National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

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Proposal for new standards according to the Water Framework Directive

RIVM Letter report 270006003/2014

R. van Herwijnen | E.M.J. Verbruggen

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Abstract

New environmental quality standards for uranium in water
Uranium is listed as a specific pollutant in the Dutch decree on monitoring for the Water Framework Directive (*Regeling monitoring Kaderrichtlijn water*). The compound is frequently detected in Dutch surface waters at concentrations above the current standards. New standards are necessary because the current ones do not comply with the most recent guidelines. On request of the Dutch ministry of Infrastructure and Environment (I&M), the RIVM presents a proposal for these new standards. The ministry has accepted the proposals in this report, and will set the new quality standards when updating the decree on monitoring in 2015.

Emission sources
Uranium is a natural compound present in rocks and soils. Its main entry in the environment is through mining, combustion of coal and the use of artificial fertiliser. Because of these sources the environmental concentration of uranium may increase above its natural background concentration. Uranium is commonly known for its radioactivity and use of enriched uranium in nuclear power plants and nuclear weapons. These sources, however, hardly contribute to the anthropogenic emission of uranium to the environment. Furthermore, the chemical toxicity of natural uranium is much more harmful than the potential environmental impact through its radioactivity. Therefore, this proposal is based on the (eco)toxicity of uranium and does not cover radioactivity

Two quality standards for water
Under the Water Framework Directive two types of quality standards are handled: the Annual Average Environmental Quality Standard (AA-EQS) and the Maximum Acceptable Concentration EQS (MAC-EQS). The AA-EQS is the concentration which should protect the ecosystem against adverse effects resulting from long-term exposure. The proposed AA-EQS is 0.5 microgram per litre. The MAC-EQS protects aquatic ecosystems from effects due to short-term exposure or concentration peaks. The latter standard did not exist for uranium and is proposed at 8.9 microgram per litre. Both standards are expressed as dissolved uranium, including background levels. The prosed AA-EQS is lower than the current value. Monitoring data indicate that the proposed value is currently exceeded in some of the Dutch surface waters.

Keywords:
environmental quality standard, uranium, negligible concentration

Publiekssamenvatting

Nieuwe waterkwaliteitsnormen voor uranium
In de Regeling Monitoring Kaderrichtlijn Water (KRW) staat aan welke eisen het oppervlaktewater in Nederland moet voldoen, onder andere voor uranium. Uranium wordt op veel locaties aangetroffen in concentraties boven de huidige norm. Deze norm is echter niet afgeleid volgens de meest recente methodiek. In opdracht van het ministerie van Infrastructuur en Milieu (IenM) heeft het RIVM nieuwe waterkwaliteitsnormen voorgesteld, die het ministerie vervolgens heeft overgenomen – de nieuwe waarden zullen eind 2015 worden opgenomen in de nieuwe Regeling monitoring KRW.

Bronnen van uranium
Uranium is een stof die van nature in rotsen en in de bodem zit. Uranium komt hoofdzakelijk in het milieu terecht via mijnbouw, de verbranding van steenkool en het gebruik van kunstmest. Dit kan ertoe leiden dat de concentratie van uranium in het milieu hoger wordt dan de van nature aanwezige achtergrondconcentratie. Uranium is vooral bekend vanwege de radioactiviteit en het gebruik van de sterk radioactieve vorm in kerncentrales en atoomwapens. Deze bronnen leveren echter maar een kleine bijdrage aan de hoeveelheid uranium in het milieu. De chemische eigenschappen van natuurlijk uranium zijn daarentegen veel schadelijker dan de radioactieve eigenschappen ervan. De normvoorstellen zijn daarom alleen gebaseerd op de (eco)toxicologische eigenschappen van uranium en hebben geen betrekking op de radioactiviteit.

Twee waterkwaliteitsnormen
De Kaderrichtlijn Water hanteert twee typen waterkwaliteitsnormen: de Jaargemiddelde Milieukwaliteitsnorm (JG-MKN) en de Maximaal Aanvaardbare Concentratie (MAC-MKN). De JG-MKN is de concentratie in water waarbij geen schadelijke effecten te verwachten zijn na langdurige blootstelling (0,5 microgram per liter). De MAC-MKN beschermt het ecosysteem tegen kortdurende concentratiepieken (8,9 microgram per liter). Beide normen gelden voor de concentratie uranium die in water is opgelost en de achtergrondconcentratie is in de norm verrekend. De voorgestelde JG-MKN is iets aangescherpt in vergelijking met de huidige norm en zal naar verwachting op een aantal locaties worden overschreden.

Trefwoorden:
uranium, jaargemiddelde milieukwaliteitsnorm, verwaarloosbaar risiconiveau

Contents

Summary

Uranium is listed as a specific pollutant in the Dutch decree on WFD-monitoring (*Regeling monitoring Kaderrichtlijn water*).In this report a proposal is made for environmental quality standards (EQSs) for uranium in surface water. The quality standards are derived using ecotoxicological, physico-chemical, and human toxicological data originating from an evaluation of the available recent literature. They represent environmental concentrations of the substance offering different levels of protection to man and ecosystems. It should be noted that the proposed EQSs are scientifically derived values. They serve as advisory values for the Dutch Ministry of Infrastructure and the Environment. The ministry has accepted the proposals in this report, and will set the new quality standards when updating the decree on WFD-monitoring in 2015.

Under the WFD, two types of EQSs are derived to cover both long term and short term effects resulting from exposure: an annual average concentration (AA-EQS) to protect against the occurrence of prolonged exposure, and a maximum acceptable concentration (MAC-EQS) to protect against possible effects from short term concentration peaks. For the derivation of the AA-EQS and MAC-EQS for water, the methodology used is in accordance with the WFD. The AA-EQS considers direct ecotoxicity, secondary poisoning of predatory birds and mammals, and exposure of humans via consumption of fish and shellfish. The MAC-EQS is based on direct ecotoxicity only. Since the 'chemical toxicity' of natural uranium is much higher than its 'radiotoxicity', only the first is considered in this report. Recent data on background concentrations in Dutch surface water are taken into account.

Next to the AA-EQS and MAC-EQS, the WFD also considers a standard for surface water used for drinking water abstraction. In addition to these WFD-standards, this report also contains additional risk limits that can be used for the purpose of national water quality policy, e.g. discharge permits or specific policy measures. These are the Negligible Concentration (NC), and the Serious Risk Concentration for ecosystems (SRC_{eco}). For the NC and the SRC_{eco}, existing national guidance was used.

Direct ecotoxicity appeared to be the most critical route for derivation of the AA-EQS. There are strong indications that for birds, exposure to contaminated water plants is a major exposure route. This is not included in the current WFD-methodology, and it is advised to further evaluate the importance of this route. For the saltwater compartiment, reliable data on bioaccumulation and ecotoxicity were absent and it is not possible to propose new standards. An overview of the derived environmental risk limits is given in Table 1. The proposed $AA\text{-}EQS_{fw}$ is lower than the current quality standard. Monitoring data indicate that the proposed value will most likely be exceeded in some of the Dutch surface waters.

Table 1. Summary of proposed water quality standards for uranium. Values in bold are required standards according to the WFD. Values are expressed as dissolved uranium, including background concentrations

	Value [µg U/L]
Freshwater	
AA-EQS	**0.5**
MAC-EQS	**8.9**
NC	0.33
SRC_{eco}	56
Surface water for drinking water production	
$QS_{dw, hh}$	**30**

1 Introduction

1.1 Background and aim

In this report, a proposal is made for environmental quality standards (EQSs) for uranium in surface water. Uranium is listed in the Dutch decree on monitoring within the context of the Water Framework Directive (WFD), also referred to as *Regeling monitoring KRW*. The current water quality standards for uranium do not comply with the most recent methodology for EQS derivation. The list of so-called 'specific pollutants' included in the *Regeling monitoring KRW* has been evaluated in view of the second round of river basin management plans for 2015–2021 [1]. For those substances remaining on the list, including uranium, updated water quality standards according to the methodology of the WFD have to be derived.

Under the WFD, two types of EQSs are derived to cover both long- and short-term effects resulting from exposure:

- an annual average concentration (AA-EQS) to protect against the occurrence of prolonged exposure, and
- a maximum acceptable concentration (MAC-EQS) to protect against possible effects from short term concentration peaks.

In Dutch, these two WFD-standards are indicated as 'JG-MKN' and 'MAC-MKN', respectively[1].

Quality standards for soil, sediment, groundwater and suspended matter in surface water will not be derived in this report, because they are not relevant for compliance check under the *Regeling Monitoring KRW*.

Since the 'chemical toxicity' of natural uranium is much higher than its 'radio toxicity', only the first is considered for the EQSs in this report.

1.2 Standards considered

As indicated above, this report primarily focuses on the WFD-water quality standards. Next to the AA-EQS and MAC-EQS, the WFD also considers a standard for surface water used for drinking water abstraction. Below, a short explanation on the respective standards is provided and the terminology is summarised in Table 2. Note that all standards refer to dissolved concentrations in water.

- Annual Average EQS (AA-EQS) – a long-term standard, expressed as an annual average concentration (AA-EQS) and normally based on chronic toxicity data which should protect the ecosystem against adverse effects resulting from long-term exposure.

  The AA-EQS should not result in risks due to secondary poisoning and/or risks for human health aspects. These aspects are therefore also addressed in the AA-EQS, when triggered by the characteristics of the compound (i.e. human toxicology and/or potential to bioaccumulate).

[1] JG = Jaargemiddelde = annual average; MKN = milieukwaliteitsnorm = environmental quality standard.

Separate AA-EQSs are derived for the freshwater and saltwater environment.

- Maximum Acceptable Concentration EQS (MAC-EQS) for aquatic ecosystems – the concentration protecting aquatic ecosystems from effects due to short-term exposure or concentration peaks. The MAC-EQS is derived for freshwater and saltwater ecosystems, and is based on direct ecotoxicity only.

- Quality standard for surface water that is used for drinking water abstraction ($QS_{dw,\ hh}$). This is the concentration in surface water that meets the requirements for use of surface water for drinking water production. The $QS_{dw,\ hh}$ specifically refers to locations that are used for drinking water abstraction.

The quality standards in the context of the WFD refer to the absence of any impact on community structure of aquatic ecosystems. Hence, not the potential to recover after transient exposure, but long-term undisturbed function is the protection objective under the WFD. Recovery in a test situation, after a limited exposure time, is therefore not included in the derivation of the AA- and MAC-EQS.

Table 2. Overview of the different types of WFD-quality standards for freshwater (fw), saltwater (sw) and surface water used for drinking water (dw) considered in this report.

Type of QS	**Protection aim**	**Terminology for temporary standard**[1]	**Notes**	**Final selected quality standard**
long-term	Water organisms	$QS_{fw,\ eco}$ $QS_{sw,\ eco}$	Refers to direct ecotoxicity	lowest water-based QS is selected as $AA\text{-}EQS_{fw}$ and $AA\text{-}EQS_{sw}$
	Predators (secondary poisoning)	$QS_{biota,\ secpois,\ fw}$ $QS_{biota,\ secpois,\ sw}$ $QS_{fw,\ secpois}$ $QS_{sw,\ secpois}$	QS for fresh- or saltwater expressed as concentration in biota, converted to corresponding concentration in water	
	Human health (consumption of fishery products)	$QS_{biota,\ hh\ food}$ $QS_{water,\ hh\ food}$	QS for water expressed as concentration in biota, converted to corresponding concentration in water; valid for fresh- and saltwater	
short-term	Water organisms	$MAC\text{-}QS_{fw,\ eco}$ $MAC\text{-}QS_{sw,\ eco}$	Refers to direct ecotoxicity; check with $QS_{fw,\ eco}$ and $QS_{sw,\ eco}$	$MAC\text{-}EQS_{fw}$ $MAC\text{-}EQS_{sw}$
dw	Human health (drinking water)		Relates to surface water used for abstraction of drinking water	$QS_{dw,\ hh}$

[1] Note that the subscript "fw" refers to the freshwater, "sw" to saltwater; subscript "water" is used for all waters, including marine.

For the purpose of national water quality policy, e.g. discharge permits or specific policy measures, two additional risk limits are derived:

- Negligible Concentration (NC) – the concentration in fresh- and saltwater at which effects to ecosystems are expected to be negligible and functional properties of ecosystems are safeguarded fully. It defines a safety margin which should exclude combination toxicity. The NC is derived by dividing the AA-EQS by a factor of 100, in line with the Dutch policy [2,3].

- Serious Risk Concentration for ecosystems (SRC_{eco}) – the concentration in water at which possibly serious ecotoxicological effects are to be expected. The SRC_{eco} is valid for the freshwater and saltwater compartment.

According to the WFD-methodology, the fact that uranium is a naturally occurring element may be taken into account by using the 'added risk approach'. In short, this means that the standards are expressed as concentrations that may be added to the natural background concentration. In this report, the expression of values as an added concentration is indicated by using the subscript 'added', e.g. $QS_{added,\ fw,\ eco.}$ Note that the added risk approach is only applicable to direct ecotoxiciy, see section 2.2 for more information.

1.3 Current standards

Since natural background concentrations for uranium in the Netherlands have only recently been officially established, the current standards for uranium are only available as added concentrations, excluding background values. The current Maximum Permissible Additions (MPAs, comparable to the $QS_{added,\ fw,\ eco}$) for uranium in fresh- and salt surface water and in groundwater are 1 µg/L. The derivation of these values is reported by Van de Plassche et al. [4].

1.4 Use and sources of uranium

Uranium is a natural element which is mainly known for its use in nuclear power plants and in nuclear weapons. Other (civilian) uses are as counter weight in airplanes and in ammunition. These uses are in general not the main sources of anthropogenic uranium in the environment. Because of its natural presence in rocks and soil, anthropogenic activities like mining, ore processing, agriculture (phosphate fertilizers) and coal combustion contribute to an increased presence of uranium above is natural background concentration [5]. These sources can all be considered relevant for the anthropogenic uranium in the Dutch rivers.

1.5 Uranium, radioactivity and speciation

Uranium is a radioactive substance that is naturally present in the environment in three different isotopes: ^{234}U, ^{235}U and ^{238}U. The latter isotope is most present in the environment (99.3%), has the longest half-life and is therefore the least radioactive. See Table 3 for more details. Only studies performed with uranium in its natural isotope ratio are considered relevant for the EQS derivation. In natural oxygenated systems, the most common oxidation state is the hexavalent uranyl ion (UO^{2+})[6]. The uranyl ion will be available in the toxicity tests when compounds like uranyl nitrate, uranyl acetate, uranyl chloride are dissolved. UO^{2+} itself is not soluble but after release it complexes readily with carbonate, phosphate or sulfate ions. In these complexes uranium is soluble [7].

Table 3. Isotopes of uranium [8]

Isotope	natural presence (%)	half-life (years)
^{233}U	not natural	1.592×10^{3}
^{234}U	0.0055	2.455×10^{5}
^{235}U	0.72	7.038×10^{8}
^{236}U	not natural	2.342×10^{7}
^{238}U	99.27	4.468×10^{9}

2 Methods

2.1 General

The methodology is in accordance with the European guidance document for derivation of environmental quality standards under the WFD [9]. This document is further referred to as the WFD-guidance. Additional guidance for derivation of EQSs that are specific for the Netherlands, such as the NC and SRC, can be found in Van Vlaardingen and Verbruggen [10]. This guidance document was prepared for derivation of EQSs in the context of the project "International and national environmental quality standards for substances in the Netherlands (INS)", and is further referred to as the INS-guidance. Similar to the WFD-guidance, the INS-guidance is based on the Technical Guidance Document (TGD), issued by the European Commission and developed in support of the risk assessment of new notified chemical substances, existing substances and biocides [11] and on the Manual for the derivation of Environmental Quality Standards in accordance with the Water Framework Directive [12]. The WFD-guidance also takes into account the most recent guidance developed under REACH [13].
It should be noted that the recent WFD-guidance deviates from the INS-guidance for some of aspects. This specifically applies to the treatment of data for freshwater and marine species (see section 4.2) and the derivation of the MAC (see section 5.3), and also holds for the QS for surface waters intended for the abstraction of drinking water ($QS_{dw,\ hh}$, see section 5.2). Where applicable, the WFD-guidance is followed and the INS-guidance is used for situations which are not covered by the former.

2.2 Added risk approach

For derivation of EQSs for metals, the WFD Guidance [9] proposes to follow the added risk approach and to include background concentrations in the final EQS for metals.

The added risk approach is used to take natural background concentrations into account when calculating EQSs for naturally occurring substances. The approach starts by calculating a maximum addition for chronic exposure and short-term concentration peaks equivalent to the QS_{eco} and MAC-QS_{eco}. These additions, denoted as $QS_{added,\ eco}$ and MAC-$QS_{added,\ eco}$, are derived on the basis of available data from laboratory toxicity tests (with added amounts of toxicants). The $QS_{added,\ eco}$ and MAC-$QS_{added,\ eco}$ are considered to be the maximum concentrations to be added to the background concentration (C_b), without causing deleterious effects. Hence, the QS_{eco} is the sum of C_b and $QS_{added,\ eco}$, and the MAC-QS_{eco} is the sum of C_b and MAC-$QS_{added,\ eco}$:

$$QS_{eco} = C_b + QS_{added,\ eco}$$
$$MAC\text{-}QS_{eco} = C_b + MAC\text{-}QS_{added,\ eco}$$

The background concentration and the $QS_{added,\ eco}$/MAC-$QS_{added,\ eco}$ are independently derived values, where the $QS_{added,\ eco}$ and MAC-$QS_{added,\ eco}$ are derived using a similar approach as the QS_{eco} and MAC-QS_{eco} for substances having no natural background concentration.

The aquatic EQSs derived in this report are for dissolved uranium. Monitoring data [14] showed that the uranium in filtered samples is comparable to the concentration in the unfiltered samples. Therefore all measured concentrations in the test solutions are considered as dissolved concentrations. The dissolved concentration of uranium is also considered to be fully bioavailable. In contrast, the background concentration is assumed to be completely unavailable, since at present there is insufficient information to determine the bioavailability of the background concentrations for metals. For uranium, a background concentration of 0.33 µg/L for the Netherlands has been set [15]. In the database that might be used according to the WFD Guidance (EC, 2011): http://www.gsf.fi/publ/foregsatlas/; (accessed on 1 November 2012) background concentrations for uranium in the Netherlands are reported ranging from 0.087 to 0.97 µg/L. The new background concentration falls within this range.

The WFD Guidance also notes that the recent developments in the area of biotic ligand modelling (BLM) may be used in the future for the assessment of bioavailability and the calculation of local quality standards after comprehensive data have become available for validation. In the case of uranium no BLMs are present.

2.3 Data collection and evaluation

An online literature search was performed on SCOPUS, the search profile is given in Appendix 1. This profile was run at 27-1-2012. At 28-8-2012 this profile was repeated for the year 2012. The total search resulted in approximately 1700 references, of which more than 90 references were considered relevant. In addition to this, references given in Danish and Canadian reports on derivation of environmental risk limits for uranium [6,16] have been checked for additional references. A REACH dossier on uranium is currently not available.

Studies were evaluated according to the Klimisch criteria [17], where, in the case of uranium, only studies where the endpoints were based on measured values were considered to be valid. Valid L(E)C50-or NOEC/EC10-values were used to construct aggregated data tables for acute and chronic toxicity, respectively, with one effect value per species. Details for construction of these aggregated data tables are given in section 4.1.

3 Substance identification, physico-chemical properties, fate and human toxicology

3.1 Identity

The identities of uranium and uranium salts used in the toxicity tests discussed in chapter 4 are given in the tables below.

Table 4. Identification of uranium

Parameter	Name or number
Chemical name	uranium
CAS number	7440-61-1
EC number	231-170-6
Molecular formula	U
Molecular structure	-

Table 5. Identification of uranyl acetate dihydrate

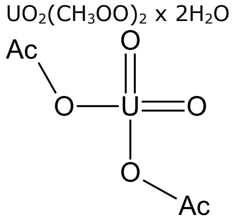
Parameter	Name or number
Chemical name	uranyl acetate; bis(acetato-O)dioxouranium
CAS number	541-09-3
EC number	208-767-5
Molecular formula	$UO_2(CH_3OO)_2 \times 2H_2O$
Molecular structure	

Table 6. Identification of uranyl dinitrate hexahydrate

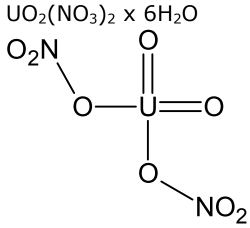
Parameter	Name or number
Chemical name	bis(nitrato-O)dioxouranium
CAS number	13520-83-7
EC number	233-266-3
Molecular formula	$UO_2(NO_3)_2 \times 6H_2O$
Molecular structure	

Table 7. Identification of uranyl sulphate trihydrate

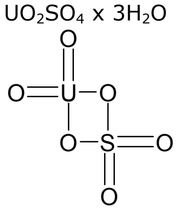
Parameter	Name or number
Chemical name	dioxouraniumsulfate
CAS number	20910-28-5
EC number	215-240-3
Molecular formula	$UO_2SO_4 \times 3H_2O$
Molecular structure	

Table 8. Identification of uranyl phosphate tetrahydrate

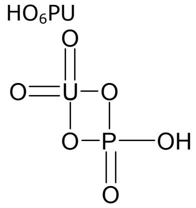
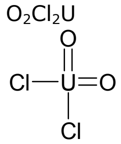
Parameter	Name or number
Chemical name	dioxouranium hydrogen phosphate
CAS number	18433-48-2
EC number	242-306-9
Molecular formula	HO_6PU
Molecular structure	

Table 9. Identification of uranyl dichloride

Parameter	Name or number
Chemical name	dichlorodioxouranium
CAS number	7791-26-6
EC number	232-246-1
Molecular formula	O_2Cl_2U
Molecular structure	

3.2 Physico-chemical properties

Table 10. Physico-chemical properties of uranium

Parameter	Unit	Value	Remark	Ref.
Molecular weight	[g/mol]	238		[18]
Water solubility	[mg/L]			
log K_{OW}	[-]	n.a.		
K_d	[L/kg]	see Table 16		
Vapour pressure	[Pa]	131.6	at 2450°C	[19]
		2.5×10^{-81}	at 25°C	[18]
Melting point	[°C]	1135		[18]
Boiling point	[°C]	4131		[18]
Henry's law constant	[Pa.m^3/mol]	-		

n.a. = not applicable.

Table 11. Physico-chemical properties of uranyl acetate dihydrate

Parameter	Unit	Value	Remark	Ref.
Molecular weight	[g/mol]	424.15		[6]
Water solubility	[mg/L]	10^5	exp., temp. unknown	[20]
		77×10^3	15°C	[6]
log K_{OW}	[-]	1.42	estimated	[20]
K_d	[L/kg]	see Table 16		
Vapour pressure	[Pa]	0.086	25°C, estimated	[20]
Melting point	[°C]	loses 2 H_2O at 110		[6]
Boiling point	[°C]	-	decomposes at 275	[6]
Henry's law constant	[Pa m^3/mol]	3.3×10^{-5}	MW x VP / WS	

n.a. = not applicable.
- = not available

Table 12. Physico-chemical properties of uranyl dinitrate hexahydrate

Parameter	Unit	Value	Remark	Ref.
Molecular weight	[g/mol]	502.129		[6]
Water solubility	[mg/L]	soluble, 1.3×10^6		[6]
		1.9×10^5	estimated from fragments	[21]
log K_{OW}	[-]	2.19	estimated	[21]
K_d	[L/kg]	see Table 16		
Vapour pressure	[Pa]	1.5×10^{-13}	25°C, estimated	[21]
Melting point	[°C]	60		[8]
Boiling point	[°C]	decomposes at 118		[6]
Henry's law constant	[Pa.m^3/mol]	3.1×10^{-16}	MW x VP / WS, calculated from EPIWIN value	

n.a. = not applicable.
- = not available

Table 13. Physico-chemical properties of uranyl sulphate trihydrate

Parameter	Unit	Value	Remark	Ref.
Molecular weight	[g/mol]	420.138		[6]
Water solubility	[mg/L]	soluble		[6]
log K_{OW}	[-]	-		
K_d	[L/kg]	see Table 16		
Vapour pressure	[Pa]	-		
Melting point	[°C]	-		
Boiling point	[°C]	-		
Henry's law constant	[Pa.m^3/mol]	-		

n.a. = not applicable.
- = not available

Table 14. Physico-chemical properties of uranyl phosphate tetrahydrate

Parameter	Unit	Value	Remark	Ref.
Molecular weight	[g/mol]	437		[6]
Water solubility	[mg/L]	-		
log K_{OW}	[-]	-		
K_d	[L/kg]	see Table 16		
Vapour pressure	[Pa]	-		
Melting point	[°C]	-		
Boiling point	[°C]	-		
Henry's law constant	[Pa.m^3/mol]	-		

n.a. = not applicable.
- = not available

Table 15. Physico-chemical properties of uranyl dichloride

Parameter	Unit	Value	Remark	Ref.
Molecular weight	[g/mol]	340.93		[21]
Water solubility	[mg/L]	1.6×10^5	estimated from fragments	[21]
log K_{OW}	[-]	2.85	estimated	[21]
K_d	[L/kg]	see Table 16		
Vapour pressure	[Pa]	2840	25°C, estimated	[21]
Melting point	[°C]	-		
Boiling point	[°C]	-		
Henry's law constant	[Pa.m^3/mol]	-		

n.a. = not applicable.
- = not available

Table 16. Soil sorption properties (Kd) for uranyl in a set of 178 soils (L/kg)

Mean value	Range	Number of soil tested	Soil characteristic	Ref.
2.0×10^{2}	7×10^{-1} – 6.7×10^{4}	178	all soils	[22]
1.8×10^{2}	7×10^{-1} – 6.7×10^{4}	146	mineral soils	[22]
1.2×10^{3}	3.3×10^{2} – 7.6×10^{3}	9	organic soils	[22]
$7.1 \times 10^{1}1$	7×10^{-1} – 6.7×10^{3}	36	pH < 5	[22]
7.4×10^{2}	2.6×10^{0} – 6.7×10^{4}	78	pH 5-7	[22]
6.5×10^{1}	9×10^{-1} – 6.2×10^{3}	60	pH>7	[22]
5.0×10^{1}	2.0×10^{1} – 1.0×10^{3}	unknown	sediment	[22]

3.3 Detection limit

The detection limit for uranium reported by the WHO is 0.1 μg/L for ICP-MS and 0.2 μg/L for ICP-AES [23].

3.4 Bioaccumulation, bioconcentration and biomagnification

In the WFD guidance [9] is stated that for metals a bioconcentration factor (BCF) should not be used, because bioconcentration is dependent of the actual exposure concentration and BCF are usually not determined at environmentally realisitic concentrations. Therefore, field-determined bioaccumulation factors (BAF) are preferred over BCFs. An overview of collected BAF and BCF values is given in Table 17 and Table 18 respectively. Only data for freshwater species were available. The BCF values are only presented as indicative values. More details can be found in Appendix 2. Bioaccumulation and bioconcentration of uranium has been studied in a variety of organisms but only data for fish, molluscs and large crustaceans are reviewed because only these are considered relevant for humans. Secondary exposure of predators is considered less relevant because of the relatively high QS_{biota} value (see Section 5.1.2). For secondary poisoning, plant eating birds could also be relevant, but since this route is not implemented in the WFD-guidance, this issue is only briefly discussed in Section 5.1.2 and no full evaluation of bioaccumulation in water plants is performed.

BAFs were determined from uranium concentrations in field collected animals and concentrations in water from the same water body. For bioconcentration, when evaluating the available literature, special consideration is given to maintenance and analysis of exposure concentrations and the accomplishment of equilibrium. Studies in which aqueous concentrations were not analysed were not considered reliable. Static BCFs estimated from the ratio between concentrations in organisms and water were only accepted as valid when actual concentrations were constant and equilibrium had been reached. Kinetic BCFs, estimated from uptake- and elimination rates, could be accepted without equilibrium being reached.

Only whole body BAF/BCFs are presented in Table 17 and Table 18. Data indicate that the internal distribution of uranium in fish differs between organs. In general, concentrations in bone and stomach are highest as compared to other parts of the body. For secondary poisoning, a distinction between organs is not relevant, since predators eat the fish as a whole. For risk limits based on human fish consumption, using whole fish BAFs may overestimate exposure in case only fillet is consumed. Since consumption of other parts cannot be fully excluded, whole body BAFs for fish are used for further calculations.

In Table 17 it can be seen that the highest BAF for fish is the geometric mean for the bony bream *Nematalosa erebi* of 109 L/kg. Underlying values were obtained under exposure concentrations ranging from 0.04 to 0.8 µg/L which cover the proposed Dutch natural background concentration of 0.33 µg/L [15]. For molluscs, higher BAF values are reported. The highest geometric mean presented is 660 L/kg for the mussel *Velesunio angasi* originating from 115 different BAFs that were obtained from a large number of animals covering different ages, locations and sampling periods. The reported water concentrations cover the range of 0.01 to 0.2 µg/L. Although the period of water sampling is not entirely clear, it is presumed that it represents the exposure period.

Since the bioconcentration of metals is dependent of the actual exposure concentration, the BAF could also be affected by the exposure concentration. To evaluate this, Table 17 also presents the different exposure concentrations for each species. The actual exposure dependence of the BAF and which BAF is used to set the risk limits is further assessed in Section 5.1.2.

Table 17. Summary of valid BAF data for the bioaccumulation of uranium in freshwater fish and molluscs.

Species	**BAF (L/kg)**							**Exp. conc. (µg/L)**	**Ref.**
	Min.	**Max.**	**Avg.**	**SD**	**Geom.**	**Median**	**N**		
Fish									
Arius leptaspis	0.85	1.0	0.93	0.11	0.92	0.93	2	0.76	[24]
	25	41	33	11	32	33	2	0.037	
all exp. conc.	*0.85*	*41*	*17*	*20*	*5.4*	*13*	*4*		
Catostomus catostomus	0.3	-	-	-	-	-	1	3000	[25]
	6.9	-	-	-	-	-	1	5.2	
all exp. conc.	*0.3*	*6.9*	*3.6*	*4.7*	*1.4*	*3.6*	*2*		
Catostomus commersoni	0.2	-	-	-	-	-	1	2916	[25,26]
	8.9	-	-	-	-	-	1	300	
	13	17	15	2.8	14.9	15	2	267	
	24	-	-	-	-	-	1	210	
all exp. conc.	*0.2*	*24*	*12.6*	*8.9*	*6.2*	*13*	*5*		
Coregonus artedii	2	-	-	-	-	-	1	267	[25]
Coregonus clupeaformis	4	-	-	-	-	-	1	267	[25]
Couesius plumbeus	0.5	-	-	-	-	-	1	2916	[26]
	1.8	-	-	-	-	-	1	338	
	2	-	-	-	-	-	1	267	
	4	-	-	-	-	-	1	210	
	6.6	-	-	-	-	-	1	300	
all exp. conc.	*0.5*	*6.6*	*3.0*	*2.4*	*2.2*	*2*	*5*		
Lates calcarifer	36	48	42	8.5	41	42	2	0.037	[24]
Megalops cyprinoides	7.1	7.8	7.5	0.45	7.5	7.5	2	0.052	[24]
Nematalosa erebi	26.6	26.8	26.7	0.14	26.7	26.7	2	0.76	[24]
	203	224	213.5	14.8	213.2	213.5	2	0.052	
	194	261	227.5	47.4	225.0	227.5	2	0.037	
all exp. conc.	*27*	*261*	*156*	*103*	*109*	*199*	*6*		
Notropis hudsonius	3	-	-	-	-	-	1	210	[25]
	5	-	-	-	-	-	1	267	
all exp. conc.	*3*	*5*	*4*	*1.4*	*3.9*	*4*	*2*		

Species	BAF (L/kg) Min.	Max.	Avg.	SD	Geom.	Median	N	Exp. conc. (µg/L)	Ref.
Oxyeleotris lineolatus	45	47	46	1.4	46	46	2	0.052	[24]
Percopsis omiscomaycus	2	-	-	-	-	-	1	267	[25]
Prosopium cylindraceum	10.9	-	-	-	-	-	1	5.2	[25]
Pungitius pungitius	1	-	-	-	-	-	1	267	[25]
Salmo trutta	1.5	-	-	-	-	-	1	60	[27]
Salvenius namaycush	0.4	-	-	-	-	-	1	267	[25]
	3.2	-	-	-	-	-	1	5.2	
all exp. conc.	*0.4*	*3.2*	*1.8*	*2.0*	*1.1*	*1.8*	*2*		
Strongylura kreffti	1.2	1.4	1.3	0.14	1.3	1.3	2	0.76	[24]
	4.3	5.6	5.0	0.9	4.9	5.0	2	0.037	
all exp. conc.	*1.2*	*5.6*	*3.1*	*2.2*	*2.5*	*2.9*	*4*		
Molluscs									
Corbicula fluminea	200						1	12.4	[28]
	810						1	4.2	
all exp. conc.	*200*	*810*	*510*	*430*	*400*	*510*	*2*		
*Hyridella depressa**	28	-	-	-	-	-	1	0.074	[29]
*Velesunio ambiguus**	17	-	-	-	-	-	1	0.074	[29]
*Velesunio angasi**	581	1162	941	235	911	996	9	0.010	[30-32]
	415	913	658	172	636	656	19	0.014	
	664	1079	847	180	832	747	5	0.018	
	581	1660	961	260	931	913	42	0.020	
	556	1577	837	284	804	768	10	0.033	
	398	797	536	134	523	498	7	0.048	
	127	479	254	129	227	276	7	0.079	
	226	327	277	72	272	277	2	0.104	
	324	473	407	50	404	411	8	0.133	
	194	516	322	137	299	281	6	0.161	
all exp. conc.	*130*	*1700*	*740*	*320*	*660*	*750*	*115*		

*Values for this species have been recalculated from dry weight to fresh weight on the basis of a moisture content of 91.7 % for bivalves [33].

