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# Environmental risk limits for carbendazim

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RIVM Letter report 601716014/2008

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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 the project "Standard setting for other relevant substances within the WFD".

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# Rapport in het kort

## Environmental risk limits for carbendazim

Dit rapport geeft milieurisicogrenzen voor het fungicide carbendazim in water. 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 are derived for the fungicide carbendazim. 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). Carbendazim 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, DAR) was consulted (EC, 1997; 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 ($MPC_{eco, water}$), secondary poisoning ($MPC_{sp, water}$) or human consumption of fishery products ($MPC_{hh\ food, water}$); derivation of the latter two is depends 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 carbendazim

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

### 3.1.1 Identity

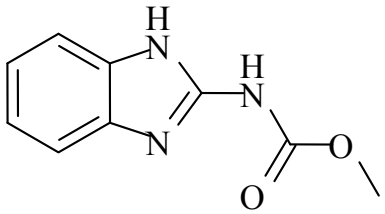

Figure 1. Structural formula of carbendazim.

Table 1. Identification of carbendazim.

| Parameter | Name or number | Source |
|---|---|---|
| Common/trivial/other name | carbendazim, carbendazime, carbendazol | EC, 1997; Tomlin, 2002 |
| Chemical name | methyl 1H-benzimidazol-2-ylcarbamate | EC, 1997 |
| CAS number | 10605-21-7 | EC, 1997 |
| EC number | EEC: 613-048-00-8<br>EINECS:234-232-0 | EC, 1997 |
| SMILES code | COC(=O)NC1=NC2=CC=CC=C2N1 | US EPA, 2007 |
| Use class | Fungicide | EC, 1997 |
| Mode of action | Systemic fungicide with protective and curative action. Absorbed through the roots and green tissues, with translocation acropetally. Acts by inhibiting development of the germ tubes, the formation of appressoria, and the growth of mycelia. | EC, 1997 |
| Authorised in NL | Only in combination | |
| Annex 1 listing | Yes | |

### 3.1.2 Physico-chemical properties

Table 2. Physico-chemical properties of carbendazim.

| Parameter | Unit | Value | Remark | Reference |
|---|---|---|---|---|
| Molecular weight | [g/mol] | 191.21 | | EC, 1997 |
| Water solubility | [mg/L] | 28 to 36 | pH 4 ambient temp. | EC, 1997 |
| | | 5 to 7 | pH 7-8, ambient temp. | |
| p$K_a$ | [-] | 4.2 | | EC, 1997 |
| log $K_{OW}$ | [-] | 1.5 | pH -range 5 – 9 | EC, 1997 |
| | | 0.9 | pH 4 | |
| log $K_{OC}$ | [-] | 2.35 | $K_{oc}$ 200-246 | EC, 1997 |
| Vapour pressure | [Pa] | $9 \times 10^{-5}$ $1.5 \times 10^{-4}$ | 20 °C | EC, 1997 |
| | | | 25 °C | |
| Melting point | [°C] | Above 302 – 307 °C | under decomposition | EC, 1997 |
| Boiling point | [°C] | Not applicable | | EC, 1997 |
| Henry's law constant | [Pa.m3/mol] | $3.6 \times 10^{-3}$ | 24 °C | EC, 1997 |

### 3.1.3 Behaviour in the environment

Table 3. Selected environmental properties of carbendazim.

| Parameter | Unit | Value | Remark | Reference |
|---|---|---|---|---|
| Hydrolysis half-life | DT50 [d] | stable at pH 5, 7 | 22 °C | EC, 1997 |
| | | pH 9: 22 – 124 d | 22 °C | |
| Photolysis half-life | DT50 [d] | stable | | EC, 1997 |
| Readily biodegradable | | no | | EC, 1997 |
| Water/sediment systems | DT50 [d]] | 10.8, 5.8 | water | EC, 1997 |
| | | 16.1, 73.6 | whole system | |
| Relevant metabolites | | 2-AB: 6.3 % in sediment after 76 d | | EC, 1997 |

### 3.1.4 Bioconcentration and biomagnification

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

Table 4. Overview of bioaccumulation data for CARBENDAZIM.

| Parameter | Unit | Value | Remark | Reference |
|---|---|---|---|---|
| BCF (fish) | [L/kg] | 23 | | EC, 1997 |
| BMF | [kg/kg] | 1 | Default value for BCF < 2000 L/kg | |

### 3.1.5 Human toxicological threshold limits and carcinogenicity

The following R-phrases related to human toxicology are proposed in the DAR: R40 (Muta. Cat. 3), R62, R63 (Repr. Cat. 3). According to ESIS (http://ecb.jrc.it/esis/; date of search 26 March 2008), carbendazim is assigned R46 (Muta. Cat. 2), R60, R61 (Repr. Cat. 2). Carbendazim is not classified as being carcinogenic. The ADI is 0.02 mg/kg bw (based on developmental studies in rats and rabbits).

## 3.2 Trigger values

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

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

| Parameter | Value | Unit | Method/Source | Derived at section |
|---|---|---|---|---|
| Log $K_{p,susp\text{-}water}$ | 1.35 | [-] | $K_{OC} \times f_{OC,susp}$ [1] | $K_{OC}$: 3.1.2 |
| BCF | 23 | [L/kg] | | 3.1.4 |
| BMF | 1 | [kg/kg] | | 3.1.4 |
| Log $K_{OW}$ | 1.5 | [-] | | 3.1.2 |
| R-phrases | R40, R62, R63, 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 $kg_{OC}/kg_{solid}$ (EC, 2003).

- Carbendazim has a log $K_{p,\ susp\text{-}water} < 3$; derivation of $MPC_{sediment}$ is not triggered.
- Carbendazim has a log $K_{p,\ susp\text{-}water} < 3$; expression of the $MPC_{water}$ as $MPC_{susp,\ water}$ is not required.
- Carbendazim has a BCF < 100 L/kg; assessment of secondary poisoning is not triggered.
- Carbendazim is classified and labelled with R46, R60, R61. Therefore, an $MPC_{water}$ for human health via food (fish) consumption ($MPC_{hh\ food,\ water}$) should be derived.
- For carbendazim, 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 carbendazim is given in Table 6. There are no valid marine toxicity data. Detailed toxicity data for carbendazim are tabulated in Appendix 2.

It should be noted that the quality of reporting in the DAR (EC, 1997) is very poor: no study summaries are included, aquatic toxicity data are only reported in tables with some additional notes. Data from the DAR were only accepted with Ri 2 if the notes to the tables in the DAR did not give any reason to question the outcome. The lowest endpoints used for ERL-derivation do not originate from the DAR.

Table 6. Carbendazim: 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 | 10200 | Protozoa | 6380[h] |
| Turbellaria | **3.4**[c] | Algae | 340 |
| Clitellata | 21[d] | Turbellaria | 134 |
| Gastropoda | 103 | Clitellata | 980 |
| Gastropoda | 301 | Clitellata | 821 |
| Crustacea | 10[e] | Crustacea | 55[i] |
| Crustacea | 8.0[f] | Crustacea | 234[j] |
| Insecta | 13.3 | Pisces | 440 |
| Pisces | 11[g] | Pisces | **10**[k] |
| Pisces | 1000 | Pisces | 145[l] |
| | | Pisces | 390 |

[a] For detailed information see Appendix 2. Bold values are used for risk assessment.
[b] geometric mean of 10 and 10.4 mg/L, parameter growth for *Scenedesmus subspicatus*
[c] most sensitive endpoint (# neonates) for *Dugesia lugubris*
[d] $LC_{10}$ for *Stylana lacustris*
[e] $LC_{10}$ *Gammarus pulex*
[f] geometric mean of 25.8, 13.0 and 1.5 µg/L, parameter reproduction for *Daphnia magna*
[g] most relevant endpoint (mortality) and most sensitive exposure time for *Oncorhynchus mykiss*
[h] most sensitive test duration (36 h) for *Tetrahymena pyriformis*
[i] most sensitive life stage *Gammarus pulex*
[j] geometric mean of 190, 390, 130, 150, 180, 350, 87, 460, 690 µg/L, parameter immobilisation or mortality for *D. magna*; data for >3 mm animals (adults) omitted and most sensitive endpoint selected for <1.5 mm
[k] most sensitive relevant life stage (fry) for *Ictalurus punctatus*
[l] most sensitive life stage for *O. mykiss*

#### 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 carbendazim, no marine toxicity data are available and ERLs for the marine compartment cannot be derived.

