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Environmental Risk Limits for aminomethylphosphonic acid (AMPA)

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This investigation has been performed for the account Directorate-General for Environmental Protection, Directorate for Chemicals, Waste and Radiation, in the context of the project 'Setting Integrated Environmental Quality Standards', RIVM-project no. 601501.

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Abstract

In this report environmental risk limits are derived for aminomethylphosphonic acid (AMPA), a primary metabolite of the herbicide glyphosate and a metabolite of phosphonates, ingredients of household and chemical detergents. The MPC for AMPA is 79.7 μg/L. MPCs for soil and sediment could not be established.

Preface

Thanks are due to drs E.M. Maas, who is contact person at the Ministry of Housing, Spatial Planning and the Environment (VROM-DGM/SAS), and to dr. M.P.M. Janssen who is program coordinator for RIVM-project 601501 in which the work was performed.

The results as presented in this report have been discussed by the members of the ‘Setting Integrated Environmental Quality Standards Advisory Group’ (OZBG-eco), who are acknowledged for their contribution. The advisory group provides a non-binding scientific comment on the final draft of a report in order to advise the steering committee of the project Setting Integrated Environmental Quality Standards (INS) on the scientific merits of the report.

The work described in this report relies partly upon a recently published RIVM-SEC advisory report: nr. 08461a00 on glyphosate. Therefore we want to acknowledge A. van der Linde and J.W.A. Scheepmaker who contributed to this report.

Contents

Samenvatting

In dit rapport is een Maximaal Toelaatbaar Risiconiveau (MTR) en een Verwaarloosbaar Risiconiveau (VR) afgeleid voor aminomethylfosfonzuur (AMPA). AMPA is een metaboliet van verschillende stoffen, waaronder het herbicide glyfosaat en fosfonaten, o.a ingrediënten van wasmiddelen. MTRs worden afgeleid met gebruik van ecotoxicologische en milieuchemische data, en representeren het potentiële risico van stoffen voor een ecosysteem. MTRs vormen de wetenschappelijke basis voor milieukwaliteitsnormen die worden vastgesteld door het ministerie van VROM.

In deze studie is gebruik gemaakt van een zogenaamde adviesrapport om de toelating van bestrijdingsmiddelen te beoordelen. Deze adviesrapporten worden opgesteld door het RIVM, Centrum voor Stoffen en Risico's, in opdracht van het College Toelating Bestrijdingsmiddelen (CTB). Alleen toxiciteitstudies met eindpunten die gerelateerd zijn aan overleving, groei of reproductie zijn in beschouwing genomen.

Water
De beschikbare gegevens zijn acute toxiciteit voor algen, watervlooien en vissen. De MTR_{water} is afgeleid door toepassing van een assessment factor van 1000 op de laagste EC50 en is vastgesteld op 79,7 µg/L. het VR is vastgesteld op 0,8 µg/L.

Sediment
Toxiciteitsgegevens voor sediment-bewonende organismen zijn niet beschikbaar. Aangezien de sorptie van AMPA geen relatie vertoont met organische stof- of kleigehaltes, is de toepassing van equilibrium partitie-theorie niet gerechtvaardigd. Een MTR voor sediment is niet beschikbaar.

Bodem
Data betreffende de toxiciteit van AMPA voor bodemprocessen is niet beschikbaar. Omdat er slechts 1 chronische studie voor wormen beschikbaar is in een studie waar geen effecten zijn aangetoond, kan er geen MTR bodem worden berekend. Equilibrium partitie is niet toegepast vanwege bovengenoemde bezwaren.

Voorlopige risk assessment
AMPA wordt regelmatig gemeten in monitoringprogramma's voor oppervlaktewater, met maximumconcentraties tot 5,4 µg/L. De gemeten concentraties zijn beneden de hier afgeleide MTR_{water}. Op basis van deze metingen wordt verwacht dat de soortsamenstelling en daarmee het functioneren van aquatische ecosystemen voldoende wordt beschermd.