Table 18. Summary of valid BCF data for the bioconcentration of uranium in freshwater fish, molluscs and large crustaceans.

Species	**BCF (L/kg)**							**Exp. conc. (µg/L)**	**Ref.**
	Min.	Max.	Avg.	SD	Geom.	Median	N		
Fish									
*Danio rerio** (adult)	81	93	87	8.6	87	87	2	501	[34-37]
	105	466	190	127	166	137	7	94-102	
	973	973	973	-	973	973	1	20	
all exp. conc.	*81*	*973*	*250*	*280*	*170*	*130*	*10*		
*Danio rerio** (embryo)	563	1408	3747	2271	3385	3747	2	16.8	[38]
	1230	1230	1230	-	1230	1230	1	87	
all exp. conc.	*560*	*1400*	*1100*	*450*	*990*	*1200*	*3*		
*Mogurnda mogurnda**	26	26	26	-	26	26	1	90	[39]
	20	20	20	-	20	20	1	180	
	15	17	16	1.4	16.0	16	2	380-410	
	18	23	21	3.5	20.3	21	2	770-800	
	33	34	34	0.7	33.5	34	2	1230-1400	
all exp. conc.	*15*	*34*	*23*	*7.1*	*22*	*21*	*8*		
*Oncorhynchus mykiss**	0.7	0.7	0.7	-	0.7	0.7	1	960	[40]
	5.5	5.5	5.5	-	5.5	5.5	1	0.078	
all exp. conc.	*0.7*	*5.5*	*3.1*	*3.4*	*1.9*	*3.1*	*2*		
Salvelinus fontinalis	1.9	1.9	1.9	-	1.9	1.9	1		[27]
	2.5	2.5	2.5	-	2.5	2.5	1		
	2.7	2.7	2.7	-	2.7	2.7	1		
	2.9	2.9	2.9	-	2.9	2.9	1		
	3	3	3	-	3	3	1		
	4	4	4	-	4	4	1		
	4.3	4.3	4.3	-	4.3	4.3	1		
all exp. conc.	*1.9*	*4.3*	*3.0*	*0.8*	*3.0*	*2.9*	*7*		

Species	BCF (L/kg)							Exp. conc. (µg/L)	Ref.
	Min.	Max.	Avg.	SD	Geom.	Median	N		
Molluscs									
Corbicula fluminea	345	500	407	82.2	401	375	3	10-20	[41,42,28,43]
	160	217	189	40.3	186	189	2	45-63	
	9	107	72	54.7	45.8	100	3	100	
	22	40	31	12.7	29.7	31	2	500	
	10	10	10	-	10	10	1	1500	
all exp. conc.	*9*	*500*	*170*	*170*	*86*	*107*	*11*		
Large crustaceans									
Orconectes limosus	0.012	0.13	0.073	0.086	0.040	0.073	2	0.9	[28]
	0.022	0.075	0.049	0.037	0.041	0.049	2	2.5	
	0.05	0.02	0.013	0.010	0.01	0.013	2	2.5	
	0.012	0.012	0.012	-	0.012	0.012	1	10.7	
	0.65	0.10	0.084	0.026	0.081	0.084	2	19.6-20.2	
all exp. conc.	*0.0050*	*0.13*	*0.050*	*0.046*	*0.030*	*0.022*	*9*		

*Some values for this species have been recalculated from dry weight to fresh weight on the basis of a moisture content of 73.7 % for fish [33].

3.5 Human toxicological threshold limits and carcinogenicity

Elemental uranium has obtained a harmonised classification according to Annex VI of Regulation (EC) No 1272/2008 (CLP Regulation). Uranium is classified with respect to human toxicology as H300 (fatal if swallowed), H330 (fatal if inhaled) and H373 (may cause damage to organs through prolonged or repeated exposure) (www.echa.europa.eu; accessed 29 August 2012). Based on H300 and H373 and the fact that uranium has the potential to accumulate (see Section 3.4), derivation of the $QS_{water,\ hh\ food}$ for exposure of humans via fish consumption is triggered. Derivation of the $QS_{dw,\ hh}$ is also relevant for drinking water.

For human toxicity, the World Health Organization (WHO) has established a tolerable daily intake (TDI) for soluble uranium of 0.6 µg/kg b.w. per day [44,23], this value was based on the lowest-observed-adverse-effect-level (LOAEL) for uranium nephrotoxicity (degenerative lesions in the proximal convoluted tubule of the kidney) of 0.06 mg/kg b.w. per day from a 91-day study in male rats [45]. The assessment factor of 100 was considered sufficient because of the minimal degree of severity of the lesions reported. Also, an additional uncertainty factor for the length of the study (91 days) was considered not necessary because the estimated half-life of uranium in the kidney is 15 days, and there is no indication that the severity of the renal lesions would be exacerbated following continued exposure [23]. The Panel on Contaminants in the Food Chain (CONTAM Panel) of the European Food Safety Authority (EFSA) has reviewed this TDI and noted that no new data were identified that would require a revision of this TDI and endorsed it [46]. This value is taken as the TDI for the calculation of the $QS_{dw,\ hh}$. In 2011, the WHO has renewed the provisional drinking water guideline value for uranium on the basis of epidemiological studies in human populations [23,47], the new value is raised to 30 µg/L.

4 Aquatic toxicity data

4.1 Laboratory toxicity data

An overview of the aggregated freshwater toxicity data for uranium is given in Table 19 for acute and in Table 20 for chronic endpoints. Saltwater values are given in Table 21. Detailed toxicity data for uranium are given in Appendix 2. Mesocosm or field studies with uranium are not available.

For inclusion of endpoints, the following aspects were taken into consideration:

- In static tests, concentration measurements should be performed at least at the start and the end of the exposure. For renewal tests, measurement of fresh medium only was accepted if renewal was performed every 24 hours. For flow-through tests, analysis of the fresh medium was considered acceptable.

- The aquatic EQSs derived in this report are for dissolved uranium (i.e., after filtration of water samples over a filter with a maximum pore size of 0.45 μm). However several studies showed little difference in uranium concentration between filtered and unfiltered samples. Therefore, studies reporting endpoints based on measured concentrations in filtered as well as unfiltered samples were used for the derivation of the aquatic EQSs.

- DOC: From studies where the level of DOC was varied, it could be observed that the presence of DOC reduces the toxicity. Therefore endpoints from studies with a DOC level < 2 mg/L, as being considered relevant for Dutch surface water, are preferred. In cases where these are not available, the endpoint from the study with the lowest level of DOC is selected (indicated between brackets) and used with care.

- Hardness and alkalinity: In general, the influence of hardness on the toxicity data for uranium is not clear; in many cases where hardness was varied in the same study, the results were variable. For alkalinity there is not enough information to determine the effect of alkalinity. However, it seems that in individual cases there might be an influence of hardness and alkalinity. For example, Sheppard et al. [7] state that hardness and alkalinity have an effect on the sensitivity of fish. Therefore, this influence is considered at the species level.

- pH: From different studies performed at varying pH, it could be observed that a pH higher than 7 reduces the toxicity. Therefore, only studies performed at a pH lower than 7 are used.

When several effect data are available for one species, the geometric mean of multiple values for the same endpoint was calculated where possible. Subsequently, when several endpoints (like growth, mortality and/or reproduction) were available for one species, the lowest of these endpoints (per species) is reported in the aggregated data table.

Table 19. Aggregated acute toxicity data for freshwater organisms. Bracketed values in italics originate from tests with high DOC and should be used with care.

Taxonomic group	L(E)C50 (µg U/L)	Reason for selection
Algae		
Chlorella sp.	67	Levels of hardness below 100 mg $CaCO_3$/L don't seem to influence the toxicity for Chlorella sp. The endpoint is therefore based on a geometric mean of 56, 72 and 74 µg U/L for hardness levels ranging from 3.6 to 40 mg $CaCO_3$/L at a pH of 7 or lower.
Euglena gracillis	*(57)*	The endpoint for the lowest DOC level (10 mg/L) available is selected. It should be noted that a test without DOC could result in a lower endpoint.
Macrophyta		
Lemna aequinoctialis	758	From tests without DOC. The relatively high hardness could have influenced the endpoint.
Ctenophora		
Hydra viridissima	104	Experiments performed at higher hardness result in higher endpoints. Therefore selected endpoint based on 114 and 95 µg U/L obtained at a hardness of 6.6 and 3.9 mg $CaCO_3$/L only.
Crustacea		
Ceriodaphnia dubia	80	Geometric mean of 60, 89, 45, 100, 70, 100, 190 and 50 µg U/L.
Dadaya macrops	1100	Only available value.
Daphnia magna	390	Most sensitive endpoint for 48 h exposure at pH 7.
Diaphanosoma excisum	1000	Only available value.
Latonopsis fasciculate	410	Only available value.
Moinodaphnia macleayi	1290	Only available value.
Pisces		
Ambassus macleayi	800	Most sensitive endpoint for 96 h exposure.
Craterocephalus marianae	1220	Most sensitive endpoint for 96 h exposure.
Melanotaenia nigrans	1700	Most sensitive endpoint for 7 day old fish exposed for 96 h.
Melanotaenia splendida inornata	2660	Most sensitive endpoint for 7 day old fish exposed for 96 h without DOC.
Mogurnda mogurnda	1110	Most sensitive endpoint for 7 day old fish exposed for 96 h in water without DOC.
Pseudomugli tenellus	730	Most sensitive endpoint for 96 h exposure.
Salvenius fontinalis	5500	Most sensitive endpoint for pH 6.7, low hardness and low alkalinity.

Table 20. Aggregated chronic toxicity data for freshwater organisms. Bracketed values in italics originate from tests with high DOC and should be used with care.

Taxonomic group	NOEC/EC10 (µg U/L)	Reason for selection
Bacteria		
Desulfovibrio desulfuricans	2618	Only available value.
Algae		
Chlorella sp.	2.7	Levels of hardness below 100 mg $CaCO_3$/L don't seem to influence the toxicity for *this species*. Endpoint is therefore based on a geom. mean of 0.7, 0.7 and 38 µg U/L for hardness levels ranging from 8 to 40 mg $CaCO_3$/L at a pH of 7 without DOC.
Euglena gracillis	*(5)*	The endpoint for the lowest DOC level available is selected. It should be noted that a test without DOC could result in a lower value.
Macrophyta		
Lemna aequinoctialis	*(213)*	Endpoints from tests without DOC are preferred, however these are not available. Therefore the endpoint is based on a geometric mean of EC10 values of 189, 234, 244 and 191 µg U/L determined at a DOC level of 3-4 mg/L. It should be noted that a test without DOC could result in a lower value.
Ctenophora		
Hydra viridissima	49	Only available value.
Mollusca		
Amerianna cumingi	*(12)*	Geometric mean of EC10 values 20, 5, 13 and 15 µg U/L because the pH of 7.3 does not seem to influence the toxicity. Endpoints from tests without DOC are preferred, however these are not available. Therefore the endpoint is based on a geometric mean of EC10 values of 20, 5, 13 and 15 µg U/L (including the pH of 7.3 which does not seem to influence the toxicity) determined at a DOC level of 2-6 mg/L. It should be noted that a test without DOC could result in a lower value.
Crustacea		
Ceriodaphnia dubia	7.7	Geometric mean of EC10 values 22.4, 9, 5, 14 and 18 µg U/L.
Daphnia magna	14	Most sensitive endpoint EC10 for reproduction at neutral pH.
Hyalella azteca	144	Geometric mean of 72 and 290 µg U/L for a pH around 7.
Moinodaphnia macleayi	5.2	Most sensitive endpoint EC10 for mortality, geometric mean of 1.6 and 16.7. Endpoints for lab and wild strains are combined in this endpoint since they represent a natural variety.
Procambarus clarkia	*(≥ 8340)*	Only available value, included as indicative value.
Insecta		
Chironomus tentans	11.2	Most sensitive endpoint for dry weight.

Taxonomic group	NOEC/EC10 (µg U/L)	Reason for selection
Pisces		
Catostomus commersoni	6400	Only available value.
Danio rerio	138	Only available value.
Mogurnda mogurnda	880	Geometric mean of EC10 values 1014 and 764 µg U/L for dry weight of < 10 h old animals exposed for 28 days at DOC of 2.1 and 4.2. It should be noted that a test without DOC is also available but that test resulted in a different endpoint with a higher EC10 value of 1114 µg U/L. Therefore, this value is considered more appropriate. It should however be noted that a test without DOC could result in a lower endpoint. The difference between hardness and alkalinity for these endpoints was small and therefore not taken into account.

Table 21. Aggregated toxicity data for salt water organisms.

Chronic Taxonomic group	NOEC/EC10 (µg U/L)	Reason for selection
Bacteria		
Vibrio fischeri	2380	Only available value.

4.2 Treatment of fresh- and salt-water toxicity data

According to the WFD-guidance [9], fresh and saltwater toxicity data for metals should only be combined when there is no demonstrable difference in sensitivity. Since for salt water only a reliable endpoint for one bacterium species is available, it cannot be determined if there are differences in sensitivity. Therefore the datasets cannot be combined and the derivation of EQSs for salt water is not possible.

5 Derivation of water quality standards

5.1 Derivation of AA-EQS$_{fw}$ and AA-EQS$_{sw}$

5.1.1 QS$_{fw, eco}$ and QS$_{sw, eco}$

For fresh water, a full base set is available and the lowest chronic value available is 2.7 µg U/L for *Chlorella* sp.

Assessment factor approach
Chronic endpoints are available for algae, daphnia and fish, therefore, an assessment factor of 10 can be applied. The QS$_{added, fw, eco}$ derived from this value will then be 0.27 µg U/L.

SSD approach
As an alternative for the assessment factor method, derivation of the QS$_{added, fw, eco}$ by the SSD method is examined. When endpoints from studies with DOC levels > 2 mg/L are not taken into account, the chronic dataset does not fulfil the requirements for an SSD because data for higher plants are missing:

- Fish: *Danio rerio*
- A second family in the phylum Chordata: *Catostomus commersoni* and *Mogurnda mogurnda*
- A crustacean: C*eriodaphnia dubia, Daphnia magna, Hyalella azteca, Moinodaphnia macleayi* and *Procambarus clarkia.*
- An insect: *Chironomus tentans*
- A family in a phylum other than Arthropoda or Chordata: *Desulvibrio desulfuricans*
- A family in any order of insect or any phylum not already represented: *Hydra viridissima*
- Algae: *Chlorella* sp.
- Higher plants: <u>no data</u>

When studies with DOC > 2 mg/L are taken into account the requirements would be fulfilled, with *Euglena gracillis*, *Lemna aequinoctialis*, and *Amerianna cumingi* as additional species for the SSD. Therefore, it is investigated what the influence of the studies with DOC is on the HC5.
The SSD determined with ETX [48] for endpoints without studies with a too high DOC-content is shown in Figure 1. The calculated HC5 is 0.82 µg U/L, with a two sided 90% confidence interval of 0.043 - 4.6 µg U/L. The goodness of fit is accepted at all levels by the three statistical tests available in the program. When the endpoints based on studies with levels of DOC exceeding 2 mg/L would be included, the calculated HC5 is 0.87 µg U/L, with a two sided 90% confidence interval of 0.086 - 3.7 µg U/L. The goodness of fit is accepted at almost all levels by the three statistical tests available in the program. It is only rejected by the Kolmogorov-Smirnov test at the 0.1 level. The SSD including the endpoints from tests with DOC > 2 mg/L is given in Figure 2.

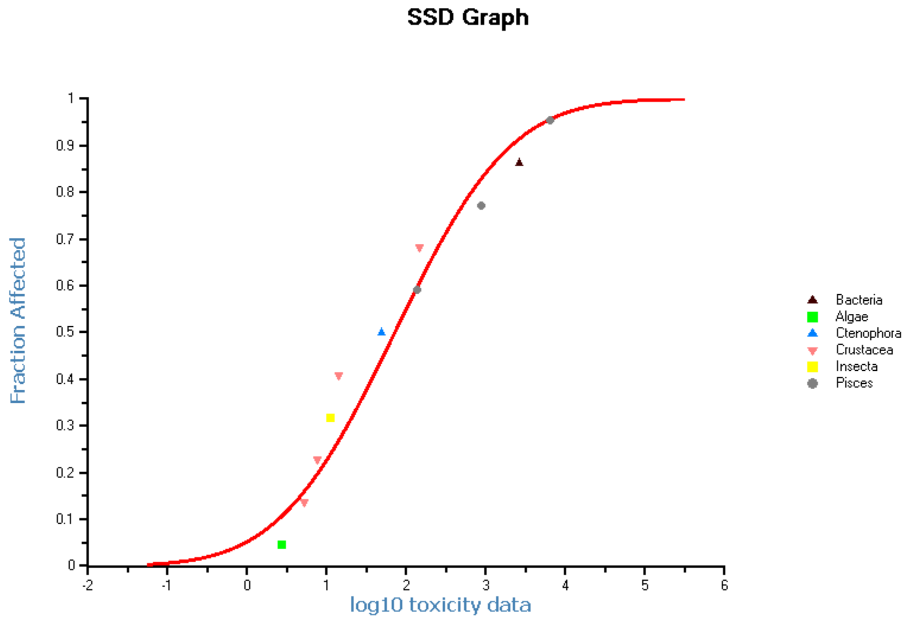


Figure 1 Species Sensitivity Distribution for uranium (chronic data) excluding endpoints from studies with DOC > 2 mg/L. The X-axis represents log-transformed NOEC/EC10-values in µg U/L, the Y-axis represents the fraction of species affected.

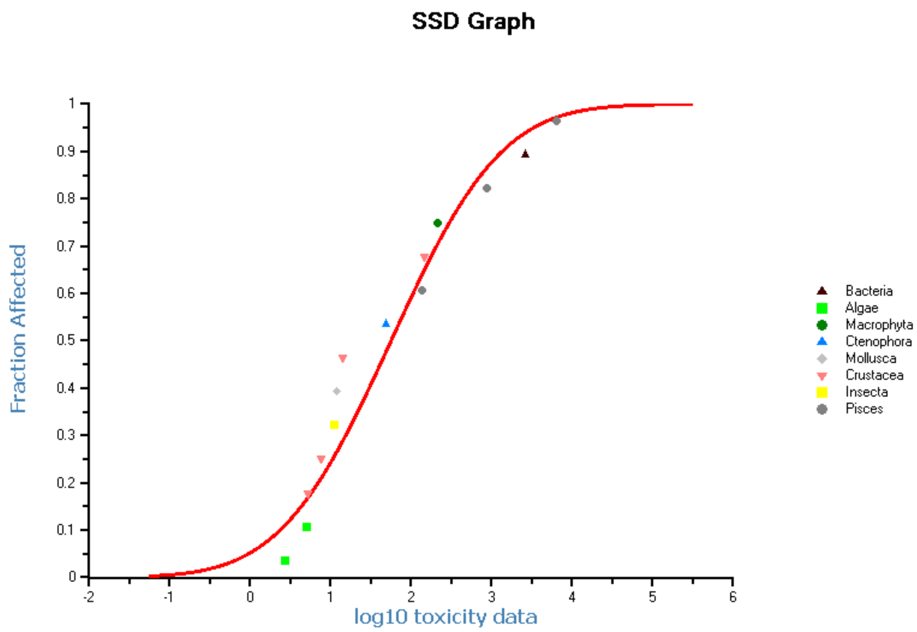


Figure 2 Species Sensitivity Distribution for uranium (chronic data) including endpoints from studies with DOC > 2 mg/L. The X-axis represents log-transformed NOEC/EC10-values in µg U/L, the Y-axis represents the fraction of species affected.

When the HC5 of the SSD without studies with high DOC would be used to determine the $QS_{added,\ fw,\ eco}$ with the default assessment factor 5, the $QS_{added,\ fw,\ eco}$ is 0.16 µg U/L. For the SSD including the endpoints from studies

with DOC this would be 0.17 µg U/L. This small difference between the two values and their comparable reliability indicates that the absence of an endpoint for a higher plant in the preferred dataset, nor the inclusion of endpoints derived in the presence of DOC has a major influence on the outcome.
Nevertheless, these are uncertainties and because of these, it is considered not appropriate to reduce the default assessment factor of 5. Therefore, the value of 0.17 µg U/L based on the full dataset is put forward as $QS_{added,\ fw,\ eco}$ from the SSD method.

Choice of the $QS_{added,\ fw,\ eco}$
The value from the SSD method is in the same order of magnitude as the $QS_{added,\ eco}$ derived with the assessment factor method. The SSD method is preferred over the latter because it is based on the total chronic dataset. Therefore, the $QS_{added,\ fw,\ eco}$ will be 0.17 µg U/L.
The $QS_{fw,\ eco}$ is determined as $QS_{fw,\ eco} = QS_{added,\ eco} + C_b = 0.17 + 0.33 = 0.5$ µg/L.

For saltwater, not enough toxicity data are available to derive an $QS_{added,\ sw,\ eco}$.

5.1.2 *$QS_{fw,\ secpois}$ and $QS_{sw,\ secpois}$*

No numeric trigger values are defined for the assessment of secondary poisoning for metals [9]. There is not much information on the regulation and the toxic mode of action of uranium in birds and mammals and most BAFs reported for accumulation of uranium by molluscs exceed 100 L/kg (see Section 3.4), and thus, the route secondary poisoning is further assessed. Therefore toxicological data on birds and mammals have been reviewed from which the $QS_{fw,\ secpois}$ and $QS_{sw,\ secpois}$ can be derived. Since the water concentrations, on which the BAF values are based includes the natural background concentration, the added risk approach does not apply.

5.1.2.1 Derivation of the $QS_{biota,\ secpois}$

It should be considered that some mammal studies have been performed with uranyl fluoride, and uranium tetrafluoride. In human studies it is considered that co-exposure to hydrogen fluoride could occur [8]. In the present report it is assumed that similar co-exposure could occur in the reviewed studies and therefore studies with these compounds were considered not reliable. An overview of all data considered for the QS is given in Appendix 3 and all relevant endpoints are given in Table 22. Unbound values are not directly used for QS derivation and are only included as indication. According to the guidance, reproduction parameters and parameters like growth and mortality are considered relevant for effects on the population level. The TDI is based on a nephrotoxicity endpoint. Nephrotoxicity is considered to be fatal on the individual level, and is therefore considered to be population relevant. However, the endpoint for the TDI was only based on histopathological findings. The underlying study was part of the dataset [45] and no effects on terminal body weight, body weight gain, feed intake, fluid consumption or kidney weight were observed up to a dose of 37 mg U/kg_{bw}/day (equivalent to 740 mg U/kg_{food} if it is assumed that a rat eats $1/20^{th}$ of its body weight each day). Therefore, the nephrotoxicity endpoint was not included in Table 22 and Appendix 2. The QS_{biota} per species is calculated applying the appropriate assessment factor (AF) (see Table 22) and daily food intake rates following the WFD-guidance. For the assessment factor, it is indicated how they are compiled (AF for caloric content x AF for acute to chronic x AF for QS level). The lowest value is used for QS derivation. Reliable toxicity data for birds were not available. The only study that was available used powdered uranium metal.

Table 22. Toxicity data for birds and mammals

	Duration	NOEC diet [mg U/kg_{fd}]	AF	$QS_{biota, mammal}$ $QS_{biota, bird}$ [mg U/kg_{fd}]	Reference
mammals					
Dog	30 days	500	3 x 10 x 10	1.7	[49]
Mouse	day 13 of pregnancy to day 21 of lactation	23	3 x 3 x 10	0.26	[50]
Rabbit	30 days	95	3 x 10 x 10	0.32	[49]
Rat	2 year [a]	474	3 x 1 x 10	16	[51]
	2 generations [b]	< 80	3 x 1 x 10	< 2.7	[52]

[a] endpoint: growth.
[b] endpoint: reproduction.

The lowest $QS_{biota, secpois}$ is 0.26 mg/kg_{fd}. This value is a factor of 10 lower than the unbounded endpoint for 2 generation exposure in rats from Hao et al. [52]. An EC10 calculated from the two exposure concentrations applied by Hao et al. would result in an $QS_{biota, secpois}$ higher than that for the mouse and rabbit. Therefore, the $QS_{biota, secpois}$ of 0.26 mg/kg_{fd} is also considered to be protective for reproduction effects in rats.

The calculation presented above is performed as described in the current WFD-guidance. A new guideline is currently being developed [53] where the actual caloric value of the consumed species (e.g. fish or mollusc) is taken into account. In advance of the new guidance the calculation is performed as follows: the underlying NOAEL of the lowest $QS_{biota, secpois}$ is 2.8 mg/kg_{bw}/day for mice with an average weight of 0.028 kg (see Table A3.5 in Appendix 3). For a mouse of 0.028 kg a Daily Energy Expenditure of 70.5 kJ can be calculated [54]. This results in a dose of 0.0011 mg/kJ diet. For consumption of molluscs with a caloric content of 1.6 kJ/g_{fw} [33] this results in 1.8 mg/kg_{fd}. For consumption of fish with a caloric content of 5.5 kJ/g_{fw} this results in 6.1 mg/kg_{fd}. On these values an assessment factor of 30 is applied for the correction from subchronic to chronic exposure and from mouse to ecosystem. This then results in $QS_{biota, secpois}$ of 59 µg/kg_{fd} and 205 µg /kg_{fd} for molluscs and fish respectively.

Table 23. Overview of $QS_{biota, secpois}$ values used in the derivation of QSs for secondary poisoning

QS	QS_{biota} [µg/kg]
secondary poisoning, consumption of fish	205
secondary poisoning, consumption of molluscs	59

5.1.2.2 Derivation of the $QS_{fw, secpois}$ and $QS_{sw, secpois}$

According to the guidance, the next step in the derivation of the QS for secondary poisoning is the conversion of the biotastandard ($QS_{biota, secpois}$) in a corresponding concentration in water using data on bioaccumulation. The bioaccumulation data are summarised in section 3.4. For the selection of the appropiate BAF, the WFD-guidance points at the importance of evaluating the possibility of BAFs being dependent on external concentrations. In order to investigate the exposure dependence of the BAFs, the collected BAFs for fish and molluscs are plotted against the exposure concentration in Figure 3 and Figure 4, respectively. For producing a general regression line, it is presumed that the dependence of the bioaccumulation on the exposure concentration is the same for all species, although the level of bioaccumulation itself may vary between the species. Therefore, using the program GraphPad Prism [55], a straight line is fitted through the data points for each individual species, but the slope of these lines is set equal for the datasets of the individual species. The individual lines are presented in Figure 3 and Figure 4. In this way, the slope is determined by the total dataset for fish or molluscs but the Y-intercepts (given in Table 24) are determined by the data points for the individual species. The slopes for fish and molluscs are -0.715 and -0.510 respectively.

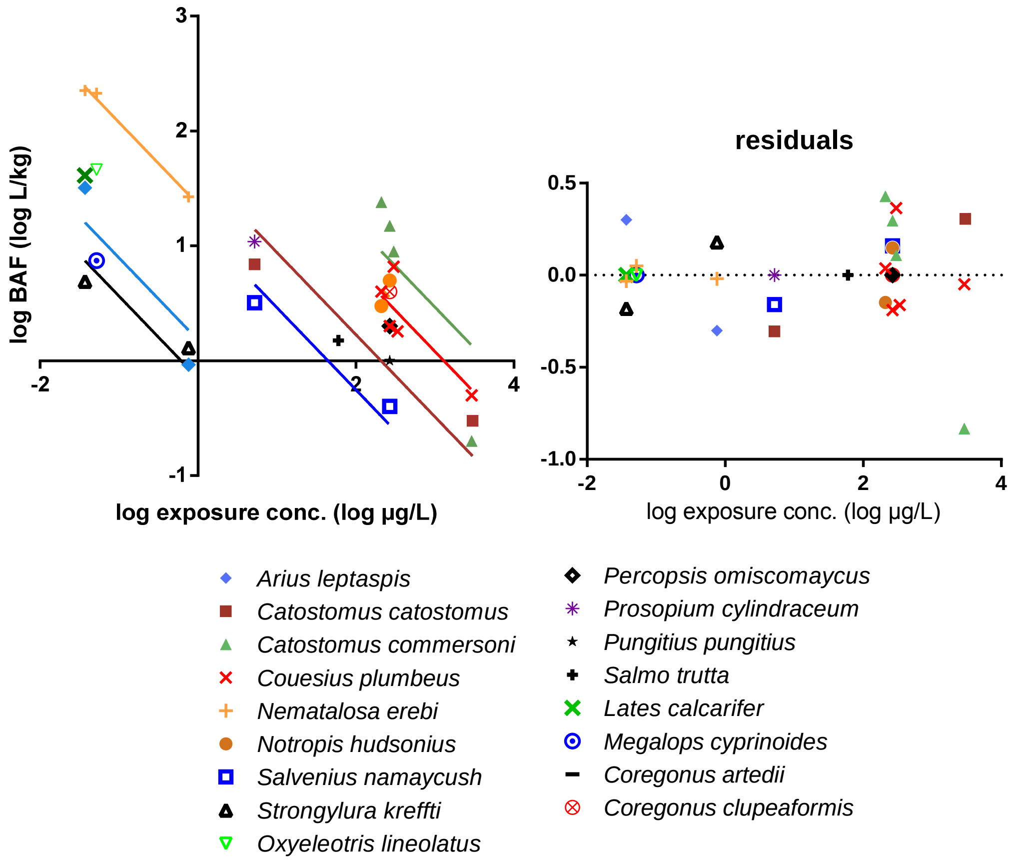


Figure 3. Regression between exposure concentration and BAF for individual fish species (left). The plot on the right shows the residuals of the fit. See also text.

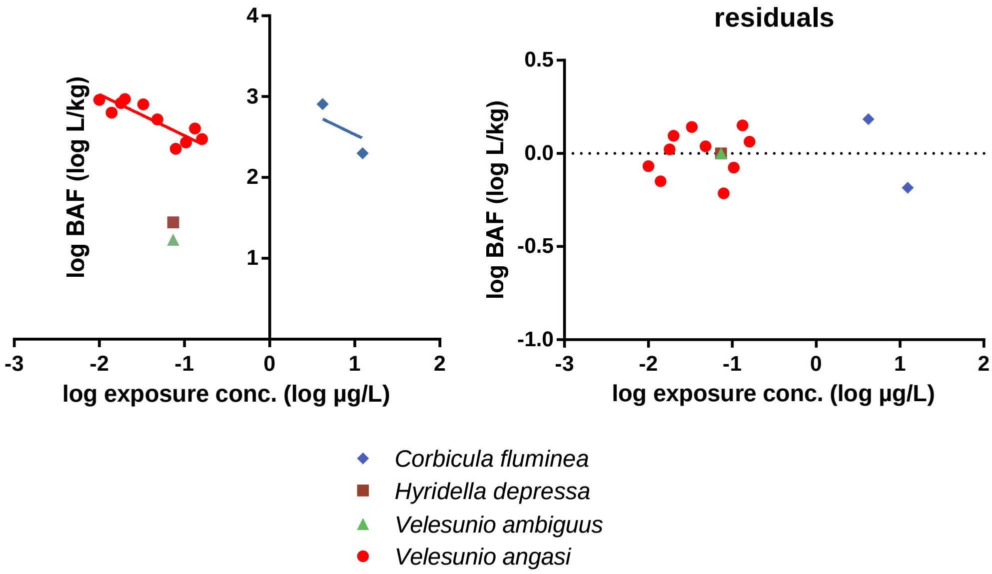


Figure 4. Regression between exposure concentration and BAF for individual mollusc species (left). The plot on the right shows the residuals of the fit. See also text.

