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Environmental risk limits for esfenvalerate

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Rapport in het kort

Environmental risk limits for esfenvalerate

Dit rapport geeft milieurisicogrenzen voor het insecticide esfenvaleraat in water en sediment. Milieurisicogrenzen zijn de technisch-wetenschappelijke advieswaarden voor de uiteindelijke milieukwaliteitsnormen in Nederland. De milieurisicogrenzen zijn afgeleid volgens de methodiek die is voorgeschreven in de Europese Kaderrichtlijn Water. Hierbij is gebruikgemaakt van de beoordeling in het kader van de Europese toelating van gewasbeschermingsmiddelen (Richtlijn 91/414/EEG), aangevuld met gegevens uit de openbare literatuur.

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1 Introduction

1.1 Background and scope of the report

In this report, environmental risk limits (ERLs) for surface water and sediment are derived for esfenvalerate. The derivation is performed within the framework of the project 'Standard setting for other relevant substances within the WFD', which is closely related to the project 'International and national environmental quality standards for substances in the Netherlands' (INS). Esfenvalerate is part of a series of 25 pesticides that appeared to have a high environmental impact in the evaluation of the policy document on sustainable crop protection ('Tussenevaluatie van de nota Duurzame Gewasbescherming'; MNP, 2006) and/or were selected by the Water Boards ('Unie van Waterschappen'; project 'Schone Bronnen'; http://www.schonebronnen.nl/).

The following ERLs are considered:

- Maximum Permissible Concentration (MPC) – the concentration protecting aquatic ecosystems and humans from effects due to long-term exposure.
- Maximum Acceptable Concentration (MAC_{eco}) – the concentration protecting aquatic ecosystems from effects due to short-term exposure or concentration peaks.
- Serious Risk Concentration (SRC_{eco}) – the concentration at which possibly serious ecotoxicological effects are to be expected.

More specific, the following ERLs can be derived depending on the availability of data and characteristics of the compound:

$MPC_{eco, water}$	MPC for freshwater based on ecotoxicological data (direct exposure)
$MPC_{sp, water}$	MPC for freshwater based on secondary poisoning
$MPC_{hh\ food, water}$	MPC for fresh and marine water based on human consumption of fishery products
$MPC_{dw, water}$	MPC for surface waters intended for the abstraction of drinking water
$MAC_{eco, water}$	MAC for freshwater based on ecotoxicological data (direct exposure)
$SRC_{eco, water}$	SRC for freshwater based on ecotoxicological data (direct exposure)
$MPC_{eco, marine}$	MPC for marine water based on ecotoxicological data (direct exposure)
$MPC_{sp, marine}$	MPC for marine water based on secondary poisoning
$MAC_{eco, marine}$	MAC for marine water based on ecotoxicological data (direct exposure)

1.2 Status of the results

The results presented in this report have been discussed by the members of the scientific advisory group for the INS-project (WK-INS). It should be noted that the Environmental Risk Limits (ERLs) in this report are scientifically derived values, based on (eco)toxicological, fate and physico-chemical data. They serve as advisory values for the Dutch Steering Committee for Substances, which is appointed to set the Environmental Quality Standards (EQSs). ERLs should thus be considered as proposed values that do not have any official status.

2 Methods

The methodology for the derivation of ERLs is described in detail by Van Vlaardingen and Verbruggen (2007), further referred to as the 'INS-Guidance'. This guidance is in accordance with the guidance of the Fraunhofer Institute (FHI; Lepper, 2005).

The process of ERL-derivation contains the following steps: data collection, data evaluation and selection, and derivation of the ERLs on the basis of the selected data.

2.1 Data collection

In accordance with the WFD, data of existing evaluations were used as a starting point. For esfenvalerate, the evaluation report prepared within the framework of EU Directive 91/414/EC (Draft Assessment Report, DAR) was consulted (European Commission, 1996; further referred to as DAR) as well as the review report of 2005 (EC, 2005). An on-line literature search for esfenvalerate and fenvalerate (see 2.2.2) was performed on TOXLINE (literature from 1985 to 2001) and Current Contents (literature from 1997 to 2007). In addition to this, all potentially relevant references in the RIVM e-tox base and EPA's ECOTOX database were checked.

2.2 Data evaluation and selection

For substance identification, physico-chemical properties and environmental behaviour, information from the List of Endpoints of the DAR was used. When needed, additional information was included according to the methods as described in Section 2.1 of the INS-Guidance. Information on human toxicological threshold limits and classification was also primarily taken from the DAR.

2.2.1 Evaluation of reliability

Ecotoxicity studies (including bird and mammal studies) were screened for relevant endpoints (i.e. those endpoints that have consequences at the population level of the test species). All ecotoxicity and bioaccumulation tests were then thoroughly evaluated with respect to the validity (scientific reliability) of the study. A detailed description of the evaluation procedure is given in the INS-Guidance (see Section 2.2.2 and 2.3.2). In short, the following reliability indices were assigned:

- Ri 1: Reliable without restriction
  'Studies or data … generated according to generally valid and/or internationally accepted testing guidelines (preferably performed according to GLP) or in which the test parameters documented are based on a specific (national) testing guideline … or in which all parameters described are closely related/comparable to a guideline method.'
- Ri 2: Reliable with restrictions
  'Studies or data … (mostly not performed according to GLP), in which the test parameters documented do not totally comply with the specific testing guideline, but are sufficient to accept the data or in which investigations are described which cannot be subsumed under a testing guideline, but which are nevertheless well documented and scientifically acceptable.'
- Ri 3: Not reliable
  'Studies or data … in which there are interferences between the measuring system and the test

substance or in which organisms/test systems were used which are not relevant in relation to the exposure (e.g., unphysiologic pathways of application) or which were carried out or generated according to a method which is not acceptable, the documentation of which is not sufficient for an assessment and which is not convincing for an expert judgment.'

- Ri 4: Not assignable
  'Studies or data … which do not give sufficient experimental details and which are only listed in short abstracts or secondary literature (books, reviews, etc.).'

All available studies were summarised in data-tables, that are included as Appendices to this report. These tables contain information on species characteristics, test conditions and endpoints. Explanatory notes are included with respect to the assignment of the reliability indices.

With respect to the DAR, it was chosen not to re-evaluate the underlying studies. In principle, the endpoints that were accepted in the DAR were also accepted for ERL-derivation with Ri 2, except in cases where the reported information was too poor to decide on the reliability or when there was reasonable doubt on the validity of the tests. This applies especially to DARs prepared in the early 1990s, which do not always meet the current standards of evaluation and reporting.

In some cases, the characteristics of a compound (i.e. fast hydrolysis, strong sorption, low water solubility) put special demands on the way toxicity tests are performed. This implies that in some cases endpoints were not considered reliable, although the test was performed and documented according to accepted guidelines. If specific choices were made for assigning reliability indices, these are outlined in Section 3.3 of this report.

Endpoints with Ri 1 or 2 are accepted as valid, but this does not automatically mean that the endpoint is selected for the derivation of ERLs. The validity scores are assigned on the basis of scientific reliability, but valid endpoints may not be relevant for the purpose of ERL-derivation (e.g. due to inappropriate exposure times or test conditions that are not relevant for the Dutch situation).

2.2.2 Data selection

After data collection and validation, toxicity data were combined into an aggregated data table with one effect value per species according to Section 2.2.6 of the INS-Guidance. When for a species several effect data were available, the geometric mean of multiple values for the same endpoint was calculated where possible. Subsequently, when several endpoints were available for one species, the lowest of these endpoints (per species) is reported in the aggregated data table.

Esfenvalerate is one of the four stereoisomers of fenvalerate. Fenvalerate is a mixture of:

(αS,2S)fenvalerate = esfenvalerate = (S)-α-cyano-3-phenoxybenzyl-(S)-2-(4-chlorophenyl)-3-methylbutyrate,
(αR,2S)fenvalerate = (R)-α-cyano-3-phenoxybenzyl-(S)-2-(4-chlorophenyl)-3-methylbutyrate,
(αS,2R)fenvalerate = (S)-α-cyano-3-phenoxybenzyl-(R)-2-(4-chlorophenyl)-3-methylbutyrate and
(αR,2R)fenvalerate = (R)-α-cyano-3-phenoxybenzyl-(R)-2-(4-chlorophenyl)-3-methylbutyrate.

Only the first isomer is named esfenvalerate. In organic solvents and also in water under certain conditions racemisation at the α site of the molecule can take place.

Although data from both esfenvalerate and fenvalerate were collected and studied, only data on esfenvalerate have been selected for the following reasons:

- the actual active substance in pesticides registered in The Netherlands is esfenvalerate; therefore ERLs based on esfenvalerate should be derived;
- the DAR is almost completely based on esfenvalerate;

- it has been shown that esfenvalerate is much more toxic to fish (one of the most sensitive taxa) than the other stereoisomers.Bradbury et al. (1987) showed that (αS,2R)fenvalerate and (αR,2R)fenvalerate are not toxic to fish and that the (αR,2S)isomer after i.p. injection of fish (which excludes racemisation in the water phase) is less toxic than esfenvalerate. Esfenvalerate was about 5 times more toxic to *Lepomis macrochirus* than fenvalerate (the mixture of all isomers).
- Holdway et al. (1994) supposed that the toxicity of esfenvalerate to the fish *Melanotaenia fluviatilis* may be reduced by the 2R isomers.

Toxicity data of esfenvalerate to birds were lacking. In this exceptional case data for fenvalerate were used. The fact that fenvalerate data were used for birds is a worst case situation, since Table 7 shows that birds are more sensitive to fenvalerate than mammals to esfenvalerate.

2.3 Derivation of ERLs

For a detailed description of the procedure for derivation of the ERLs, reference is made to the INS-Guidance. With respect to the selection of the final MPC_{water} an additional comment should be made:

2.3.1 Drinking water

The INS-Guidance includes the MPC for surface waters intended for the abstraction of drinking water ($MPC_{dw, water}$) as one of the MPCs from which the lowest value should be selected as the general MPC_{water} (see INS-Guidance, Section 3.1.6 and 3.1.7). According to the proposal for the daughter directive Priority Substances, however, the derivation of the AA-EQS (= MPC) should be based on direct exposure, secondary poisoning, and human exposure due to the consumption of fish. Drinking water was not included in the proposal and is thus not guiding for the general MPC value. The exact way of implementation of the $MPC_{dw, water}$ in the Netherlands is at present under discussion within the framework of the "AMvB Kwaliteitseisen en Monitoring Water". No policy decision has been taken yet, and the $MPC_{dw, water}$ is therefore presented as a separate value in this report. The MPC_{water} is thus derived considering the individual MPCs based on direct exposure ($MPC_{eco, water}$), secondary poisoning ($MPC_{sp, water}$) or human consumption of fishery products ($MPC_{hh\ food, water}$); the need for derivation of the latter two is dependent on the characteristics of the compound.

Related to this is the inclusion of water treatment for the derivation of the $MPC_{dw, water}$. According to the INS-Guidance, Section 3.1.7, a substance specific removal efficiency related to simple water treatment should be derived in case the $MPC_{dw, water}$ is lower than the other MPCs. For pesticides, there is no agreement as yet on how the removal fraction should be calculated, and water treatment is therefore not taken into account. In case no A1 value is set in Directive 75/440/EEC, the $MPC_{dw, water}$ is set to the general Drinking Water Standard of 0.1 µg/L for organic pesticides as specified in Directive 98/83/EC.

3 Derivation of environmental risk limits for esfenvalerate

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

3.1.1 Identity

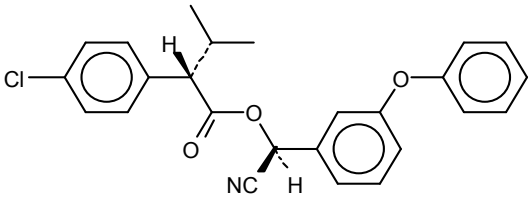

Figure 1. Structural formula of esfenvalerate.

Table 1. Identification of esfenvalerate.

Parameter	Name or number	Source
Common/trivial/other name	Esfenvalerate	EC, 2005
Chemical name	(S)-α-Cyano-3-phenoxybenzyl-(S)-2-(4-chlorophenyl)-3-methylbutyrate	EC, 2005
CAS number	66230-04-4	EC, 2005
EC number	-	
SMILES code	c1cc(Cl)ccc1C(C(C)C)C(=O)OC(C#N)c2cccc(Oc3ccccc3)c2	U.S. EPA, 2007
Use class	Insecticide	Tomlin, 2002
Mode of action	Pyrethroid; interaction with pre-synaptic sodium channels	Tomlin, 2002
Authorised in NL	Yes	
Annex 1 listing	Yes	

3.1.2 Physico-chemical properties

Table 2. Physico-chemical properties of esfenvalerate.

Parameter	Unit	Value	Remark	Reference
Molecular mass	[g/mol]	419.9		EC, 2005
Water solubility	[g/L]	$< 10^{-6}$ (< 1 µg/L)	pH 5.3, 20 ºC	EC, 2005
		2×10^{-6} (2 µg/L)	selected value	Tomlin, 2002; Mackay et al., 2006
		2.6×10^{-6} (2.6 µg/L)	calculated[a]	U.S. EPA, 2000
pK_a	[-]	n.a.		EC, 2005
log K_{OW}	[-]	6.24	25 ºC (selected)	EC, 2005
		6.65	MlogP	BioByte, 2006
log K_{OC}	[-]	5.8		EC, 2005
Vapour pressure	[Pa]	1.17×10^{-9}	20 ºC	EC, 2005
Melting point	[°C]	59.1-60.1		EC, 2005
Boiling point	[°C]	> 360		EC, 2005
Henry's law constant	[Pa.m^3/mol]	4.92×10^{-4}		EC, 2005

n.a. = not applicable
[a] Calculated using log K_{ow} = 6.65 (MlogP value)

3.1.3 Behaviour in the environment

Table 3. Selected environmental properties of esfenvalerate.