Summary

In this report the Maximum Permissible Concentration (MPC), and a negligible concentration (NC) is derived for aminomethylphosphonic acid (AMPA), a metabolite of a number of substances. One of the parent compounds is glyphosate, that is used as a herbicide. Other important parent compounds are phosphonates, ingredients of detergents and coolants. MPCs are derived using data on (eco)toxicology and environmental chemistry, and represent the potential risk of the substances to the ecosystem. They are the scientific basis for Environmental Quality Standards (EQSs) set by the Ministry of VROM.

Water
Only acute data for algae, daphnids and fish are available, the MPC_{water} is derived by application an assessment factor of 1000 to the lowest EC50 and is established as 79.7 µg/L. The Negligible Concentration (NC) is established as 0.8 µg/L.

Sediment
No data for toxicity of the studied compounds to organisms living in sediments were found. As sorption of AMPA is not related to organic matter or clay content, application of the equilibrium partitioning theory is not justified and a $MPC_{sediment}$ is not established.

Soil
Data on the toxicity to soil processes are not available. For soil species, a chronic NOEC of ≥ 28.1 mg/kg at 10% o.m. is obtained for earthworms. As no effects were observed in this study, this value is not used for derivation of the MPC_{soil}. Equilibrium partitioning is not applied in view of the reasons stated above.

Preliminary risk assessment
AMPA is widely occurring in surface waters, maximum concentrations of up to 5.4 µg/L are reported from monitoring networks. The measured concentrations are below the derived MPC_{water}. Species composition and thereby ecosystem functioning in aquatic ecosystems is considered as protected.

1. Introduction

In Dutch surface water, aminomethylphosphonic acid (AMPA) concentrations exceed the European limit for drinking water preparation on a regular base. This prevailing limit, which is set at 0.1 μg/l for individual pesticides and their metabolites, is the main reason for the current policy attention (Kalf and Berbee, 2002). One of the most important parent compounds of AMPA is glyphosate, that is widely used as a herbicide. Other important parent compounds are several synthetic phosphonates used in coolants and detergents. The current study deals with the toxicity of AMPA and the derivation of environmental risk limits (ERLs) for AMPA. The meaning and scientific aspects of ERLs in The Netherlands are discussed below.

Table 1.1. Environmental Risk Limits (ERLs) and the related Environmental Quality Standards (EQS) that are set by the Dutch government in The Netherlands for the protection of ecosystems.
NC Negligible Concentration
MPC Maximum Permissible Concentration
SRC_{eco} Serious Risk Concentration for the ecosystem

Description	ERL	EQS
The NC represents a value causing negligible effects to ecosystems. The NC is derived from the MPC by dividing it by 100. This factor is applied to take into account possible combined effects.	NC (for air, water, soil, groundwater and sediment)	Target Value (for air, water, soil, groundwater and sediment)
The MPC is a concentration of a substance in air, water, soil or sediment that should protect all species in ecosystems from adverse effects of that substance. A cut-off value is set at the fifth percentile if a species sensitivity distribution of NOECs is used. This is the Hazardous Concentration for 5% of the species, the HC_5^{NOEC} .	MPC (for air, water, soil, groundwater and sediment)	MPC (for air, water, sediment and air)
The SRC_{ECO} is a concentration of a substance in the soil, sediment, water or groundwater at which functions in these compartments will be seriously affected or are threatened to be negatively affected. This is assumed to occur when 50% of the species and/or 50% of the microbial and enzymatic processes are possibly affected.	SRC_{ECO} (for water, soil, groundwater and sediment)	Intervention Value (for soil, sediment and groundwater)

This report is part of the project 'Setting Integrated Environmental Quality Standards'. The general aim of the project is to derive environmental risk limits (ERLs) for substances in the environment for the compartments air, (ground)water, sediment and soil. Environmental risk limits (ERLs) serve as advisory values to set environmental quality standards (EQS) by the Ministry of Housing, Spatial Planning and the Environment (VROM) for various policy purposes. The term EQS is used to designate all legally and non-legally binding standards that are used in Dutch environmental policy and Table 1.1 shows the correspondence between ERLs and EQSs.

