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Rapport in het kort

Milieurisicogrenzen voor styreen

Dit rapport geeft milieurisicogrenzen voor styreen in (grond)water, bodem en lucht. Milieurisicogrenzen zijn de technisch-wetenschappelijke advieswaarden voor de uiteindelijke milieukwaliteitsnormen in Nederland. De milieurisicogrenzen voor styreen zijn gebaseerd op de uitkomsten van de EU risicobeoordeling voor styreen (Bestaande Stoffen Verordening 793/93). De afleiding van de milieurisicogrenzen sluit tevens aan bij de richtlijnen uit de Kaderrichtlijn Water. De beschikbare monitoringsgegevens voor de periode 2001 tot 2006 overschrijden de in dit rapport afgeleide milieurisicogrenzen niet.

Trefwoorden: milieukwaliteitsnormen; milieurisicogrenzen; styreen; maximaal toelaatbaar risiconiveau; verwaarloosbaar risiconiveau

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Contents

Summary

Environmental risk limits (ERLs) are derived using ecotoxicological, physico-chemical, and human toxicological data. They represent environmental concentrations of a substance offering different levels of protection to man and ecosystems. It should be noted that the ERLs are scientifically derived values. They serve as advisory values for the Dutch Steering Committee for Substances, which is appointed to set the Environmental Quality Standards (EQSs) from these ERLs. ERLs should thus be considered as preliminary values that do not have any official status.

This report contains ERLs for styrene in water, groundwater, soil and air. The following ERLs are derived: negligible concentration (NC), maximum permissible concentration (MPC), maximum acceptable concentration for ecosystems (MAC_{eco}), and serious risk concentration for ecosystems (SRC_{eco}). The risk limits were solely based on data presented in the Risk Assessment Reports (RAR) for this compound, created under the European Existing Substances Regulation (793/93/EEC).

For the derivation of the MPC and MAC_{eco} for water, the methodology used is in accordance with the Water Framework Directive. This methodology is based on the Technical Guidance Document on risk assessment for new and existing substances and biocides (European Commission (Joint Research Centre), 2003). For the NC and the SRC_{eco}, the guidance developed for the project 'International and National Environmental Quality Standards for Substances in the Netherlands' was used (Van Vlaardingen and Verbruggen, 2007). An overview of the derived environmental risk limits is given in Table 1.

Available monitoring data for styrene in the Dutch environment for the period 2001-2006 do not exceed the derived ERLs.

Table 1. Derived MPC, NC, MAC_{eco}, and SRC_{eco} values for styrene.

ERL	**unit**	**value**			
		MPC	NC	MAC_{eco}	SRC_{eco}
water [a]	$\mu g.L^{-1}$	40	0.40	4.0×10^{2}	6.0×10^{2}
drinking water [b]	$mg.L^{-1}$	0.42			
marine	$\mu g.L^{-1}$	4.0	4.0×10^{-2}	40	6.0×10^{2}
sediment	$mg.kg_{dwt}^{-1}$	n.d.			
soil [c]	$mg.kg_{dwt}^{-1}$	0.85	8.5×10^{-3}		13
groundwater	$\mu g.L^{-1}$	40	0.40		6.0×10^{2}
air	$mg.m^{-3}$	0.90	9.0×10^{-3}		

[a] From the $MPC_{eco, water}$, $MPC_{sp, water}$ and $MPC_{hh, food, water}$ the lowest one is selected as the 'overall' MPC_{water}.

[b] The exact way of implementation of the $MPC_{dw, water}$ in the Netherlands is at present under discussion. Therefore, the $MPC_{dw, water}$ is presented as a separate value in this report.

[c] Expressed on Dutch standard soil.

n.d. = not derived.

