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Een studie is uitgevoerd naar de impact op de toelaatbaarheid van gewasbeschermingsmiddelen als de nieuwe oppervlaktewater exposure scenario's voor substraatteelten in Nederlandse kassen worden ingevoerd. Ook is de gevoeligheid van de modeluitkomsten bepaald voor een aantal belangrijke modelparameters. De berekende milieuconcentratie in oppervlaktewater van de 35 bekeken gewas-gewasbeschermingsmiddel combinaties lag in 27 gevallen hoger dan het bijbehorende toelatingscriterium. Voor deze combinaties zullen end-of-pipe reductietechnieken nodig zijn om de milieuconcentraties voldoende te verlagen.

The impact of the newly developed surface water exposure scenarios for soilless cultivation in Dutch greenhouses on the availability of Plant Protection Products for this agricultural sector was assessed as well as the sensitivity of the model outcomes to important model parameters. The calculated Predicted Environmental Concentrations for 27 out of 35 Plant Protection Product – crop combinations exceeded the authorisation criterion. For these combinations end-of-pipe reduction techniques are required to reduce the Predicted Environmental Concentrations sufficiently.

Keywords: Environmental Risk Assessment, Impact Assessment, Exposure Scenarios, Soilless Cultivation, Plant Protection Products, Greenhouses.

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Preface

A few years ago the Dutch government decided to initiate an improvement of the methodology for the assessment of effects of plant protection products on aquatic organisms. As part of this improvement, the Dutch government installed two working groups to develop new exposure assessment scenarios for soilless and soil bound greenhouse crops. This report is produced by the working group for soilless greenhouse crops. This working group developed a new methodology for calculating exposure concentrations in surface water resulting from Plant Protection Product use in Dutch soilless cultivation (greenhouses). The new exposure scenarios are described in:

- Van der Linden, A.M.A., E.A. van Os, E.L. Wipfler, A.A. Cornelese, T. Vermeulen, D.J.W. Ludeking, 2015. Scenarios for exposure of aquatic organisms to plant protection products in the Netherlands. Soilless cultivations in greenhouses. RIVM report 607407005.

The report describes the impact analyses performed to assess the impact of the newly developed scenarios on the availability of Plant Protection Products for this agricultural sector.

Extended summary

Over the last two years, a new methodology was drafted for the exposure part of the environmental risk assessment methodology for Plant Protection Products (PPP) used in soilless cultivation. In contrast to the former methodology, this methodology accounts for the major emission routes to surface water, being the filter cleaning discharge and discharge of recirculation water needed to control the water sodium content.

To evaluate the consequences of the new methodology, its impact on the availability of PPPs for soilless cultivation was assessed, i.e. whether currently approved PPP could still be approved with the new scenarios. A secondary objective was to perform a number of example calculations to assess the sensitivity to a number of model input parameters.

In the environmental risk evaluation procedure, the Predicted Environmental Concentration is compared to a reference effect concentration for the substances. In this report, the Ecotoxicologically relevant concentration was defined as the X^{th} percentile of the annual peak concentration averaged over 100 m of ditch, downstream of the greenhouse discharge location. Which percentile should be used in the registration process has not been decided yet, therefore the impact analysis was done for a 50^{th} percentile as well as a 90^{th} percentile concentration. The authorisation criterion was used as the reference effect concentration for surface water organisms, being the first tier effect concentrations of the most sensitive species registered by the Ctgb or by EFSA times an assessment factor. The assessment factors were 0.1 for NOEC and 0.01 for EC50.

A selection of relevant crops was made by experts and 7-11 PPP were assigned to each selected crop. The selected crops were rose, tomato, sweet pepper and ficus. Overall, 35 crop – PPP combinations were evaluated. Three parameterised models were used consecutively to calculate the predicted environmental concentration (WATERSTROMEN, Substance Emission Model and TOXSWA).

