB		2	3	1		1		3	4	2	3	1	4		3		2	1	2		2		3	2		4		4	3	4		3	1		4	3	2	4	4	2	2
cR_Ter_pp_shrub_NHB		2	3	1		1		3	4	2	3	1	4		3		2	1	2		2		3	2		4		4	3	4		3	1		4	3	2	4	4	2	2
cR_Ter_pp_tree_NHB		2	3	1		1		3	4	2	3	1	4		3		2	1	2		2		3	2		4		4	3	4		3	1		4	3	2	4	4	2	2
cR_Ter_rept_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
cR_Ter_soil_inv_NHB		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
K_d_PM_lake		1	2	1				1	1	1	2		2		1		2		2		1		1	1		1		1	2	2		1			2	1	1	2	1		1
K_d_PM_sea		1	1					1	1	1	1		1		1		1		1		1		1	1		1		1	1	1		1			1	1	1	1	1		1
K_d_regoGL	2	2	2	1	2	2	2	2	1	1	1	2	2	1		2	2	1	2	1	2		1	2	2	2	2	2	2	1		2	2	2	2	2	1	2	2	2	2
K_d_regoLow	2	2	2	1	2	2	2	2	1	1	1	2	2	1		2	2	1	2	1	2		1	2	2	2	2	2	2	1		2	2	2	2	2	1	2	2	2	2
K_d_regoPeat	2	2	2	1	2	2	2	2	1	1	2	2	2	2		2	2	1	2	1	2		1	2	2	2	2	2	2	2		2	2	2	1	2	1	2	2	2	2
K_d_regoPG	1	1	2	1	1	1	1	1	1	1	2	1	2	2		1	1	1	1	1	2		2	1	1	2	1	1	2	2		2	1	1	1	1	1	1	1	2	2
K_d_regoUp_aqu		2	3	1				2	2	2	3		3		2		3		3		2		2	2		2		2	3	3		2			3	2	2	3	2		2
K_d_regoUp_drain	2	2	2	1	2	2	2	2	1	1	2	2	2	2		2	2	1	2	1	2		1	2	2	2	2	2	2	2		2	2	2	1	2	1	2	2	2	2
K_d_regoUp_garden	2	2	2	1	2	2	2	2	1	1	1	2	2	1		2	2	1	2	1	2		1	2	2	2	2	2	2	1		2	2	2	2	2	1	2	2	2	2
K_d_regoUp_io	2	2	2	1	2	2	2	2	1	1	1	2	2	1		2	2	1	2	1	2		1	2	2	2	2	2	2	1		2	2	2	2	2	1	2	2	2	2
K_d_regoUp_ter	2	2	2	1	2	2	2	2	1	1	2	2	2	2		2	2	1	2	1	2		1	2	2	2	2	2	2	2		2	2	2	1	2	1	2	2	2	2

Table B-2. Agreement among literature data sources associated to each parameter. A value of 1.0 represents overlap among all possible combinations of the literature sources, whereas lower numbers represent the fraction ov overlapping combination compared to the total number of possible combinations.

Parameter	Ac	Ag	Am	Ba	Bi	Br	Ca	Cd	Cl	Cm	Co	Cr	Cs	Cu	Eu	Ho	I	La	Mn	Mo	Nb	Nd	Ni	Np	Pa	Pb	Pd	Po	Pu	Ra	Re	Se	Sm	Sn	Sr	Tc	Te	Th	U	Zn	Zr
cR_Lake_amph_NHB																																									
cR_Lake_bent_fish_NHB																																									
cR_Lake_bird_NHB																																									
cR_Lake_bivalve_NHB			1.0								1.0		1.0				1.0		1.0											1.0					1.0						
cR_Lake_Cray																																									
cR_Lake_crust_NHB			1.0								1.0		1.0				1.0												1.0	1.0					1.0						
cR_Lake_Fish		1.0		0.0		1.0	0.0		1.0		1.0	1.0	1.0	1.0	1.0		0.7	1.0	1.0	0.0			1.0			1.0			0.0	1.0		1.0			0.7		1.0		1.0	1.0	1.0
cR_Lake_Fish_NHB		1.0		1.0			1.0		1.0		1.0	1.0	1.0	1.0	1.0		0.8	1.0	1.0	1.0	1.0		1.0			1.0		1.0	1.0	1.0		1.0			1.0	1.0	1.0	1.0	1.0	1.0	0.0
cR_Lake_gastr_NHB																																									
cR_Lake_ins_larvae_NHB																																									
cR_Lake_mammal_NHB																																									
cR_Lake_pel_fish_NHB																																									
cR_lake_pp_macro			1.0								1.0		1.0				1.0		1.0										1.0	1.0					1.0				1.0		
cR_lake_pp_micro																																									
cR_Lake_pp_plank_NHB			1.0							0.0	1.0		1.0				1.0		1.0									0.0	1.0	1.0					0.7				0.7		
cR_Lake_pp_vasc_NHB			1.0							0.0	1.0		1.0				1.0		1.0									0.0	1.0	1.0					0.7				0.7		
cR_Sea_bent_fish_NHB																																									
cR_Sea_bent_moll_NHB																																									
cR_Sea_bird_NHB																																									
cR_Sea_crust_NHB								1.0					1.0																						1.0	0.0					
cR_Sea_Fish			1.0								1.0		1.0						1.0				1.0						1.0						1.0						
cR_Sea_Fish_NHB		1.0	1.0					1.0			0.8		1.0		1.0				1.0				1.0					1.0	1.0	1.0		1.0			1.0	1.0			1.0		1.0
cR_Sea_mammal_NHB																																									
cR_Sea_pel_fish_NHB																																									
cR_Sea_polych_NHB																																									
cR_sea_pp_macro		1.0	1.0					1.0		1.0	1.0		1.0						1.0		1.0			1.0		1.0			1.0						1.0	1.0			1.0		1.0
cR_Sea_pp_macro_NHB		0.7	0.3					1.0		0.3	1.0		1.0						1.0		1.0			1.0		0.3		0.0	0.3	0.0		1.0			1.0	0.3		0.0	0.7		0.3
cR_sea_pp_micro																																									
cR_sea_pp_plank																																									
cR_Sea_pp_plank_NHB		0.7	0.3					1.0		0.3	1.0		1.0						1.0		1.0			1.0		0.3		0.0	0.3	0.0		1.0			1.0	0.3		0.0	0.7		0.3
cR_Sea_pp_vasc_NHB		0.7	0.3					1.0		0.3	1.0		1.0						1.0		1.0			1.0		0.3		0.0	0.3	0.0		1.0			1.0	0.3		0.0	0.7		0.3
cR_Sea_zoopl_NHB																																									
cR_agri_cereal			1.0					1.0	0.0		1.0		1.0				0.0		1.0							1.0			1.0	1.0					1.0			1.0	1.0	1.0	
cR_agri_fodder			1.0	0.0							1.0		1.0						1.0				1.0	1.0		1.0			1.0	1.0					1.0			0.7	1.0		
cR_agri_tuber			1.0							1.0	1.0		1.0					1.0	1.0					1.0		1.0		1.0	1.0	1.0					1.0			1.0	1.0		
cR_agri_veg		1.0	1.0							1.0	1.0		1.0						1.0					1.0		1.0			1.0	1.0					1.0			1.0	1.0	1.0	
cR_food_herbiv																																									
cR_Ter_amph_NHB								1.0					1.0													1.0									1.0						
cR_Ter_bird_egg_NHB																																									
cR_Ter_bird_NHB													1.0																						1.0						
cR_Ter_detr_inv_NHB								1.0	1.0				1.0				1.0									1.0															
cR_Ter_fl_ins_NHB																																									
cR_Ter_gastr_NHB																																									
cR_Ter_mammal_large_NHB			1.0										1.0																1.0						1.0						
cR_Ter_mammal_NHB			0.7					1.0			1.0		1.0						1.0				1.0			1.0		1.0	1.0	1.0		1.0			1.0			1.0	1.0		
cR_Ter_mammal_small_NHB			0.0								1.0		1.0													1.0			1.0	1.0					1.0						
cR_Ter_Mush																																									
cR_Ter_pp			0.7					1.0	1.0				1.0										1.0			1.0		1.0	1.0	1.0		1.0			1.0	1.0		0.7	1.0		
cR_Ter_pp_grass_NHB			0.7					1.0	1.0				1.0										1.0			1.0		1.0	1.0	1.0		1.0			1.0	1.0		0.7	1.0		
cR_Ter_pp_lich_NHB																																									
cR_Ter_pp_NHB			0.0					0.7	0.7		1.0		0.8										1.0			1.0		1.0	1.0	0.5		1.0			0.8	1.0		0.3	1.0	0.0	
cR_Ter_pp_shrub_NHB			0.0					0.7	0.7		1.0		0.8										1.0			1.0		1.0	1.0	0.5		1.0			0.8	1.0		0.3	1.0	0.0	
cR_Ter_pp_tree_NHB								0.7	0.5		0.7		0.8						1.0				0.7			1.0		1.0		0.3		1.0			0.7			0.3	1.0	0.0	
cR_Ter_rept_NHB																																									
cR_Ter_soil_inv_NHB																																									
K_d_PM_lake			1.0								1.0		1.0				1.0		1.0										1.0	1.0					1.0			1.0			
K_d_PM_sea																																									
K_d_regoGL	1.0	1.0	1.0		1.0	1.0	1.0	1.0				1.0	1.0			1.0	1.0		1.0					1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
K_d_regoLow	1.0	1.0	1.0		1.0	1.0	1.0	1.0				1.0	1.0			1.0	1.0		1.0					1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
K_d_regoPeat			1.0					1.0			1.0	1.0	1.0	1.0			1.0		1.0					1.0		1.0			1.0							1.0		1.0	1.0	1.0	
K_d_regoPG			1.0								1.0		1.0	1.0							1.0		1.0			1.0			1.0	1.0		1.0								1.0	1.0
K_d_regoUp_aqu			1.0								1.0		1.0				1.0		1.0										1.0	1.0					1.0			1.0			
K_d_regoUp_drain			1.0					1.0			1.0	1.0	1.0	1.0			1.0		1.0					1.0		1.0			1.0							1.0		1.0	1.0	1.0	
K_d_regoUp_garden	1.0	1.0	1.0		1.0	1.0	1.0	1.0				1.0	1.0			1.0	1.0		1.0					1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
K_d_regoUp_io	1.0	1.0	1.0		1.0	1.0	1.0	1.0				1.0	1.0			1.0	1.0		1.0					1.0	1.0	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0
K_d_regoUp_ter			1.0					1.0			1.0	1.0	1.0	1.0			1.0		1.0					1.0		1.0			1.0							1.0		1.0	1.0	1.0	