The slope was significantly lower than 0, indicating that the BAF is really dependent of the exposure concentration. The R^2 of the individual regression lines with the data points for each species is also given in Table 24 (only for the species for which the BAF was determined for more than one exposure concentration). From this table can be seen that for eight out of ten species (eight fish and two molluscs) a reasonable correlation ($R^2 > 0.5$) is found. Additionally, the residuals for the fit for fish and molluscs are also presented in Figure 3 and Figure 4 respectively. A Shapiro-Wilk test was run to show that the residuals were normally distributed (p> 0.05). These details support the conclusion that the bioaccumulation of uranium is indeed dependent of the exposure concentration. In order to deduce a general BAF from the datasets, the mean of the log transformed individual Y-intercepts is calculated (see Table 24). In order to support the use of a mean, the Y-intercepts are plotted in a distribution curve (see Figure 5). The fit of these curves are accepted by all statistical test available in the ETX programm [48] indicating a normal distribution of the log transformed data. The calculated mean, in combination with the slope, determines the red regression line presented in Figure 6 and Figure 7.

Table 24. Overview of Y-intercept for all species and correlation parameters (R^2) for species for which the BAF was determined for more than one exposure concentration. See also Figure 3 and Figure 4.

	number of exposure conc.	Y-intercept (log L/kg)	R^2
Fish			
Arius leptaspis	2	0.181	0.85
Catostomus catostomus	3	1.657	0.80
Catostomus commersoni	4	2.61	0.64
Couesius plumbeus	5	2.23	0.72
Nematalosa erebi	3	1.36	0.99
Notropis hudsonius	2	2.29	-0.79*
Salvenius namaycush	2	1.18	0.87
Strongylura kreffti	2	-0.153	0.61
Oxyeleotris lineolatus	1	0.745	-
Percopsis omiscomaycus	1	2.04	-
Prosopium cylindraceum	1	1.55	-
Pungitius pungitius	1	1.74	-
Salmo trutta	1	1.45	-
Lates calcarifer	1	0.589	-
Megalops cyprinoides	1	-0.0463	-
Coregonus artedii	1	2.03	-
Coregonus clupeaformis	1	2.34	-
	Mean	1.40	
Molluscs			
Corbicula fluminea	2	3.04	0.633
Hyridella depressa	1	0.871	-
Velesunio ambiguus	1	0.654	-
Velesunio angasi	10	2.01	0.720
	Mean	1.64	

* A negative R^2 seems impossible but this is not the case. R^2 is calculated as: 1.0 - (SS_{res}/SS_{tot}), where SS_{res} is the sum of the squares of the distances of the points from the best-fit curve determined by nonlinear regression and SS_{tot} is the sum of square of the distances of the points from a horizontal line through the mean of all Y values. When SS_{res} is larger than SS_{tot}, R^2 will be negative. It merely indicates that the fit for this species is very poor. However, it should be noted that this is caused by the fact that both the two exposure concentration and BAF values were very close to each other (two BAF at almost equal water concentration). For more details see the help file of the GraphPad Prism program [55].

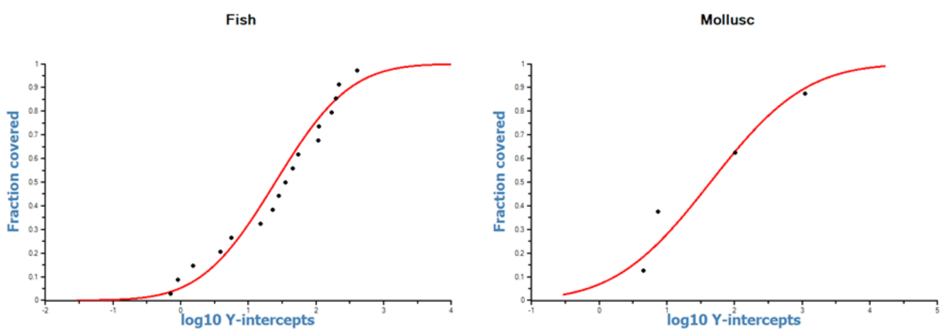


Figure 5. Distribution curve of Y-intercepts for fish (left) and molluscs (right).

The internal concentration in biota can be expressed as: C_{biota} = BAF x $C_{exp.}$ For the blue line in Figure 6 and Figure 7 it is converted to BAF = C_{biota} / C_{exp}, where C_{biota} is set to the $QS_{biota,\ secpois}$ for fish or mollusc as derived above and C_{exp} is the x-axis. From these graphs, a BAF and exposure concentration can be determined that are required to produce the C_{biota}. This is the intercept of the red and blue line.

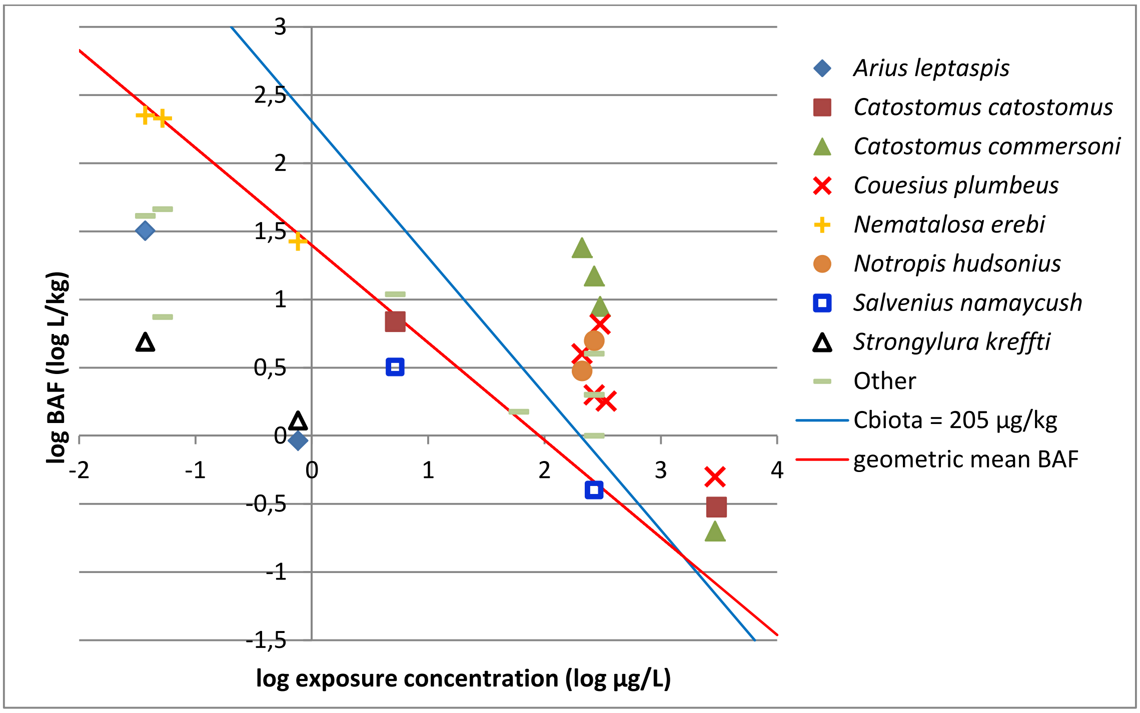


Figure 6. Bioaccumulation of uranium in fish as a function of water concentrations. The regression (red line) is based on the mean of all data points. The blue line is the line where BAF = C_{biota} / $C_{exp.}$ for C_{biota} = 205 µg/kg. See also text below.

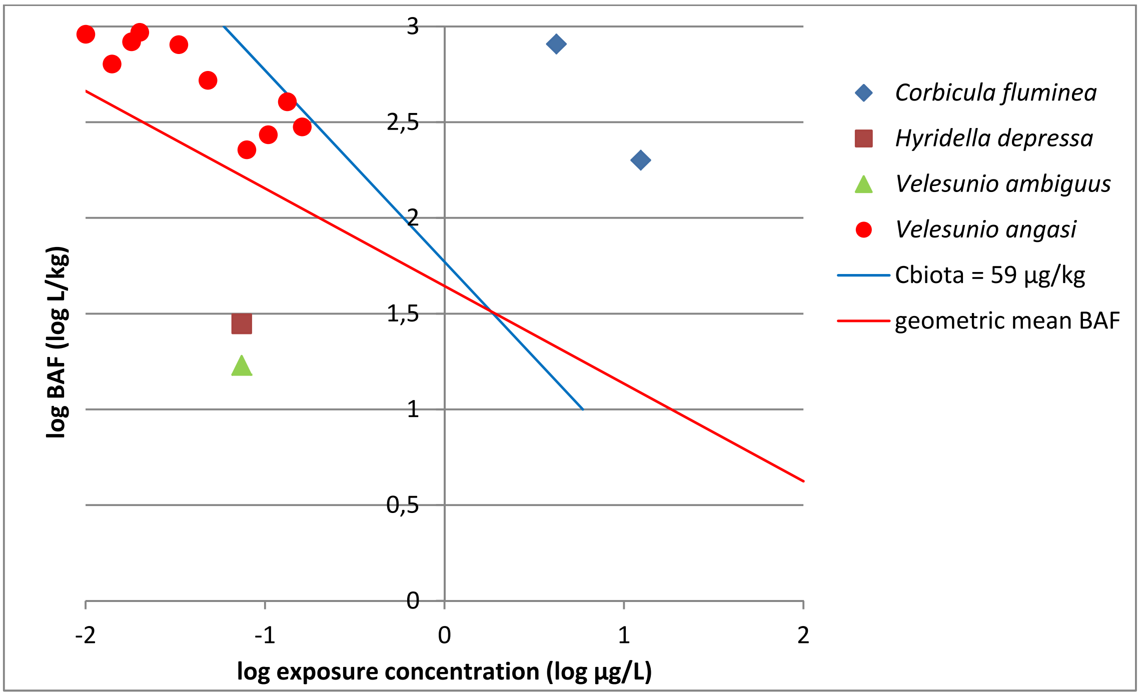


Figure 7. Bioaccumulation of uranium in mollusc as a function of water concentrations. The regression (red line) is based on the mean of all data points. The blue line is the line where BAF = C_{biota} / $C_{exp.}$ for C_{biota} = 59 µg/kg. See also text below.

Following the exercise as described above, the following BAFs and exposure concentrations are determined:

Secondary poisoning through fish
C_{biota} = $QS_{biota,\ secpois}$ = 205 μg/kg; BAF = 0.13 L/kg; C_{water} = 1593 μg/L

Secondary poisoning through molluscs
C_{biota} = $QS_{biota,\ secpois}$ = 59 μg/kg; BAF = 31.9 L/kg; C_{water} = 1.8 μg/L

It is considered that there are species consuming only molluscs (e.g. Tufted duck - *Aythya fuligula*), therefore, the values for molluscs are used to assess the exposure through secondary poisoning. The resulting the $QS_{fw,\ secpois}$ is therefore the C_{water} calculated for molluscs: 1.8 μg/L.

Bioaccumulation of metals is potentially different between fresh and salt water. Since no bioaccumulation data is available for the saltwater environment, a $QS_{sw,\ secpois}$ could not be derived.

5.1.2.3 Risks of exposure to water plants

Exposure of birds feeding on water plants is generally no part of the assessment of secondary exposure. The main reason is that it is not clear if mammal toxicity data can be used as a representative for birds, when data for the latter are missing. It should however be noted that several water plants have a high potential for accumulation of uranium as well as other metals [56,57]. For example, mean BAFs ranging from 221 L/kg to 22000 L/kg based on dry weight were reported for a large range of aquatic plant species [58-60] and values for *Nuphar lutea* range from 377 in summer to 2052 L/kg in spring [61]. For the latter study, it is not clear whether concentration factors are on a wet or dry weight basis, but presumably dry weight as well. Further, the reported units do not match with the reported concentration factors. In the Pratas and Favas studies [58-60], mean BAF values for 28 different species were given. For some species a correlation between the BAFs and the uranium concentration in the water was reported but details (e.g. slope and y-intercept) are not given. Nevertheless for most species no correlation between BAFs and exposure concentration was found and at the level of the derived $QS_{fw,\ secpois}$ the BAFs reported for these plants exceed critical levels. Therefore is concluided that the $QS_{fw,\ secpois}$ most likely is not protective for birds feeding exclusively on water plants. In this conclusion it is provided that birds are equally sensitive as mammals and the geometric mean of the concentration factors in the studies of Pratas and Favas are realistic for the level of the $QS_{fw,\ secpois}$. It is advised that this route is examined in the near future when new methodology on this is available [53].

5.1.3 $QS_{water,\ hh\ food}$

Derivation of $QS_{water,\ hh\ food}$ for uranium is triggered (see Section 3.5). This derivation is based on the TDI of 0.6 μg/kg_{bw}/day. From this TDI the $QS_{biota,\ hh\ food}$ can be calculated as 0.1 * 0.6*70/0.115 = 36.5 μg/kg_{food}. The amount of fishery products consumed by humans is not considered to be determined by the Daily Energy Expenditure and correction for caloric content is therefore not performed.

In order to determine the $QS_{water,\ hh\ food}$ and take concentration dependence of the BAF into account, the same exercise as performed for secondary poisoning is performed. In this case, the C_{biota} is set equal to $QS_{biota,\ hh,\ food}$ and the bioaccumulation by molluscs is used as worst case approach. This results in a shift in the blue line (see Figure 8). Bioaccumulation of metals is potentially different between fresh and salt water. Since only bioaccumulation data for freshwater are available, the $QS_{water,\ hh\ food}$ can only be derived for the freshwater compartment. In this way the following BAFs and exposure concentrations are determined:

C_{biota} = $QS_{biota,\ hh\ food}$ = 36.5 µg/kg; BAF = 52.6 L/kg; C_{water} = 0.69 µg/L

The resulting $QS_{fw,\ hh\ food}$ is the calculated C_{water}: 0.69 µg/L.
Since the BAF includes the natural back ground concentration, the added risk approach does not apply.

Since no bioaccumulation data is available for the saltwater environment, a $QS_{sw,\ hh\ food}$ cannot be derived.

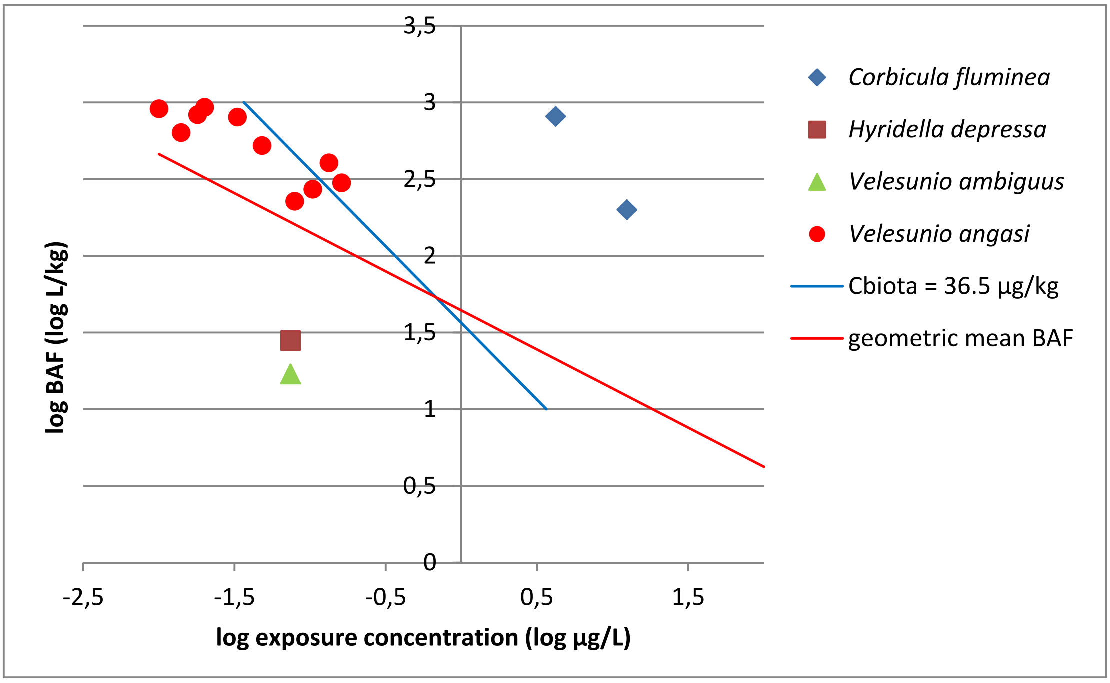


Figure 8. Bioaccumulation of uranium in molluscs as a function of water concentrations. The regression (red line) is based on the geometric mean of all data points where a species gets a higher weight on the basis of the number of data points. The blue line is the line where BAF = C_{biota} / C_{exp} for C_{biota} = 36.5 µg/kg as determined for human consumption of fishery products. See also text above.

5.1.4 *Selection of the AA-EQS_{fw} and AA-EQS_{sw}*

The derived QSs for the freshwater compartment are:

Direct toxicity ($QS_{fw,\ eco}$)	0.50 µg/L
Secondary poisoning ($QS_{fw,\ secpois}$)	1.8 µg/L
Human consumption of fishery product ($QS_{fw,\ hh\ food}$)	0.69 µg/L

The AA-EQS_{fw} is determined by the lowest QS_{fw}. This is the $QS_{fw,\ eco}$ of 0.50 µg/L, expressed as dissolved uranium and including the background concentration of 0.33 µg/L. The value without background is 0.17 µg/L.

For the saltwater environment no AA-EQS could be derived.

5.2 Derivation of $QS_{dw, hh}$

For the calculation of the $QS_{dw, hh}$, the added risk approach is not applied. A drinking water standard of 30 µg/L is available from the WHO [23,47]. This value will set the $QS_{dw, hh}$: 30 µg/L.

5.3 Derivation of $MAC\text{-}EQS_{eco}$

For derivation of the $MAC\text{-}QS_{added, fw, eco}$, a full base set is available.

5.3.1 Assessment factor approach

For derivation of the $MAC\text{-}QS_{added, fw, eco}$ with the assessment factor method, the default assessment factor of 100 can be applied to the lowest acute value available (67 µg U/L for *Chlorella* sp.*)*. The $MAC\text{-}QS_{added, fw, eco}$ will then be: 0.67 µg U/L. If however it could be argued that the mode of toxic action is known and the most sensitive taxonomic group is included in the dataset. Then an assessment factor of 10 would be applied. This is however not the case, the mode of action is not fully understood and toxic effects varies between species [62,6]. Also, the standard deviation of the log LC50 values is higher than 0.5.

5.3.2 SSD approach

The acute dataset does not fulfil all requirements for an SSD because endpoints for insects and a family in a phylum other than Arthropoda or Chordata are missing:

- Fish: *Ambassus macleayi*
- A second family in the phylum Chordata: *Craterocephalus marianae, Melanota splendida inorata, Melanotaenia nigrans, Mogurnda mogurnda, Pseudomugli tenellus* and *Salvenius fontinalis*
- A crustacean: *Ceriodaphnia dubia*, *Dadaya macrops*, *Daphnia magna, Diaphanosoma excisum, Latonopsis fasciculate* and *Moinodaphnia macleayi*
- An insect: no data
- A family in a phylum other than Arthropoda or Chordata: no data
- A family in any order of insect or any phylum not already represented: *Hydra viridissima*
- Algae: *Chlorella* sp.
- Higher plants: *Lemna aequinoctialis*

Nevertheless, from the chronic data set can be observed that the sensitivity of *Chironomus tentans* falls within the range of endpoints for the Crustacea. Since the acute dataset contains endpoints for six crustaceans, it can be concluded that the absence of an endpoint for insects is well covered by the endpoints for crustaceans. Furthermore, there are 16 acute endpoints, which is higher than the preferred minimum of 10-15. Therefore, an SSD is applied on the acute dataset. The SSD determined with ETX [48] is shown in Figure 9. The calculated HC5 is 86 µg U/L, with a two sided 90% confidence interval of 31 - 170 µg U/L. The goodness of fit is accepted at the levels 0.01, 0.025 and 0.05 by the three statistical tests available in the program. Because of this acceptable fit, the HC5 of the SSD can be used to determine the $MAC\text{-}QS_{added, fw, eco}$. With the default assessment factor 10, the $MAC\text{-}QS_{added, fw, eco}$ is 8.6 µg U/L. As can be seen from the acute data, this value is protective for all species in the dataset, including the lowest acute value for algae of 67 µg/L

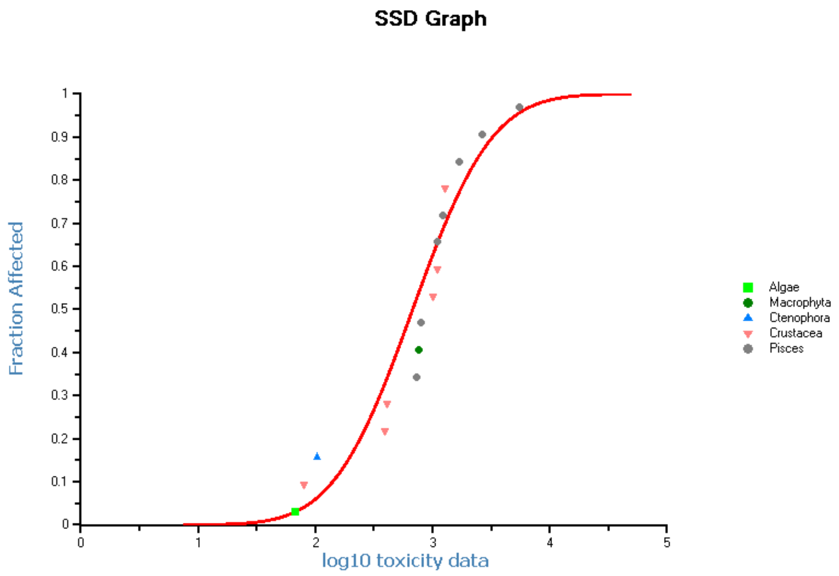


Figure 9 Species Sensitivity Distribution for uranium (acute data)

5.3.3 *Choice of the MAC-EQS$_{fw, eco}$*

The value from the AF method is about one order of magnitude lower than the MAC-QS$_{added}$ derived with the SSD. Nevertheless, the SSD method is preferred over the assessment factor method because it is based on the total acute dataset and is protective for all species in the dataset. Therefore the MAC-QS$_{added, fw, eco}$ will be 8.6 µg U/L. The MAC-EQS$_{fw}$ = MAC-QS$_{added}$ + C_b = 8.6 + 0.33 = 8.9 µg/L.

For saltwater, not enough toxicity data are available to derive a MAC-QS$_{sw, eco}$.

5.4 Derivation of NC

Negligible additions (NA) are derived by dividing the QS$_{added}$ by a factor of 100. With the AA-EQS$_{fw}$ based on the QS$_{added, fw, eco}$, the NA$_{added, fw, eco}$ will be: 0.17 / 100 = 1.7 ng U/L. With this value the NC$_{fw}$ will be equal to the backgound concentration: 0.33 µg U/L.

5.5 Derivation of SRC$_{water, eco}$

The SRA$_{fw, eco}$ is calculated as the HC50 of the SSD of the chronic endpoints including those from studies with a DOC-content of > 2mg/L. The calculated value is 56 µg U/L, with a two sided 90% confidence interval of 17 - 182 mg/L. The SRC$_{fw, eco}$ is determined by SRC = SRA + C_b = 56 + 0.33 = 56 µg/L.

6 Comparison of derived EQSs with monitoring data

The Dutch Ministry of Infrastructure and Environment does present monitoring data for substances in water and sediment on its website (life.waterbase.nl), but data on uranium are not included. An evaluation of monitoring data over 2006-2009 by Van Duijnhoven [63] showed that the current MPC for uranium was exceeded at several monitoring locations. In 2009, measured 90th percentile concentrations in filtered freshwater samples ranged from 0.22 to 1.5 μg/L, concentrations in saltwater were between 0.78 and 2.44 μg/L. These measurements are partly higher than the proposed AA-EQS values, but since they involve 90th percentiles rather than annual averages, a direct comparison cannot be made.

The RIWA (Dutch Association of River Water companies) reports monitoring data for uranium in the Rhine and Meuse basins. Total concentrations and concentrations after filtration are given are given in Table 25 for the years 2006-2012. It can be concluded that annual average concentrations in the Rhine exceed the newly proposed AA-EQS_{fw} (0.5 μg U/L, dissolved). For the Meuse the proposed AA-EQS_{fw} was only exceeded in a few occasions. None of the maximum concentrations exceeds the MAC-EQS_{eco} for freshwater (8.9 μg U/L, dissolved). In 2012, the annual average was below the QS derived for human consumption of fish of 0.69 μg/L in almost all cases, and a risk for humans is not expected.

Since agricultural use is one of the potential sources of uranium emission, it may be expected that higher concentrations may be found in smaller water bodies adjacent to places of fertiliser use. A full evaluation of such data, if available, is outside the scope of this report. The new standards will be used for the preparation of the river basin management plans for the next assessment period (2016-2021), and this will reveal if measures are needed on a river basin scale.

Table 25 Total and dissolved concentrations (µg U/L) of uranium in surface water of the Rhine and Meuse for the years 2006-2012. Source: RIWA

Location	**2006**		**2007**		**2008**		**2009**		**2010**		**2011**		**2012**		**Average 2006-2012**
	aa.[d]	max	aa.	max	aa.	max	aa.	max	aa.	max	aa.	max	aa.	max	
Rhine															
Lobith	0.76	0.89	0.75	0.90	0.77	0.85	0.76	0.88	0.76	0.80	0.81	0.94	0.72	0.84	0.76
after filtration	0.72	0.91	0.71	0.75	0.76	0.84	0.74	0.85	0.73	0.85	0.77	0.95	0.70	0.81	0.73
Nieuwegein [a]	- [e]	-	-	-	-	-	-	-	0.77	0.88	0.83	0.98	0.72	0.85	0.77
after filtration	-	-	-	-	-	-	-	-	0.74	0.85	0.78	0.99	0.69	0.83	0.74
Nieuwersluis [b]	0.72	0.80	-	-	-	-	-	-	0.70	0.74	0.72	0.85	0.67	0.78	0.70
after filtration	-	-	-	-	-	-	-	-	0.69	0.74	0.70	0.86	0.66	0.78	0.68
Andijk [c]	-	-	-	-	-	-	-	-	0.65	0.73	0.67	0.79	0.60	0.69	0.64
after filtration	-	-	-	-	-	-	-	-	0.64	0.67	0.66	0.80	0.60	0.67	0.63
								Overall average for the Rhine basin					before filtration		0.72
													after filtration		0.70
Meuse															
Eijsden	0.48	0.87	0.40	0.66	0.45	1.2	-	-	-	-	0.51	0.68	0.36	0.56	0.44
after filtration	0.46	0.84	0.39	0.59	0.44	0.87	-	-	-	-	0.50	0.67	0.35	0.56	0.43
Heel	-	-	-	-	-	-	-	-	0.44	0.58	0.49	0.61	0.37	0.51	0.43
after filtration	-	-	-	-	-	-	-	-	0.42	0.58	0.48	0.61	0.36	0.51	0.42
Brakel	-	-	-	-	-	-	-	-	0.48	0.54	0.46	0.53	0.42	0.54	0.45
after filtration	-	-	-	-	-	-	-	-	0.48	0.53	0.46	0.55	0.43	0.54	0.46
Keizersveer	0.40	0.52	0.36	0.45	0.35	0.45	-	-	0.57	0.62	0.41	0.46	0.34	0.39	0.41
after filtration	0.39	0.48	0.36	0.45	-	-	-	-	0.37	0.45	0.39	0.45	0.32	0.39	0.37
Stellendam	-	-	-	-	-	-	-	-	0.65	0.77	0.74	0.89	0.61	0.73	0.67
after filtration	-	-	-	-	-	-	-	-	0.66	0.78	0.73	0.89	0.61	0.75	0.67
								Overall average for the Meuse basin					before filtration		0.48
													after filtration		0.47

[a] Lek canal.

[b] Amsterdam-Rhine canal.

[c] Lake IJsselmeer

[d] aa. = annual average.

[e] - = not reported.

7 Conclusions

In this report, the Annual Average Environmental Quality Standard (AA-EQS), Maximum Acceptable Concentration for ecosystems (MAC-EQS), additional risk limits Negligible Concentration (NC), and Serious Risk Concentration for ecosystems (SRC_{eco}) are derived for uranium in fresh surface waters. Direct ecotoxicity appeared to be the most critical route for derivation of the AA-EQS. However, the potential risks for birds feeding exclusively on water plants have not been fully examined. It is therefore not clear if the proposed AA-EQS for freshwater is sufficiently protective for this route.
Corresponding values for the saltwater compartment could not be derived due to a lack of data on bioaccumulation and ecotoxicity data for saltwater species.
The proposed EQSs and additional risk limits are summarised in the table below.
The proposed AA-EQS for freshwater of 0.5 µg U/L is lower than the current standard of 1.33 µg U/L.
Monitoring data indicate that the proposed $AA\text{-}EQS_{fw}$ will most likely be exceeded in some of the Dutch surface waters. In the recent past, there have been no cases where the proposed $MAC\text{-}EQS_{fw}$ has been exceeded.

Table 26. Summary of proposed water quality standards for uranium. Values in bold are required standards according to the WFD. Values are expressed as dissolved concentrations, including background levels.