The PPPs were chosen according to their importance/use in greenhouse horticultural practice and their calculated environmental impact. For all of the selected PPPs, physico-chemical and fate properties were collected as well as effect data. These data were taken from EFSA reports, renewal assessment reports and DG SANCO reports. As no information was available on the degradation rates within the recirculation water in greenhouses, it was assumed that the substances degraded due to hydrolysis only. Information about the application timing was taken from the Table of Intended Use and verified by comparison with information contained in the Dutch Environmental Risk Indicator for Plant Protection Products.

Example calculations

Soilless cultivation water discharge to nearby ditches was considered to take place owing to both filter cleaning and sodium control. Discharge regimes varied between the selected crops. The differences were mainly caused by different water demands and different sodium tolerance levels. The crop with the highest annual and daily discharge was rose, while ficus had the lowest annual discharge. Rose is a crop with a relatively high water demand (8250 m^3/ha/yr) and a low sodium tolerance (4 mmol/L), whereas ficus has a lower water demand of 4640 m^3/ha/yr and a sodium tolerance of 6 mmol/L.

Discharged PPP mass was higher for applications shortly before or during a discharge event. The longer the PPP remains in the greenhouse circulation water, the less the discharged mass became. Processes that reduced the discharged mass were degradation and plant uptake.

Sodium sensitive crops had a higher total discharged mass as well as a higher maximum daily mass discharge than sodium tolerant crops. As the residence time of recirculation water in sensitive crops

was shorter, the effects of degradation and plant uptake were less. A lower water supply-plant uptake ratio increased the impacts of plant uptake and degradation and decreases the total discharged mass.

Application by spraying results in lower emissions of PPP to surface water as compared to application along with the nutrient solution. Entry of PPP into the recirculation water only takes place via partitioning of PPP vapour into condensation water, that is compulsorily used as a water source for the cultivation. In the example calculation 7.5% of the total applied mass came into the recirculation system.

Water level and flow dynamics in a ditch varied independently of the greenhouse processes. This leads to additional concentration dynamics in the water body.

Impact

For 27 out of the 35 PPP-crop combinations the Predicted Environmental Concentrations (PECs) in the surface water exceeded their authorisation criterion, when using a 90th percentile concentration. For the 50th percentile concentration the number of combinations that exceeded the criterion was 22. For 17 of the 35 combinations an emission reduction percentage larger than 90% would be needed if the 90th percentile concentration was used.

The calculations show that, if no end-of-pipe treatment is considered, the implementation of the new assessment procedure in the registration process, including the newly developed scenarios, may lead to exclusion of a large number of PPPs from being used in soilless cultivation in greenhouses. The decision which percentile, 50th or 90th percentile of the concentration in surface water, to be used appears to have a limited impact on the calculated PEC. Higher tier effect concentrations as well as higher tier fate data will increase the number of PPPs that pass the authorisation criterion.

The PEC is sensitive to the ditch length that is used for calculating the annual peak concentration. However, decreasing the target length of the ditch from 100 m to e.g. 50 m will have limited impact on the availability of PPP for use in soilless horticulture. An example calculation pointed to a factor 1.5 higher for 50 m ditch length.

In the calculations it was assumed that degradation in greenhouses only occurs due to hydrolysis. This is a conservative assumption. The working group recommends investigating the use of more realistic degradation rates by the development of a proper methodology to derive degradation rates in greenhouses. Application of these rates may decrease the concentrations in the discharge water as well as in the ditch.

Sorption to substrate was not included in the scenarios. This is a conservative assumption as sorption may lower the concentrations in the water phase and therewith the emissions to surface water. It is recommended to further assess the role of sorption to substrate and to consider including sorption processes into the calculations.

Uitgebreide samenvatting

Er is een nieuwe methode ontwikkeld voor het blootstellingsdeel van de milieurisicobeoordeling van gewasbeschermingsmiddelen die worden gebruikt in substraatteelten (in kassen). Deze methode houdt rekening met de belangrijkste emissieroutes naar oppervlaktewater, namelijk lozing met het filterspoelwater en met het recirculatiewater. Dit in tegenstelling tot de huidige beoordelingsmethode.