Appendix C

Conversion factors

Table C-1. Conversion factors muscle tissue to whole body CR values.

Element	cR_Lake_Fish_NHB	cR_Sea_bent_moll_NHB	cR_Sea_crust_NHB	cR_Sea_Fish_NHB	cR_Ter_mammal_large_NHB	cR_Ter_mammal_NHB	cR_Ter_mammal_small_NHB
Ag	1	1	1	1	120	120	120
Al	2	1	1	1	1	1	1
Am	1	1	1	1	13	13	13
As	1	1	1	1	1	1	1
B	1	1	1	1	1	1	1
Ba	5.6	1	1	1	1	1	1
Be	1	1	1	1	1	1	1
Ca	42	3.9	10	1	1	1	1
Cd	1	14	15	3	1	1	1
Ce	2	2.7	13	1	34	34	34
Co	1	3.5	8	1.8	1	1	1
Cr	2.3	1	1	1	1	1	1
Cs	1	1	1	1	1	1	1
Cu	1.8	1	3.5	1	1	1	1
Dy	1	2.7	15	1	1	1	1
Er	1	2.7	9.7	1	1	1	1
Eu	2.3	2.8	12	1	1	1	1
Fe	2.7	5.9	26	1	1	1	1
Gd	1	2.5	10	1	1	1	1
Hg	1	1	1	0.63	1	1	1
Ho	1	2.2	29	1	1	1	1
I	1	1	1	1	1	1	1
K	1	1	1	1	1	1	1
La	1.9	2.1	19	1	1	1	1
Lu	1	2.3	1	1	1	1	1
Mg	1.6	1	1	1	1	1	1
Mn	10	2.7	14	1	1	1	1
Mo	1	5	5.3	1	1	1	1
Na	1.6	1.7	1	1	1	1	1
Nb	1	1	1	1	1	1	1
Nd	1	2.7	24	1	1	1	1
Ni	1.3	2.3	12	1	1	1	1
P	3.1	1	1	1	1	1	1
Pb	1	3.3	6	2.4	1	1	1
Po	1	2.9	1	7	2	2	2
Pr	1	2.5	23	1	1	1	1
Pu	1	1.8	1	36	5.3	5.3	5.3
Ra	2.4	1	1	1.7	38	38	38
Rb	1	1	1	1	1	1	1
Ru	1	1	1	1.8	1.1	1.1	1.1
Sb	1.6	1	1	1	1	1	1
Sc	3.8	1	1	1	1	1	1
Se	1	1	1	1	1	1	1
Sm	1	2.8	11	1	1	1	1
Sr	38	3.6	9.3	3.1	1	1	1
Tb	1	2.3	15	1	1	1	1
Te	1	1	1	1	1	1	1
Th	2.2	1	1	1	1	1	1
Ti	1	1	1	1	1	1	1
Tl	2.4	1	1	1	1	1	1
Tm	1	2.2	24	1	1	1	1
U	2.5	4.2	17	1	4.7	4.7	4.7
V	1	11	21	8.3	1	1	1
Y	1.8	5.2	10	1	1	1	1
Yb	1	3.2	58	1	1	1	1
Zn	2.1	1	1	1	1.8	1.8	1.8
Zr	1	1	1	2.4	1	1	1

Appendix D

Quality assurance of selected data

In this section the result of the QA checks are presented. This QA process aims at identifying mistakes in the data selection process by examining the ratio between parameters where the selected data are identical. Since many of the parameters used in the radionuclide model are similar (and in some cases identical) PA are used in many cases, this data selection step is done manually be doing an override with selected PA, this step adds an additional risk of mistakes. In order to eliminate these mistakes this quality assurance process has been conducted. This process is done for every update of data as a part of the iterative parameterisation work flow. First the parameters which are parameterised with the same data are identified, these are then selected and a ratio between the GM of the parameters is calculated. The ratio is aimed to identify cases where data that should be identical are not.

