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Environmental risk limits for teflubenzuron

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This investigation has been performed by order and for the account of Directorate-General for Environmental Protection, Directorate for Soil, Water and Rural Area (BWL), within the framework of Standard setting for other relevant substances within the WFD

Rapport in het kort

Environmental risk limits for teflubenzuron

Dit rapport geeft milieurisicogrenzen voor het insecticide teflubenzuron 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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Contents

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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 the insecticide teflubenzuron. 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). Teflubenzuron 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 pesticides, the evaluation report prepared within the framework of EU Directive 91/414/EC (Draft Assessment Report) was consulted (EC, 2007; further referred to as DAR). An on-line literature search 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.

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 Annexes 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). Endpoints from tests with formulated products were not selected if the results (expressed on the basis of the active substance) differed by more than a factor of 3 from the results obtained with the active substance itself.

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.

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 ($MPC_{eco, water}$), seconEC, 2006y poisoning ($MPC_{sp, water}$) or human consumption of fishery products ($MPC_{hh\ food, water}$); 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 (see 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 teflubenzuron

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

3.1.1 Identity

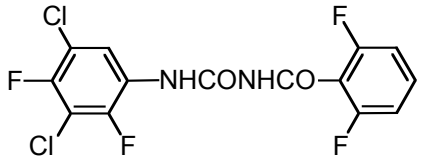

Figure 1. Structural formula of teflubenzuron.

Table 1. Identification of teflubenzuron.

Parameter	Name or number	Source
Common/trivial/ other name	teflubenzuron	EC, 2007
Chemical name	1-(3,5-Dichloro-2,4-difluorophenyl)-3-(2,6-difluorobenzyl)-urea (IUPAC)	EC, 2007
CAS number	83121-18-0	EC, 2007
EC number	not assigned	EC, 2007
SMILES code	Fc1cccc(F)c1C(=O)NC(=O)Nc2cc(Cl)c(F)c(Cl)c2F	Footprint pesticide properties database
Use class	Insecticide	EC, 2007
Mode of action	Insect growth regulator. It acts by inhibition of chitin synthesis and moulting, disrupting chitin deposition in the insect cuticle after ingestion. It may affect fertility of female insects after contact or ingestion.	EC, 2007
Authorised in NL	Yes	
Annex 1 listing	No	

3.1.2 Physico-chemical properties

Table 2. Physico-chemical properties of teflubenzuron.

Parameter	Unit	Value	Remark	Reference
Molecular weight	[g/mol]	381.1		EC, 2007
Solubility	[mg/L]	0.01		EC, 2007
	[mg/L]	0.019		Tomlin, 2002
pK_a	[-]	9.2	in water/ methanol 33/67 v/v	
		9.7	extrapolated to water	
log K_{OW}	[-]	> 4.3	20 ºC, pH 7, 99.3% pure	EC, 2007
		4.98	20 ºC, pH 5, 99.5% pure	EC, 2007
	[-]	4.58	ClogP	BioByte, 2006
	[-]	4.56	MlogP	BioByte, 2006
	[-]	4.64	KowWin	US EPA, 2007
log K_{OC}	[-]	4.42	Koc 26062 L/kg	EC, 2007
Vapour pressure	[Pa]	1.3 x 10^{-8}	25 ºC	EC, 2007
Melting point	[°C]	228.7	99.5 % pure	EC, 2007
Boiling point	[°C]	unknown		EC, 2007
Henry's law constant	[Pa.m^3/mol]	6.98 x 10^{-3}		EC, 2007

The log K_{ow} of 4.98 is used as a worst-case on the basis of the available data.

3.1.3 Behaviour in the environment

Table 3. Selected environmental properties of teflubenzuron.

Parameter	**Unit**	**Value**	**Remark**	**Reference**
Hydrolysis half-life	DT50 [d]	stable	pH 5, 7 (30 d)	EC, 2007
		8.7	pH 9	
Photolysis half-life	DT50 [d]	10		EC, 2007
Readily biodegradable		no		EC, 2007
Water/sediment systems	DT50 [d]	11.4-21.4	whole system	EC, 2007
		5.0-9.7	water	EC, 2007
Relevant metabolites	3,5-dichloro-2,4-difluorophenylurea			EC, 2007
	3,5-dichloro-2,4-difluoroaniline			
	2,6-difluorobenzoic acid			
	2,6-difluorobenzamide			
	N-(2,4-difluoro-3,5-dichlorobenzene)-5-fluoro[3H]-dihydroquinazoline-2,4-dione			

3.1.4 Bioconcentration and biomagnification

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

Table 4. Overview of bioaccumulation data for teflubenzuron.

Parameter	**Unit**	**Value**	**Remark**	**Reference**
BCF (fish)	[L/kg]	300		EC, 2007
BMF	[kg/kg]	1	default value for BCF < 2000 L/kg	

3.1.5 Human toxicological threshold limits and carcinogenicity

The following R-phrase is proposed for teflubenzuron: R 40 (EC, 2007). An ADI of 0.01 mg/kg_{bw}/d is proposed in the DAR, based on a number of toxicity studies with a lowest relevant NOAEL value of 2.1 mg/kg_{bw}/d for mice (EC, 2007).

3.2 Trigger values

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

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

Parameter	Value	Unit	Method/Source	Derived at section
Log $K_{p,susp\text{-}water}$	3.42	[-]	$K_{OC} \times f_{OC,susp}$ [1]	K_{OC}: 3.1.2
BCF	300	[L/kg]		3.1.4
BMF	1	[kg/kg]		3.1.4
Log K_{OW}	4.56	[-]		3.1.2
R-phrases	R40, R50/53	[-]		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 $kg_{OC}.kg_{solid}^{-1}$ (European Commission (Joint Research Centre), 2003).

- teflubenzuron has a log $K_{p,\ susp\text{-}water} \geq 3$; derivation of $MPC_{sediment}$ is triggered.
- teflubenzuron has a log $K_{p,\ susp\text{-}water} \geq 3$; expression of the MPC_{water} as $MPC_{susp,\ water}$ is required.
- teflubenzuron has a BCF ≥ 100 L/kg; assessment of secondary poisoning is triggered.
- teflubenzuron has an R40 classification. Therefore, an MPC_{water} for human health via food (fish) consumption ($MPC_{hh\ food,\ water}$) should be derived.
- For teflubenzuron, 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 aquatic toxicity data for teflubenzuron is given in Table 6 for freshwater and in Table 7 for the marine environment. Detailed toxicity data for teflubenzuron are tabulated in Appendix 2.