In deze rapportage wordt de impact van nieuwe methode geëvalueerd. Van een groot aantal toegelaten middelen wordt beoordeeld of deze middelen bij het toepassen van de nieuwe toetsingsmethode nog steeds zouden worden toegelaten. Daarnaast wordt de gevoeligheid van een aantal modelparameters beschreven aan de hand van voorbeeldberekeningen.

In milieurisicobeoordelingen wordt de berekende milieuconcentratie getoetst aan een referentie-effectconcentratie. In de risicobeoordeling van gewasbeschermingsmiddelen toegepast in substraatteelt is er daartoe een Ecotoxicologische Relevante Concentratie (ERC) gedefinieerd. Deze is gedefinieerd als het X^{ste} percentiel van de jaarlijkse piekconcentratie verdeeld over 100 m ontvangende sloot. Het exacte percentiel voor de beoordeling moet nog worden vastgesteld door de risicomanagers. Er is daarom gekozen om zowel het 50 en het 90 percentiel te berekenen. De referentie-effectconcentratie die wordt gehanteerd is het zogenaamde toelatingscriterium, gedefinieerd als de eerste tier van de gevoeligste soort die is geregistreerd bij het Ctgb of bij EFSA vermenigvuldigd met een veiligheidsfactor. De veiligheidsfactoren waren 0.1 voor de NOEC en 0.01 voor de EC50.

Allereerst zijn de belangrijkste gewassen geselecteerd. Voor elk van deze gewassen zijn 7 tot 11 regelmatig gebruikte beschermingsmiddelen uitgekozen. De geselecteerde gewassen waren roos, tomaat, paprika en ficus. In totaal zijn er 35 gewas-middel combinaties geselecteerd en doorgerekend. Voor elk van de combinaties zijn drie modellen achtereenvolgens gerund om de water concentratie in de ontvangende sloot te kunnen berekenen. De gebruikte modellen zijn het WATERSTROMEN model, het Substance Emission Model en het TOXSWA model.

Gewasbeschermingsmiddelen zijn geselecteerd op basis van gebruik in substraatteelt en op basis van hun milieu-impact. Voor alle geselecteerde middelen zijn de fysisch-chemische en blootstellings-parameters verzameld uit EFSA rapporten en DG SANCO rapporten en ook de ecotoxicologische parameters. Wanneer er geen informatie aanwezig was over de afbraak in het recirculatiewater, dan werd aangenomen dat de stof afbreekt als gevolg van uitsluitend hydrolyse. Toedieningsschema's zijn overgenomen van de dossiers en geverifieerd door ze te vergelijken met gegevens uit de NMI.

Voorbeeldberekeningen

Waterlozingen vanuit substraatteelten naar dichtbijgelegen sloten komen door het schoonspoelen van het filter en door lozingen om natriumophoping te voorkomen. De lozingsvolumes en frequenties verschillen per gewas. De verschillen worden met name veroorzaakt door verschillen in waterbehoefte en in natriumtolerantie. Roos heeft de hoogste jaarlijkse emissie en tevens de hoogste dagelijkse pieklozing en ficus heeft de laagste. Roos is een gewas met een relatief hoge waterbehoefte (8250 m3/ha/jr) en een lage natriumtolerantie (4 mmol/L) en ficus heeft een lage waterbehoefte (4640 m3/ha/jr) en een lage natriumtolerantie van 6 mmol/L.

De geloosde vracht is hoger voor toedieningen kort voor of tijdens een lozing. Hoe langer het middel in het recirculatiewater blijft hoe lager de geloosde vracht. Belangrijke reductieprocessen zijn daarbij afbraak en plantopname. Natriumintolerante gewassen hebben een hogere vracht en ook een hogere maximum dagelijkse lozing. Dit kan worden verklaard uit de verblijftijd; als de verblijftijd groter is, is er meer tijd voor processen als afbraak en plantopname. Ook geldt dat een groter watergiftverdampings-ratio de impact van afbraak en plantopname verhoogt en de geloosde massa middel verlaagt.

