Common Implementation Strategy for the Water Framework Directive

Environmental Quality Standards (EQS)

Substance Data Sheet

Priority Substance No. 21

Mercury and its Compounds

CAS-No. 7439-97-6

Final version
Brussels, 15 January 2005

Disclaimer

This data sheet provides background information on the setting of the Environmental Quality Standard in accordance with Article 16 of the Water Framework Directive (2000/60/EC). The information was compiled, evaluated and used as outlined in the Manual [4] and has been discussed in a consultative process with the Expert Advisory Forum on Priority Substances and the Expert Group on Quality Standards. Furthermore, it has been peer-reviewed by the SCTEE [19]. The substance data sheet may, however, not necessarily represent the views of the European Commission.

New upcoming information was considered and included up to the date of finalisation of this data sheet. Information becoming available after finalisation of this document will be evaluated in the review process of priority substances according to Art. 16(4) of the Water Framework Directive. If necessary, the Environmental Quality Standard substance data sheets will then be revised in the light of technical and scientific progress.

1 Identity of substance

Priority Substance No: 21	Mercury and its compounds
CAS-Number:	7439-97-6
Classification WFD Priority List *:	PHS

* PS: priority substance; PHS: priority hazardous substance; PSR: priority substance under review according to Decision 2455/2001.

2 Proposed quality standards

Note:

Although in this data sheet the use of the Added Risk Approach is suggested for setting quality standards for cadmium and its compounds (see section 8) the Commission may decide to refer to the Total Risk Approach and propose quality standards that already account for and comprise the natural background concentration.

2.1 Overall quality standards

Ecosystem	**Quality Standard**	**Quality Standard "rounded value"**	**Comment**
AA-QS all types of surface waters covered by the WFD	Protection against direct effects: MPA = 0.047 µg/l (total dissolved Hg) Protection against secondary poisoning: 22 µg/kg prey tissue (methyl-Hg)	Protection against direct effects: **MPA = 0.05 µg/l (total dissolved Hg)** Protection against secondary poisoning: **20 µg/kg prey tissue (methyl-Hg)**	QS = $C_{background}$ + MPA . See section 8.3, 8.4 & 8.6
MAC-QS (ECO)	MAC-MPA 0.07 µg/l (total dissolved Hg) MAC-QS Rhine = 0.075 µg/l	**MAC-MPA 0.07 µg/l (total dissolved Hg)**	See sections 8.1 & 8.1.2

2.2 Specific quality standards

Protection Objective	**Quality Standard**	**Comment**
Pelagic community (freshwater & saltwater)	MPA = 0.047 µg/l (dissoved Hg) corresponding conc. in SPM (with Kp 100,000 l/kg as example): 4.7 mg/kg (dry wt) QS_{water} calculated for the Rhine as example: 0.052 µg/l (dissolved Hg) corresponding conc. in SPM (Rhine "mean" Kp of 100,000 l/kg): 3.8 mg/kg dry wt	QS = $C_{background}$ + MPA see section 8.1 – 8.1.2
Benthic community (freshwater & marine sediment)	MPA (by EP-method, with Kp 100,000 l/kg as example) 470 µg/kg dry wt QS for Rhine sediment (Kp 100,000): $QS_{sediment}$ = 670 µg/kg dry wt QS based on toxicity test: 9.3 mg/kg dry wt	QS = $C_{background}$ + MPA tentative values derived by EP method or by the only toxicity test available; no reliable MPA/QS could be derived; see 8.2
Predators (second. poisoning)	22 µg methyl-Hg/kg prey tissue (wet wt)	due to considerable uncertainties about bioaccumulation of methylmercury no reliable corresponding concentration in water could be derived. Therefore it is suggested to set a QS referring to biota; see 8.3
Food uptake by man	0.5 mg total Hg/kg fishery products (wet wt)	limit value of CR 466/2001; see 8.4 due to to the uncertainties with regard to bioaccumulation of Hg no reliable corresponding conc. in water could be derived
Abstraction of water intended for human consumption (AWIHC)	1 µg/l	A-1 value in CD 75/440/EEC; see 8.5
Water intended for human consumption (WIHC)	1 µg/l	standard set by CD 98/83/EC

3 Classification

CAS No.	Name	R-Phrases and Labelling	Reference
7439-97-6	Mercury and its compounds	T; R23 - R33 - N; R50-53	[20]

4 Physical and chemical properties

Property	Value	Ref.	Comments
Mol. Weight:			
Water Solubility	20-30 ng/l	[10]	elemental Hg
Vapour Pressure:	0.25 Pa (25 °C)	[10]	elemental Hg