#### 3.3.1.2 Microcosm and mesocosm studies

For carbendazim, two cosm studies were available, a summary and evaluation is given in Appendix 3. In the first study, an indoor microcosm study described in Van den Brink et al. (2000) and Cuppen et al. (2000), the concentration was kept constant for four weeks. The NOEC of 3.3 µg/L can be considered for derivation of an $MPC_{eco, water}$.
In the other study by Slijkerman et al. (2004) one dose was applied, but in view of the slow disappearance from the system, the chronic NOEC of 1.79 µg/L can be considered for the derivation of the $MPC_{eco, water}$.
From the same study, an acute NOEC of 2.17 µg/L can be derived. Fish were not included in the experiment, whereas the lowest $LC_{50}$ in the acute dataset was obtained for a fish species. Therefore the results of this mesocosm study are not considered suitable be used for derivation of the $MAC_{eco, water}$.

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

For carbendazim, a complete base set for toxicity to freshwater organisms is available. Moreover, long-term NOECs of at least three species representing three trophic levels are available. Therefore, the $MPC_{eco, water}$ is derived using an assessment factor of 10 on the lowest NOEC, i.e. the 21-d NOEC for *Dugesia lugubris* of 3.4 µg/L. The initial $MPC_{eco, water}$ based on laboratory tests is 3.4/10 = 0.34 µg/L.

NOECs of 3.3 and 1.79 µg/L are available from micro/mesocosm studies, that are considered valid for derivation of the MPC (see 3.3.1.2). 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.
In addition, the variation between mesocosms is not studied in as much detail for fungicides as e.g. for insecticides. In this case, two studies available which both cover a wide range of tested species, including Turbellaria and Cladocera, which appeared to be most sensitive in the laboratory studies. The NOEC for *Dugesia lugubris*, the species with the lowest laboratory NOEC, was established as 3.3 µg/L in the microcosm experiment. However, fish are not present in the cosms, while the available data indicate that fish may be very sensitive. A valid 96-h $LC_{50}$ of 7 µg/L is available for yolk-sac fry of *Ictalurus punctatus* (see Appendix 2). In view of the life stage, this test duration is chronic but since the endpoint is an $LC_{50}$ rather than a NOEC, it cannot be added to the chronic dataset. It indicates, however, that there is remaining uncertainty as to whether the cosm data do fully cover the potentially sensitive species. Therefore an assessment factor of 3 is kept on the lowest NOEC, resulting in an $MPC_{cosms}$ of 0.60 µg/L.

For comparison, the $MPC_{eco, water}$ is also derived applying Species Sensitivity Distribution (SSD) to the chronic data. This is allowed when at least 10 NOECs (preferably 15) are available for different species covering at least eight taxonomic groups. The taxonomic groups to be covered and their representatives in the present dataset are as follows:

- fish: represented by *Ictalurus punctatus* (familiy Ictaluridae)
- a second family in the phylum Chordata: represented by *Oncorhynchus mykiss* (family Salmonidae)
- crustacea: represented by *Gammarus pulex* and *Daphnia magna*
- insects: represented by *Chironomus riparius*
- a family in another phylum than Arthropoda or Chordata: represented by the phyla Platyhelminthes (Turbellaria)
- a family in any order of insect or any phylum not already represented: represented by Clitellata (phylum Annelida) and Gastropoda (phylum Mollusca)
- algae: represented by *Scenedesmus subspicatus*
- macrophyta: -

The present dataset does not include macrophytes, but carbendazim was shown not to have a direct effect on macrophytes in the mesocosm study of Van den Brink et al., 2000 (see Appendix 3). Therefore, the minimum requirements for performing an SSD are considered to be met.

The data are normally distributed (P = 0.1 Anderson-Darling and Cramer von Mises test; P = 0.05 Kolmogorov-Smirnov test). The median estimate of the HC5 is 0.71 µg/L (90% CI 0.032 - 4.1 µg/L), calculated with ETX 2.0 (Van Vlaardingen et al., 2004). The SSD is shown in Figure 2.

[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.

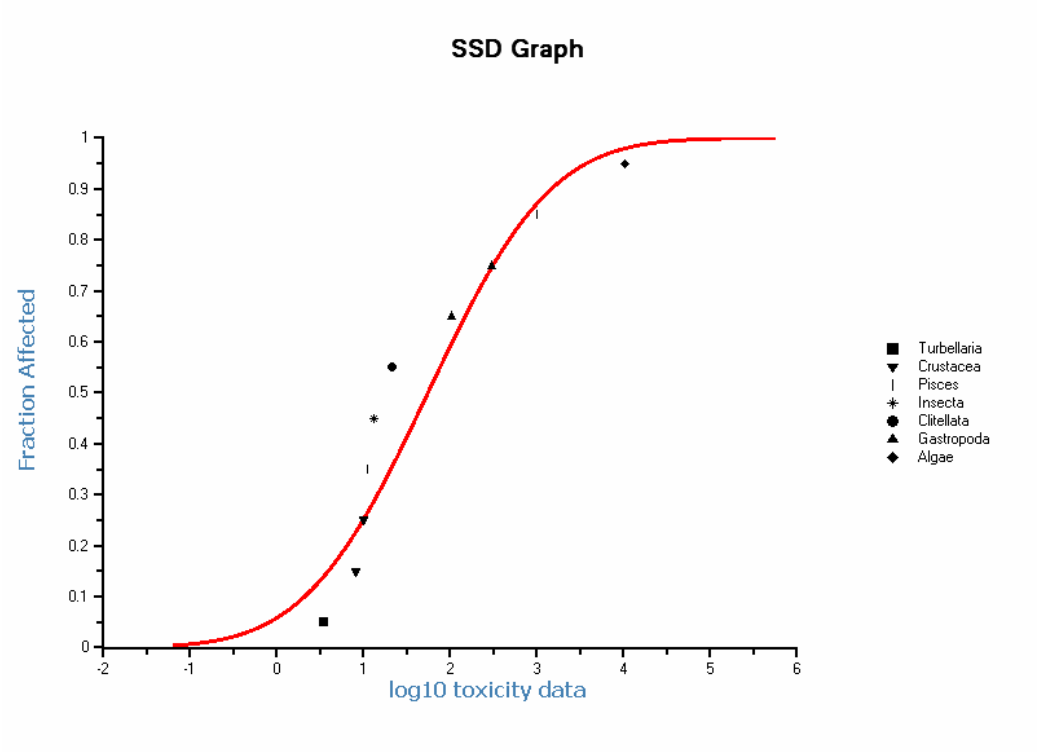


Figure 2. Carbendazim: Species Sensitivity Distribution.

An assessment factor of 1 – 5 should be put on the $HC_5$. The following points are considered for determining the assessment factor (according to p. 75 of the INS-Guidance):

- The overall quality of the dataset is good, all data refer to chronic studies in which sensitive life stages were exposed.
- The dataset is considered to be representative for the aquatic ecosystem, different life forms, feeding strategies and trophic levels are included. The absence of macrophyta is not considered crucial for the estimated $HC_5$. Macrophytes were shown not to be sensitive in the mesocosm study. It is thus not expected that data for plants, if present, would influence the lower end of the curve. In view of the solubility of carbendazim, the NOEC for algae (10 mg/L) is at the upper range of valid NOECs. Additional NOECs for macrophytes far above this highest NOEC of the dataset are thus not expected either. Although the number of data is at the minimum of what is accepted (n = 10), it is considered that the present dataset adequately reflects the range of toxicity.
- The mode of action is known, but is not relevant for the tested species. For fungicides it is not possible to predict beforehand which taxon will be sensitive. The present data show that there is a large variation in toxicity, even within one species group (fish: factor of 90 difference between *Carassius auratus* and *Oncorhynchus mykiss*).
- The goodness of fit is acceptable based on the statistical tests for normal distribution of data, but based on visual judgement the fit is not good. The shape of the curve is most likely influenced to a great extent by the data points in the lower left range. The confidence interval around the HC5 is rather large and spans more than a factor of 130. On the other hand, the $HC_5$ of 0.71 µg/L is about a factor of 5 lower than the lowest NOEC (3.4 µg/L).
- From the mesocosm studies, NOECs of 3.3 and 1.79 µg/L are available (see above) that are considered valid for derivation of the MPC. The NOECs are in good agreement with the lowest NOEC of the laboratory dataset (3.4 µg/L), but are a factor of 2.5 to about 5 higher than the $HC_5$. Fish are, however, not included in the cosm experiments.