Endpoints based on nominal concentrations were only accepted when below water solubility (10 µg/L). For algae and fish, no acute effect was observed at nominal concentrations that were far above the water solubility. In view of teflubenzuron being an insecticide with a specific mode of action (growth regulator), algae and fish are not expected to be sensitive and therefore the data are treated as would have been done with a complete base set.

Table 6. teflubenzuron: selected freshwater toxicity data for ERL derivation.

Chronic[a]		Acute[a]	
Taxonomic group	**NOEC/EC10 (µg/L)**	**Taxonomic group**	**L(E)C50 (µg/L)**
Algae		**Algae**	
Scenedesmus subspicatus	≥ 8.15[b]	*Scenedesmus subspicatus*	> solubility
Crustacea		**Crustacea**	
Daphnia magna	**0.062**[c]	*Daphnia magna*	1.3[e]
Pisces		**Insecta**	
Oncorhynchus mykiss	18.6[d]	*Aedes aegypti*	**0.53**[f]
		Pisces	
		Lepomis macrochirus	> 6.5[g]

[a] For detailed information see Appendix 2. Bold values are used for ERL derivation.
[b] value included to show that fish are not sensitive, endpoint is not used for ERL-derivation
[c] lowest endpoint length parents from test with active substance
[d] based on measured concentrations, endpoint within 2 times water solubility
[e] geometric mean of 0.33, 2.1 and 2.8 µg/L
[f] geometric mean of 0.41, 0.60 and 0.60 µg/L
[g] value included to show that fish are not sensitive, value is not used for ERL-derivation

Table 7. teflubenzuron: selected marine toxicity data for ERL derivation.

Chronic[a]		Acute[a]	
Taxonomic group	**NOEC/EC10 (µg/L)**	**Taxonomic group**	**L(E)C50 (µg/L)**
Crustacea		**Crustacea**	
Mysidopis bahia	0.043	*Crassostrea gigas*	> solubility

[a] For detailed information see Appendix 2.

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 teflubenzuron, there are not enough marine data available to make this comparison.

3.3.1.2 Mesocosm and field studies

An indoor microcosm and outdoor mesocosm study are summarised in the DAR (EC, 2007). For a more detailed description see Appendix 3. The mesocosm study (Study 2 in Appendix 3) was considered to be sufficiently reliable to get a Ri 2
In this study, the treatment of 0.005 µg/L was considered as the NOEC, based on effects on the zooplankton community. Effects occurred within 3 days after application and lasted for 8 weeks after treatment. This NOEC is a factor of 12 lower than the lowest NOEC in the laboratory dataset. Because exposure was not continuous, the study cannot be used for MPC-derivation. The initial concentration of 0.005 µg/L is considered for the $MAC_{eco, water}$.

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

Considering the fact that algae and fish did not show effects at the level of the water solubility and assuming that algae and fish are not the sensitive species groups, the data are treated assuming a complete base set.
Long-term NOECs are available for three trophic levels, which in principle allows for an assessment factor of 10. However, insects are not included in the chronic dataset. According to the Guidance Document on Aquatic Ecotoxicology (EC, 2002), special attention should be paid to insect growth regulators, since they have more pronounced effects over longer time periods due to the working mechanism (effect on moulting). Therefore, it is advised that chronic studies with insects (*i.e.* Chironomus) are conducted, unless it can be clearly demonstrated that the onset of effects is rapid and that *Daphnia* are of similar sensitivity as compared to chironomids. In the mesocosm study, crustacea appeared to be the most sensitive species group, but cladocera were less sensitive as compared to copepods. Furthermore, the number of chironomids was too low to derive a reliable NOEC. It is therefore not considered to be demonstrated that *Daphnia* is representative for the most sensitive species groups, and an assessment factor of 50 should be applied to the lowest NOEC of 0.062 µg/L, resulting in an $MPC_{eco, water}$ of 0.0012 µg/L (1.2 ng/L).

Not enough marine data are available to derive ERLs (acute base set not complete, no data for fish). The $MPC_{eco, marine}$ cannot be derived.

3.3.1.4 $MPC_{sp, water}$ and $MPC_{sp, marine}$

Teflubenzuron has a BCF > 100 L/kg, thus assessment of secondary poisoning is triggered. Available toxicity data and MPC_{oral} for mammals and birds are given in Table 8. Relevant data for birds are not available.
The lowest MPC_{oral} for rats is 0.33 mg/kg_{diet}, based on a short-term toxicity study. There are, however, also long-term data available, which according to the INS-Guidance prevail over the short-term study, and lead to a MPCoral for the rat of 3.3 mg/kg_{diet}. Taking the lowest MPC_{oral} from the data of rat, mice and dogs, the $MPC_{oral, min}$ is set to 0.5 mg/kg_{diet}.

Table 8. Teflubenzuron: selected mammal data for ERL derivation

Species[a]	Exposure time	Criterion	Effect concentration (mg/kg diet)	Assessment factor	MPC_{oral} (mg/kg diet)
mammals					
Rats	28 days	NOAEL	100	300	0.33
Rats	91 d	NOAEL	100	30	3.3
Rats	120 weeks	NOAEL	100	30	3.3
Rat	two-generation	NOAEL	40	30	1.33
Mice	91 d	NOAEL	100	30	3.3
Mice	18 months	NOAEL	**15**	**30**	**0.5**
Dogs	28 days	NOAEL	10000	300	33.3
Dogs	91 d	NOAEL	100	30	3.3

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

The $MPC_{sp, water}$ can be calculated as $MPC_{oral, min}$ / (BCF × BMF). Using the $MPC_{oral, min}$ of 0.5 mg/kg_{diet}, a BCF of 300 L/kg and a BMF of 1 (Table 5), the $MPC_{sp, water}$ becomes 0.5/ (300 × 1) = 8.3×10^{-4} mg/L = 1.7 µg/L
Because toxicity data for marine predators are generally not available, the $MPC_{oral, min}$ as derived above is used as a representative for the marine environment also. To account for the longer food chains in the

marine environment, an additional biomagnification step is introduced (BMF_2). This factor is the same as given in Table 4. The $MPC_{sp, marine}$ is calculated as MPC_{oral} / (BCF x BMF_1 x BMF_2) = 0.5/ (300 × 1 x 1) = 4.2×10^{-4} mg/L = 1.7 µg/L.