Parameter	Unit	Value	Remark	Reference
Hydrolysis half-life	DT50 [d]	129	pH 5; at pH 7 limited hydrolysis	EC, 2005
Photolysis half-life	DT50 [d]	6	Artificial sunlight	EC, 2005
Readily biodegradable		No		EC, 2005
Degradation in water/sediment systems	DT50 [d]	54-80	system	EC, 2005
Relevant metabolites	2-(4-Chlorophenyl)-3-methyl-butyric acid		44-48% after 100 d	EC, 2005
	α-Cyano-3-phenoxybenzyl alcohol		2-13% after 30 d	

3.1.4 Bioconcentration and biomagnification

An overview of the bioaccumulation data for esfenvalerate is given in Table 4. Detailed bioaccumulation data for esfenvalerate are tabulated in Appendix 1.

Table 4. Overview of bioaccumulation data for esfenvalerate.

Parameter	Unit	Value	Remark	Reference
BCF (fish)	[L/kg]	3369	Geometric mean of 2 values	EC, 2005
BMF	[kg/kg]	2	Default value for BCF 2000-5000 L/kg	Van Vlaardingen en Verbruggen (2007)

3.1.5 Human toxicological threshold limits and carcinogenicity

Esfenvalerate has the following R phrases: R23/25, R43, R50/53 (European Chemicals Bureau; date of search 2008). The ADI is 0.02 mg/kg bw. The AOEL systemic is 0.018 mg/kg bw/day. Esfenvalerate is not a known or suspected carcinogen, mutagen or a substance known or suspected to affect reproduction (EC, 1996).

3.2 Trigger values

This section reports on the trigger values for ERLwater derivation (as demanded in WFD framework).

Table 5. Esfenvalerate: collected properties for comparison to MPC triggers.

Parameter	Value	Unit	Method/Source	Derived at section
Log $K_{p,susp\text{-}water}$	4.8	[-]	$K_{OC} \times f_{OC,susp}$ [1]	K_{OC}: 3.1.2
BCF	3369	[L/kg]		3.1.4
BMF	2	[kg/kg]		3.1.4
Log K_{OW}	6.24	[-]		3.1.2
R-phrases	R 23/25, 43, 50/53	[-]		3.1.5
A1 value	1.0	[µg/L]	Total pesticides	
DW Standard	0.1	[µg/L]	General value for organic pesticides	

[1] $f_{OC,susp}$ = 0.1 kg_{OC}/kg_{solid} (EC, 2003).

- Esfenvalerate has a log $K_{p,\ susp\text{-}water} \geq 3$; derivation of $MPC_{sediment}$ is triggered.
- Esfenvalerate has a log $K_{p,\ susp\text{-}water} \geq 3$; expression of the MPC_{water} as $MPC_{susp,\ water}$ is required.
- Esfenvalerate has a BCF $\geq$ 100 L/kg; assessment of secondary poisoning is triggered.
- Esfenvalerate has an R23/25, R43, R50/53 classification. Therefore, an MPC_{water} for human health via food (fish) consumption ($MPC_{hh\ food\ ,\ water}$) is required, based on R23/25 and potential for bioaccumulation.
- For esfenvalerate, no specific A1 value or Drinking Water Standard is available from Council Directives 75/440, EEC and 98/83/EC, respectively. Therefore, the general Drinking Water Standard for organic pesticides applies.

3.3 Toxicity data and derivation of ERLs for water

3.3.1 $MPC_{eco, water}$ and $MPC_{eco, marine}$

An overview of the selected freshwater toxicity data for esfenvalerate is given in Table 6. Detailed aquatic toxicity data for esfenvalerate are tabulated in Appendix 2.

Because of the high log K_{ow} and the low aqueous solubility of esfenvalerate, studies in which actual concentrations were not analysed, were given a validity of 3. All static tests were also given a validity of 3, with the exception of:

- Tests with algae and acute tests with *Daphnia* (because no flow-through experiments can be carried out with these organisms);
- Experiments where a mean measured concentration over the test period could be calculated;
- Pulse experiments with a deliberate short-term exposure.

Table 6. Esfenvalerate: selected freshwater data for ERL derivation.

Chronic[a]		**Acute**[a]	
Taxonomic group	**NOEC/EC10 (µg/L)**	**Taxonomic group**	**L(E)C50 (µg/L)**
Algae	1.58[b]	Algae	>2 (above solubility)[f]
Crustacea	0.01[c]	Crustacea	3.4
Crustacea	0.055[d]	Crustacea	0.135[g]
Pisces	**0.001**	Insecta	**0.085**[h]
Pisces	0.01[e]	Pisces	0.21
Pisces	0.09	Pisces	1.07[i]
		Pisces	0.1
		Pisces	0.9
		Pisces	0.18

[a] For detailed information see Appendix 2. Bold values are used for ERL derivation.
[b] Geometric mean of 1.0 and 2.5 µg/L for *Pseudokirchneriella subcapitata* (growth rate).
[c] Lowest endpoint of *Daphnia carinata.*
[d] Geometric mean of 0.052, 0.056 and 0.056 µg/L for *Daphnia magna* (reproduction).
[e] Most sensitive test duration of *Lepomis macrochirus.*
[f] This figure is presented to show that algae are insensitive. It is not used in calculations.
[g] Geometric mean of 0.132 and 0.138 µg/L for *Gammarus pulex* (mortality).
[h] *Chironomus riparius*. First instar larvae are the most sensitive larval stage.
[i] 3-4 day old larvae of *Melanotaenia fluviatilis* are the most sensitive stage (mortality).

3.3.1.1 Treatment of fresh- and saltwater toxicity data

ERLs for freshwater and marine waters should be derived separately. For pesticides, data can only be combined if it is possible to determine with high probability that marine organisms are not more sensitive than freshwater organisms (Lepper, 2005). For esfenvalerate, no marine toxicity data are available and ERLs for the marine compartment cannot be derived.

3.3.1.2 Mesocosm and field studies

For esfenvalerate 8 field studies were available (see Appendix 3). Since esfenvalerate disappears from the water column in a relatively short time period (in general < 24 h), studies with single or repeated applications cannot be used for the derivation of an $MPC_{eco, water}$. The studies can be used for derivation of an $MAC_{eco, water}$. Most studies were assessed not reliable, mainly because the concentration of esfenvalerate is not measured after application. In the two studies that are assigned an Ri 2 (Lozano et al., 1992 and Fairchild et al., 1992), the NOEC is < 0.01 µg/L and < 0.31 µg/L, respectively. In the study of Lozano et al. (1992) effects > 50% were found at 0.01 µg/L on individual sampling dates, but for a number of sensitive endpoints, and for this reason the effects are deemed ecologically relevant, and the overall endpoint is < 0.01 µg/L. This endpoint, however, cannot be used for ERL derivation because it is a "lower than" value.

3.3.1.3 Derivation of $MPC_{eco, water}$ and $MPC_{eco, marine}$

The base-set for freshwater toxicity data is complete. Chronic NOECs are available for algae, crustaceans and fish. The lowest NOEC is 0.001 µg/L for fish (*Oncorhynchus mykiss*). Thus, with three NOECs, an assessment factor of 10 can be used on the lowest NOEC, which results in an $MPC_{eco, water}$ of 0.001 / 10 = 1.0×10^{-4} µg/L (0.1 ng/L).

For the marine environment no data are available; therefore an $MPC_{eco, marine}$ is not derived.

3.3.2 $MPC_{sp, water}$ and $MPC_{sp, marine}$

Esfenvalerate has a BCF ≥ 100 L/kg, thus assessment of secondary poisoning is triggered.

The lowest MPC_{oral} is 1.83 mg/kg diet for ducks (see Table 7). Subsequently, the $MPC_{sp, water}$ can be calculated using a BCF of 3369 L/kg and a BMF of 2 (Table 5) and becomes 1.83 / (3369 × 2) = 2.72×10^{-4} mg/L = 0.272 µg/L.

Table 7. Esfenvalerate: selected bird and mammal data for ERL derivation

Species[a]	Exposure time	Criterion	Effect concentration (mg/kg diet)	Assessment factor	MPC_{oral} (mg/kg diet)
Mallard duck	5 d	LC50	5502	3000	**1.83**
Rat	90 d	NOAEL	300	90	3.33
Rat	9 month	NOAEL [b]	75	30	2.5

[a] For detailed information see Appendix 4. Bold values are used for ERL derivation.
[b] Multigeneration reproduction study.

The $MPC_{sp, marine}$ can be calculated with an extra biomagnification factor and becomes: 1.83 / (3369 × 2 × 2) = 1.36×10^{-4} mg/L = 0.136 µg/L.

3.3.3 $MPC_{hh\ food, water}$

Derivation of the $MPC_{hh\ food, water}$ for esfenvalerate is triggered (Table 5). $MPC_{hh, food}$ is calculated from the ADI (0.02 mg/kg bw), a body weight of 70 kg and a daily fish consumption of 115 g as $MPC_{hh, food}$ = 0.1 x 0.02 x 70 / 0.115 = 1.217 mg/kg (Van Vlaardingen en Verbruggen, 2007). Subsequently the $MPC_{hh\ food, water}$ is calculated according to $MPC_{hh\ food, water} = 1.217 / (BCF_{fish} \times BMF_1) = 1.217 / (3369 \times 2) = 0.000181$ mg/L = 0.181 µg/L.

3.3.4 $MPC_{dw, water}$

The Drinking Water Standard is 0.1 µg/L. Thus, the $MPC_{dw, water}$ is 0.1 µg/L.

3.3.5 Selection of the MPC_{water} and MPC_{marine}

In the Fraunhofer document (Lepper, 2005) it is prescribed that the lowest MPC value should be selected as the general MPC. The lowest value of the routes included (see section 2.3.1) is the ecotoxicological MPC for freshwater. Therefore, the MPC_{water} is 0.0001 µg/L (0.1 ng/L).

Because the log $K_{p, susp\text{-}water} \geq 3$ (Table 5), the final MPC_{water} has to be recalculated in an $MPC_{susp, water}$, which refers to the concentration in suspended matter. The $MPC_{susp, water}$ is calculated according to:

$MPC_{susp, water} = MPC_{water, total} / ((C_{susp, Dutch\ standard} \times 10^{-6}) + (1/ K_{p, susp\text{-}water}))$,
where $C_{susp, Dutch\ standard}$ is the concentration of suspended particulate matter in freshwater.

For this calculation $K_{p, susp\text{-}water}$ is calculated using K_{OC} and the $f_{OC, susp\ dutch\ standard}$. This is not the same as the European standard $f_{OC, susp}$ which is used in the table with trigger values. With an $f_{OC, susp\ dutch\ standard}$ of 0.1176 and a log K_{OC} of 5.8, $K_{p, susp\text{-}water}$ can be calculated to be 74230 L/kg.
This results in an $MPC_{susp, water}$ of $0.0001 / (30 \times 10^{-6} + (1 / 74230)) = 2.30$ µg/kg_{dw}.

3.3.6 MAC_{eco}

3.3.6.1 $MAC_{eco, water}$

The $MAC_{eco\ , water}$ may be derived from the acute toxicity data. Short-term toxicity values for two trophic levels (fish, *Daphnia*, Insecta) are available. Because algae are insensitive for esfenvalerate, actually data for three trophic levels are available and the base set is considered to be complete. Esfenvalerate has a potential to bioaccumulate (BCF $\geq$ 100 L/kg), the mode of action for the tested species is specific and the potentially most sensitive species group (insects) is included in the data set. Therefore, an assessment factor of 100 is applied to the lowest $L(E)C_{50}$, i.e. the EC_{50} for *Chironomus riparius*: 0.085 µg/L. Therefore, the $MAC_{eco, water}$ is derived as 0.085 / 100 = 0.00085 µg/L (0.85 ng/L).

3.3.6.2 $MAC_{eco, marine}$

No data are available on the toxicity of esfenvalerate for marine organisms. Therefore, no $MAC_{eco, marine}$ can be derived.

3.3.7 $SRC_{eco, water}$

Since three long-term NOECs of all required trophic levels are available, the $SRC_{eco, water}$ is derived from the geometric mean of all available NOECs with an assessment factor 1. The geometric mean is 0.0304 µg/L. Therefore, the $SRC_{eco, water}$ is derived as 0.0304 / 1 = 0.0304 µg/L.

3.4 Toxicity data and derivation of ERLs for sediment

3.4.1 Sediment toxicity data

An overview of the selected freshwater sediment toxicity data for esfenvalerate is given in Table 8. Detailed toxicity data for esfenvalerate are tabulated in Appendix 5. Additional information on fenvalerate is not taken into account because this will most likely result in an underestimation of toxicity (see Section 2.2.2)

Table 8. Esfenvalerate: selected freshwater sediment data for ERL derivation.

Chronic[a]		**Acute**[a]	
Taxonomic group	**NOEC/EC10 (µg/kg$_{dw}$)**	**Taxonomic group**	**L(E)C50 (µg/kg$_{dw}$)**
Crustacea	24.6 [b]	-	-

[a] For detailed information see appendix 5. Bold values are used for risk assessment.
[b] Geometric mean of three equivalent tests with the sediment organism *Hyalella azteca*.