The various ERLs are:

the Negligible Concentration (NC) for water, soil, groundwater, sediment and air

the Maximum Permissible Concentration (MPC) for water, soil, groundwater sediment and air

the Ecotoxicological Serious Risk Concentration for water, soil, groundwater and sediment (SRC_{ECO}).

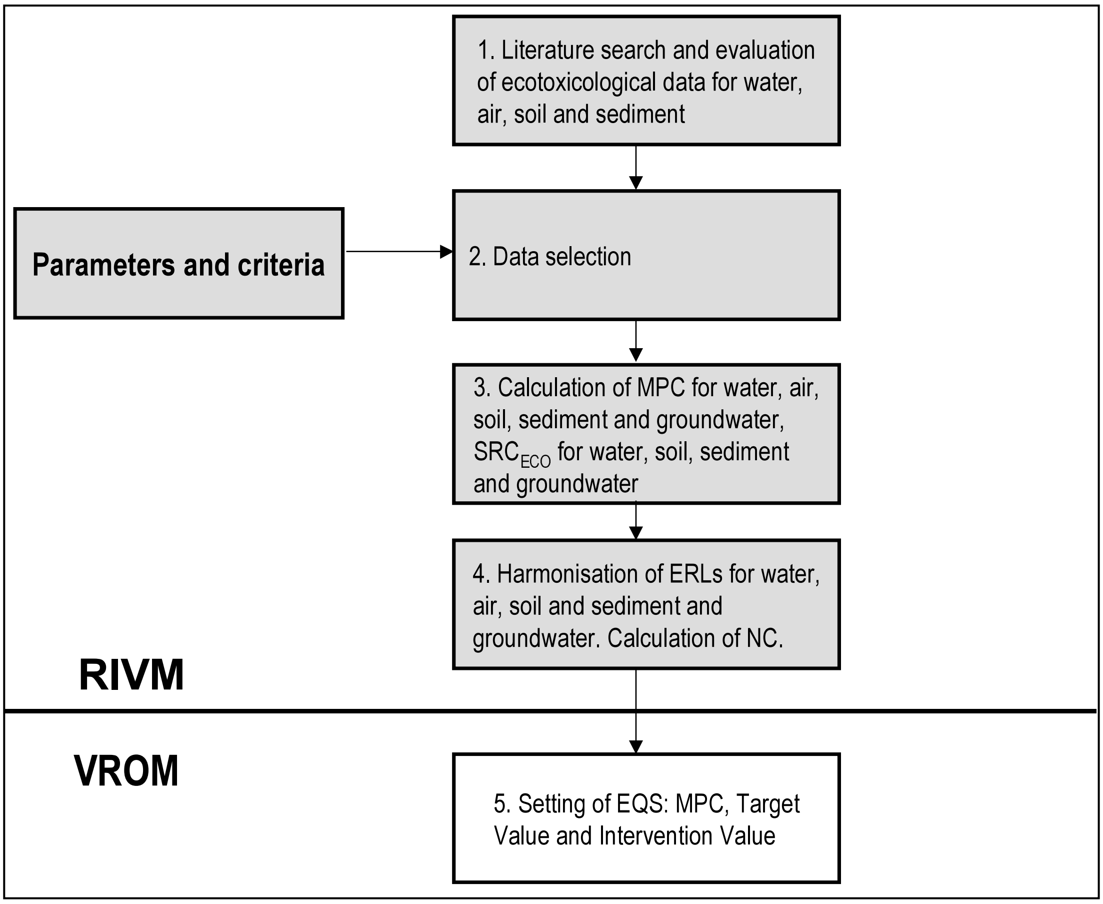


Figure 1.1 The process of deriving Integrated Environmental Risk Limits. Above the line the scientific method to derive ERLs (MPC, NC and SRC_{ECO}) is indicated,. Below the line the policy process of setting the MPC and Target Value is indicated, set by the Ministry of Housing, Spatial Planning and the Environment (VROM).