In the tables that follows the result from the calculated ratios are presented for the limnic, marine and terrestrial ecosystem as well as for the K_d parameters. Each of these tables is followed with a table where the results are evaluated. In these tables the expected results are listed and if unexpected differences are identified a note of this is done and measures to examine the cause of the unexpected pattern are taken. At the end of the parameterisation process no unexpected differences should be found.

D1 Limnic CR

For the limnic primary producers there are five parameters, cR_lake_pp_macro, cR_lake_pp_micro, cR_lake_pp_plank, cR_lake_pp_plank_NHB and cR_lake_pp_vasc_NHB. All of these are parameterised with the same data except a few cases for the parameters cR_lake_pp_plank and cR_lake_pp_plank_NHB where data selections differ. These parameters are therefore part of the QA process to examine that the data selected are identical for these parameters (see Table D-1).

There are 13 parameters representing limnic consumers in this study. For many of them PAs are used due to lack of data. Data for fishes are used for cR_lake_fish, cR_lake_fish_NHB, cR_lake_bent_fish_NHB, cR_lake_pel_fish_NHB, cR_lake_bird_NHB, cR_lake_amph_NHB, and cR_lake_mammal_NHB. Data for limnic filter feeders are used for cR_lake_bivalve, cR_lake_bivalve_NHB, cR_lake_cray, cR_lake_crust_NHB, cR_lake_gastr_NHB and cR_lake_ins_larvae_NHB. The ratios between the parameters are constructed in order to examine if the expected data selection is implemented in a correct way.

In Table D-1 the parameters used as PAs are marked.

Table D-1. List of used PAs for the limnic parameters.

	cR_lake_bivalve_NHB (m^3/kg_{dw})	cR_lake_fish (m^3/kg_{dw})	cR_lake_fish_NHB (m^3/kg_{dw})	cR_lake_pp_macro (m^3/kg_{dw})
cR_lake_amph_NHB (m^3/kg_{dw})			X	
cR_lake_bent_fish_NHB (m^3/kg_{dw})			X	
cR_lake_bird_NHB (m^3/kg_{dw})		X		
cR_lake_bivalve (m^3/kg_{dw})	X			
cR_lake_bivalve_NHB (m^3/kg_{dw})	X			
cR_lake_cray (m^3/kg_{dw})	X			
cR_lake_crust_NHB (m^3/kg_{dw})	X			
cR_lake_fish (m^3/kg_{dw})		X		
cR_lake_fish_NHB (m^3/kg_{dw})			X	
cR_lake_gastr_NHB (m^3/kg_{dw})	X			
cR_lake_ins_larvae_NHB (m^3/kg_{dw})	X			
cR_lake_mammal_NHB (m^3/kg_{dw})			X	
cR_lake_pel_fish_NHB (m^3/kg_{dw})			X	
cR_lake_pp_macro (m^3/kg_{dw})				X
cR_lake_pp_micro (m^3/kg_{dw})				X
cR_lake_pp_plank (m^3/kg_{dw})				X
cR_lake_pp_plank_NHB (m^3/kg_{dw})				X
cR_lake_pp_vasc_NHB (m^3/kg_{dw})				X
cR_lake_zoopl_NHB (m^3/kg_{dw})		X		X

Table D-2. Results of the QA ratios for the limnic parameters.

Element	cR_lake_pp_macro /cR_lake_pp_micro	cR_lake_pp_macro/cR_lake_pp_plank	cR_lake_pp_macro/cR_lake_pp_vasc_NHB	cR_lake pp_plank/cR_lake_pp_plank_NHB	cR_lake_fish/cR_lake_fish_NHB	cR_lake_bent_fish_NHB/cR_lake_pel_fish_NHB	cR_lake_fish_NHB/cR_lake_pel_fish_NHB	cR_lake_cray/cR_lake_crust_NHB	cR_lake_gastr_NHB/cR_lake_bivalve_NHB	cR_lake_cray/cR_lake_bivalve_NHB	cR_lake_amph_NHB/cR_lake_fish_NHB	cR_lake_bird_NHB /cR_lake_fish_NHB	cR_lake_ins_larv_NHB/cR_lake_crust_NHB	cR_lake_mammal/cR_lake_fish_NHB	cR_lake_zoopl_NHB/cR_sea_zoopl_NHB	cR_lake_zoopl_NHB/cR_lake_fish_NHB
Ac	1.00	1.00	1.00	1.00	0.53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	34561.82
Ag	1.00	0.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	157.70
Am	1.00	1.00	1.00	1.00	0.53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	34561.82
Ba	1.00	1.00	1.00	1.00	0.18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	29.42
Ca	1.00	1.00	1.00	1.00	0.02	1.00	1.00	1.00	1.00	1.00	2.01	1.00	1.00	1.00	1.00	0.40
Cd	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.04	1.00	342.73
Cl	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	23.17	1.00
Cm	1.00	1.00	1.00	1.00	0.53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	34561.82
Co	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.24	26.75
Cs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	18.67	0.47
Eu	1.00	1.00	1.00	1.00	0.53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6710.62
Ho	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	432.14
I	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.72	18.47
Mo	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	40.87
Nb	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Ni	1.00	1.00	1.00	1.00	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	342.64
Np	1.00	9.61	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	310.49
Pa	1.00	1.00	1.00	1.00	0.53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	34561.82
Pb	1.00	1.00	1.00	1.00	0.07	1.00	1.00	1.00	1.00	1.00	0.02	1.00	1.00	1.00	1.48	71.70
Pd	1.00	1.00	1.00	1.00	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	342.64
Po	1.00	0.06	1.00	1.00	0.23	1.00	1.00	1.00	0.60	0.31	1.00	1.00	1.00	1.00	0.80	265.10
Pu	1.00	6.99	1.00	1.00	1069.56	1.00	1.00	1.00	1.00	0.92	1.00	0.08	1.00	9.15	0.09	21.01
Ra	1.00	1.00	1.00	1.00	0.18	1.00	1.00	1.00	0.15	0.18	1.35	1.35	1.00	1.00	0.46	1.35
Se	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	28.36
Sm	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	7208.65
Sn	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Sr	1.00	1.00	1.00	1.00	0.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.91
Tc	1.00	0.85	1.00	1.00	1.00	1.00	1.00	2.00	1.26	1.00	1.00	1.00	1.00	1.00	0.20	0.68
Th	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	10.32	662.88
U	1.00	1.00	1.00	1.00	0.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.41	142.82
Zr	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	858.54

Table D-3. Comments on the ratios and results of the QA procedure.