In view of the above listed points, there are reasons to apply an assessment factor to the $HC_5$, mainly because of the small dataset, the visual lack of fit and the large confidence interval. The remaining uncertainty is assumed to be covered by a factor of 3, leading to a $MPC_{HC5}$ of 0.24 µg/L.
In the present case, the available information indicates that $MPC_{HC5}$ is rather conservative. The $MPC_{cosm}$ is 0.60 µg/L, which is over a factor of 5 lower than the lowest laboratory NOEC. It is considered justified to use the $MPC_{cosm}$ and set the $MPC_{eco, water}$ to 0.60 µg/L.

No $MPC_{eco, marine}$ can be derived because no valid marine data are available.

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

Carbendazim has a BCF < 100 L/kg, thus assessment of secondary poisoning is not triggered.

### 3.3.3 $MPC_{hh\ food, water}$

Derivation of $MPC_{hh\ food, water}$ for carbendazim is triggered (Table 5). The $MPC_{hh\ food}$ 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 $MPC_{hh\ food, water}$ = 0.02 x 0.1 x 70/0.115 = 1.2 (Van Vlaardingen and Verbruggen, 2007). Subsequently the $MPC_{hh\ food, water}$ is calculated according as 1.2/BCF = 1.2/23 = 0.05 mg/L = 50 µg/L.

### 3.3.4 $MPC_{dw, water}$

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

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

The lowest value of the routes included (see Chapter 2.3) is the $MPC_{eco, water}$. Therefore, the $MPC_{water}$ is 0.60 µg/L.

No $MPC_{marine}$ can be selected due to the absence of data.

### 3.3.6 $MAC_{eco}$

#### 3.3.6.1 $MAC_{eco, water}$

The $MAC_{eco, water}$ may be derived from the acute toxicity data. Fourteen short-term values for three trophic levels are available, carbendazim has no potential to bioaccumulate (BCF <100 L/kg), the mode of action for the tested species is non-specific and the interspecies variation is high. Therefore, an assessment factor of 100 is applied to the lowest $L(E)C_{50}$, i.e. the $EC_{50}$ for *Ictalurus punctatus*: 10 µg/L. Therefore, the $MAC_{eco}$ is initially derived as 10 / 100 = 0.1 µg/L. However, because the $MPC_{water}$ (0.60 µg/L) is higher, the $MAC_{eco, water}$ is put level with the $MPC_{water}$ and becomes 0.60 µg/L.

#### 3.3.6.2 $MAC_{eco, marine}$

Because no data are available for marine organisms, no $MPC_{eco, marine}$ can be derived.

### 3.3.7 $SRC_{eco, water}$

Since more than three long-term NOECs of three 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 55.2 µg/L. Therefore, the $SRC_{eco, water}$ is derived as 55.2 / 1 = 55 µg/L.

## 3.4 Toxicity data and derivation of ERLs for sediment

The log $K_{p, susp\text{-}water}$ of carbendazim is below the trigger value of 3, therefore, ERLs are not derived for sediment.

# 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 carbendazim in fresh water. Derivation of ERLs for the marine compartment was not possible due to lack of data. Derivation of risk limits for sediment was not triggered.

The ERLs that were obtained are summarised in the table below. The MPC value that was set for this compound until now, is also presented in this table for comparison reasons.

Table 7. Derived MPC, $MAC_{eco}$, and SRC values for carbendazim.

| ERL | Unit | MPC | $MAC_{eco}$ | SRC |
|---|---|---|---|---|
| Water, old[a] | µg/L | 0.5 | - | - |
| Water, new [b] | µg/L | 0.60[b] | 0.60 | 55 |
| Drinking water[b] | µg/L | 0.1[d] | - | - |
| Marine | µg/L | n.d.[c] | n.d.[c] | n.d.[c] |

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

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

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

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# 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Bluegill sunfish* | | | | F | | | | | 28 | 0.018 | 27 | | | 2 | | EC, 1997 |
| *Bluegill sunfish* | | | | F | | | | | 28 | 0.17 | 23 | | | 2 | | EC, 1997 |

# Appendix 2. Detailed aquatic toxicity data

Table A2.1. Acute toxicity of carbendazim 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 [mg/L] | Ri | Notes | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bacteria** | | | | | | | | | | | | | | | | |
| *Rhodobacter sphaeroides* | 1B | N | S | Derosol | 50 | am | | 30±2 | | 7d | EC25 | growth | 300 | 3 | 1,2 | Chalam et al., 1997 |
| *Rhodobacter sphaeroides* | 1B | N | S | Derosol | 50 | am | | 30±2 | | 7d | EC25 | nitrogenease act | 300 | 3 | 1,2 | Chalam et al., 1997 |
| *Rhodopseudomonas palustris* | 3A | N | S | Derosol | 50 | am | | 30±2 | | 7d | LOEC | growth | 400 | 3 | 1,2 | Chalam et al., 1997 |
| *Rhodopseudomonas palustris* | 3A | N | S | Derosol | 50 | am | | 30±2 | | 7d | LOEC | nitrogenease act | 400 | 3 | 1,2 | Chalam et al., 1997 |
| **Protozoa** | | | | | | | | | | | | | | | | |
| *Tetrahymena pyriformis* | 20 h old culture | N | S | | ag | am | | 23±1 | | 12h | EC50 | growth | 10.86 | 2 | 20 | Rankin et al., 1976 |
| *Tetrahymena pyriformis* | 20 h old culture | N | S | | ag | am | | 23±1 | | 36h | EC50 | growth | 6.38 | 2 | 20 | Rankin et al., 1976 |
| **Algae** | | | | | | | | | | | | | | | | |
| *Chlorella pyrenoidosa* | | N | S | | | | | | | 72h | EC50 | growth | 0.34 | 4 | 4,8 | DAR, Canton, 1976 |
| *Chlorella pyrenoidosa* | in log phase | N | S | | 97.4 | am | | 24±1 | 96 | 48h | EC50 | growth inhibition | 0.34 | 2 | 4,21,22 | Canton, 1976 |
| *Scenedesmus subspicatus* | | N | S | | | | | | | 72h | EC50 | growth | 419 | 3 | 2,4 | DAR, Heusel, 1991 |
| *Scenedesmus subspicatus* | | N | S | | 32.7 | | | | | 72h | EC50 | growth | 43.8 | 3 | 4,9,24 | DAR, Fischer 1981 |
| *Scenedesmus subspicatus* | | | | | | | | | | 72h | EC50 | | >8.0 | 4 | 2,4 | DAR, List of Endpoints 2005 |
| *Scenedesmus subspicatus* | | N | S | | 98-99.4 | am | | 22 | | 96h | EC50 | growth rate | 54 | 3 | 29 | Maslankiewicz and Linders, 1993 |
| *Pseudokirchneriella subcapitata* | | N | S | | | | | | | 72h | EC50 | growth | 1.3 | 3 | 4,7 | DAR, Douglas, Handley, 1987 |
| *Pseudokirchneriella subcapitata* | | Y | S | | | | | | | 72h | EC50 | | 7.7 | 4 | 3 | DAR, Addendum 2000 |
| **Fungi** | | | | | | | | | | | | | | | | |
| *Campylospora chaetocladia* | | N | S | Bavistin | | | | 28±2 | | 24h | NOEC | conidial germination | 5 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Campylospora chaetocladia* | | N | S | Bavistin | | | | 28±2 | | 24h | EC100 | conidial germination | 2500 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Flabellospora verticillata* | | N | S | Bavistin | | | | 28±2 | | 24h | NOEC | conidial germination | 5 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Flabellospora verticillata* | | N | S | Bavistin | | | | 28±2 | | 24h | EC100 | conidial germination | 2500 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Flagellospora penicilloides* | | N | S | Bavistin | | | | 28±2 | | 24h | NOEC | conidial germination | 10 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Flagellospora penicilloides* | | N | S | Bavistin | | | | 28±2 | | 24h | EC100 | conidial germination | 2500 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Helicosporium sp.* | | N | S | Bavistin | | | | 28±2 | | 24h | NOEC | conidial germination | 10 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Helicosporium sp.* | | N | S | Bavistin | | | | 28±2 | | 24h | EC100 | conidial germination | 2500 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Lunulospora curvula* | | N | S | Bavistin | | | | 28±2 | | 24h | NOEC | conidial germination | 5 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Lunulospora curvula* | | N | S | Bavistin | | | | 28±2 | | 24h | EC100 | conidial germination | 2500 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Wiesneriomyces javanicus* | | N | S | Bavistin | | | | 28±2 | | 24h | NOEC | conidial germination | 1 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| *Wiesneriomyces javanicus* | | N | S | Bavistin | | | | 28±2 | | 24h | EC100 | conidial germination | 2500 | 3 | 2,10,11 | Chandrashekar, Kaveriappa, 1994 |
| **Turbellaria** | | | | | | | | | | | | | | | | |
| *Dugesia lugubris* | half to fully grown | Y | R | Derosal | 511 g/L | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 96h | LC50 | mortality | 0.134 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| **Clitellata** | | | | | | | | | | | | | | | | |
| *Dero digitata* | fully grown | Y | S | Derosal | | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 48h | LC50 | mortality | 0.98 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Stylaria lacustris* | fully grown | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 96h | LC50 | mortality | 0.821 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| **Crustacea** | | | | | | | | | | | | | | | | |
| *Daphnia magna* | <1.5 mm | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | | 48h | EC50 | immobilisation | 0.192 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | <1.5 mm | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | | 96h | EC50 | immobilisation | 0.087 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | <1.5 mm | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | | 48h | LC50 | mortality | 0.32 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | >3 mm | Y | S | Derosal | | dtw | 7.9-8.4 | 18±1 | | 48h | EC50 | immobilisation | 1.34 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | >3 mm | Y | S | Derosal | | dtw | 7.9-8.4 | 18±1 | | 96h | EC50 | immobilisation | 0.186 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | >3 mm | Y | S | Derosal | | dtw | 7.9-8.4 | 18±1 | | 48h | LC50 | mortality | >8 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | >3 mm | Y | S | Derosal | | dtw | 7.9-8.4 | 18±1 | | 96h | LC50 | mortality | 0.399 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | | Y | S | | | | | | | 48h | EC50 | immobilisation | 0.39 | 2 | 3 | DAR, Baer, 1992 |
| *Daphnia magna* | | N | S | | | | | | | 48h | EC50 | immobilisation | 0.087 | 3 | 4,6 | DAR, Hutton, 1988 |