Spuittoepassingen geven en lagere vracht dan toepassingen met de voedingsoplossing. Gewasbeschermingsmiddellen kunnen bij spuittoepassingen in het recirculatiewater komen door partitie tussen de dampfase (lucht) en condensatiewater. Telers zijn verplicht om het condensatiewater te hergebruiken. In de voorbeeldsimulatie kwam 7.5% van de toegediende massa in het recirculatiewater terecht de rest bleef in de kaslucht of verdween via luchtventilatie naar buiten.

Waterdiepte en stroomsnelheden in de ontvangende sloot varieerde onafhankelijk van de kaslozingen. Deze processen zorgden voor een additionele concentratiedynamiek in de sloot.

Impact

Voor 27 van de 35 beoordeelde gewas-middelcombinaties was de berekende blootstellingsconcentratie hoger dan het toelatingscriterium. Dit geldt wanneer voor de doel-blootstellingsconcentratie het 90^{ste} percentiel werd genomen. Wanneer het 50^{ste} percentiel werd gekozen lagen 22 van de 35 combinaties de concentratie boven het gehanteerde toelatingscriterium. Voor 17 van de gewas-middel combinaties is een end-of-pipe zuivering nodig waarbij meer dan 90% van het middel moet worden verwijderd.

De berekeningen laten zien dat de invoering van de nieuwe methode kan leiden tot de uitsluiting van een groot aantal stoffen voor gebruik in substraatteelt. De keuze van het percentiel, ofwel het 50 ofwel het 90 percentiel, lijkt niet veel invloed te hebben op dit resultaat. Het gebruik van hogere tier effectconcentraties en hogere tier blootstellingsgegevens zal het aantal stoffen dat onder het toelatingscriterium blijft waarschijnlijk verhogen.

De berekende concentratie is gevoelig voor de gehanteerde slootlengte. Het verkorten van de lengte geeft een hogere berekende concentratie. Een indicatieve berekening gaf een verschil van een factor 1.5 tussen de sloot van 100 m en een sloot van 50 m. Naar verwachting zal dit een beperkt effect hebben op het aantal stoffen dat onder het toelatingscriterium ligt.

In de berekeningen is aangenomen dat afbraak in het recirculatiewater alleen werd veroorzaakt door hydrolyse. Dit is een conservatieve benadering. De werkgroep adviseert om afbraak in recirculatiewater nader te onderzoeken en realistischere afbraaksnelheden mee te nemen in de berekeningen. Het gebruik van realistische afbraaksnelheden zal de berekende concentratie in het lozingswater en de sloot naar verwachting verlagen.

Sorptie is niet meegenomen in de simulaties. Dit is een conservatieve aanname. De werkgroep adviseert om de rol van sorptie in substraatteelt nader te onderzoeken en indien relevant op te nemen in de simulaties.

1 Introduction

1.1 Background and aim

The environmental risk assessment methodology of plant protection products (PPP) used in greenhouses has remained unchanged over the last 30 years regarding emissions to surface water and impact on aquatic organisms. The currently used methodology does not reflect agricultural practices in soilless cultivations as it does not account for the potential major emission routes to surface water in these cultivations (Vermeulen *et al.* 2010). In addition, Dutch water boards frequently measure PPP surface water concentrations above environmental quality standards in greenhouse production areas. The Dutch government considered this situation as undesirable and charged a working group to develop a new risk assessment methodology for soilless systems and a separate working group to do so for soil-bound cultivation systems as well. This report addresses the soilless systems.

Over the last two years, the working group drafted a new methodology for assessing the environmental impact of plant protection products on aquatic organisms after use in soilless cultivation in greenhouses. The considered protection goal was the aquatic ecosystem in edge-of-field ditches. The working group developed a number of exposure scenarios that enable to calculate realistic worst case surface water concentrations. These scenarios are intended to become part of a tiered approach.

To evaluate the consequences of the new methodology, the impact on the availability of PPP for soilless horticulture was assessed, i.e. whether currently approved PPP could still be approved according to the new scenarios and calculation methods. This report describes the approach, the methodology and results of the impact assessment. In addition, a number of example calculations are discussed to show the sensitivity of the calculated concentrations to a number of system parameters. Detailed description of the scenarios and the models used can be found in Van der Linden *et al.,* 2015.