	Comment	To do
cR_lake_pp_macro/cR_lake_pp_micro	These parameters have identical GM	ok
cR_lake_pp_macro/cR_lake_pp_plank	These parameters have identical GM, except for Ag, Tc, Po, Pu and Np which differs in data selection.	ok
cR_lake_pp_macro/cR_lake_pp_vasc_NHB	These parameters have identical GM	ok
cR_lake pp_plank/cR_lake_pp_plank_NHB	These parameters have identical GM	ok
cR_lake_fish/cR_lake_fish_NHB	For Pb, Po and Pu different data are selected, site data are used for Ac, Am, Ba, Ca, Cl, Cm, Co, Cs, Eu, Ho, I, Mo, Nb, Ni, Pa, Pd, Se, Sm, Sr, U and Zr. Out of these the data differs for Ac, Am, Ba, Ca, Cm, Ni, Pa, Pd, Sr and U.	ok
cR_lake_bent_fish_NHB/cR_lake_pel_fish_NHB	These parameters have identical GM	ok
cR_lake_fish_NHB/cR_lake_pel_fish_NHB	These parameters have identical GM	ok
cR_lake_cray/cR_lake_crust_NHB	These parameters have identical GM	ok
cR_lake_gastr_NHB/cR_lake_bivalve_NHB	These parameters have identical GM, except for Tc, Po and Ra which differs in data selection.	ok
cR_lake_cray/cR_lake_bivalve_NHB	These parameters have identical GM, except for Tc, Po, Pu and, Ra which differs in data selection.	ok
cR_lake_amph_NHB/cR_lake_fish_NHB	These parameters have identical GM, except for Ca and Pb which differs in data selection.	ok
cR_lake_bird_NHB /cR_lake_fish_NHB	These parameters have identical GM, except for Pu which differs in data selection.	ok
cR_lake_ins_larv_NHB/cR_lake_crust_NHB	These parameters have identical GM except for Pu and Np. Needs to be checked!!	ok
cR_lake_mammal/cR_lake_fish_NHB	These parameters have identical GM except for Cd and Po.	ok
cR_lake_zoopl_NHB/cR_sea_zoopl_NHB	GM for Ac, Am. Ba, Ca, Cd, Cm, Co, Eu, Ho, Mo, Ni, Np, Pa, Pd, Se, Sm, Sr, Th and Zr are identical to GM for cR_sea_ zoooplank_NHB.	ok
cR_lake_zoopl_NHB/cR_lake_fish_NHB	GM for Cl, Ra, Nb and Sn are identical to GM for cR_sea_ zoooplank_NHB.	ok

D2 Marine CR

There are five parameters for marine primary producers and nine parameters for marine consumes used within this study. For several of these no data are available and therefore PAs are used. Site data are available for marine fish, primary producers, mussels and crayfish. These data are used as PA in many cases as listed in Table D-4. The ratios between parameters in Table D-5 are constructed in order to examine if the expected data selection is implemented in a correct way.

Table D-4. List of the PAs used for the marine parameters.

	cR_sea_bent_moll_NHB (m^3/kg_{dw})	cR_sea_crust_NHB (m^3/kg_{dw})	cR_sea_fish (m^3/kg_{dw})	cR_sea_fish_NHB (m^3/kg_{dw})	cR_sea_pp_macro (m^3/kg_{dw})
cR_sea_bent_fish_NHB (m^3/kg_{dw})				X	
cR_sea_bent_moll_NHB (m^3/kg_{dw})	X				
cR_sea_bird_NHB (m^3/kg_{dw})				X	
cR_sea_crust_NHB (m^3/kg_{dw})		X			
cR_sea_fish (m^3/kg_{dw})			X		
cR_sea_fish_NHB (m^3/kg_{dw})				X	
cR_sea_mammal_NHB (m^3/kg_{dw})				X	
cR_sea_pel_fish_NHB (m^3/kg_{dw})				X	
cR_sea_polych_NHB (m^3/kg_{dw})	X	X			
cR_sea_pp_macro (m^3/kg_{dw})					X
cR_sea_pp_micro (m^3/kg_{dw})					X
cR_sea_pp_plank (m^3/kg_{dw})					X
cR_sea_pp_plank_NHB (m^3/kg_{dw})					X
cR_sea_pp_vasc_NHB (m^3/kg_{dw})					X
cR_sea_zoopl_NHB (m^3/kg_{dw})					

Table D-5. Results of the QA ratios for the marine parameters.

Element	cR_sea_pp_pp /cR_sea_vasc_NHB	cR_sea_pp_macro/cR_sea_pp_macro_NHB	cR_sea_pp_macro/cR_sea_pp_micro	cR_sea_pp_plank/cR_sea_pp_plank_NHB	cR_sea_pp_macro/cR_sea_pp_plank	cR_sea_fish/cR_sea_fish_NHB	cR_sea_pel_fish_NHB/cR_sea_fish_NHB	cR_sea_bent_fish_NHB/cR_sea_fish_NHB	cR_sea_bird_NHB/cR_sea_fish_NHB	cR_sea_mammal_NHB/cR_sea_fish_NHB	cR_sea_polych_NHB/cR_sea_bent_moll_NHB	cR_sea_polych_NHB/cR_sea_crust_NHB
Ac	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.56
Ag	1.00	1.00	1.00	1.00	0.05	1.00	1.00	1.00	10.26	7.59	1.05	1.69
Am	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.56
Ba	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.22
Ca	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.65
Cd	1.00	1.00	1.00	1.00	1.00	0.33	1.00	1.00	1.00	1.00	0.03	0.00
Cl	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	7.07
Cm	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.56
Co	1.00	1.00	1.00	1.00	1.00	0.56	1.00	1.00	1.00	1.00	0.81	0.09
Cs	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.80	0.23
Eu	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.52
Ho	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.39
I	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	25.72
Mo	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.58
Nb	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.62
Ni	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6.37	0.74
Np	1.00	1.00	1.00	1.00	0.42	1.00	1.00	1.00	3.13	0.31	1.00	4.24
Pa	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.56
Pb	1.00	1.00	1.00	1.00	1.00	0.42	1.00	1.00	1.00	1.00	1.00	0.39
Pd	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6.37	0.74
Po	1.00	1.00	1.00	1.00	0.05	1.00	1.00	1.00	0.00	0.34	0.59	0.44
Pu	1.00	1.00	1.00	1.00	0.03	1.00	1.00	1.00	5.28	8.98	0.91	7.02
Ra	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	4.83	1.90	1.00
Se	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.07	2.95
Sm	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.32
Sn	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.40
Sr	1.00	1.00	1.00	1.00	1.00	0.32	1.00	1.00	1.00	1.00	1.00	0.65
Tc	1.00	1.00	1.00	1.00	######	1.00	1.00	1.00	1.00	1.25	1.85	1.00
Th	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.35
U	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	17.79	1.78	1.00	36.54
Zr	1.00	1.00	1.00	1.00	1.00	0.42	1.00	1.00	1.00	1.00	1.00	0.38

Table D-6. Comments and results of the QA procedure.