| 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 [mg/L] | Ri | Notes | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Daphnia magna* | | N | S | | | | | | | 48h | EC50 | immobilisation | 0.35 | 2 | 4 | DAR, Stahl, 1985 |
| *Daphnia magna* | | Y | S | | | | | | | 48h | EC50 | immobilisation | 0.15 | 2 | 4 | DAR, Fischer 1988 |
| *Daphnia magna* | | N | S | | 50 | | | | | 48h | EC50 | immobilisation | 0.13 | 2 | 4,9 | DAR, Fischer 1981 |
| *Daphnia magna* | | N | S | | 36 | | | | | 48h | EC50 | immobilisation | 0.18 | 2 | 4,9 | DAR, Heusel, 1992 |
| *Daphnia magna* | <24h old | N | S | | 97.4 | | | 20±1 | | 48h | LC50 | mortality | 0.46 | 2 | 4,21,23 | Canton, 1976 |
| *Daphnia magna* | <24h old | N | S | | 98-99.4 | | 7.4-7.6 | 20 | | 24h | LC50 | mortality | 0.9 | 3 | 25 | Maslankiewicz and Linders, 1993 |
| *Daphnia magna* | | N | S | product | | | 7.7 | 20 | | 48h | LC50 | mortality | 0.27 | 4 | 11,24 | Maslankiewicz and Linders, 1993 |
| *Daphnia magna* | | Y | S | | | | | | | 48h | EC50 | immobilisation | 0.19 | 2 | 3 | DAR, Addendum 2000 |
| *Daphnia magna* | | Y | S | 500 SC | | | | | | 48h | EC50 | immobilisation | 0.19 | 4 | 1,3 | DAR, Addendum 2000 |
| *Daphnia magna* | 5d | N | S | | 97.6 | | 6.9 | 20.5 | | 48h | LC50 | mortality | 0.69 | 2 | 4,30 | Przybylski, Rogoz, 1989 |
| *Gammarus pulex* | juvenile | Y | S | Derosal | | dtw | 7.9-8.4 | 18±1 | | 96h | LC50 | mortality | 0.055 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Gammarus pulex* | adult | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | | 96h | LC50 | mortality | 0.177 | 2 | 3,9 | van Wijngaarden et al, 1998 |
| *Mesocyclops sp.* | adults | N | S | | 50 | nw | | 25±2 | | 24h | LC50 | mortality | 0.101 | 4 | 1,17 | Manonmani et al., 1989 |
| *Simocephalus vetulus* | subadult | Y | S | Derosal | | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 48h | LC50 | mortality | > sol. | 4 | 2,3,9 | van Wijngaarden et al, 1998 |
| **Insecta** | | | | | | | | | | | | | | | | |
| *Chaoborus obscuripes* | larvae | Y | S | Derosal | | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | | EC50 | ability to stay in susp. | > 3435 | 2 | 2,3,9 | van Wijngaarden et al, 1998 |
| **Pisces** | | | | | | | | | | | | | | | | |
| *Carassius auratus* | 40-70mm;6.3g | N | S | | 60 | | 7.8 | 22 | 196 | 96 | LC50 | mortality | >1666 | 3 | 1,4,27 | Maslankiewicz and Linders, 1993 |
| *Cyprinus carpio* | | Y | S | | | | | | | 96h | LC50 | mortality | 0.44 | 2 | 3,5 | DAR, Fischer 1988 |
| *Cyprinus carpio* | | N | S | | 43.6 | | | | | 96h | LC50 | mortality | >436.0 | 3 | 2,4,9 | DAR, Fischer 1981 |
| *Cyprinus carpio* | 40-100g | N | S | | 97 | nw | 7.1 | 16±1 | 400 | 96h | LC50 | mortality | > 5000 | 3 | 1,12 | Lakota et al., 1993 |
| *Cyprinus carpio* | eggs | N | S | | 50 0r 96 | buffer (tris 0.1 M) | 7 | 16 | | 96 h | LC100 | hatching | <2.5 | 3 | 4 | Gilet, Roubaud, 1983 |
| *Cyprinus carpio* | eggs | N | S | | 50 or 96 | buffer (glycine 0.1 M) | 9 | 16 | | 30 min | LC100 | hatching | <5 | 3 | 4 | Gilet, Roubaud, 1983 |
| *Cyprinus carpio* | 62mm;3.5g | N | S | | 10.5 | dw/tw | 8.6 | 22 | 272 | 96 | LC50 | mortality | 240 | 3 | 1,2,4,28 | Maslankiewicz and Linders, 1993 |
| *Cyprinus carpio* | | N | S | | | dw/tw | 8.2 | 22 | | 96 | LC50 | mortality | >1000 | 3 | 1,4,24 | Maslankiewicz and Linders, 1993 |
| *Ictalurus punctatus* | | | | | | | | | | 96h | LC50 | mortality | 0.019 | 4 | 26 | DAR, Palawski, 1984 |
| *Ictalurus punctatus* | Yolk-sac fry | N | S | | 99 | rw | 7.4 | 22 | 40-48 | 96h | LC50 | mortality | 0.007 | 2 | 4,19,31 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Swim-up fry | N | S | | 99 | rw | 7.4 | 22 | 40-48 | 96h | LC50 | mortality | 0.012 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fry; 0.2g | N | S | | 99 | rw | 7.4 | 22 | 40-48 | 96h | LC50 | mortality | 0.01 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fingerling; 1.2 | N | S | | 99 | rw | 7.4 | 22 | 40-48 | 96h | LC50 | mortality | 0.019 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fingerling | N | S | | 99 | rw | 7.4 | 12 | 40-48 | 96h | LC50 | mortality | >0.56 | 3 | 4,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fingerling | N | S | | 99 | rw | 7.4 | 17 | 40-48 | 96h | LC50 | mortality | 0.14 | 3 | 4,18,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fingerling | N | S | | 99 | rw | 7.4 | 22 | 40-48 | 96h | LC50 | mortality | 0.032 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fingerling | N | S | | 99 | rw | 6.5 | 22 | 40-48 | 96h | LC50 | mortality | 0.023 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fingerling | N | S | | 99 | rw | 7.5 | 22 | 40-48 | 96h | LC50 | mortality | 0.014 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fingerling | N | S | | 99 | rw | 8.5 | 22 | 40-48 | 96h | LC50 | mortality | 0.023 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fingerling | N | S | | 99 | rw | 8 | 22 | 40 | 96h | LC50 | mortality | 0.018 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Ictalurus punctatus* | Fingerling | N | S | | 99 | rw | 8 | 22 | 320 | 96h | LC50 | mortality | 0.024 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Lepomis macrochirus* | Fry; 0.2g | N | S | | 99 | rw | 7.4 | 22 | 40-48 | 96h | LC50 | mortality | >3.2 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Lepomis macrochirus* | | N | S | | | | | | | 96h | NOEC | mortality | >17.25 | 2 | 4 | DAR, Hutton 1984 |
| *Lepomis macrochirus* | | | | | | | | | | 96h | LC50 | mortality | 3.2 | 4 | 26 | DAR, Palawski, 1984 |
| *Oncorhynchus mykiss* | | Y | S | | | | | | | 96h | LC50 | mortality | 0.83 | 2 | 3 | DAR, Fischer 1988 |
| *Oncorhynchus mykiss* | | | | | | | | | | 96h | LC50 | mortality | 0.87 | 4 | 26 | DAR, Palawski, 1984 |
| *Oncorhynchus mykiss* | | N | S | | 50 | | | | | 96h | LC50 | mortality | 0.18 | 2 | 4,9 | DAR, Heinemann, 1971 |
| *Oncorhynchus mykiss* | | N | S | | 36 | | | | | 96h | LC50 | mortality | 0.5 | 2 | 4,9 | DAR, Heusel, 1991 |
| *Oncorhynchus mykiss* | 49mm; 1.6g | N | S | | | dw/tw | 7.1 | 15.1 | 251 | 96h | LC50 | mortality | 2.30 | 3 | 4,27 | Maslankiewicz and Linders, 1993 |