1.2 Outline of the report

The approach used for the example calculations and for the impact assessment of the new scenarios is outlined in Chapter 2. In Chapter 3 results are presented and discussed. Chapter 4 provides a general discussion, conclusions and recommendations.

2 Materials and methods

2.1 Summary of the soilless cultivation scenarios

The specific protection goal for the risk assessment of PPP used in soilless cultivation is the aquatic ecosystem in surface water. In the risk assessment part of the PPP authorisation procedure, it is common practice to assess the exposure concentration for the 90th percentile vulnerable situation, i.e. to derive the 90th percentile overall vulnerable situation out of the population of considered situations. However, for soilless cultivation this percentile had not been decided by the risk managers. In line with the approach taken for surface water risk assessment for open field applications, the endpoint of the scenario selection was defined as the annual peak concentration over a length of 100 m downstream of the greenhouse discharge point (see Figure 2.1).

Based on earlier inventories, the working group drafted the main lay-out of Dutch soilless cultivation systems, as well as common management practices and PPP emission routes. In the Netherlands the excess water supplied in soilless cultivation is collected and reused. Emission of PPP is mainly due to (incidental) discharges to surface water to control the quality of the recirculation water. Discharge of filter cleaning water also causes PPP emission to surface water. The higher the volume of water discharged, the higher the discharged mass of PPP to the ditch may be. Pesticide emission to surface water appears to be sensitive to crop type, and more specifically, to water demand and the sodium tolerance of the crop. To limit the number of scenarios, soilless crops were grouped into four classes according to their water demand and sodium tolerance. Then, standard water fluxes inside greenhouses were calculated for each of the crop classes over a period of 20 years, using the WATERSTROMEN model (Voogt *et al.*, 2012).

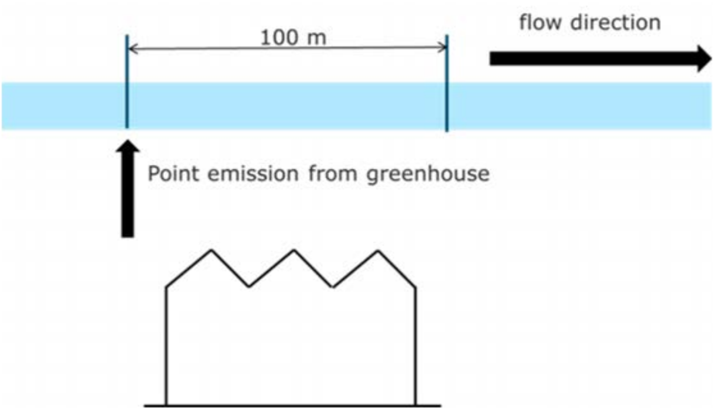

Figure 2.1 *The endpoint of the exposure assessment was defined as the Xth percentile annual peak concentration over a length of 100 m downstream of the greenhouse discharge point.*

2.1.1 Water fluxes in the greenhouses

The WATERSTROMEN model calculates water fluxes based on crop type, temperature and incoming radiation and water sources that are used (mostly rainwater, groundwater, tap water or reversed osmosis water). The main drivers for water supply and discharge are transpiration of the crop, sodium content of the supply water, sodium uptake and sodium tolerance. Water is recirculated as long as the sodium concentration in the recirculation water is below crop specific threshold levels.

For the exposure scenarios, the maximum allowed nitrogen emission for greenhouses according to the Activiteitenbesluit Landbouw (2012) was identified as the main (external) limiting factor for water discharge. Model parameters were set such that realistic water management practices were simulated while considering the maximum allowed nitrogen emission as the external limiting factor, as well as the corresponding maximum annual discharge volume, for each of the crop classes. Four greenhouse discharge regimes were developed, one for each crop class. For all greenhouses the rainwater basin volume was 1500 m^3/ha, with a sodium concentration of the incoming rainwater of 0.1 mmol/L. The additional water source was reverse osmosis water with a sodium concentration of 0.1 mmol/L. Filter rinsing discharge per ha was 1.5 m^3/day. An overview of the greenhouse discharge regimes is given in Table 2.1

Table 2.1
Main characteristics of discharge regimes for the four classes of soilless cultivation water regimes.