1 Introduction

1.1 Project framework

In this report environmental risk limits (ERLs) for surface water (freshwater and marine), soil and groundwater are derived for styrene. The following ERLs are considered:

- Negligible Concentration (NC) – concentration at which effects to ecosystems are expected to be negligible and functional properties of ecosystems must be safeguarded fully. It defines a safety margin which should exclude combination toxicity. The NC is derived by dividing the MPC (see next bullet) by a factor of 100.
- Maximum Permissible Concentration (MPC) – concentration in an environmental compartment at which:
  1. no effect to be rated as negative is to be expected for ecosystems;
  2a no effect to be rated as negative is to be expected for humans (for non-carcinogenic substances);
  2b for humans no more than a probability of 10^{-6} over the whole life (one additional cancer incident in 10^{6} persons taking up the substance concerned for 70 years) can be calculated (for carcinogenic substances) (Lepper, 2005).
- Maximum Acceptable Concentration (MAC_{eco}) – concentration protecting aquatic ecosystems for effects due to short-term exposure or concentration peaks.
- Serious Risk Concentration (SRC_{eco}) – concentration at which serious negative effects in an ecosystem may occur.

It should be noted that ERLs 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) from these ERLs. ERLs should thus be considered as preliminary values that do not have any official status.

1.2 Production and use of styrene

The Risk Assessment Report (RAR) (European Commission, 2002) states that styrene is produced commercially from crude oil by a sequence of processes. The production in 1993 was estimated at 3,743,000 tonnes. Styrene is processed in closed systems as an intermediate in the chemical industry. It is the monomer for polystyrene and copolymer systems and in the production of styrene-butadiene rubber and related latices. It is also used as a component of unsaturated polyester resins. More details can be found in the RAR (European Commission, 2002).

2 Methods

2.1 Data collection

The final Risk Assessment Report (RAR) of styrene (European Commission, 2002) produced in the framework of Existing Substances Regulation (793/93/EEC) was used as only source of physico-chemical and (eco)toxicity data. Information given in the RARs was checked thoroughly by European Union member states (Technical Committee) and afterwards approved by the Scientific Commission on Health and Environmental Risk (SCHER). Therefore, no additional evaluation of data is performed for the ERL derivation. Only valid data combined in an aggregated data table are presented in the current report. Occasionally, key studies are discussed when relevant for the derivation of a certain ERL.

In the aggregated data table only one effect value per species is presented. When for a species several effect data are available, the geometric mean of multiple values for the same endpoint is calculated where possible. Subsequently, when several endpoints are available for one species, the lowest of these endpoints (per species) is reported in the aggregated data table.

2.2 Methodology for derivation of environmental risk limits

The methodology for data selection and ERL derivation is described in Van Vlaardingen and Verbruggen (2007) which is in accordance with Lepper (2005). For the derivation of ERLs for air, no specific guidance is available. However, as much as possible the basic principles underpinning the ERL derivation for the other compartments are followed for the atmospheric ERL derivation (if relevant for a chemical).

2.2.1 Drinking water abstraction

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_{water} 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 $MPC_{dw,\ water}$ is also used to derive the MPC_{gw}. For the derivation of the $MPC_{dw,\ water}$, a substance specific removal efficiency related to simple water treatment may be needed. Because there is no agreement as yet on how the removal fraction should be calculated, water treatment is not taken into account.

2.2.2 $MAC_{eco,\ marine}$

In this report, a MAC_{eco} is also derived for the marine environment. The assessment factor for the $MAC_{eco,\ marine}$ value is based on:

- the assessment factor for the $MAC_{eco, water}$ value, when acute toxicity data for at least two specific marine taxa are available, or
- using an additional assessment factor of 5, when acute toxicity data for only one specific marine taxon are available (analogous to the derivation of the MPC according to Van Vlaardingen and Verbruggen, 2007), or
- using an additional assessment factor of 10, when no acute toxicity data are available for specific marine taxa.

If freshwater and marine data sets are not combined the $MAC_{eco, marine}$ is based on the marine toxicity data using the same additional assessment factors as mentioned above. It has to be noted that this procedure is currently not agreed upon. Therefore, the $MAC_{eco, marine}$ value needs to be re-evaluated once an agreed procedure is available.