	Comment	To do
cR_sea_pp_pp /cR_sea_vasc_NHB	These parameters have identical GM.	ok
cR_sea_pp_macro/cR_sea_pp_macro_NHB	These parameters have identical GM.	ok
cR_sea_pp_macro/cR_sea_pp_micro	These parameters have identical GM.	ok
cR_sea_pp_plank/cR_sea_pp_plank_NHB	These parameters have identical GM.	ok
cR_sea_pp_macro/cR_sea_pp_plank	These parameters have identical GM, except for Ag, Po, Pu, Np and Tc which differs in data selection.	ok
cR_sea_fish/cR_sea_fish_NHB	These parameters have identical GM. Data for Cd, Co, Pb Sr and Zr differs due to correction to whole body concentrations.	ok
cR_sea_pel_fish_NHB/cR_sea_fish_NHB	These parameters have identical GM.	ok
cR_sea_bent_fish_NHB/cR_sea_fish_NHB	These parameters have identical GM.	ok
cR_sea_bird_NHB/cR_sea_fish_NHB	These parameters have identical GM for all except Ag, Np, Po, Pu and U where literature data have been used.	ok
cR_sea_mammal_NHB/cR_sea_fish_NHB	These parameters have identical GM for all except Ag, Np, Po, Pu, Ra, Tc and U where literature data have been used.	ok
cR_sea_polych_NHB/cR_sea_bent_moll_NHB	These parameters have identical GM for Ac, Am, Ba, Ca, Cl, Cm, Eu, Ho, I, Mo, Nb, Np, Pa, Pb, Ra, Sm, Sn, Sr, Th, U, Zr. Differences should be found for Ag, Cd, Co, Cs, Ni, Pd, Po, Pu, Ra, Se, Tc.	ok
cR_sea_polych_NHB/cR_sea_crust_NHB	These parametrs are identical only for Ra and Tc.	ok

D3 Terrestrial CR

There are eleven parameters for the terrestrial primary producers and thirteen for terrestrial consumers. In addition to this there are two parameters representing domestic animals (cows) uptake in milk and meat. Iin order to examine if the expected data selection is implemented in a correct way the PAs used for the terrestrial parameters are identified. The ratios between parameters are presented in Table D-8 in order to examine if the expected data selection is implemented in a correct way.

Table D-7. List of the PAs used for the terrestrial parameters.

	cR_Ter_bird_NHB (kg$_{dw}$/kg$_{dw}$)	cR_agri_cereal (kg$_{dw}$/kg$_{dw}$)	cR_Ter_detr_inv_NHB (kg$_{dw}$/kg$_{dw}$)	cR_Ter_gastr_NHB (kg$_{dw}$/kg$_{dw}$)	cR_Ter_mammal_large_NHB (kg$_{dw}$/kg$_{dw}$)	cR_Ter_mammal_NHB (kg$_{dw}$/kg$_{dw}$)	cR_Ter_pp (kg$_{dw}$/kg$_{dw}$)	cR_Ter_pp_NHB (kg$_{dw}$/kg$_{dw}$)	cR_Ter_soil_inv_NHB (kg$_{dw}$/kg$_{dw}$)
cR_agri_veg (kg$_{dw}$/kg$_{dw}$)		X					X		
cR_food_herbiv (kg$_{dw}$/kg$_{dw}$)									
cR_food_herbiv_NHB (kg$_{dw}$/kg$_{dw}$)									
cR_Ter_amph_NHB (kg$_{dw}$/kg$_{dw}$)						X			
cR_Ter_bird_egg_NHB (kg$_{dw}$/kg$_{dw}$)	X					X			
cR_Ter_bird_NHB (kkg$_{dw}$/kg$_{dw}$)						X			
cR_agri_cereal (kg$_{dw}$/kg$_{dw}$)									
cR_Ter_detr_inv_NHB (kg$_{dw}$/kg$_{dw}$)				X					
cR_Ter_fl_ins_NHB (kkg$_{dw}$/kg$_{dw}$)			X						
cR_Ter_gastr_NHB (kg$_{dw}$/kg$_{dw}$)			X						X
cR_Ter_mammal_large_NHB (kkg$_{dw}$/kg$_{dw}$)						X			
cR_Ter_mammal_small_NHB (kg$_{dw}$/kg$_{dw}$)						X			
cR_Ter_Mush (kg$_{dw}$/kg$_{dw}$)		X					X		
cR_agri_fodder (kg$_{dw}$/kg$_{dw}$)		X					X		
cR_Ter_pp (kg$_{dw}$/kg$_{dw}$)		X							
cR_Ter_pp_grass_NHB (kg$_{dw}$/kg$_{dw}$)		X					X		
cR_Ter_pp_lich_NHB (kkg$_{dw}$/kg$_{dw}$)									
cR_Ter_pp_NHB (kg$_{dw}$/kg$_{dw}$)		X							
cR_Ter_pp_shrub_NHB (kg$_{dw}$/kg$_{dw}$)		X						X	
cR_Ter_pp_tree_NHB (kg$_{dw}$/kg$_{dw}$)		X					X	X	
cR_Ter_rept_NHB (kg$_{dw}$/kg$_{dw}$)						X			
cR_Ter_soil_inv_NHB (kg$_{dw}$/kg$_{dw}$)			X						
cR_agri_tuber (kg$_{dw}$/kg$_{dw}$)		X					X		

Table D-8. Results of the QA ratios for the terrestrial parameters.