Crop class	1	2	3	4
Associated crop	Rose	Tomato	Sweet pepper	Ficus
Crops in this class	Gerbera, starting material vegetables	Cucumber, herbs	Aubergine, strawberry	Starting material, floriculture, other flower crops
Annual water demand	8250 m^3/ha	7670 m^3/ha	6530 m^3/ha	4640 m^3/ha
Threshold value Sodium	4 mmol/L	8 mmol/L	8 mmol/L	6 mmol/L
Water supply- plant uptake ratio	1.5	1.25	1.25	1.5

2.1.2 Plant protection product emission

The Substance Emission Model (SEM, Van der Linden *et al.*, 2015; Vermeulen *et al.*, 2010) was used for calculating PPP concentration of the discharge water. This model conceptualises a greenhouse basically as a number of connected tanks. Water flows from one tank to the other. The model simulates water recirculation until the sodium tolerance value is achieved. Within the tanks, PPP is assumed to be ideally mixed. PPP may be degraded inside the tanks and metabolites may be formed and degraded by first order kinetics. The uptake of PPP by the crop is simulated with the Briggs formula (Briggs *et al.*, 1982), which assumes passive uptake with water influenced by the lipophilicity of the substance. The model further assumes fixed volumes of the tanks. The volumes are based on typical characteristics of Dutch greenhouse systems. In Figure 2.2 the lay-out of the system is shown, including tank volumes. It is the same for all discharge regimes. Tank volumes are rescaled to one ha. PPP may be applied via the nutrient solution (dripping) or via spraying or fogging. When a PPP is applied via the nutrient solution it enters the recirculation water via the mixing tank; when it is applied via spraying or fogging it enters the recirculation water via condensation water that is compulsorily collected and added to the recirculating water or it enters the recirculation water via direct application on flooding tables. Volatilisation and deposition of PPP is considered in the model as well. Sorption to substrate is assumed to be negligible, except in case of pot plant cultivation, when PPP may be sorbed to the soil/substrate in the pots. The temperature in the greenhouse is either 18 °C or 20 °C.

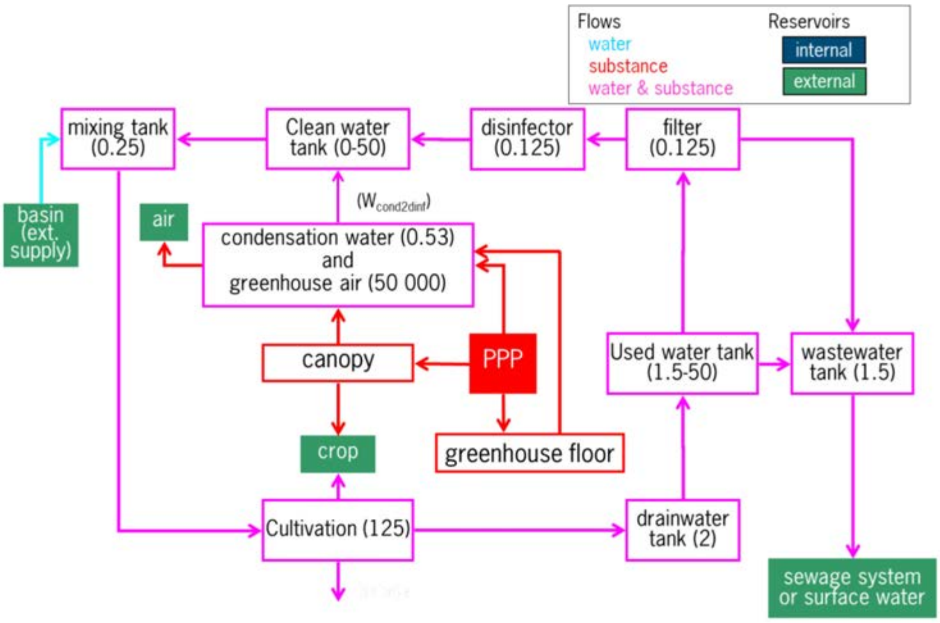

Figure 2.2 *The greenhouse PPP emission model conceptualises a greenhouse as a number of interconnected tanks. The water fluxes are taken from the WATERSTROMEN model. The volumes of the tanks (m^3) are given in brackets, they are based on expert opinion and aim to represent typical characteristics of Dutch greenhouses. This scheme shows the water and mass fluxes for application via spraying. The system is rescaled to 1 ha.*

