Common Implementation Strategy for the Water Framework Directive

Environmental Quality Standards (EQS)

Substance Data Sheet

Priority Substance No. 9

Chlorpyrifos

CAS-No. 2921-88-2

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[11]. 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: 9	Chlorpyrifos
CAS-Number:	2921-88-2
Classification WFD Priority List *:	WFD_PSR

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

2 Proposed quality standards

2.1 Overall quality standards

Ecosystem	**Quality Standard**	**Quality Standard "rounded values"**	**Comment:**
AA-QS all surface waters covered by WFD	0.033 µg/l	**0.03 µg/l**	See section 8.1
MAC-QS (ECO)	0.1 µg /l	**0.1 µg /l**	See section 6 & 8.1

2.2 Specific quality standards

Protection Objective #	**Quality Standard**	**Comment:**
Pelagic community (freshwater & saltwater)	0.033 µg/l	See section 8.1
Benthic community (freshwater & marine sediment)	No specific standard necessary	Protection of sediment covered by the QS referring to the pelagic community; see 8.2
Predators (secondary poisoning)	$QS_{secpois.biota}$ = 67 µg/kg prey (wet wt) $QS_{secpois.water}$ = 0.048 µg/l (AA-QS)	See section 8.3.
Food uptake by man	$QS_{hh.food}$ = 608 µg/kg fishery product $QS_{hh.water}$ = 0.44 µg/l	based on ADI; see section 8.4
Abstraction of water intended for human consumption (AWIHC)	< 1 µg/l	Imperative A1 value referring to drinking water abstraction set by CD 75/440/EEC; see section 8.5
Water intended for human consumption (WIHC)	0.1 µg/l	Drinking water standard set by CD 98/83/EC

\# If justified by substance properties or data available, QS for the different protection objectives are given independently for freshwater environments, transitional waters or coastal and territorial waters

3 Classification

R-Phrases and Labelling	Reference:
T; R25 - N; R50-53	[12]
T, N; R: 21-25-50/53 (proposal of rapporteur Member State)	[1]

4 Physical and chemical properties

Property	Value	Reference
Vapour pressure	1.0 x 10^{-3} Pa at 25ºC	[1]
Henry's law constant	H = 0.91 Pa x m^3 x mol^{-1} **(**It is concluded that chlorpyrifos is non-volatile from water surfaces)	[1]
Solubility in water	0.39 mg/l at 19.5ºC. pH = 6.28 0.7623 mg/l at 20ºC. pH 7.0 – 7.6 pH4 Buffer Solution : 1.04 ± 0.047 mg/l at 25ºC pH7 Buffer Solution : 1.07 ± 0.045 mg/l at 25ºC the solubility of chlorpyrifos in pH 9 buffer was not considered relevant due to known hydrolysis of Chlorpyrifos at this pH	[1]
Dissociation constant		

5 Environmental fate and partitioning

Property	Value	Ref.
Hydrolytic stability (DT_{50})	pH_4.7-5_25ºC___: 63-73 days pH__6.9-7_25ºC___: 16-35 days pH___8.1__25ºC_: 23 days	[1]
Photostability (DT_{50}) (aqueous, sunlight, state pH)	DT50: 15 (mid-summer 20ºN), 30 (mid-summer 40ºN) or 29200 days (mid-winter 60ºN)	[1]
Readily biodegradable (yes/no)	Chlorpyrifos cannot be classified as readily biodegradable under the test conditions employed (OECD 301). Percentage biodegradation results after 28 days were as follows: chlorpyrifos 22%, chlorpyrifos-methyl 25%, Dowco 439 19%.	[1]
Degradation in Water/sediment -DT_{50} water - DT_{50} whole system	 3-6 d 22 –51 d	[1]
Mineralization	1% after 100 days	[1]
Bound residue	4-5 % after 60-100 days	[1]
Distribution in water / sediment systems (active substance)	Water layer 40-60% AR after 6 hours, 13-29% after 7 days. After 100 days, chlorpyrifos residue was 3-26% in sediments	[1]
Residues relevant to the aquatic environment	TCP was the only relevant metabolite.	[1]
Partition coefficients log P_{OW} Koc	 4.69 to 5.30 4440 – 15500	 [1] [1]
BCF (fish)	1374	[1]

6 Effect data (aquatic environment)

Aquatic organisms

According to the Rapporteur MS (Spain), the notifier has presented a lot of information about the toxicity of chlorpyrifos to aquatic organisms. The studies reported in the list of endpoints are summarized in table 6.1 below.