	Value [µg U/L]
Freshwater	
AA-EQS	**0.5**
MAC-EQS	**8.9**
NC	0.33
SRC	56
Surface water for drinking water production	
$QS_{dw, hh}$	**30**

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Appendix 1 - SCOPUS search profile

((TITLE-ABS-KEY(ec50* OR ec20* OR ec10* OR lc50* OR lc20* OR lc10* OR noec* OR loec* OR matc OR tlm OR chv OR ecx OR bioassay*)) AND (TITLE-ABS-KEY(uranium OR uraniumoxide OR uraniumdioxide OR uranyl* OR "bis(acetato-O)dioxouranium" OR "bis(nitrato-O)dioxouranium") OR CASREGNUMBER(7440-61-1 OR 1344-57-6 OR 541-09-3 OR 10102-06-4))) OR ((TITLE-ABS-KEY(bioassay* OR mortalit* OR phytotox* OR reproduct* OR lethal* OR growth OR teratogen*)) AND (TITLE-ABS-KEY(uranium OR uraniumoxide OR uraniumdioxide OR uranyl* OR "bis(acetato-O)dioxouranium" OR "bis(nitrato-O)dioxouranium") OR CASREGNUMBER(7440-61-1 OR 1344-57-6 OR 541-09-3 OR 10102-06-4)))

Appendix 2 - Data on bioaccumulation

Legend to data tables	Species properties
A	Test water analysed Yes/No
Test type	S = static; R = renewal; F = flow-through
Test water	am = artificial medium; dtw = dechlorinated tap water; dw = de-ionised/dechlorinated/distilled water; nw = natural water; rw = reconstituted (sea)water; rtw = reconstituted tap water; tw = tap water
Ri	Reliability index, see section 2.2

Table A2.1 Bioaccumulation factors for aquatic organisms

Species	Species properties	Test substance	Analysis	Sampling area	Sampling period	pH	Hardness [mg CaCO3/l]	*T* [°C]	Exposure conc. [μg/L]	Exposure type	BAF [l/kg$_{w.w.}$]	BAF type	Notes	Ri	Ref.
Fish															
Arius leptaspis	Fork-tailed catfish	238U	alpha spectrometry	Georgetown billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85 monthly	near neutral			0.76	dissolved U	0.85	whole body, ww	1,3	2	[24]
Arius leptaspis	Fork-tailed catfish	238U	alpha spectrometry	Mudginberri billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85 monthly	near neutral			0.037	dissolved U	41	whole body, ww	1,2	2	[24]
Arius leptaspis	Fork-tailed catfish	234U	alpha spectrometry	Georgetown billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85 monthly	near neutral			0.76	dissolved U	1.0	whole body, ww	1,3	2	[24]
Arius leptaspis	Fork-tailed catfish	234U	alpha spectrometry	Mudginberri billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85 monthly	near neutral			0.037	dissolved U	25	whole body, ww	1,2	2	[24]
Catostomus catostomus			fluorescence	Okanagan Highlands, Central British Columbia, Canada	July				340	dissolved U	14.7	flesh, ww	25	4	[64]
Catostomus catostomus	Longnose sucker	Uranium	fluorescence	Tailings system site 2 in Beaverlodge Lake area, Saskatchewam, Canada	13-25 July '79				3000	total U	0.3	whole body, ww	4,5	2	[25]
Catostomus catostomus	Longnose sucker	Uranium	fluorescence	Fulton lake in Beaverlodge Lake area, Saskatchewam, Canada	13-25 July '79				5.2	total U	6.9	whole body, ww	4,6	2	[25]
Catostomus catostomus	Longnose sucker	Uranium		Wollaston Lake							25 - 181	tissue	7	4	[65]
Catostomus commersoni		Uranium	neutron activation	Tailings Creek Mouth	1982	7.9	81		300	total U	8.9	whole body, ww		2	[26]
Catostomus commersoni		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	33	skin, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	8	flesh, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	117	bone, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	2950	stomach, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	133	liver, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	8	gonad, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	9	skin, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	0.2	flesh, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	40	bone, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	254	stomach, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	6	liver, ww		3	[26]
Catostomus commersoni		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	2	gonad, ww		3	[26]
Catostomus commersoni	White sucker	Uranium	fluorescence	Beaverlodge Lake, Saskatchewam, Canada	13-25 July '79				267	total U	13	whole body, ww	4,5	2	[25]
Catostomus commersoni	White sucker	Uranium	fluorescence	Beaverlodge Lake, Saskatchewam, Canada	13-25 July '79				267	total U	17	whole body, ww	4,5	2	[25]
Catostomus commersoni	White sucker	Uranium	fluorescence	Mouth of ace creek in Beaverlodge Lake area, Saskatchewam, Canada	13-25 July '79				210	total U	24	whole body, ww	4,5	2	[25]
Catostomus commersoni	White sucker	Uranium	fluorescence	Tailings system site 1 in Beaverlodge Lake area, Saskatchewam, Canada	13-25 July '79				2916	total U	0.2	whole body, ww	4,5	2	[25]

Species	Species properties	Test substance	Analysis	Sampling area	Sampling period	pH	Hardness [mg CaCO3/l]	*T* [°C]	Exposure conc. [µg/L]	Exposure type	BAF [l/kg$_{w.w.}$]	BAF type	Notes	Ri	Ref.
Catostomus commersoni	White sucker	Uranium		Lake Beaverlodge							4.2 - 7.7	tissue	7	4	[65]
Catostomus commersoni	White sucker	Uranium		Wollaston Lake							4.4 - 6.3	tissue	7	4	[65]
Coregonus artedii	Cisco	Uranium	fluorescence	Beaverlodge Lake, Saskatchewam, Canada	13-25 July '79				267	total U	2	whole body, ww	4,5	2	[25]
Coregonus clupeaformis		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	83	skin, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	5	flesh, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	458	bone, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	1583	stomach, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	133	liver, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Lake Milliken	1982	7.5-7.6	56		1.2	total U	50	gonad, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	6	skin, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	0.2	flesh, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	39	bone, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	488	stomach, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	11	liver, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Beaverlodge lake	1982	7.8-7.9	79		338	total U	1	gonad, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Fredette Lake		7.5-7.6	44		3.25	total U	77	skin, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Fredette Lake		7.5-7.6	44		3.25	total U	3	flesh, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Fredette Lake		7.5-7.6	44		3.25	total U	335	bone, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Fredette Lake		7.5-7.6	44		3.25	total U	5551	stomach, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Fredette Lake		7.5-7.6	44		3.25	total U	231	liver, ww		3	[26]
Coregonus clupeaformis		Uranium	neutron activation	Fredette Lake		7.5-7.6	44		3.25	total U	129	gonad, ww		3	[26]
Coregonus clupeaformis	lake white fish	Uranium	fluorescence	Beaverlodge Lake, Saskatchewam, Canada	13-25 July '79				267	total U	4	whole body, ww	4,5	2	[25]
Coregonus clupeaformis	Lake white fish	Uranium		St Mary's Channel, Back Bay and Langley Bay of Lake Athabasca							56 - 122	tissue	7	4	[65]
Coregonus clupeaformis	Lake white fish	Uranium		Lakes near Elliot Lake, Ontario							30 - 559	tissue	7	4	[65]
Coregonus clupeaformis	Lake white fish	Uranium		Lake Beaverlodge							3.3 - 50	tissue	7	4	[65]
Couesius plumbeus		Uranium	neutron activation	Tailings Creek Mouth	1982	7.9	81		300	total U	6.6	whole body, ww		2	[26]
Couesius plumbeus		Uranium	neutron activation	Beaverlodge Lake	1982	7,8-7,9	79		338	total U	1.8	whole body, ww		2	[26]
Couesius plumbeus	Lake chub	Uranium	fluorescence	Beaverlodge Lake, Saskatchewam, Canada	13-25 July '79				267	total U	2	whole body, ww	4,5	2	[25]
Couesius plumbeus	Lake chub	Uranium	fluorescence	Mouth of ace creek in Beaverlodge Lake area, Saskatchewam, Canada	13-25 July '79				210	total U	4	whole body, ww	4,5	2	[25]
Couesius plumbeus	Lake chub	Uranium	fluorescence	Tailings system site 1 in Beaverlodge Lake area, Saskatchewam, Canada	13-25 July '79				2916	total U	0.5	whole body, ww	4,5	2	[25]
Couesius plumbeus	Lake chub	Uranium		Lake Beaverlodge							0.3 - 1.6	tissue	7	4	[65]
Esox lucius	Northern pike	Uranium		St Mary's Channel, Back Bay and Langley Bay of Lake Athabasca							0.79 - 1875	tissue	7	4	[65]
Esox lucius	Northern pike	Uranium		Lake Beaverlodge							1.2 - 1.6	tissue	7	4	[65]
Esox lucius	Northern pike	Uranium		Wollaston Lake							7.5 - 40	tissue	7	4	[65]
Fish	*Clupea harengus, Gadus morhua, Pleuronectes flesus, Sprattus sprattus*	238U	electroplating/alpha spectr.	Southern Baltic Sea	1980-1991				0.68-0.85	total U	1.3	whole body	8	3	[66-68]
Fish	*Clupea harengus, Gadus morhua, Pleuronectes flesus, Sprattus sprattus*	238U	electroplating/alpha spectr.	Southern Baltic Sea	1980-1991				0.68-0.85	total U	0.4	muscle, ww	8	3	[67,68]
Fish	*Clupea harengus, Gadus morhua, Pleuronectes flesus, Sprattus sprattus*	238U	electroplating/alpha spectr.	Southern Baltic Sea	1980-1991				0.68-0.85	total U	7.6	viscera	8	3	[67,68]
Fish											0.1-38	flesh, ww	9	4	[69]
Fish											2-800	bone, ww	9	4	[69]
Fish											0.4-150	liver, ww	9	4	[69]
Fish											0.4-150	skin, ww	9	4	[69]
Fish											0.1-38	whole body, ww	9	4	[69]
Fish		Uranium	fluoresc. (water); neutron act. (biota)	Kreminiscica stream below confluence with streams from the tip	1980				2.2	total U	0.7	whole body, ww		4	[70]
Fish		Uranium	fluoresc. (water); neutron act. (biota)	Brebovscica above confluence with mine water	1980				4.7	total U	1.3	whole body, ww		4	[70]

Species	Species properties	Test substance	Analysis	Sampling area	Sampling period	pH	Hardness [mg CaCO3/l]	*T* [°C]	Exposure conc. [µg/L]	Exposure type	BAF [l/kg$_{w.w.}$]	BAF type	Notes	Ri	Ref.
Fish		Uranium	fluoresc. (water); neutron act. (biota)	Brebovscica below confluence with mine water	1980				12.5	total U	1.6	whole body, ww		4	[70]
Fish		Uranium	fluoresc. (water); neutron act. (biota)	Sava above Hrastnik	1980				0.77	total U	2.3	whole body, ww		4	[70]
Fish		Uranium	fluoresc. (water); neutron act. (biota)	Sava below Hrastnik	1980				1.14	total U	38	whole body, ww		4	[70]
Fish		Uranium	fluoresc. (water); neutron act. (biota)	Boben below chem. Factory	1980				1.22	total U	0.9	whole body, ww		4	[70]
Fish		Uranium		two locations in Sweden	1979-1981						20-270	flesh	10	3	[71]
Fish		Uranium		two locations in Sweden	1979-1981						100-2500	liver	10	3	[71]
Fish		Uranium		two locations in Sweden	1979-1981						300-6000	bone	10	3	[71]
Fish		238U, 234U		Alligator rivers region		4.5-6.5					140			4	[72]
Fish group 1	*Nematalosa erebi, Oxyeleotris lineolatus*		alpha spectrometry	Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.037-0.76	dissolved U	250	whole body, ww		4	[24]
Fish group 2	*Arius leptaspis, Lates calcarifer, Strongylura kreffti, Megalops cyprinoides*		alpha spectrometry	Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.037-0.76	dissolved U	15	whole body, ww		4	[24]
Lates calcarifer	Barramundi	238U	alpha spectrometry	Mudginberri billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.037	dissolved U	48	whole body, ww	1,2	2	[24]
Lates calcarifer	Barramundi	234U	alpha spectrometry	Mudginberri billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.037	dissolved U	36	whole body, ww	1,2	2	[24]
Megalops cyprinoides	Tarpon	238U	alpha spectrometry	Gunirdul billabong, Cooper Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.052	dissolved U	7.8	whole body, ww	1,2	2	[24]
Megalops cyprinoides	Tarpon	234U	alpha spectrometry	Gunirdul billabong, Cooper Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.052	dissolved U	7.1	whole body, ww	1,2	2	[24]
Nematalosa erebi	Bony bream	238U	alpha spectrometry	Georgetown billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.76	dissolved U	27	whole body, ww	1,3	2	[24]
Nematalosa erebi	Bony bream	238U	alpha spectrometry	Mudginberri billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.037	dissolved U	261	whole body, ww	1,3	2	[24]
Nematalosa erebi	Bony bream	238U	alpha spectrometry	Gunirdul billabong, Cooper Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.052	dissolved U	203	whole body, ww	1,2	2	[24]
Nematalosa erebi	Bony bream	234U	alpha spectrometry	Georgetown billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.76	dissolved U	27	whole body, ww	1,3	2	[24]
Nematalosa erebi	Bony bream	234U	alpha spectrometry	Mudginberri billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.037	dissolved U	194	whole body, ww	1,3	2	[24]
Nematalosa erebi	Bony bream	234U	alpha spectrometry	Gunirdul billabong, Cooper Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.052	dissolved U	224	whole body, ww	1,2	2	[24]
Notropis hudsonius	Spottail shiner	Uranium	fluorescence	Beaverlodge Lake, Saskatchewam, Canada	13-25 July '79				267	total U	5	whole body, ww	4,5	2	[25]
Notropis hudsonius	Spottail shiner	Uranium	fluorescence	Mouth of ace creek in Beaverlodge Lake area, Saskatchewam, Canada	13-25 July '79				210	total U	3	whole body, ww	4,5	2	[25]
Oncorhynchus mykiss			fluorescence	Okanagan Highlands, Central British Columbia, Canada					340	dissolved U	14.7	flesh, ww	25	4	[64]
Oxyeleotris lineolatus	Sleepy cod	238U	alpha spectrometry	Gunirdul billabong, Cooper Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.052	dissolved U	45	whole body, ww	1,2	2	[24]
Oxyeleotris lineolatus	Sleepy cod	234U	alpha spectrometry	Gunirdul billabong, Cooper Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.052	dissolved U	47	whole body, ww	1,2	2	[24]
Percopsis omiscomaycus	Trout-perch	Uranium	fluorescence	Beaverlodge Lake, Saskatchewam, Canada	13-25 July '79				267	total U	2	whole body, ww	4,5	2	[25]
Prosopium cylindraceum	Round whitefish	Uranium	fluorescence	Fulton lake in Beaverlodge Lake area, Saskatchewam, Canada	13-25 July '79				5.2	total U	10.9	whole body, ww	4,6	2	[25]
Pungitius pungitius	Nine-spine stickleback	Uranium	fluorescence	Beaverlodge Lake, Saskatchewam, Canada	13-25 July '79				267	total U	1	whole body, ww	4,5	2	[25]
Salmo trutta	Brown trout	Uranium	tissue radioact. conv. to U conc.	Marshall Creek upstream of indian creek Gunnison National Forest, Colorado, USA	05-May-'81				1		5.9	whole body	11	3	[27]
Salmo trutta	Brown trout	Uranium	tissue radioact. conv. to U conc.	Marshall Creek downstream of indian creek Gunnison National Forest, Colorado, USA	one year, '81				60		1.5	whole body	12	2	[27]
Salmo trutta	Brown trout	Uranium	tissue radioact. conv. to U conc.	Tomichi Creek upstream of Marshall creek Gunnison National Forest, Colorado, USA	05-May-'81				2		0.08	whole body	11	3	[27]

Species	Species properties	Test substance	Analysis	Sampling area	Sampling period	pH	Hardness [mg CaCO3/l]	*T* [°C]	Exposure conc. [µg/L]	Exposure type	BAF [l/kg$_{w.w.}$]	BAF type	Notes	Ri	Ref.
Salmo trutta	Brown trout	Uranium	tissue radioact. conv. to U conc.	Tomichi Creek downstream of Marshall creek Gunnison National Forest, Colorado, USA	05-May-'81				9		0.33	whole body	11	3	[27]
Salvelinus namaycush		Uranium	ICP-MS	Quirke Lake, ON, Canada					13	total U	167	bone, ww	13	4	[73]
Salvelinus namaycush		Uranium	ICP-MS	McCabe Lake, ON, Canada					3	total U	27	bone, ww	13	4	[73]
Salvelinus namaycush		Uranium	ICP-MS	Whiskey Lake, ON, Canada					35	total U	31	bone, ww	13	4	[73]
Salvelinus namaycush		Uranium	ICP-MS	Elliot Lake, ON, Canada					1	total U	101	bone, ww	13	4	[73]
Salvelinus namaycush	Lake trout	Uranium		Lakes near Elliot Lake, Ontario							17 - 48	tissue	7	4	[65]
Salvelinus namaycush	Lake trout	Uranium		Lake Beaverlodge							1.2 - 3.4	tissue	7	4	[65]
Salvenius namaycush	lake trout	Uranium	fluorescence	Beaverlodge Lake, Saskatchewam, Canada	13-25 July '79				267	total U	0.4	whole body, ww	4,5	2	[25]
Salvenius namaycush	lake trout	Uranium	fluorescence	Fulton lake in Beaverlodge Lake area, Saskatchewam, Canada	13-25 July '79				5.2	total U	3.2	whole body, ww	4,6	2	[25]
Strongylura kreffti	Long tom	238U	alpha spectrometry	Georgetown billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.76	dissolved U	1.4	whole body, ww	1,3	2	[24]
Strongylura kreffti	Long tom	238U	alpha spectrometry	Mudginberri billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.037	dissolved U	4.3	whole body, ww	1,2	2	[24]
Strongylura kreffti	Long tom	234U	alpha spectrometry	Georgetown billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.76	dissolved U	1.2	whole body, ww	1,3	2	[24]
Strongylura kreffti	Long tom	234U	alpha spectrometry	Mudginberri billabong, Magela Creek, Alligator River Region, Northern Territory, Australia	'84-'85, monthly	near neutral			0.037	dissolved U	5.6	whole body, ww	1,2	2	[24]
Whitefish	*Coregonus clupeaformis, Prosopium cylindraceum*	Uranium	ICP-MS	McCabe Lake, ON, Canada					3	total U	208	bone, ww	13	4	[73]
Whitefish	*Coregonus clupeaformis, Prosopium cylindraceum*	Uranium	ICP-MS	Whiskey Lake, ON, Canada					35	total U	206	bone, ww	13	4	[73]
Whitefish	*Coregonus clupeaformis, Prosopium cylindraceum*	Uranium	ICP-MS	Elliot Lake, ON, Canada					1	total U	8320	bone, ww	13	4	[73]
Whitefish	*Coregonus clupeaformis, Prosopium cylindraceum*	Uranium	ICP-MS	Whiskey Lake, ON, Canada					35	total U	2	muscle, ww	13	4	[73]
Whitefish	*Coregonus clupeaformis, Prosopium cylindraceum*	Uranium	ICP-MS	Elliot Lake, ON, Canada					1	total U	24	muscle, ww	13	4	[73]
Mollusc															
Bivalves	*Astarte borealis, Cardium glaucum, Macoma balthica, Mya arenaria, Mytilus edulis*	238U	electroplating/alpha spectr.	Southern Baltic Sea	1980-1991				0.68-0.85	total U	55	whole body	14	3	[67,68]
Bivalves	*Astarte borealis,Cardium glaucum, Macoma balthica, Mya arenaria, Mytilus edulis*	238U	electroplating/alpha spectr.	Southern Baltic Sea	1980-1991				0.68-0.85	total U	82	soft tissue	14	3	[67,68]
Bivalves	*Astarte borealis, Cardium glaucum, Macoma balthica, Mya arenaria, Mytilus edulis*	238U	electroplating/alpha spectr.	Southern Baltic Sea	1980-1991				0.68-0.85	total U	30	shell	14	3	[67,68]
Corbicula fluminea	fw 0.56 g	Uranium	ICP-OES	River Ritord, Vienne, FR	42 days	6			4.2	dissolved U	810	whole body, ww	15	2	[28]
Corbicula fluminea	fw 0.65 g	Uranium	ICP-OES	River Ritord, Vienne, FR	42 days	6.4			12.4	dissolved U	200	whole body, ww	15	2	[28]
Freshwater mussel		238U, 234U		Alligator rivers region		4.5-6.5					100			4	[72]
Hyridella depressa	Length 40-69 mm	Uranium	ICPMS	Hawkesbury-Nepean River, south-eastern Australia		7.1	36.5		0.074	mean total	339	whole tissue, dw, recalc. to ww		2	[29]
Pisidium sp.			fluorescence	Okanagan Highlands, Central British Columbia, Canada					340	dissolved U	306	whole body, ww	25	4	[64]
Velesunio ambiguus	Length 40-65 mm	Uranium	ICPMS	Hawkesbury-Nepean River, south-eastern Australia		7.1	36.5		0.074	mean total	204	whole tissue, dw, recalc. to ww		2	[29]
Velesunio angasi		Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.161	dissolved U	5590	whole body, dw	16,20	2	[32]
Velesunio angasi		Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.109	dissolved U	14220	whole body, dw	17,20,21	3	[32]
Velesunio angasi		Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.079	dissolved U	3924	whole body, dw	18,20	2	[32]
Velesunio angasi		Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.104	dissolved U	3942	whole body, dw	19,20	2	[32]
Velesunio angasi	Age 1.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.161	dissolved U	2335	whole body, dw	16	2	[32]
Velesunio angasi	Age 2.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.161	dissolved U	6211	whole body, dw	16	2	[32]
Velesunio angasi	Age 3 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.161	dissolved U	2348	whole body, dw	16	2	[32]

Species	Species properties	Test substance	Analysis	Sampling area	Sampling period	pH	Hardness [mg CaCO3/l]	*T* [°C]	Exposure conc. [µg/L]	Exposure type	BAF [l/$kg_{w.w.}$]	BAF type	Notes	Ri	Ref.
Velesunio angasi	Age 3.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.161	dissolved U	3311	whole body, dw	16	2	[32]
Velesunio angasi	Age 4.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.161	dissolved U	3466	whole body, dw	16	2	[32]
Velesunio angasi	Age 3.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.109	dissolved U	4009	whole body, dw	17,21	3	[32]
Velesunio angasi	Age 4.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.109	dissolved U	4385	whole body, dw	17,21	3	[32]
Velesunio angasi	Age 2.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.079	dissolved U	5772	whole body, dw	18	2	[32]
Velesunio angasi	Age 2.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.079	dissolved U	1532	whole body, dw	18	2	[32]
Velesunio angasi	Age 3.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.079	dissolved U	1734	whole body, dw	18	2	[32]
Velesunio angasi	Age 4.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.079	dissolved U	3506	whole body, dw	18	2	[32]
Velesunio angasi	Age 5.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.079	dissolved U	1620	whole body, dw	18	2	[32]
Velesunio angasi	Age 7.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.079	dissolved U	3329	whole body, dw	18	2	[32]
Velesunio angasi	Age 3.5 y	Uranium	ICPMS	South Alligator River, North. Terr., AUS	Nov. 2000				0.104	dissolved U	2721	whole body, dw	19	2	[32]
Velesunio angasi	Age 1 y, 0.29 g, n=12	Uranium	ICP-MS	Bowerbird Billabong	May '07				0.01	dissolved U	14000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 2 y, 0.47 g, n=14	Uranium	ICP-MS	Bowerbird Billabong	May '07				0.01	dissolved U	14000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 3 y, 0.84 g, n=10	Uranium	ICP-MS	Bowerbird Billabong	May '07				0.01	dissolved U	13000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 4 y, 0.79 g, n=18	Uranium	ICP-MS	Bowerbird Billabong	May '07				0.01	dissolved U	10000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 5 y, 1.03 g, n=11	Uranium	ICP-MS	Bowerbird Billabong	May '07				0.01	dissolved U	11000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 6 y, 1.59 g, n=2	Uranium	ICP-MS	Bowerbird Billabong	May '07				0.01	dissolved U	7000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 7 y, 1.57 g, n=2	Uranium	ICP-MS	Bowerbird Billabong	May '07				0.01	dissolved U	12000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 8 y, 1.93 g, n=2	Uranium	ICP-MS	Bowerbird Billabong	May '07				0.01	dissolved U	7000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 10 y, 1.76 g, n=1	Uranium	ICP-MS	Bowerbird Billabong	May '07				0.01	dissolved U	14000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 1 y, 0.19 g, n=53	Uranium	ICP-MS	Magela Creek upstream	May '07				0.018	dissolved U	13000	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 2 y, 0.43 g, n=14	Uranium	ICP-MS	Magela Creek upstream	May '07				0.018	dissolved U	12000	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 3 y, 0.61 g, n=9	Uranium	ICP-MS	Magela Creek upstream	May '07				0.018	dissolved U	9000	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 4 y, 0.71 g, n=11	Uranium	ICP-MS	Magela Creek upstream	May '07				0.018	dissolved U	9000	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 5 y, 0.91 g, n=2	Uranium	ICP-MS	Magela Creek upstream	May '07				0.018	dissolved U	8000	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 1 y, 0.57g, n=23	Uranium	ICP-MS	Georgetown confluence	May '07				0.133	dissolved U	5700	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 2 y, 0.96 g, n=12	Uranium	ICP-MS	Georgetown confluence	May '07				0.133	dissolved U	4400	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 3 y, 1.22 g, n=11	Uranium	ICP-MS	Georgetown confluence	May '07				0.133	dissolved U	4500	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 4 y, 1.37 g, n=10	Uranium	ICP-MS	Georgetown confluence	May '07				0.133	dissolved U	4900	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 5 y, 1.44 g, n=11	Uranium	ICP-MS	Georgetown confluence	May '07				0.133	dissolved U	3900	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 6 y, 1.37 g, n=4	Uranium	ICP-MS	Georgetown confluence	May '07				0.133	dissolved U	5300	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 8 y, 1.88 g, n=2	Uranium	ICP-MS	Georgetown confluence	May '07				0.133	dissolved U	5000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 9 y, 1.68 g, n=2	Uranium	ICP-MS	Georgetown confluence	May '07				0.133	dissolved U	5500	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 1 y, 0.16 g, n=38	Uranium	ICP-MS	Magela Creek downstream	May '07				0.048	dissolved U	9600	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 2 y, 0.52 g, n=9	Uranium	ICP-MS	Magela Creek downstream	May '07				0.048	dissolved U	7100	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 3 y, 0.55 g, n=9	Uranium	ICP-MS	Magela Creek downstream	May '07				0.048	dissolved U	6900	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 4 y, 0.65 g, n=17	Uranium	ICP-MS	Magela Creek downstream	May '07				0.048	dissolved U	5400	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 5 y, 0.72 g, n=5	Uranium	ICP-MS	Magela Creek downstream	May '07				0.048	dissolved U	6000	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 6 y, 0.79 g, n=2	Uranium	ICP-MS	Magela Creek downstream	May '07				0.048	dissolved U	4800	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 7 y, 0.80 g, n=5	Uranium	ICP-MS	Magela Creek downstream	May '07				0.048	dissolved U	5400	whole body, dw	23	2	[30,31]
Velesunio angasi	Age 1 y, 0.27 g, n=10	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	8500	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 2 y, 0.31 g, n=16	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	8200	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 3 y, 0.43 g, n=19	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	8800	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 4 y, 0.41 g, n=7	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	6700	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 5 y, 0.49 g, n=6	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	9700	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 6 y, 0.45 g, n=9	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	11000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 7 y, 0.51 g, n=10	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	11000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 8 y, 0.57 g, n=5	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	10000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 9 y, 0.52 g, n=1	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	7900	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 10 y, 0.60 g, n=2	Uranium	ICP-MS	Mudginberri Billabong	May '07				0.033	dissolved U	19000	whole body, dw	22	2	[30,31]
Velesunio angasi	Age 1 y, 0.18g , n=10	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	12000	whole body, dw	22	2	[30]
Velesunio angasi	Age 2 y, 0.56 g, n=14	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	9500	whole body, dw	22	2	[30]
Velesunio angasi	Age 3 y, 0.74 g, n=13	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	9000	whole body, dw	22	2	[30]
Velesunio angasi	Age 4 y, 0.94 g, n=6	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	7500	whole body, dw	22	2	[30]
Velesunio angasi	Age 5 y, 0.89 g, n=6	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	9000	whole body, dw	22	2	[30]
Velesunio angasi	Age 6 y, 1.17 g, n=8	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	11000	whole body, dw	22	2	[30]

Species	Species properties	Test substance	Analysis	Sampling area	Sampling period	pH	Hardness [mg CaCO3/l]	*T* [°C]	Exposure conc. [μg/L]	Exposure type	BAF [l/kg$_{w.w.}$]	BAF type	Notes	Ri	Ref.
Velesunio angasi	Age 7 y, 1.15 g, n=8	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	8500	whole body, dw	22	2	[30]
Velesunio angasi	Age 8 y, 1.15 g, n=12	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	13000	whole body, dw	22	2	[30]
Velesunio angasi	Age 9 y, 1.05 g, n=6	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	13000	whole body, dw	22	2	[30]
Velesunio angasi	Age 10 y, 1.17 g, n=5	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	14000	whole body, dw	22	2	[30]
Velesunio angasi	Age 11 y, 1.77 g, n=3	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	12000	whole body, dw	22	2	[30]
Velesunio angasi	Age 14 y, 1.37 g, n=1	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '08				0.02	dissolved U	13000	whole body, dw	22	2	[30]
Velesunio angasi	Age 1 y, 0.25 g, n=4	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	12000	whole body, dw	22	2	[30]
Velesunio angasi	Age 2 y, 0.50 g, n=8	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	11000	whole body, dw	22	2	[30]
Velesunio angasi	Age 3 y, 0.83 g, n=13	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	9000	whole body, dw	22	2	[30]
Velesunio angasi	Age 4 y, 0.74 g, n=18	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	12000	whole body, dw	22	2	[30]
Velesunio angasi	Age 5 y, 0.89 g, n=16	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	14000	whole body, dw	22	2	[30]
Velesunio angasi	Age 6 y, 0.90 g, n=7	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	15000	whole body, dw	22	2	[30]
Velesunio angasi	Age 7 y, 1.02 g, n=12	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	12000	whole body, dw	22	2	[30]
Velesunio angasi	Age 8 y, 1.0 g, n=1	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	20000	whole body, dw	22	2	[30]
Velesunio angasi	Age 9 y, 0.85 g, n=3	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	19000	whole body, dw	22	2	[30]
Velesunio angasi	Age 11 y, 1.04 g, n=2	Uranium	ICP-MS	Mudginberri Billabong mid	Oct. '08				0.02	dissolved U	20000	whole body, dw	22	2	[30]
Velesunio angasi	Age 2 y, 0.42 g, n=13	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	8500	whole body, dw	22	2	[30]
Velesunio angasi	Age 3 y, 0.59 g, n=8	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	9000	whole body, dw	22	2	[30]
Velesunio angasi	Age 4 y, 0.72 g, n=18	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	10000	whole body, dw	22	2	[30]
Velesunio angasi	Age 5 y, 0.78 g, n=22	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	11000	whole body, dw	22	2	[30]
Velesunio angasi	Age 6 y, 0.91 g, n=16	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	9500	whole body, dw	22	2	[30]
Velesunio angasi	Age 7 y, 1.0 g, n=12	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	9500	whole body, dw	22	2	[30]
Velesunio angasi	Age 8 y, 1.04 g, n=5	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	14000	whole body, dw	22	2	[30]
Velesunio angasi	Age 9 y, 0.98 g, n=3	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	14000	whole body, dw	22	2	[30]
Velesunio angasi	Age 11 y, 0.96 g, n=1	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	16000	whole body, dw	22	2	[30]
Velesunio angasi	Age 13 y, 1.37 g, n=1	Uranium	ICP-MS	Mudginberri Billabong outlet	Oct. '08				0.02	dissolved U	12000	whole body, dw	22	2	[30]
Velesunio angasi	Age 1 y, 0.18 g, n=20	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	9000	whole body, dw	22	2	[30]
Velesunio angasi	Age 2 y, 0.68 g, n=19	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	7000	whole body, dw	22	2	[30]
Velesunio angasi	Age 3 y, 0.85 g, n=17	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	7500	whole body, dw	22	2	[30]
Velesunio angasi	Age 4 y, 0.99 g, n=10	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	8500	whole body, dw	22	2	[30]
Velesunio angasi	Age 5 y, 0.99 g, n=5	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	10000	whole body, dw	22	2	[30]
Velesunio angasi	Age 6 y, 1.14 g, n=6	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	9500	whole body, dw	22	2	[30]
Velesunio angasi	Age 7 y, 1.14 g, n=5	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	10000	whole body, dw	22	2	[30]
Velesunio angasi	Age 8 y, 1.03 g, n=3	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	11000	whole body, dw	22	2	[30]
Velesunio angasi	Age 9 y, 1.22 g, n=2	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	13000	whole body, dw	22	2	[30]
Velesunio angasi	Age 10 y, 1.07 g, n=2	Uranium	ICP-MS	Mudginberri Billabong inlet	Oct. '05				0.02	dissolved U	12000	whole body, dw	22	2	[30]
Velesunio angasi	Age 1 y, 0.14 g, n=13	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	7100	whole body, dw	24	2	[30]
Velesunio angasi	Age 2 y, 0.36 g, n=7	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	10000	whole body, dw	24	2	[30]
Velesunio angasi	Age 3 y, 0.84 g, n=19	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	9300	whole body, dw	24	2	[30]
Velesunio angasi	Age 4 y, 0.59 g, n=11	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	11000	whole body, dw	24	2	[30]
Velesunio angasi	Age 5 y, 0.66 g, n=19	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	7900	whole body, dw	24	2	[30]
Velesunio angasi	Age 6 y, 0.64 g, n=8	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	11000	whole body, dw	24	2	[30]
Velesunio angasi	Age 7 y, 0.87 g, n=8	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	7900	whole body, dw	24	2	[30]
Velesunio angasi	Age 8 y, 0.90 g, n=3	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	11000	whole body, dw	24	2	[30]
Velesunio angasi	Age 10 y, 0.57 g, n=1	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	10000	whole body, dw	24	2	[30]
Velesunio angasi	Age 11 y, 0.89 g, n=1	Uranium	ICP-MS	Sandy billabong	Oct. '05				0.014	dissolved U	9300	whole body, dw	24	2	[30]
Velesunio angasi	Age 1 y, 0.38 g, n=11	Uranium	ICP-MS	Sandy billabong	Oct. '08				0.014	dissolved U	5700	whole body, dw	24	2	[30]
Velesunio angasi	Age 2 y, 0.50 g, n=8	Uranium	ICP-MS	Sandy billabong	Oct. '08				0.014	dissolved U	5800	whole body, dw	24	2	[30]
Velesunio angasi	Age 3 y, 0.58 g, n=20	Uranium	ICP-MS	Sandy billabong	Oct. '08				0.014	dissolved U	5000	whole body, dw	24	2	[30]
Velesunio angasi	Age 4 y, 0.63 g, n=24	Uranium	ICP-MS	Sandy billabong	Oct. '08				0.014	dissolved U	6400	whole body, dw	24	2	[30]
Velesunio angasi	Age 5 y, 0.67 g, n=14	Uranium	ICP-MS	Sandy billabong	Oct. '08				0.014	dissolved U	8600	whole body, dw	24	2	[30]
Velesunio angasi	Age 6 y, 0.74 g, n=10	Uranium	ICP-MS	Sandy billabong	Oct. '08				0.014	dissolved U	6100	whole body, dw	24	2	[30]
Velesunio angasi	Age 7 y, 0.81 g, n=5	Uranium	ICP-MS	Sandy billabong	Oct. '08				0.014	dissolved U	6400	whole body, dw	24	2	[30]
Velesunio angasi	Age 8 y, 1.11 g, n=3	Uranium	ICP-MS	Sandy billabong	Oct. '08				0.014	dissolved U	5000	whole body, dw	24	2	[30]
Velesunio angasi	Age 9 y, 0.98 g, n=2	Uranium	ICP-MS	Sandy billabong	Oct. '08				0.014	dissolved U	7100	whole body, dw	24	2	[30]