3.4.2 Derivation of MPC$_{sediment}$

3.4.2.1 Freshwater sediment

One long-term NOEC of 24.6 µg/kg is available for sediment organisms. Therefore, the assessment factor is 100. The MPC$_{sediment}$ is derived as 24.6 / 100 = 0.246 µg/kg.

3.4.2.2 Marine sediment

No data are available on the toxicity of esfenvalerate for marine sediment organisms. Therefore, no marine sediment ERLs can be derived.

3.4.3 Derivation of SRC$_{eco, sediment}$

Because there is only one NOEC available for sediment, the SRC$_{eco,\ sediment}$ needs to be derived by applying the equilibrium partitioning method on the SRC$_{eco,water}$ of 0.0304 µg/L

First, the SRC$_{sediment}$ is calculated using TGD default values, and subsequently this SRC$_{sediment}$ is recalculated to Dutch standard sediment.

$$SRC_{sediment,TGD,EqP,ww} = \frac{K_{susp-water}}{RHO_{susp}} \times SRC_{eco,water} \times 1000$$

with $K_{susp\text{-}water}$:

$$K_{susp-water} = F\text{air}_{susp} \times K_{air-water} + F\text{water}_{susp} + F\text{solid}_{susp} \times \frac{K\text{p}_{susp}}{1000} \times RHO\text{solid}$$

Using $K_{p,\ susp}$ = 63096 L/kg (log $K_{p,\ susp}$ = 4.8), $F\text{air}_{susp}$ = 0, $F\text{water}_{susp}$ = 0.9, $F\text{solid}_{susp}$ = 0.1, RHO_{susp} = 1150 kg/m^3, $F\text{solid}_{susp}$ = 0.1, RHO_{solid} = 2500 kg/m^3, the $K_{susp\text{-}water}$ is calculated as 15775, and the SRC$_{sediment,\ TGD,\ EqP,\ ww}$ as 0.417 mg/kg$_{ww}$.

This value is converted to dry weight and subsequently to Dutch standard sediment using the following equations:

$$SRC_{sediment,TGD,EqP,dw} = \frac{RHO_{susp}}{Fsolid_{susp} \times RHOsolid} \times SRC_{sediment,TGD,EqP,ww}$$

$$SRC_{Dutch\ \ standard\ \ sediment,EqP,dw} = \frac{Foc_{Dutch\ \ standard\ \ sediment}}{Foc_{susp,\ TGD}} \times SRC_{sediment,TGD\ EqP,dw}$$

With $Foc_{\text{Dutch standard sediment}} = 0.0588$ and $Foc_{\text{susp,TGD}} = 0.1$, the $SRC_{\text{Dutch standard sediment, EqP, dw}} = 1.13$ mg/kg$_{dw}$. Because the log K_{ow} is > 5 the $SRC_{sediment}$ should be divided by 10, and the final $SRC_{\text{Dutch standard sediment, EqP, dw}}$ is 0.113 mg/kg$_{dw}$ (113 µg/kg$_{dw}$).

The $SRC_{\text{eco, sediment}}$ should also be calculated from the NOEC of 24.6 µg/kg$_{dwt}$ of the sediment dwelling crustacean *Hyalella azteca*. Since one NOEC is available the assessment factor is 1. The $SRC_{\text{eco, sediment}}$ is 24.6 / 1 = 24.6 µg/kg$_{dwt}$. Since the latter value is the lowest, the $SRC_{\text{eco, sediment}}$ is established as 24.6 µg/kg$_{dwt}$.

4 Conclusions

In this report, the risk limits Maximum Permissible Concentration (MPC), Maximum Acceptable Concentration for ecosystems (MAC_{eco}), and Serious Risk Concentration for ecosystems (SRC_{eco}) are derived for esfenvalerate in freshwater and sediment. Derivation of ERLs for the marine compartment was not possible due to lack of data.

The ERLs that were obtained are summarised in the table below. The MPC values that were set for this compound until now, are also presented in this table for comparison reasons. These values refer to an MPC for fenvalerate, expressed on the basis of total content, and an indicative MPC ("ad-hoc MTR") for esfenvalerate.

Table 9. Derived MPC, MAC_{eco} and SRC values for esfenvalerate.

ERL	Unit	MPC	MAC_{eco}	SRC
Water, old	µg/L	4.08[a], 0.00007[b]	-	-
Water, new[c]	µg/L	0.0001	0.00085	0.0304
Suspended matter	$\mu g/kg_{dw}$	2.3		
Drinking water[c]	µg/L	0.1[d]	-	-
Marine	µg/L	n.d.[e]	n.d.[e]	-
Sediment	$\mu g/kg_{dw}$	0.246	n.d.[e]	24.6

[a] MPC for fenvalerate based on total content, source: Risico's van Stoffen http://www.rivm.nl/rvs/

[b] Indicative MPC for esfenvalerate ('ad-hoc MTR'; source Helpdesk Water http://www.helpdeskwater.nl/emissiebeheer/normen_voor_het/zoeksysteem_normen/

[c] The $MPC_{dw, water}$ is reported as a separate value from the other MPC_{water} values ($MPC_{eco, water}$, $MPC_{sp, water}$ or $MPC_{hh\ food, water}$). From these other MPC_{water} values (thus excluding the $MPC_{dw, water}$) the lowest one is selected as the 'overall' MPC_{water}.

[d] provisional value pending the decision on implementation of the $MPC_{dw, water}$ (see Section 2.3.1)

[e] n.d. = not derived due to lack of data.

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Appendix 1. Information on bioconcentration

Species	Species properties	Test substance	Substance purity [%]	A	Test type	Test water	pH	Hardness/ Salinity [g/L]	Exp. time [d]	Temperature [°C]	Exp. conc.	BCF [L/kg$_{ww}$]	BCF type	Method	Ri	Notes	Reference
Cyprinus carpio		[14C-phenoxyphenyl] esfenvalerate	99.9	Y	F				28+14 d	25	0.1 µg/L	3650	Whole fish	Equilibrium	2		DAR, Oshima and Mikami, 1991
Cyprinus carpio		[14C-chlorophenyl] esfenvalerate	>99	Y	F				28+14 d	25	0.1 µg/L	3110	Whole fish	Equilibrium	2		DAR, Oshima and Mikami, 1991
Cyprinus carpio	8-20 g	[14C-CN] esfenvalerate	>99	Y	R				7+ 25 d	24	0.8 µg/L	1245	Whole fish	Equilibrium	3	1	DAR, Ohkawa et al., 1980

1 Period of uptake too short. The concentration was still increasing after the 7 days uptake period. The plateau value was not reached.

Appendix 2. Detailed aquatic toxicity data

Table A2.1. Acute toxicity of esfenvalerate to freshwater organisms.

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
Algae																
Pseudokirchneriella subcapitata		Y	S	Esfenvalerate	97	am		24		48 h	ErC50	Growth rate	> 2	2	1	DAR, Handley et al., 1991g
Pseudokirchneriella subcapitata		Y	S	Esfenvalerate	97	am		24		96 h	EbC50	Biomass (AUG)	6.5	2	2	DAR, Handley et al., 1991g
Pseudokirchneriella subcapitata		Y	S	EC formulation	5	am		24		48 h	ErC50	Growth rate	> 2	2	3	DAR, Handley et al., 1991h
Pseudokirchneriella subcapitata		Y	S	EC formulation	5	am		24		96 h	EbC50	Biomass (AUG)	6.8	2	2	DAR, Handley et al. 1991h
Crustacea																
Ceriodaphnia dubia	6-18 h old	N		Asana XL	8.6			25		48 h	LC50	Mortality	0.28	3	4	Werner et al., 2002a
Ceriodaphnia dubia		Y		Asana XL	8.6					48 h	EC50	Immobilisation	0.215	4	5	Bouldin et al., 2004
Daphnia magna	< 24 h	N		Esfenvalerate	84	tw	7.8	20	280	48 h	LC50	Mortality	0.27	3		Fairchild et al., 1992
Daphnia magna	< 24 h	N		Esfenvalerate	84	tw	7.8	20		48 h	LC50	Mortality	0.89	3	6	Fairchild et al., 1992
Daphnia magna	< 24 h	N		Esfenvalerate	98.6			20		48 h	EC50	Immobilisation	0.9	3	7	DAR, Hutton, 1987a
Daphnia magna	< 24 h	N		Esfenvalerate	98.6			20		48 h	NOEC	Immobilisation	0.11	3	7	DAR, Hutton, 1987a
Daphnia magna	< 24 h	N		Esfenvalerate	98.6			20		48 h	EC50	Immobilisation	3.5	3	8	DAR, Hutton , 1987b
Daphnia magna	< 24 h	N		Esfenvalerate	98.6			20		48 h	NOEC	Immobilisation	0.86	3	8	DAR, Hutton, 1987b
Daphnia magna	< 24 h	Y		EC formulation	5			21		48 h	EC50	Immobilisation	3.4	2	9	DAR, Handley et al., 1991d
Daphnia magna	< 24 h	Y		EC formulation	5			21		48 h	NOEC	Immobilisation	1.6	2	9	DAR, Handley et al., 1991d
Daphnia magna	< 24 h old	N	S	Sumi-Alfa		nw	7.5 ± 0.7	20 ± 3	2.34 ± 0.23	96 h	LC50	Mortality	0.029	3	11	Beketov, 2004
Daphnia pulex	< 24 h old	N	S	Esfenvalerate	94.5		7.49-7.98	20 ± 0.5		48 h	EC50	Immobilisation	0.048	4	12	PSD, 1992
Daphnia pulex	< 24 h old	N	S	Esfenvalerate	94.5		7.49-7.98	20 ± 0.5		48 h	NOEC	Immobilisation	0.018	4	12	PSD, 1992
Gammarus pulex	adult, 7-8 mm length	Y	S	Esfenvalerate	99.9	am		13	250	96 h	LC50	Mortality	0.132	2	13	Cold and Forbes, 2004
Gammarus pulex	adult, 10-14 mm length	Y	S	Esfenvalerate	99.9	am		13	250	96 h	LC50	Mortality	0.138	2	13	Cold and Forbes, 2004
Gammarus pulex	reproductive adults	Y	S	Esfenvalerate	99.9	am		13	250	1 h / 14 d	LC68 (LOEC)	Mortality	0.05	2	14	Cold and Forbes, 2004
Gammarus pulex	offspring	Y	S	Esfenvalerate	99.9	am		13	250	1 h / 14 d	LC65 (LOEC)	Mortality F1	0.05	2	15	Cold and Forbes, 2004
Gammarus pulex	ad, 9-15 mm	Y	S	Esfenvalerate	99.9	am		13	250	1 h / 14 d	LC 9 (LOEC)	Mortality	0.1	2	16	Cold and Forbes, 2004
Gammarus pulex	ad, 9-15 mm	Y	S	Esfenvalerate	99.9	am		13	250	1 h / 14 d	LC11 (LOEC)	Mortality	0.1	2	17	Cold and Forbes, 2004
Gammarus pulex	juv, 3-6 mm	Y	S	Esfenvalerate	99.9	am		13	250	1 h / 13 d	LC76 (LOEC)	Mortality	0.1	2	16	Cold and Forbes, 2004
Gammarus pulex	juv, 3-6 mm	Y	S	Esfenvalerate	99.9	am		13	250	1 h / 13 d	LC86 (LOEC)	Mortality	0.1	2	17	Cold and Forbes, 2004
Gammarus pulex	5 d old, 1-2 mm	Y	S	Esfenvalerate	99.9	am		13	250	1 h / 7 d	LC95 (LOEC)	Mortality	0.05	2	20	Cold and Forbes, 2004
Gammarus pulex	females (see note)	Y	S	Esfenvalerate	99.9	am		13	250	1 h / 13 d	LC10 (LOEC)	Mortality	0.05	2	21	Cold and Forbes, 2004