Kolumn1	cR_Ter_pp/cR_Ter_Mush	cR_agri_cereal/cR_Ter_Mush	cR_Ter_pp/cR_agri_cereal	cR_agri_veg/cR_Ter_pp	cR_Ter_pp/cR_Ter_pp_grass_NHB	cR_Ter_pp/cR_Ter_pp_shrub_NHB	cR_Ter_pp/cR_Ter_pp_tree_NHB	cR_Ter_pp/cR_Ter_pp_Past	cR_Ter_pp/cR_agri_tuber	cR_Ter_bird_NHB/cR_Ter_mammal_NHB	cR_Ter_bird_egg_NHB/cR_Ter_mammal_NHB	cR_Ter_fl_ins_NHB/cR_Ter_detr_inv_NHB	cR_Ter_soil_inv_NHB/cR_Ter_detr_inv_NHB	cR_Ter_gastr_NHB/cR_Ter_detr_inv_NHB	cR_Ter_amph_NHB/cR_Ter_mammal_NHB	cR_Ter_rept_NHB/cR_Ter_mammal_NHB	cR_Ter_mammal_NHB/cR_Ter_mammal_large_NHB	cR_Ter_mammal_small_NHB/cR_Ter_mammal_large_NHB
Ac	1.00	1.63	0.61	3.47	1.00	1.00	1.00	1.00	4.21	1.00	1.00	0.05	13.02	0.26	1.00	1.00	1.00	1.00
Ag	0.01	0.01	1.00	0.01	1.00	1.00	1.00	1.00	14.46	1.00	1.00	1.00	1.00	1.36	2.13	2.13	1.00	1.00
Am	1.00	1.63	0.61	0.16	1.00	1.00	1.00	1.00	7.82	1.00	1.00	0.90	0.65	5.21	1.00	1.00	1.00	1.00
Ba	15.43	4.22	3.66	0.19	1.00	1.00	1.00	1.00	2.99	2.21	2.21	0.75	9.35	1.42	1456.63	1.00	1.00	1.00
Ca	33.62	5.08	6.61	0.98	1.00	1.00	1.00	1.00	4.83	0.18	0.18	0.75	9.35	1.42	118.45	1.00	1.00	1.00
Cd	0.06	0.02	2.94	7.68	1.00	1.00	1.00	1.00	1.04	1.00	1.00	7.00	1.45	0.26	0.82	1.00	1.00	1.00
Cl	1.00	0.02	61.07	0.13	1.00	1.00	1.00	1.00	16.99	1.00	1.00	1.00	0.77	1.48	1.00	1.00	1.00	1.00
Cm	1.00	1.63	0.61	0.85	1.00	1.00	1.00	1.00	10.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Co	0.48	0.11	4.41	7.30	1.00	1.00	1.00	1.00	0.43	1.00	1.00	1.32	0.58	2.35	1.00	1.00	1.00	1.00
Cs	0.01	0.00	12.50	0.38	1.00	1.00	1.00	1.00	2.79	1.66	0.09	0.36	0.86	1.30	4.45	1.00	1.00	1.00
Eu	1.00	0.88	1.14	1.81	1.00	1.00	1.00	1.00	8.07	1.00	1.00	1.31	0.77	1.78	1.00	1.00	1.00	1.00
Ho	1.00	0.62	1.60	1.78	1.00	1.00	1.00	1.00	8.23	1.00	1.00	0.90	0.65	5.21	1.00	1.00	1.00	1.00
I	2.72	0.43	6.38	0.08	1.00	1.00	1.00	1.00	10.32	1.00	4804.09	2.74	0.76	2.13	1.00	1.00	1.00	1.00
Mo	2.95	11.68	0.25	3.72	1.00	1.00	1.00	1.00	0.43	1.00	1.00	1.00	1.00	1.36	1.00	1.00	1.00	1.00
Nb	1.00	1.05	0.95	4.12	1.00	1.00	1.00	1.00	1.03	426.87	1280.60	1.31	0.77	1.78	1.00	1.00	1.00	1.00
Ni	0.49	0.05	9.30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.49	0.39	1.21	1.00	1.00	1.00	1.00
Np	1.00	1.63	0.61	16.43	1.00	1.00	1.00	1.00	0.29	1.00	1.00	0.17	3.40	0.29	1.00	1.00	1.00	1.00
Pa	1.00	1.63	0.61	3.47	1.00	1.00	1.00	1.00	4.21	1.00	1.00	0.05	13.02	0.26	1.00	1.00	1.00	1.00
Pb	1.18	0.20	5.83	4.68	1.00	1.00	1.00	1.00	11.40	3.65	3.65	0.14	28.04	0.01	0.98	1.00	1.00	1.00
Pd	0.49	0.05	9.30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.49	0.39	1.21	1.00	1.00	1.00	1.00
Po	1.00	1.00	1.00	2.46	1.00	1.00	1.00	1.00	1.11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Pu	0.15	0.41	0.36	0.14	1.00	1.00	1.00	1.00	5.45	0.54	0.54	0.58	1.02	6.04	1.00	1.00	21.49	21.49
Ra	0.92	0.55	1.69	3.17	1.00	1.00	1.00	1.00	2.61	0.93	0.93	1.00	1.00	0.51	1.00	1.00	1.00	1.00
Se	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.31	0.77	0.03	1.00	1.00	1.00	1.00
Sm	1.00	1.18	0.85	3.33	1.00	1.00	1.00	1.00	4.39	1.00	1.00	0.90	0.65	5.21	1.00	1.00	1.00	1.00
Sn	12.81	3.83	3.35	0.02	1.00	1.00	1.00	1.00	296.34	1.00	1.00	1.00	1.00	1.36	1.00	1.00	1.00	1.00
Sr	18.84	4.31	4.37	1.30	1.00	1.00	1.00	1.00	3.65	30.67	193.44	0.75	9.35	1.42	657.69	1.00	1.00	1.00
Tc	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.14	0.45	72.97	1.00	1.00	1.36	2.43	2.13	1.00	1.00
Th	1.23	0.92	1.33	0.21	1.00	1.00	1.00	1.00	28.44	0.15	0.15	1.00	1.00	1.36	1.00	1.00	1.00	1.00
U	0.15	0.41	0.36	33.34	1.00	1.00	1.00	1.00	0.12	1.82	1.82	1.00	1.00	1.36	1.00	1.00	1.00	1.00
Zr	1.00	2.61	0.38	0.28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.36	1.00	1.00	1.00	1.00

Table D-9. Comments and results of the QA for the terrestrial parameters.

	Comment	To do
cR_Ter_pp/cR_Ter_Mush	Gm should be identical for Ac, Am, Cl, Cm, Eu, Ho, Nb, Np, Pa, Sm, Zr. And also for Po Se and Tc were cereal data are used.	ok
cR_agri_cereal/cR_Ter_Mush	Data should be identical for Po, Se and Tc.	ok
cR_Ter_pp/cR_agri_cereal	Data for Ag, Tc, Se and Po should be identical.	ok
cR_agri_veg/cR_Ter_pp	GM should be the same for Ni, Pd. And also for Se and Tc since Cereal data ae used for both Ter_pp and Ter_cereal.	ok
cR_Ter_pp/cR_Ter_pp_grass_NHB	These parameters have identical GM.	ok
cR_Ter_pp/cR_Ter_pp_shrub_NHB	These parameters have identical GM.	ok
cR_Ter_pp/cR_Ter_pp_tree_NHB	These parameters have identical GM.	ok
cR_Ter_pp/cR_Ter_agri_fodder	These parameters have identical GM.	ok
cR_Ter_pp/cR_agri_tuber	These parameters have identical GM for Ni, Se, Pd and Zr.	ok
cR_Ter_bird_NHB/cR_Ter_mammal_NHB	Thses parameters have identical GM for all ecxept Ba, Ca, Cs, Nb, Ra, Pu, Pb, Sr, Tc, Th and U.	ok
cR_Ter_bird_egg_NHB/cR_Ter_mammal_NHB	Data should differ for Cs, I, Nb, Pb, Pu, Ra, Sr, Tc, Th and U.	ok
cR_Ter_fl_ins_NHB/cR_Ter_detr_inv_NHB	Should be identical for Cl, Cm Po. Ag, Mo, Ra, Sn, Tc, Th, U and Zr are identical since ERICA uses the same data for these two organisms.	ok
cR_Ter_soil_inv_NHB/cR_Ter_detr_inv_NHB	GM should be identical for Cm and Po. ERICA uses the same data for the other element were the data are identical.	ok
cR_Ter_gastr_NHB/cR_Ter_detr_inv_NHB	GM identical for Cm and Po.	ok
cR_Ter_amph_NHB/cR_Ter_mammal_NHB	GM should be identical for all except Ag, Ba, Ca, Cd, Cs, Pb, Sr and Tc.	ok
cR_Ter_rept_NHB/cR_Ter_mammal_NHB	GM should be identical for all except Ag and Tc.	ok
cR_Ter_mammal_NHB/cR_Ter_mammal_large_NHB	These parameters have identical GM, except for Pu were data selection differs.	ok
cR_Ter_mammal_small_NHB/cR_Ter_mammal_large_NHB	These parameters have identical GM, except for Pu.	ok

D4 K_d

For the K_d parameters relevant data are available in most cases and PAs are used in only three element cases, therefore this QA process is not relevant to perform for the K_d parameters.