The process of deriving integrated ERLs is shown schematically in Figure 1.1. ERLs for soil and sediment are calculated for a standardised soil. ERLs for water are reported for dissolved and total concentrations (including a standard amount of suspended matter) and if found significantly different, differentiated to freshwater and saltwater. Each of the ERLs and its corresponding EQS represents a different level of protection, with increasing numerical values in the order Target Value < MPC[1] < Intervention Value. The EQS demand different actions when one of them is exceeded, explained elsewhere (VROM, 1994).

[1] A complicating factor is that the term MPC is used both as an ERL and as an EQS. For historical reasons, however, the same abbreviation is used.

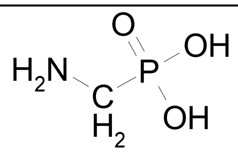
2. Substance properties and use

This section reports the basic properties, use, production and discharge of the compound.

2.1 Physico-chemical properties

The main physico-chemical properties of AMPA are derived from Smit et al. (2001), unless stated otherwise (Table 2.1). The structural formula shows the phosphonic group with the C-P bond which is characteristic for this class of substances.

Table 2.1. Physico-chemical properties of aminomethylphosphonic acid (AMPA).

Property	Value(s)	Reference
IUPAC Name	Aminomethylphosphonic acid	
CAS number	1066-51-9	
EINECS number		
Structural formula (diagram)		
Empirical formula	C H_6 N O_3 P	
Molar Mass	111.04 g/mol	
n-Octanol/water partition coefficient (K_{ow})	-2.17 (estimated KOWWIN) -2.36 (estimated ClogP)	
Freundlich sorption coefficient (K_F)	15.7-1570 L/kg	Smit et al., 2001
PK_a values (dissociation constant)	pKa_1: 0.9 pKa_2: 5.6 pKa_3: 10.2	Smit et al., 2001

2.2 Use, production and discharge[2]

AMPA is a degradation product originating from a number of parent compounds, among which glyphosate (Figure 2.1). An in-depth study on AMPA revealed that glyphosate is the main but not the only source of AMPA (Staats et al., 2002).