Based on the results of the micro- and mesocosm studies, the Rapporteur had originally drawn the following conclusions: Concentrations of 1 µg/l and above are expected to produce relevant effects on aquatic ecosystems. Concentrations between 0.05 and 1 µg/l could affect the most sensitive taxa. The ecological relevance of these effects is expected to be related to the role of these sensitive taxa within each particular ecosystem. An overall NOEC of 0.1 µg/l was proposed. Because the multi-species test designs mostly represented Northern European conditions, the role of invertebrate population to control algae "blooms" in Southern Europe was not covered, and a safety factor of 2 on the NOEC ecosystem was agreed for covering this hazard. However, in December 2002 additional studies for covering the specific Mediterranean conditions have been submitted. Although the concern has been confirmed, the studies indicated that the level of 0.1 µg/l is also relevant for Mediterranean aquatic systems. Based on these new studies, the Rapporteur proposes a Predicted No Effect Concentration (PNEC) of 0.1 µg/l.

Table 6.1: Toxicity data for aquatic species (most sensitive species of each group) (Annex IIA, point 8.2, Annex IIIA, point 10.2) [1]

Group	Test substance	Time-scale	Endpoint	Toxicity (mg/l)
Laboratory tests				
Fish	technical formulated	Acute	96h LC50 (10 species) (5 species)	0.0013-520 0.00054-203
Fish	technical	Chronic	35d NOEC ELS	0.00014
Fish	Metabolite TCP	Chronic	31d NOEC	0.0808
Invertebrates	formulated technical	Acute	48h EC50	0.000014a.i. 0.0001
Invertebrates	Technical formulated	Chronic	35 days NOEC M.bahia 21 days NOEC D.magna	0.0046 [1] 0.000056
Algae	Technical formulated	Acute Chronic	72h EC50 NOEC NOEC	1.2 0.1-0.001 0.027-0.063
Microcosm or mesocosm tests				
a) Studies evaluated and considered in the monograph				
Giddings, 1993a Outdoor microcosms, three levels of treatment Level 1. Three spray drift applications (1µg/l) plus three runoff (0.6 µg/l) over six weeks. Lorsban 4E Averaged measured concentration 0.93 µg/l in water. Sediment residues 1.7-20.5 µgkg Rotifers: No effects Zooplankton crustaceans: Decrease 30%, recovered at the end of the study Macroinvertebrates: some sporadic changes Fish (bluegill): Reduction in fish growth Level 2. Six spray drift applications (0.3µg/l) plus six runoff (0.6 µg/l) over six weeks. Lorsban 4E Averaged measured concentration 0.75 µg/l in water. Sediment residues 1.7-20.5 µgkg				

[1] This value appears to be incorrectly reported. In the 1999 Monograph available to FHI it is reported as 0.0000046 mg/l (4.6 ng/l). To be checked by Rapporteur MS (Spain).