5 Environmental fate and partitioning

Property	Value:	Ref:	Comments:
<u>Partition coefficients</u>			
Kp	$1.46*10^6$	[6]	
Kd	316,000 m^3/m^3	[10]	Used in the risk assessment by [10]
$Kp_{water-SPM}$	100,000 l/kg (mean value)	[7]	
	124000 - 164000 L/kg (suspended pariculate matter) 57000 L/kg 250000 - 330000 L/kg 5000 – 900000 L/kg	[5]	Figures from different reports cited in [5]
<u>Bioaccumulation</u>			
<u>BCF fish:</u>			
Trout	5 ($HgCl_2$, 50 µg/L, 4 d, 5°C)	[5]	
Oncorhynchus mykiss	1800 ($HgCl_2$, freshw., whole body, 60 d) 85700 ($HgCH_3Cl$, freshw., whole body, 75 d)	[5]	
Pimephales promelas	4994 ($HgCl_2$, freshw., whole body, 287 d) 44130 – 81670 ($HgCH_3Cl$, whole body, 336 d)	[5]	
Salvelinus fontinalis	11000 – 33000 ($HgCH_3Cl$, muscle, 273 d)	[5]	
Riverine fish	1000 – 15000 (freshwater, muscle, natl. environment) 2000 – 10000 (freshwater, muscle, natl. environment)	[5]	
Fish	3030 (OSPAR 1996, geometric mean for inorganic mercury) 3640 (OSPAR 1996) ; 8140 (Slooff et al. 1996) – geometric means for methyl mercury	[10]	
<u>BCF molluscs:</u>	24- 2500 (calculated from mean Hg conc. in marine molluscs and mean conc. of dissolved Hg in North Sea estuaria)	[10]	
	3500 (mean BCF for organic Hg in molluscs)	[10]	
Mytilus edulis	190 –5300 (BCF range of inorganic Hg; Slooff et al. 1995)	[10]	
	1750 (geometric mean, OSPAR 1996)	[10]	
<u>Biomagnification:</u>	Mercury can lead to biomagnification with an increase in concentration in subsequent trophic levels. Mercury, and methylmercury in particular, can also be accumulated to a large extent from food which leads to higher mercury levels under field conditions than expected on the basis of the theoretical BCF-values. This should be taken into account for higher trophic levels (secondary poisoning).	[10]	
<u>BAF fish</u> <u>(field measurements)</u>	21700 (Sloof et al. 1995) 1600 000 – 6800000 (US-EPA 1997 120000 – 27000000 (US-EPA 2001); 200000 – 78000000 (France 2004)	[14] [15] [16] [17]	geometric means for methyl mercury,

6 Effect data (aquatic environment)

Table 6.1: Overview on toxicity data of most sensitive species from different sources (master reference). Values are related to inorganic Hg, bold records indicate those data used for the SSD (see 8.1)

Species	Taxonomic Group	Duration	Effect	Endpoint	Value µg Hg/l	Master reference	Reference in master reference	Comments on data reliability in master reference *
Freshwater, (sub)chronic								
Scenedesmus acuminatus	**Algae**	**72 h**	**Growth**	**EC10**	**0.2**	**[5]**	**Kusel-Fetzmann 1989**	
Salvelinus fontinalis	**Pisces**	**730 d**		**NOEC**	**0.29**	**[5]**	**Mance 1987**	
Pimephales promelas	**Pisces**	**30-60 d**	**Growth**	**NOEC**	**0.3**	**[8]**	**RIVM Rep. 601501001, 601014008**	**geometric mean (n=4)**
Pimephales promelas	Pisces	41 w	Growth and reproduction	NOEC	0.5	[10]	Snarski & Olson, 1982	RI: 2
Pimephales promelas	Pisces	60 d	Growth	NOEC LOEC	1 2	[6]	Snarski et Olson (1982)	
Pimephales promelas	Pisces	32 d	Growth and mortality	NOEC	0.63	[10]	Spehar & Fiandt, 1986	RI: 1
Hyalella azteca	**Crustacea**	**6-10 w**	**Reproduction**	**NOEC** **LOEC**	**0.62** **2.42**	**[10]**	**Borgmann et al., 1993**	**RI: 2**
Daphnia magna	**Crustacea**	**21 d**	**Reproduction**	**NOEC**	**0.7**	**[8]**	**RIVM Rep. 601501001, 601014008**	**geometric mean (n=3)**
Daphnia magna	Crustacea	21 d	Reproduction	NOEC LOEC	0.72 1.28	[6]	Biesinger et al (1982)	
Daphnia magna	Crustacea	21 d	Mortality, growth	NOEC LOEC	2.2 7.0	[10]	Enserink et al., 1991	RI: 2
Brachydanio rerio	**Pisces**	**14 d**	**Mortality**	**NOEC**	**1**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Scenedesmus capricornutum	**Algae**	**72 h**	**Growth**	**EC10**	**1**	**[5]**	**Kusel-Fetzmann 1989**	
Scenedesmus capricornutum	Algae	10 d	Growth	NOEC	9	[8]	RIVM Rep. 601501001, 601014008	
Microcystis aeruginosa	**Cyanobacteria**	**8 d**	**Growth**	**NOEC**	**2.5**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Chilomonas paramecium	**Protozoa**	**48 h**	**Growth**	**NOEC**	**8**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Ceriodaphnia dubia	**Crustacea**	**7 d**	**Reproduction and mortality**	**NOEC**	**8.5**	**[10]**	**Spehar & Fiandt, 1986**	**RI: 1, also used in** RIVM Rep. 601501001, 601014008
Enthosiphon sulcatum	**Protozoa**	**72 h**	**Growth**	**NOEC**	**9**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Daphnia similis	Crustacea	28 d	Mortality	NOEC	10	[8]	RIVM Rep. 601501001, 601014008	
Cyclops sp.	**Crustacea**	**14 d**	**Reproduction**	**NOEC**	**18**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Scenedesmus acutus	Algae	10 d	Growth	NOEC	20	[8]	RIVM Rep. 601501001, 601014008	
Chara vulgaris	**Macroalgae**	**14 d**	**Growth**	**NOEC**	**20**	**[10]**	**Heumann, 1987**	**RI: 1, also used in** RIVM Rep. 601501001, 601014008