| 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 [mg/L] | Ri | Notes | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Oncorhynchus mykiss* | 59mm;2.9g | N | S | | 10.5 | dw/tw | 7.9 | 16.7 | | 96h | LC50 | mortality | 2.1 | 3 | 1,4,28 | Maslankiewicz and Linders, 1993 |
| *Oncorhynchus mykiss* | Yolk-sac fry | N | S | | 99 | rw | 7.4 | 10 | 40-48 | 96h | LC50 | mortality | 0.145 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Swim-up fry | N | S | | 99 | rw | 7.4 | 10 | 40-48 | 96h | LC50 | mortality | 0.32 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fry; 0.2g | N | S | | 99 | rw | 7.4 | 10 | 40-48 | 96h | LC50 | mortality | 0.37 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fingerling; 1.2 | N | S | | 99 | rw | 7.4 | 10 | 40-48 | 96h | LC50 | mortality | 0.87 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fingerling | N | S | | 99 | rw | 7.4 | 7 | 40-48 | 96h | LC50 | mortality | >1.8 | 3 | 4,18,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fingerling | N | S | | 99 | rw | 7.4 | 12 | 40-48 | 96h | LC50 | mortality | 0.87 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fingerling | N | S | | 99 | rw | 7.4 | 17 | 40-48 | 96h | LC50 | mortality | 0.1 | 3 | 4,18,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fingerling | N | S | | 99 | rw | 6.5 | 10 | 40-48 | 96h | LC50 | mortality | 0.64 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fingerling | N | S | | 99 | rw | 7.5 | 10 | 40-48 | 96h | LC50 | mortality | 0.41 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fingerling | N | S | | 99 | rw | 8.5 | 10 | 40-48 | 96h | LC50 | mortality | 0.34 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fingerling | N | S | | 99 | rw | 8 | 10 | 40 | 96h | LC50 | mortality | 0.78 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | Fingerling | N | S | | 99 | rw | 8 | 10 | 320 | 96h | LC50 | mortality | 0.88 | 2 | 4,19 | Palawski, Knowles, 1986 |
| *Oncorhynchus mykiss* | | Y | R | | | | | | | 96h | LC50 | mortality | 0.98 | 2 | 3 | DAR, Addendum 2000 |
| *Oncorhynchus mykiss* | | Y | R | SC 500 | 50 | | | | | 96h | LC50 | mortality | 5.5 | 4 | 1,3 | DAR, Addendum 2000 |
| *Oncorhynchus mykiss* | 3 m old | N | S | | 97.4 | tw | | 10±1 | | 48h | LC50 | mortality | 1.8 | 2 | 4,21 | Canton, 1976 |
| *Salmo trutta* | | N | S | | | dw/tw | 8.7 | 16 | | 96 | LC50 | mortality | 1 | 3 | 1,4,24 | Maslankiewicz and Linders, 1993 |
| *Salmo trutta* | | N | | | 50 | | | | | 96h | LC50 | mortality | 0.39 | 2 | 4,9 | DAR, Fischer, 1981 |
| **Amphibia** | | | | | | | | | | | | | | | | |
| *Rata limnocharis* | 0.28 g | N | S | | 50 | tw | | | | 48h | LC50 | mortality | 173.80 | 3 | 2, 4 | Pan and Liang, 1993 |
| *Rana hexadactyla* | 20mm(15-25mm); 500mg(350-800mg) | N | R | Bavistin | 50 | | 6.2(6.0-6.4) | 14(12-17) | 20(15-25) | 96h | LC50 | mortality | 16.02 | 4 | 1,14,15 | Khangarot et al., 1985 |

**NOTES**

1 not written, if corrected for purity
2 test concentration and/or test result > 3 times above water solubility (29 mg/L - EPIWIN, measured ws: 8 mg/L)
3 Test result based on measured concentrations.
4 Test result based on nominal concentrations.
5 results were recalculated by authors of DAR
6 animals were fed during the test; endpoint not used for risk assessment in DAR
7 cell concentration in the control cultures have not increased by a factor of at least 16 within 3 days
8 incomplete description of test condition, temperature higher than 22°C, replications "at least" in duplicate
9 results are reported as active ingredients
10 1% sucrose solution
11 Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient
12 hardness recalculated form 8mval
13 test solution was change once a week
14 stock solution was prepared in acetone, no information about amount of solvent in test solution, in solvent control was not observed mortality
15 48 h LC50=22.73mg/l
17 sterilized paddy field water
17 sterilized paddy field water
18 too high/low temperature
19 testing for determine effect of pH or Temperature or hardness
20 1% DMSO, but reported not to have effect on cell growth
21 test solution minimally aerated
22 medium according Wanka, 1965
23 medium according Freeman and Fowler 1953
24 test concentration and/or test result above water solubility, but formulated product used
24 product not specified
25 Tylose as solvent, 0.25%
26 figure only cited in DAR, further information not given
27 precipitation of undissolved test substance
28 product with 74.6% maneb as second active ingredient
29 endpoint most likely based on two alage tests above
30 10 animals in 25 mL medium; 96-h LC50 0.270 mg/L
31 not considered for ERL derivation because this is embryonal stage

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

| Species | Species properties | A | Test type | Test compound | Purity [%] | Test water | pH | T [°C] | Salinity [‰] | Exp. time | Criterion | Test endpoint | Value [mg/l] | Ri | Notes | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Polychaeta** | | | | | | | | | | | | | | | | |
| *Pomatoceros lamarckii* | oocytes | N | S | | | am | | 15 | | 5.15h | NOEC | fertilization | 0.0191 | 4 | 1,2,3 | Dixon et al., 1999 |
| *Pomatoceros lamarckii* | oocytes | N | S | | | am | | 15 | | 5.15h | EC100 | fertilization | 1.91 | 4 | 1,2 | Dixon et al., 1999 |
| *Pomatoceros lamarckii* | embryo | N | S | | | am | | 15 | | 6-6.5h | NOEC | development | 0.0019 | 4 | 1,2 | Dixon et al., 1999 |
| *Pomatoceros lamarckii* | embryo | N | S | | | am | | 15 | | 6-6.5h | EC100 | development | 1.9119 | 4 | 1,2 | Dixon et al., 1999 |
| **Pisces** | | | | | | | | | | | | | | | | |
| *Cyprinodon variegatus* | | Y | S | | | | | | | 96h | NOEC | mortality | >1.158 | 2 | 4 | DAR, Boeri, 1988 |

NOTES
1 Eddystone seawater
2 Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient
3 there are also results of frequency of anaphase abberations
4 Test result based on measured concentrations