Table 6.1: Toxicity data for aquatic species (most sensitive species of each group) (Annex IIA, point 8.2, Annex IIIA, point 10.2) [1]

Rotifers: No effects
Zooplankton crustaceans: Decrease 45%, recovered at the end of the study
Macroinvertebrates: some sporadic changes
Fish (bluegill): Reduction in fish growth

Level 3. Six spray drift applications (1µg/l) plus six runoff (0.6 µg/l) over six weeks. Lorsban 4E
Averaged measured concentration 1.36 µg/l in water, peak concentration 2.3 µg/l. Sediment residues 1.7-20.5 µg/l
Rotifers: No effects
Zooplankton crustaceans: Decrease 45%, recovered at the end of the study
Macroinvertebrates: some sporadic changes
Fish (bluegill): Reduction in fish survival and biomass

Giddings, 1993b Outdoor microcosms.
Five single doses (nominal 0.03 to 3 µg/l) simulating either spray drift or runoff.
Rotifers and ostracoda: No affected
Zooplankton crustaceans: Affected at 0.3 µg/l and above for up to four weeks.
Benthic invertebrates reduced at 0.1 µg/l and above
Chironomid emergence: reduced at 3 µg/l
Fish (bluegill): effects on growth at 1µg/l, effects on survival at 3 µg/l.

Leeuwangh, 1994 [6]. Several systems
Indoor micro-ecosystem: Recirculating systems with algae, daphnids and bacteria in different compartments. One or two applications.
Daphnia: decrease number at 0.3 (mean) 0.5 (max.) µg/l. Recovered in 3 weeks (after dissipation of the pesticide).
Algae and Bacteria: No effects.

Indoor microcosms (water/sediment with or without macrophytes). Single application at nominal 35 µg/l.
Mortality in Copepoda, Amphipoda, Isopoda, Insecta, Cladocerans. Recovery in several groups (not for insects and Gammarus)
No effects on non-arthropod invertebrates and plants
Indirect effects on all populations and community metabolisms.

Outdoor mesocosms. Single application of nominal 0.1 to 44 µg/l
NOEC for single applications >0.065 but <0.7 µg/l
Recovery of several populations
Secondary (Indirect) effects on the system including water quality.

Siefert et al. 1989 [7]. Natural enclosure.
Single applications of nominal 0.5 to 20 µg/l
Decline of micro- and macro-invertebrates community.
Decrease of fish growth
Secondary effects on algae and plants

Macek et al., 1972 [8]. Freshwater ponds.
Two nominal spray drift application of 11 or 56 g/ha, resulting in 1 and 5.7 µg/l respectively.
Insects (mostly midges) high decrease at the highest dose, no effects at the lowest dose.
Fish (bluegill and bass): Cumulative mortalities of 55-46% (highest dose); 3-10% (lowest dose); 1% (control).

Hurlbert et al., 1970 [9]. Freshwater pond.
Four applications (2-w interval) at four doses: 11 to 1122 g ai/ha of Durban.
Water concentration: 200 µg/l at 4 hours; 6 µg/l at 7 days for the highest dose. High residues (up to 26 ppm after 4 hours for the highest dose) in vegetation.
Birds: Duckling mortality of 42%.

Table 6.1: Toxicity data for aquatic species (most sensitive species of each group) (Annex IIA, point 8.2, Annex IIIA, point 10.2) [1]
Fish (Mosquito-fish): Mortality at the highest dose. Corixids (Corisella spp.): Recover after first but not subsequent treatments for 112 g ai/ha and below. Microinvertebrates: Direct and indirect effects. **Brock et al 1992 [10].** Indoor systems with or without macrophytes. Single dose of 5 or35 µg/l Loss of arthropoda population Secondary effects on primary producers, herbivores, carnivores and detritivores.
b) Additional studies not included in the monograph: **Van der Brink et al., 1995** (also reported in Van Wijngaarden, 1996 and related papers): Outdoor experimental diches, single application. The proposed NOEC for the ecosystem is 0.1 µg/l **Pusey et al, 1994**; Outdoor artificial stream, single application. The proposed NOEC for the ecosystem is 0.1 µg/l
c) December 2002 – Submission of additional studies addressing the specific Mediterranean conditions **R.P.A. van Wijngaarden & T.C.M. Brock September 2001** The microcosms showed a reduction of zooplankton at 1 and 10 µg/l and indirect effects on phytoplankton. NOEC of 0.1 µg/l. **Van Wijngaarden and Brock (2002)** The results of microcosms sµggested signs of eutrophication in Mediterranean conditions at levels higher than 0.1 µg/l. NOEC = 0.1 µg/l.