Species	Taxonomic Group	Duration	Effect	Endpoint	Value µg Hg/l	Master reference	Reference in master reference	Comments on data reliability in master reference *
Scenedesmus quadricauda	Algae	8 d	Growth	NOEC	35	[8]	RIVM Rep. 601501001, 601014008	
Viviparus bengalensis	**Mollusca**	**7 d**	**Mortality**	**NOEC**	**45**	**[8]**	**RIVM Rep. 601501001, 601014008**	**geometric mean (n=6)**
Selenastrum capricornutum	Algae	96 h	Growth	NOEC	80	[6]	Sloof et al (1983)	
Chlorella vulgaris	Algae	33 d	Growth	NOEC	100	[8]	RIVM Rep. 601501001, 601014008	
Freshwater, acute								
Carassius auratus	Pisces	8 d	Mortality	LC50	0.7	[5]	Westerman 1984	
Gastrophryne carolinensis	Amphibia	7 d	Mortality	LC50	1	[5]	Birge et al. 1979	
Crangonyx pseudogracilis	Crustacea	96 h	Mortality	LC50	1	[10]	Martin & Holdich, 1986	RI: 2
Daphnia magna	Crustacea	48 h	Mortality	LC50	3	[6]	Canton et Adema (1978)	
Daphnia pulex	Crustacea	48 h	Immobilisation	EC50	3.8	[10]	Elnabarawy & Welter, 1986	RI: 2
Chrysophrys major	Pisces	96 h	Mortality	LC50	4	[5]	Lan et al. 1991	
Daphnia magna	Crustacea	48 h	Immobilisation	EC50	5.2	[10]	Khangarot & Ray, 1987b	RI: 2
Selenastrum capricornutum	Algae	96 h	Growth	EC50	9	[5], [10]	Chen et al, 1997	RI: 2
Chironomus sp	Insecta	96 h	Mortality	LC50	20	[5]	Rehwoldt et al. 1973	
Poecilia reticulata	Pisces	96 h	Mortaliy	LC50	26	[10]	Khangarot & Ray, 1987b	RI: 2
Chironomus tentans	Insecta	48 h	Intoxication	EC50	29	[5]; [10]	Khangarot et al. 1989	RI: 1
Bufo melanostictus	Amphibia	4 d	Mortality	LC50	43.6	[5]	Khangarot et al. 1987	
Rana hexadactyla (tadpoles)	Amphibia	96 h	Mortality	LC50	51	[10]	Khangarot et al., 1985	RI: 1
Tubifex tubifex	Annelida	96 h	Intoxication	EC50	51	[5]	Khangarot 1991	
Pimephales promelas	Pisces	7 d	Growth	LC50	74	[6]	Snarski et Olson (1982)	
Pimephales promelas	Pisces	4 d 7 d	Mortality	LC50 LC50	168 74	[10]	Snarski & Olson, 1982	RI: 1
Viviparus bengalensis	Mollusca	7 d	Mortality	LC50	80	[10]	Muley & Mane, 1988	RI: 1
Thymallus arcticus (alevins)	Pisces	96 h	Mortality	LC50	124	[10]	Buhl & Hamilton, 1991	RI: 2
Cyprinus carpio (juvenile)	Pisces	96 h	Mortality	LC50	160	[10]	Alam & Maughan, 1992	RI: 2
Oncorhynchus mykiss	Pisces	96 h	Mortality	LC50	193	[10]	Buhl & Hamilton, 1991	RI: 2
Caenorhabditis elegans	Nematoda	96 h	Mortality	LC50	440	[10]	Williams & Dusenberry, 1990	RI: 2
Saltwater, (sub)chronic								
Clavopsella michaeli	**Coelenterata**	**8 d**	**Reproduction**	**NOEC**	**0.1**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Crepidula fornicata	**Mollusca**	**112 d**	**Reproduction**	**NOEC** LOEC	**0.25** 0.42	**[10]**	**Thain, 1984**	**RI: 1, also used in** RIVM Rep. 601501001, 601014008
Mysidopsis bahia	**Crustacea**	**44 d**	**Reproduction and mortality, life cycle**	**NOEC** LOEC	**0.8** 1.6	**[10]**	**Gentile et al., 1982**	**RI: 1, also used in** RIVM Rep. 601501001, 601014008

Species	Taxonomic Group	Duration	Effect	Endpoint	Value µg Hg/l	Master reference	Reference in master reference	Comments on data reliability in master reference *
Streptotheca tamesis	**Algae**	**10 d**	**Growth**	**NOEC**	**0.9**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Synechococcus bacillaris	Algae	10 d	Growth	NOEC	0.9	[8]	RIVM Rep. 601501001, 601014008	
Fucus serratus	**Macroalgae**	**10 d**	**Growth**	**NOEC**	**0.9**	**[10]**	**Strömgren, 1980**	**RI: 2**
Crassostrea virginica	**Mollusca**	**42 – 48 h**	**Hatching**	**NOEC**	**1**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Laminaria saccharina	**Macroalgae**	**14 d**	**Development of zoospores**	**NOEC** LOEC	**1** 5	**[10]**	**Thompson & Burrows, 1984**	**RI: 2**
Skeletonema costatum	**Algae**	**6 d**	**Growth**	**NOEC**	**1**	**[10]**	**Rice et al, 1973**	**RI: 2**
Skeletonema costatum	Algae	10 d	Growth	NOEC	9	[8]	RIVM Rep. 601501001, 601014008	
Cristigera sp.	**Protozoa**	**4-9 h**	**Reproduction**	**NOEC**	**2.5**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Mercenaria mercenaria	**Mollusca**	**8-10 d**	**Reproduction**	**NOEC**	**4**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Callinectes sapidus	**Crustacea**	**10 – 35 d**	**Mortality**	**NOEC**	**4.9**	**[10]**	**McKenney & Costlow, 1982**	**RI: 1, also used in** RIVM Rep. 601501001, 601014008
Palvetia canaculata	Algae	10 d	Growth	NOEC	5	[8]	RIVM Rep. 601501001, 601014008	
Clupea harengus membras	**Pisces**	**250 – 300 h**	**ELS, hatching of larve, mortality**	**NOEC**	**5**	**[9]**	**Ojaveer et al. 1980**	
Penaeus indicus	**Crustacea**	**28 d**	**Growth**	**NOEC**	**6**	**[8]**	**RIVM Rep. 601501001, 601014008**	
Fucus spiralis	Macroalgae	10 d	Growth	NOEC	9	[10]	Strömgren, 1980	RI: 2
Ctenodrilus serratus	**Annelida**	**21-31 d**	**Reproduction**	**NOEC**	**10**	**[8]**	**RIVM Rep. 601501001, 601014008**	**geometric mean (n=2)**
Fundulus heteroclitus	**Pisces**	**32 d**	**Hatching**	**NOEC**	**10**	**[8], [10]**	RIVM Rep. 601501001, 601014008	**RI: 1**
Ophryotrocha diadema	**Annelida**	**28 d**	**Reproduction**	**NOEC**	**71**	**[8]**	**RIVM Rep. 601501001, 601014008**	**geometric mean (n=2)**
Saltwater, acute								
Mytilus galloprovincialis	Mollusca	48 h	Development	EC50	3.5	[5]	Pavicic et al. 1994	
Mya arenaria	Mollusca	7d	Mortality	LC50	4	[5]	Eisler et al. 1977	
Crassostrea gigas	Mollusca	48 h	Development	EC50	4.2	[5]	Glickstein 1978	
Crassostrea virginica	Mollusca	96 h	Embryos	LC50	5.6	[10]	Calabrese et al., 1973	RI: 1
Mytilus edulis	Mollusca	48 h	Embryos, abnormal transformation	EC50	5.8	[10]	Martin et al., 1981	RI: 1
Ditylum brightwelli	Algae	120 h	Growth	EC50	10	[10]	Canterford & Canterford, 1980	RI: 2
Acartia tonsa	Crustacea	7 d	Mortality	LC50	10	[10]	Sosnowski & Gentile, 1978	RI:2
Capitella capitata	Annelida	96 h	Trochophore larvae	LC50	14	[10]	Reish & Carr, 1978	RI: 2
Neanthes arenaceodentata	Annelida	96 h	Mortality	LC50	20	[10]	Reish & Carr, 1978	RI: 2
Penaeus merguiensis (juvenile)	Crustacea	96 h	Mortality	LC50	30 - 290	[10]	Denton & Burdon-Jones, 1982	RI: 1