3.3.2 $MPC_{hh\ food,water}$

Derivation of $MPC_{hh\ food, water}$ for teflubenzuron is triggered (Table 5). The $MPC_{hh\ food}$ is calculated from the ADI (0.01 mg/kg_{bw}/d), a body weight of 70 kg and a daily fish consumption of 115 g, as $MPC_{hh\ food}$ = 0.01 x 0.1 x 70/0.115 = 0.61 mg/kg. Subsequently the $MPC_{hh\ food, water}$ is calculated according as 0.61 / (BCF_{fish} x BMF_1) = 0.61 / (300 x 1) = 1.0×10^{-3} mg/L = 2.0 µg/L.

3.3.3 $MPC_{dw, water}$

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

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

The lowest MPC value of the routes included (see Section 2.3.1) should be selected as the general MPC. Therefore, the MPC_{water} is based on the $MPC_{eco, water}$ and set to 0.0012 µg/L

The MPC_{marine} cannot be derived due to lack of data.

3.3.4.1 $MPC_{susp, water}$ and $MPC_{susp, marine}$

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:

$$MPC_{susp, water} = MPC_{water, total} / (C_{susp, Dutch\ standard} \times 10^{-6} + (1/ K_{p,susp\text{-}water}))$$

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 4.42, $K_{p, susp\text{-}water}$ is calculated as 3094.

This results in an $MPC_{susp, water}$ of $0.0012 \text{ x } 10^{-3} / (30 \times 10^{-6} + (1 / 3094)) = 3.4 \text{ x } 10^{-3}$ mg/kg_{dw} = 3.4 $\mu g/kg_{dw}$.

3.3.5 MAC_{eco}

3.3.5.1 $MAC_{eco, water}$

The MAC_{eco} is initially based on the acute laboratory toxicity data. The base set is complete. Teflubenzuron has a potential to bioaccumulate (BCF > 100 L/kg), has a known mode of action and a potentially sensitive species *Aedes aegyptii* is included in the dataset. Therefore, the default assessment factor of 100 applies. There is no concern for effects due to bioaccumulation, because toxicity for fish is low (LC_{50} above water solubility) and bioaccumulation is considered not relevant for small insects This might be a reason to lower the assessment factor to 10 (leading to a $MAC_{eco, water}$ of 0.05 µg/L), but the results of the mesocosm experiment as summarised in Appendix 3 (severe effects at 0.033 µg/L, based on initial concentrations) indicate that sensitive species will most likely not be protected by an assessment factor of 10. A factor of 100 might also be under-protective, in view of the mesososm NOEC of 0.005 µg/L.

For derivation of the $MAC_{eco, water}$, the NOEC 0.005 µg/L from the mesocosm study is used (see 3.3.1.2 and Appendix 3). From a comparison of mesocosm studies with the insecticides chlorpyrifos and lambda-cyhalothrin, it can be concluded that an assessment factor of 3 may be necessary to cover variation at the level of the NOEAEC[1] in case one reliable study is available (De Jong et al., 2008, based on Brock et al., 2006). Lepper (2005) argues that the scope of protection of an environmental quality standard under the WFD is broader than that of the "acceptable concentration" under Directive 91/414. It should be considered that the quality standard must be protective for all types of surface waters and communities that are addressed by the respective standard. Mesocosm studies performed in the context of 91/414 are normally focused on agricultural ditches that can be characterised as eutrophic shallow water bodies. Environmental quality standards under the WFD, however, must assure protection also for water bodies that significantly differ from this paradigm (Lepper, 2005). It is therefore in principle proposed to use an assessment factor of 3 on the NOEC instead of on the NOEAEC. The $MAC_{mesocosm}$ of 0.005 / 3 = 0.0017 µg/L. This value is used for the $MAC_{eco, water}$.

3.3.5.2 $MAC_{eco, marine}$

Not enough marine toxicity data are available to derive a $MAC_{eco, marine}$.

3.3.6 $SRC_{eco, water}$

Chronic data are available for algae. crustaceans (among which *Daphnia*) and fish, the geometric mean of all chronic data (8.15, 0.062, 0.001 and 18.6 µg/L) is 0.31 µg/L.

3.4 Toxicity data and derivation of ERLs for sediment

The log $K_{p, susp-water}$ of teflubenzuron is above the trigger value of 3, therefore, ERLs need to be derived for sediment.

3.4.1 Sediment toxicity data

Detailed toxicity data for teflubenzuron are tabulated in Appendix 5. An 28-days NOEC of 0.05 mg/kg_{dw} was derived at 5% om, this is equivalent to 0.1 mg/kg_{dw} for Dutch standard sediment.

3.4.2 Derivation of $MPC_{sediment}$

Because there is one chronic toxicity test available, the $MPC_{sediment}$ is derived by applying an assessment factor of 1000 to the NOEC of 0.1 mg/kg_{dw}. The $MPC_{sediment}$ is 0.1 $µg/kg_{dw}$, based on Dutch standard sediment with 10% om.

3.4.3 Derivation of $MPC_{marine\ sediment}$

The derivation of $MPC_{marine\ sediment}$ is not possible due to a lack of data.

3.4.4 Derivation of $SRC_{eco, sediment}$

The $SRC_{eco,sediment}$ is calculated using the $SRC_{eco, water}$ and the partitioning method.

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

[1] NOEAEC = No Observed Ecologically Adverse Effect Concentration. Concentration at which effects observed in a study are considered acceptable from a regulatory point of view.

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

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 $K_{p,susp}$ = 2630 L/kg (log $K_{p,\,susp}$ = 3.42), $F\text{air}_{susp}$ = 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 658.5, and the $SRC_{sediment,\,TGD,\,EqP,\,ww}$ as 177 µg/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 $Foc_{susp,TGD}$ = 0.1, the $SRC_{\text{Dutch standard sediment, EqP, dw}}$ = 480 µg/kg$_{dw}$.