Table A2.3. Chronic toxicity of carbendazim 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 [mg/L] | Ri | Notes | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bacteria** | | | | | | | | | | | | | | | | |
| *Azospirillum brasilense* | 72h old Isolate No. 13 ( *Paspalum dilatum)* | N | S | Bavistin | | am | | 30 | | 10d | NOEC | N2 fixation | 2000 | 3 | 7,10,18,19 | Zambre, Konde, 1985 |
| *Azospirillum brasilense* | 72 h old Isolate No. 16 ( *Pennisetum americanum)* | N | S | Bavistin | | am | | 30 | | 10d | NOEC | N2 fixation | 2000 | 3 | 7,10,18,19 | Zambre, Konde, 1985 |
| *Azospirillum brasilense* | 72 h old Isolate No. 19 ( Cynodon dactylon) | N | S | Bavistin | | am | | 30 | | 10d | NOEC | N2 fixation | 2000 | 3 | 7,10,18,19 | Zambre, Konde, 1985 |
| **Protozoa** | | | | | | | | | | | | | | | | |
| *Tetrahymena pyriformis* | 20 h old culture | N | S | | ag | am | | 23±1 | | 36h | NOEC | growth | <5.0 | 2 | 20 | Rankin et al., 1976 |
| **Algae** | | | | | | | | | | | | | | | | |
| *Anabaena sp.* | | N | S | Bavistin | | am | | | | 30d | NOEC | growth | 1 | 4 | 11,15,16,17,28 | Shivaprakash, Shetty, 1986 |
| *Anabaena variabilis* | | N | S | Bavistin | | am | | | | 30d | NOEC | growth | 1 | 4 | 11,15,16,17,28 | Shivaprakash, Shetty, 1986 |
| *Aulosira fertilissima* | | N | S | | | am | | 25±3 | | 30d | NOEC | growth | 1000 | 3 | 10,11,12,13 | Gangawane and Saler, 1979 |
| *Calothrix* sp. | | N | S | | | am | | 25±3 | | 30d | NOEC | growth | 500 | 3 | 10,11,12,13 | Gangawane and Saler, 1979 |
| *Calothrix sp.* | | N | S | Bavistin | | am | | | | 30d | NOEC | growth | 20 | 4 | 11,15,16,17,28 | Shivaprakash, Shetty, 1986 |
| *Cylindrospermum musicola* | | N | S | Bavistin | | am | | | | 30d | NOEC | growth | 1 | 4 | 11,15,16,17,28 | Shivaprakash, Shetty, 1986 |
| *Nostoc commune* | | N | S | Bavistin | | am | | | | 30d | NOEC | growth | 20 | 4 | 11,15,16,17,28 | Shivaprakash, Shetty, 1986 |
| *Nostoc muscorum* | | N | S | Bavistin | | am | | | | 30d | NOEC | growth | <1 | 4 | 11,15,16,17,28 | Shivaprakash, Shetty, 1986 |
| *Nostoc* sp. | | N | S | | | am | | 25±3 | | 30d | NOEC | growth | 500 | 3 | 10,11,12,13 | Gangawane and Saler, 1978 |
| *Pseudokirchneriella subcapitata* | | N | S | | | | | | | 72h | NOEC | growth | 0.5 | 3 | 2,22 | DAR, Douglas, Handley, 1987 |
| *Pseudokirchneriella subcapitata* | | Y | S | | | | | | | 72h | NOEC | | 2.5 | 4 | 1 | DAR, Addendum 2000 |
| *Scenedesmus subspicatus* | | N | S | | | | | | | 72h | NOEC | growth | 10 | 2 | 2 | DAR, Heusel, 1991 |
| *Scenedesmus subspicatus* | | N | S | | 32.7 | | | | | 72h | NOEC | growth | 10.4 | 2 | 2,23 | DAR, Fischer 1988 |
| *Scytonema hofmani* | | N | S | Bavistin | | am | | | | 30d | NOEC | growth | 5 | 4 | 11,15,16,17,28 | Shivaprakash, Shetty, 1986 |
| *Tolypothrix tenuis* | | N | S | | | am | | 25±3 | | 30d | NOEC | growth | 1000 | 3 | 10,11,12,13 | Gangawane and Saler, 1978 |
| **Macrophyta** | | | | | | | | | | | | | | | | |
| *rice (Oryza sp.)* | seeds, varieta Suhasini | N | S | | | | | | | 7d | NOEC | germination | 500 | 3 | 10,13,14 | Gangawane and Saler, 1978 |
| *rice (Oryza sp.)* | seeds, varieta Surya | N | S | | | | | | | 7d | NOEC | germination | 500 | 3 | 10,13,14 | Gangawane and Saler, 1978 |
| *rice (Oryza sp.)* | seeds, varieta Satya | N | S | | | | | | | 7d | NOEC | germination | ≥ 1000 | 3 | 10,13,14 | Gangawane and Saler, 1978 |
| **Fungi** | | | | | | | | | | | | | | | | |
| aquatic hyphomycetes | | N | R | Bavistin | | dw | | 28±2 | | 60d | NOEC | sporulation | 5 | 3 | 6,7,8,10 | Chandrashekar, Kaveriappa, 1994 |
| aquatic hyphomycetes | | N | R | Bavistin | | dw | | 28±2 | | 60d | LOEC | sporulation | 500 | 3 | 6,7,9, 10 | Chandrashekar, Kaveriappa, 1994 |
| **Turbellaria** | | | | | | | | | | | | | | | | |
| *Dugesia lugubris* | half to fully grown | Y | R | Derosal | 511 g/L | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 21d | LC10 | mortality | 0.012 | 2 | 1,13 | van Wijngaarden et al, 1998 |
| *Dugesia lugubris* | half to fully grown | Y | R | Derosal | 511 g/L | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 21d | NOEC | reproduction | 0.0034 | 2 | 1,13,29 | van Wijngaarden et al, 1998 |
| *Dugesia lugubris* | half to fully grown | Y | R | Derosal | 511 g/L | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 21d | NOEC | reproduction | 0.011 | 2 | 1,13,30 | van Wijngaarden et al, 1998 |
| **Clitellata** | | | | | | | | | | | | | | | | |
| *Stylaria lacustris* | fully grown | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 7d | LC10 | mortality | 0.021 | 2 | 1,13 | van Wijngaarden et al, 1998 |
| **Gastropoda** | | | | | | | | | | | | | | | | |
| *Bithynia tentaculata* | subadult | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 28d | LC10 | mortality | 1.193 | 2 | 1,13 | van Wijngaarden et al, 1998 |
| *Bithynia tentaculata* | subadult | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 28 | NOEC | reproduction | 0.103 | 2 | 1,13,31 | van Wijngaarden et al, 1998 |
| *Planorbis planorbis* | subadult | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | 28 | NOEC | reproduction | 0.301 | 2 | 1,13,32 | van Wijngaarden et al, 1998 |
| **Crustacea** | | | | | | | | | | | | | | | | |
| *Asellus aquaticus* | subadult | Y | R | Derosal | | dtw | 7.9-8.4 | 18±1 | 71.2-89.2 | | | | | 3 | 1,13 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | <1.5 mm | Y | R | Derosal | | dtw | 7.9-8.4 | | | 25d | EC10 | immobilisation | 0.03 | 2 | 1,13 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | <1.5 mm | Y | R | Derosal | | dtw | 7.9-8.4 | | | 25d | EC50 | immobilisation | 0.044 | 2 | 1,13 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | >3 mm | Y | S | Derosal | | dtw | 7.9-8.4 | | | 25d | NOEC | reproduction | 0.0258 | 2 | 1,13 | van Wijngaarden et al, 1998 |
| *Daphnia magna* | | Y | R | | tg | | | | | 21d | NOEC | immobilisation | 0.027 | 2 | 1,3 | DAR, Baer, 1992 |
| *Daphnia magna* | | Y | R | | tg | | | | | 21d | NOEC | reproduction | 0.013 | 2 | 1 | DAR, Hutton, 1988 |
| *Daphnia magna* | | Y | R | | tg | | | | | 21d | NOEC | reproduction | >0.010 | 2 | 2 | DAR, Fischer, 1988 |