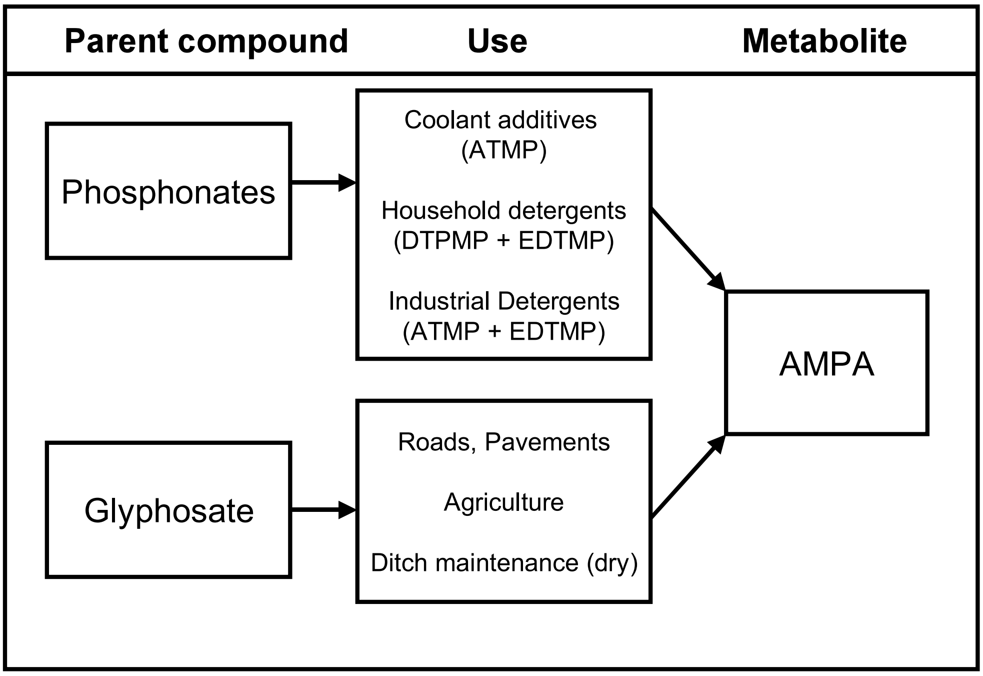


Figure 2.1: Parent compounds, their use and the subsequent formation of the metabolite AMPA (after Kalf and Berbee, 2002).

Glyphosate is the main, best known parent compound. It is authorised in The Netherlands for use as a herbicide in agriculture and forestry and for amenity use on pavements and uncultivated areas. The latter use is only permitted when the product is applied by means of brushing or by spraying with an infrared sensor. The estimated annual use of glyphosate in The Netherlands is 151 ton/year for use on hard surfaces, 681 ton/year in agricultural use and 28 ton/year for maintenance and clearance of (dry) ditches and ditch sides. More detail on use and emissions is reported in Staats et al. (2002).

Phosphonates in coolants are used to prevent scaling in cooling systems and thus to preserve their heat-transfer properties. The main substances used are nitrilo-trismethylene-triphosphonic acid (ATMP), phosphonobutane tricarboxylic acid (PBTC) and hydroxyethane diphosphonate (HEDP), accounting for up to 53 ton/year.

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[2] This summary is based on Kalf and Berbee (2002) Institute for Inland Water Management and Waste Water Treatment (RIZA).

The use of phoshonates in household detergents is to prevent formation of calcium salts and to stabilise bleaching agents. The three main products are HEDP, di-ethenetrisaminopentamethanephosponic acid (DTPMP) and ethenediaminotetramethane-phosphonic acid (EDTMP). The estimated total use is estimated to be 387 ton/year.
For industrial detergents, ATMP, HEDP, DTPMP and EDTMP are used with a total use of about 91 ton/year. More detail on use and emissions is reported in Staats et al. (2002).
Breakdown routes and estimated half lives of the phosphonic acids are given in great detail in Kalf and Berbee (2002) and in Staats et al. (2002). From their calculations, it is estimated that about 7 ton of AMPA is emitted yearly to the surface water from the use of various phosphonates and about 63 ton/year is emitted to surface water from the use of glyphosate. It is shown that due to predominant use in the summer, AMPA formation from glyphosate will also occur in this period of the year. Other sources of AMPA formation contribute to a low, year round background emission to surface water.

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3. Methods

3.1 Data Search and selection

Data on AMPA were obtained from the advisory report on glyphosate (Smit et al., 2001), prepared by the RIVM for the account of the Dutch Board for the Authorisation of Pesticides (CTB). An on-line literature search was performed for the period 1983-summer 1999. The TOXLINE and BIOSYS databases were used.

A toxicity study is considered reliable if the design of the experiment is in agreement with international accepted guidelines, e.g. OECD guidelines. To judge studies that have not been performed according to these guidelines criteria are developed for this project, as documented in Traas (2001). Effects on growth, reproduction or survival are used in the derivation of ERLs, as they are related to population dynamics. Toxicity data from soil or sediment studies are normalised to 10% organic matter. For each species and each compound, the most sensitive toxicity test is selected. If for a single species several toxicity values are found for the same effect parameter, the geometric mean is calculated.

3.2 Derivation of ERLs

The maximum permissible concentrations and negligible concentrations are derived according to the methods generally applied within the project ‘Setting Integrated Environmental Quality Standards’ (Traas, 2001). Due to the small data set that is available, the method of preliminary effect assessment was used.