Table 6.2: Mammal and bird oral toxicity data relevant for the assessment of non compartment specific effects relevant for the food chain (secondary poisoning)

Type of study	Species, test result	Ref.
Long-term toxicity to mammals	NOEL 0.1 mg/kg bw/day; 2-year dietary study for rat	[1]
Acute oral toxicity to birds	LD50 8.41 mg/kg bw *(Phasianus colchicus)*	[1]
Short term dietary toxicity to birds	LD50 180 mg/kg food (*Anas platyrhynchos*)	[1]
Reproductive toxicity to birds	NOEC 25 mg/kg food (*Anas platyrhynchos*)	[1]

Summary on endocrine disrupting potential

Comment	Reference
No endocrine potential is expected for chlorpyrifos	Rapporteur MS

7 Effect data (human health) [1]

Table 7.1: Data relevant for human health effects assessment

	Value	Study	Safety factor
ADI	0.01 mg/kg bw /d	NOAEL critical in animal studies for the ADI calculation is 1 mg/kg bw in the two year dog studies	100

8 Calculation of quality standards

8.1 Quality standards for water

Quality standard accounting for transient concentration peaks (MAC-QS)

The Rapporteur in the context of the risk assessment according to Council Directive 91/414/EEC (Spain) proposes that, for the particular case of chlorpyrifos, the most relevant parameter considered should be the MAC-QS, due to the rapid dissipation in the aquatic environment. The proposed quality standard is based on the results of the mesocosm studies. The tested conditions cover a wide range and similar results have been obtained indicating that the value of 0.1 µg/l can be regarded as the ecotoxicological threshold. Therefore, the Rapporteur proposes a MAC-QS of 0.1 µg/l.

MAC-QS = 0.1 µg chlorpyrifos /l

Annual average quality standard, freshwater

Some of the microcosm/mesocosm studies listed in table 6.1 report the occurrence of transient effects at initial peak levels as low as 0.1 µg/l. Hence the ecosystem NOECs in these cases take recovery into account. It is therefore necessary to provide protection against a too frequent occurrence of the MAC-QS [5] suggested by the Rapporteur. Further, the representativeness of the microcosm/mesocosm test systems for the water bodies to be covered by the QS needs to be taken into account. The QS must be protective for all types of surface waters and communities that are addressed by the standard. Higher-Tier studies in the context of the plant protection product risk assessment are usually focused to euthrophic water bodies occurring in the immediate vicinity of agriculturally used areas. A QS under the WFD, however, must assure protection also for water bodies that significantly differ from this paradigm [5].

Taking the above considerations into account, an additional assessment factor of 3 on the MAC-QS seems appropriate to derive the required annual average quality standard for the protection of the pelagic community.

$QS_{freshwater}$ = MAC-QS (0.1 µg/l) / AF (3) = 0.033 µg/l

Annual average quality standard, transitional, coastal and territorial waters

Beside freshwater species toxicity tests, tests with marine fish, crustacean and algae species are reported in the monograph [1]. No significant differences exist in the sensitivity of freshwater or saltwater species belonging to the same taxonomic group. Therefore, according to guidance outlined in the revised TGD, effects data for marine and freshwater species may be pooled. As chlorpyrifos is an organophosphate insecticide with a specific mode of action, through inhibition of cholinesterase activity in the nervous system of target species, it is deemed very unlikely that marine taxonomic groups exist that are significantly more sensitive to chlorpyrifos than crustaceans.

Therefore, the proposed QSfreshwater may be considered as protective for transitional, coastal and territorial waters as well.

$QS_{saltwater}$ = $QS_{freshwater}$ = 0.033 µg chlorpyrifos / l

8.2 Quality standard for sediment

According to the Rapporteur the protection of the sediment and the benthic community is covered by the proposed QS for the water column / pelagic community. This QS is based on mesocosm studies in which effects on benthic organisms were also investigated (e.g., Giddings et al, 1993a and 1993b; Leeuwangh et al, 1994; Macek et al, 1972; see tab. 6.1). A complete description is given in the monograph [1]. Endpoints as taxonomic richness and emergence were measured in these mesocosms.