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
Gammarus pulex	males (see note)	Y	S	Esfenvalerate	99.9	am		13	250	1h / 13 d	LC20 (LOEC)	Mortality	0.1	2	21	Cold and Forbes, 2004
Scapholeberis kingi	1-day old	N	S	EC formulation	20	dw	6.8-8.0	25		3 h	LC50	Mortality	29	3	23	Feei, 1987
Insecta																
Caenis miliaria	larvae	N	S	Sumi-Alfa		nw	7.5 ± 0.7	20 ± 3	2.34 ± 0.23	96 h	LC50	Mortality	0.015	3	24	Beketov, 2004
Chironomus riparius	first instar larvae	Y	S	Esfenvalerate	tg					96 h	LC50	Mortality	0.085	2	25	Samsoe-Petersen et al., 2001
Chironomus riparius	2nd instar larvae	Y	S	Esfenvalerate	tg					96 h	LC50	Mortality	0.13	2	25	Samsoe-Petersen et al., 2001
Chironomus riparius	3rd instar larvae	Y	S	Esfenvalerate	tg					96 h	LC50	Mortality	0.94	2	25	Samsoe-Petersen et al., 2001
Cloeon dipterum	larvae	N	S	Sumi-Alfa		nw	7.5 ± 0.7	20 ± 3	2.34 ± 0.23	96 h	LC50	Mortality	0.01	3	24	Beketov, 2004
Cordulia aenea	larvae	N	S	Sumi-Alfa		nw	7.5 ± 0.7	20 ± 3	2.34 ± 0.23	96 h	LC50	Mortality	0.262	3	24	Beketov, 2004
Cymatia coleoptrata	adults	N	S	Esfenvalerate	tg	nw		25		72 h	EC50	Immobilisation	3.3	3	27	Samsoe-Petersen et al., 2001
Lestes sponsa	larvae	N	S	Sumi-Alfa		nw	7.5 ± 0.7	20 ± 3	2.34 ± 0.23	96 h	LC50	Mortality	0.012	3	24	Beketov, 2004
Pisces																
Cyprinus carpio	2-4 cm	N	R	EC formulation	20	dw	6.8-8.0	25	50-250	96 h	LC50	Mortality	3.1	3	23	Feei, 1987
Cyprinus carpio	juveniles	N	S	Esfenvalerate	94.5		7.7-7.8	25 ± 1		96 h	LC50	Mortality	1.17	4	29	PSD, 1992
Gambusia affinis	2-2.5 cm	N	R	EC formulation	20	dw	6.8-8.0	25	50-250	48 h	LC50	Mortality	3.8	3	23	Feei, 1987
Lepomis macrochirus	av. weight 2.07 g, av. length 5.6 cm	Y	F	Esfenvalerate				25		96 h	LC50	Mortality	0.21	2	31	DAR, Hagino et al., 1985
Lepomis macrochirus	juveniles	N	S	Esfenvalerate						96 h	LC50	Mortality	0.44	3	32	Stay and Jarvinen, 1995
Lepomis macrochirus		N		Esfenvalerate	84		7.8	22	280	96 h	LC50	Mortality	0.31	3		Fairchild et al., 1992
Lepomis macrochirus	juveniles	Y	F	Esfenvalerate	tg			25 ± 1		96 h	LC50	Mortality	0.2	4	33	PSD, 1992
Lepomis macrochirus	juveniles	Y	F	Esfenvalerate	tg			25 ± 1		96 h	NOEC	Mortality	0.14	4	33	PSD, 1992
Melanotaenia fluviatilis	eggs < 24 h post fertilisation	Y	S	Esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	25	1 h	NOEC	Hatching	> 10	3	34	Barry et al., 1995a
Melanotaenia fluviatilis	eggs 1-6 d post fertilisation	Y	S	Esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	25	1 h	NOEC	Hatching	> 10	3	34	Barry et al., 1995a
Melanotaenia fluviatilis	larvae, < 48 h old	Y	S	Esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	LC50	Mortality	2.32	2	35	Barry et al., 1995a
Melanotaenia fluviatilis	larvae, 3-4 days old	Y	S	Esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	LC50	Mortality	1.07	2	35	Barry et al., 1995a
Melanotaenia fluviatilis	larvae, 7-8 days old	Y	S	Esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	LC50	Mortality	28.11	3	37	Barry et al., 1995a
Melanotaenia fluviatilis	larvae, 14-16 days old	Y	S	Esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	LC50	Mortality	33.42	3	37	Barry et al., 1995a
Melanotaenia fluviatilis	larvae, 28-32 days old	Y	S	Esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	LC50	Mortality	48.04	3	37	Barry et al., 1995a
Melanotaenia fluviatilis	85-95 days old	Y	S	Esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	LC50	Mortality	3960	3	37	Barry et al., 1995a
Melanotaenia fluviatilis	adults	Y	R	Emulsified esfenvalerate		tw	7.0 ± 0.2	25 ± 1	20	96 h	LC50	Mortality	6.2	3	41	Holdway et al., 1994
Melanotaenia fluviatilis	<48 h old	Y	F	Esfenvalerate	tg	tw	7.0 ± 0.2	25 ± 1	20	1 h	LC50	Mortality	1.2	2	42	Holdway et al., 1994
Melanotaenia fluviatilis	<48 h old	Y	F	Emulsified esfenvalerate		tw	7.0 ± 0.2	25 ± 1	20	1 h	LC50	Mortality	2	4	43	Holdway et al., 1994
Melanotaenia fluviatilis	<48 h old	Y	F	Emulsified esfenvalerate		tw	7.0 ± 0.2	25 ± 1	20	1 h	NOEC	Mortality	0.1	4	44	Holdway et al., 1994

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
Melanotaenia fluviatilis	<48 h old	Y	F	Emulsified esfenvalerate		tw	7.0 ± 0.2	25 ± 1	20	1 h	LC50	Mortality	3.8	3	45	Holdway et al., 1994
Melanotaenia fluviatilis	<48 h old	Y	F	Emulsified esfenvalerate		tw	7.0 ± 0.2	25 ± 1	20	1 h	LC50	Mortality	4.4	3	46	Holdway et al., 1994
Melanotaenia fluviatilis	eggs, 1 h old	Y	S	Emulsified esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	NOEC	Hatching	≥ 10	3	47	Barry et al., 1995a
Melanotaenia fluviatilis	eggs, 2 h old	Y	S	Emulsified esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	NOEC	Hatching	≥ 10	3	38	Barry et al., 1995a
Melanotaenia fluviatilis	eggs, 4 h old	Y	S	Emulsified esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	NOEC	Hatching	≥ 10	3	38	Barry et al., 1995a
Melanotaenia fluviatilis	eggs, 8 h old	Y	S	Emulsified esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	NOEC	Hatching	≥ 10	3	38	Barry et al., 1995a
Melanotaenia fluviatilis	eggs, 24 h old	Y	S	Emulsified esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	NOEC	Hatching	≥ 10	3	38	Barry et al., 1995a
Melanotaenia fluviatilis	eggs, 3 d old	Y	S	Emulsified esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	NOEC	Hatching	≥ 10	3	38	Barry et al., 1995a
Melanotaenia fluviatilis	eggs, 6 d old	Y	S	Emulsified esfenvalerate		tw	6.8 - 6.9	23.5 - 24.5	20	1 h	NOEC	Hatching	≥ 10	3	38	Barry et al., 1995a
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Mortality	0.06	2	36	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Mortality	≥ 0.32	2	30	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Length	≥ 0.32	2	28	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Dry weight	0.06	2	36	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Dry weight	≥ 0.32	2	30	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	length/weight ratio	0.06	2	36	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	length/weight ratio	≥ 0.32	2	30	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Mortality	< 0.06	2	19	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Length	≥ 0.32	2	19	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Dry weight	≥ 0.32	2	19	Barry et al., 1995c
Melanotaenia fluviatilis	> 48 h old	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	length/weight ratio	≥ 0.32	2	19	Barry et al., 1995c
Melanotaenia fluviatilis	7 d old larvae	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Mortality	≥ 0.32	3	26	Barry et al., 1995c
Melanotaenia fluviatilis	7 d old larvae	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Length	≥ 0.32	3	26	Barry et al., 1995c
Melanotaenia fluviatilis	7 d old larvae	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Dry weight	≥ 0.32	3	26	Barry et al., 1995c
Melanotaenia fluviatilis	7 d old larvae	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	length/weight ratio	≥ 0.32	3	26	Barry et al., 1995c
Melanotaenia fluviatilis	14 d old larvae	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Mortality	0.32	2	18	Barry et al., 1995c
Melanotaenia fluviatilis	14 d old larvae	Y	S	Emulsified		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Mortality	≥ 0.7	2	22	Barry et al., 1995c

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
				esfenvalerate												
Melanotaenia fluviatilis	14 d old larvae	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Length	≥ 0.7	2	61	Barry et al., 1995c
Melanotaenia fluviatilis	14 d old larvae	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	Dry weight	≥ 0.7	2	61	Barry et al., 1995c
Melanotaenia fluviatilis	14 d old larvae	Y	S	Emulsified esfenvalerate		tw	7.2 ± 0.1	24 ± 1.5	20	1 h	NOEC	length/weight ratio	≥ 0.7	2	61	Barry et al., 1995c
Melanotaenia fluviatilis	ad, 2 y ,8 cm females, 10 cm males	Y	S	Emulsified esfenvalerate		tw	6.9 ± 1	25 ± 1.5	20	24 h	NOEC	Ad. male mortality	3.2	2	48	Barry et al., 1995d
Melanotaenia fluviatilis	ad, 2 y, 8 cm females, 10 cm males	Y	S	Emulsified esfenvalerate		tw	6.9 ± 1	25 ± 1.5	20	24 h	NOEC	Hatching	< 1	2	49	Barry et al., 1995d
Melanotaenia fluviatilis	ad, 2 y, 8 cm females, 10 cm males	Y	S	Emulsified esfenvalerate		tw	6.9 ± 1	25 ± 1.5	20	24 h	NOEC	Hatchability	10	3	48	Barry et al., 1995d
Melanotaenia fluviatilis	ad, 2 y, 8 cm females	Y	S	Emulsified esfenvalerate		tw	6.9 ± 1	24 ± 1	20	24 h	NOEC	Larval mortality	≥ 32	3	51	Barry et al., 1995d
Melanotaenia fluviatilis	ad, 2 y, 8 cm females	Y	S	Emulsified esfenvalerate		tw	6.9 ± 1	24 ± 1	20	24 h	NOEC	Larval length	≥ 32	3	52	Barry et al., 1995d
Morone saxatilis	81 d old; 5.3-8.0 cm long		S	Esfenvalerate		nw	7.8	20	200	24 h	LC50	Mortality	2.17	3	53	Geist et al., 2007
Oncorhynchus mykiss	av. weight 0.56 g, av. length 4.1 cm	N	S	Esfenvalerate	98.8			12		96 h	LC50	Mortality	0.26	3		DAR, Forbes et al., 1985
Oncorhynchus mykiss	av. weight 0.56 g, av. length 4.1 cm	N	S	Esfenvalerate	98.8			12		96 h	NOEC	Mortality	0.1	3		DAR, Forbes et al., 1985
Oncorhynchus mykiss	av. weight 0.9 g, av. length 4.1 cm	Y	F	Esfenvalerate	94.5			14		96 h	NOEC	Mortality	0.01	2		DAR, Takimoto and Ashida, 1986
Oncorhynchus mykiss	av. weight 0.9 g, av. length 4.1 cm	Y	F	Esfenvalerate	94.5			14		96 h	LC50	Mortality	0.1	2		DAR, Takimoto and Ashida, 1986
Oncorhynchus mykiss	av. weight 1.38 g, av. length 4.6 cm	Y	F	EC formulation	5			14		96 h	LC50	Mortality	4.5	3	54	DAR, Handley et al., 1991a
Oncorhynchus mykiss	av. weight 1.38 g, av. length 4.6 cm	Y	F	EC formulation	5			14		96 h	NOEC	Mortality	3	3	54	DAR, Handley et al., 1991a
Oncorhynchus mykiss	juveniles	Y	F	Esfenvalerate	94.5		7.33-7.58	14 ± 1		96 h	LC50	Mortality	0.1	4*	55	PSD, 1992
Oncorhynchus mykiss	juveniles	Y	F	Esfenvalerate	94.5		7.33-7.58	14 ± 1		96 h	NOEC	Abnormal behaviour	0.01	4*	55	PSD, 1992
Oncorhynchus tshawytscha	4-5 months old	Y	R	Esfenvalerate	98	nw	8.4 ± 0.2	14.8 ± 0.5		96 h	NOEC	Mortality	0.1	2	57	Wheelock et al., 2005
Oncorhynchus tshawytscha	4-5 months old	Y	R	Esfenvalerate	98	nw	8.4 ± 0.2	14.8 ± 0.5		96 h	EC100	Mortality	1	2	57	Wheelock et al., 2005
Oryzias latipes	postlarvae (28 days old)	N	S	Esfenvalerate	tg		7.4-7.6	25 ± 1		96 h	LC50	Mortality	1.75	4	59	PSD, 1992
Oryzias latipes	juveniles (56 days old)	N	S	Esfenvalerate	tg		7.4-7.6	25 ± 1		96 h	LC50	Mortality	5.57	4	59	PSD, 1992
Oryzias latipes	adults (4 months old)	N	S	Esfenvalerate	tg		7.4-7.6	25 ± 1		96 h	LC50	Mortality	1.9	4	59	PSD, 1992
Oryzias latipes	postlarvae (28 days old)	N	S	Esfenvalerate	tg		7.4-7.6	25 ± 1		96 h	NOEC	Mortality	0.35	4	59	PSD, 1992
Oryzias latipes	juveniles (56 days old)	N	S	Esfenvalerate	tg		7.4-7.6	25 ± 1		96 h	NOEC	Mortality	2.5	4	59	PSD, 1992
Oryzias latipes	adults (4 months old)	N	S	Esfenvalerate	tg		7.4-7.6	25 ± 1		96 h	NOEC	Mortality	1.1	4	59	PSD, 1992
Oryzias latipes	4.5 months old	Y	R	Esfenvalerate				22.7-22.9		96 h	LC50	Mortality	0.9	2	60	Werner et al., 2002b
Pimephales macrolepidotus	21 d old	N		Asana XL	8.6					96 h	LC50	Mortality	0.5	3	58	Werner et al., 2002a
Pimephales promelas	av. weight 0.02 g, av. length 1.1 cm	Y	S	Esfenvalerate	98			22		96 h	LC50	Mortality	0.18	2		DAR, Ward, 1984
Pimephales promelas	av. weight 0.02 g, av. length 1.1 cm	Y	S	Esfenvalerate	98			22		96 h	NOEC	Mortality	0.13	2		DAR, Ward, 1984