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 teflubenzuron in freshwater. No risk limits were derived for the marine compartment because data were not available. The MPC and SRC for sediment were also derived.

The ERLs that were obtained are summarised in the table below. The MPC values that were set for this compound until now, is also presented in this table for comparison reasons. It should be noted that these are indicative MPCs ('ad-hoc MTR'), derived using a different methodology and based on limited data.

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

ERL	Unit	MPC	MAC_{eco}	SRC
Water, old[a]	µg/L	0.1×10^{-3}		
Sediment, old[a]	$\mu g/kg_{dw}$	0.16		
Water, new[b]	µg/L	1.2×10^{-3}	1.7×10^{-3}	0.31
Water, suspended matter	$\mu g/kg_{dw}$	3.4	-	-
Drinking water[b]	µg/L	0.1[c]	-	-
Sediment	$\mu g/kg_{dw}$	0.1	-	4.8×10^{2}
Marine	µg/L	n.d.[d]	n.d.[d]	-
Marine sediment	$\mu g/kg_{dw}$	n.d.[d]	-	-

[a] indicative MPC ('ad-hoc MTR'), source: Helpdesk Water http://www.helpdeskwater.nl/emissiebeheer/normen_voor_het/zoeksysteem_normen/

[b] 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}.

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

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

References

BioByte. 2006. BioLoom [computer program]. version 1.5. Claremont, CA, USA: BioByte Corporation.

Brock TCM, Arts GHP, Maltby L, Van den Brink PJ. 2006. Aquatic risks of pesticides, ecological protection goals and common claims in EU legislation. Integrated Environmental Assessment and Management 2: E20-E46.

Chui, VWD, Wong, KW, Tsoi, KW. 1995. Control of mosquito larvae (Diptera: Culicidae) using Bti and teflubenzuron: laboratory evaluation and semi-field test. Environment International 21 (4): 433-440.

De Jong FMW, Brock TCM, Foekema EM, Leeuwangh P. 2008. Guidance for summarizing and evaluating aquatic micro- and mesocosm studies. A guidance document of the Dutch Platform for the Assessment of higher Tier Studies. Bilthoven, The Netherlands: National Institute for Public Health and the Environment (RIVM). Report no. 601506009/2008. 59 pp.

EC. 2002. Guidance Document on Aquatic Ecotoxicology in the context of the Directive 91/414/EEC. Working document. European Commission, Health and Consumer Protection Directorate-General. SANCO/3268/2001 rev.4 (final). 17 October 2002.

EC. 2003. Technical Guidance Document in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances, Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances and Directive 98/9/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market. Part II. Ispra, Italy: European Chemicals Bureau, Institute for Health and Consumer Protection. Report no. EUR 20418 EN/2.

EC. 2007. Draft Assessment Report Teflubenzuron. Rapporteur Member State: United Kingdom.

Footprint pesticide properties database. Hatfield, United Kingdom: Agriculture & Environment Research Unit, University of Hertfordshire http://sitem.herts.ac.uk/aeru/footprint/en/index.htm.

Lepper P. 2005. Manual on the Methodological Framework to Derive Environmental Quality Standards for Priority Substances in accordance with Article 16 of the Water Framework Directive (2000/60/EC). 15 September 2005 (unveröffentlicht) ed. Schmallenberg, Germany: Fraunhofer-Institute Molecular Biology and Applied Ecology.

MNP. 2006. Tussenevaluatie van de nota Duurzame gewasbescherming. Bilthoven, The Netherlands: Milieu- en Natuurplanbureau. MNP-publicatienummer: 500126001.

Tomlin CDS. 2002. e-Pesticide Manual 2002-2003 (Twelfth edition) Version 2.2. British Crop Protection Council.

U.S. EPA. 2007. EPI Suite™ [computer program]. Version 3.2. Washington, DC, U.S.A: U.S. Environmental Protection Agency (EPA), Office of Pollution Prevention Toxics and Syracuse Research Company (SRC).

Van Vlaardingen PLA, Verbruggen EMJ. 2007. Guidance for the derivation of environmental risk limits within the framework of the project 'International and National Environmental Quality Standards for Substances in the Netherlands' (INS). Bilthoven, The Netherlands: National Institute for Public Health and the Environment (RIVM). Report no. 601782001. 146 pp.

rivm

Appendix 1. Information on bioconcentration

Species	Species properties	Substance purity(%)	Analysed	Test type	Test water	pH	Hardness/ Salinity [g/L]	Temp. [°C]	Exp. time	Exp. concn. [mg/L]	BCF [L/kg_{ww}]	BCF type	Calculation method	Ri	Notes	Reference
Cyprinus carpio	5.8 cm, 5.3 g	>99	LSC+TLC	F	dtw			25 ± 1	28	0.00169 ± 0.0021	300	whole fish	k1/k2	2	1	EC, 2007

1) BCF based on total radioactivity was 640 L/kg. Based on 14C-residue of the parent compount in water and fish, the BCF was recalculated to be 300 L/kg