8.3 Secondary poisoning of top predators

The BCF of Chlorpyrifos is 1374 [1]. Thus, the trigger criterion to derive a quality standard referring to the protection of top predators from secondary poisoning is met (see table 1a of the Manual [4]).

According to section 4.3.2.5 of the Manual [4] a $NOEL_{oral}$ may be converted to a $NOEC_{food}$ by multiplication with a conversion factor (CONV) accounting for the ratio between body weight and food uptake. For rats >6 weeks a CONV of 20 is recommended.

$NOEC_{food.rat}$ = $NOEL_{rat}$ (0.1 mg/kg bw.d) * CONV 20 (kg bw/ kg food.d) = 2 mg chlorpyrifos /kg food

According to the TGD an assessment factor of 30 is appropriate to derive a $PNEC_{food}$ from a chronic $NOEC_{food}$. The $PNEC_{food}$ is equivalent to the "save" concentration in the prey of predators and thus is the quality standard for biota ($QS_{secpois.biota}$).

$QS_{secpois.biota}$ = 2 mg/kg food / AF (30) = **67 µg Chlorpyrifos / kg prey (wet wt)**

The BCF of 1374 [1] is used to calculate the concentration in water that corresponds to the $QS_{secpois.biota}$. No information is available on observed biomagnification of chlorpyrifos. However, it is known that the clearance of chlorpyrifos in fish is rapid [1]. Therefore, and because the BCF of this substance is <2000, biomagnification needs not be considered in the calculation of the water concentration that corresponds to the $QS_{secpois.biota}$.

The $QS_{secpois.water}$ is calculated as follows:

$QS_{secpois.water}$ = $QS_{secpois.biota}$ (67 [µg/kg prey]) / BCF (1374) = 0.048 µg Chlorpyrifos /l

The above calculation of the $QS_{secpois.water}$ highlights the necessity to establish an annual average quality standard (AA-QS) beside the MAC-QS of 0.1 µg/l.

8.4 Quality standard referring to food uptake by humans

The BCF proposed in the monograph for chlorpyrifos is 1374. The rapporteur considers the potential for biomagnification of this substance as low because the clearance time (CT50) is in the range of two to three days.

The acceptable daily intake (ADI) calculated for chlorpyrifos is 0.01 mg/kg bw/day.

In the final report [4] it is suggested that the ADI may not be exhausted for more than 10% by consumption of fishery products. For a person weighing 70 kg this results in an acceptable daily intake of 70 µg chlorpyrifos per day.

The average fish consumption of an EU citizen is 115 g d-1 (TGD [3]). Thus, 115 g fishery products must not contain more than 70 µg chlorpyrifos.

$$\mathbf{QS_{hh.food}} = \frac{\text{70 µg Chlorpyrifos}}{\text{115g fishery product intake}} * 1000\ g = \mathbf{608\ µg\ Chlorpyrifos\ /\ kg\ fishery\ product}$$

In the TGD approach for the assessment of secondary poisoning (see section .4.3.2.5of the Manual [4]) it is foreseen to consider bioconcentration and biomagnification as relevant factors affecting body burdens and the PEC, respectively. If no information on BMF values is available, it is proposed in the TGD to use default BMFs for substances with a BCF_{fish} >2000. As the BCF_{fish} of Chlorpyrifos is 1374, biomagnification is not considered for the calculation of the concentration in water corresponding to the $QS_{hh.food}$, which is calculated as follows:

$$\mathbf{QS_{hh.food.water}} = \frac{QS_{hh.food}\ (608\ [µg/kg])}{BCF\ \ (1374\ [kg/l])} = 0.44\ µg\ Chlorpyrifos\ /\ l$$

The protection of the pelagic community and of top predators do require a lower QS than the protection of human health from adverse effects by oral uptake of fishery products.