3 Derivation of environmental risk limits for styrene

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

3.1.1 Identity

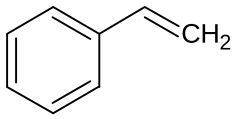

Figure 1. Structural formula of styrene.

Table 2. Identification of styrene.

Parameter	Name or number
Chemical name	ethenyl benzene
Common/trivial/other name	styrene, cinnamene, phenylethene, phenylethylene, vinylbenzene
CAS number	100-42-5
EC number	202-851-5
Molecular formula	C_8H_8
SMILES code	c(cccc1)(c1)C=C

3.1.2 Physico-chemical properties

Table 3. Physico-chemical properties of styrene.

Parameter	Unit	Value	Remark
Molecular weight	[g.mol^{-1}]	104.15	
Water solubility	[g.L^{-1}]	0.3	20°C
log K_{OW}	[-]	3.02	
K_{OC}	[L.kg^{-1}]	352	
Vapour pressure	[Pa]	667	20°C
Melting point	[°C]	-30.6	
Boiling point	[°C]	145-146	1 atmosphere
Henry's law constant	[Pa.m^3.mol^{-1}]	232	

3.1.3 Behaviour in the environment

Table 4. Selected environmental properties of styrene.

Parameter	Unit	Value	Remark
Hydrolysis half-life	DT50 [d]	-	styrene contains no hydrolysable groups
Photolysis half-life	DT50 [h]	<16h	direct photolysis is unlikely, but hydroxyl radicals and tropospheric ozone rapidly degrade styrene
Degradability			readily biodegradable

3.1.4 Bioconcentration and biomagnification

An overview of the bioaccumulation data for styrene is given in Table 5.

Table 5. Overview of bioaccumulation data for styrene.

Parameter	Unit	Value	Remark
BCF (fish)	[$L.kg^{-1}$]	13.5	experimental
	[$L.kg^{-1}$]	74	calculated in the RAR from Kow
BMF	[$kg.kg^{-1}$]	1	Default value since biomagnification is not considered relevant.

The RAR evaluates the only available report (dated 1984) on the measurement of the bioconcentration factor of styrene in fish. This gives a result of 13.5 $L.kg^{-1}$ in the goldfish, *Carassius auratus*. This value is lower than would be expected for a substance with a log K_{ow} of 3.02; using the K_{ow} value and the equation for BCF from the TGD gives a BCF of 74 $L.kg^{-1}$. The measured BCF can be lower than that predicted from log K_{ow}, for example if the substance is rapidly metabolised. Therefore, the calculated BCF is not contradicting the experimental value and the experimental value is used.

3.1.5 Human toxicologicy: classification and limit values

According to the RAR for styrene, classification according to directive 67/548/EEC is:
R10 (flammable)
R20 (harmful by inhalation)
R36/38 (irritating to eyes and skin)
Currently, no classification for the environment is applicable. In the RAR, bioconcentration data of related substances are evaluated. The highest BCF of 90 $L.kg^{-1}$ was reported for toluene. On the basis of comparison of bioconcentration data, styrene was not expected to bioaccumulate significantly. Therefore, R53 was not considered applicable to styrene.

The draft RAR (version November 2007) concludes that there is no concern for mutagenicity and carcinogenicity based on the available data. The draft RAR reports an oral NOAEL for repeated dose toxicity of 150 $mg.kg_{bw}^{-1}.day^{-1}$ from a 2-year oral toxicity study in mice and an inhalation NOAEL of 50 ppm (216 $mg.m^{-3}$) from epidemiological studies in humans. Pending RAR finalisation the RIVM-limit values as proposed by Baars et al. (2001) can be used. They proposed a oral limit value (Tolerable Daily Intake, TDI) of 120 $\mu g.kg_{bw}^{-1}.day^{-1}$ based on an NOAEL of 12 $mg.kg_{bw}^{-1}.day^{-1}$ from a chronic toxicity study in rats. In the same report an inhalation limit value (Tolerable Concentration in Air, TCA) of 900 $\mu g.m^{-3}$ was derived based on a LOAEL of 25 ppm (107 $mg.m^{-3}$) from human epidemiological studies.