Species	Taxonomic Group	Duration	Effect	Endpoint	Value µg Hg/l	Master reference	Reference in master reference	Comments on data reliability in master reference *
Fundulus heteroclitus (embyros)	Pisces	96 h	Mortality	LC50	67	[10]	Sharp & Neff, 1980	RI: 1
Artemia franciscana	Crustacea	3 d	Hatching, emergence	NOEC	2	[8]	RIVM Rep. 601501001, 601014008	
Ilyanassa obsoleta	Mollusca	2.5 h	Development	NOEC	2	[8]	RIVM Rep. 601501001, 601014008	

RI = reliability index (by Euro Chlor, based on IUCLID system): 1 (valid without restriction); 2 (valid with restrictions, to be considered with care); 3 (invalid); 4 (not assignable)

Table 6.2: Mammal and bird oral toxicity data for inorganic mercury

Species		**Duration**	**Effect**	**NOEC mg/kg food**	**Reference:**
Coturnix c. japonica	Japanese quail	365 d	egg-fertility	4	[8]: RIVM Rep. No. R679101012
Gallus domesticus	Chicken	21 d	egg-hatching	10	[8]: RIVM Rep. No. R679101012
Mus musculus	Mouse	560 d	body weight	20	[8]: RIVM Rep. No. R679101012

Table 6.3: Mammal and bird oral toxicity data for methylmercury according to RIVM report 601501009 [14]

Species		**Duration**	**Effect**	**NOEC food [mg/kg]**	**Reference**
Mammals					
Mamaca spec.	rhesus monkey	365 d	growth	0.22	Kawaskaki et al. 1986
Rattus norwegicus	Norwegian rat	3 gen	reproduction	0.43	Verschuren et al. 1976
Mustela vison	American mink	60 d	mortality	0.5	Wren 1987
Mustela vison	American mink	93 d	mortality	1.2	Wobeser et al. 1976
Mustela vison	American mink	100 d	mortality	2.5	Jenelöv et al. 1976
Mus musculus	domestic mouse	60 d	growth	2.25	Berthoud et al. 1976
Birds					
Anas platyrhynchos	mallard duck	3 gen	egg production	0.25	Heinz 1979
Phasianus colchicus	ring necked pheasant	20 d	mortality	0.36	Gardiner 1972
Gallus domesticus	chicken	20 d	mortality	0.36	Gardiner 1972
Gallus domesticus	chicken	20 d	mortality	0.86	Fimreite 1970
Coturnix c. japonica	Japanese quail	63 d	mortality	1.7	Hill & Soares 1984
Poephila guttata	zebra finch	67 d	mortality	2.7	Scheuhamer 1988
Buteo jamaicensis	red-tailed hawk	84 d	mortality, growth	2.8	Fimreite & Karstad 1971
Colinus virginianus	bobwhite quail	54 d	mortality	4.3	Spann et al. 1986

6.1 Summary on endocrine disrupting potential

Mercury is not mentioned in the Community Strategy for Endocrine Disruptors [2]. No hints on possible effects of Hg and its compounds on the endocrine system have been found in the information provided to the consultant by Member States and NGOs.

7 Effect data (human health)

The Joint Expert Committee for Food Additives of the World Health Organization has defined a Tolerable Weekly Intake of 5 µg Mercury (total) per kilogram body weight per week including a maximum of 3.3 µg methyl Hg /kg bw/week [11].

The U.S.-EPA has derived an Oral Reference Dose (RfD) for methyl-mercury in fish [16]. The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It hence is comparable with a tolerable daily intake (TDI). The RfD is 0.3 mg methyl-Hg/kg edible fish tissue for a daily fish/fishery product consumption of 17.5 g. EPA strongly recommends to adjust the RfD using local data on fishery product consumption rather than to use the default values.

8 Calculation of quality standards

According to section 8.6 of the draft report on the identification of quality standards [4] the added risk approach is used to derive the water quality standards for mercury.