8.5 Quality standard for drinking water abstraction

The imperative A1 value referring to drinking water abstraction by simple treatment is 1 µg/l for the total amount of pesticides (Council Directive 75/440/EEC). The drinking water standard set in CD 98/83/EC is 0.1 µg/l for individual pesticides.

The DWS is a limit value never to be exceeded at the tap. The MAC-QS derived for the protection of the pelagic community in freshwater (0.1 µg/l) is therefore also protective for drinking water abstraction. Hence, the derivation of a specific MAC-QS for areas designated in accordance with Art. 7 WFD for the **a**bstraction of **w**ater **i**ntended for **h**uman **c**onsumption (AWIHC) is not necessary.

MAC-QS (AWIHC) = MAC-QS (ECO) = 0.1 µg/l

8.6 Overall Quality Standard

The AA-QS derived for the protection of the pelagic communities in freshwater as well as in transitional, coastal and territorial waters is suggested as overall quality standard.

9 References

[1] Monograph according Council Directive 91/414/EEC: Chlorpyrifos, Volume 1, Levels 1-4, Annexes A & B1-B9; February 1999

[2] COM(2001)262 final: Communication from the Commission to the Council and the European Parliament on the implementation of the Community Strategy for Endocrine Disrupters – a range of substances suspected of interfering with the hormone system of humans and wildlife.

[3] Technical Guidance Document on Risk Assessment in Support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances and Commission Regulation (EC) No 1488/94 on Risk Assessment for Existing Substances and Directive 98/8/EC of the European Parliament and the Council Concerning the placing of biocidal products on the market. Part II. European Commission Joint Research Centre, EUR 20418 EN/2, © European Communities 2003. Available at the internet-site of the European Chemicals Bureau: http://ecb.jrc.it/existing-chemicals/

[4] Manual of the Methodological Framework Used to Derive Environmental Quality Standards for Priority Substances of the Water Framework Directive. Peter Lepper, Fraunhofer-Institute Molecular Biology and Applied Ecology, 15 November 2004. Available at the internet-site of the European Commission: http://europa.eu.int/comm/environment/water/water-dangersub/pri_substances.htm

[5] Compatibility of Acceptable Concentrations Derived in the Higher-Tier Aquatic Risk Assessment for Plant Protection Products with the Objectives of Surface Water Quality Standards in the Context of the Water Framework Directive. Paper presented by FHI and endorsed at the QS-peer-review workshop in Brussels (12-16 May 2003)

[6] Leeuwangh, Brock, Kersting. 1994. An evaluation of four types of freshwater model ecosystem for assessing the hazard of pesticides. Hum. Exp. Toxicol. 13: 888-899.

[7] Siefert et al. 1989. Littoral enclosures for aquatic field testing of pesticides: effects of chlorpyrifos on a natural system. Entomological Society of America, Miscellaneous Publications, No. 75.

[8] Macek et al. 1972. Toxicity of the insecticide Dursban to fish and aquatic invertebrates in ponds. Trans. Amer. Fish. Soc. 101(3):420-427.

[9] Hurlbert et al. 1970. Biological effects and persistence of Dursban in freshwater pond. J. Econ. Entomol. 63(1): 43-52.

[10] Brock et al. 1992. Fate and effects of the insecticide Dursban 4E in indoor Elodea-dominated and macrophyte free freshwater model ecosystem:II. Secondary effects on community structure. Arch. Environ. Contam. Toxicol. 23: 391-409.

[11] Opinion of the Scientific Committee on Toxicity, Ecotoxicity and the Environment (SCTEE) on "The Setting of Environmental Quality Standards for the Priority Substances included in Annex X of Directive 2000/60/EC in Accordance with Article 16 thereof", adopted by the CSTEE during the 43rd plenary meeting of 28 May 2004, European Commission Health & Consumer Protection Directorate General, Brussels. http://europa.eu.int/comm/health/ph_risk/committees/sct/documents/out230_en.pdf

[12] ESIS: European Chemicals Bureau – ESIS (European Substances Information System), January 2005. http://ecb.jrc.it/existing-chemicals/ ⇒ tick ESIS button, then enter CAS or EINECS number of substance.