Appendix 2. Detailed aquatic toxicity data

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

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Hardness CaCO3 [mg /l]	Exp time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
Algae																
Scenedesmus subspicatus	1000 cells/mL	Y	S	BAS 309 I	99.5	am	5.9-6.5	23.4 ± 0.7		96 h	growth	EC50	> 20	2	10,11,12,21	EC, 2007
Pseudokirchneriella subcapitata		N	S	CME 134 06/formulation	13.3		7.9			72 h	growth	EC50	>133000	3	4,6,9,16	EC, 2007
Crustacea																
Daphnia magna	<1 day old	Y	S	BAS 309 I	>99.5	am	7.6-8.2	21.0		48 h	immobility	EC50	2.80	2	2,10,12,20	EC, 2007
Daphnia magna	<1 day old	N	S	CME 134 06/formulation	13.3	dw	8.1-8.2	20.0		48 h	immobility	EC50	0.33	2	1,4,13,22	EC, 2007
Daphnia magna	<1 day old	N	S	CME 134 06/formulation	13.3			20 ± 1		48 h	immobility	EC50	2.10	2	2,4,22	Ctgb, 1999
Sida crystallins										48 h	immobility	EC50	10.35	4	10	Chui et al. 1993
Palaemonetes sp.										24 h	survival	EC50	40	4	10	Chui et al. 1993
Palaemonetes paucidens	young adult, 3 cm	N	R	teflubenzuron	>95			24-25		96 h	survival	LC50	>1000	3	7	Ctgb, 1999
Insecta																
Aedes aegypti	Bora-bora	N	S	teflubenzuron	rg			25		24 h	mortality	LC50	0.60	2	7	Chui et al., 1993
Aedes aegypti	wild type	N	S	teflubenzuron	rg			25		24 h	mortality	LC50	0.41	2	7	Chui et al., 1993
Aedes aegypti	Bora-bora	N	S	teflubenzuron	rg			25		24 h	mortality	LC50	0.60	2	7	Chui, Wong and Tsoi, 1995
Pisces																
Onchorhynchus mykiss	juveniles	Y	S	CME 134	96.5	rw	7.8-8.1	14.6-16		96 h	mortality	LC50	>4000	3	1,2,8,9,17	EC, 2007
Onchorhynchus mykiss	juveniles	Y	S	CME 134 06/formulation	13.3			13.7-14.2		96 h	mortality	LC50	>15100	3	1,2,4,6,9	EC, 2007
Lepomis macrochirus	juveniles	Y	CF	CME 134	99		7.7-7.9	22-23		96 h	mortality	LC50	>6.5	2	1,2,18	EC, 2007
Cyprinus carpio	juveniles	Y	S	CME 134	96.5	rw	7.8-8.1	14.6-16		96 h	mortality	LC50	>24000	3	1,2,3,8,9,19	EC, 2007
Cyprinus carpio	juveniles	Y	S	CME 134 06/formulation	13.3			20-20.7		96 h	mortality	LC50	>67000	3	1,2,4,6,9	EC, 2007
Gambusia patruelis										96 h	mortality	LC50	>10000	4	9,10	Chui et al. 1993

NOTES

1 OECD 203
2 based on mean measured concentrations
3 based on measured concentration at the end of the study
4 based on the pure active substance
6 content of active substance not given, according to other study the content of this formulation is 13.3%
7 not conform GLP or guidelines
8 vehicle was Tween 80 (0.01%)
9 (measured) concentration is > 3 times above water solubility limit of 10 µg/L
10 vehicle was acetone
11 based on nominal concentrations
12 92/96/EEC
13 not used as formulation is factor 3 more active than the active substance
14 laboratory strain
15 local field derived strain
16 OECD 201
17 Limit test; nominal concentration of 500 mg a.s./L (measured 370 mg a.s./L) declined to 4 mg a.s./L after 96 h.
18 Limit test; measured concentration of 0.0074 mg/L at test initiation declined to 0.005 mg/L at end of test
19 Limit test; nominal concentration of 500 mg a.s./L (measured 93.5%) declined to 4.8% of nominal after 96 h.
20 recovery 64-11% of nominal
21 limit test at nominal 0.2 mg/L; actual conc. 81.5% at test initiation and decline to no test item at test end.
22 OECD 202
23 dissolved in acetone0.001%

Table A2.2. Acute toxicity of teflubenzuron to marine organisms.

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
Crustacea																
Artemia salina													50	3	2	Chui et al. 1993
Mollusca																
Crassostrea gigas	embryos	Y	S	CME 134	98.7	am	7.8-8.4	22-26.5	32	48 h	inhibition	EC50	> 10	2	1,3,4	EC, 2007

NOTES

1 inhibition of development into D-shaped embryos
2 no further details given; result > 3 times above limit of aqueous solubility of 10 µg/L
3 initial measured concentrations were 1-12% of nominal
4 endpoint set at > water solubility (10 µg/L)
5 acetone as solvent; control included

Table A2.3. Chronic toxicity of teflubenzuron to freshwater organisms.

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Hardness CaCO3 [mg/L]	Exp, time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
Algae																
Scenedesmus subspicatus	1000 cells/mL	Y	S		99.5	am	5.9-6.5	23.4 ± 0.7		96 h	growth	NOEC	≥ 8.15	2	5,6,13,17	EC, 2007
Pseudokirchneriella subcapitata		N	S	CME 134 06/formulation	13.3		7.9			72 h	growth	NOEC	13300	3	3,14,15,16	EC, 2007
Crustacea																
Daphnia magna		Y	S		>99.5		7.5-8.3	19.2-20.3		21 d	length parent	NOEC	0.062	2	1	EC, 2007
Daphnia magna		Y	S		>99.5		7.5-8.3	19.2-20.3		21 d	reproduction	NOEC	0.185	2	1	EC, 2007
Daphnia magna		N	R	CME 134 06 SC/formulation	13.3	rtw	8.1-8.5	20.5-22.5		21 d	reproduction	NOEC	0.013	2	1,2,3,7	EC, 2007
Daphnia magna	< 1d old	N	R		>90	am		20.5-22.5		21 d	reproduction	NOEC	20	3	1,8	Ctgb, 1999
Palaemonetes paucidens	young adult, 3 cm	N	R		>95			24-25		35 d	survival	NOEC	0.001	3	4,10	Ctgb, 1999
Pisces																
Onchorhynchus mykiss	8 weeks old, 963 mg	Y	F		>99.5	rtw	7.36	21.8 ± 1.8	248	28 d	growth inhibition	NOEC	18.6	2	9,11	EC, 2007

1 OECD 202
2 despite lack of analysis, study considered suitable as it was shown in other studies that levels could be maintained.
3 based on pure active substance
4 guideline unknown
5 vehicle acetone
6 based on nominal concentrations
7 formulation factor 3 more active than the active substance; endpoint not selected
8 estimated NOEC higher than water solubility, value unrealistically high
9 actual concentrations were in the range of the water solubility limit during exposure.
10 test solution dissolved in DMSO (0.02%) and HCO-100 (dispersant, 10 mg/L); unknown if solvent control was included
11 OECD 215
12 92/96/EEC
13 limit test at nominal 0.2 mg/L; actual conc. 81.5% at test initiation and decline to no test item at test end.
14 OECD 201
15 content of active substance not given, according to other study the content of this formulation is 13.3%
16 measured concentration is > 3 times above water solubility limit of 10 µg/L
17 nominally 20 µg/L. Results were recalculated to average actual concentrations (0.815 x 20/2)

Table A2.4. Chronic toxicity of teflubenzuron to marine organisms.