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
Pimephales promelas	1 day old	N	S	Esfenvalerate						96 h	LC50	Mortality	0.32	3	58	Stay and Jarvinen, 1995
Pimephales promelas	7 to 10 days old	N	S	Esfenvalerate						96 h	LC50	Mortality	0.23	3	58	Stay and Jarvinen, 1995
Pimephales promelas	36 days old	N	S	Esfenvalerate						96 h	LC50	Mortality	0.22	3	58	Stay and Jarvinen, 1995
Pimephales promelas	21 d old	N		Asana XL	8.6			25		96 h	LC50	Mortality	0.25	3	58	Werner et al., 2002a
Pimephales promelas		Y		Asana XL	8.6					48 h	LC50	Mortality	0.616	4	56	Bouldin et al., 2004
Pimephales promelas	larvae (7 days old)	Y	R	Esfenvalerate	98.0	rw		20		96 h	LC50	Mortality	0.2	3	50	Denton et al., 2003
Pogonichthys macrolepidotus	6 weeks old larvae (0.032 mg weight, 16.9 mm length)	N	R	Esfenvalerate	98.0	nw	8.1 ± 0.2	18.0 ± 0.2	240 ± 29	96 h	LC50	Mortality	0.95	3	40	Teh et al., 2004
Pogonichthys macrolepidotus	6 weeks old larvae (0.032 mg weight, 16.9 mm length)	N	R	Esfenvalerate	98.0	nw	8.1 ± 0.2	18.0 ± 0.2	240 ± 29	96 h	LC50	Mortality	0.83	3	39	Teh et al., 2004
Amphibia																
Rana blairi	tadpoles,6-8 d p-hatch	Y	S	Technical esfenvalerate	85	nw		18		96 h	EC50	Deformities	3.4	3	62	Materna et al., 1995
Rana blairi	tadpoles,6-8 d p-hatch	Y	S	Technical esfenvalerate	85	nw		22		96 h	EC50	Deformities	6.14	3	62	Materna et al., 1995
Rana blairi	tadpoles,6-8 d p-hatch	Y	S	Technical esfenvalerate	85	nw		22		96 h	LC50	Mortality	7.29	3	62	Materna et al., 1995
Rana limnocharis	Tadpoles, 0.28 g	N	S	EC formulation	5					48 h	LC50	Mortality	28	3	10	Pan and Liang, 1996
Rana pipiens	tadpoles,6-8 d p-hatch	Y	S	Technical esfenvalerate	85	nw		20		24 h	NOEC	Activity	0.8	3	63	Materna et al., 1995
Rana pipiens	tadpoles,6-8 d p-hatch	Y	S	Technical esfenvalerate	85	nw		20		96 h	EC50	Convulsions	4.85	3	64	Materna et al., 1995
Rana sphenocephala	tadpoles,6-8 d p-hatch	Y	S	Technical esfenvalerate	85	nw		18		96 h	EC50	Deformities	3.4	3	62	Materna et al., 1995
Rana sphenocephala	tadpoles,6-8 d p-hatch	Y	S	Technical esfenvalerate	85	nw		22		96 h	EC50	Deformities	6.14	3	62	Materna et al., 1995
Rana sphenocephala	tadpoles,6-8 d p-hatch	Y	S	Technical esfenvalerate	85	nw		22		96 h	LC50	Mortality	7.29	3	62	Materna et al., 1995

1 Above solubility. The original reported value is 10 µg/L. Used to show that algae are not sensitive.
2 Growth rate is preferred over biomass (Area Under Growth Curve) as endpoint. Above solubility.
3 Assuming a density of 1 kg/L of the EC formulation. Above solubility. The originally reported value is 11 µg/L. Used to show that algae are not sensitive.
4 The test conditions were not described.
5 The test conditions were not described. Esfenvalerate was dosed at one point (in water and as soil slurry) in a slowly flowing ditch. Samples were taken in space and time and the % mortality and concentration of esfenvalerate were determined. Mortality and concentration could be correlated.
6 Test carried out with 10% sediment (2.1% o.c.). Concentration not measured.
7 The test compound was not measured during the test.
8 The test compound was not measured during the test; the Daphnids were fed.
9 Values based on measured concentrations. Assuming a density of 1 kg/L of the EC formulation. The value with formulation deviates more than a factor 3 from the value with a.s.
10 Value > solubility in water. The test conditions were not described.
11 Test result based on nominal concentrations. Performed by conventional methods: Method for Measuring Water Toxicity by Mortality and Fecundity Changes in Daphnia. PND FT 14.1:2:3:4.3-99 (Moscow). Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient. Static test → concentration of esfenvalerate surely decreased over exposure time.
12 Test result based on nominal concentrations. Solvent used in unknown concentration. Tween 80 used as solubiliser.
13 Acetone used in concentration of 0.03%. No mortality in solvent control. Test result based on nominal concentrations. Measured concentrations were close to nominal (concentrations were measured in a parallel series without animals). Hardness calculated (composition of medium is reported).
14 Acetone used in concentration of 0.03%. No mortality in solvent control. Test result based on nominal concentrations. Measured concentrations were close to nominal (concentrations were measured in a parallel series without animals). Hardness calculated (composition of medium is reported). Copulatory parent animals were pulse exposed for 1 h; rinsed and transferred to clean medium for the remaining test duration; mortality of parents is the expressed result, which was still increasing at termination of test.

15 Acetone used in concentration of 0.03%. No mortality in solvent control. Test result based on nominal concentrations. Measured concentrations were close to nominal (concentrations were measured in a parallel series without animals). Hardness calculated (composition of medium is reported). Copulatory parent animals were pulse exposed for 1 h; rinsed and transferred to clean medium for the remaining test duration; mortality of offspring is the expressed result, which was still increasing at termination of test.
16 Acetone used in concentration of 0.03%. No mortality in solvent control. Test result based on nominal concentrations. Measured concentrations were close to nominal (concentrations were measured in a parallel series without animals). Hardness calculated (composition of medium is reported). Animals were pulse exposed for 1 h in medium containing sediment; then rinsed and transferred to clean medium + clean sediment for the remaining test duration.
17 Acetone used in concentration of 0.03%. No mortality in solvent control. Test result based on nominal concentrations. Measured concentrations were close to nominal (concentrations were measured in a parallel series without animals). Hardness calculated (composition of medium is reported). Animals were pulse exposed for 1 h in medium containing sediment; then rinsed and transferred to clean medium + sediment that was also exposed for 1 h, for the remaining test duration.
18 Polyethylene containers used as experimental vessels. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. There is only one type of control, but it is not reported whether this is a solvent or solvent free control. Endpoint determined at 7 days post-exposure. Test result based on measured concentrations. Concentrations did not decrease more than 10 % during a 1 h period. Hardness from Holdway et al., 1994. 0.004% acetone; control mortality c. 20%.
19 Polyethylene containers used as experimental vessels. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. There is only one type of control, but it is not reported whether this is a solvent or solvent free control. Endpoint determined at 7 days post-exposure. 20 larvae per replicate in control and 60 ng/l, 40 larvae in 130 and 320 ng/l exposures at the start of the test. Test result based on measured concentrations. Concentrations did not decrease more than 10% during a 1 h period. Hardness from Holdway et al., 1994. 0.004% acetone; control mortality 25%.
20 Acetone used in concentration of 0.03%. No mortality in solvent control. Test result based on nominal concentrations. Measured concentrations were close to nominal (concentrations were measured in a parallel series without animals). Hardness calculated (composition of medium is reported). Animals were pulse exposed for 1 h in medium; then rinsed and transferred to clean medium for the remaining test duration.
21 Acetone used in concentration of 0.03%. No mortality in solvent control. Test result based on nominal concentrations. Measured concentrations were close to nominal (concentrations were measured in a parallel series without animals). Hardness calculated (composition of medium is reported). Males and females exposed separately pre-copulation and pairs reformed after exposure: animals were pulse exposed 1 h in medium; then rinsed and transferred to clean medium for the remaining test duration.
22 Polyethylene containers used as experimental vessels. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. There is only one type of control, but it is not reported whether this is a solvent or solvent free control. Endpoint determined at 14 days post-exposure. Test result based on measured concentrations. Concentrations did not decrease more than 10 % during a 1 h period. Hardness from Holdway et al., 1994. 0.004% acetone; control mortality c. 4%.
23 Value > solubility in water.
24 Test result based on nominal concentrations. Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient. Static test → concentration of esfenvalerate surely decreased over exposure time. Test compound is Sumi-alfa, which is an "esfenvalerate emulsion" (not further specified).
25 Carried out according to Canadian Guideline. Result recalculated for 65% mean measured values. Only sand on the bottom of the test vessels.
26 Polyethylene containers used as experimental vessels. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. There is only one type of control, but it is not reported whether this is a solvent or solvent free control. Endpoint determined at 7 days post-exposure. Test result based on measured concentrations. Concentrations did not decrease more than 10% during a 1 h period. Hardness from Holdway et al., 1994. 0.004% acetone; 40% control mortality.
27 It is unclear whether the test substance was Sumi-Alpha 5FW or esfenvalerate tg. Value > solubility in water.
28 Polyethylene containers used as experimental vessels. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. There is only one type of control, but it is not reported whether this is a solvent or solvent free control. Endpoint determined at 7 days post-exposure. Endpoint determined at 14 days post-exposure. Endpoint determined at 28 days post-exposure. 80 larvae per replicate at the start of the test. Test result based on measured concentrations. Concentrations did not decrease more than 10% during a 1 h period. Hardness from Holdway et al., 1994. 0.004% acetone; control mortality 24% (at 7 d), <5% (at 14 d) and 0% (at 28 d).
29 Test result based on nominal concentrations. Test result and/or some test concentrations above solubility limits. Solvent used in unknown concentration. Tween 80 used as solubiliser.
30 Polyethylene containers used as experimental vessels. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. There is only one type of control, but it is not reported whether this is a solvent or solvent free control. Endpoint determined at 14 days post-exposure. Endpoint determined at 28 days post-exposure. 80 larvae per replicate at the start of the test. Test result based on measured concentrations. Concentrations did not decrease more than 10% during a 1 h period. Hardness from Holdway et al., 1994. 0.004% acetone; control mortality <5% (at 14 d) and 0% (at 28 d).
31 pH and dissolved oxygen were not reported.
32 The test conditions were not described.
33 Test result based on nominal concentrations, measured concentrations varied from nominal by ~ 20% (published elsewhere). Solvent used in unknown concentration. Tween 80 used as solubiliser; measured concentrations varied between 80-105%; result based on nominal concentrations of technical esfenvalerate of unreported purity.
34 Test result and/or some test concentrations above solubility limits. Only one concentration tested; 1 h pulse exposure, eggs were then rinsed and transferred to incubation chambers for hatching; 0.002% acetone used as solvent.
35 Acetone was used as solvent at 0.004%. 1 hour pulse-exposure. Larvae were then transferred to growth chambers for monitoring. Polyethylene containers used as experimental vessels. Mortality measured at 96 h after exposure. Hardness from Holdway et al., 1994. Test result based on measured concentrations. Concentrations did not decrease more than 10% during a 1 h period. Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient.
36 Polyethylene containers used as experimental vessels. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. There is only one type of control, but it is not reported whether this is a solvent or solvent free control. Endpoint determined at 7 days post-exposure. 80 larvae per replicate at the start of the test. Test result based on measured concentrations. Concentrations did not decrease more than 10% during a 1 h period. Hardness from Holdway et al., 1994. 0.004% acetone; control mortality 24%.
37 Acetone was used as solvent at 0.004%. Test result and/or some test concentrations above solubility limits. 1 hour pulse-exposure. Larvae were then transferred to growth chambers for monitoring. Polyethylene containers used as experimental vessels. Mortality measured at 96 h after exposure. Hardness from Holdway et al., 1994. Test result based on measured concentrations. Concentrations did not decrease more than 10% during a 1 h period. Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient.
38 Polyethylene containers used as experimental vessels. Acetone was used as solvent in non exceeding concentration. Test result based on nominal concentrations. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. Test result and/or some test concentrations above solubility limits. Only one concentration tested. Hardness from Holdway et al., 1994. Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient.
39Test result based on nominal concentrations. Methanol used as a solvent: max. 0.05%. No mortality in control and solvent control. LC50 at 14 days post 96-h exposure.
40 Test result based on nominal concentrations. Methanol used as a solvent: max. 0.05%. No mortality in control and solvent control.