3.2 Trigger values

This section reports on the trigger values for ERL_{water} derivation (as demanded in WFD framework).

Table 6. Styrene: collected properties for comparison to MPC triggers.

Parameter	Value	Unit	Method/Source
Log $K_{p,susp-water}$	1.55	[-]	$K_{OC} \times f_{OC,susp}$[1]
BCF	13.5	[L.kg^{-1}]	
BMF	1	[kg.kg^{-1}]	
Log K_{OW}	3.02	[-]	
R-phrases	10, 20, 36/38	[-]	
A1 value	-	[µg.L^{-1}]	
DW standard	-	[µg.L^{-1}]	

1 $f_{OC,susp}$ = 0.1 $kg_{OC}.kg_{solid}^{-1}$ (European Commission (Joint Research Centre), 2003).

- o styrene has a log $K_{p, susp-water}$ < 3; derivation of $MPC_{sediment}$ is not triggered.
- o styrene has a log $K_{p, susp-water}$ < 3; expression of the MPC_{water} as $MPC_{susp, water}$ is not required.
- o styrene has a BCF < 100 L.kg^{-1}; assessment of secondary poisoning is not triggered.
- o styrene has no R-classification for which an MPC_{water} for human health via food (fish) consumption ($MPC_{hh food, water}$) needs to be derived.

3.3 Toxicity data and derivation of ERLs for water

An overview of the selected freshwater toxicity data for styrene as reported in the RAR is given in Table 7 and marine toxicity data are shown in Table 8.

Table 7. Styrene: selected freshwater toxicity data for ERL derivation.

Chronic		**Acute**	
Taxonomic group	**$NOEC/EC_{10}$ (mg.L^{-1})**	**Taxonomic group**	**$L(E)C_{50}$ (mg.L^{-1})**
Bacteria		**Algae**	
Pseudomonas putida	72 (16h)	*Pseudokirchneriella subcapitata*	4.9 (72h)
Pseudomonas fluorescens	72 (16h)	QSAR	5.8
Protozoa		**Crustacea**	
Chilomonas paramaecium	>100 (48h)	*Daphnia magna*	4.7 (48h)
Entosiphon sulcatum	>256 (72h)	*Hyalella azteca*	9.5 (96h)
Uronema parduzci	185 (20h)	QSAR	6.7
Algae		**Pisces**	
Pseudokirchneriella subcapitata	0.28 (96h)	*Pimephales promelas*	6.3 (96h)*
		Oncorhynchus mykiss	5.9 (96h)
		QSAR	11

* Geometric mean of 10 and **4.02** mg.L^{-1}. In the RAR, the PNEC has been based on the lowest one of these two and not on the geometric mean.
bold values are used for MPC derivation

Table 8. Styrene: selected marine toxicity data for ERL derivation.

Chronic Taxonomic group	NOEC/EC_{10} ($mg.L^{-1}$)	Acute Taxonomic group	$L(E)C_{50}$ ($mg.L^{-1}$)
		Bacteria	
		Vibrio fischeri	5.4

3.3.1 Treatment of fresh- and saltwater toxicity data

Considering the fact that there is only one value for marine species, the fresh- and saltwater data will be pooled.

3.3.2 Mesocosm studies

No mesocosm studies are presented in the RAR.