Notes

1 Concentration ratios are based on average water concentrations and appear to be generally lower than those summarised in the paper for individual water samples
2 n=1
3 n=2
4 Exposure concentration determined in samples taken in June 1979,
5 BAFs from paper could not be recalculated from data in paper but recalculation are in same order of magnitude
6 BAFs calculated from data in paper
7 Tissue was mainly flesh, bone and organs
8 Filtered over 0.45 µm; near Gdansk, Poland; concentrations muscle<skeleton<viscera
9 Secondary sources
10 Concentrations only given in Becquerel and for specific isotopes
11 Exposure concentration for day of collection only, at other location the day concentration was in the same order of magnitude as the annual mean concentration
12 BAF recalculated for annual mean concentration, unclear if wet weight or dry weight, wet weight is presumed
13 Total water was used, but differences between total and dissolved are small; low total concentrations were often lower than dissolved concentrations; discrepancy in water concentrations between different tables
14 Filtered over 0.45 µm; near Gdansk, Poland; higher values in molluscs, lower values in crustacean
15 Clams from reference site transplanted upstream from discharge point in U-mining area; corresponding concentration total 5.1 µg U/L; average of 10 individuals
16 BAF calculated from reported measured concentrations in water and mussels at site 2
17 BAF calculated from reported measured concentrations in water and mussels at site 3
18 BAF calculated from reported measured concentrations in water and mussels at site 5
19 BAF calculated from reported measured concentrations in water and mussels at site 6
20 Residues in mussel are mean of samples from different size classes
21 Reported mean residue (1.55 µg/g dwt) is much higher than values reported for individual mussels from different size classes (0.437 and 0.478 µg/g dwt)
22 Period of water sampling unclear
23 Water concentration measured during three wet seasons in period 2005-2008
24 Water concentration estimated from graph
25 In the paper errors are made in the calculation of wet weight endpoints and not enough details are reported to be able to be certain of the real value of the actual endpoints

Table A2.2 Bioconcentration factors for aquatic organisms

Species	Species properties	Test substance	Purity	Analysis	Test type	Test water	pH	Hardness /Salinity	*T*	Exposure time	Exposure concentration	BCF	BCF type	Method	Notes	Ri	Ref.
			[%]					[mg/l]	[°C]	[d]	[µg/L]	[l/kg$_{w.w.}$]					
Carassius auratus	5-6 cm, 1.5-3.0 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-MS	S	rw	≥8	hard	20±1	4 + 4 d	100	144	dw, dorsal muscle	kin	1,2	3	[74]
Carassius auratus	5-6 cm, 1.5-3.0 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-MS	S	rw	≥8	hard	20±1	4 + 4 d	450	23	dw, dorsal muscle	kin	1	3	[74]
Carassius auratus	5-6 cm, 1.5-3.0 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-MS	S	rw	≥8	hard	20±1	4 + 4 d	2025	5	dw, dorsal muscle	kin	1	3	[74]
Danio rerio	0.22±0.04 g	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES	FT	am	6.5±0.1	48.5	24±1 (25)	20 d	26.7	1033.3	ww, whole body	ss	3,4	3	[36,75]
Danio rerio	0.22±0.04 g	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES	FT	am	6.5±0.1	48.5	24±1 (25)	20 d	118	359.5	ww, whole body	ss	3,5	3	[36,75]
Danio rerio	0.22±0.04 g	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES	FT	am	6.5±0.1	48.5	24±1 (25)	20 d	501	92.8	ww, whole body	ss	6	2	[36,75]
Danio rerio	0.22±0.04 g	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES	FT	am	6.5±0.1	48.5	24±1 (25)	20 d	501	80.7	ww, whole body	kin	6,7	2	[36,75]
Danio rerio	adult, ♂	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-MS/ICP-AES	FT	tap	8.1	241.6	26±1	20 d	17±6.5	21.5	ww, whole body	ss	8	3	[41]
Danio rerio	adult, ♀	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-MS/ICP-AES	FT	tap	8.1	241.6	26±1	20 d	17±6.5	39.4	ww, whole body	ss	8	3	[41]
Danio rerio	adult, ♂, 120 d, 3.9±0.3 cm, 0.458±0.107 g	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES	R	am		48.5	24±1	20 d	102±27	137.5	ww, whole body	ss	6	2	[37]
Danio rerio	adult, ♂, 120 d, 3.9±0.3 cm, 0.458±0.107 g	93.35% depleted and 6.65% ^{233}U $UO_2(NO_3)_2$		alpha-LSC	R	am		48.5	24±1	20 d	94±23	130.4	ww, whole body	ss	6	2	[37]
Danio rerio	adult, ♂, 3.6±0.2 cm, 0.345±0.045 g	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES	R	am	6.5±0.1	48.5	24±1	20 d	102±27	120	ww, whole body	ss	6	2	[35]
Danio rerio	adult, ♂, 3.6±0.2 cm, 0.345±0.045 g	93.35% depleted and 6.65% ^{233}U $UO_2(NO_3)_2$		alpha-LSC	R	am	6.5±0.1	48.5	24±1	20 d	94±23	149	ww, whole body	ss	6	2	[35]
Danio rerio	adult, ♂, 3.6±0.2 cm, 0.345±0.045 g	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES	R	am	6.5±0.1	48.5	24±1	20 d	102±27	105	ww, whole body	kin	6,7	2	[35]
Danio rerio	adult, ♂, 3.6±0.2 cm, 0.345±0.045 g	93.35% depleted and 6.65% ^{233}U $UO_2(NO_3)_2$		alpha-LSC	R	am	6.5±0.1	48.5	24±1	20 d	94±23	221	ww, whole body	kin	6,7	2	[35]
Danio rerio	embryo/larval	depl. $UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	R	am	6.5±0.2	48.4	25±1	15 d (dpf)	16.8±1.5	5352	dw, whole body	ss		2	[38]
Danio rerio	embryo/larval	233U uranyl nitrate		alpha-LSC	R	am	6.5±0.2	48.4	25±1	15 d (dpf)	16.8±0.2	2141	dw, whole body	ss		2	[38]
Danio rerio	embryo/larval	233U uranyl nitrate		alpha-LSC	R	am	6.5±0.2	48.4	25±1	15 d (dpf)	87±1.5	4679	dw, whole body	ss		2	[38]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	rw	6.4	27.5	24.5±0.3	28 d	32±10	12	dw, skeletal muscle	ss	9	2	[76]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	rw	6.4	27.5	24.5±0.3	28 d	32±10	12	dw, brain	ss	9	2	[76]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	rw	6.4	27.5	24.5±0.3	28 d	105±16	15	dw, skeletal muscle	ss	9	2	[76]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	rw	6.4	27.5	24.5±0.3	28 d	105±16	8	dw, brain	ss	9	2	[76]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	am	6.4±0.2	27.5	24.5±0.5	28 d	23±6	3	dw, brain	ss	9,10	2	[77]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	am	6.4±0.2	27.5	24.5±0.5	28 d	130±34	4	dw, brain	ss	9,10	2	[77]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	am	6.4±0.2	27.5	24.5±0.5	28 d	23±6	11	dw, skeletal muscle	ss	9,10	2	[77]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	am	6.4±0.2	27.5	24.5±0.5	28 d	130±34	5	dw, skeletal muscle	ss	9,10	2	[77]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	am	6.4±0.2	27.5	24.5±0.5	28 d	23±6	22	dw, liver	ss	9,10	2	[77]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	am	6.4±0.2	27.5	24.5±0.5	28 d	130±34	20	dw, liver	ss	9,10	2	[77]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	am	6.4±0.2	27.5	24.5±0.5	28 d	23±6	27	dw, gills	ss	9,10	2	[77]
Danio rerio	adult, ♂, 3.33±0.14 cm, 0.70±0.08 g	$UO_2(NO_3)_2\cdot 6H_2O$		ICP-AES (water); ICP-MS (fish)	CF	am	6.4±0.2	27.5	24.5±0.5	28 d	130±34	38	dw, gills	ss	9,10	2	[77]
Danio rerio		uranyl acetate		ICP-MS	S	dtw	7.9±0.2	178		28 + 31 d	151	12	ww, whole body	kin	11	3	[78]
Danio rerio		uranyl acetate		ICP-MS	S	dtw	7.9±0.2	178		28 d	151	0.009	ww, whole body	ss	11	3	[78]
Danio rerio	adult	depleted uranium		ICP-AES	S	am	6.5		26	37 d	20	3700	dw, whole fish	ss	12	2	[34]
Danio rerio	adult	depleted uranium		ICP-AES	S	am	6.5		26	37 d	100	1770	dw, whole fish	ss	12	2	[34]
Mogurnda mogurnda	larvae, newly hatched (<10 h)	$UO_2SO_4\cdot 3H_2O$		ICP-MS	FT	nw	6.7	4.2	27±1	28 d	90	98	dw, whole body	ss	13	2	[39]
Mogurnda mogurnda	larvae, newly hatched (<10 h)	$UO_2SO_4\cdot 3H_2O$		ICP-MS	FT	nw	6.7	4.2	27±1	28 d	180	76	dw, whole body	ss	13	2	[39]
Mogurnda mogurnda	larvae, newly hatched (<10 h)	$UO_2SO_4\cdot 3H_2O$		ICP-MS	FT	nw	6.7	4.2	27±1	28 d	380	66	dw, whole body	ss	13	2	[39]
Mogurnda mogurnda	larvae, newly hatched (<10 h)	$UO_2SO_4\cdot 3H_2O$		ICP-MS	FT	nw	6.7	4.2	27±1	28 d	770	69	dw, whole body	ss	13	2	[39]
Mogurnda mogurnda	larvae, newly hatched (<10 h)	$UO_2SO_4\cdot 3H_2O$		ICP-MS	FT	nw	6.7	4.2	27±1	28 d	1400	129	dw, whole body	ss	13	2	[39]
Mogurnda mogurnda	larvae, newly hatched (<10 h)	$UO_2SO_4\cdot 3H_2O$		ICP-MS	FT	nw	6.2	1.7	27±1	28 d	410	59	dw, whole body	ss	13	2	[39]
Mogurnda mogurnda	larvae, newly hatched (<10 h)	$UO_2SO_4\cdot 3H_2O$		ICP-MS	FT	nw	6.1	1.7	27±1	28 d	800	86	dw, whole body	ss	13	2	[39]
Mogurnda mogurnda	larvae, newly hatched (<10 h)	$UO_2SO_4\cdot 3H_2O$		ICP-MS	FT	nw	6	1.7	27±1	28 d	1230	126	dw, whole body	ss	13	2	[39]
Omnivorous fish												0.7-38				4	[79]

Species	Species properties	Test substance	Purity [%]	Analysis	Test type	Test water	pH	Hardness /Salinity [mg/l]	*T* [°C]	Exposure time [d]	Exposure concentration [μg/L]	BCF [l/kg$_{w.w.}$]	BCF type	Method	Notes	Ri	Ref.
Oncorhynchus mykiss	juvenile, 5.8±1.3 g, 7.9±0.6 cm	$UO_2(NO_3)_2{\cdot}6H_2O$		ICP-AES	FT	am	6.5	48.2	10	10 d	20	15.1	ww, gills	kin	14	3	[80]
Oncorhynchus mykiss	juvenile, 5.8±1.3 g, 7.9±0.6 cm	$UO_2(NO_3)_2{\cdot}6H_2O$		ICP-AES	FT	am	6.5	48.2	10	10 d	100	5.7	ww, gills	kin	14	3	[80]
Oncorhynchus mykiss	juvenile, 5.8±1.3 g, 7.9±0.6 cm	$UO_2(NO_3)_2{\cdot}6H_2O$		ICP-AES	FT	am	6.5	48.2	10	10 d	500	4.2	ww, gills	kin	14	3	[80]
Oncorhynchus mykiss	juvenile, 4.2 g, 7.0 cm	238U, $UO_2(NO_3)_2{\cdot}6H_2O$			S	nw	7.5-8.0		10.5-13.6	6 d	960	19.0	dw, whole fish	ss	15,16	3	[81]
Oncorhynchus mykiss	juvenile, 4.2 g, 7.0 cm	238U, $UO_2(NO_3)_2{\cdot}6H_2O$			S	nw	7.5-8.0		10.5-13.6	35 d	960	2.6	dw, whole fish		16	2	[81]
Oncorhynchus mykiss	juvenile, 4.2 g, 7.0 cm	232U			S	nw	7.5-8.0		10.5-13.6	6 d	0.078	37.4	dw, whole fish		15,16	3	[81]
Oncorhynchus mykiss	juvenile, 4.2 g, 7.0 cm	232U			S	nw	7.5-8.0		10.5-13.6	35 d	0.078	20.9	dw, whole fish		16	2	[81]
Piscivorous fish		238U										0.5-0.7				4	[79]
Planktivorous fish		238U										0.3-0.6				4	[79]
Planktivorous fish												8				4	[79]
Salvelinus fontinalis	juvenile, 60 days post hatch	$UO_2SO_4{\cdot}3H_2O$			F	nw+dw	8	201	13.5	77 d	0.23	4.28	ww, whole fish	ss		2	[27]
Salvelinus fontinalis	juvenile, 60 days post hatch	$UO_2SO_4{\cdot}3H_2O$			F	nw+dw	8	201	13.5	77 d	0.3	4	ww, whole fish	ss	17	2	[27]
Salvelinus fontinalis	juvenile, 60 days post hatch	$UO_2SO_4{\cdot}3H_2O$			F	nw+dw	8	201	13.5	77 d	0.6	3	ww, whole fish	ss	17	2	[27]
Salvelinus fontinalis	juvenile, 60 days post hatch	$UO_2SO_4{\cdot}3H_2O$			F	nw+dw	8	201	13.5	77 d	1.1	2.9	ww, whole fish	ss	17	2	[27]
Salvelinus fontinalis	juvenile, 60 days post hatch	$UO_2SO_4{\cdot}3H_2O$			F	nw+dw	8	201	13.5	77 d	2.2	2.7	ww, whole fish	ss	17	2	[27]
Salvelinus fontinalis	juvenile, 60 days post hatch	$UO_2SO_4{\cdot}3H_2O$			F	nw+dw	8	201	13.5	77 d	4.2	2.5	ww, whole fish	ss	17	2	[27]
Salvelinus fontinalis	juvenile, 60 days post hatch	$UO_2SO_4{\cdot}3H_2O$			F	nw+dw	8	201	13.5	77 d	9.1	1.94	ww, whole fish	ss		2	[27]
Molluscs																	
Corbicula fluminea	adult, 2-2.5 cm	uranyl acetate		ICP-MS	S	dtw	7.9±0.2	178	20	28 + 27 d	93500	0.30	ww, whole body	kin	18	3	[78]
Corbicula fluminea	adult, 2-2.5 cm	uranyl acetate		ICP-MS	S	dtw	7.9±0.2	178	20	28 d	93500	0.06	ww, whole body	ss	18	3	[78]
Corbicula fluminea	field collected; fw 0.42-0.53 g	not specified		ICP-OES	FT	am	7	62	19-20	14	500	40	ww, whole body	C_{org}/C_{water}	19,20	2	[28]
Corbicula fluminea	field collected; fw 0.42-0.53 g	not specified		ICP-OES	FT	am	7	62	19-20	7	1500	10	ww, whole body	C_{org}/C_{water}	19,21	2	[28]
Corbicula fluminea	field collected; fw 0.42-0.53 g	not specified		ICP-OES	FT	am	7	62	19-20	42	100	107	ww, whole body	C_{org}/C_{water}	19,21	2	[28]
Corbicula fluminea	field collected; fw 0.42-0.53 g	not specified		ICP-OES	FT	am	8.1	62	19-20	30	100	9	ww, whole body	C_{org}/C_{water}	19,21	2	[28]
Corbicula fluminea	field collected; fw 2.26 g	uranyl nitrate		ICP-OES	FT	am	7	57	15	10	85	13	ww, whole body	C_{org}/C_{water}	22	3	[82]
Corbicula fluminea	field collected	uranyl nitrate		ICP-AES	FT	am	6.5	62	20	10	10	500	ww, whole body	C_{org}/C_{water}	23	2	[41]
Corbicula fluminea	field collected	uranyl nitrate		ICP-AES	FT	am	6.5	62	20	10	20	375	ww, whole body	C_{org}/C_{water}	23	2	[41]
Corbicula fluminea	field collected	uranyl nitrate		ICP-AES	FT	am	6.5	62	20	10	100	100	ww, whole body	C_{org}/C_{water}	23	2	[41]
Corbicula fluminea	field collected	uranyl nitrate		ICP-AES	FT	am	6.5	62	20	10	500	22	ww, whole body	C_{org}/C_{water}	23	2	[41]
Corbicula fluminea	field collected; fw 0.26 g	uranyl nitrate		ICP-AES	FT	am	6.5	62	20	90	14.5	345	ww, whole body	C_{org}/C_{water}	24	2	[41]
Corbicula fluminea	field collected; fw 0.76 g	uranyl nitrate		ICP-OES	FT	am	6.5	204	20	15	45	217	ww, whole body	C_{org}/C_{water}	25	2	[43]
Corbicula fluminea	field collected; fw 0.30 g	uranyl nitrate		ICP-AES	FT	am	7	62	20	42	63	160	ww, whole body	C_{org}/C_{water}	26	2	[42]
Crustaceans																	
Orconectes limosus	12 m adult, ♂, 10.7 g	not specified		ICP-OES	FT	tw	8.1		20	10	0.9	0.1340	ww, whole body		27,28	2	[28]
Orconectes limosus	12 m adult, ♂, 10.7 g	not specified		ICP-OES	FT	tw	8.1		20	30	0.9	0.0120	ww, whole body		28,29,30	2	[28]
Orconectes limosus	12 m adult, ♂, 10.7 g	not specified		ICP-OES	FT	tw	8.1		20	10	2.5	0.0750	ww, whole body		28,31	2	[28]
Orconectes limosus	12 m adult, ♂, 10.7 g	not specified		ICP-OES	FT	tw	8.1		20	30	2.5	0.0220	ww, whole body		28,29,32	2	[28]
Orconectes limosus	12 m adult, ♂, 10.7 g	not specified		ICP-OES	FT	tw	8.1		20	10	3.4	0.0200	ww, whole body		28,33	2	[28]
Orconectes limosus	12 m adult, ♂, 10.7 g	not specified		ICP-OES	FT	tw	8.1		20	30	3.4	0.0050	ww, whole body		28,29,34	2	[28]
Orconectes limosus	12 m adult, ♂, 10.7 g	not specified		ICP-OES	FT	tw	8.1		20	10	10.7	0.0120	ww, whole body		28,29,35	2	[28]
Orconectes limosus	12 m adult, ♂, 10.7 g	not specified		ICP-OES	FT	tw	8.1		20	10	19.6	0.1020	ww, whole body		28,36	2	[28]
Orconectes limosus	12 m adult, ♂, 10.7 g	not specified		ICP-OES	FT	tw	8.1		20	10	20.2	0.0650	ww, whole body		28,37	2	[28]

Notes

1. Water concentration not measured, fish load not exceeding 1 g/L, fish not fed during exposure, kinetic fit through data
2. Data did not fit model
3. Data do not follow first-order kinetics;
4. Last point 15 times higher; fed 1% of body weight per day
5. Straight line; fed 1% of body weight per day
6. Fed 1% of body weight per day
7. Kinetic fit through uptake data
8. Feeding experiment; fed 5% of body weight per day; water concentration measured
9. Fish fed 2% of body weight per day
10. Kinetic data did not fit well, half-lifes in the order of 3 d for liver up to more than 10 d for brain and muscles

11	Fish fed twice a week; five fish/L; water concentrations possibly not measured; reported concentrations do not match BCF
12	Calculated from graph in paper, exposure concentration was monitored and corrected to nominal concentrations
13	Fed with *Artemia nauplii*
14	Kinetic fit through uptake data; water concentrations were not analysed
15	Exposure very short
16	Method of analysis not reported
17	Estimated from graph in paper
18	Animals fed twice a week; five fish/L; water concentrations possibly not measured; reported concentrations do not match BCF
19	Concentrations as dissolved U
20	Hardness calculated from reported concentrations of Ca^{2+} and Mg^{2+}; BCF calculated from reported concentrations in whole body and nominal concentrations in water
21	Average of 10 individuals
22	Concentration in whole body calculated as sum of gills, viscera, mantle and muscle, using reported weight of individual body parts and measured concentrations (read from graph); equilibrium not reached
23	BCF calculated from reported nominal exposure concentration and whole body residue read from graph; authors indicate that accumulation after 6 h is not different from 10 d, indicating steady state.
24	Exposure concentration expressed as geometric mean of reported average concentrations in 3 replicates; BCF calculated from reported concentration in whole body of 5 µg/g, calculated by author on the basis of sum of organs; concentration reported to be constant over time
25	Concentration expressed as mean measured dissolved U; corresponding total 52 µg/L; concentration in organisms read from digitised graph using TechDig; equilibrium reached, internal concentrations similar at t=15 similar to t=7
26	Exposure concentration based on mean measured concentration of U (nominal 100 µg/L); concentration in whole body calculated from sum of organs; BCF reported by author in text
27	Crayfish fed 1 clam/day for 10 d; food ration 3-9% of body mass; clams previously exposed to water with 100 µg U/L for 30 d
28	BMF reported by author as total burden in crayfish divided by ingested burden
29	Moulting observed
30	Crayfish fed 1 clam/day for 30 d; food ration 3-9% of body mass; clams previously exposed to water with 100 µg U/L for 30 d;
31	Crayfish fed 1 clam/day for 10 d; food ration 3-9% of body mass; clams previously exposed to natural water with 12.4 µg U/L for 42 d;
32	Crayfish fed 1 clam/day for 30 d; food ration 3-9% of body mass; clams previously exposed to natural water with 12.4 µg U/L for 42 d;
33	Crayfish fed 1 clam/day for 10 d; food ration 3-9% of body mass; clams previously exposed to natural water with 4.2 µg U/L for 42 d;
34	Crayfish fed 1 clam/day for 30 d; food ration 3-9% of body mass; clams previously exposed to natural water with 4.2 µg U/L for 42 d;
35	Crayfish fed 1 clam/day for 10 d; food ration 3-9% of body mass; clams previously exposed to water with 100 µg U/L for 42 d;
36	Crayfish fed 1 clam/day for 10 d; food ration 3-9% of body mass; clams previously exposed to water with 500 µg U/L for 14 d;
37	Crayfish fed 1 clam/day for 10 d; food ration 3-9% of body mass; clams previously exposed to water with 1500 µg U/L for 7 d

Table A2.3 Feeding Bioconcentration factors for aquatic organisms

Species	Species properties	Test substance	Purity [%]	Analysis	Test type	Test water	pH	Hardness/ Salinity [mg/l]	*T* [°C]	Exposure time [d]	Exposure concentration [μg/g]	BMF [$kg_{d.w}/kg_{w.w.}$]	BMF type	Method	Notes	Ri	Ref.
Coregonus clupeaformis	3.5 y, 625±15 g and 34.9±0.3 cm,	uranyl acetate dihydrate, 99.8% 238U, 0.3% 235U, 0.187 μCi/g		Argon Plasma Opt. Em. Spectr.	FT	tap	7.7±0.01	90.4	10.9±0.1	100 d	982±71.7	0.0041	ww, whole body	kin	1		[83]
Coregonus clupeaformis	3.5 y, 625±15 g and 34.9±0.3 cm,	uranyl acetate dihydrate, 99.8% 238U, 0.3% 235U, 0.187 μCi/g		Argon Plasma Opt. Em. Spectr.	FT	tap	7.7±0.01	90.4	10.9±0.1	100 d	9892±754	0.0078	ww, whole body	kin	1		[83]
Danio rerio	adult, male	^{233}U		alpha spectroscopy	FT	tap	8.1	241.6	26±1	20 d	4.8±2.5	0.0054	ww, whole body	ss	2		[41]
Danio rerio	adult, female	^{233}U		alpha spectroscopy	FT	tap	8.1	241.6	26±1	20 d	4.8±2.5	0.0027	ww, whole body	ss	2		[41]
Danio rerio	adult, male	^{233}U		alpha spectroscopy	FT	tap	8.1	241.6	26±1	20 d	58.2±11.96	0.0022	ww, whole body	ss	2		[41]
Danio rerio	adult, female	^{233}U		alpha spectroscopy	FT	tap	8.1	241.6	26±1	20 d	58.2±11.96	0.0022	ww, whole body	ss	2		[41]
Danio rerio	adult, male	depleted $UO_2(NO_3)_2{\cdot}6H_2O$		ICP-MS/ICP-AES	FT	tap	8.1	241.6	26±1	20 d	58.2±11.96	0.0026	ww, whole body	ss	2		[41]
Danio rerio	adult, female	depleted $UO_2(NO_3)_2{\cdot}6H_2O$		ICP-MS/ICP-AES	FT	tap	8.1	241.6	26±1	20 d	58.2±11.96	0.0020	ww, whole body	ss	2		[41]
Danio rerio	adult, male	depleted $UO_2(NO_3)_2{\cdot}6H_2O$		ICP-MS/ICP-AES	FT	tap	8.1	241.6	26±1	20 d	448±79	0.0008	ww, whole body	ss	2,3		[41]
Danio rerio	adult, female	depleted $UO_2(NO_3)_2{\cdot}6H_2O$		ICP-MS/ICP-AES	FT	tap	8.1	241.6	26±1	20 d	448±79	0.0015	ww, whole body	ss	2,3		[41]

Notes

1 Whole body concentrations estimated from organ data and detection limits; fed 0.8% of body weight per day
2 Fed 5% of body weight per day
3 17±6.5 μg/L in water

Appendix 3 - Detailed ecotoxicity data

Legend to data tables	Species properties
A	Test water analysed Yes/No
Test type	S = static; R = renewal; F = flow-through
Test water	am = artificial medium; dtw = dechlorinated tap water; dw = de-ionised/dechlorinated/distilled water; nw = natural water; rw = reconstituted (sea)water; rtw = reconstituted tap water; tw = tap water
Ri	Reliability index, see section 2.2

Table A3.1 Acute toxicity for freshwater organisms

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness CaCO$_3$ [mg/L]	Alkalinity CaCO$_3$ [mg/L]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Bacteria																		
anaerobic sludge		y	UO_2Cl_2 x $3H_2O$	>99	S	am	7.5	30				6 d	EC50	nitrate reduction	35000	3	12,14	[84]
anaerobic sludge		y	UO_2Cl_2 x $3H_2O$	>99	S	am	7.5	30				2 d	EC50	nitrate reduction	48000	3	12,15	[84]
anaerobic sludge		y	UO_2Cl_2 x $3H_2O$	>99	S	am	7.5	30				13 d	EC50	nitrate reduction	76000	3	12,16	[84]
mixed culture	thiosulfate adapted	y	UO_2Cl_2 x $3H_2O$	>99	S	am	7.5	30				14 d	EC50	methane prod.	38000	3	12,14	[84]
Pseudomonas aeruginosa		y	$UO_2(NO_3)_2$ x $6H_2O$		S	am	7.4		40			24 h	EC50	growth	< 10000	3	2,17,18	[85]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			28 h	IC50	growth rate	37260	3	1,19,23	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			24 h	IC50	growth rate	27810	3	1,20,23	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			22 h	IC50	growth rate	24570	3	1,21,24	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			46 h	IC50	growth rate	51	3	1,22,25	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			46 h	IC50	growth rate	41040	3	1,26	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			28 h	EC50	growth rate	28500	3	1,19,23,27	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			24 h	EC50	growth rate	28300	3	1,20,23,27	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			22 h	EC50	growth rate	16200	3	1,21,24,27	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			46 h	EC50	growth rate	44.6	3	1,22,25,27	[86]
Thiobacillus ferrooxidans		n	UO_2SO_4 x $3H_2O$		S	am	1.3	28	165			48 h	EC50	oxidation	103500	3	1	[87]
Thiobacillus ferrooxidans		n	UO_2SO_4 x $3H_2O$		S	am	1.8-2.2	30				80 min	EC50	oxygen cons.	16400000	3	1,28,29	[87]
Zoogloea ramigera		n	$UO_2(NO_3)_2$ x $6H_2O$		S	am	6-7	24	81			24 h	EC50	growth rate	19	3	1,13,30	[88]
Zoogloea ramigera		n	$UO_2(NO_3)_2$ x $6H_2O$		S	am	6-7	24	81			66 h	EC50	growth rate	75000	3	1,31	[88]
Algae																		
Chlorella sp.	wild type, 4-5 days	y	UO_2SO_4 x $3H_2O$		S	am	7.0	27	8		< 0.2	72 h	EC50	growth rate	56	2	32	[89]
Chlorella sp.	wild type, 4-5 days	y	UO_2SO_4 x $3H_2O$		S	am	7.0	27	40		< 0.2	72 h	EC50	growth rate	72	2	32	[89]
Chlorella sp.	wild type, 4-5 days	y	UO_2SO_4 x $3H_2O$		S	am	7.0	27	100		< 0.2	72 h	EC50	growth rate	150	2	32	[89]
Chlorella sp.	wild type, 4-5 days	y	UO_2SO_4 x $3H_2O$		S	am	7.0	27	400		< 0.2	72 h	EC50	growth rate	270	2	32	[89]
Chlorella sp.							7.0		8			48 h	EC50		23	4	4	[89]
Chlorella sp.							7.0		400			48 h	EC50		230	4	4	[89]
Chlorella sp.		y	UO_2SO_4 x $3H_2O$		S	am	5.7	27	2-4			72 h	EC50	growth rate	78	3	33	[90]
Chlorella sp.		y	UO_2SO_4 x $3H_2O$		S	am	6.5	27	2-4			72 h	EC50	growth rate	44	3	33	[90]
Chlorella sp.		y		ag	S	am	6.4-6.6	29	3.6	2.63		72 h	EC50	growth rate	74	2	34	[91]
Chlorella sp.		y		ag	S	nw	6.5-6.8	29	3.9	11	4.1	72 h	EC50	growth rate	177	2	34	[91]
Chlorella sp.		y		ag	S	nw	6.2-6.4	29	3.9		3.4	72 h	EC50	growth rate	166	2	34	[91]
Chlorella sp.		y		ag	S	nw	6.4-6.6	29	3.9	7	8.1	72 h	EC50	growth rate	238	2	34	[91]
Chlorella sp.		y		ag	S	nw	6.3-6.6	29	3.9	<5	2.6	72 h	EC50	growth rate	137	2	34	[91]