$QS_{water} = C_{background} + MPA$

8.1 Maximum permissible addition (MPA) for water

There are many long-term no effect and short-term acute toxicity data for a broad range of species from different taxonomic groups available (see table 6.1 for a selection). With regard to long-term/chronic exposure algae, fish and crustaceans appear to be the most sensitive groups in freshwater whereas in saltwater molluscs and coelenterata (e.g. jellyfish) appear to be even more sensitive as the before mentioned groups. However, as there is obviously no difference in the lower limit of the sensitivity range of freshwater and saltwater species, it is suggested to derive the quality standards applicable to freshwater or saltwater environments from the same data set (i.e. the data reported in table 6.1).

The TGD [3] offers the option to support the effects assessment performed with the assessment factor method by a statistical extrapolation method if the database is sufficient for its application. The TGD requires reliable NOECs from chronic/long-term studies for a minimum of 10 (preferably more than 15) different species from at least 8 taxonomic groups. In the mercury database long-term/chronic NOECs are available for 9 different taxonomic groups (freshwater & saltwater together, 7 groups for each of the environments). However, of the minimum species requirement mentioned in section 3.3.1.2 of the TGD, only tests with higher plant species are not available. Since it is known that higher plants are not the group most sensitive to mercury it was deemed reasonable to apply a statistical extrapolation method in order to explore to which extent the results of this method and the standard TGD assessment factor method differ. Details of application and the results of the SSD method are described in section 8.1.1.

According to section 4.46 of the Manual [4] the added risk approach is used to derive the water quality standards for mercury.

$QS_{water} = C_{background} + MPA$

Freshwater

Long-term toxicity data as well as short-term acute data are available for many species of 9 different taxonomic groups. The lowest NOEC has been obtained for the marine coelenterate *Clavopsella michaeli* (0.1 µg/l) but the lowest freshwater toxicity test result is only slightly higher

(0.2 µg/l, EC10 of *Scenedesmus acuminatus*). The appropriate assessment factor according to the TGD [3] is 10 (long-term toxicity data across at least 3 trophic levels for 3 different taxonomic groups are available and the species for which the lowest acute result has been obtained belongs to the groups for which long-term data are available). Therefore the maximum permissible addition of mercury to the background concentration is calculated as follows:

$MPA_{freshwater}$ = 0.1 µg/l / AF (10) = 0.01 µg Mercury /l

Transitional, coastal and territorial waters

As there is a comprehensive data base on marine species available it is suggested in accordance with the section on marine risk assessment in the TGD [3] to apply a safety factor of 10 on the lowest reported NOEC. Hence, the suggested quality standard for the saltwater pelagic community is equal to that calculated for freshwater.

$MPA_{saltwater}$ = $MPA_{freshwater}$ = 0.01 µg Mercury /l

Maximum permissible addition for transient concentration peaks (MAC-MPA)

The MAC-QS is calculated as $C_{background}$ + MAC-MPA (where MAC-MPA is the maximum permissible addition based on acute toxicity data).

It is suggested to derive the MAC-MPA on the basis of the lowest acute toxicity test available. This is a 8 days test with the Gold fish *Carassius auratus.* The LC50 reported is 0.7 µg/l. Based on the guidance given in the TGD on the effects assessment for intermittent releases (section 4.4.7 of the Manual [4]) it is suggested to apply a reduced assessment factor of 10 on the selected LC50 in order to derive the MAC-MPA. This appears justified as acute test results are available for a very broad spectrum of freshwater and marine taxonomic groups showing that these groups do not have a higher acute sensitivity to inorganic mercury.

MAC-MPA = 0.7 µg/l / AF (10) = 0.07 µg Mercury /l

8.1.1 Calculation of the maximum permissible addition by statistical extrapolation

The 5-percentile cut-off value (5P-COV) was calculated with the method of Aldenberg & Jaworska [13] (for details see also sections 4.4.2 and 4.3.4 of the Manual [4]). For the calculation the software package ETX 1.407 was used [11].

The toxicity tests given in bold in table 6.1 were used as input-data. As far as possible the different taxonomic groups have been given equal weight (i.e. the same numbers of toxicity tests per taxonomic group have been included if enough data were available, only one test result per species was used).

The 5P-COVs of the species sensitivity distribution have been calculated for 3 data sets:

1. set of selected freshwater and saltwater NOECs
2. set of selected freshwater NOECs
3. set of selected saltwater NOECs

The selected log-transfomed data fit well to the expected distribution curve (see figure 8.1 for the combined freshwater and saltwater data set) and the Anderson-Darling as well as the Cramer von Mises tests accept the assumption of normal distribution of the input data at the highest level of significance. Results of the SSD calculations are given in table 8.1.

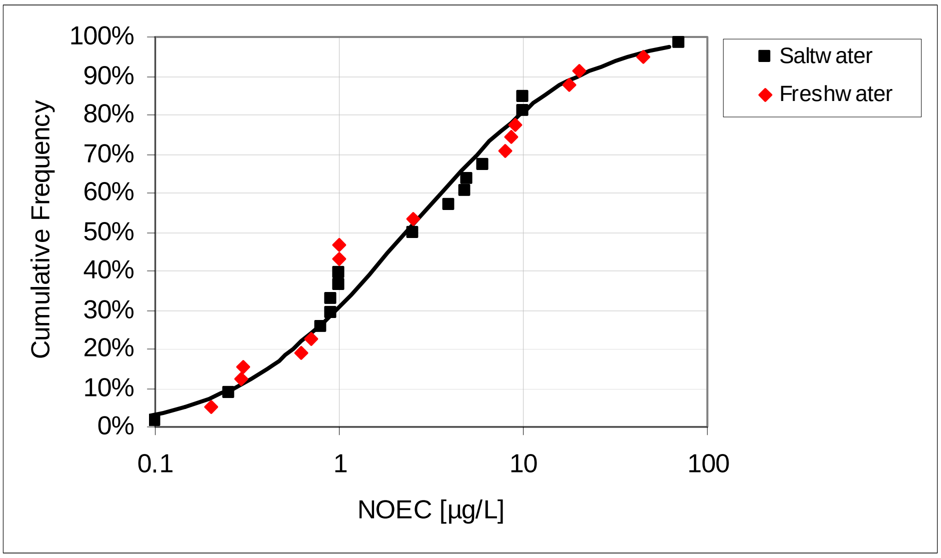

Figure 8.1: Cumulative frequency distribution of the combined freshwater and saltwater data set used for the derivation of the 5 percentile cut off value (5P-COV) by the method of Aldenberg and Jaworska [13]