Species	Species properties	A	Test type	Test compound	Purity [%]	Test water	pH	T [°C]	Salinity [‰]	Exp. time	Criterion	Test endpoint	Value [µg/L]	Ri	Notes	Reference
Crustacae																
Mysidopsis bahia	<24 h	Y	F	teflubenzuron	98.7	nw	8 - 8.2	27 ± 1	20	27 d	reproduction	NOEC	0.043	2	1	EC, 2007

1) according to current guidelines

Appendix 3. Description of cosm studies

Study 1: Chronic toxicity for *Daphnia magna* under modified exposure conditions.

Species; Population; Community	aquarium A with fish, algae, snails, duckweed, connected to aquarium B with daphnids
Test Method	indoor microcosm
System properties	aquarium A: 80 L water, 5 kg soil; aquarium B: 40 L water
Formulation	^{14}C-teflubenzuron, radiochemical purity >99%
Exposure regime	0.001 mg/L, applied to Aquarium A
Analysed	Y
Temperature [°C]	25-26 °C
pH range	7.5-8.2
Hardness [mg $CaCO_3$/L]	
Exposure time	28 d
Criterion	NOEC
Test endpoint	daphnid survival and reproduction
Value [µg/L]	0.0001 mg/L (measured)
GLP	N
Guideline	
Notes	
Ri	3
Reference	EC, 2007 (Study of Yamauchi et al., 1988)

In the DAR on teflubenzuron, an indoor microcosm study, performed with ^{14}C-teflubenzuron is evaluated. The present evaluation of the microcosm study is solely based on the summary in the DAR.
Test system. A flow-through system was set up that consisted of two connected units: Aquarium A contained 80 L water, 5 kg soil (air dried upland sandy loam, 5 mm sieved), eight additional sampling beakers with 45 g soil, 100 killifish (*Oryzias latipes*; 2 cm, 0.2 g), 10 g algae (*Scenedesmus subspicatus*), 40 snails (*Physa acuta*) and 1 g duckweed (*Spirodela polyrhiza*). Aquarium B contained 40 L water, one 5 L glass beaker with 100 *Daphnia magna* (7-day old; for cultivation as fish food) and five 1 L glass beakers with 20 daphnids (<24 h old) each to follow effects on survival and reproduction.
At the start of the test, ^{14}C-teflubenzuron was added to Aquarium A to reach a concentration of 0.001 mg/L (1 µg/L), flow rate (to Aquarium B) was 8 L/d. Temperature 25 ± 1 °C, 16:8 h L:D. Dilution water was dechlorinated, aerated tap water, 25 °C. One system for treatment, one as control.
Analytical sampling. At each sampling time (individual times not reported), water samples from each aquarium were analysed with LSC and TLC for teflubenzuron and metabolites after sequential extraction with ethyl-acetate (pH 2). From the sediment beakers, 1 g was analysed for each of the 0-1, 1-2 and 2-3 cm layers by LSC after combustion, three remaining beakers were used for determination of teflubenzuron and metabolites. One fish was combusted for determination of total ^{14}C, four fish were homogenised to determine teflubenzuron and metabolites, two fish were submitted to autoradiography for determination of ^{14}C-distribution. One snail was combusted for determination of total ^{14}C, three snails were homogenised to determine teflubenzuron and metabolites. Duckweed (0.06-0.22 g) was analysed for ^{14}C after combustion.
Observations on *D. magna*. The number of survivors and offspring was determined three times a week. Effects on other organisms in Aquarium A were not reported.

RESULTS
Chemical analysis. ^{14}C-residue in water of Aquarium A declined to about 50% of the initial concentration after 1 day and further to 0.034 µg/L after 28 days. In Aquarium B, ^{14}C-residue in water reached a maximum of 0.24 µg/L after 7 days, and then declined at a similar rate as compared to Aquarium A. In Aquarium B, the concentration of ^{14}C-teflubenzuron reached a maximum of 0.11 µg/L after 1 day, and then declined more slowly. Teflubenzuron in water of both aquaria rapidly decreased to ca. 5% after 7 days and then remained constant. It is stated in the DAR that more than 40-50% of the ^{14}C-residue was not extracted from the water. Radioactivity in sediment (0-1 cm) increased up to 7 days and reached a plateau at 8 µg/kg. The concentration of teflubenzuron reached a maximum of 2.3 µg/kg after 4 days, then decreased and reached a plateau of ca. 1.2 µg/kg after 14 days.
Results of the analysis of fish, snails and duckweed are not given here, since they were only used for a qualitative assessment of metabolisation.

Observations on *D. magna*. There was no significant effect on survival and reproduction of daphnids during the 28-days exposure period.

Based on the results of the study, the NOEC for survival and reproduction of *D. magna* is set to 0.0001 mg/L, based on the measured initial concentration of teflubenzuron.

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, water living macro-invertebrates are not included, and one species of each group is present. The system thus represents a multi-species test rather than a freshwater community experiment.
2. Is the description of the experimental set-up adequate and unambiguous? Yes, although individual sampling dates are not given.
3. Is the exposure regime adequately described? No. Total recovery is not given, individual time points are not reported. The maximum concentration of teflubenzuron in Aquarium B on day 1 (0.11 µg/L) was ca. 10 times lower than the nominal initial concentration in Aquarium A (1 µg/L). The reported concentration in the water phase of 5% after 7 days is equivalent to 0.05 µg/L. It is stated in the summary that more than 40-50% of the ^{14}C-residue was not extracted from the water. It is not clear whether the 40-50% relates to total ^{14}C in the water phase, or to total ^{14}C applied to the system. The first option would be indicative of a poor extraction method, the second option would be indicative of sorption to sediment. In conclusion, the actual initial concentration and the exposure concentration over the 28-days test duration are not clear.
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.