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness CaCO$_3$ [mg/L]	Alkalinity CaCO$_3$ [mg/L]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Chlorella sp.													EC25	growth rate	120	4	4	[7]
Chlamydomonas reinhardtii		y	$UO_2(NO_3)_2 \times 6H_2O$		S	nw	7.7	24	15			72 h	EC50	growth rate	> 15000	3	6,17,35	[92]
Chlamydomonas reinhardtii							5					72 h	EC50		730	4		[92]
Chlamydomonas reinhardtii	exp. Growth phase						5					48 h	EC50		68.3	4	4	[6]
Chlamydomonas reinhardtii	exp. Growth phase						7					48 h	EC50		4000	4	4	[6]
Cryptomonas erosa		y			R		7.1-9.1	20.8	101			6 d	EC50		1260	4	4	[6]
Euglena gracilis	cells from a 4 day old cult.	y	$UO_2SO_4 \times 3H_2O$		S	am	6	28				96 h	EC50	growth	8900	3	2,36	[93]
Euglena gracilis	cells from a 4 day old cult.	y	$UO_2SO_4 \times 3H_2O$		S	am	6	28				96 h	EC50	growth	3500	3	2,37	[93]
Euglena gracilis	cells from a 4 day old cult.	y	$UO_2SO_4 \times 3H_2O$		S	am	6	28				96 h	EC50	growth	>4000	3	2,38	[93]
Euglena gracilis	cells from a 4 day old cult.	y	$UO_2SO_4 \times 3H_2O$		S	am	6	28	0.7	50		96 h	EC50	growth	300	3	2,39	[93]
Euglena gracilis	cells from a 4 day old cult.	y	$UO_2SO_4 \times 3H_2O$		S	am	6	28	0.7	50	10	96 h	EC50	growth rate	57	2	3,39	[93]
Euglena gracilis	cells from a 4 day old cult.	y	$UO_2SO_4 \times 3H_2O$		S	am	6	28	0.7	50	30	96 h	EC50	growth rate	254	2	3,39	[93]
Scenedesmus subspicatus												5 d	EC50		36300	4		[94]
Macrophyta																		
Lemna aequinoctialis		y	$UO_2SO_4 \times 3H_2O$		R	am	6.5	27	40	16		96 h	EC50	growth rate	758	2	40	[95]
Lemna aequinoctialis		n	$UO_2SO_4 \times 3H_2O$		S	nw	6.7-7.5	29	3.9-4.8		3-4	96 h	IC50	growth rate	704	2	41	[96]
Lemna aequinoctialis		y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	29	3.9-4.8		3-4	96 h	IC50	growth rate	>880	3	42	[96]
Lemna aequinoctialis		y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	29	3.9-4.8		3-4	96 h	IC50	growth rate	1479	3	42	[96]
Lemna aequinoctialis		y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	29	3.9-4.8		3-4	96 h	IC50	growth rate	>1352	3	42	[96]
Lemna gibba		y	$UO_2(NO_3)_2 \times 6H_2O$	ag.	R	am		24/16	6			21 d	EC50	growth rate	330	3	2,17,29,43,45	[97]
Lemna gibba		y	$UO_2(NO_3)_2 \times 6H_2O$	ag.	R	am		24/16	6			21 d	EC50	growth rate	78	3	2,17,29,43,46	[97]
Lemna gibba		y	$UO_2(NO_3)_2 \times 6H_2O$	ag.	R	am		24/16	6			21 d	EC50	growth rate	338	3	2,17,29,43,47	[97]
Lemna gibba		y	$UO_2(NO_3)_2 \times 6H_2O$	ag.	R	am		24/16	6			21 d	EC50	growth rate	1271	3	2,17,29,43,48	[97]
Lemna gibba		y	$UO_2(NO_3)_2 \times 6H_2O$	ag.	R	am		24/16	6			21 d	EC50	growth rate	>7000	3	2,17,29,43,44,49	[97]
Lemna minor		y	$UO_2(NO_3)_2 \times 6H_2O$		S		5.8-7.4		35	7-9		7 d	EC50	frond no	7400	4	3,4	[6]
Lemna minor		y	$UO_2(NO_3)_2 \times 6H_2O$		S		5.8-7.4		35	7-9		7 d	EC50	dry weight	13100	4	3,4	[6]
Ctenophora																		
Hydra viridissima		y			R	am	6	27	6.6	16		96 h	EC50	population growth	114	2	50	[98]
Hydra viridissima		y			R	am	6	27	165			96 h	EC50	population growth	177	2	50	[98]
Hydra viridissima		y			R	am	6	27	165			96 h	EC50	population growth	171	2	50	[98]
Hydra viridissima		y			R	am	6	27	330			96 h	EC50	population growth	219	2	50	[98]
Hydra viridissima	adult	y		ag.	R	nw	6	27	3.9			96 h	EC50	population growth	95	2	3,10,11	[99]
Nematoda																		
Caenorbis elegans	wild type		$UO_2Ac_2 \times 2H_2O$		S							30 min	LC50	mortality	15900	4	1,51	[100]
Caenorbis elegans	strain mtl-1 KO		$UO_2Ac_2 \times 2H_2O$		S							30 min	LC50	mortality	3400	4	1,51	[100]
Caenorbis elegans	strain mtl02 KO (VC128)		$UO_2Ac_2 \times 2H_2O$		S					7-9		30 min	LC50	mortality	4900	4	1,51	[100]
Caenorbis elegans	mtl-1 and mtl-2 double KO		$UO_2Ac_2 \times 2H_2O$		S					7-9		30 min	LC50	mortality	3700	4	1,51	[100]
Mollusca																		
Corbicula sp.		n						20				96 h	LC50	mortality	1.87E+06	4*	1,52,91	[101]
Corbicula fluminea	adult, shell length 2-2.5 cm	n	$UO_2Ac_2 \times 2H_2O$		S	dtw	7.86	20	178			96 h	LC50	mortality	1.87E+06	3	1	[78]
Corbicula fluminea	shell length 27.5 mm, wet weight 0.68 g	y	$UO_2(NO_3)_2 \times 6H_2O$		S	am	5.5	20	207			5 h	EC50	valve closure	11.9	3	8,53,54	[102]
Corbicula fluminea	shell length 27.5 mm, wet weight 0.68 g	y	$UO_2(NO_3)_2 \times 6H_2O$		S	am	6.5	20	203			5 h	EC50	valve closure	30.9	3	8,53,54,87	[102]
Corbicula fluminea		y	$UO_2(NO_3)_2 \times 6H_2O$		F	am	7	15	58			10 d	NOEC	valve activity	< 86	3	2,7,55,56, 57,58,87	[103]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	5	28	3.9		0	48 h	EC50	valve movement	103	3	8,11,59,60,87	[104]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	5	28	3.9		3.7	48 h	EC50	valve movement	127	3	8,11,59,60,87	[104]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	5	28	3.9		8.9	48 h	EC50	valve movement	218	3	8,11,59,60,87	[104]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	5.3	28	3.9		0	48 h	EC50	valve movement	124	3	8,11,59,60,87	[104]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	5.5	28	3.9		0	48 h	EC50	valve movement	144	3	8,11,59,60,87	[104]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	5.5	28	3.9		3.7	48 h	EC50	valve movement	213	3	8,11,59,60,87	[104]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	5.5	28	3.9		8.9	48 h	EC50	valve movement	438	3	8,11,59,60,87	[104]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	5.8	28	3.9		0	48 h	EC50	valve movement	256	3	8,11,59,60,87	[104]

Species	Species properties	A	Test compound	Purity	Test type	Test water	pH	T	Hardness CaCO$_3$	Alkalinity CaCO$_3$	DOC	Exp. time	Crit.	Endpoint	Value	Ri	Notes	Ref
				[%]				[°C]	[mg/L]	[mg/L]	[mg/L]				[µg U/L]			
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	6	28	3.9		0	48 h	EC50	valve movement	599	3	8,11,59,60,87	[104]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	6	28	3.9		3.7	48 h	EC50	valve movement	726	3	8,11,59,60,87	[104]
Velesunio angasi	field coll. unpoll. site	y	UO_2SO_4		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	1082	3	8,11,59,60,87	[104]
Velesunio angasi	♂; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	559	3	8,59,60,87	[105]
Velesunio angasi	♂; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	395	3	8,59,60,87	[105]
Velesunio angasi	♀; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	554	3	8,59,60,87	[105]
Velesunio angasi	♀; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	387	3	8,59,60,87	[105]
Velesunio angasi	36.8 mm; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	509	3	8,59,60,87	[105]
Velesunio angasi	36.8 mm; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	354	3	8,59,60,87	[105]
Velesunio angasi	53.4 mm; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	555	3	8,59,60,87	[105]
Velesunio angasi	53.4 mm; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	392	3	8,59,60,87	[105]
Velesunio angasi	61.3 mm; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	604	3	8,59,60,87	[105]
Velesunio angasi	61.3 mm; field coll. unpoll. site	y	$UO_2SO_4 \times 3H_2O$		F	am	6	28	3.9		8.9	48 h	EC50	valve movement	426	3	8,59,60,87	[105]
Velesunio angasi	adult	y			F	am	5	28	3.9		< 0.2	48 h	EC50	behaviour	78	3	61,87	[99]
Velesunio angasi	adult	y			F	am	5	28	3.9		3.7	48 h	EC50	behaviour	99	3	61,87	[99]
Velesunio angasi	adult	y			F	am	5	28	3.9		8.9	48 h	EC50	behaviour	171	3	61,87	[99]
Velesunio angasi	adult	y			F	am	5.3	28	3.9		< 0.2	48 h	EC50	behaviour	93	3	61,87	[99]
Velesunio angasi	adult	y			F	am	5.5	28	3.9		< 0.2	48 h	EC50	behaviour	111	3	61,87	[99]
Velesunio angasi	adult	y			F	am	5.5	28	3.9		3.7	48 h	EC50	behaviour	167	3	61,87	[99]
Velesunio angasi	adult	y			F	am	5.5	28	3.9		8.9	48 h	EC50	behaviour	352	3	61,87	[99]
Velesunio angasi	adult	y			F	am	5.8	28	3.9		< 0.2	48 h	EC50	behaviour	185	3	61,87	[99]
Velesunio angasi	adult	y			F	am	6	28	3.9		< 0.2	48 h	EC50	behaviour	393	3	61,87	[99]
Velesunio angasi	adult	y			F	am	6	28	3.9		3.7	48 h	EC50	behaviour	526	3	61,87	[99]
Velesunio angasi	adult	y			F	am	6	28	3.9		8.9	48 h	EC50	behaviour	829	3	61,87	[99]
Annelida																		
Tubifex tubifex	field collected	n	$UO_2Ac_2 \times 2H_2O$	rg	R	nw	7.6	30	245	400		96 h	LC50	mortality	2050	3	1,86	[106]
Crustacea																		
Ceriodaphnia dubia	≤ 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R	nw	6.9-7.8	26	6.1	1.1		48 h	LC50	mortality	60	2	3,9	[107]
Ceriodaphnia dubia	≤ 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R	nw	6.2-6.8	25-26	3.9	3.5		48 h	LC50	mortality	89	2	3,9	[107]
Ceriodaphnia dubia	≤ 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R	nw	6.2-6.4	24	3.0-4.0	1.2-2.1		48 h	LC50	mortality	45	2	3,9,62	[107]
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	6.3-6.5	24	3.4-3.8	2.1-2.2		48 h	LC50	mortality	100	2	9,63	[107]
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	5.9-6.4	24-25	3.8-11.5	30		48 h	LC50	mortality	70	2	3,9,64	[107]
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	5.7-6.5	24-25	2.0-3.0	1.0-2.0		48 h	LC50	mortality	100	2	3,9	[107]
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	5.7-6.4	24-25	2.0-4.0	<0.05-1.0		48 h	LC50	mortality	>260	3	3,9,65	[107]
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	6.7-7.1	25-26	3.9-5.1	3		48 h	LC50	mortality	190	2	2,7,9	[107]
Ceriodaphnia dubia	≤ 24 h	y	UO_2		R	nw	6.1-6.4	25	4.0-4.1			48 h	LC50	mortality	50	2	7,9,66	[107]
Ceriodaphnia dubia		y	soil extract		R	nw	8.36	25	176	126		96 h	LC50	mortality	10500	3	67	[108]
Cypris subglobosa	field collected	n	$UO_2Ac_2 \times 2H_2O$	>98	R	nw	7.4-7.7	20-22	245	400		24 h	EC50		55.29	3	1	[109]
Cypris subglobosa	field collected	n	$UO_2Ac_2 \times 2H_2O$	>98	R	nw	7.4-7.7	20-22	245			48 h	EC50		9.18	3	1	[109]
Dadaya macrops	< 6h	y	UO_2SO_4		S	nw	6.6		4.6	3.26		24 h	LC50	mortality	1100	2	3,64,68,76	[110]
Daphnia magna	first instar	n	$UO_2(NO_3)_2 \times 6H_2O$	rg	S	nw	7.6-8.1	20	66-73	54-60	1.15	24 h	LC50	mortality	10000-50000	3	1,44,62	[40]
Daphnia magna	first instar	n	$UO_2(NO_3)_2 \times 6H_2O$	rg	S	nw	7.6-8.1	20	66-73	54-60	1.15	48 h	LC50	mortality	1000-10000	3	1,44,62	[40]
Daphnia magna		y	$UO_2(NO_3)_2 \times 6H_2O$	rg	S	nw	7.9-8.0	20	66-73	54-60	1.15	48 h	LC50	mortality	6300	3	6,17,70	[40]
Daphnia magna		y	$UO_2(NO_3)_2 \times 6H_2O$	rg	S	rw	7.9-8.0	20	126-140	126-140	1.15	48 h	LC50	mortality	36800	3	6,17,71	[40]
Daphnia magna		y	$UO_2(NO_3)_2 \times 6H_2O$	rg	S	rw	7.9-8.0	20	188-205	188-205	1.15	48 h	LC50	mortality	46900	3	6,17,71	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.6-8.1	20	66-73	54-60	1.15	48 h	LC50	mortality	860-1440	3	44,62,72	[40]
Daphnia magna	clone C	y	UO_2SO_4		S	am	7.73	20	90.7	62.1	0.48	96 h	LC50	mortality	8250	2	3,8,10	[111]
Daphnia magna	clone F	y	UO_2SO_4		S	am	8.07	20	90.7	126	0.41	96 h	LC50	mortality	5180	2	3,8,10	[111]
Daphnia magna	clone C	y	UO_2SO_4		S	am	7.73	20	179	62.1	0.48	96 h	LC50	mortality	22400	2	3,8,10	[111]
Daphnia magna	clone F	y	UO_2SO_4		S	am	8.07	20	179	126	0.41	96 h	LC50	mortality	15300	2	3,8,10	[111]
Daphnia magna	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		S	am	8	24	249			24 h	LC50	mortality	9700	3	6,17	[92]
Daphnia magna	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		S	am	8	24	249			48 h	LC50	mortality	6540	3	6,17	[92]
Daphnia magna			$UO_2Ac_2 \times 2H_2O$									48 h	EC50	immobility	13000	4*		[112]

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness CaCO3 [mg/L]	Alkalinity CaCO3 [mg/L]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Daphnia magna	< 24 h	n	$UO_2Ac_2 \times 2H_2O$		S			23				48 h	EC50		13000	3	1	[113]
Daphnia magna												24 h	LC50		32700	4		[94]
Daphnia magna	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		S	am	7	20	254			48 h	LC50	mortality	390	2	3,10	[114]
Daphnia magna	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		S	am	8	20	254			48 h	LC50	mortality	7800	2	3,10	[114]
Daphnia pulex												96 h	LC50	mortality	150	4	4	[7]
Daphnia pulex	neonates	y	$UO_2(NO_3)_2 \times 6H_2O$		S		5.1-5.6	20-21	2.3-3.3	<0.1-0.6		48 h	LC50	mortality	220	4	4	[6]
Diaphanosoma excisum	< 6h	y	UO_2SO_4		S	nw	6.6		4.6	3.26		24 h	LC50	mortality	1000	2	3,64,68,73,77	[110]
Hyalella azteca	7-14 d	y	$UO_2(NO_3)_2 \times 6H_2O$	99	S	tw	8.0-8.2	23	112-127	84-100		96 h	LC50	mortality	8200	2	3,10	[115]
Latonopsis fasciculata	< 6h	y	UO_2SO_4		S	nw	6.6		4.6	3.26		24 h	LC50	mortality	410	2	3,10,64,68,73,78	[110]
Macrobrachium sp.	adult	n			S	nw	7	25	10			96 h	LC50	mortality	> 5000	2	11,79	[99]
Moinodaphnia macleayi	< 6h	y	UO_2SO_4		S	nw	6.6		4.6	3.26		24 h	LC50	mortality	1290	2	3,10,64,68,73,79	[110]
Moinodaphnia macleayi	< 6h	y	$UO_2SO_4 \times 3H_2O$		R	nw	5.9-6.3	27				48 h	LC50	mortality	122	3	63,80,81	[116]
Moinodaphnia macleayi	< 6h, lab cultured strain	y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	27	4-6			48 h	LC50	mortality	160	3	5	[117]
Moinodaphnia macleayi	< 6h, lab cultured strain	y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	27	4-6			48 h	LC50	mortality	240	3	5	[117]
Moinodaphnia macleayi	< 6h, wild strain BB	y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	27	4-6			48 h	LC50	mortality	360	3	5	[117]
Moinodaphnia macleayi	< 6h, wild strain BB	y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	27	4-6			48 h	LC50	mortality	260	3	5	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	27	4-6			48 h	LC50	mortality	390	3	5,82	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	27	4-6			48 h	LC50	mortality	210	3	5,82	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		S	nw	6.6-6.9	27	4-6			48 h	LC50	mortality	90	3	5,83	[117]
Moinodaphnia macleayi	< 6h	y			R	n	6.5	27	4			48 h	LC50	mortality	185	4	84	[99]
Insecta																		
Chironomus dilutus	8 d	y	$UO_2(NO_3)_2 \times 6H_2O$	99	S	tw	8.0-8.2	23	112-127	84-100		96 h	LC50	mortality	33500	2	3,10	[115]
Chironomus tentans	larvae	n	$UO_2(NO_3)_2 \times 6H_2O$	rg	S	nw	7.6-8.1	20	66-73	54-60	1.15	48 h	LC50	mortality	> 40000	3	1,44,62	[40]
Chironomus tentans	larvae	n	$UO_2(NO_3)_2 \times 6H_2O$	rg	S	nw	7.6-8.1	20	66-73	54-60	1.15	96 h	LC50	mortality	10000-50000	3	1,44,62	[40]
Chironomus riparius						am						96 h	LC50	mortality	17700	4		[92]
Chironomus crassiforceps	4 days old	y			S	dw	4	27				72 h	LC50	mortality	58000	3	6,88	[118]
Chironomus crassiforceps	4 days old	y			S	dw	6	27				72 h	LC50	mortality	36000	3	6,88	[118]
Pisces																		
Ambassus macleayi	juvenile, 8.1 mm, 315 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		24 h	LC50	mortality	2230	2	3,10,64,68,73	[110]
Ambassus macleayi	juvenile, 8.1 mm, 315 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		48 h	LC50	mortality	800	2	3,10,64,68,73	[110]
Ambassus macleayi	juvenile, 8.1 mm, 315 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		72 h	LC50	mortality	800	2	3,10,64,68,73	[110]
Ambassus macleayi	juvenile, 8.1 mm, 315 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		96 h	LC50	mortality	800	2	3,10,64,68,73,89	[110]
Amniataba percoides	adult	n			S	nw	7	25	10			96 h	LC50	mortality	2500	4	4	[99]
Danio rerio		n						20				96 h	LC50	mortality	3020	4*	1,90,91	[101]
Danio rerio		n	$UO_2Ac_2 \times 2H_2O$		S	dtw	7.86		178			96 h	LC50	mortality	3050	3	1	[78]
Danio rerio												24 h	LC50		6400	4		[94]
Catostomus latipinnis	larvae12-13 d post hatch, 20 mg, 16 mm	n	$UO_2(NO_3)_2$		S	rw	7.93		144	103		96 h	LC50	mortality	43500	3	1,92,93	[119]
Craterocephalus marianae	juvenile, 18.6 mm, 386 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		24 h	LC50	mortality	1860	2	3,10,64,68,73	[110]
Craterocephalus marianae	juvenile, 18.6 mm, 386 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		48 h	LC50	mortality	1810	2	3,10,64,68,73	[110]
Craterocephalus marianae	juvenile, 18.6 mm, 386 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		72 h	LC50	mortality	1220	2	3,10,64,68,73	[110]
Craterocephalus marianae	juvenile, 18.6 mm, 386 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		96 h	LC50	mortality	1220	2	3,10,64,68,73,94	[110]
Craterocephalus marjoriae	adult	n			S	nw	7	25	10			96 h	LC50	mortality	4250	4	4,11	[99]
Gambusia holbrooki			$UO_2(NO_3)_2$									96 h	LC50	mortality	4000	4	95	[120]
Gila elegans	fry 11-18 days old	n	$UO_2(NO_3)_2$			am	7.0-8.5		196	107		96 h	LC50	mortality	46000	3	1,96	[121]
Gila elegans	juv, 1.1g, 138-145days old	n	$UO_2(NO_3)_2$			am	7.0-8.5		196	107		96 h	LC50	mortality	46000	3	1,96	[121]
Gila elegans	juv., 2.6g, 220-234days old	n	$UO_2(NO_3)_2$			am	7.0-8.5		196	107		96 h	LC50	mortality	46000	3	1,96	[121]
Hypseleotris compressus	adult	n			S	nw	6	25	8		11	96 h	LC50	mortality	6596	4	4,11	[99]
Lepomis macrochirus												96 h	LC25	mortality	1400	4	4	[7]
Lepomis macrochirus	2.7 g; 5.61 cm	y	$UO_2(NO_3)_2 \times 6H_2O$			nw	5.1-5.6	19	2.5-3.2	< 0.1-3.8	5.9-8.7	96 h	LC50	mortality	1460	4	4,85	[6]
Madigania unicolor	adult	n			S	nw	7	25	10			96 h	LC50	mortality	4096	4	4,11	[99]
Melanotaenia splendida inorata	14 days, 0.8 g fish/l	y	$U(SO_4)_2 \times 4H_2O$		F	nw	6.56	30		3.2	5.8	96 h	LC50	mortality	1390	2	3,97,98	[122]
Melanotaenia splendida inorata	31 days, 0.36 g fish/l	y	$U(SO_4)_2 \times 4H_2O$		F	nw	6.3	30		1.8	1.5	7 d	LC50	mortality	1570	2	3,97,99, 100	[122]
Melanotaenia splendida inorata	7 days, 7.37 mm, 0.96 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		24 h	LC50	mortality	3240	2	3,10,64,68,73	[110]

Species	Species properties	A	Test compound	Purity	Test type	Test water	pH	T	Hardness CaCO3	Alkalinity CaCO3	DOC	Exp. time	Crit.	Endpoint	Value	Ri	Notes	Ref
				[%]				[°C]	[mg/L]	[mg/L]	[mg/L]				[µg U/L]			
Melanotaenia splendida inorata	7 days, 7.37 mm, 0.96 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		48 h	LC50	mortality	2750	2	3,10,64,68,73	[110]
Melanotaenia splendida inorata	7 days, 7.37 mm, 0.96 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		72 h	LC50	mortality	2660	2	3,10,64,68,73	[110]
Melanotaenia splendida inorata	7 days, 7.37 mm, 0.96 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		96 h	LC50	mortality	2660	2	3,10,64,68,73,103	[110]
Melanotaenia splendida inorata	90 days, 23.7 mm, 415 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		24 h	LC50	mortality	4370	2	3,10,64,68,73	[110]
Melanotaenia splendida inorata	90 days, 23.7 mm, 415 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		48 h	LC50	mortality	3840	2	3,10,64,68,73	[110]
Melanotaenia splendida inorata	90 days, 23.7 mm, 415 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		72 h	LC50	mortality	3460	2	3,10,64,68,73	[110]
Melanotaenia splendida inorata	90 days, 23.7 mm, 415 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		96 h	LC50	mortality	3460	2	3,10,64,68,73,94	[110]
Melanotaenia splendida inorata	adult	n			S	nw	6	25	8		11	96 h	LC50	mortality	6000	4	4,11	[99]
Melanotaenia nigrans	7 days, 7.6 mm, 0.91 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		24 h	LC50	mortality	2640	2	3,10,64,68,73	[110]
Melanotaenia nigrans	7 days, 7.6 mm, 0.91 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		48 h	LC50	mortality	2110	2	3,10,64,68,73	[110]
Melanotaenia nigrans	7 days, 7.6 mm, 0.91 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		72 h	LC50	mortality	1880	2	3,10,64,68,73	[110]
Melanotaenia nigrans	7 days, 7.6 mm, 0.91 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		96 h	LC50	mortality	1700	2	3,10,64,68,73,101	[110]
Melanotaenia nigrans	90 days, 22.1 mm, 304 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		24 h	LC50	mortality	3240	2	3,10,64,68,73	[110]
Melanotaenia nigrans	90 days, 22.1 mm, 304 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		48 h	LC50	mortality	2370	2	3,10,64,68,73	[110]
Melanotaenia nigrans	90 days, 22.1 mm, 304 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		72 h	LC50	mortality	1970	2	3,10,64,68,73	[110]
Melanotaenia nigrans	90 days, 22.1 mm, 304 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		96 h	LC50	mortality	1900	2	3,10,64,68,73,102	[110]
Melanotaenia nigrans	adult	n			S	nw	6	25	8		11	96 h	LC50	mortality	4500	4	4,11	[99]
Mogurnda mogurnda	sac-fry (1 d)	y			R	am	6	27	3.9	3.26	< 0.2	96 h	EC50	mortality	1377	2	3,10,11	[99]
Mogurnda mogurnda	7days, 4.73mm, 0.94mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		24 h	LC50	mortality	2470	2	3,10,64,68,73	[110]
Mogurnda mogurnda	7days, 4.73mm, 0.94mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		48 h	LC50	mortality	2050	2	3,10,64,68,73	[110]
Mogurnda mogurnda	7days, 4.73mm, 0.94mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		72 h	LC50	mortality	1110	2	3,10,64,68,73	[110]
Mogurnda mogurnda	7days, 4.73mm, 0.94mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		96 h	LC50	mortality	1110	2	3,10,64,68,73,104	[110]
Mogurnda mogurnda	90days, 26.4mm, 138.2mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		24 h	LC50	mortality	2930	2	3,10,64,68,73	[110]
Mogurnda mogurnda	90days, 26.4mm, 138.2mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		48 h	LC50	mortality	2150	2	3,10,64,68,73	[110]
Mogurnda mogurnda	90days, 26.4mm, 138.2mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		72 h	LC50	mortality	1460	2	3,10,64,68,73	[110]
Mogurnda mogurnda	90days, 26.4mm, 138.2mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		96 h	LC50	mortality	1460	2	3,10,64,68,73,105	[110]
Mogurnda mogurnda	6 days, 0.8 g fish/l	y	$U(SO_4)_2$ x $4H_2O$		F	nw	6.56	30	4	3.2	5.8	96 h	LC50	mortality	1570	2	3,97,98, 107	[122]
Mogurnda mogurnda	40 days, 0.8 g fish/l	y	$U(SO_4)_2$ x $4H_2O$		F	nw	6.56	30	4	3.2	5.8	96 h	LC50	mortality	3290	2	3,97,98, 107	[122]
Mogurnda mogurnda	40 days, 0.8 g fish/l	y	$U(SO_4)_2$ x $4H_2O$		F	nw	6.56	30	4	3.2	5.8	7 d	LC50	mortality	2690	2	3,97,98, 107	[122]
Mogurnda mogurnda	40 days, 0.8 g fish/l	y	$U(SO_4)_2$ x $4H_2O$		F	nw	6.56	30	4	3.2	5.8	7 d	LC50	mortality	1440	2	3,74,97,98,107	[122]
Mogurnda mogurnda	70 days, 0.8 g fish/l	y	$U(SO_4)_2$ x $4H_2O$		F	nw	6.56	30	4	3.2	5.8	96 h	LC50	mortality	3290	2	3,97,98, 107	[122]
Mogurnda mogurnda	70 days, 0.8 g fish/l	y	$U(SO_4)_2$ x $4H_2O$		F	nw	6.56	30	4	3.2	5.8	7 d	LC50	mortality	3290	2	3,97,98, 107	[122]
Mogurnda mogurnda	70 days, 0.8 g fish/l	y	$U(SO_4)_2$ x $4H_2O$		F	nw	6.56	30	4	3.2	5.8	7 d	LC50	mortality	2700	2	3,74,97,98,107	[122]
Mogurnda mogurnda	recently hatched fry	y	UO_2SO_4 x $3H_2O$		R	am	6	27	6.6	4		96 h	LC50	mortality	1730	2	3,7,9	[123]
Mogurnda mogurnda	recently hatched fry	y	UO_2SO_4 x $3H_2O$		R	am	6	27	6.6	4		96 h	LC50	mortality	1965	2	3,7,9	[123]
Mogurnda mogurnda	recently hatched fry	y	UO_2SO_4 x $3H_2O$		R	am	6	27	165	4		96 h	LC50	mortality	1335	2	3,7,9	[123]
Mogurnda mogurnda	recently hatched fry	y	UO_2SO_4 x $3H_2O$		R	am	6	27	165	4		96 h	LC50	mortality	1710	2	3,7,9	[123]
Mogurnda mogurnda	recently hatched fry	y	UO_2SO_4 x $3H_2O$		R	am	6	27	330	4		96 h	LC50	mortality	1270	2	3,7,9	[123]
Mogurnda mogurnda	recently hatched fry	y	UO_2SO_4 x $3H_2O$		R	am	6	27	330	4		96 h	LC50	mortality	1770	2	3,7,9	[123]
Oncorhynchus mykiss												96 h	LC50	mortality	6200	4	4	[7]
Oncorhynchus mykiss	130 mm; 27.8 g	y			F		6.8-7.0	14.2	30.8	26		96 h	LC50	mortality	6200	4	4,6,75	[6]
Oncorhynchus mykiss	0.58 g	y	$UO_2(NO_3)_2$ x $6H_2O$		S		6.2-7.0	15-16	20	11-12		96 h	LC50	mortality	4200	4	3,4	[6]
Oncorhynchus mykiss	0.58 g	y	$UO_2(NO_3)_2$ x $6H_2O$		S		6.2-7.0	15-16	68	11-12		96 h	LC50	mortality	3900	4	3,4	[6]
Oncorhynchus mykiss	0.58 g	y	$UO_2(NO_3)_2$ x $6H_2O$		S		6.2-7.0	15-16	126	11-12		96 h	LC50	mortality	4000	4	3,4	[6]
Oncorhynchus mykiss	0.58 g	y	$UO_2(NO_3)_2$ x $6H_2O$		S		6.2-7.0	15-16	243	11-12		96 h	LC50	mortality	3800	4	3,4	[6]
Pimephales promelas	< 2.5 cm fork length	n	$UO_2(NO_3)_2$ x $6H_2O$	rg	S	nw	7.6-8.1	20	66-73	54-60	1.15	48 h	LC50	mortality	> 100000	3	1,44,62	[40]
Pimephales promelas	< 2.5 cm fork length	n	$UO_2(NO_3)_2$ x $6H_2O$	rg	S	nw	7.6-8.1	20	66-73	54-60	1.15	96 h	LC50	mortality	> 100000	3	1,44,62	[40]
Pimephales promelas		n	UO_2SO_4 x $3H_2O$				7.4		20	18		96 h	LC50	mortality	2800	3	1	[124]
Pimephales promelas		n	UO_2SO_4 x $3H_2O$				8.2		400	360		96 h	LC50	mortality	135000	3	1	[124]
Pimephales promelas		n	$UO_2(NO_3)_2$ x $6H_2O$				7.4		20	18		96 h	LC50	mortality	3100	3	1	[124]
Pimephales promelas		n	UO_2Ac_2 x 2 H_2O				7.4		20	18		96 h	LC50	mortality	3700	3	1	[124]
Pimephales promelas	< 24 h	y	$UO_2(NO_3)_2$ x $6H_2O$		R		6.3-7.0	24-26	23			96 h	LC50	mortality	2000	4	3,4	[6]
Pimephales promelas	< 24 h	y	$UO_2(NO_3)_2$ x $6H_2O$		R		6.3-7.0	24-26	72			96 h	LC50	mortality	2000	4	3,4	[6]
Pimephales promelas	< 24 h	y	$UO_2(NO_3)_2$ x $6H_2O$		R		6.3-7.0	24-26	131			96 h	LC50	mortality	2100	4	3,4	[6]
Pimephales promelas	< 24 h	y	$UO_2(NO_3)_2$ x $6H_2O$		R		6.3-7.0	24-26	244			96 h	LC50	mortality	1800	4	3,4	[6]