Table 8.1: Results of the SSD calculations

		90 % Confidence Interval	
Data set	**5-Percentile Cut-Off Value (50% confidence)**	5P-COV (95% conf.)	5P-COV (5% conf.)
1. Combined NOECs	**0.142**	**0.054**	**0.284**
2. Freshwater NOECs	0.160	0.022	0.332
3. Saltwater NOECs	0.143	0.033	0.360

From the data given in table 8.1 it can be seen that the 50% confidence 5P-COVs for the freshwater and saltwater data sets are nearly identical. It is therefore deemed appropriate to use the 5P-COV of the combined freshwater and saltwater NOECs for the calculation of the maximum permissible addition.

In order to derive the PNEC (≈MPA) it is suggested in the TGD to divide the 5P-COV by an appropriate assessment factor between 1 and 5, reflecting further uncertainties identified.

The data base used for the calculation of the 5-percentile cut-off value covers 9 different taxonomic groups (but not all groups that should be covered according to the TGD, e.g. higher plants), tests covering the full life cycle or at least sensitive life stages are available for algae, invertebrates and fish. However, results from field studies are not available. The spread between the 5% and the 95 % confidence interval of the SSD is rather small (factor 5 between 5% certainty and 95% certainty). It is therefore suggested to use 3 as assessment factor for the derivation of the MPA.

$MPA_{water.SSD}$ = 5P-COV (0.142 µg/l) / AF (3) = 0.047 µg Mercury /l

As the MPA based on statistical extrapolation is with more than 95% confidence lower than the concentration that probably could affect 5% of the species it is suggested to derive the final water quality standard based on this MPA.

As the log $Kp_{Water-SPM}$ is >3, the QS for water is additionally given as concentration in SPM (see section 4.3.1 of the Manual [4]). The Kp-value reported as mean value in the river Rhine [7] is used as *example* for the calculation (Kp (mean, Rhine) ≈ 100,000 l/kg):

MPA_{SPM} [mg/kg] = MPA_{water} (0.047 µg Hg /l) * Kp (100,000 l/kg) = **4.7 mg Hg / kg SPM**

The partition coefficient $Kp_{water-SPM}$ is the decisive parameter in the derivation of the local QS_{SPM}. It is, therefore, very important to use a figure that is representative for the spatial unit for which the QS_{water} is to be transformed to the corresponding QS_{SPM}.

8.1.2 Calculation of the water quality standards

Freshwater and saltwater

The natural Hg background concentration in the river Rhine is used as an example in order to illustrate the calculation of the quality standard. The natural background concentration of "dissolved" mercury in Rhine water is 0.005 µg Hg/l and in suspended sediment the background is 0.2 mg Hg/kg [7].

The example of a quality standard for the Rhine is calculated on the basis of the background concentration in the Rhine and the MPA as calculated in section 8.1.1:
QS_{water} = $C_{background}$ (0.005 µg Hg /l) + MPA (0.047 µg Hg /l) = 0.052 µg Hg /l

For the Rhine as example, the QS for mercury in SPM is therefore calculated as follows:
QS_{SPM} = $C_{background}$ (0.2 mg/kg) + MPA_{SPM} (4.7 mg/kg) = 4.9 mg Mercury /kg SPM

Quality standard for transient concentration peaks (MAC-QS)

The MAC-QS is calculated on the basis of the background concentration (0.005 µg Hg /l, see section on QS for freshwater and saltwater above) and the MAC-MPA as calculated in section 8.1:

MAC-QS = $C_{background}$ (0.005 µg/l) + MAC-MPA (0.07 µg/l) = 0.075 µg Mercury /l

8.2 Quality standard for sediment

Since the partition coefficient water – SPM is >1000 (trigger value) the calculation of a sediment quality standard is required.

$QS_{sediment} = C_{background.sed} + MPA_{sediment}$

Calculation of the $MPA_{sediment}$

According to the TGD the $PNEC_{sediment}$ ($\approx MPA_{sediment}$) may be calculated using the equilibrium partitioning method in the absence of toxicity data for sediment dwelling organisms (Manual, sections 4.4.2.2 & 4.3.2.3 & 4.3.2.4).

The equilibrium partitioning approach only considers uptake via the water phase. However, uptake may also occur via other exposure pathways like ingestion of sediment and direct contact with sediment. In such cases it is recommended in the TGD to use the equilibrium method in a modified way. The suggestion is to increase the $PEC_{sed}/PNEC_{sed}$ ratio by a factor of 10 for the risk assessment. However, division of the $PNEC_{water}$ by a factor of 10 will result in the same ratio. Thus, it can be inferred that division of the MPA_{water} by a factor of 10 will result in a tentative $MPA_{sediment}$ that accounts for possible uptake via the mentioned additional routes of exposure.

As there is clear evidence for mercury that exposure routes other than direct uptake via the water significantly contribute to its uptake into biota (see section 5 of this data sheet) these additional uptake routes are accounted for by dividing the MPA_{water} by ten as described above. According to the TGD the partition coefficient water-sediment is used for the calculation.