Appendix E

Excluded samples

Table E-1. Compilation of excluded samples from the original database, and comments. SKB_SAMPLE_NR refer to the unique ID in the SKB database Sicada.

SKB_SAMPLE_NO	Comment
23022	Dubbelprov, struket
23024	Spikade prover?
23107	Koncentrationerna avviker, dessa prover är kopplade till suspended matter samples.
23109	Koncentrationerna avviker, dessa prover är kopplade till suspended matter samples.
23111	Koncentrationerna avviker, dessa prover är kopplade till suspended matter samples.
23126	Spikade prover?
23128	Spikade prover?
23129	Spikade prover?
23130	Dubbelprov, struket
23131	Dubbelprov, struket
23132	Spikade prover?
23133	Spikade prover?
23134	Spikade prover?
23135	Dubbelprov, lägre prec?
23138	Spikade prover?
23139	Spikade prover?
23140	Dubbelprov, struken
23142	Dubbelprov, struken
23143	Spikade prover?
23337	Spikade prover?
23338	Spikade prover?
23340	Spikade prover?
23341	Spikade prover?
23343	Dubbelprov, struket
23344	Spikade prover?
23347	Spikade prover?
23348	Dubbelprov, struken
23349	Dubbelprov, struket
23350	Dubbelprov, struken
23351	Dubblett, identisk, struken
23352	Spikade prover?
23353	Spikade prover?
23356	Trippelprov, strukna
23358	Dubbelprov, struken
23359	Spikade prover?
23360	Trippelprov, strukna
23361	Spikade prover?
23362	Spikade prover?
23363	Spikade prover?
23364	Dubbelprov, lägre nogr?
23365	Spikade prover?
23366	Spikade prover?
23367	Spikade prover?
23368	Dubblett, struken
23370	Spikade prover?
23440	Dubbelprov, struket
23456	Dubbelprov, struket
23467	Dubbelprov, struket
23476	Dubbelprov, struket
23482	Dubbelprov, struket
23484	Dubbelprov, struket
23544	Dubbelprov, struken
23660	This sample hade significantly higher conc for Ag, Cl, Cs and, assumingly due to contamination or measurments error. This sample is excluded for all element.
23926	Sannolikt mineralkontaminerat prov!

Appendix F

Generic dry weight and carbon content data

Table F-1. Generic dry weight and carbon content data utilised in this report.

Biota Type	Biota Type Detail	Original Biota Type DMC	Original Reference DMC	DMC	Original Biota Type CC	Original Reference CC	CC
Benthic fish	n	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Bentic plankton	n	Algae	IAEA 2010	0.16	Algae, whole	IAEA 2010	0.48
Berries	n	Fruit	IAEA 2010	0.15	Fruit	IAEA 2010	0.41
Berries and fruits	n	Fruit	IAEA 2010	0.15	Fruit	IAEA 2010	0.41
Cereals	Grain	Cereals (including rice)	IAEA 2010	0.88	Cereals (including rice)	IAEA 2010	0.44
Cereals	n	Cereals (including rice)	IAEA 2010	0.88	Cereals (including rice)	IAEA 2010	0.44
Cereals	Roots	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Cereals	stem	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Cereals	Stems and shoots	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Cow	Meat	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Generic	Meat	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Pork	Meat	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Sheep	Meat	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Cow	Milk						
Goat	Milk						
Horse	Milk						
Sheep	Milk						
All species	Milk						
Crayfish	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Crustacean	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Edible primary producers	n	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38
Field vegetables (generic: leafy and nonleafy vegetables and root crops)	n	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38

Biota Type	Biota Type Detail	Original Biota Type DMC	Original Reference DMC	DMC	Original Biota Type CC	Original Reference CC	CC
Filter Feeders	n	Bivalves (without shell)	IAEA 2010	0.18	Molluscs, soft tissue	IAEA 2010	0.40
Fish	Fish Muscle tissue	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Fish	Fish Whole body	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Fish	Marine Fish	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Fish	n	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Fish muscle	n	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Freshwater invertebrates	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Freshwater plant	n	Aquatic macrophytes	IAEA 2010	0.13	Aquatic macrophytes	IAEA 2010	0.31
Grasses	Stems and leaves	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Grasses	Stems and shoots	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Grasses & Herbs	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Herbivore	n	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Herbs	Herbs	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Herbs	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Herbs	Stems and leaves	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Herbs	Stems and shoots	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Invertebrate	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Leafy vegetables	Leaves	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38
Leguminous fodder	Stems and leaves	Leguminous vegetables Vegetative mass	IAEA 2010	0.19	Leguminous vegetables Vegetative mass	IAEA 2010	0.31
Leguminous fodder	Stems and shoots	Leguminous vegetables Vegetative mass	IAEA 2010	0.19	Leguminous vegetables Vegetative mass	IAEA 2010	0.31
Leguminous vegetables	Seeds and pods	Leguminous vegetables Seed	IAEA 2010	0.88	Leguminous vegetables Seed	IAEA 2010	0.47
Leguminous vegetables	Stems and shoots	Leguminous vegetables Vegetative mass	IAEA 2010	0.19	Leguminous vegetables Vegetative mass	IAEA 2010	0.31
Lichen & bryophytes	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Macroalgae	n	Algae	IAEA 2010	0.16	Algae, whole	IAEA 2010	0.48
Maize	Grain	Maize Feed corn	IAEA 2010	0.84	Maize Feed corn	IAEA 2010	0.45
Maize	Stems and shoots	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Mammal	n	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Mammal (Deer)	n	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47

Biota Type	Biota Type Detail	Original Biota Type DMC	Original Reference DMC	DMC	Original Biota Type CC	Original Reference CC	CC
Mammal (Rat)	n	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Microphytobentos	n	Algae	IAEA 2010	0.16	Algae, whole	IAEA 2010	0.48
Mushrooms	n					Nordén et al. 2010	0.46
Mussles	n	Bivalves (without shell)	IAEA 2010	0.18	Molluscs, soft tissue	IAEA 2010	0.40
n	n						
Natural vegetation	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Nonleafy vegetables	Fruits, heads, berries, buds	Fruit	IAEA 2010	0.15	Fruit	IAEA 2010	0.41
Nonleafy vegetables	Stems and shoots	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38
Other	Sunflower	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Other	Tea leaves	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38
Other crops	Stems and leaves	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38
Other crops	Stems and shoots	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38
Other crops	Sunflower (grain)	Cereals (including rice)	IAEA 2010	0.88	Cereals (including rice)	IAEA 2010	0.44
Other crops	Sunflower (leaves)	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38
Other crops	Tea leaves	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38
Pasture	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Pasture	Stems and shoots	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Peas (generic: legumes)	n	Leguminous vegetables Seed	IAEA 2010	0.88	Leguminous vegetables Seed	IAEA 2010	0.47
Pelagic fish	n	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Phytoplankton	n	Algae	IAEA 2010	0.16	Algae, whole	IAEA 2010	0.48
Plant	Marine plant	Aquatic macrophytes	IAEA 2010	0.13	Aquatic macrophytes	IAEA 2010	0.31
potato (generic: tubers)	n	Tubers	IAEA 2010	0.25	Tubers	IAEA 2010	0.41
Root crops	Leaves	Root crops	IAEA 2010	0.13	Root crops	IAEA 2010	0.35
Root crops	n	Root crops	IAEA 2010	0.13	Root crops	IAEA 2010	0.35
Root crops	Roots	Root crops	IAEA 2010	0.13	Root crops	IAEA 2010	0.35
Root crops	Stems and shoots	Root crops	IAEA 2010	0.13	Root crops	IAEA 2010	0.35
Shrub	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42