3.3.3 Derivation of MPC_{water} and MPC_{marine}

3.3.3.1 $MPC_{eco,\ water}$ and $MPC_{eco,\ marine}$

In the RAR, the $PNEC_{water}$ has been derived from the lowest LC50 available, the LC50 of 4.02 $mg.L^{-1}$ for *Pimephales promelas*. The RAR does not explain why the lowest LC50 value for *Pimephales promelas* has been selected for the PNEC and the geometric mean of the two available LC50. The NOEC of 0.28 $mg.L^{-1}$ for the algae was not considered a chronic value and the bacterial and protozoan data were not used in the $PNEC_{water}$ derivation. For these reasons, in the RAR, only the base set was considered available and an assessment factor of 1000 should have been applied. However, in the RAR it was argued that there was no large difference in sensitivity between the species and that there was a good agreement between the QSAR predictions and the measured values. Therefore the assessment factor was lowered to 100 and the $PNEC_{water}$ derived was 40 $\mu g.L^{-1}$. The $MPC_{eco,\ water}$ will be set equal to the $PNEC_{water}$ at 40 $\mu g.L^{-1}$.

Since the data for the marine and freshwater environment have been pooled, the $MPC_{eco,\ marine}$ will be based on the same species as used for the $PNEC_{water}$. Following the same reasoning for the assessment factor applied for the derivation of the $PNEC_{water}$, an assessment factor of 1000 should be used to derive the $MPC_{eco,\ marine}$. The $MPC_{eco,\ marine}$ is: 4.0 $\mu g.L^{-1}$

3.3.3.2 $MPC_{sp,\ water}$ and $MPC_{sp,\ marine}$

Styrene has a BCF < 100 $L.kg^{-1}$, thus assessment of secondary poisoning is not triggered.

3.3.3.3 $MPC_{hh\ food,\ water}$

Derivation of $MPC_{hh\ food,\ water,}$ for styrene is not triggered (Table 6).

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

The MPC_{water} will be the only MPC_{water} derived: the $MPC_{eco,\ water}$ of 40 $\mu g.L^{-1}$. The MPC_{marine} is: 4.0 $\mu g.L^{-1}$.

3.3.4 Derivation of $MPC_{dw,\ water}$

No A1 value and DW standard are available for styrene. With the ADI of 120 $\mu g.kg_{bw}^{-1}.d^{-1}$ an $MPC_{dw,\ water,\ provisional}$ can be calculated with the following formula:
$MPC_{dw,\ water,\ provisional}$ = $0.1.TL_{hh}.BW / Uptake_{dw}$ where the TL_{hh} is the ADI, BW is a body weight of

70 kg, and $uptake_{dw}$ is a daily uptake of 2 L. As described in section 2.2 water treatment is currently not taken into account. Therefore the $MPC_{dw, water}$ = The $MPC_{dw, water, provisional}$ and becomes: 0.1 * 120 * 70 / 2 = 420 µg.L^{-1}.

3.3.5 Derivation of MAC_{eco}

The MAC_{eco} will be based on the lowest L(E)C50 as used in the RAR for the PNEC, the EC50 of 4.02 mg.L^{-1} for *Pimephales promelas*. The following facts are considered for the assessment factor: a complete base set, styrene has no potential to bioaccumulate (BCF < 100 L.kg^{-1}), and the most sensitive species is included in the dataset. Therefore, an assessment factor of 10 can be applied. The $MAC_{eco, water}$ will be 4.02 / 10 = 0.4 mg.L^{-1}.

The $MAC_{eco, marine}$ is set a factor of 10 lower than the $MAC_{eco, water}$ because there is no acute toxicity data for additional marine taxonomic groups. The marine bacterial species in Table 8 does not account as an additional marine taxonomic group since it has the same life form and feeding strategy as freshwater bacteria. The $MAC_{eco, marine}$ is set at 0.04 mg.L^{-1}. It has to be noted that this procedure for $MAC_{eco, marine}$ is currently not agreed upon. Therefore the $MAC_{eco, marine}$ needs to be re-evaluated once an agreed procedure is available.

3.3.6 Derivation of NC

The NC_{water} and NC_{marine} are set a factor of 100 lower than the final MPC. The NC_{water} is 0.4 µg.L^{-1}; the MPC_{marine} is 0.04 µg.L^{-1}.