Again, the mean partition coefficient of the Rhine (Kp 100,000 l/kg) is used as an example. The $MPA_{sediment}$ is therefore calculated as follows:

$\mathbf{MPA_{sediment}}$ [µg/kg SPM] = Kp (100,000 l/kg) * MPA_{water} (0.047 µg/l) / 10 = 470 µg/kg

Calculation of the quality standard for sediment

The background concentration in Rhine sediment is 0.2 mg Hg / kg SPM [7]. The $QS_{sediment}$ is therefore:

$\mathbf{QS_{sediment.rhine}}$ = $C_{background}$ (200 µg/kg) + MPA (470 µg/kg) **= 670 µg Mercury / kg (dry wt)**

There is one chronic toxicity test with the sediment dwelling larvae of the insect *Chironomus riparius* available. The NOEC observed in the 28 d test with Hg_2Cl_2 spiked sediment was 930 mg/kg sediment (measured, dry weight basis; Thompson et al. 1998, cited in [10]). The appropriate assessment factor for the derivation of a $PNEC_{sediment}$ form this NOEC according to the TGD is 100, resulting in a **tentative $QS_{sediment}$ of 9.3 mg Hg/kg sediment dry wt**.

The value derived by the EP-method can only be considered as a tentative standard. Also, the result of the only available long term test with a sediment organism is not considered as a basis on which alone the derivation of a reliable sediment quality standard should rely on. The calculation of a reliable standard for the sediment compartment requires therefore the availability of more long term tests conducted with benthic organisms. For the time being no reliable $QS_{sediment}$ can be derived.

8.3 Secondary poisoning of top predators

Predators such as mammals and birds feed on prey (fish, mussels) that may contain mercury of which 70-99% is organic mercury [10, 17], which is deemed to be more toxic than inorganic Hg (see table 6.2 and 6.3). Therefore, in line with the recommendation of the CSTEE [19], it is suggested to base the assessment for secondary poisoning of top predators on methyl mercury.

Available NOECs for effects of methyl mercury on mammals and birds are listed in Table 6.3. The lowest reported NOECs for birds and mammals are very similar (0.25 respecitvely 0.22 mg/kg food). The lower value is used in the following calculations.

According to the TGD, the $PNEC_{oral}$ (≈$QS_{secpois.biota}$, i.e. the quality standard for the concentration in the prey of the predators) is calculated as follows:

$PNEC_{oral}$ = $NOEC_{oral}$ / AF (30 for chronic oral studies with birds or mammals)

However, because of the large number of NOECs available for methyl mercury, it may be considered to use a lower assessment factor. Thus, instead of the default AF suggested in the TGD, a reduced factor of 10 seems to be appropriate and may be used. The possible range of the $QS_{secppois,biota}$ is then 7.3 – 22 µg/kg (Table 8.2).

Table 8.2: Qualtiy Standards for methyl mercury in fish as prey for birds and mammals using different assessment factors (AS) applied to the lowest available NOEC

Scenario	NOEC [mg/kg]	AF	QS sp,biota [µg/kg]
A)	0.22	30	7.3
B)	0.22	10	22.0

The concentration in water corresponding to the prey body burden ($QS_{secpois.water}$) is calculated as follows:

$QS_{secpois.water}$ = $QS_{secpois.biota}$ [µg/kg prey] / BCF * BMF

Considerable uncertainty exists with regard to the bioconcentration and biomagnification of mercury. Whereas the reported BCFs measured in laboratory studies for inorganic and organic mercury are highly variable, there is no quantitative information on biomagnification along the food chain available (e.g. BMFs). However, there are some data available providing BAFs from measurements of methyl mercury in water and biota in the field (Table 8.3).

The BAF values span around 4 orders of magnitude - from a geometric mean of 21 700 used by RIVM [14] to calculate MPAs for the Netherlands up to79 000 000 reported by Horvat et al. (2003) [18] for sharks as top predators in the marine environment. The US-EPA stresses that within an individual trophic level BAFs generally ranged up to two orders of magnitude due to various site specific biotic and abiotic factors [16].

Given these uncertainties, it is not deemed possible to derive a reliable quality standard for methylmercury in water that corresponds to the $QS_{secpois.biota}$. However, the derivation of a quality standard addressing secondary poisoning is deemed necessary as the protection of predators from secondary poisoning may require environmental mercury levels by far lower than the standard derived for the protection of the pelagic communities in freshwater and saltwater against direct effects. This is illustrated by the scenario calculations shown in table 8.4, where the 2 calculated $QS_{secpois.biota}$ from table 8.2 were combined with BAFs of 21 700, 10^6 and 10^7.

Table 8.3: BAF measured in the field. Numbers printed in italic were recalculated from the reported BAF respectively log(BAF) values

Taxa	**BAF**	**log BAF**	**Data**	**Reference**	**Master Ref**
fish	21 700	*4.3*	geom.mean (n=18)	Sloof et al. 1995	[14]
fish	100 000	*5.0*	max (n=18)	Sloof et al. 1995	[14]
planktivorous fish	1 600 000	*6.2*	geom.mean	EPA-452/R-97-008	[15]
psicivorous fish	6 800 000	*6.8*	geom.mean	EPA-452/R-97-008	[15]
BCF	33 000	*4.5*	geom.mean	Draft National MeHg Bioaccumulation factors	[16]
BAF level 2	120 000	*5.1*	geom.mean		[16]
BAF level 3	680 000	*5.8*	geom.mean		[16]
BAF level 4	27 000 000	*7.4*	geom.mean		[16]
fish	*200 000 - 20 000 000*	5.3 - 7.3	range	Bowles et al. 2001	[18]
Various trophic level	*200 000*	5.3	range	Meili 1997	[18]
Perch & piscivorous fish	*630 000 - 790 000*	5.8 - 5.9	range	Boudou & Ribeyre 1997	[18]
dogfish, flat fish, shark	*500 000 - 79 000 000*	5.7 - 7.9	range	Laurier et al. 2003, Horvat et al. 2003	[18]

Table 8.4: Scenario calculations for "safe" water concentrations with respect to secondary poisoning using different “safe” concentrations in biota (=$QS_{secpois.biota}$) in biota and different BAFs. The resulting $QS_{secpois,\ water}$ are reported as ng MeHg/l.