ANNEX 1: Aquatic toxicity data of chlorpyrifos (from Annex B.8 of [1])

Table 8.2.1.1 : Summary of acute toxicity on fish.

Species	**Substance**	**Value observed: µg a.i./l (95%CL)**	**Reference**
Onchorhynchus mykiss	Active substance	25 (20-32)	Bowman, H.J., 37188, 9/28/88 (IIA, 8.2.1/02)
Rutilus rutilus	Active substance	250 (170-360)	Douglas, M.T. and Bell, I.B., GHE-T-204, 7/11/85 (IIA, 8.2.1/03)
Leuciscus idus	Active substance	10 (7.4-14)	Douglas, M.T. and Bell, I.B., GHE-T-203, 7/10/85 (IIA, 8.2.1/04)
Cyprinodon variegates	Active substance	>76	Surprenant, D.C., 89-1-2909, 9/29/89 (IIA, 8.2.1/07)
Opsanus beta *Cyprinodon variegatus* *Menidia mendina* *M.peninsulae* *M.beryllina* *Leuresthes tenius*	Active substance	520 (-) 136 (-) 1.7 (-) 1.3 (-) 4.2 (-) 1.3 (-)	Clark, J.R., *et al*. Ecotox. and Environ. Safety 10, 382-390 (1985), (IIA, 8.2.1/06)
O*nchorhynchus mykiss* *Lepomis macrochirus* *Ictalurus punctatus*	Formulated	3.0 (-) 3.3 (-) 13.4 (-)	Alexander , H.C. and Batchelder, T.L., Presentation, 4/14/66 (IIA, 8.2.1/01)
Oncorhynchus mykiss	Formulated	18 (12-25)	Bell, G. *et al*., DWC 721(c)/950721, 8/2/95 (IIIA, 10.2.1.1)
Oncorhynchus mykiss	Formulated	43.5 (25.8 -)	van der Kolk, J., 96-117-1020, 2/19/96 (IIIA, 10.2.1/01)
Oncorhynchus mykiss *Pimephales promelas*	Formulated	8 (6.8-9.4) 203 (191-217)	Holcombe, G.W. *et al.*, 82101.WP, 1982 (IIA, 8.2.1/01)
Anguilla anguilla	Formulated	0.54 (0.42-0.65)	Ferrando, M.D. *et al*., 1991 (IIA, 8.3.4/01)
Pimephales promelas	Act. subst. Formulated	140 (120-160) 120 (110-130)	Jarvinen, A.W. & Tanner, D.K., CPFL 30, 1982 (IIA, 8.2.2/01)

Table 8.2.2-1: Summary of chronic toxicity data for fish.

Species	**Response Variable**	**Toxicity Measure**	**Value Observed (ppb)**	**References**
Pimephales promelas	Mortality	NOEC	0.568	Mayes, M.A., *et al*., DECO-ES-2557b, 6/16/93 (IIA, 8.2.2.1/01)
Pimephales promelas	Mortality	NOEC	1.6	Jarvinen, A.W. and Tanner, D.K., 82201, 1982 (IIA, 8.2.2/01)
Leuresthes tenuis	Embryo mortality Mortality	NOEC NOEC	0.14 0.28	Goodman L.R. *et al*., 82202.WP, 1985 (IIA, 8.2.2/02)
M. beryllina *M. menidia* *M. peninsulae*	Mortality	NOEC	0.75 0.28 0.38	Goodman L.R. *et al*., CPFL 33, 1985 (IIA, 8.2.3/02)
Onchorhynchus mykiss	Mortality, growth, behaviour, colour, feeding and loss of equilibrium	NOEC	0.51	Adema, D.M.M., R 89/415, 2/8/90 (IIA, 8.2.2.2/02)