2.1.3 Concentration in the ditch

Although part of the greenhouse population discharges waste water to the sewage system, greenhouses were assumed to discharge to surface water only. This is a conservative approach. The scenario ditch was selected from a population of ditches that potentially receive water from greenhouses. This ditch was considered a median ditch. The ditch had a bottom width of 1.88 m, a side slope of 1.2 and a (winter) water depth of 0.26 m. The water fluxes were taken from a calibrated hydrological model and vary between 0 m/s and 0.1 m/s. The data series of water fluxes was limited to the period of 2000-2006. Hence, the simulation period was limited to 7 years.

Concentrations in the ditch were calculated with the TOXSWA model (Adriaanse, 1996). The model calculates the PPP concentrations in both the water phase and the sediment phase by numerically solving a set of differential equations. TOXSWA considers PPP transport (advection, diffusion, dispersion), first order degradation and the formation of metabolites in both water and sediment phase as well as sorption to the sediment and suspended solids. Sorption to the sediment/suspended solids is described by the Freundlich equation. The ditch is discretised into a number of water segments and sediment layers. The equations for water conservation and PPP mass balance are solved separately.

2.2 Approach to the impact assessment

The three models WATERSTROMEN, Substance Emission Model (SEM) and TOXSWA were used consecutively to calculate the Predicted Environmental Concentration. To provide a band width of the impact of the new scenarios on the availability of PPP for soilless horticulture, two percentiles were considered, being the (overall) 50th and the 90th percentile concentrations in the ditch. The overall percentile corresponded to the same temporal percentile, which was derived from the annual peak concentrations in the ditch for each selected PPP-crop combination. In exposure risk assessments usually 20 years are simulated, however due to limited data availability only 7 years could be simulated (see Section 2.1.3). The methodology used is still valid, only the robustness of the solution is lower.

In the environmental risk evaluation procedure, authorisation is only possibly when the (calculated) Predicted Environmental Concentration (PEC) is below a reference effect concentration. To assess the impact of the new scenarios, we used the authorisation criterion for reference, being the EC50 or NOEC of the most sensitive species registered by the Ctgb or by EFSA times a corresponding assessment factor, where EC50 is the concentration that affects 50% of the test-organism and the NOEC is the No Observed Effect Concentration. The assessment factors were 0.1 on the lowest NOEC and 0.01 on the lowest EC50 of standard test organisms. Note that the authorisation criterion is based on the first tier effect concentration of the most sensitive standard test species and is therefore a conservative choice, i.e. higher tier effect concentrations may increase the number of PPP that could pass the authorisation criterion.

The impact analysis as well as the sensitivity analysis was performed for a number of selected greenhouse crops. For each crop, frequently used plant protection products were selected.
The selected crops were rose, tomato, sweet pepper and ficus, for the crop classes 1, 2, 3 and 4, respectively. These crops were considered important for the Dutch greenhouse economic sector.
The PPP selection was based on expert knowledge and information contained in the Dutch Environmental Risk Indicator for Plant Protection Products (NMI; Kruijne *et al.* 2011, 2012). The PPPs were chosen according to their importance/use in agricultural practice and their environmental impact. Between 7 and 11 PPPs were assigned to each crop. The selected substances (i.e. active ingredients) were known to be frequently used on this crop. At least one insecticide, one fungicide and one acaricide were chosen for each crop. For ficus, additionally one plant growth regulator was selected. One PPP could be selected for more crops. In Table 2.2, the selected PPPs are listed per crop including their estimated annual use in greenhouse horticulture in the Netherlands and the environmental impact according to the database of the NMI. This database is based on a national survey (in 2008) among growers and contains average sold volumes per PPP for the years 2008-2010. Four of the selected substances were not in this database as these products were relatively new on the market. The table shows that most of the selected substances are either frequently used/ have a high dose or they are considered to have a high environmental impact.