3.3.7 Derivation of $SRC_{eco, aquatic}$

Acute and chronic data are presented in Table 7 and 8. There is a NOEC available for one of the three specified taxa (algae). Therefore the geometric mean of the chronic data (including the bacteria and protozoa) and the acute data (experimental values only) divided by a factor 10 will be compared. Unbounded values (>) were not used in this calculation. The geometric mean of the experimental chronic data (22.8 mg.L^{-1}) is higher than the geometric mean of the acute data divided by 10 (0.6 mg.L^{-1}). Therefore the $SRC_{eco, aquatic}$ will be: 0.6 mg.L^{-1}. The $SRC_{eco, aquatic}$ is valid for the marine and the freshwater environment.

3.4 Toxicity data and derivation of ERLs for sediment

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

3.5 Toxicity data and derivation of ERLs for soil

An overview of the selected soil toxicity data for styrene is given in Table 9.

Table 9. Styrene: selected soil data for ERL derivation.

Chronic Taxonomic group	NOEC/EC10 (mg.kg$_{dwt}^{-1}$)	Acute Taxonomic group	L(E)C50 (mg.kg$_{dwt}^{-1}$)
Eisenia fetida	34		

3.5.1 Derivation of MPC_{soil}

3.5.1.1 $MPC_{eco, soil}$

The RAR presents only one result for terrestrial organisms and the exposure conditions of this test are not well defined. Therefore, the $PNEC_{terrestrial}$ in the RAR has been derived using equilibrium partitioning. The PNEC value derived in the RAR is: 255 µg.kg_{ww}^{-1}. Recalculation to dry weight Dutch standard soil gives an $MPC_{eco, soil}$ of 845 µg.kg_{dwt}^{-1} for Dutch standard soil.

3.5.1.2 $MPC_{sp, soil}$

Styrene has a BCF < 100 L.kg^{-1} and therefore secondary poisoning is not triggered.

3.5.1.3 $MPC_{human, soil}$

For the derivation of the $MPC_{human, soil}$, the TDI of 120 µg.$kg_{bw}^{-1}$$day^{-1}$ can be used as TL_{hh} with the method as described in Van Vlaardingen and Verbruggen (2007). Specific human intake routes are allowed to contribute 10% of the human toxicological threshold limit. Four different routes contributing to human exposure have been incorporated: consumption of leafy crops, root crops, mild and meat. Uptake via root crops was determined to be the critical route. The calculated $MPC_{human, soil}$ is 2.9 mg.kg_{dwt}^{-1} for Dutch standard soil.

3.5.1.4 Selection of the MPC_{soil}

The $MPC_{eco, soil}$ is the lowest MPC_{soil}: 0.85 mg.kg_{dwt}^{-1} for Dutch standard soil.

3.5.2 Derivation of NC_{soil}

Negligible concentrations are derived by dividing the MPCs by a factor of 100. This gives an NC_{soil} of 8.5 µg.kg_{dwt}^{-1}.

3.5.3 Derivation of $SRC_{eco, soil}$

The equilibrium partitioning method can be used to calculate an $SRC_{eco, soil}$ from the $SRC_{eco, aquatic}$ (0.6 mg.L^{-1}). This method gives an $SRC_{eco, soil, dwt}$ of 4.3 mg.kg_{dwt}^{-1}. Conversion to Dutch standard soil gives an $SRC_{eco, soil}$ of 12.7 mg.kg_{dwt}^{-1}.

3.6 Derivation of ERLs for groundwater

3.6.1 Derivation of MPC_{gw}

3.6.1.1 $MPC_{eco, gw}$

Since groundwater-specific ecotoxicological ERLs for the groundwater compartment are absent, the surface water $MPC_{eco, water}$ is taken as substitute. Thus, $MPC_{eco, gw} = MPC_{eco, water}$ = 40 µg.L^{-1}.