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

Study 2: Outdoor mesocosm experiment

Species; Population; Community	phytoplankton; zooplankton; macro-invertebrates
Test Method	outdoor mesososm
System properties	636 L; sediment
Formulation	Nomolt 150 SC (157.6 g as/L)
Exposure regime	0.005, 0.033, 0.1, 0.33, 1.2, 3.3 and 10 µg as/L; two applications with 14-d interval
Analysed	Y; treatments at t=24 h, separate systems (2011 L; 0.1 and 10 µg/L) followed over 120 d
Temperature [°C]	15-25
pH range	6.5-8.5; only small deviations from control
Hardness [mg $CaCO_3$/L]	
Exposure time	190 d
Criterion	NOEC
Test endpoint	community
Value [µg/L]	2 x 0.005 (nominal)
GLP	Y
Guideline	OECD; SETAC;
Notes	
Ri	2
Reference	EC, 2007 (study of Huber et al., 2006)

In the DAR on teflubenzuron, an outdoor mesocosm study performed with Nomolt 150 SC in compliance with GLP is evaluated. The present evaluation of the study is solely based on the summary in the DAR.

Test system. Pond enclosures (∅ 0.9 m, 1 m water depth) with sediment (characteristics/volume not reported) were treated twice (interval 14 d) with Nomolt 150 SC, nominal application rates 0.005, 0.033, 0.1, 0.33, 1.2, 3.3 and 10 µg as/L (spray or mixing not reported). Replicate ponds for treatments, five control ponds (Series A). The initial set-up of the biological system is not reported. Two additional ponds (Series B), with equivalent biological system but larger (2000 L), were set up to monitor fate of teflubenzuron at 0.1 and 10 µg as/L.

Analytical sampling. Treatment solutions were analysed. Water samples were taken from the Series A test enclosures 45 min. after application to determine actual initial concentrations. Series B was sampled 45 min., 4, 8 and 24 h, and 3, 7, 13, 14, 28, 56, 83 and 120 d after treatment.
Biological sampling. Biological samples were taken before and until 119 days after treatment. The following parameters were evaluated:

- Zooplankton: total density, taxa abundance/richness, density of dominant taxa (*Cladocera, Rotifera, Copepoda*)
- Phytoplankton: taxa richness and abundance
- Peripthyon: taxa richness and abundance
- Macro-invertebrates: total density, taxa abundance/richness, density of dominant taxa
- Chlorophyll a

Data treatment and statistics. Abundance of single species and/or taxa were evaluated with William's test after log(x+1) transformation. Logistic regression analysis was performed for selected sample occasions where effects were observed. PRC-analysis with Monte-Carlo simulation to detect for significant effects of the treatment on the community. PCA for each sampling date combined with William's test to determine the $NOEC_{community}$.
RESULTS
Chemical analysis.
Series A (treatments 0.005 – 10 µg as/L). Overall mean recovery in treatment solutions was 97%. Measured concentrations at 45 min. after application were very high in one replicate of the 0.033 µg as/L treatment (pond 8), where 455 and 394% of nominal was recovered after the first and second treatment, respectively. In one replicate of the 0.005 µg as/L treatment (pond 6), recovery was >1000% of nominal. From the phrasing that "otherwise, the test item residues measured in the pond water samples was in the range of the theoretical values", it may be concluded that actual concentrations in the other ponds were acceptable, but results are not presented in detail.
Series B (fate control, 0.1 and 10 µg as/L). Measured concentrations in the water phase at 120 d after the first application were <30% of nominal at 0.1 µg as/L and 1% of nominal at 10 µg as/L. Concentrations at earlier time points are not reported. Concentrations in sediment reached a maximum after 7 d at 0.1 µg as/L and after 83 d at 10 µg as/L. After 120 d, appr. 43 and 2% of the applied teflubenzuron was found in sediment at 0.1 and 10 µg as/L, respectively. Considering the whole system, concentrations of teflubenzuron decreased with time, the peak was found one day after each application. A mass balance could not be established, but the $DT_{50,system}$ was estimated to be about 20 to 50 d.
Physico-chemical parameters. Characteristics of treated ponds were similar to the controls, small deviations from the control occurred in pH, conductivity or alkalinity, these were related to increased photosynthesis due to decreased grazing pressure. DO was between 2.5 and 11.5 mg/L, low levels at the bottom were considered to due to enhanced degradation as a result of high concentrations of organic material.
Biological system. In the DAR, the description of effects is sometimes inconsistent between text, figures and tables. In the summary below, only those endpoints are reported which could be traced back with certainty from the information presented. Lowest NOEC-values are indicated in bold.

Taxonomic group/ parameter	NOEC [µg as/L]	Notes (days refer to days after 1st treatment)
Chlorophyll a		Concentrations increased transiently at 0.1 µg as/L and higher from day 13-83 after first treatment. Considered to be a secondary effect resulting from decreased grazing pressure.
Phytoplankton		
Community	0.1	strongest effect on Naupliae larvae (Copepoda)
Scenedesmus spp.	0.033	NOEC 0.033 µg as/L at t=42; NOEC 0.1 µg as/L at t = 7, 13, 17, 21, 28, 56, 70
Zooplankton		
Community	**0.005**	strongest effect on Naupliae larvae (Copepoda)
Taxa richness	0.033/0.1	NOEC 0.033 µg as/L at t=42; NOEC 0.1 µg as/L at t = 7, 13, 17, 21, 28, 56, 70
Crustacea	**0.005**	significant effects on total # Crustacea at 0.033 µg as/L and higher
Copepoda	**0.005**	Nauplius larvae at t=7-56; copepodits and adults at t= 3-13 and 17-70 d
Cladocera	**0.005**	NOEC for *Simocephalus vetulus*, *Alona costata* and *Alonella nana* on several time points; at 0.005 µg as/L, these species showed significant effects on one isolated sampling date
Rotatoria	**0.005**	NOEC for *Synchaeta* spp. from day 28-83 (increase at 0.033 µg as/L and higher)
Ostracoda	≥ 10	no effects
Macro-invertebrates		
Community	0.033	some deviations at 0.1 and 0.33 µg as/L; major deviations at 1.2 µg as/L and higher
Taxa richness	0.033	minor, transient decreases at 0.1 and 0.33 µg as/L, full recovery during the course of the study
Chaoborus crystallinus	0.1	numbers failed to increase with control from day 7-35
Chironomidae	0.1	less reliable due to low numbers
Mayflies	0.33	effects on *C. dipterum* and other mayflies at 1.2 µg as/L and higher
Zygoptera spp.	0.1	non significant trend towards inhibition at 0.005 and 0.033 µg as/L
Asellus aquaticus	0.1	clear effects on at 0.33 µg as/L and higher
Plea leachi	0.033	transient negative effects at 0.1 µg as/L and higher, recovery within 8 weeks after 2nd application
Naididae (Oligochaeta)	0.33	increase at higher concentrations

For some taxa, effects were observed at 2 x 0.005 µg as/L, but only on one isolated sampling date. The RMS considers 0.005 µg as/L as the NOEC for this mesocosm study. Since recovery, if applicable, was only established after > 8 weeks, the nominal concentration of 0.005 µg as/L is also considered as the NOEAEC. To further study the potential for recovery, the study was prolonged. Since recovery is not taken into account for standard setting, the second part of the study is not evaluated.