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness CaCO3 [mg/L]	Alkalinity CaCO3 [mg/L]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Pseudomugli tenellus	juvenile, 8.1 mm, 315 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		24 h	LC50	mortality	2070	2	3,10,64,68,73	[110]
Pseudomugli tenellus	juvenile, 8.1 mm, 315 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		48 h	LC50	mortality	820	2	3,10,64,68,73	[110]
Pseudomugli tenellus	juvenile, 8.1 mm, 315 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		72 h	LC50	mortality	730	2	3,10,64,68,73	[110]
Pseudomugli tenellus	juvenile, 8.1 mm, 315 mg	y	UO_2SO_4		R	nw	6.6	27	4.6	3.26		96 h	LC50	mortality	730	2	3,10,64,68,73,106	[110]
Ptychocheilus lucius	fry 17-31 days old	n	$UO_2(NO_3)_2$		S	am	7.0-8.5		196	107		96 h	LC50	mortality	46000	3	1,96	[121]
Ptychocheilus lucius	juv., 0.4-1.1g, 99-115days	n	$UO_2(NO_3)_2$		S	am	7.0-8.5		196	107		96 h	LC50	mortality	46000	3	1,96	[121]
Ptychocheilus lucius	juv., 1.7g, 193-207 days	n	$UO_2(NO_3)_2$		S	am	7.0-8.5		196	107		96 h	LC50	mortality	46000	3	1,96	[121]
Salvenius fontinalis	juvenile	y	$UO_2SO_4 \times 3H_2O$		R	nw+ dw	6.7	13	32	12		96 h	LC50		5500	2	7,9	[27]
Salvenius fontinalis	juvenile	y	$UO_2SO_4 \times 3H_2O$		R	nw+ dw	7.5	14	210	54		96 h	LC50		23000	2	7,9,107	[27]
Salvenius fontinalis	juvenile, 0.6 g, 44 mm	y	$UO_2SO_4 \times 3H_2O$		F	nw+ dw	7.4	16	184	146		48 h	LC50		59000	2	7,69,107	[27]
Salvenius fontinalis												96 h	LC50	mortality	6200	4	4	[7]
Salvenius fontinalis	81 mm, 7.8 g	y			F		6.8-7.0	14.2	30.8	26		96 h	LC50	mortality	8000	4	4,6	[6]
Xyrauchen texanus	fry 10-17 days old	n	$UO_2(NO_3)_2$			am	7.0-8.5		196	107		96 h	LC50	mortality	46000	3	96	[121]
Xyrauchen texanus	juv., 0.9g, 133-139 days old	n	$UO_2(NO_3)_2$			am	7.0-8.5		196	107		96 h	LC50	mortality	46000	3	96	[121]
Xyrauchen texanus	juv., 2.0g, 176-186 days old	n	$UO_2(NO_3)_2$			am	7.0-8.5		196	107		96 h	LC50	mortality	46000	3	96	[121]

Notes

1 Not analysed
2 Endpoint based on nominal concentrations
3 Endpoint based on mean measured concentrations
4 Original reference not available
5 Analysis only performed at the start of the experiment
6 Unclear if endpoint based on measured or nominal concentrations
7 Measured concentrations within 20% of nominal
8 Measured concentrations within 10% of nominal
9 Renewal every 24 h
10 Analysis performed at the start and end of the test
11 Recalculated from concentration in UO_2
12 Not a pure culture
13 Endpoint extrapolated
14 Acetate as substrate
15 H2 as substrate
16 Sulphur (S0) as substrate
17 Result of analysis unknown
18 Effect on growth was mainly caused by increased lag times, at maximum growth for the control (24 h) there was almost no growth at the treatments. Maximum growth for lowest exposure was reached after 48 hours, finally all treatments reached the same optical density.
19 Growth substrate butyrate
20 Growth substrate dextrose
21 Growth substrate lactate
22 Growth substrate ethanol
23 Exponential phase of control ± 16 h
24 Exponential phase of control ± 10 h
25 Exponential phase of control ± 18 h
26 Increased level of sodium bicarbonate (10 mM), tested with multiple carbon sources
27 Recalculated for exponential phase with data from graph in paper
28 Highest test concentration exceeds maximum water solubility not included in estimation of endpoint
29 Endpoint determined with data from graph in paper
30 Lowest exposure concentration 1 mg/L
31 Exposure time much longer than exponential phase of the control
32 Measured concentrations at the start of the experiment within 20% of nominal concentrations, endpoint based on initial measured concentrations; analysis performed at the end of the experiment showed a mass balance in each treatment of >90%, 75% in solution, 10% bound to the cell surface and ca. 15% adsorbed to the walls of the flasks, this recovery is considered high enough to assign Ri2
33 Endpoint based on measured concentrations, analysis only performed at the start of the experiment, mass balance at similar exposure showed only 50-70% in solution after 72 h and up to 40% of the U added adsorbed to the walls of the flasks throughout this similar test. Therefore endpoints based on initial measured concentrations considered Ri3;
34 Endpoint based on measured concentrations; analysis only performed at the start of the experiment, contact with the author revealed that the same apparatus was used as in Hogan et al. [96] where loss in concentration over 96 h was less than 20% therefore considered acceptable
35 Growth inhibition at highest concentration was 17%, original uranium concentration in test water 0.7 µg/L
36 Performed in low nutrient medium based on a 1.5% dilution of a high nutrient medium
37 Performed in low nutrient medium based on a 0.5% dilution of a high nutrient medium
38 Performed in low nutrient medium containing 333 uM glucose
39 Performed in low nutrient medium based on aspartic acid (150 uM)
40 Measured concentrations within 20% of nominal concentrations, endpoint based on measured concentrations after renewal only, same method used as and same research group as Hogan et al. [91] for which contact with the author revealed that the same apparatus was used as in Hogan et al. [96] where loss in concentration over 96 h was less than 20% therefore considered acceptable; renewal every 48 hours

41 Range finding test not analysed, a separate fate test for the higher test concentrations showed a reduction of 11 to 16% of the uranium concentration over 96 h therefore nominal concentrations considered acceptable as total, U background concentration in test water 0.016-1.67 µg/L; reported pH range is in the U treatments over the exposure period
42 Endpoint based on pooled data of three tests based on measured values, analysis only performed at start of the test but a separate fate test for the higher test concentrations showed a reduction of 11 to 16% of the uranium concentration over 96 h therefore nominal concentrations considered acceptable as total, U background concentration in test water 0.016-1.67 µg/L; reported pH is at start of experiment, an increase of the actual pH of test solutions of 1.1 unit from starting pH was reported since this indicated a pH rise above 7, this endpoint is considered unreliable.
43 Renewal 20% of medium every 2 days
44 Unreliable fit
45 Phosphate concentration 0.01 mg/L
46 Phosphate concentration 0.14 mg/L
47 Phosphate concentration 1.36 mg/L
48 Phosphate concentration 4.0 mg/L
49 Phosphate concentration 8.0 mg/L
50 Same test protocol as performed by Markich and Camileri [99]
51 Effect determined 24 h after exposure
52 Same study as Labrot et al. [78]
53 EC50 based on bivalve closure time during the total exposure time of 300 min
54 Exposure in PVC tanks
55 Only one concentration tested
56 Analysis result of filtered and unfiltered samples were similar
57 Exposure in tanks with sand
58 Continuous feeding
59 Control phase of 48 h followed by an exposure phase of 48 h (same animals)
60 Fulvic acid added to test medium
61 Citation of unpublished data of the author, enough details are given to assess reliability
62 Endpoint determined with data from paper
63 Endpoint corrected for measured concentrations
64 Measured concentrations < 80% of nominal
65 Animals fed during test
66 Nominal concentrations based on measured stock solution
67 Animals exposed to extract from soil containing more metals
68 Natural uranium concentration in test water was 0.2 µg/L
69 Comparison of filtered versus unfiltered samples showed that >93% of the uranium was in the dissolved form
70 Geometric mean of three tests
71 Geometric mean of two tests
72 Determined after 48 hours in chronic experiment, a second test gave no mortalities at all after 48 h
73 Alkalinity 3.26
74 Endpoint determined after post exposure period of 7 days
75 No partial mortalities
76 LC1 = 0.14 mg/L
77 LC1 = 0.9 mg/L
78 LC1 = 0.17 mg/L
79 LC1 = 0.49 mg/L
80 Fed with vitamin enriched fermented food and algae
81 Analysis only performed in stock solution added to test water
82 Strain pre-cultured in contaminated water
83 Animals were unhealthy during test
84 Citation of unpublished data
85 Concentration before filtration was 1670 µg/L
86 Natural water was well water
87 Not a population relevant endpoint
88 Water spiked water-sediment system consisting of ashed natural sand
89 LC1 = 0.073 mg/L
90 According to OECD guideline
91 Limited details reported
92 According to ASTM method
93 Confidence interval 34.8 - 53.4 mg/L
94 LC1 = 0.26 mg/L
95 Results from range-finding test in previous study (not reported)
96 No partial mortality observed, endpoint calculated as geometric mean of lowest conc. with 100% mortality and highest concentration with 0% mortality
97 Animals exposed in separate compartment of larger tank
98 TOC 9.2 mg/l,
99 Unclear whether samples for uranium analysis taken from dilution medium of from the exposure tanks
100 TOC 2.7 mg/l
101 LC1 = 0.37 mg/L
102 LC1 = 0.92 mg/L
103 LC1 = 0.88 mg/L
104 LC1 = 0.158 mg/L
105 LC1 = 0.23 mg/L
106 LC1 = 0.071 mg/L
107 Analysis performed daily

Table A3.2 Chronic toxicity for freshwater organisms

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Alkalinity $CaCO_3$ [mg/L]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Bacteria																		
anaerobic sludge		y	UO_2Cl_2 x $3H_2O$	>99	S	am	7.5	30				6 d	EC10	nitrate reduction	7100	3	12,14	[84]
anaerobic sludge		y	UO_2Cl_2 x $3H_2O$	>99	S	am	7.5	30				2 d	EC10	nitrate reduction	16000	3	12,15	[84]
anaerobic sludge		y	UO_2Cl_2 x $3H_2O$	>99	S	am	7.5	30				13 d	EC10	nitrate reduction	12000	3	12,16	[84]
Desulfovibrio desulfuricans	strain G20	y	UO_2Cl_2 x $3H_2O$		S	am		25				25 d	NOEC	growth	2618	2	35	[125]
Escherichia coli		n	UO_2Ac_2 x $2H_2O$		S	am	7.5	27	204			48 h	NOEC	acid formation	1700-2200	3	1	[113]
mixed culture	thiosulfate adapted	y	UO_2Cl_2 x $3H_2O$	>99	S	am	7.5	30				14 d	EC10	methane prod.	2600	3	12,14	[84]
Pseudomonas aeruginosa		y	$UO_2(NO_3)_2$ x $6H_2O$		S	am	7.4		40			24 h	NOEC/EC10	growth	< 10000	3	2,17,18	[85]
Pseudomonas fluorescens		n			S	am	6	25	3.4			24 h	NOEC	growth	< 270	3	1,36	[126]
Pseudomonas fluorescens		n	UO_2Ac_2 x $2H_2O$		S		7.5-7.8	25	204			24 h	NOEC	growth	1120	3	1	[127]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			28 h	NOEC	growth rate	< 13500	3	1,19	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			24 h	NOEC	growth rate	< 13500	3	1,20	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			22 h	NOEC	growth rate	< 13500	3	1,21	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			46 h	NOEC	growth rate	27	3	1,22	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			28 h	EC10	growth rate	21400	3	1,19,23,27	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			24 h	EC10	growth rate	22300	3	1,20,23,27	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			22 h	EC10	growth rate	9000	3	1,21,24,27	[86]
Pseudomonas sp.		n	UO_2Cl_2		S	am	7	20	7			46 h	EC10	growth rate	12.7	3	1,22,25,27	[86]
Thiobacillus ferrooxidans		n	UO_2SO_4 x $3H_2O$		S	am	1.3	28	165			48 h	EC10	oxidation	50000	3	1	[87]
Thiobacillus ferrooxidans		n	UO_2SO_4 x $3H_2O$		S	am	1.8-2.2	30				80 min	EC10	oxygen consump.	1740000	3	1,28,29	[128]
Zoogloea ramigera		n	$UO_2(NO_3)_2$ x $6H_2O$		S	am	6-7	24	81			24 h	EC10	growth rate	0.87	3	1,13,30	[88]
Zoogloea ramigera		n	$UO_2(NO_3)_2$ x $6H_2O$		S	am	6-7	24	81			66 h	NOEC	lag time	< 1000	3	1,31	[88]
Zoogloea ramigera		n	$UO_2(NO_3)_2$ x $6H_2O$		S	am	6-7	24	81			66 h	EC10	growth rate	2100	3	1,31	[88]
Cyanobacteria																		
Fischerella muscicola		n	$UO_2(NO_3)_2$ x $6H_2O$		S	am		24					NOEC	mortality	< 119000	3	1	[129]
Algae																		
Chlorella sp.	wild type, 4-5 days	y	UO_2SO_4 x $3H_2O$		S	am	7.0	27	8	8.7	< 0.2	72 h	EC10	growth rate	0.7	2	32	[89]
Chlorella sp.	wild type, 4-5 days	y	UO_2SO_4 x $3H_2O$		S	am	7.0	27	40	8.7	< 0.2	72 h	EC10	growth rate	0.7	2	32	[89]
Chlorella sp.	wild type, 4-5 days	y	UO_2SO_4 x $3H_2O$		S	am	7.0	27	100	8.7	< 0.2	72 h	EC10	growth rate	23	2	32	[89]
Chlorella sp.	wild type, 4-5 days	y	UO_2SO_4 x $3H_2O$		S	am	7.0	27	400	8.7	< 0.2	72 h	EC10	growth rate	4.5	2	32	[89]
Chlorella sp.							7.0		8			48 h	EC10		0.9	4	4	[89]
Chlorella sp.							7.0		400			48 h	EC10		3.5	4	4	[89]
Chlorella sp.		y	UO_2SO_4 x $3H_2O$		S	am	5.7	27	2-4			72 h	EC10	growth rate	21	3	26,33	[90]
Chlorella sp.		y	UO_2SO_4 x $3H_2O$		S	am	6.5	27	2-4			72 h	EC10	growth rate	11	3	26,33	[90]
Chlorella sp.		y			S	am	6.4-6.6	29	3.6	2.63	-	72 h	NOEC	growth rate	38	2	34	[91]
Chlorella sp.		y			S	nw	6.5-6.8	29	3.9	11	4.1	72 h	NOEC	growth rate	150	2	34	[91]
Chlorella sp.		y			S	nw	6.2-6.4	29	3.9		3.4	72 h	NOEC	growth rate	109	2	34	[91]
Chlorella sp.		y			S	nw	6.4-6.6	29	3.9	7	8.1	72 h	NOEC	growth rate	157	2	34	[91]
Chlorella sp.		y			S	nw	6.3-6.6	29	3.9	<5	2.6	72 h	NOEC	growth rate	72	2	34	[91]
Cryptomonas erosa		y			R		7.1-9.1	20.8	101	52		6 d	NOEC		1310	4	4	[6]
Cryptomonas erosa		y			R		7.1-9.1	20.8	101	52		6 d	EC10	growth	172	4	4,10	[6]
Euglena gracilis	cells from 4 d old cult.	y	UO_2SO_4 x $3H_2O$		S	am	6	28	0.7	50	10	96 h	EC10	growth rate	5	2	3,39	[93]
Euglena gracilis	cells from 4 d old cult.	y	UO_2SO_4 x $3H_2O$		S	am	6	28	0.7	50	30	96 h	EC10	growth rate	17	2	3,39	[93]
Pseudokirchneriella subcapitata		y	$UO_2(NO_3)_2$ x $6H_2O$		R		7.8-9.7	22	70	64		72 h	NOEC		570	4	4	[6]
Pseudokirchneriella subcapitata		y	$UO_2(NO_3)_2$ x $6H_2O$		R		7.8-9.7	22	70	64		72 h	EC10	growth	57	4	4,10	[6]
Pseudokirchneriella subcapitata		y	$UO_2(NO_3)_2$ x $6H_2O$		S		6.8-8.2	24-26	5-228	7-8		72 h	EC10	growth	5.4-120	4	3,4,10,37	[6]
Scenedesmus quadricauda			UO_2Ac_2 x $2H_2O$									96 h	NOEC	growth	2200	4*	38	[112]
Scenedesmus quadricauda		n	UO_2Ac_2 x $2H_2O$		S	am	7.5	24	204			96 h	NOEC	growth	2200	3	1,43	[113]
Protozoa																		
Microregma heterostoma			UO_2Ac_2 x $2H_2O$		S		7.5-7.8	27	214			28 h	NOEC	food consumption	28000	3		[130]

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Alkalinity $CaCO_3$ [mg/L]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Macrophyta																		
Lemna aequinoctialis		y	UO_2SO_4 x $3H_2O$		R	am	6.5	27	40	19		96 h	LOEC	growth rate	112	2	40,71	[95]
Lemna aequinoctialis		n	UO_2SO_4 x $3H_2O$		S	nw	6.7-7.5	29	3.9-4.8		3-4	96 h	NOEC	growth rate	82	2	41	[96]
Lemna aequinoctialis		n	UO_2SO_4 x $3H_2O$		S	nw	6.7-7.5	29	3.9-4.8		3-4	96 h	EC10	growth rate	189	2	41	[96]
Lemna aequinoctialis		y	UO_2SO_4 x $3H_2O$		S	nw	6.6	29	3.9-4.8		3-4	96 h	NOEC	growth rate	221	2	3,42	[96]
Lemna aequinoctialis		y	UO_2SO_4 x $3H_2O$		S	nw	6.6	29	3.9-4.8		3-4	96 h	EC10	growth rate	234	2	3,42	[96]
Lemna aequinoctialis		y	UO_2SO_4 x $3H_2O$		S	nw	6.7	29	3.9-4.8		3-4	96 h	NOEC	growth rate	226	2	3,42	[96]
Lemna aequinoctialis		y	UO_2SO_4 x $3H_2O$		S	nw	6.7	29	3.9-4.8		3-4	96 h	EC10	growth rate	244	2	3,42	[96]
Lemna aequinoctialis		y	UO_2SO_4 x $3H_2O$		S	nw	6.9	29	3.9-4.8		3-4	96 h	NOEC	growth rate	80	2	3,42	[96]
Lemna aequinoctialis		y	UO_2SO_4 x $3H_2O$		S	nw	6.9	29	3.9-4.8		3-4	96 h	EC10	growth rate	191	2	3,42	[96]
Lemna gibba		y			R	am							NOEC	yield	< 100	3	6	[131]
Lemna gibba		n	$UO_2(NO_3)_2$ x $6H_2O$		S	am	6.5	24/16	29			21 d	NOEC	growth rate	< 50	3	45,77	[132]
Lemna gibba		y	$UO_2(NO_3)_2$ x $6H_2O$	ag.	R	am		24/16	6			21 d	EC10	growth rate	46	3	2,13,17,46,47	[97]
Lemna gibba		y	$UO_2(NO_3)_2$ x $6H_2O$	ag.	R	am		24/16	6			21 d	EC10	growth rate	0.29	3	2,13,17,46,47	[97]
Lemna gibba		y	$UO_2(NO_3)_2$ x $6H_2O$	ag.	R	am		24/16	6			21 d	EC10	growth rate	105	3	2,17,46	[97]
Lemna gibba		y	$UO_2(NO_3)_2$ x $6H_2O$	ag.	R	am		24/16	6			21 d	EC10	growth rate	54	3	2,13,17,46,47	[97]
Lemna gibba		y	$UO_2(NO_3)_2$ x $6H_2O$	ag.	R	am		24/16	6			21 d	EC10	growth rate	>7000	3	2,17,44,46	[97]
Lemna minor		y	$UO_2(NO_3)_2$ x $6H_2O$		S		5.8-7.4		35	7-9		7 d	EC10	frond no	3400	4	3,4,10	[6]
Lemna minor		y	$UO_2(NO_3)_2$ x $6H_2O$		S		5.8-7.4		35	7-9		7 d	EC10	dry weight	3100	4	3,4,10	[6]
Fungi																		
Hansenula fabianii		y	$UO_2(NO_3)_2$ x $6H_2O$		S	am		30				165 h	NOEC	growth	< 23800	2	2,47,48	[133]
Saccharomyces cerevisiae		y	$UO_2(NO_3)_2$ x $6H_2O$		S	am		30				165 h	NOEC	growth	< 23800	3	2,17,47	[133]
Ctenophora																		
Hydra viridissima	adult	y			R	nw	6.5	30	4			96 h	NOEC	population growth	<140	4	3,4,11,49	[99]
Hydra viridissima	adult	y			R	nw	6.5	30	4			96 h	NOEC	population growth	< 170	4	3,4,11,50	[99]
Hydra viridissima	adult	y		a.g.	R	am	6	27	3.9			96 h	EC10	population growth	49	2	3,11,51	[99]
Hydra viridissima	adult	y		a.g.	R	am	6	27	3.9			96 h	NOEC	population growth	40	2	3,11,51	[99]
Hydra viridissima			UO_2SO_4 x $3H_2O$		R	nw	6.1-6.7	30				72 h	NOEC	population growth	< 200	3	1	[134]
Hydra viridissima			UO_2SO_4 x $3H_2O$		R	nw	6.1-6.7	30				5 d	NOEC	population growth	150	3	1	[135]
Hydra viridissima			UO_2SO_4 x $3H_2O$		R	nw	6.5	30					NOEC	population growth	< 150	3	1	[135]
Hydra viridissima		y			R	am	6	27	6.6			96 h	NOEC	population growth	< 32	2	52	[98]
Hydra viridissima		y			R	am	6	27	165			96 h	NOEC	population growth	< 90	2	52	[98]
Hydra viridissima		y			R	am	6	27	165			96 h	NOEC	population growth	< 42	2	52	[98]
Hydra viridissima		y			R	am	6	27	330			96 h	NOEC	population growth	< 62	2	52	[98]
Hydra vulgaris	adult	y			R	nw	6.5	30	4			96 h	NOEC	population growth	<649	4	3,4,11,49	[99]
Hydra vulgaris			UO_2SO_4 x $3H_2O$		R	nw	6.1-6.7	30					LOEC	population growth	≤ 400	3	1	[135]
Mollusca																		
Amerianna cumingi	adult, 10-12.9 mm	y	UO_2SO_4 x $3H_2O$		R	nw	5.8	30	2.7-3.7		2-6	96 h	NOEC	egg production	60	2	3,53,54	[96]
Amerianna cumingi	adult, 10-12.9 mm	y	UO_2SO_4 x $3H_2O$		R	nw	5.8	30	2.7-3.7		2-6	96 h	EC10	egg production	20	2	3,53,54	[96]
Amerianna cumingi	adult, 10-12.9 mm	y	UO_2SO_4 x $3H_2O$		R	nw	5.9	30	2.7-3.7		2-6	96 h	NOEC	egg production	29	2	3,53,54	[96]
Amerianna cumingi	adult, 10-12.9 mm	y	UO_2SO_4 x $3H_2O$		R	nw	5.9	30	2.7-3.7		2-6	96 h	EC10	egg production	5	2	3,53,54	[96]
Amerianna cumingi	adult, 10-12.9 mm	y	UO_2SO_4 x $3H_2O$		R	nw	7.3±1	30	2.7-3.7		2-6	96 h	NOEC	egg production	155	2	3,53,54	[96]
Amerianna cumingi	adult, 10-12.9 mm	y	UO_2SO_4 x $3H_2O$		R	nw	7.3±1	30	2.7-3.7		2-6	96 h	EC10	egg production	13	2	3,53,54	[96]
Amerianna cumingi	adult, 10-12.9 mm	y	UO_2SO_4 x $3H_2O$		R	nw	7.3±1	30	2.7-3.7		2-6	96 h	NOEC	egg production	16	2	3,53,54	[96]
Amerianna cumingi	adult, 10-12.9 mm	y	UO_2SO_4 x $3H_2O$		R	nw	7.3±1	30	2.7-3.7		2-6	96 h	EC10	egg production	15	2	3,53,54	[96]
Crustacea																		
Ceriodaphnia dubia	≤ 24 h	y	$UO_2(NO_3)_2$ x $6H_2O$		R	nw	6.7-7.6	25-26	6.1	1.1		7 d	NOEC	reproduction	< 1.3	2	3,9,44,55	[107]
Ceriodaphnia dubia	≤ 24 h	y	$UO_2(NO_3)_2$ x $6H_2O$		R	nw		24-26	3.8	3		7 d	NOEC	reproduction	2.50	2	3,9,56	[107]
Ceriodaphnia dubia	≤ 24 h	y	$UO_2(NO_3)_2$ x $6H_2O$		R	nw		24-26	3.8	3		7 d	EC10	reproduction	2.40	2	3,9,46	[107]
Ceriodaphnia dubia	≤ 24 h	y	$UO_2(NO_3)_2$ x $6H_2O$		R	nw	6.0-6.2	24-25	3.4-3.7	1.7-2.1		7 d	NOEC	reproduction	< 7	2	3,9,57	[107]
Ceriodaphnia dubia	≤ 24 h	y	$UO_2(NO_3)_2$ x $6H_2O$		R	nw	6.0-6.2	24-25	3.4-3.7			7 d	EC10	reproduction	9	2	3,9,57	[107]
Ceriodaphnia dubia	≤ 24 h	y	HUO_2PO_4 x $4H_2O$		R	nw	6.0-6.3	24-25	3.1-4.0			7 d	NOEC	reproduction	< 6	2	2,7,9	[107]

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Alkalinity $CaCO_3$ [mg/L]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	6.0-6.3	24-25	3.1-4.0			7 d	EC10	reproduction	5	2	2,7,9,46	[107]
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	5.9-6.4	24-25	3.8			7 d	NOEC	reproduction	50	2	3,9	[107]
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	5.9-6.4	24-25	3.8			7 d	EC10	reproduction	14	2	3,9,46	[107]
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	5.9-6.3	24-25	2.6-3.6	1.3-3.6		7 d	NOEC	reproduction	2	2	3,9	[107]
Ceriodaphnia dubia	≤ 24 h	y	$HUO_2PO_4 \times 4H_2O$		R	nw	5.9-6.3	24-25	2.6-3.6	1.3-3.6		7 d	EC10	reproduction	18	2	3,9,46	[107]
Ceriodaphnia dubia	≤ 24 h	n	$HUO_2PO_4 \times 4H_2O$		R	nw	6.0-6.8	24-26	5.0-5.1			7 d	NOEC	reproduction	50	3	2,9	[107]
Ceriodaphnia dubia	≤ 24 h	n	$HUO_2PO_4 \times 4H_2O$		R	nw	6.0-6.8	24-26	5.0-5.1			7 d	EC10	reproduction	52	3	2,9,46	[107]
Ceriodaphnia dubia	≤ 24 h	y	UO_2		R	nw	6.0-6.2	24-25	3.4-4.0			7 d	NOEC	reproduction	21	2	9,58	[107]
Ceriodaphnia dubia	≤ 24 h	y	UO_2		R	nw	6.0-6.2	24-25	3.4-4.0			7 d	EC10	reproduction	0.02	3	9,46,58,59	[107]
Ceriodaphnia dubia		y	soil extract		R	nw	8.49	25	190	148		7 d	NOEC	reproduction	1970	3	60	[108]
Ceriodaphnia dubia		y	soil extract		R	nw	8.49	25	190			7 d	EC10	reproduction	4950	3	29,60	[108]
Ceriodaphnia dubia	neonates	y	$UO_2(NO_3)_2 \times 6H_2O$		R		8.2-8.4	23.9	76			7 d	EC10	reproduction	1900	4	4	[6]
Ceriodaphnia dubia	neonates	y	$UO_2(NO_3)_2 \times 6H_2O$		R		8.2-8.4	23.9	76			7 d	NOEC		1540	4	4	[6]
Ceriodaphnia dubia	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.5-7.3	21-26	5			7 d	EC10	reproduction	33	4	4,61	[6]
Ceriodaphnia dubia	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.5-7.3	21-26	17			7 d	EC10	reproduction	59	4	4,61	[6]
Ceriodaphnia dubia	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.5-7.3	21-26	124			7 d	EC10	reproduction	22	4	4,61	[6]
Ceriodaphnia dubia	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.5-7.3	21-26	252			7 d	EC10	reproduction	25	4	4,61	[6]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	NOEC	mortality	< 520	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	EC10	mortality	330	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	NOEC	mortality	200	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	EC10	mortality	840	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	NOEC	reproduction	< 520	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	EC10	reproduction	380	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	NOEC	reproduction	< 520	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	EC10	reproduction	180	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	NOEC	reproduction	1290	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	EC10	reproduction	2080	2	3,48,62	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	NOEC	reproduction	1290	3	3,48,62,63	[40]
Daphnia magna	first instar	y	$UO_2(NO_3)_2 \times 6H_2O$	rg	R	nw	7.9-8.0	20	66-73	54-60	1.15	21 d	EC10	reproduction	1240	3	3,48,62,63	[40]
Daphnia magna						am	7.0					21 d	EC10	reproduction	14	4*		[136]
Daphnia magna		y	$UO_2(NO_3)_2 \times 6H_2O$		R	am	7.0	20	250	2.7		21 d	LOEC	repro + growth	≤ 10	2	9,64	[136]
Daphnia magna	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R	am	7.0	20	254	2.7		21 d	NOEC	mortality	74.7	2	3,65	[114]
Daphnia magna	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R	am	7.0	20	254	2.7		21 d	NOEC	reproduction	10.1	2	3,65	[114]
Daphnia magna	< 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R	am	7.0	20	254	2.7		21 d	EC10	reproduction	14	2	3,65	[114]
Daphnia magna	neonates	y	$UO_2(NO_3)_2 \times 6H_2O$		R		8.0-8.4	22	75			21 d	EC10	reproduction	570	4	4	[6]
Hyalella azteca		y	soil extract		R	nw	7.91	23	157	137		14 d	LC50	survival	1520	3	60	[108]
Hyalella azteca		y	soil extract		R	nw	7.91	23	157			14 d	LC10	survival	230	3	29,60	[108]
Hyalella azteca	2-9 days old	y	$UO_2(NO_3)_2 \times 6\ H_2O$		R		8.2	23	73	80		28 d	EC10	growth	12	4	4,10	[6]
Hyalella azteca	8-9 days	y	$UO_2(NO_3)_2 \times 6\ H_2O$		R		6.4-7.1	21-23	17-238			14 d	LC10	survival	55-88	4	4,10	[6]
Hyalella azteca		n			S	tw	8.21		124	84	1.4	7 d	LC50	mortality	1651	3	1,92,97	[137]
Hyalella azteca		y			S	am	7.39		18	14	0.28	7 d	LC50	mortality	21	3	3,92,93,97	[137]
Hyalella azteca	adult	y	$UO_2(NO_3)_2 \times 3\ H_2O$		R	am	6.9-7.1	25	120			7 d	LC10	mortality	72	2	94,95	[138]
Hyalella azteca	juvenile	y	$UO_2(NO_3)_2 \times 3\ H_2O$		R	am	6.9-7.1	25	120			7 d	LC10	mortality	290	2	94,95	[138]
Moinodaphnia macleayi	< 6h, lab cultured strain	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	reproduction	8	2	5,9,66	[117]
Moinodaphnia macleayi	< 6h, lab cultured strain	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	reproduction	46	2	5,9,67	[117]
Moinodaphnia macleayi	< 6h, lab cultured strain	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	EC10	reproduction	0.86	2	5,9,29,68	[117]
Moinodaphnia macleayi	< 6h, lab cultured strain	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	EC10	reproduction	39.1	2	5,9,29,68	[117]
Moinodaphnia macleayi	< 6h, lab cultured strain	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	EC10	reproduction	39.1	2	5,9,29,68	[117]
Moinodaphnia macleayi	< 6h, wild strain BB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	reproduction	25	2	5,9,66	[117]
Moinodaphnia macleayi	< 6h, wild strain BB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	reproduction	29	2	5,9,67	[117]
Moinodaphnia macleayi	< 6h, wild strain BB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	EC10	reproduction	25.4	2	5,9,29,68	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	reproduction	22	2	5,9,66	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	reproduction	31	2	5,9,67	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	EC10	reproduction	35.6	2	5,9,29,68	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	EC10	reproduction	21.2	2	5,9,29,68	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	EC10	reproduction	21.2	2	5,9,29,68	[117]