3.6.1.2 $MPC_{human, gw}$

The $MPC_{human, gw}$ is set equal to the $MPC_{dw, water}$. Therefore the $MPC_{human, gw} = MPC_{dw, water}$: 420 µg.L^{-1}.

3.6.1.3 Selection of the MPC_{gw}

The lowest available MPC is the $MPC_{eco, gw}$ of 40 µg.L^{-1}. Thus, the final MPC_{gw} = 40 µg.L^{-1}.

3.6.2 Derivation of NC_{gw}

The NC_{gw} is set a factor 100 lower than the MPC_{gw}. Thus, NC_{gw} = 40/100 = 0.4 µg.L^{-1}.

3.6.3 Derivation of $SRC_{eco, gw}$

The $SRC_{eco, gw}$ is set equal to the $SRC_{eco, aquatic}$. Thus, the $SRC_{eco, gw}$ = 0.6 mg.L^{-1}.

3.7 Derivation of ERLs for air

3.7.1 Derivation of MPC_{air}

3.7.1.1 $MPC_{eco, air}$

In the RAR, the available data for exposure in air was considered not suitable to derive a PNEC. Therefore also no $MPC_{eco, air}$ can be derived.

3.7.1.2 $MPC_{human, air}$

The $MPC_{human, air}$ can be set equal to the TCA at: 900 µg.m^{-3}.

3.7.1.3 Selection of the MPC_{air}

The only MPC_{air} available is the $MPC_{human, air}$: 900 µg.m^{-3}.

3.7.2 Derivation of NC_{air}

The MPC_{air} divided by 100 is the NC_{air}: 9 µg.m^{-3}.

3.8 Comparison of derived ERLs with monitoring data

The RIWA (Dutch Association of River Water companies, www.riwa.org) presents monitoring data for styrene in their annual reports for the years 2001 to 2006 showing monthly averages ranging from below the detection limit (0.01 µg.L^{-1}) to 0.04 µg.L^{-1}. These values are well below the MPC and NC derived for freshwater. High peak values were observed in 2003 and 2005 of 0.54 µg.L^{-1} and 1.4 µg.L^{-1}, respectively. These peak exposures were also well below the MAC of 400 µg.L^{-1} derived for the water compartment.

4 Conclusions

In this report, the risk limits Negligible Concentration (NC), Maximum Permissible Concentration (MPC), Maximum Acceptable Concentration for ecosystems (MAC_{eco}), and Serious Risk Concentration for ecosystems (SRC_{eco}) are derived for styrene in water, groundwater, soil and air. The ERLs that were obtained are summarised in the table below. Available monitoring data for styrene in the Dutch environment for the period 2001-2006 do not exceed the derived ERLs.

Table 10. Derived MPC, NC, MAC_{eco}, and SRC_{eco} values for styrene.

ERL	**unit**	**value**			
		MPC	NC	MAC_{eco}	SRC_{eco}
water [a]	$\mu g.L^{-1}$	40	0.40	4.0×10^{2}	6.0×10^{2}
drinking water [b]	$mg.L^{-1}$	0.42			
marine	$\mu g.L^{-1}$	4.0	4.0×10^{-2}	40	6.0×10^{2}
sediment	$mg.kg_{dwt}^{-1}$	n.d.			
soil [c]	$mg.kg_{dwt}^{-1}$	0.85	8.5×10^{-3}		13
groundwater	$\mu g.L^{-1}$	40	0.40		6.0×10^{2}
air	$mg.m^{-3}$	0.90	9.0×10^{-3}		

[a] From the $MPC_{eco, water}$, $MPC_{sp, water}$ and $MPC_{hh, food, water}$ the lowest one is selected as the ‘overall’ MPC_{water}.

[b] The exact way of implementation of the $MPC_{dw, water}$ in the Netherlands is at present under discussion. Therefore, the $MPC_{dw, water}$ is presented as a separate value in this report.

[c] Expressed on Dutch standard soil.

n.d. = not derived.

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