41 Acetone was used as solvent at 0.004%. Test result and/or some test concentrations above solubility limits. Concentration measurement was made in blank (fish free) aquaria and thus calculated LC50 values are higher than actual values (significant quantities of pesticide were absorbed by the fish in experiment).
42 Acetone was used as solvent at 0.004%. Concentration measurement was made in blank (fish free) aquaria and thus calculated LC50 values are higher than actual values (significant quantities of pesticide were absorbed by the fish in experiment). 1 hour pulse-exposure. Larvae were then transferred to growth chambers for monitoring. Polyethylene containers used as experimental vessels. Mortality measured at 96 h after exposure. Mean of 4 replicate experiments. Concentration measurement was made in blank (fish free) aquaria and thus calculated LC50 values are higher than actual values (significant quantities of pesticide were absorbed by the fish in experiment).
43 Acetone was used as solvent at 0.004%. Concentration measurement was made in blank (fish free) aquaria and thus calculated LC50 values are higher than actual values (significant quantities of pesticide were absorbed by the fish in experiment). 1 hour pulse-exposure. Larvae were then transferred to growth chambers for monitoring. Polyethylene containers used as experimental vessels. Mortality measured at 96 h after exposure. Mean of 4 replicate experiments; emulsifier used, chemical identity and amount not reported.
44 Acetone was used as solvent at 0.004%. Concentration measurement was made in blank (fish free) aquaria and thus calculated LC50 values are higher than actual values (significant quantities of pesticide were absorbed by the fish in experiment). 1 hour pulse-exposure. Larvae were then transferred to growth chambers for monitoring. Polyethylene containers used as experimental vessels. Mortality measured at 96 h after exposure. Unclear whether this endpoint is obtained with esfenvalerate of emulsified esfenvalerate.
45 Acetone was used as solvent at 0.004%. Concentration measurement was made in blank (fish free) aquaria and thus calculated LC50 values are higher than actual values (significant quantities of pesticide were absorbed by the fish in experiment). 1 hour pulse-exposure. Larvae were then transferred to growth chambers for monitoring. Polyethylene containers used as experimental vessels. Mortality measured at 48 h after exposure. Unfed larvae. Unclear whether this endpoint is obtained with esfenvalerate of emulsified esfenvalerate.
46 Acetone was used as solvent at 0.004%. Concentration measurement was made in blank (fish free) aquaria and thus calculated LC50 values are higher than actual values (significant quantities of pesticide were absorbed by the fish in experiment). 1 hour pulse-exposure. Larvae were then transferred to growth chambers for monitoring. Polyethylene containers used as experimental vessels. Mortality measured at 48 h after exposure. Fed larvae. Unclear whether this endpoint is obtained with esfenvalerate of emulsified esfenvalerate.
47 Polyethylene containers used as experimental vessels. Acetone was used as solvent in non exceeding concentration. Test result based on nominal concentrations. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. Test result and/or some test concentrations above solubility limits. Only one concentration tested. Hardness from Holdway et al., 1994. Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient.
48 Controls only with acetone, solvent-free controls not used. Test result based on nominal concentrations. Pulse exposure. Test result and/or some test concentrations above solubility limits. Hardness from Holdway et al., 1994. Solvent (acetone) concentration unknown since test volume was not reported; presumably 0.0008%; single dose of emulsified esfenvalerate; concentrations decreased exponentially to >50%, 41%, 46%, 48% and 45% of initial at 8 h and to <1% at t = 24 h.
49 Controls only with acetone, solvent-free controls not used. Test result based on nominal concentrations. Pulse exposure. Hardness from Holdway et al., 1994. Solvent (acetone) concentration unknown since test volume was not reported; presumably 0.0008%; single dose of emulsified esfenvalerate; concentrations decreased exponentially to >50%, 41%, 46%, 48% and 45% of initial at 8 h and to <1% at t = 24 h.
50 According to standard procedures: Weber CI, ed. 1993. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Estuarine Organisms, 4th ed. EPA/600/4-90/027F. U.S. Environmental Protection Agency, Office of Research and Development, Duluth, MN. Methanol used as solvent in concentration of less than 0.05%. Solvent control survival > 90%. Unclear whether LC50s were recalculated on the basis of the measured concentration (50-133% recovery and 70-90% recovery for esfenvalerate by two different methods). LC50 is result of three combined tests which gave individual LC50s of 0.18, 0.22 and 0.22 µg/L.
51 Controls only with acetone, solvent-free controls not used. Test result based on nominal concentrations. Pulse exposure. Maternal exposure; larvae were transferred in plastic containers and monitored for 8 days. Hardness from Holdway et al., 1994. Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient. Solvent (acetone) concentration unknown since test volume was not reported; presumably 0.0008%; single dose of emulsified esfenvalerate; concentrations decreased exponentially to >50%, 41%, 46%, 48% and 45% of initial at 8 h; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient.
52 Controls only with acetone, solvent-free controls not used. Test result based on nominal concentrations. Pulse exposure. Only one concentration tested. Hardness from Holdway et al., 1994. Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient. Solvent (acetone) concentration unknown since test volume was not reported; presumably 0.0008%; single dose of emulsified esfenvalerate; concentrations decreased exponentially to >50%, 41%, 46%, 48% and 45% of initial at 8 h and to <1% at t = 24 h.
53 The exposure period is too short.
54 Assuming a density of 1kg/L of the EC formulation.
54s The value with formulation deviates more than a factor 3 from the value with a.s.
55 Test result based on nominal concentrations, measured concentrations varied from nominal by ~ 20% (published elsewhere). Solvent used in unknown concentration. Tween 80 used as solubiliser; measured concentrations varied between 107-125%, reported for two (of ten) tested concentrations; result based on nominal concentrations of technical esfenvalerate of unreported purity. No reference to author.
56 Esfenvalerate was dosed at one point (in water and as soil slurry) in a slowly flowing ditch. Samples were taken in space and time and the % mortality and concentration of esfenvalerate were determined. Mortality and concentration could be correlated.
57 Methanol was used as solvent in maximally 0.005%. Test result based on nominal concentrations, measured concentrations varied from nominal by ~ 20% (published elsewhere).
58 The test conditions were not described.
59 Test result based on nominal concentrations. Solvent used in unknown concentration. Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient. Static test → concentration of esfenvalerate surely decreased over exposure time. Tween 80 used as solubiliser; result based on nominal concentrations of technical esfenvalerate of unreported purity. No reference to author.
decreased over exposure time. Tween 80 used as solubiliser; result based on nominal concentrations of technical esfenvalerate of unreported purity. No reference to author.
60 Methanol used as a solvent: max. 0.05%. No mortality in control and solvent control. Test result based on measured concentrations. Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient.
61 Polyethylene containers used as experimental vessels. 1 hour pulse-exposure. Larvae (or eggs) were then transferred to growth chambers for monitoring. There is only one type of control, but it is not reported whether this is a solvent or solvent free control. Endpoint determined at 7 days post-exposure. Endpoint determined at 14 days post-exposure. Test result based on measured concentrations. Concentrations did not decrease more than 10 % during a 1 h period. Hardness from Holdway et al., 1994. 0.004% acetone; control mortality c. 4%.
62 Substantial decrease of esfenvalerate in water column. Test result based on nominal concentrations. Test result and/or some test concentrations above solubility limits. Results are reported in active ingredient. Acetone used as solvent in concentration of 0.5 mL/L, recommended by standard methods: American Public Health Association, American Water Works Association and Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Waste-water, 17th ed. American Public Health Association, Washington, DC.
63 Substantial decrease of esfenvalerate in water column. Test result based on nominal concentrations. Results are reported in active ingredient. High control mortality. Acetone used as solvent in concentration of 0.5 mL/L, recommended by standard methods: American Public Health Association, American Water Works Association and Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Waste-water, 17th ed. American Public Health Association, Washington, DC. Test compound is technical grade esfenvalerate, containing 85% (S,S)esfenvalerate; 0.05% acetone used as co-solvent; control and solvent-control included in test; organisms were not fed.

64 Substantial decrease of esfenvalerate in water column. Test result based on nominal concentrations. Test result and/or some test concentrations above solubility limits. Results are reported in active ingredient. High control mortality. Acetone used as solvent in concentration of 0.5 mL/L, recommended by standard methods: American Public Health Association, American Water Works Association and Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Waste-water, 17th ed. American Public Health Association, Washington, DC.

Table A2.2. Chronic toxicity of esfenvalerate to freshwater organisms.

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Hardness $CaCO_3$ [mg/L]	Exp. time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
Algae																
Pseudokirchneriella subcapitata		Y	S	Esfenvalerate	97	am		24		48 h	NOEC	Growth rate	1.0	2		DAR, Handley et al., 1991g
Pseudokirchneriella subcapitata		Y	S	EC formulation	5	am		24		48 h	NOEC	Growth rate	2.5	2		DAR, Handley et al., 1991h
Crustacea																
Daphnia carinata	≤ 24 h old	Y	R	Esfenvalerate		rw	6.8-7.0	19-21		6 d	NOEC	Mortality	0.1	2	1	Barry et al., 1995b
Daphnia carinata	≤ 24 h old	Y	R	Esfenvalerate		rw	6.8-7.0	19-21		6 d	NOEC	Length F1	0.05	2	1	Barry et al., 1995b
Daphnia carinata	≤ 24 h old	Y	R	Esfenvalerate		rw	6.8-7.0	19-21		6 d	NOEC	Fecundity F1	0.05	2	1	Barry et al., 1995b
Daphnia carinata	≤ 24 h old	Y	R	Esfenvalerate		rw	6.8-7.0	19-21		until 2nd brood	NOEC	Length F2	0.01	2	1	Barry et al., 1995b
Daphnia carinata	≤ 24 h old	Y	R	Esfenvalerate		rw	6.8-7.0	19-21		until 2nd brood	NOEC	Fecundity F2	0.01	2	1	Barry et al., 1995b
Daphnia magna	< 24 h old	Y	R	Esfenvalerate	98.6			20		21 d	NOEC	Reproduction	0.052	2		DAR, Hutton, 1987d
Daphnia magna	< 24 h old	Y	R	Esfenvalerate	98.6			20		21 d	EC50	Reproduction	0.079	2		DAR, Hutton, 1987d
Daphnia magna	< 24 h old	Y	R	Esfenvalerate	97			21		21 d	NOEC	Reproduction	0.056	2		DAR, Handley et al., 1991e
Daphnia magna	< 24 h old	Y	R	Esfenvalerate	97			21		21 d	EC50	Reproduction	0.018	2		DAR, Handley et al., 1991e
Daphnia magna	< 24 h old	Y		EC formulation	5			21		21 d	NOEC	Reproduction	0.056	2		DAR, Handley et al., 1991f
Pisces																
Lepomis macrochirus	juv,1.01±0.34 g, 41±4 mm	Y	F	Esfenvalerate	84	nw		22	283	30 d	NOEC	Mortality	0.092	2	2	Little et al., 1993
Lepomis macrochirus	juv,1.01±0.34 g, 41±4 mm	Y	F	Esfenvalerate	84	nw		22	283	60 d	NOEC	Mortality	0.052	2	3	Little et al., 1993
Lepomis macrochirus	juv,1.01±0.34 g, 41±4 mm	Y	F	Esfenvalerate	84	nw		22	283	90 d	NOEC	Mortality	0.010	2	3	Little et al., 1993
Lepomis macrochirus	juv,1.01±0.34 g, 41±4 mm	Y	F	Esfenvalerate	84	nw		22	283	90 d	NOEC	Growth	≥ 0.052	2	5	Little et al., 1993
Lepomis macrochirus	juv,1.01±0.34 g, 41±4 mm	Y	F	Esfenvalerate	84	nw		22	283	6 x 55 h	NOEC	Mortality	≥ 0.172	2	6	Little et al., 1993
Lepomis macrochirus	juv,1.01±0.34 g, 41±4 mm	Y	F	Esfenvalerate	84	nw		22	283	6 x 55 h	NOEC	Growth	≥ 0.172	2	6	Little et al., 1993
Oncorhynchus mykiss	2.14 g, 5.2 cm	Y	F	Esfenvalerate	97		7.4-7.8	14		21 d	LC50	Mortality	0.013	2		DAR, Handley et al., 1991b
Oncorhynchus mykiss	2.14 g, 5.2 cm	Y	F	Esfenvalerate	97		7.4-7.8	14		21 d	NOEC	Mortality	0.001	2		DAR, Handley et al., 1991b
Oncorhynchus mykiss	1.04 g, 4.2 cm	Y	F	EC formulation	5			14		21 d	LC50	Mortality	0.36	3	7	DAR, Handley et al., 1991c
Oncorhynchus mykiss	1.04 g, 4.2 cm	Y	F	EC formulation	5			14		21 d	NOEC	Mortality	0.18	3	8	DAR, Handley et al., 1991c
Pimephales promelas	eggs, ELS test	Y	F	Esfenvalerate	96			25		260 d	NOEC	fry survival	0.090	2	4	DAR, Anon., 1978

1 Polyethylene containers used as experimental vessels. Controls only with acetone, solvent-free controls not used. Medium was changed every 24 hours. Substantial decrease of esfenvalerate in water column. Test result based on nominal concentrations. 0.004% acetone; other experiments did not show effect of acetone at this level; therefore only acetone controls were included; result presented in nominal concentrations; measured concentrations were close to nominal after addition and rapidly decreased, measured in 100 and 500 ng/L treatments only.

2 Technical formulation tested is composed primarily of esfenvalerate; solvent (acetone) concentration unknown since test volume was not reported; but highest test concentration received ≤ 0.0025% (based on maximum aquarium volume), other treatments received lower solvent concentrations; results expressed as average actual concentrations, which were close to nominal; NOEC for mortality determined at 30, 60 and 90d from the same experiment.

3 Technical formulation tested is composed primarily of esfenvalerate; solvent (acetone) concentration unknown since test volume was not reported; but highest test concentration received ≤ 0.0025%, other treatments received lower solvent concentrations; results expressed as average actual concentrations, which were close to nominal; NOEC for mortality determined at 30, 60 and 90d from the same experiment.

4 The value with the formulation differed more than a factor 3 from the value with the a.s.

5 Technical formulation tested is composed primarily of esfenvalerate; solvent (acetone) concentration unknown since test volume was not reported; but highest test concentration received ≤ 0.0025%, other treatments received lower solvent concentrations; results expressed as average actual concentrations, which were close to nominal.

6 High control mortality. No effect at highest concentration which had the following (flow through) exposure: 11 h in 0.172 µg/L, and subsequently 11 h in each lower concentration, until (and including) control exposure until the next exposure period, 2 weeks later (thus mimicking field exposure); exposure was repeated 6 times with 2 week intervals; technical formulation tested is composed primarily of esfenvalerate; solvent (acetone) concentration unknown since test volume was not reported; but highest test concentration received ≤ 0.0025%, other treatments received lower solvent concentrations; results expressed as average actual concentrations, which were close to nominal.