3.2.1 Preliminary effect assessment

If chronic or acute toxicity data are available for less than four taxonomic groups, assessment factors are used. The assessment factors used are laid down in the Technical Guidance Document (ECB, 1996), which is developed in the framework of EU council regulation 793/93. In the case that there is no complete base-set (acute toxicity to algae, daphnia and fish), the modified EPA method as described in the guidance document is used (Traas, 2001). However, the assessment factor of the modified EPA cannot be less strict than the corresponding factors laid down in the TGD (ECB, 1996).

3.2.2 Derivation of negligible concentrations (NCs)

Multiplying the MPCs with a factor 0.01 defines the NCs. This factor is supposed to function as protection against different factors influencing total toxicity in the field, such as mixture toxicity. In the environment species are always exposed to mixtures of chemicals and complex mixtures of chemicals are generally best described as concentration-additive (e.g., Deneer 2000).

3.2.3 Equilibrium partitioning and harmonisation between the compartments

By applying the equilibrium-partitioning concept (DiToro et al., 1991), it is assumed that there is equilibrium between the concentration in organic carbon and (pore) water. In addition, it is assumed that toxicity is related to pore water concentrations, and that the sensitivity of aquatic organisms is comparable to that of organisms living in soil or sediment. The partition coefficient between organic carbon in the soil/sediment and water (K_{oc}) is used to derive an MPC for soil/sediment when no data on terrestrial or sediment-dwelling organisms are available. By applying equilibrium partitioning, the K_{oc} is used to harmonise the MPCs between the different compartments.

4. Toxicity data and derivation of MPCs and NCs for water

4.1 Data and analysis

The literature search did not yield any useful additional toxicity data, the only available data thus originate from the RIVM-SEC advisory report. Given the substance properties of AMPA, it is unlikely that AMPA will show significant bioaccumulation (Kalf and Berbee, 2002), therefore no additional search for bioaccumulation data was performed.

4.2 Derivation of ERL for water

The available aquatic toxicity data for AMPA presented in Appendix 2 and are summarised in Table 4.1.

Table 4.1. Aquatic toxicity data for AMPA

Organism	Method	Period [h]	EC50 [mg/L]	Remark
Scenedesmus subspicatus	static	72	79.7	nominal[1]
Daphnia magna	static	48	691	nominal[2]
Oncorhynchus mykiss	static	96	520	nominal[3]

1: test concentrations stable
2: actual concentrations 96-102% of nominal
3: actual concentrations 100-105% of nominal

Acute toxicity data are available for algae, crustaceans, and fish. There are no available chronic data. The MPC_{water} is thus derived according to the methods of the Technical Guidance Document (ECB, 1996), applying an assessment factor of 1000 on the lowest toxicity value. This leads to a MPC_{water} of 79.7 μg/L.

4.3 Toxicity data and derivation of ERLs for soil and sediment

4.3.1 ERL for sediment

There are no toxicity data for sediment dwelling organisms. Data from batch adsorption experiments are summarised in Table 4.2. From these data it is clear that sorption of AMPA is not clearly related to organic matter content. With dissociation constants pK_a's of 0.9 to 10.2, AMPA will occur in dissociated state in any soil. A relationship with clay content could exist for these kind of substances, but such a relationship could not be obtained from the experimental values either. In view of this, application of equilibrium partitioning is not justified and an $MPC_{sediment}$ cannot be derived from the MPC_{water}.

Table 4.2. Sorption of AMPA

Soil type	Organic matter [%]	pH	Clay [%]	K_F [L/kg]	1/n
clay loam	1.6	7.6	28.7	532	0.79
clay loam	3.6	7.7	34.7	77.1	0.79
loamy sand	2.7	6.3	4.7	110	0.77
sand	0.5	4.6	0.7	73	0.79
sand	2.3	7.4	2.7	15.7	0.75
sand	32.2	4.7	0.7	1570	0.9

4.3.2 MPC for soil

There are no data on the effects of AMPA on microbial processes or enzyme functioning. For terrestrial species, an earthworm reproduction study is available, from which a NOEC of $\geq$ 28.1 mg/kg (10% o.m.) is obtained. As no effects were observed in this study, this value is not used to derive a MPC_{soil}. As stated in the previous section, application of equilibrium partitioning is not justified for AMPA.