Biota Type	Biota Type Detail	Original Biota Type DMC	Original Reference DMC	DMC	Original Biota Type CC	Original Reference CC	CC
Sugar beet (generic: root crops)	n	Root crops	IAEA 2010	0.13	Root crops	IAEA 2010	0.35
Terrestrial primary producers	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Tree	Foliage	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Tree	Wood	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Tubers	n	Tubers	IAEA 2010	0.25	Tubers	IAEA 2010	0.41
Tubers	Shoots	Tubers	IAEA 2010	0.25	Tubers	IAEA 2010	0.41
Tubers	Stems and shoots	Tubers	IAEA 2010	0.25	Tubers	IAEA 2010	0.41
Tubers	Tubers	Tubers	IAEA 2010	0.25	Tubers	IAEA 2010	0.41
Understory plants	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Unspecified	Stems and leaves	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Unspecified	Unspecified	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Vascular plant	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Water plant	n	Aquatic macrophytes	IAEA 2010	0.13	Aquatic macrophytes	IAEA 2010	0.31
Vegetables	n	Leafy and non-leafy vegetables	IAEA 2010	0.08	Leafy and non-leafy vegetables	IAEA 2010	0.38
Brown seaweed	n	Algae	IAEA 2010	0.16	Algae, whole	IAEA 2010	0.48
Crab	Adult crab	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Deer	Adult deer	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Duck	Adult duck	Mallard duck (flesh only)	IAEA 2010	0.32	Hen	IAEA 2010	0.75
Earthworm	Adult earthworm	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Flatfish	Adult	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Flatfish	Adult flatfish	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Frog	Adult frog	Frogs/toads	IAEA 2010	0.15	Animals	IAEA 2010	0.47
Pine tree	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Rat	Adult rat	Mice/voles/rabbits	IAEA 2010	0.32	Animals	IAEA 2010	0.47
Salmonid	Adult salmonid	Bony fishes	IAEA 2010	0.25	Animals	IAEA 2010	0.47
Wild grass	Grass spike	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Wild Grass	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
(Wading) bird	n	Mallard duck (flesh only)	IAEA 2010	0.32	Hen	IAEA 2010	0.75

Biota Type	Biota Type Detail	Original Biota Type DMC	Original Reference DMC	DMC	Original Biota Type CC	Original Reference CC	CC
Amphibian	n	Frogs/toads	IAEA 2010	0.15	Animals	IAEA 2010	0.47
Benthic mollusc	n	Bivalves (without shell)	IAEA 2010	0.18	Molluscs, soft tissue	IAEA 2010	0.40
Bird	n	Mallard duck (flesh only)	IAEA 2010	0.32	Hen	IAEA 2010	0.75
Bird egg	n	Mallard duck (flesh only)	IAEA 2010	0.32	Hen	IAEA 2010	0.75
Bivalve mollusc	n	Bivalves (without shell)	IAEA 2010	0.18	Molluscs, soft tissue	IAEA 2010	0.40
Detritivorous invertebrate	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Flying insects	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Gastropod	n	Bivalves (without shell)	IAEA 2010	0.18	Molluscs, soft tissue	IAEA 2010	0.40
Insect larvae	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Polychaete worm	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Reptile	n	Frogs/toads	IAEA 2010	0.15	Animals	IAEA 2010	0.47
Sea anemones or true corals - colony	n	Bivalves (without shell)	IAEA 2010	0.18	Molluscs, soft tissue	IAEA 2010	0.40
Sea anemones or true corals - polyp	n	Bivalves (without shell)	IAEA 2010	0.18	Molluscs, soft tissue	IAEA 2010	0.40
Soil Invertebrate (worm)	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48
Tree	n	Grass, fodder, pasture	IAEA 2010	0.24	Grass, fodder, pasture	IAEA 2010	0.42
Zooplankton	n	Isopods	IAEA 2010	0.25	Invertebrates, whole	IAEA 2010	0.48

Appendix G

Guide for evaluation of data

This appendix is a guide into the report with the purpose to support the evaluation of the confidence of specific parameter values. In Chapters 5-8, considerations behind each parameter value are found, which gives a detailed background why a specific value is chosen. The confidence of the parameters is revealed in Chapter 9 – "Uncertainties and confidence in selected parameter values and comparison with previous safety assessments", where uncertainties are quantified and the relative confidence among the parameters are discussed.

A first overview of data is found in Section 9.2.8 and Table 9-14 where data sources and the results of various comparisons are summarised for all parameter and element combinations.

The checklist below can be used as a guide into Chapter 9 when assessing the level of confidence in specific parameter values. The entries for the checklist (SO, SV,SX etc) are derived from Table 9-14.

1. Site data are utilised for the parameterisation (SO, SV, SX, SM):

a. Do site and literature data overlap?
   i. Check Table 9-3 where site data and literature data are compared.

b. How consistent are available literature data utilised for comparisons?
   i. Check Table 9-1 for comparisons among literature sources.
   ii. Check Table 9-2 for the number of samples of the literature data source.

c. Are FM and LX site data consistent?
   i. Check Table 9-4 where site data from FM and LX are compared.

d. How many samples are site data estimations based on?
   i. Check Table 9-5 where critical N is compiled.

e. Do the parameter show extensive variation?
   i. Check Section 9.2.3 if variation is large due to expanded GSD or inherent large variation.

f. Are values below reporting limits excluded?
   i. Check Table 9-7, for number of samples below reporting limits.
   ii. Check Table 9-12 if this might cause a difference between GM and BE.

g. Are there element specific considerations that might affect confidence in selected data?
   i. Check Section 9.1.3 if methodological issues might affect the specific element in any direction.
   ii. Check Section 9.1.4 if conversion factors might affect the specific element in any direction.
   iii. For terrestrial CR parameters, check Section 9.2.7 if K_d correlations are plausible.
   iv. Check Section 9.1.1 if low spatial and temporal representatively might affect the selected parameter, e.g. due to redox conditions, physical soil properties, etc.

2. Element or parameter analogues are used for the parameterisation (EA, PA, EP):

a. Which analogues are used?
   i. Check Table 9-9 for selected element analogues.
   ii. Check Table 9-11 for selected parameter analogues.
   iii. Check the selected analogue according to points 1 or 3.
   iv. Check the assumptions on element analogues in Section 2.7.

3. Literature data are used for the parameterisation (LO, LV, LX):

a. How confident are available literature data?
   i. Review Table 9-1 for comparisons among literature sources.
   ii. Review Table 9-2 for the number of underlying references of the literature data source.

b. Are there element specific considerations that might affect the confidence in selected data?
   i. Check Section 9.1.4 if conversion factors might affect the specific element in any direction.
   ii. Check Section 9.2.7 if K_d correlations are plausible in the case of terrestrial CR parameters.