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Alkalinity $CaCO_3$ [mg/L]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Moinodaphnia macleayi	< 6h, lab cult. strain	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	mortality	4	2	5,9,66	[117]
Moinodaphnia macleayi	< 6h, lab cult. strain	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	mortality	46	2	5,9,67	[117]
Moinodaphnia macleayi	< 6h, lab cult. strain	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	EC10	mortality	1.6	2	5,9,29,68	[117]
Moinodaphnia macleayi	< 6h, wild strain BB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	mortality	25	2	5,9,66	[117]
Moinodaphnia macleayi	< 6h, wild strain BB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	mortality	29	2	5,9,67	[117]
Moinodaphnia macleayi	< 6h, wild strain BB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	EC10	mortality	16.7	2	5,9,29,68	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	mortality	22	2	5,9,66	[117]
Moinodaphnia macleayi	< 6h, wild strain DjB	y	$UO_2SO_4 \times 3H_2O$		R	nw	6.9-7.1	27	4-6			5 d	NOEC	mortality	31	2	5,9,67	[117]
Moinodaphnia macleayi	< 6h	y	$UO_2SO_4 \times 3H_2O$		R	nw	5.9-6.3	27				5 d	NOEC	reproduction	10	3	69	[116]
Moinodaphnia macleayi	< 6h	y			R	n	6.5	27	4			5 d	NOEC	reproduction	17.5	4	8	[99]
Procambarus clarkii	♂, 27.2 g, 9 cm	y	$UO_2(NO_3)_2$ depl.		R	am	7	17.2				10 d	NOEC	mortality	≥ 8340	2	3,70	[62]
Simocephalus serrulatus	neonates	y	$UO_2SO_4 \times 3H_2O$		R		8.0-8.4	17.2	78			21 d	NOEC		460	4	4	[6]
Simocephalus serrulatus	neonates	y	$UO_2SO_4 \times 3H_2O$		R		8.0-8.4	17.2	78			21 d	EC10	reproduction	480	4	4,10	[6]
Insecta																		
Chironomus tentans	10 day old	y	$UO_2(NO_3)_2 \times 6H_2O$		R	tw	7.8	23	132-136	65-66		51 d	LOEC	emerging	≤ 31	2	3,29,71,72,73	[139]
Chironomus tentans	10 day old	y	$UO_2(NO_3)_2 \times 6H_2O$		R	tw	7.8	23	132-136	65-66		51 d	EC10	emerging	25	2	3,29,71,72,73	[139]
Chironomus tentans	10 day old	y	$UO_2(NO_3)_2 \times 6H_2O$		R	tw	7.8	23	132-136	65-66		10 d	EC10	dry weight	11.2	2	3,29,72,73	[139]
Chironomus tentans	larvae	y	$UO_2(NO_3)_2 \times 6H_2O$		R		7.18	23.1	125	84		10 d	IC50	growth	10200	4	4	[6]
Chironomus tentans	larvae	y	$UO_2(NO_3)_2 \times 6H_2O$		R		8.0	23.1	80			28 d	EC50	growth	4320	4	4	[6]
Chironomus riparius	1 d old	y	$UO_2(NO_3)_2 \times 6H_2O$		S	am	6.8-7.8	20-22	38.5			10 d	LC50	mortality	24.8	3	3,46,96	[140]
Pisces																		
Catostomus commersoni	fry 52 days post fert.	y	$UO_2(NO_3)_2 \times 6H_2O$	99	R	nw	7.9	14.3	72	68		30 d	NOEC	survival	6400	2	3,7,74,76	[141]
Catostomus commersoni	fry 52 days post fert.	y	$UO_2(NO_3)_2 \times 6H_2O$	99	R	nw	7.9	14.3	72	68		30 d	NOEC	length	6400	2	3,7,74,76	[141]
Catostomus commersoni	fry 52 days post fert.	y	$UO_2(NO_3)_2 \times 6H_2O$	99	R	nw	7.9	14.3	72	68		30 d	NOEC	dry weight	6400	2	3,7,74,76	[141]
Danio rerio	eggs	y	$UO_2(NO_3)_2$ depl.		R	am	9.56	25	48.4				NOEC	hatching time	138.2	2	3,75,76	[38]
Danio rerio	eggs	y	$UO_2(NO_3)_2$ depl.		R	am	9.56	25	48.4			9 and 15 d post hatching	LOEC	length	≤ 16.8	2	3,75,76	[38]
Danio rerio	eggs	y	$UO_2(NO_3)_2$ depl.		R	am	9.56	25	48.4			9 d post hatching	LOEC	dry weight	≤ 16.8	2	3,75,76	[38]
Danio rerio	eggs	y	$UO_2(NO_3)_2$ depl.		R	am	9.56	25	48.4			from fert. up to 15 d post hatching	LOEC	mortality	≤ 16.8	2	3,75,76	[38]
Danio rerio	eggs	y	$UO_2(NO_3)_2$ depl.		R	am	9.56	25	48.4			24 h post fert.	NOEC	embryonic develop.	≥ 212	2	3,75,76	[38]
Danio rerio	adult, 0.22 g		$UO_2(NO_3)_2$ depl.		R	am	6.5	24				20 d	NOEC	growth	≥ 483	2	3,74	[36]
Danio rerio	eggs	y	$UO_2(NO_3)_2 \times 6H_2O$		R	nw	7.7	24		20		18 d	NOEC	hatching time	< 30	3	6,45,78	[92]
Danio rerio	eggs	y	$UO_2(NO_3)_2 \times 6H_2O$		R	nw	7.7	24		20		18 d	NOEC	mortality	<300	3	6,45,78	[92]
Danio rerio	adults	y	depleted		R	am	6.5	26				37 d	NOEC	egg production	< 100	2	3,79	[34]
Esox lucius	embryo	y	$UO_2(NO_3)_2 \times 6H_2O$		R		7.9	8.1	63	60		65 d	NOEC		1510	4	4	[6]
Mogurnda mogurnda	< 10 h	y			R	nw	6.6-6.8	27	3-6	7	2.1	28 d	NOEC	mortality	1400	2	2,7	[39]
Mogurnda mogurnda	< 10 h	y			R	nw	6.6-6.8	27	3-6	7	2.1	28 d	EC10	dry weight	1014	2	2,7,29	[39]
Mogurnda mogurnda	< 10 h	y			R	nw	6.6-6.8	27	3-6	7	2.1	28 d	NOEC	dry weight	770	2	2,7	[39]
Mogurnda mogurnda	< 10 h	y			R	nw	6.6-6.8	27	3-6	7	2.1	28 d	EC10	length	1233	2	2,7,29	[39]
Mogurnda mogurnda	< 10 h	y			R	nw	6.6-6.8	27	3-6	7	2.1	28 d	NOEC	length	770	2	2,7	[39]
Mogurnda mogurnda	< 10 h	y			R	nw	5.7-6.3	27	3-6	5	4.2	28 d	NOEC	mortality	800	2	2,7	[39]
Mogurnda mogurnda	< 10 h	y			R	nw	5.7-6.3	27	3-6	5	4.2	28 d	EC10	dry weight	764	2	2,7,29	[39]
Mogurnda mogurnda	< 10 h	y			R	nw	5.7-6.3	27	3-6	5	4.2	28 d	NOEC	dry weight	410	2	2,7	[39]
Mogurnda mogurnda	< 10 h	y			R	nw	5.7-6.3	27	3-6	5	4.2	28 d	EC10	length	869	2	2,7,29	[39]
Mogurnda mogurnda	< 10 h	y			R	nw	5.7-6.3	27	3-6	5	4.2	28 d	NOEC	length	410	2	2,7	[39]
Mogurnda mogurnda	1 day, 20.8 mg fish/l	y	$U(SO_4)_2 \times 4H_2O$		F	nw	6.4	27.1	3.2	2.99	5.07	14 d	LC1	mortality	750	2	3,75,80	[122]
Mogurnda mogurnda	1 day, 20.8 mg fish/l	y	$U(SO_4)_2 \times 4H_2O$		F	nw	6.4	27.1	3.2	2.99	5.07	14 d	LC1	mortality	280	2	3,75,80,81	[122]
Mogurnda mogurnda	1 day, 20.8 mg fish/l	y	$U(SO_4)_2 \times 4H_2O$		F		6.4	27.1	3.2	2.99	5.07	14 d	EC10	weight and length	1700	2	3,29,75,80	[122]
Mogurnda mogurnda	1 day, 20.8 mg fish/l	y	$U(SO_4)_2 \times 4H_2O$		F		6.4	27.1	3.2	2.99	5.07	14 d	NOEC	weight and length	880	2	3,75,80	[122]
Mogurnda mogurnda	1 day, 20.8 mg fish/l	y	$U(SO_4)_2 \times 4H_2O$		F		6.4	27.1	3.2	2.99	5.07	14 d	NOEC	weight and length	≥ 1790	2	3,75,80,81,82	[122]
Mogurnda mogurnda	1 day, 0.36 g fish/l	y	$U(SO_4)_2 \times 4H_2O$		F		6.3	30	4.1	1.8	1.5	7 d	NOEC	length	< 400	2	3,75,82,83,84,85	[122]
Mogurnda mogurnda	1 day, 0.36 g fish/l	y	$U(SO_4)_2 \times 4H_2O$		F	nw	6.3	30	4.1	1.8	1.5	7 d	LC1	mortality	1270	2	3,75,83,84,86	[122]
Mogurnda mogurnda	1 day, 0.36 g fish/l	y	$U(SO_4)_2 \times 4H_2O$		F	nw	6.3	30	4.1	1.8	1.5	7 d	LC1	mortality	410	2	3,75,83,84,85,86	[122]

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Alkalinity $CaCO_3$ [mg/L]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Mogurnda mogurnda	sac-fry (1 d)	y			R	am	6	27	3.9		< 0.2	96 h	EC10	mortality	1114	2	3,11,51	[99]
Mogurnda mogurnda	sac-fry (1 d)	y			R	am	6	27	3.9		< 0.2	96 h	NOEC	mortality	1049	2	3,11,51	[99]
Oncorhynchus mykiss	embryo	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.3-7.2	13-15	6	6-7		30 d	EC10	viability	260	4	3,4,10,61	[6]
Oncorhynchus mykiss	embryo	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.3-7.2	13-15	61	6-7		30 d	EC10	viability	480	4	3,4,10,61	[6]
Pimephales promelas	embryo, < 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.3-7.2	24-26	23	10-14		7 d	EC10	growth	1200	4	3,4,10,61	[6]
Pimephales promelas	embryo, < 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.3-7.2	24-26	72	10-14		7 d	EC10	growth	1300	4	3,4,10,61	[6]
Pimephales promelas	embryo, < 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.3-7.2	24-26	131	10-14		7 d	EC10	growth	760	4	3,4,10,61	[6]
Pimephales promelas	embryo, < 24 h	y	$UO_2(NO_3)_2 \times 6H_2O$		R		6.3-7.2	24-26	244	10-14		7 d	EC10	growth	980	4	3,4,10,61	[6]
Salvenius fontinalis	eggs	y	$UO_2SO_4 \times 3H_2O$		F	nw+dw	8	13.5	201	189		77 d	NOEC	hatch., mort. growth	≥9080	3	7,75,87,88	[27]
Salvenius namaycush	embryo-alevin-fry	y	$UO_2(NO_3)_2 \times 6H_2O$		R		7.9-8.1	7.6-8.6	74-80			141 d	NOEC	multiple	6050	4	4,89	[6]
Amphibia																		
Xenopus laevi	embryo	y	contam. soil extr.		R	nw	8.0-8.2	23-24	177-226			64 d	NOEC	development rate	< 13090	3	90,91	[142]
Xenopus laevi	embryo	y	contam. soil extr.		R	nw	8.0-8.2	23-24	177			96 h	EC50	mortality/develop.	> 77720	3	90	[142]

Notes

1 Not analysed
2 Endpoint based on nominal concentrations
3 Endpoint based on mean measured concentrations
4 Original reference not available
5 Analysis only performed at the start of the experiment
6 Unclear if endpoint based on measured or nominal concentrations
7 Measured concentrations within 20% of nominal
8 Citation of unpublished data
9 Renewal every 24 h
10 EC10 calculated in cited report
11 Recalculated from concentration in UO_2
12 Not a pure culture
13 Endpoint extrapolated
14 Acetate as substrate
15 H2 as substrate
16 Sulphur (S0) as substrate
17 Result of analysis unknown
18 Effect on growth was mainly caused by increased lag times, at maximum growth for the control (24 h) there was almost no growth at the treatments. Maximum growth for lowest exposure was reached after 48 hours, finally all treatments reached the same optical density.
19 Growth substrate butyrate
20 Growth substrate dextrose
21 Growth substrate lactate
22 Growth substrate ethanol
23 Exponential phase of control ± 16 h
24 Exponential phase of control ± 10 h
25 Exponential phase of control ± 18 h
26 BEC10 taken over as EC10
27 Recalculated for exponential phase with data from graph in paper
28 Highest test concentration exceeds maximum water solubility not included in estimation of endpoint
29 Endpoint determined with data from graph in paper
30 Lowest exposure concentration 1 mg/L
31 Exposure time much longer than exponential phase of the control
32 Measured concentrations at the start of the experiment within 20% of nominal concentrations, endpoint based on initial measured concentrations; analysis performed at the end of the experiment showed a mass balance in each treatment of >90%, 75% in solution, 10% bound to the cell surface and ca. 15% adsorbed to the walls of the flasks, this recovery is considered high enough to assign Ri2
33 Endpoint based on measured concentrations, analysis only performed at the start of the experiment, mass balance at similar exposure showed only 50-70% in solution after 72 h and up to 40% of the U added adsorbed to the walls of the flasks throughout this similar test. Therefore endpoints based on initial measured concentrations considered Ri3;
34 Endpoint based on measured concentrations; analysis only performed at the start of the experiment, contact with the author revealed that the same apparatus was used as in Hogan et al. [96] where loss in concentration over 96 h was less than 20% therefore considered acceptable
35 Actual exposure 25 d but endpoint based on 48 h exposure in which full growth of the control was achieved; anaerobic test; experiment performed in pipes buffer which enabled good solubility in contrast to a bicarbonate buffer
36 Growth determined as CFU on agar plates (incubation at 30°C) after exposure
37 Unclear which of 5 values for hardness fits which of with 4 EC10 values (5.4, 55, 54, 120)
38 Value reported as TGK (Toxische Grenzkonzentration) considered as NOEC
39 Performed in low nutrient medium based on aspartic acid (150 µM)
40 Measured concentrations within 20% of nominal concentrations, endpoint based on measured concentrations after renewal only, same method used as and same research group as Hogan et al. [91] for which contact with the author revealed that the same apparatus was used as in Hogan et al. [96] where loss in concentration over 96 h was less than 20% therefore considered acceptable; reported as minimum detectable effect concentration
41 Range finding test not analysed, a separate fate test for the higher test concentrations showed a reduction of 11 to 16% of the uranium concentration over 96 h therefore nominal concentrations considered acceptable as total, U background concentration in test water 0.016-1.67 µg/L

42 Analysis only performed at start of the test but a separate fate test for the higher test concentrations showed a reduction of 11 to 16% of the uranium concentration over 96 h therefore initial measured concentrations considered acceptable as total, U background concentration in test water 0.016-1.67 µg/L
43 In a similar paper from the same year by the same authors, this endpoint was reported one order of magnitude higher
44 Unreliable fit
45 Dose response correlation not observed
46 Endpoint determined with data from paper
47 Analysis perform through LSC
48 Analysis indicated constant concentration of Uranium
49 Test water sampled in dry season
50 Test water sampled in wet season
51 Analysis performed at start and end of the test
52 Same test protocol as performed by Markich and Camileri [99]
53 Analysis performed at start, after 48 hours and end of the test
54 Difference in pH between the four tests did not influence the endpoints; uranium background concentration in test water was 0.025-0.053 µg/L
55 Nominal NOEC was 1.5 µg/L
56 Nominal NOEC was 12.7 µg/L
57 Lowest test concentration excluded because of relative high mortality
58 Measurement only performed on highest concentration, NOEC corrected for ratio measured : nominal in highest concentration
59 No clear dose-response curve
60 Animals exposed to extract from soil containing more metals
61 According to Environment Canada methodology
62 Renewal every 3 days
63 Poor reproduction in control
64 Measured concentrations at renewal >70% of nominal, measured concentration of new medium within 10% of nominal
65 Analysis performed twice weekly
66 Lowest value of three experiments, middle value not reported
67 Highest value of three experiments, middle value not reported
68 Not for all experiments a reliable fit could be made
69 Fed with vitamin enriched fermented food and algae, concentration of uranium only determined in stock solutions added to test water
70 No significant mortality at the highest concentration; analysis performed before and after renewal
71 Renewal every 48 hours
72 Water spiked water-sediment system consisting of silica sand (250-425 µm); measured concentrations 78 - 86% of nominal
73 Analysis performed before renewal
74 Analysis performed repeatedly
75 Analysis performed daily
76 Analysis performed before and after renewal
77 Results for control not presented
78 Original uranium concentration in test water 0.7 µg/L
79 Only two concentration tested and a blank; test concentration monitored on a daily base and corrected to nominal concentration by addition of stock solution
80 TOC 5.43 mg/l
81 Endpoint determined after 15 days additional observation in clean water
82 Calculation of EC10 value not possible
83 TOC 2.7 mg/L
84 Animals exposed in separate compartment of larger tank
85 Endpoint determined after post exposure period of 7 days
86 Unclear whether samples for uranium analysis taken from dilution medium or from the exposure tanks
87 Comparison of filtered versus unfiltered samples showed that >93% of the uranium was in the dissolved form
88 Control survival of fry 52% therefore Ri = 3
89 Following EC guidance
90 Test concentrations obtained by mixing 2 kg of contaminated oil with 16 L of well water for 2 months. The overlying water was used for the test. Toxicity of other elements cannot be excluded
91 High mortality in controls due to a parasite
92 Animals fed during test
93 Analysis performed at the end of the test, measured concentrations 39% of nominal
94 Measured concentrations < 80% of nominal
95 After communication author explained that the endpoints are based on measured concentrations; sorption to cotton gauze possible
96 Sediment contaminated water-sediment system; analysis performed in water during exposure; analysis performed after filtration of samples but the samples were acidified before filtration, therefore it is presumed that the measured concentration is the total concentration; water concentration increasing during exposure, therefore, the water concentration is probably overestimating the toxicity.
97 NOEC or EC10 not available

Table A3.3 Acute toxicity for marine organisms

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Crustacea																
Allorchestes compressa		n	$UO_2(NO_3)_2 \times 6H_2O$	AR	F	nw				4 w	EC50	growth	> 2000	3	1	[143]

Notes
1 data from tests with enriched uranium (7% 235U) not included in endpoint; not analysed

Table A3.4 Chronic toxicity for marine organisms

Species	Species properties	A	Test compound	Purity [%]	Test type	Test water	pH	T [°C]	Salinity [‰]	DOC [mg/L]	Exp. time	Crit.	Endpoint	Value [µg U/L]	Ri	Notes	Ref
Bacteria																	
Vibrio fischeri	resuspended lyophilized bacteria	n	UO_2Ac		S	am	6.7	15	20		2 h	NOEC	luminescence	2380	2		[144]
Crustacea																	
Allorchestes compressa		n	$UO_2(NO_3)_2 \times 6H_2O$	AR	F	nw					10 w	NOEC	sex ratio	100	3	1	[143]
Allorchestes compressa ♂		n	$UO_2(NO_3)_2 \times 6H_2O$	AR	F	nw					10 w	NOEC	respiration rate	< 100	3	1	[143]

Notes

1 Not analysed

Table A3.5 Toxicity for birds and mammals

Species	Species properties	Test compound	Purity [%]	Application route	Exp. time	Crit.	Endpoint	Effect conc. - water [mg U/L]	Effect conc. - gavage/water [mg U/kg_{bw}/d]	Effect conc. - diet [mg U/kg_{diet}]	Ri	Notes	Ref
Mammals													
Dog	beagle, 10 kg	UO_2F_2		diet	30 days	NOAEL	mortality		7.7		3	1,2	[49]
Dog	beagle, 10 kg	UCl_4		diet	30 days	NOAEL	mortality		12.5		2	1	[49]
Dog	beagle, 10 kg	UO_4		diet	30 days	NOAEL	mortality		15.8		2	1	[49]
Dog	beagle, 10 kg	$UO_2(NO_3)_2$ x $6H_2O$		diet	30 days	NOAEL	mortality		47.4		2	1	[49]
Dog	beagle, 10 kg	UO_2		diet	30 days	NOAEL	mortality		88.1		2	1	[49]
Dog	beagle, 10 kg	$Na_2U_2O_7$		diet	30 days	NOAEL	mortality		75		2	1	[49]
Dog	beagle, 10 kg	$(NH_4)_2U_2O_7$		diet	30 days	NOAEL	mortality		76		2	1	[49]
Dog	beagle, 10 kg	UF_4		diet	30 days	NOAEL	mortality		3790		3	1,2	[49]
Dog	beagle, 10 kg	U_3O_8		diet	30 days	NOAEL	mortality		17000		2	1	[49]
Dog	beagle, 10 kg	UO_2		diet	30 days	NOAEL	mortality		≥ 17600		2	1	[49]
Dog	beagle, 10 kg	UO_2F_2		diet	1 year	NOAEL	growth		1.9		3	1,2,3	[51]
Dog	beagle, 10 kg	UCl_4		diet	1 year	NOAEL	growth		31		2	1,3	[51]
Dog	beagle, 10 kg	$UO_2(NO_3)_2$ x 6H2O		diet	1 year	NOAEL	growth		47		2	1,3	[51]
Dog	beagle, 10 kg	UF_4		diet	1 year	NOAEL	growth		758		3	1,2,3	[51]
Dog	beagle, 10 kg	UO_2		diet	1 year	NOAEL	growth		8800		2	1,3	[51]
Mouse	♀	$UO_2(NO_3)_2$		drinking water	15 w	NOAEL	body weight	≥242	≥100		3	4,5,6	[145]
Mouse	♀, 25-30 g	UO_2Ac_2 x $2H_2O$	a.g.	gavage	day 6 to 15 of gestation	NOAEL	weight gain		< 2.8		2		[146]
Mouse	♀, 25-30 g	UO_2Ac_2 x $2H_2O$	a.g.	gavage	day 6 to 15 of gestation	NOAEL	feed intake		< 2.8		2		[146]
Mouse	♀, 25-30 g	UO_2Ac_2 x $2H_2O$	a.g.	gavage	day 6 to 15 of gestation	NOAEL	foetal body weight		< 2.8		2		[146]
Mouse	♀, 26-30 g	UO_2Ac_2 x $2H_2O$	a.g.	gavage	d 13 of pregn.to day 21 of lact.	NOAEL	food intake		≥ 28		2		[50]
Mouse	♀, 26-30 g	UO_2Ac_2 x $2H_2O$	a.g.	gavage	d 13 of pregn. to day 21 of lact.	NOAEL	body weight		≥ 28		2		[50]
Mouse	♀, 26-30 g	UO_2Ac_2 x $2H_2O$	a.g.	gavage	d 13 of pregn. to day 21 of lact.	NOAEL	mortality (parent)		0.28		3	11	[50]
Mouse	♀, 26-30 g	UO_2Ac_2 x $2H_2O$	a.g.	gavage	d 13 of pregn. to day 21 of lact.	NOAEL	litter size		2.8		2		[50]
Mouse	♀, 16.6 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	49 d	NOAEL	general health	≥ 40	≥ 6.9		2	12	[147]
Mouse	♀, 16.6 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	49 d	NOAEL	embryo develop. (oocyte quality)	10	1.9		2	12	[147]
Mouse	♀, 21 d	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	40 d	NOAEL	reprod. (oocyte ovulation)		≥ 10		3	4,6	[148]
Mouse	♂ and ♀, 28-30 g	UO_2Ac_2 x $2H_2O$		drinking water	64 d	NOAEL	pregnancy rate	< 26	< 5.6		2	13,14	[149]
Mouse	26-30 g	UO_2Ac_2 x $2H_2O$		oral	60 and 14 days	NOAEL	embryo mortality		5.6		2	9	[150]
Mouse	26-30 g	UO_2Ac_2 x $2H_2O$		oral	60 and 14 days	NOAEL	offspring growth (body weight)		< 2.8		2	9,15	[150]
Mouse	26-30 g	UO_2Ac_2 x $2H_2O$		oral	60 and 14 days	NOAEL	offspring growth (length)		5.6		2	9,15	[150]
Mouse	26-30 g	UO_2Ac_2 x $2H_2O$		oral	60 and 14 days	NOAEL	offspring mortality		2.8		2	9,15	[150]
Mouse	♀, 28 days	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	30 days	NOAEL	body weight	≥ 28	≥ 5.3		3	16	[151]
Mouse	♂ 2-3 months; ♀ 3-5 months	$UO_2(NO_3)_2$ x $6H_2O$		diet	47 weeks	NOEC	growth and mort.			< 4700	2	17	[152]
Mouse	♂ 2-3 months; ♀ 3-5 months	UCl_4		diet	47 weeks	NOEC	growth			≥ 5000	2	17	[152]
Mouse	♂ 2-3 months; ♀ 3-5 months	UO_2F_2		diet	47 weeks	NOEC	growth and mort.			< 2300	3	2,17	[152]
Mouse	♂ 2-3 months	U_3O_8		diet	47 weeks	NOEC	growth			≥ 8500	2	17	[152]
Mouse	♂ 2-3 months	UF_4		diet	47 weeks	NOEC	growth			≥ 23000	3	2,17	[152]
Rabbit	♂, 3200 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	91 d	NOAEL	body weight gain	≥ 323.0	≥ 28.7		2	18	[153]
Rabbit	♀, 3100 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	91 d	NOAEL	body weight gain	≥ 306.4	≥ 43.02		2	18	[153]
Rabbit	♂, 3000 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	91 d	NOAEL	body weight gain	≥ 302.4	≥ 40.98		2	18	[154]
Rabbit		$UO_2(NO_3)_2$ x $6H_2O$		diet	30 days	NOEC	mortality			95	2	17	[49]

Species	Species properties	Test compound	Purity [%]	Application route	Exp. time	Crit.	Endpoint	Effect conc. - water [mg U/L]	Effect conc. - gavage/water [mg U/kg$_{bw}$/d]	Effect conc. - diet [mg U/kg$_{diet}$]	Ri	Notes	Ref
Rabbit		$UO_2(NO_3)_2$ x $6H_2O$		diet	30 days	NOEC	growth			95	2	17	[49]
Rat	♂ and ♀, 220-240g	UO_2Ac_2 x $2H_2O$		drinking water	3 months	NOAEL	reproduction		≥ 5.6		2	13,19,20	[155]
Rat	♂	UO_2Ac_2 x $2H_2O$		drinking water	6 months 2 weeks?	NOAEL	weight gain	75	14		3	4,6	[156]
Rat	♀	UO_2Ac_2 x $2H_2O$		drinking water	6 months	NOAEL	weight gain	75	14		3	4,6	[156]
Rat	200-250 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	9 months	NOAEL	weight gain	19	<1.5 - 4		3	21,22	[157]
Rat	♀, 60 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	28 d	NOAEL	body weight gain	≥ 284	≥ 40		2	23	[45]
Rat	♂, 60 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	28 d	NOAEL	body weight gain	≥ 284	≥ 35.3		2	23	[45]
Rat	♀, 60 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	91 d	NOAEL	body weight gain	≥ 284	≥ 53.56		2	23,24,25	[45]
Rat	♂, 60 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	91 d	NOAEL	body weight gain	≥ 284	≥ 36.73		2	23,24	[45]
Rat	♂, 250 g	$UO_2(NO_3)_2$ x $6H_2O$		drinking water	9 months	NOAEL	body weight	≥ 20	≥ 4		3	4,6,22	[158]
Rat	♂ and ♀ 5.2-6.2 g	$UO_2(NO_3)_2$ x $6H_2O$		diet	2 gen	NOAEL	reproduction		< 4		2	26,27	[52]
Rat	♂ and ♀, 220-240 g	UO_2Ac_2 x $2H_2O$		drinking water	3 months	NOAEL	reproduction		≥ 5.6		2*	13,19,20,28	[159]
Rat		$UO_2(NO_3)_2$ x $6H_2O$		drinking water	4 months	NOAEL	testes weight	<200-540	<20-54		3	29	[160]
Rat	♂ and ♀	$UO_2(NO_3)_2$ x $6H_2O$		diet	30 days	NOEC	growth			<4740	2	17	[49]
Rat	♂ and ♀	$UO_2(NO_3)_2$ x $6H_2O$		diet	30 days	NOEC	mortality			2370	2	17	[49]
Rat	♂ and ♀	UO_2F_2		diet	30 days	NOEC	mortality			3860	3	2,17	[49]
Rat	♀	UCl_4		diet	30 days	NOEC	mortality			6260	2	17	[49]
Rat	♂	UCl_4		diet	30 days	NOEC	mortality			3130	2	17	[49]
Rat	♀	UO_4		diet	30 days	NOEC	mortality			1970	2	17	[49]
Rat	♂	UO_4		diet	30 days	NOEC	mortality			3940	2	17	[49]
Rat	♂	UO_3		diet	30 days	NOEC	mortality			4440	2	17	[49]
Rat	♂	UO_2Ac_2		diet	30 days	NOEC	mortality			3310	2	17	[49]
Rat	♂ and ♀	UO_2		diet	30 days	NOEC	mortality			176000	2	17	[49]
Rat	♂ and ♀	U_3O_8		diet	30 days	NOEC	mortality			170000	2	17	[49]
Rat	♂ and ♀	UF_4		diet	30 days	NOEC	mortality			152000	3	2,17	[49]
Rat	♂ and ♀	UO_2F_2		diet	1 y	NOEC	growth			386	3	2,17	[49]
Rat	♂ and ♀	$UO_2(NO_3)_2$ x $6H_2O$		diet	2 y	NOEC	growth			474	2	17	[49]
Rat	♂ and ♀	UF_4		diet	2 y	NOEC	growth			15200	3	2,17	[49]
Rat	♂ and ♀	UO_2		diet	2 y	NOEC	growth			≥176000	2	17	[49]
Rat	♂ and ♀	$UO_2(NO_3)_2$ x $6H_2O$		diet	7 months	NOEC	reproduction			< 9480	2	17	[49]
Rat	♂ and ♀; 17 d to 6 m old	$UO_2(NO_3)_2$ x $6H_2O$		diet	30 days	NOEC	mortality			< 9500	4*	3,17,22	[51]
Rat	♂ and ♀	$UO_2(NO_3)_2$ x $6H_2O$		diet	1 year	NOEC	growth			474	2	3,17	[51]
Rat	♂ and ♀	UO_2		diet	2 years	NOEC	growth			≥176000	4*	3,17	[51]
Rat	♂ and ♀	UF_4		diet	2 years	NOEC	growth			15200	3	2,3,17	[51]
Rat	♂ and ♀	UO_2F_2		diet	2 years	NOEC	growth			386	3	2,3,17	[51]
Rat	♂ and ♀	$UO_2(NO_3)_2$ x $6H_2O$		diet	2 years	NOEC	growth			474	4*	3,17	[51]
Rat	♂, 70-90 g	UO_2Ac_2 x $2H_2O$		drinking water	4 weeks	NOAEL	general health		≥ 9.0		3	30	[161]
Rat	♀, adult	UO_2Ac_2 x $2H_2O$		drinking water	4 weeks pre mating until lactation d. 21	NOAEL	maternal body weight gain		22.5		2	13,31	[162]
Rat	♀, adult	UO_2Ac_2 x $2H_2O$		drinking water	4 weeks pre mating until lactation d. 21	NOAEL	offspring growth (body weight)		<22.5		2	13,31,32	[162]
Birds													
Anas rubripes	9 months	powdered elemental U		diet	6 weeks	NOEC	body weight			≥ 1600	3	33	[163]

Notes

1 Concentration in feed not reported
2 Co-exposure to fluoride possible
3 Details obtained from detailed summary
4 No monitoring of water intake
5 Dose calculated from assumed water intake 2-5 mL/d
6 No clear indication of actual dose
7 Exposure period before mating
8 Original ref: Llobet et al. [149]
9 Exposure of males 60 d and female 14d before mating
10 Original ref: Paternain et al. [150]
11 Reported as "some death attributed to treatment", no further data
12 Actual dose based on average daily water intake per cage over the whole exposure period
13 The dose was based on measured daily fluid intake and body weight and adjusted twice weekly
14 Only males exposed 64 days prior to mating
15 Observation of offspring was performed for 21 days after birth
16 Uranium concentration in water given only, no details on water consumption, as indication this was converted to a dose on the basis of the mean conversion rate as used by Feugier et al. [147] presuming the tested animals were of the same age
17 Concentration calculated from reported percentage of test compound in food
18 Actual dose based on average daily water intake over the whole exposure period
19 Only males exposed to uranium
20 Effect not dose related
21 Monitoring of water intake not specific enough to determine an exact dose and a range reported
22 Only one concentration tested
23 Endpoint based on time-weighted-average dose
24 Exposure declined during test due to reduced water intake
25 Some significant not dose related effects observed for body weight
26 Uranylnitrate generated by dissolving depleted uranium in concentrated nitric acid
27 Exposure in paper expressed as mg DU/kg/d, it is presumed that this indicates elemental depleted uranium, actual concentration in food not reported
28 Same study as from Albina et al. [155]
29 The uranium was dosed at one concentration as 0.1% uranyl nitrate solution no details on water consumption given, as indication this is converted to a dose on the basis of the same conversion as used in Bussy et al. [157] presuming the tested animals were of the same age
30 Unclear if the doses reported were based on actual water intake
31 Only females exposed, before and after mating
32 Offspring exposed through lactation
33 The form in which the uranium is dosed is insoluble and therefore irrelevant for secondary poisoning, therefore assigned with Ri 3

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