5. Preliminary risk analysis

5.1 Environmental distribution

Within the framework of the project 'Enforcement of Environmental Laws' (Handhaving Milieuwetten) commissioned by the Ministry of Housing Spatial Planning and the Environment (VROM) surface water that is used for preparation of drinking water is monitored for a number of pesticides and metabolites. Data for AMPA are shown in Table 5.1.

Table 5.1. Measured concentrations of AMPA in Dutch surface waters near drinking water intake stations

Year	Drinking water intake station	Number of measurements	Minimum concentration [µg/L]	Maximum concentration [µg/L]	Average concentration [µg/L]	Reference
1994	Brabantse Biesbosch	17	0.23	2.00	1.00	Versteegh et al., 1996
1995	Andijk	4	0.04	0.76	0.29	Versteegh et al., 1997
	Amsterdam	4	0.50	1.00	0.80	
	Brabantse Biesbosch	26	0.19	5.40	1.30	
1996	Andijk	7	0.26	1.50	0.55	Versteegh & Lips, 1998
	Braakman Stelleweg	13	0.08	1.10	0.47	
	Brabantse Biesbosch	26	0.18	4.70	1.90	
	Andijk	7	0.26	1.50	0.55	
1997	Andijk	8	0.04	0.47	0.27	Versteegh & Lips, 2000
	Braakman Stelleweg	5	0.27	2.05	0.82	
	Brabantse Biesbosch	13	0.36	1.9	1.1	
1998	Andijk	7	0.04	0.25	0.17	Versteegh & Cleij, 2000
	Brabantse Biesbosch	14	0.19	1.70	0.68	
1999	Andijk	6	0.03	0.17	0.12	Versteegh (in press)
	Brabantse Biesbosch	14	0.19	1.70	0.68	

Monitoring data from the Institute for Inland Water Management and Waste Water Treatment (published in Staats et al., 2002) are given in Table 5.2.

Table 5.2. Concentrations of AMPA in Dutch surface waters

Period	Area	Number of measurements	Minimum concentration [µg/L]	Maximum concentration [µg/L]	95-percentile concentration [µg/L]
1997-2000	Rijn en IJssel	87	<0.05 (dl)	5.27	1.39
1999-2000	DWR	186	<0.05 (dl)	33	4
1999-2001	ZHEW	430	-1.2	8.67	0.86
2000	Zeeuwse Eilanden	41	<1.0 (dl)	6.9	3.6
2000	Zeeuws Vlaanderen	30	<1.0	6.4	4.58
2000	Regge en Dinkel	61	<0.05 (dl)	3.66	3.15

dl = detection limit

From these data it appears that the MPC_{water} is not exceeded nor is it likely that it has been exceeded.

6. Conclusions and recommendations

The MPC_{water} for AMPA is 79.7 µg/L. MPCs for soil and sediment could not be established.

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66. Sectordirecteur Milieurisico's en Externe Veiligheid
67. Hoofd Stoffen Expertise Centrum
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70. dr. D. Sijm (RIVM/SEC)
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74. dr. P. van Beelen (RIVM/LER)
75. ir. J. Lijzen (RIVM/LBG)
76. drs. T. Aldenberg (RIVM/LER)
77. drs. T.P. Traas (RIVM/SEC)
78. drs. R. Luttik (RIVM/SEC)
79. drs. T. Vermeire (RIVM/SEC)
80. drs. M.H.M.M. Montforts (RIVM/SEC)
81. dr E.J. Verbruggen (RIVM/SEC)
82. dr. W. Slooff (RIVM/SEC)
83. dr. M.P.M. Janssen (RIVM/SEC)
84. mevr. R. Posthumus (RIVM/SEC)
85. ing. P. van Vlaardingen (RIVM/SEC)
86. SBC/ Voorlichting
87. Bureau Rapportenregistratie
88. Bibliotheek RIVM