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.
2. Is the description of the experimental set-up adequate and unambiguous? No, most likely due to insufficient reporting in the DAR. Establishment of mesocosms is not described; way of application is not reported and individual sampling dates are not given. However, the study was carried out recently, under GLP and by a renowned institute.
3. Is the exposure regime adequately described? Yes/No. Recovery in treatment solutions was adequate. The test substance was applied twice, but actual concentrations in the treated systems were determined 24 h after the first application only. Results of this analysis are reported as being "in the range of the theoretical values" . In parallel systems at concentrations of 20 and 2000 x NOEC, the test substance disappeared relatively slowly from the system, a $DT_{50,\,system}$ of 20 – 50 d is derived from the data. The rate of initial decline from the water phase is not reported in the DAR. The fact that the concentration of teflubenzuron in sediment peaked after 7 or 83 days at 0.1 and 10 µg/L, respectively, suggests that there was no immediate complete transfer to the sediment phase.
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? Yes, although reporting in the DAR is unclear at some points, the PRC-figures are consistent with the reported NOECs.

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

Selection of endpoints for ERL-derivation
Effects on the zooplankton community were apparent immediately after the first application. Significant effects were observed in zooplankton as from 3 – 7 days after treatment. This indicates that a single peak results in long-term effects, which is consistent with the mode of action of teflubenzuron. There was no indication of a cumulative effect after the second treatment, except for copepods which showed more pronounced effects after the second application as compared to the first. The estimated disappearance rate of 20 – 50 d (whole system) is in agreement with the DAR ($DT_{50,system}$-values of 11.4 and 21.4 days; $DT_{50,water}$ 4.9 and 9.7 days). The fact that actual concentrations after the 2nd treatment are reported to be close to nominal, indicates that there were no residues left from the 1st application at the time the product was applied for the 2nd time. This implies that there was no continuous exposure, and the study is therefore not suitable for MPC-derivation. The initial concentration of 0.005 µg/L is considered for the MAC.

Appendix 4. Detailed bird and mammal toxicity data

Species	Species properties (age, sex)	Purity [%]	Application route	Exp. time	Criterion	Test endpoint	NOAEL [mg/kg$_{bw}$/d]	NOAEC Diet [mg/kg$_{diet}$]	Validity	Notes	Reference
Birds											
mallard duck	57-58 g	92.4	diet	5 d	LC50	mortality		>5000	2		EC, 2007
bobwhite quail	10.5-11	92.4	diet	5 d	LC50	mortality		>5000	2		EC, 2007
bobwhite quail		99.5	diet	42 d	NOEC	mortality, body weight		>1000	3	14	EC, 2007
bobwhite quail		99.5	diet	27 w	NOEC	reproductive parameters			3	15	EC, 2007
bobwhite quail		99.4	diet	28 w	NOEC	reproductive parameters			3	15	EC, 2007
Mammals											EC, 2007
rats	Wistar	96.7	diet	28 d	NOAEL	mortality		100	2	1,4	EC, 2007
rats	Wistar	96.5	diet	91 d	NOAEL	mortality		100	2	2, 5	EC, 2007
rats	Wistar	92.4	diet	120 w	NOAEL	carcinogenic effects		100	2	2, 10, 11	EC, 2007
rats	Sprague-Dawley	92.4	diet	2-gen	NOAEL	reproduction		500	2	13	EC, 2007
mice		91.4	diet	91 d	NOAEL	mortality		100	2	2, 6	EC, 2007
mice		92.4	diet	18 months	NOAEL	carcinogenic effects		15	2	11, 12	EC, 2007
dogs		96.7	diet	28 d	NOAEL	mortality		10000	2	7	EC, 2007
dogs		96.5	diet	91 d	NOAEL	mortality		100	3	2, 3, 8	EC, 2007

NOTES
1 NOAEL based on females
2 NOAEL based on males
3 supportive data only
4 OECD 407
5 US EPA
6 EEC, B.7
7 US EPA 163.82-1
8 OECD 409
9 OECD 452
10 OECD 453
11 US EPA 163.82-2
12 OECD 451
13 OECD 416
14 full range of reproductive endpoints was not considered; pilot study
15 NOEC could not be determined

Appendix 5. Detailed sediment toxicity data

Table A5.1. Chronic toxicity of teflubenzuron to 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 sediment [mg/kg$_{dw}$]	Result std. sediment [mg/kg$_{dw}$]	Ri	Notes	Reference
Chironomus riparius	larvae	artificial	Y		> 99.5	7.3-8.1			20.7-22.1	28 d	female emergence ratio	NOEC	0.05	0.1	1	1,2,3,4,5,6	EC, 2007

NOTES

1 according to current guidelines
2 hardness higher than recommended
3 vehicle acetone
4 based on nominal concentrations
5 sediment spiked
6 sediment prepared according to OECD 218, 5%

rivm

Appendix 6. References used in the appendices

Chui VWD, Wong KW, Tsoi KW. 1995. Control of mosquito larvae (Diptera: Culicidae) using BTI and teflubenzuron: Laboratory evaluation and semi-field test. Environment International 21: 433-440.

Chui VWD, Koo CW, Lo WM, Qiu X-J. 2993. Laboratory evaluation of VectobacR-12AS and teflubenzuron against *Culex* and *Aedes* mosquito larvae under different physical conditions. Environment International 19: 193-202

Ctgb. Verlengingsbesluit van het middel NOMOLT. 26 maart 1999.

EC. 2007. Draft Assessment Report Teflubenzuron. Rapporteur Member State: United Kingdom.

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