rivm

| 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 [mg/L] | Ri | Notes | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Daphnia magna* | | N | R | Punch CS | 12.1 | | | | | 21d | NOEC | reproduction | 0.01573 | 3 | 2,4,24 | DAR, Baer, 1992 |
| *Daphnia magna* | | N | R | Punch C | 12.1 | | | | | 21d | NOEC | mortality | 0.0605 | 3 | 2,4,24 | DAR, Baer, 1991 |
| *Daphnia magna* | | N | R | Punch C | 12.1 | | | | | 21d | NOEC | reproduction | 0.01573 | 3 | 2,4,24 | DAR, Baer, 1991 |
| *Daphnia magna* | | N | R | Punch C | 12.1 | | | | | 21d | NOEC | growth | 0.007623 | 3 | 2,4,24 | DAR, Baer, 1991 |
| *Daphnia magna* | | N | | | 97.4 | | | | | 18d | EC50 | reproduction | ca. 0.02 | 3 | 2,20 | Canton, 1976 |
| *Daphnia magna* | | N | | | 97.4 | | | | | 18d | EC10 | reproduction | 0.016 | 4 | 2,20 | Canton, 1976 |
| *Daphnia magna* | | N | | | 97.4 | | | | | 18d | NOEC | reproduction | 0.01 | 4 | 2,20,25 | Canton, 1976 |
| *Daphnia magna* | | Y | R | | 99.5 | | | | | 21d | NOEC | reproduction | 0.0015 | 2 | 1 | DAR, Addendum 2000 |
| *Gammarus pulex* | adult | Y | R | Derosal | | dtw | 7.9-8.4 | | | 21d | LC10 | mortality | 0.010 | 2 | 1,13 | van Wijngaarden et al, 1998 |
| **Insecta** | | | | | | | | | | | | | | | | |
| *Chironomus riparius* | | Y | S | 500 SC | 50 | | | | | 28d | NOEC | emergence | 0.0133 | 2 | 4,5 | List of End Points |
| **Pisces** | | | | | | | | | | | | | | | | |
| *Oncorhynchus mykiss* | | N | F | | tg | | | | | 21d | NOEC | mortality | 0.018 | 2 | 2 | DAR, Fischer 1988 |
| *Oncorhynchus mykiss* | | Y | F | | tg | | | | | 79d | NOEC | mortality | 0.011 | 2 | 1 | DAR, Baer, 1993 |
| *Oncorhynchus mykiss* | | N | F | Punch CS | 12.1 | | | | | 21d | NOEC | growth | 0.01452 | 3 | 2,4,24 | DAR, Hutton, 1992 |
| *Oncorhynchus mykiss* | | N | F | Punch C | 12 | | | | | 21d | NOEC | mortality | 0.0228 | 3 | 2,4,24 | DAR, Hutton, 1991 |
| *Cyprinus carpio* | 40-100g | N | R | | 97 | nw | 7.1 | 16±1 | 400 | 14d | LC50 | mortality | 3.16 | 2 | 2,26,27 | Lakota et al., 1993 |
| *Cyprinus carpio* | 40-100g | N | R | | 97 | nw | 7.1 | 16±1 | 400 | 14d | NOEC | mortality | 1 | 2 | 2,26,27 | Lakota et al., 1993 |
| *Cyprinus carpio* | 40-100g | N | R | | 97 | nw | 7.1 | 16±1 | 400 | 24d | LC50 | mortality | 3.16 | 2 | 2,26,27 | Lakota et al., 1993 |
| *Cyprinus carpio* | 40-100g | N | R | | 97 | nw | 7.1 | 16±1 | 400 | 24d | NOEC | mortality | 1 | 2 | 2,26,27 | Lakota et al., 1993 |

NOTES

1 Test result based on measured concentrations.
2 Test result based on nominal concentrations.
3 21-d EC50= 0.066 mg/l; invalid concerning reproduction because results within 2 groups tested are not plausible
4 corrected for purity (recalculated)
5 others results from list of End Points are the same as in DAR
6 18 species on coffee and rubber leaves collected from a free flowing stream
7 Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient
8 no effect of any of 18 species, at the concentration 25 mg/L sporulated 8 test species
9 inhibited sporulation for all 18 species
10 test concentration and/or test result above water solubility (29 mg/L- EPIWIN)
11 Fogg´s nitrogen free medium
12 incubation for 8 hours at light intensity 1500lux at 25±3 and than allowed to grow for 30 days
13 results are reported as active ingredients
14 test petri dishes moist chamber, seeds were irrigated with 10 ml of pesticide suspension, no other data available about test conditions; two concentrations
15 purity is not clear; results are reported in mg/L formulation
16 12 hlight/12 dark; light intensity 2000 flux
17 in the study they examine also nitrogen fixation, but there is regular lack of pattern and changes can be caused by individual metabolism of algae
18 microaerophilic nitrogen-fixing bacterium, in Dobereiner´s N- free semi-solid medium
19 stimulatory effect
20 no information about test condition
21 test concentration and/or test result above water solubility (29 mg/l - EPIWIN, measure ws: 8 mg/l)
22 cell concentration in the control cultures have not increased by a factor of at least 16 within 3 days
23 results are reported as active ingredients
24 product with 23-24.9% flusilazole as second active ingredient
25 read from graph, no statistics
26 hardness recalculated form 8mval
27 test solution was change once a week
28 not clear whether effects are significant
29 # neonates
30 # cocoons
31 # egg clutches
32 increased # egg clutches

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

| Species | Species properties | A | Test type | Test compound | Purity [%] | Test water | pH | T [°C] | Salinity [‰] | Exp. time | Criterion | Test endpoint | Value [mg/l] | Validity | Notes | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Polychaeta** | | | | | | | | | | | | | | | | |
| *Pomatoceros lamarckii* | oocytes | N | S | | | am | | 15 | | 2h15min | NOEC | fertilization | 0.0019 | 4 | 1,2,3 | Dixon et al., 1999 |
| *Pomatoceros lamarckii* | oocytes | N | S | | | am | | 15 | | 2h15min | EC100 | fertilization | 1.91 | 4 | 1,2 | Dixon et al., 1999 |
| *Pomatoceros lamarckii* | embryo | N | S | | | am | | 15 | | 48h | LOEC | development | ≤0.0019 | 4 | 1,2 | Dixon et al., 1999 |
| *Pomatoceros lamarckii* | embryo | N | S | | | am | | 15 | | 48h | EC100 | development | 1.91 | 4 | 1,2 | Dixon et al., 1999 |

NOTES
1 Eddystone seawater
2 Purity is not clear; it is also not clear if results are reported in mg/L formulation or mg/L active ingredient
3 there are also results of frequency of anaphase abberations

# Appendix 3. Description of mesocosm studies

**Study 1: Microcosm study with natural populations of algae, zooplankton and macroinvertebrates.**

| | |
|---|---|
| Species; Population; Community | Algae, plants, zooplankton, macroinvertebrates; decomposition |
| Test Method | Indoor microcosm |
| System properties | Microcosms 1.1 x 1.1 m, height 70 cm, 600 L, 10 cm lake sediment and 50 cm water |
| Formulation | Derosal |
| Exposure regime | 0, 3.3, 33, 100, 330 and 1000 µg/L in duplicate (January 1995) |
| Analysed | Y |
| Temperature [°C] | 19 ± 2 ° |
| pH range | 7.9 - 10 |
| Hardness [mg $CaCO_3$/L] | Not reported |
| Exposure time | 4 weeks, effects followed during 11 weeks |
| Criterion | NOEC 17 |
| Test endpoint | Community and populations of macroinvertebrates and zooplankton |
| Value [µg/L] | 3.3 |
| GLP | N |
| Guideline | |
| Notes | |
| Ri | 2 |
| Reference | Cuppen et al., 2000; Van den Brink et al., 2000 |