89-104. Bureau Rapportenbeheer

105-115. Reserve-exemplaren

Appendix 2. Information on aquatic toxicity

Legend

$L(E)C50_{aqua\ min}$	lowest short term test result showing 50% effect or mortality
MPC	maximum permissible concentration
$MPC_{chronic}$	MPC derived using assessment factors, based solely on chronic test results
$MPC_{short\ term}$	MPC derived using assessment factors, based solely on short term test results
NOEC	no observed effect concentration
$NOEC_{aqua\ min}$	lowest no observed effect concentration
Organism	species used in the test, if available followed by age, size, weight or life stage
A	Y = test substance analysed in test solution N = test substance not analysed in test solution or no data
Test type	S = static, R = static with renewal, F = flow through
Test water	a.m. = artificial medium, a.s.w. = artificial seawater, n.f.s = natural filtered seawater, r.t.w. = reconsituted tap water (+additional salts)
Test substance purity	percentage active ingredient
Exposure time	h = hours, d = days, w = weeks, m = months, min. = minutes.

Table A2-1. Aquatic species, acute toxicity

Species	Species Prop.	Anal.	Test type	Subst. Purity	Test water	pH	Hardness [mg $CaCO_3$]	Exp. Time	Criterion	Test Endpoint	Value [mg/L]	Reference
algae/chlorophyta												
Scenedesmus subspicatus		Y	S	>95%	-	-[1]	-	72 h	EC50	biomass	79.7	Smit et al., 2001
crustacea												
Daphnia magna	<24h	Y	S	>95%	-	-[1]	-	48 h	EC50	immobilisation	691	Smit et al., 2001
pisces												
Oncorhynchus mykiss	-	Y	S	>95%	-	4.2-7.6	-	96 h	LC50	mortality	520	Smit et al., 2001

1: pH reported to be within accepted limits

Appendix 3. Information on soil or sediment toxicity

Legend

Species	species used in the test, if available followed by age, size, weight or life stage
Soil type	OECD art = artificial soil (OECD 207)
Exposure time	h = hours, d = days, w = weeks, m = months, min. = minutes
Results	> and ≥ values = highest concentration used in the test

Table A3-1. Soil species, chronic toxicity

Species	Species Prop.	Soil Type	pH	o.m. [%]	Clay [%]	Temp.	Exp. Time	Criterion	Test Endpoint	Result test soil [mg/kg]	NOEC stand. soil [mg/kg]	Reference
Oligochaeta												
Eisenia fetida	adult	OECD art.	6.5	10		19	56 d	NOEC	reproduction	28.1	28.1	Smit et al., 2001

Appendix 4. Information on equilibrium partitioning

Legend

Soil type	according to USDA classification
CEC	Cation Exchange Capacity
Mass balance	Y = both soil and water analysed, N = water analysed
Equil. time	equilibration time in h = hours or d = days

Table A4-1. Soil adsorption data

Test Substance	Purity [%]	Soil Type	o.m. [%]pH	pH	Clay [%]	CEC [mmol/kg]	Solid/water [g/ml]	Mass balance	Equil. time	K_F	1/n	Reference
AMPA	>95	clay loam	1.6	7.6	28.7	310	20	Y	16 h	532	0.79	Smit et al., 2001
AMPA	>95	clay loam	3.6	7.7	34.7	328	20	Y	16 h	77.1	0.79	Smit et al., 2001
AMPA	>95	loamy sand	2.7	6.3	4.7	102	20	Y	16 h	110	0.77	Smit et al., 2001
AMPA	>95	sand	0.5	4.6	0.7	48	100	Y	16 h	73	0.79	Smit et al., 2001
AMPA	>95	sand	2.3	7.4	2.7	120	20	Y	16 h	15.7	0.75	Smit et al., 2001
AMPA	>95	sand	32.2	4.7	0.7	283	20	Y	16 h	1570	0.9	Smit et al., 2001