Species	**Response Variable**	**Toxicity Measure**	**Value Observed (ppb)**	**References**
Pimephales promelas	Growth	NOEC	3.02	Norberg-King, T.J. Environ. Toxicol. and Chem. 8, 1075-1089. 1989 (IIA 8.2.1/01).
Pimephales promelas	Deformities Reduction growth	NOEC NOEC	1.29 7.08	Jarvinen, A.W., *et al*. Ecotox. and Environ. Safety 15, 78-95, 1988 (IIA, 8.2.2.1/02)
Pimephales promelas	Reproduction Growth (2nd generation)	NOEC	0.27 <0.12	Jarvinen, A.W., *et al*. Ecotox. and Environ. Safety 7, 423-434, 1983 (IIA, 8.2.2.2/01)
Tilapia mossambica	feeding rate and yield of hatchlings	NOEC	5	Mani, V.G.T. and Konar, S.K. Environ. And Ecology, vol. 4, nº4, 517-520. 1986, (IIA 8.2.2.1/02).

Table 8.2.4.1 : Summary of Acute Toxicity of chlorpyrifos to aquatic invertebrates

Species	**Substance**	**Toxicity Measure**	**alue observed: a.i./l (95%CL)**	**Reference**
Daphnia magna	Active substance	48h LC_{50}	1.7 (1.0-2.0)	McCarty, W.M., ES-164, 10/24/77 (IIA, 8.2.4/01)
Daphnia magna	Active substance	48h LC_{50}	0.1 (0.09-0.12)	Burgess, D., 37190, 9/28/88 (IIA, 8.2.4/02)
Daphnia magna	Formulated	48h LC_{50}	0.032 (0.025-0.041)	Douglas, M.T., DWC 653(a)/931708, 6/29/93 (IIIA, 10.2.2/02)
Daphnia magna	Formulated	48h LC_{50}	0.26 (0.23-0.30)	Bell, G. *et al*., DWC 721(b)/950720, 8/24/95 (IIIA, 10.2.1.2)
Daphnia magna	Formulated	48h LC_{50}	0.314 (0.213-0.462)	Van der Kolk, J., 96-118-1020, 2/14/96 (IIIA, 10.2.2/01)

Table 8.2.5-1: Chronic toxicity of chlorpyrifos to the aquatic invertebrates

Species	**Response Variable**	**Toxicity Measure**	**Value Observed (µg/l)**	**Reference**
Mysidopsis bahia	Survival of First Generation	NOEC	0.0046	Sved, D. *et al*, 103ª-103C, 1/29/93 (IIA, 8.2.5/01)
Daphnia magna	Mortality or Reproduction	NOEC	0.056	Adema D.M.M. and De Ruiter A., R89/231, 1/30/90 (IIA, 8.2.5/02)

Table 8.2.6.1: Acute Toxicity of Chlorpyrifos to Alga

Substance	**Toxicity Measure**	**Value observed: µg/l (95%CL)**	**Reference**
Active substance	NOEC 48 h EC_{50}	100 1200	Walsh, G.E., 1983 (IIA, 8.2.7/01)
Active substance	NOEC	1.2	Brown, J.R., *et al*. (1976). Bull. Environ. Contam. Toxicol. 15 (4):437-441 (IIA 8.2.7/01)
Formulate	NOEC 96 h EC_{50}	43 480	Douglas, M.T., *et al*, DWC 538/891942, 3/2/90 (IIA, 8.2.6/01)
Formulate	NOEC 72 h EC_{50}	2200 3400	Bell, G., DWC 693/941028, 7/29/94 (IIIA, 10.2.3)
Formulate	NOEC 72 h EC_{50}	27 46	Bell, G. *et al*., DWC 721(a)950719, 11/10/95 (IIIA, 10.2.1.3)
Formulate	NOEC 72 h EC_{50}	63 1360	van der Kolk, J., 96-119-1020, 2/19/96 (IIIA, 10.2.5/01)