7 Assuming a density of 1 kg/L of the EC formulation. It is not clear whether the values were expressed as a.s. The value with the formulation differed more than a factor 3 from the value with the a.s.

rivm

Appendix 3. Description of mesocosm studies

For esfenvalerate 8 field studies were available. Since esfenvalerate disappears from the water column in a relatively short time period (in general < 24 h), studies with single or repeated applications cannot be used for the derivation of an MPC. The studies can be used for derivation of an MAC. Most studies were assessed not reliable, mainly because the concentration of esfenvalerate is not measured after application. In the two studies that are assigned a Ri 2 (Lozano et al., 1992 and Fairchild et al., 1992) the NOEC is < 0.01 µg/L and < 0.31 µg/L, respectively. In the study of Lozano et al. (1992), effects > 50% were found at 0.01 µg/L on individual sampling dates, but for a number of sensitive endpoints, and for this reason the effects are deemed ecologically relevant, and the overall endpoint is < 0.01 µg/L.

Study 1: Lozano et al., 1992
Enclosure study with natural populations of algae, plants, invertebrates and caged fish

Species; Population; Community	Fish, algae, zooplankton, macroinvertebrates
Test Method	Enclosure
System properties	Enclosures 5 x 10 m, depth avg 0.62 m
Formulation	Esfenvalerate
Exposure regime	0, 0.01, 0.08, 0.2, 1 and 5 µg/L in duplicate, 2 applications (June 20 and July 18)
Analysed	Y
Temperature [°C]	Not reported
pH range	Not reported
Hardness [mg $CaCO_3$/L]	Not reported
Exposure time	8 weeks
Criterion	NOEC
Test endpoint	Survival of micro- and macroinvertebrates
Value [µg/L]	< 0.01
GLP	N
Guideline	
Notes	Analytical details reported in Heinis and M.L. Knuth, 1992
Ri	2
Reference	Lozano et al., 1992

DESCRIPTION

Test system

Twelve enclosures of 5 x 10 m were placed in a 2 ha pond in Minnesota, between 17-19 May 1988. Natural populations of phytoplankton and periphyton were present. Macrophytes biomass was dominated by the macroalgae *Chara*. Natural populations of micro- and macroinvertebrates were studied. Caged 9 months old commercially obtained *Lepomis macrochirus* were added. Larvae of *Phoxinus eos* and *Pimephales promelas* were captured in the pond, an a total of 245 larvae were assigned in cages to each enclosure, 7 days before application. Application took place on June 20 and July 18, dosages 0, 0.01, 0.08, 0.2, 1 and 5 µg/L in duplicate.

Analytical sampling

No details are given.

Effect sampling.

Phytoplankton was collected on nine sampling dates until 80 days, algal species were identified, biomass and chlorophyll-*a* were determined. Periphyton samples were collected 7 times using glass rods, and chlorophyll-*a* was determined. Aquatic macrophytes were identified and counted on three sampling dates; biomass was estimated on day 58. Productivity was determined from daily changes in dissolved oxygen. Invertebrate funnel traps were used to sample micro-invertebrates until day 54. Macroinvertebrates were sampled using artificial substrate. Survival of caged fish was monitored daily in the first week after treatment and twice weekly during the rest of the study period.

Statistical analysis

The results were analysed using regression techniques and analysis of variance.

RESULTS

Chemical analysis
It is reported that concentrations are close to nominal for both treatments, and no measurable esfenvalerate was found in the 0.01 and 1.0 µg/L treatments after 24 h, and in the 5 µg/L treatment after 48 h. However, in a separate publication of Heinis and M.L. Knuth (1992) the fate of esfenvalerate in the enclosures is described in detail. The results of the study show that esfenvalerate very rapidly disappears from the water column. In the lowest concentration, the concentration applied (0.01 µg/L) is below the limit of quantification (LOQ = 0.047 µg/L), and the measured concentration is below the LOQ too. In the 0.08 and the 0.2 µg/L treatment the concentration is below the LOQ within 1 day after application, in the highest concentrations this is the case within 4 days. Part of the esfenvalerate is found in the sediment and plants.
Biological observations
Chlorophyll-*a* concentrations in phytoplankton showed no significant treatment related effects. In the highest treatments, cell volume was significantly increased at 3 days after first application, indicating an indirect effect. Periphyton chlorophyll-*a* concentrations were significantly higher in all treatments compared to the control on day 11. For *Chara,* a positive correlation between treatment and stem height was found on day 70; the authors suggest that this is an indirect effect.
For the microinvertebrates clear dose related responses were found. Clear dose related effects, with effects > 50% at the lowest treatment level (after first application) were found for *Alona, Paracyclops, Bosmina, Sida, and Copepodites.* At this moment an increase was found for the Rotifera, indicated as a an indirect effect.
For the macroinvertebrates, clear (≥ 50%) dose related effects with effects in the lowest treatment were found for *Orthocladinae.*
Bluegill survival was not affected at concentrations ≤ 0.2 µg/L. Larval survival of Cyprinids appears to be affected from the 0.08 µg/L treatments onwards.

Evaluation of the scientific reliability of the field study
Criteria for a suitable (semi)field study
1. Does the test system represent a realistic freshwater community? Yes, natural populations of algae, macrophytes, micro- and macroinvertebrates were present. Fish were studied using caged fish, partly from the research area.
2. Is the description of the experimental set-up adequate and unambiguous? Yes, individual sampling dates can be read from figures.
3. Is the exposure regime adequately described? No. Total recovery is not given, individual time points are not reported. Measured concentrations are not reported in the present paper, but are reported in Heinis and M.L. Knuth, 1992.
4. Are the investigated endpoints sensitive and in accordance with the working mechanism of the compound? Yes.
5. Is it possible to evaluate the observed effects statistically? No, data of the individual replicates and statistical methods are not reported. No multivariate analysis is provided, community response is not analysed as such.

These criteria result in an overall assessment of the study reliability. The study is considered to be less reliable (Ri 2).

This results indicate that it is not possible to derive a chronic NOEC from this study. For a short term NOEC the nominal value of < 0.01 µg/L can be used. At 0.01 µg/L effects of ≥ 50% were found for a number of species (see above).

Study 2: Webber et al., 1992
Mesocosm study simulating drift and run-off

Species; Population; Community	Fish, algae, zooplankton, macroinvertebrates
Test Method	Mesocosm
System properties	mesocosms 16.6 x 61 m, 1.5 m deep, 6.1 m littoral zone, clay soil.
Formulation	Esfenvalerate, EC formulation Asana XL (8.4% a.i.)
Exposure regime	10 weekly simulated drift applications of 11, 280 and 1134 µg/pond per application, 5 biweekly simulated run-off applications of 22.5, 225.5 and 2250 µg/pond.
Analysed	Y
Temperature [°C]	ca. 25-32 (estimated from figures) in the exposure period
pH range	ca. 7-8.5 (estimated from figures) in the exposure period
Hardness [mg $CaCO_3$/L]	Not reported
Exposure time	10 weeks
Criterion	
Test endpoint	
Value [µg/L]	
GLP	N
Guideline	
Notes	Analytical details not reported
Ri	3
Reference	Webber et al., 1992

Because in this study only average concentrations of esfenvalerate in soil and water for the whole study period are reported, it is not possible to evaluate the exposure. Therefore the study is considered to be not reliable, and a further detailed assessment of the study is not necessary.

Study 3: Fairchild et al., 1994
Mesocosm study with natural populations of algae, plants, invertebrates and caged fish

Species; Population; Community	Fish, macrophytes, algae, zooplankton
Test Method	Mesocosm
System properties	1000 m^2 , 1,5 m deep, 600-850 m^3
Formulation	Esfenvalerate
Exposure regime	0, 0.25, 0.40, 0.67, 1.12 and 1.71 µg/L, no replicates, 2 applications (May 26 and July 8)
Analysed	Y
Temperature [°C]	Not reported
pH range	Not reported
Hardness [mg $CaCO_3$/L]	Not reported
Exposure time	3.5 months
Criterion	NOEC
Test endpoint	Crustacean zooplankton community, mortality of bluegill
Value [µg/L]	
GLP	N
Guideline	
Notes	Analytical details not reported
Ri	3
Reference	Fairchild et al., 1994

Short description the test
The test was set up to study the impact of the use of the herbicide atrazine on the effects of esfenvalerate. For this aim six cosms were used without atrazine and six cosms with 50 µg/L atrazine. For the use of deriving an ERL the cosms with atrazine are left out of consideration, meaning that a non-replicated test design remains.

Analytical details are not given, but a half-life of 10 h is reported. For the effects only community response is reported. Due to the lack of replicates, and the lack of raw data, no statistics are available or can be calculated. The data presented suggest an effect on zooplankton community at the lowest treatment level of 0.25 µg/L nominal concentration. However, the pre-treatment sample indicates a very high variation between treatments. For this reason, among others, the study is assigned less reliable Ri 3, and the endpoints cannot be used for ERL derivation.

Study 4: Fairchild et al., 1992
Mesocosm study with natural populations of algae, plants, invertebrates and added fish

Species; Population; Community	Fish, algae, macrophytes, benthic invertebrates, zooplankton
Test Method	Mesocosm
System properties	1000 m^2, 1.5 m deep, 700 m^3
Formulation	Esfenvalerate
Exposure regime	0, 0.25, 0.67, 1.71 µg/L in triplicate; 6 applications with two week intervals (June 6 – August 15)
Analysed	Y
Temperature [°C]	Not reported
pH range	6.37-9.20 (mean 7.57, s.d. 0.59)
Hardness [mg $CaCO_3$/L]	106-230 (mean 161, s.d. 27)
Exposure time	125 d
Criterion	NOEC
Test endpoint	Population response of benthic invertebrates and zooplankton
Value [µg/L]	< 0.31 (mean actual concentration).
GLP	N
Guideline	
Notes	
Ri	2
Reference	Fairchild et al., 1992

DESCRIPTION

Test system

Twelve mesocosms of 1000 m^2, 1.5 m deep, 700 m^3 were placed in Columbia; clay sediment (3.2% carbon). Natural populations of phytoplankton and periphyton were present. Submerged vegetation was comprised of *Chara* sp. and *Naja* sp., emergents consisted primarily of *Thypha* sp. and *Sagittaria* sp. Natural populations of zooplankton and benthic invertebrates were studied. 9 Months old adult *Lepomis macrochirus* were added at 2 g/m^3, and removed at the end of the test. 30 Caged bluegills were exposed for 2 weeks after each application. Application took place on June 6, June 20, July 5, July 18, August 2 and August 15 of 1988. Treatments of 0, 0.25, 0.67 and 1.71 µg/L in triplicate. Esfenvalerate was injected below the water surface.

Analytical sampling

Sampling took place 0.25, 1, 2, 4, 8, 24, 48, 60, 120 and 240 h post-treatment.

Effect sampling

Primary production was determined at two weeks intervals with the diurnal oxygen method, measured at 0, 0.5 and 1 m depth. Macrophyte biomass and species composition was measured monthly (four samples per cosm, 0.1 m^2). Four benthic samples were taken monthly (400 cm^2), and benthic invertebrates were identified to species level. Zooplankton was sampled weekly (PVC column, 1 m x 5 cm).

Statistical analysis

The results were analysed using regression techniques and non-parametric analysis of variance.

RESULTS

Chemical analysis

Measured concentrations are between 0.27 and 0.37 µg/L for the 0.25 µg/L treatment, 0.77 and 0.94 µg/L in the 0.67 µg/L treatment and between 1.38 and 2.79 µg/L in the 1.71 µg/L treatment. The DT50 in the water column was 10.4 h.

Biological observations

No effects were found on macrophytes and primary production. Effects were found on chlorophyll-*a* in the two highest treatments. According to the authors this is due to indirect effects. Abundance of zooplankton was reduced at all concentrations after the first treatment especially for Cladocera and Copepods. Copepods got affected 2 days after each treatment, but appear to recover 9 days after treatment. Macroinvertebrate numbers were reduced in all treatments after the first application, effects on Ephemeroptera, Gastropoda and Diptera were significant.

Increased mortality of bluegill was found in the highest (1.71 µg/L) treatment. Reduction in reproductive success was found in the 0.67 and the 1.71 µg/L treatment.

Evaluation of the scientific reliability of the field study
Criteria for a suitable (semi)field study

1. Does the test system represent a realistic freshwater community? Yes, natural populations of algae, macrophytes, micro- and macroinvertebrates were present. Fish were added and studied using caged fish.
2. Is the description of the experimental set-up adequate and unambiguous? Yes.
3. Is the exposure regime adequately described? Yes.
4. Are the investigated endpoints sensitive and in accordance with the working mechanism of the compound? Yes.
5. Is it possible to evaluate the observed effects statistically? Data for individual taxa are given. No multivariate analysis is provided, community response is not analysed as such.

These criteria result in an overall assessment of the study reliability. The study is considered to be less reliable (Ri 2).

Because the compound rapidly disappears from the water column, and levels return to zero between treatments, and recovery of organisms is seen between the treatments, the repeated exposure design cannot be used to mimic a chronic exposure.
The study however can be used for acute exposure, and the NOEC after first treatment is < 0.25 µg/L nominal, mean actual concentration < 0.31 µg/L.