Test system. 12 indoor microcosms of glass, 1.1 x 1.1 m, height 70 cm, 600 L, 10 cm lake sediment and 50 cm water. Constant room temperature 19 ± 2 ºC 14 h light.
Natural populations of plankton and soil dwelling macroinvertebrates were introduced into the microcosms with natural sediment and well water. *Elodea nuttallii* and several populations of macroinvertebrates and zooplankton were deliberately introduced, and left to acclimatise during a 3 month period, in which all microcosm were interconnected. The cosms were disconnected before the start of the experiment.
Application took place on January 1995. Nominal initial dosages 0, 3.3, 33, 100, 330 and 1000 g/L in duplicate. The concentration was kept constant during 4 weeks, after which effects were followed for another 6 weeks. The formulation Derasol was sprayed evenly over the surface, mixed through the water column and water was circulated in the cosm during the whole experimental period. Carbendazim was added five times to maintain the intended concentration during the first 4 weeks of the experiment
Analytical sampling. Samples were taken at several moments after the start of the experiment..
Effect sampling.
Phytoplankton was collected several times before and on 1, 2, 3, 4, 5, 6, 7, and 9 weeks after start of exposure. Algal species were identified and counted, chlorophyll *a* determined. Periphyton samples were collected 1, 3, 5, 7, and 9 weeks after start of exposure using glass slides, and chlorophyll a was determined. Standing stock of aquatic macrophytes was determined at the end of the experiment. Bioassays were performed in the cosm with *Lemna minor, Elodea nuttallii* and *Oedogonium.*.
Zooplankton was collected several times before and on 1, 2, 3, 4, 5, 6, 7, and 9 weeks after start of exposure, and species were identified and counted. Apart from this, bioassays with *Daphnia magna* were conducted in the cosm. Macroinvertebrates were sampled at 2 weekly intervals by means of artificial substrate (pebble baskets and multiplates) and from the litterbags (see below). At the end of the experiment all macroinvertebrates in the microcosms were sampled and identified. Bioassays were conducted with *Gammarus pulex, Asellus aquaticus* and *Bithynia tentaculata.* Effects on decomposition were studied using litterbags, containing *E. nuttallii* shoots and *Populus* leaves. In one experiment litterbags were left to decompose during two weeks, and then replaced by new ones. In a second experiment, litterbags were introduced at the start of the experiment, and sampled after 2, 4, 6 and 8 weeks.
Statistical analysis
The results were analysed using analysis of variance, logistic models, and multivariate analyses.
RESULTS

Chemical analysis. The Average Exposure Concentration deviated less than 10% from the nominal concentrations. After this period the half life appeared to be dependent on the dose: 25 weeks in the lowest levels, to 6 weeks in the highest level.
Biological observations.
The PRC for phytoplankton showed a NOEC of 33 µg/L (increase). The lowest NOEC found for individual species (important for the PRC) is 100 µg/L. Chlorophyll-*a* also increased at the highest two treatment levels. A bioassay with *Scenedesmus acutus* showed a decreased growth in the highest dose.
The PRC for periphyton did not show treatment related effects, and for the individual species no clear treatment related effects were found.
The biomass of the macrophytes was significantly increased at the end of the experiment for *E. nuttallii* in the two highest dosages. The same effect was found in the bioassays.
For zooplankton the PRC indicates a NOEC community of 33 µg/L. For individual species the lowest NOEC is found for *Acroperus harpae* (3.3 µg/L). The bioassay with *D. magna* resulted in a 28 d EC10 value of 20 µg/L.
For macroinvertebrates the PRC shows clear effects in the 33 µg/L treatment, resulting in a NOEC community of 3.3 µg/L 1, 5, 7 and 9 weeks after treatment. For 3 species a NOEC < 3.3 was found in the post treatment period. In one case (*Nemertea* sp.) numbers were very low and variable. In the other two cases (*Lymnea stagnalis* and *Segmentina nitida*)higher number were found in the treated microcosms. The bioassays showed effects on *B. tentaculata* in the highest treatment only. For *G. pulex* a NOEC < 3.3 µg/L was found between weeks 3 and 6.
Decomposition: the experiments in which the decomposition period was 2 weeks showed no significant effects. The experiment with longer decomposition periods showed significant lower decomposition 4 weeks after application in the 330 and 1000 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. No fish.
2. Is the description of the experimental set-up adequate and unambiguous? Yes
3. Is the exposure regime adequately described? Unclear. Not all data are reported, but results indicate that measured concentrations are close to nominal during the 4 week exposure period.
4. Are the investigated endpoints sensitive and in accordance with the working mechanism of the compound? Unclear. Carbendazim is a fungicide. Laboratory data show that the substance is toxic to a number of different invertebrate species.
5. Is it possible to evaluate the observed effects statistically? Yes, statistical significant results are reported for community and individual species.

These criteria result in an overall assessment of the study reliability. The study is considered to be less reliable mainly due to the lack of raw exposure and effect data and (Ri 2).

Since in this study a chronic exposure of 4 weeks is maintained, the results can be used for derivation of a $MPC_{eco}$. Based on this mesocosm study study, a NOEC of 3.3 µg/L can be used.

**Study 2: Mesocosm study with natural populations of algae, zooplankton and macroinvertebrates.**

| | |
|---|---|
| Species; Population; Community | Algae, macro-invertebrates |
| Test Method | Outdoor mesocosm |
| System properties | Mesocosms 1.7 (bottom) and 2.25 m (top) diameter, 1.95 m high, 3,000 L, 10 cm sand and 5 cm organic rich sediment from an artificial pond were added. |
| Formulation | Carbendazim |
| Exposure regime | 0 (n = 5), .3 (n = 3), 30 (n = 3) and 300 (n = 3) µg/L (October 3, 2000) |
| Analysed | Y |
| Temperature [°C] | Not reported |
| pH range | 7.9 – 8.5 |
| Hardness [mg $CaCO_3$/L] | Not reported |
| Exposure time | 1 application, mixing during 4 h, effects followed for 4 weeks |
| Criterion | NOEC |
| Test endpoint | Community and populations of phyto- and zooplankton |
| Value [µg/L] | 2.17 |
| GLP | N |
| Guideline | |
| Notes | |
| Ri | 2 |
| Reference | Slijkerman et al., 2004 |

Test system. 17 outdoor mesocosms 1.7 (bottom) and 2.25 m (top) diameter, 1.95 m high, 3000 L, 10 cm sand and 5 cm organic rich sediment from an artificial pond were added.
Natural populations of phytoplankton and zooplankton were introduced into the microcosms with natural sediment and Markermeer water. The cosms were interconnected during two weeks before exposure. The cosms were disconnected before the start of the experiment.
Application took place on October 3, 2000. Nominal initial dosages 0, 3, 30, and 300 g/L in triplo, 5 controls. Carbendazim was dosed under the water surface, and water was circulated during 4 h.
Analytical sampling. Analytical results are reported from day 0 and 29.
Effect sampling.
Zooplankton was collected one day before exposure and 3, 7, 14, 21 and 28 days after exposure and species were identified and counted. Apart from this bioassays with *Daphnia magna* were conducted in the cosm. Feeding activity and survival were measured.
Statistical analysis
The results were analysed using multivariate analyses.
RESULTS
Chemical analysis. The actual concentrations were 30% lower than nominal on day 0. The disappearance rate of the compound was higher in the lower treatment levels than in the higher. The initial measured exposure concentration was: 0.28 µg/L in the untreated control, 2.17 µg/L in the 3 µg/L treatment, 20.67 µg/L in the 30 mg/L treatment and 226 µg/L in the 300 µg/L treatment. Concentrations after 20 days were 0.11, 1.47, 15.33 and 212 µg/L respectively and average exposure concentrations were 0.18, 1.79 µg/L 17.82, 218.8 µg/L, respectively.
Biological observations.
Feeding behaviour of *D. magna* was inhibited in the highest (300 µg/L) treatment only 1 and 3 days after treatment. The PRC for zooplankton showed a clear treatment related response. For the PRC and for the most sensitive group, the Cladocerans, it is clear that significant effects are seen at the 30 µg/L treatment. Effects on the 3 µg/L treatment are also seen, but the are not indicated as significant, and in the PRC the effects on the lowest treatment are more severe than on the middle treatment, until day 14 after treatment. Chlorophyll-*a* also increased at the highest treatment level.

**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, macrophytes, macro-invertebrates and fish are not included.
2. Is the description of the experimental set-up adequate and unambiguous? Yes

3. Is the exposure regime adequately described? Unclear. Not all data are reported, but results indicate that measured concentrations are 30% of nominal shortly after exposure (start and 29 d reported)
4. Are the investigated endpoints sensitive and in accordance with the working mechanism of the compound? Unclear. Carbendazim is a fungicide. Laboratory data show that the substance is toxic to a number of different invertebrate species.
5. Is it possible to evaluate the observed effects statistically? Yes, statistical significant results are reported or can be read from figures for community and individual species-groups..

This criteria result in an overall assessment of the study reliability. The study is considered to be less reliable mainly due to the lack of raw exposure and effect data and (Ri 2).

Since in this study one dose is given, and the actual dose differs considerable from the nominal dose, the actual value of 2.17 µg/L could be used to underpin a MAC-value, with the restriction that the value refers to zooplankton (and algae) only. Since the compound disappears only slowly, it could be considered to use the average exposure concentration of 1.79 µg/L as indicative for an MPC, with the same restrictions concerning the species.

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