			BAF		
Lowest NOEC [mg/kg]	**AF**	**$QS_{secpois,biota}$ [µg/kg]**	**21 700**	**1 000 000**	**10 000 000**
0.22	30	7.3	0.338	0.007	0.001
0.22	10	22.0	1.014	0.022	0.002

The resulting $QS_{secpois,\ biota}$ span over three orders of magnitude ranging from 0.001 up to 1 ng/L. For comparison, the RIVM report 601501009[14] calculates an MPA for secondary poisoning of 2.2 ng/L (using an correction factor around 0.3 for the NOECs, a BAF of 21 700, and a statistical extrapolation method to calculate the MPA) while the US-EPA[15] uses a different approach based on species specific consumption data to calculate a Wildlife Criterion (WC) of 0.05 ng/L. This latter value is close to the value 0f 0.022 ng/l deemed most reliable in Table. 8.4 calculated with an assessment factor of 10 and a BAF of 1 000 000. A higher AF seems to be too conservative due to the large number of available NOECs while the BAF of 21 700 used by RIVM seems to be very low compared to the other reported BAFs measured in several ecosystems. On the other side, a BAF of ten million might be too conservative because it is unlikely that a bird or a mammal would only prey on psicivorous fish characterised by higher BAFs than fish from lower trophic levels.

Due to the different site specific factors driving bioaccumulation of mercury in aquatic food webs, it seems on the basis of the current knowledge not appropriate to derive a general $QS_{secpois,\ water}$. An in depth assessment of the uncertainties associated with the bioaccumulation potential of (inorganic and organic) mercury and its toxicity to predators is required in order to derive reliable quality standards depending on site specific factors.

Thus, it is suggested to set the QS for methylmercury for the time being for the concentration in biota only. Based on the NOEC of the most sensitive taxon and an assessment factor of 10 the resulting QS is:

$QS_{secpois,\ food}$ = 22 µg methyl-Hg /kg food (prey tissue; wet wt)

The use of fish tissue residue water quality criterion is also suggested by the US-EPA[16], but the value of 300 µg/kg fish was calculated for the protection of human health and therefore cannot be considered to be protective for birds or mammals which feed almost exclusively on fish.

8.4 Quality standard referring to food uptake by humans

Mercury compounds are classified as very toxic and they are liable to bioaccumulate. Therefore the derivation of a quality standard referring to ingestion of food from aquatic environments by humans is required.

A maximum level for Hg in fishery products has been set in the context of Commission Regulation (EC) No 466/2001 [12]. This maximum level of 0.5 mg Hg/kg (wet wt) refers to the edible parts of fishery products (for certain fish species such as e.g. pike, eel, tuna, redfish, halibut and sharks the maximum level is 1 mg/kg). The level set by the Commission Regulation is legally binding. Therefore the respective quality standard referring to the intake of fishery products by humans is:

$QS_{hh.food}$ = 500 µg Hg /kg fishery products (wet wt)

As shown in the section about secondary poisoning, large uncertainties do exist about bioaccumulation of mercury in aquatic food webs. Therefore, it is concluded that it is for the time being not possible to calculate a reliable $QS_{hh.water}$.

The Joint Expert Committee for Food Additives of the World Health Organization calculated a Tolerable Weekly Intake corresponding to a tolerable daily intake (TDI) of 0.71 µg/kg bw/d total mercury and 0.47 µg/kg bw/d organic mercury. Acknowledging that the by far most important exposure route of humans to mercury is uptake of fishery products (>90%), this WHO TDI would result in a fish tissue concentration of 0.39 mg total Hg/kg edible fishery product, assuming the European average fishery product uptake of 115g/d and an exhaustion of the TDI of 90% by this exposure route.

An Oral Reference Dose referring to the protection of human health was as well calculated by the US-EPA [16]. Based on a on a total fish and shellfish consumption-weighted rate of 17.5 g fish/day a concentration of 0.3 mg methyl-Hg/kg fish shall not be exceeded.

Compared with the WHO-TWI and the US-EPA RfD, taking account of the fishery product consumption of the avererage European citizen, the EU-Limit value for Hg as fixed in Commission Regulation (EC) No 466/2001 appears quite high.

8.5 Quality standard for drinking water abstraction

The imperative A1 value referring to drinking water abstraction by simple treatment is 1 µg Hg/l (Council Directive 75/440/EEC). The drinking water standard (DWS) set in CD 98/83/EC is also 1 µg Hg/l.

The DWS is a limit value never to be exceeded at the tap. The MAC-MPA (ECO) derived for the protection of the freshwater community (0.07 µg/l) is by far lower than the DWS.

8.6 Overall quality standard

In its opinion on the mercury quality standard [19], the SCTEE suggested to derive this standard for methyl-mercury in biota tissue. This proposal is appreciated and has been followed in this data sheet.

The maximum permissible addition (respectively quality standards) derived for the protection of the pelagic communities in surface waters may not be low enough to protect predators from secondary poisoning or humans from adverse effects due to the ingestion of fishery products. Reliable water-based quality standards for the latter objectives of protection could not be calculated as considerable uncertainty exists with regard to the bioaccumulation potential of inorganic and organic forms of mercury and the transformation of inorganic mercury into organic species along the trophic levels of the food web. It is therefore suggested to set two quality standards for mercury – one water-based maximum permissible addition (MPA) for protection of aquatic organisms against direct effects of mercury ($QS_{water} = C_{background} + MPA$) and one biota-based standard for protection of predators (and humans) against secondary poisoning ($QS_{secpois.biota}$). In principle, the QS_{water} for protection against direct toxicity of mercury is referring to inorganic forms of mercury whereas the $QS_{secpois.biota}$ is set for methyl-Hg. However, in the light of evidence from various studies that methyl-Hg in water typically amounts to only 1-10% of total Hg [17], total Hg instead of inorganic Hg may be monitored in water.

In order to derive a quality standard for sediment organisms, long term toxicity data for sediment organisms are required.

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