Study 5: Stay and Jarvinen, 1995
Multispecies laboratory test with invertebrates and zooplankton

Species; Population; Community	Invertebrates, zooplankton, algae
Test Method	Indoor multispecies
System properties	1 L beaker, 1000 mL, 950 mL medium and 50 mL culture with organisms
Formulation	Esfenvalerate
Exposure regime	Single application 0, 0.01, 0.05, 0.15, 0.50 and 5.00 µg/L. 5 replicates
Analysed	Y
Temperature [°C]	Not reported
pH range	Not reported
Hardness [mg $CaCO_3$/L]	Not reported
Exposure time	42 d
Criterion	NOEC
Test endpoint	Population response of *Hyalella azteca*
Value [µg/L]	0.01 (nominal)
GLP	N
Guideline	
Notes	
Ri	3
Reference	Stay and Jarvinen, 1995

DESCRIPTION
Test system
Microcosms, 1 L, indoor, 12 h light and 12 h dark. 1 application, 5 replicates, applications 0, 0.01, 0.05, 0.15, 0.50 and 5.00 µg/L.
Populations of invertebrates and zooplankton were present. Species composition and origin not reported in detail.
Analytical sampling
Details about sampling times and the resulting concentrations were not reported systematically.
Effect sampling
Zooplankton sampling: 1, 2, 3, 5, 7, 10, 14, 21, 28, 35 and 42 days after application. 50 mL was sampled and after counting returned to the microcosm.
Statistical analysis
Dunnett's procedure was used.

RESULTS
Chemical analysis
Details about sampling times and the resulting concentrations were not reported systematically. A loss of 60% from the water phase in 4 h is reported.
Biological observations
For the most sensitive invertebrate (*Hyalella azteca*) a NOEC of 0.01 µg/L is reported. For other, less sensitive groups, a NOEC of 0.05 is reported. Major changes were found at 0.50 and 5.00 µg/L.

Evaluation of the scientific reliability of the field study
Criteria for a suitable (semi)field study

1. Does the test system represent a realistic freshwater community? Unclear, species composition is not reported, different taxa of zooplankton present.
2. Is the description of the experimental set-up adequate and unambiguous? Yes.
3. Is the exposure regime adequately described? No, details about application are not described in the paper. Results of analyses are reported only partially.
4. Are the investigated endpoints sensitive and in accordance with the working mechanism of the compound? Yes.
5. Is it possible to evaluate the observed effects statistically? No, data of the individual replicates and statistical methods are not reported. No multivariate analysis is provided, community response is not analysed as such.

This criteria result in an overall assessment of the study reliability. The study is considered to be not reliable (Ri 3).

Study 6: Bouldin et al., 2004
Drainage ditch with simulated run-off event

Bouldin et al. (2004) report a simulated run-off event in a drainage ditch. The effects, however, are not studied in the ditch itself, but water, sampled at different distances from the exposure point and at different time intervals is used to determine the toxicity to standard test organisms *Ceriodaphnia dubia, Pimephales promelas* and *Chironomus tentans* in a test. Therefore this test is not further analysed here.

Study 7: Samsoe-Petersen et al., 2001
Enclosure study with natural populations of algae and zooplankton.

Species; Population; Community	algae, zooplankton
Test Method	Enclosure
System properties	Diameter 0.44 m, 1.2 m depth, 200 m^3
Formulation	Esfenvalerate
Exposure regime	0, 0.05, 0.18, 0.61. 2.1, 7.5 and 26 µg/L; control in triplicate, treatments without replications
Analysed	N
Temperature [°C]	11.0 – 11.3 °C
pH range	7.01-7.54
Hardness [mg $CaCO_3$/L]	
Exposure time	10 d
Criterion	NOEC
Test endpoint	Population response of zooplankton
Value [µg/L]	< 0.05
GLP	N
Guideline	
Notes	
Ri	3
Reference	Samsoe-Petersen et al., 2001

Test system
Nine floating enclosures, diameter 0.44 m, 1.2 m depth, 200 m^3 in Castle lake in Denmark. Eutrophic lake, test starting at 28 September 1996, lasting 10 d. Natural populations of zooplankton and algae were present.
Treatments 0, 0.05, 0.18, 0.61, 2.1, 7.5 and 26 µg/L; untreated in triplicate, treatments without replications. In the paper 0.005 is reported, but since this is not logical in the concentration range and not in accordance with the figures in the paper, it is assumed that 0.05 µg/L is right.
Analytical sampling
No details reported for the enclosures (in the paper the fate of esfenvalerate in ponds is described in detail).
Effect sampling
Primary production, chlorophyll-*a* and phytoplankton biomass, and zooplankton were determined daily. Zooplankton was identified and counted.
Statistical analysis
The results were analysed using regression techniques.

RESULTS
Biological observations
Increase of chlorophyll-*a* at concentrations > 1 µg/L. Zooplankton: significant reduction of Cladocera and Copepoda and increase of Rotifers at all concentrations.

Evaluation of the scientific reliability of the field study
Criteria for a suitable (semi)field study

1. Does the test system represent a realistic freshwater community? Yes, enclosures in a natural lake, although only algae and zooplankton are reported.
2. Is the description of the experimental set-up adequate and unambiguous? Yes.
3. Is the exposure regime adequately described? No, no details about exposure are given for the enclosures.
4. Are the investigated endpoints sensitive and in accordance with the working mechanism of the compound? Yes.
5. Is it possible to evaluate the observed effects statistically? No, data of the individual replicates and statistical methods are not reported. No multivariate analysis is provided, community response is not analysed as such.

This criteria result in an overall assessment of the study reliability. The study is considered to be not reliable (Ri 3).

Study 8: Schroll et al., 1998
Artificial pond study aimed at indirect effects on periphytic algae and benthic organisms

Species; Population; Community	Periphytic algae, benthic organisms
Test Method	Artificial pond
System properties	72 m^2, 0.6 – 0.7 m depth
Formulation	Sumialpha
Exposure regime	0, 0.035, 0.077, 0.132 µg/L nominal; no replications
Analysed	N
Temperature [°C]	
pH range	
Hardness [mg $CaCO_3$/L]	
Exposure time	46 d
Criterion	NOEC
Test endpoint	Population response of Ephemeroptera
Value [µg/L]	< 0.035
GLP	N
Guideline	
Notes	
Ri	3
Reference	Schroll et al., 1998

DESCRIPTION
Test system
Artificial ponds, 72 m^2, 0.6 – 0.7 m depth, set up in 1994. Sediment was taken from a natural pond and added to the artificial ponds. Glass plates used as a substrate for periphyton, were added on July 27, ponds were sprayed 10 days later, and glass plates were removed 12, 19, 33 and 46 days after spraying. Dosage: 0, 0.035, 0.077, 0.132 µg/L. Nominal; no replications.
Analytical sampling
Not reported.
Effect sampling
Periphytic algae were identified and counted. Invertebrates were collected in the sediments by 10 sub-samples of 22 cm^2.
Statistical analysis
Two way ANOVA.

RESULTS
Biological observations
Significant increase was found in all concentrations for *Epithemia turgida*. Significant decrease was found for Ephemeroptera in all treatments.

Evaluation of the scientific reliability of the field study
Criteria for a suitable (semi)field study

1. Does the test system represent a realistic freshwater community? No, only periphytic algae and benthic invertebrates are reported.
2. Is the description of the experimental set-up adequate and unambiguous? Yes.
3. Is the exposure regime adequately described? No, "sprayed as if they were farmland", no analyses of the compound.
4. Are the investigated endpoints sensitive and in accordance with the working mechanism of the compound? Yes, although zooplankton is not studied, and the study is aimed at indirect effects.
5. Is it possible to evaluate the observed effects statistically? No, data of the individual replicates are not reported. No multivariate analysis is provided, community response is not analysed as such.

This criteria result in an overall assessment of the study reliability. The study is considered to be not reliable (Ri 3).

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Appendix 4. Detailed bird and mammal toxicity data

Species	Species properties (age, sex)	Product substance	Purity [%]	Application route	Vehicle	Test duration	Exposure time	Criterion	Endpoint	Endpoint oral dosing [mg/kg bw/d]	Endpoint [mg/kg diet]	Ri	Notes	Reference
Birds														
Bobwhite quail	10-d old	Fenvalerate	97.6	Diet	2% corn oil	8 d	5 d	LC50	Mortality		> 5000	2	1	DAR, Beavers et al., 1991a
Bobwhite quail	10-d old	Fenvalerate	97.6	Diet	2% corn oil	8 d	5 d	NOEC	Body weight		1250	2	1	DAR, Beavers et al., 1991a
Bobwhite quail	14-d old	Fenvalerate	96	Diet	Corn oil	8 d	5 d	LC50	Mortality		> 10000	2	1	DAR, Fink, 1975a
Bobwhite quail	14-d old	Fenvalerate	96	Diet	Corn oil	8 d	5 d	NOEC	Body weight		4640	2	1	DAR, Fink, 1975a
Bobwhite quail	Mature male & female	Fenvalerate		Diet	Corn oil	19 w	19 w	NOEC	reproduction		≥ 125	2	1	DAR, Beavers and Fink, 1980a
Mallard duck	10 d old	Fenvalerate	96.7	Diet	2% corn oil	8 d	5 d	LC50	Mortality		> 5000	2	1	DAR, Beavers et al., 1991b
Mallard duck	10 d old	Fenvalerate	96.7	Diet	2% corn oil	8 d	5 d	NOEC	Body weight		< 312.5	2	1	DAR, Beavers et al., 1991b
Mallard duck	14 d old	Fenvalerate	96	Diet	Corn oil	8 d	5 d	LC50	Mortality		5502	2	1	DAR, Fink, 1975b
Mallard duck	14 d old	Fenvalerate	96	Diet	Corn oil	8 d	5 d	NOEC	Body weight		464	2	1	DAR, Fink, 1975b
Mallard duck	Mature ♀, ♂	Fenvalerate		Diet	Corn oil	20 w	20 w	NOEC	reproduction		≥ 125	2	1	DAR, Beavers and Fink, 1980b
Mammals														
Rat	♀, ♂, F1; Crl:CDBR	Esfenvalerate		Diet		Multi generation reproduction	9 months	NOAEL	Reproduction	5.56♀; 4.21♂	75	2		DAR, Biegel 1994
Rat	♀, ♂Sprague Dawley	Esfenvalerate		Diet		90 d	90 d	NOAEL	Mortality		300	2		DAR, Kelly, 1984
Rat	♀, ♂Sprague Dawley	Esfenvalerate	tg	Diet		90 d	90 d	NOAEL	Mortality		≥ 500	2		DAR, Larson, 1987
Dog	Beagle	Esfenvalerate	98.7	Diet		1 year	1 year	NOAEL	Toxic symptoms, pathology		> 200	1		DAR, Dickie (1986)

1 The tests were carried out with fenvalerate instead of esfenvalerate.

Appendix 5. Detailed sediment toxicity data

Table A5.1. Acute toxicity of esfenvalerate to freshwater sediment organisms.

Species	Species properties (age, sex)	Sediment type	A	Test compound	Purity %]	pH	o.m. [%]	Clay [%]	T [°C]	Exp. time	Criterion	Test endpoint	Result test sediment [mg/kg dw]	Result std. sediment [mg/kg dw]	Ri	Notes	Reference
Crustacea																	
Hyalella azteca	6-12 days old		Y	Asana	8.4		1.87	31.7	23	10 d	LC50	Mortality	0.0104	0.0556	2	1,2,3,5	Amweg et al., 2005
Hyalella azteca	6-12 days old		Y	Asana	8.4		2.38	43.1	23	10 d	LC50	Mortality	0.0141	0.0592	2	1,2,3,5	Amweg et al., 2005
Hyalella azteca	6-12 days old		Y	Asana	8.4		11.05	21.3	23	10 d	LC50	Mortality	0.0483	0.0437	2	1,2,3,5	Amweg et al., 2005
Hyalella azteca	6-12 days old		Y	Asana	8.4		1.87	31.7	23	10 d	NOEC	Growth	0.0033	0.0175	2	1,2,3,4,5	Amweg et al., 2005
Hyalella azteca	6-12 days old		Y	Asana	8.4		2.38	43.1	23	10 d	NOEC	Growth	0.0070	0.0293	2	1,2,3,4,5	Amweg et al., 2005
Hyalella azteca	6-12 days old		Y	Asana	8.4		11.05	21.3	23	10 d	NOEC	Growth	0.0322	0.0292	2	1,2,3,4,5	Amweg et al., 2005
Insecta																	
Chironomus riparius		OECD type	Y	Esfenvalerate	tg		10	20		28 d	NOEC	Emergence	ca. 5		4	6	Samsoe-Petersen et al., 2001
Chironomus tentans			Y	Asana XL	8.6					10 d	NOEC	Mortality and growth	37.1		4	7	Bouldin et al., 2004

1 Pesticide was dissolved in an acetone carrier and spiked into sediment using <200 µL acetone/kg wet sediment (0.02%). Solvent control survival averaged 95 %.
2 Performed using standard U.S. EPA protocols: U.S. Environmental Protection Agency. 2000. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates, 2nd ed. EPA/600/R-99/064. Office of Research and Development, Washington, DC.
3 Recoveries were av. 58%. Toxicity values were adjusted for mean recovery.
4 Result recalculated from µg/g o.c.
5 Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient.
6 Esfenvalerate was dosed at one point (in water and as soil slurry) in a slowly flowing ditch. Samples of sediment were taken in space and time and the % mortality and concentration of esfenvalerate (mg/kg) in the sediment were determined.
7 Amount of sediment per test flask not given. Concentration in sediment could not be calculated.

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Appendix 6. References used in the appendices

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