2.2.1 Plant Protection Product application

For all of the selected PPPs, physico-chemical and fate properties were collected as well as effect data. These data were obtained from EFSA assessment reports, renewal assessment reports (RAR) and DG SANCO reports. Only the parent substance was considered, not the metabolites. As no information was available on the degradation rates for soilless cultivation, it was assumed that substances degraded due to hydrolysis only. If the DegT50 in air or in water was not measured, a default value was taken of 100 d and 1000 d, respectively. Further default substance parameters are given in Table 2.3. In Table 2.4 for each selected PPPs the applied mass is given as well as the application timing, the number of applications and the time span between applications. Information about the application timing was taken from the Table of Intended Use and verified by comparison with information contained in NMI.

2.3 Example calculations

The objective of the example cases was to assess the sensitivity of the model to some of the model parameters. No systematic analysis was performed. The example calculations focussed on the effect of crop type to discharge volumes, the sensitivity of discharged PPP mass to crop type and application timing. Also the effect of the ditch flow dynamics on the water concentration was evaluated. All calculations apply to 1 ha of soilless cultivation.

The WATERSTROMEN model provides the discharge from the greenhouse to the ditch on a 3-hourly basis. The discharge of the four water discharge regimes was analysed. In addition, four example runs were performed with substance I1 as example PPP. Application timing and crop types were varied.

Table 2.2

Selected PPP per crop with the ranking according to sold volumes to growers and expected environmental impact (Kruijne et al., 2011, 2012). The total number of considered substances in the NMI database is 287.

ID	ID name	Ranked use on crop*	Ranked environmental impact per crop*
		Rose	
I1	Insecticide 1	13	4
F1	Fungicide 1	6	19
F2	Fungicide 2	8	14
F3	Fungicide 3	1	26
A5	Acaricide 5	19	2
F8	Fungicide 8	4	27
A1	Acaricide 1	30	7
A3	Acaricide 3	18	6
I5	Insecticide 5	15	15
A2	Acaricide 2	16	17
		Sweet pepper	
I1	Insecticide 1	9	2
I2	Insecticide 2	11	5
I8	Insecticide 8	-	-
A1	Acaricide 1	16	10
A2	Acaricide 2	12	15
I3	Insecticide 3	4	3
I4	Insecticide 4	2	4
		Tomato	
I1	Insecticide 1	31	7
I4	Insecticide 4	7	3
A3	Acaricide 3	13	6
F4	Fungicide 4	2	8
F5	Fungicide 5	1	19
A2	Acaricide 2	24	20
F6	Fungicide 6	-	-
I5	Insecticide 5	9	5
F9	Fungicide 9	-	-
A4	Acaricide 4	25	2
		Ficus	
I1	Insecticide 1	21	5
A1	Acaricide 1	30	2
A2	Acaricide 2	24	21
F7	Fungicide 7	47	-
PGR1	Plant Growth Regulator 1	-	-
I6	Insecticide 6	-	-
A3	Acaricide 3	28	6
I7	Insecticide 7	25	34

* Lower values indicate a higher impact. 1 represents the highest impact. '-' indicates that substance was not included in the NMI database (or not related to the crop group).

Table 2.3

Default substance parameters.

Parameter	Value	Unit
Half-life on crop	10	d
Half-life on floor	100	d
Molar enthalpy of transformation in recirculation water	65.4	kJ/mol
Molar enthalpy of transformation in air	45	kJ/mol
Molar enthalpy of transformation in surface water and sediment	65.4	kJ/mol
Molar enthalpy of vaporisation	95	kJ/mol
Molar enthalpy of dissolution	27	kJ/mol
Reference diffusion coefficient in air	0.43	m^2/d
Reference diffusion coefficient in water	$4.3\ e^{-5}$	m^2/d

Table 2.4

Selected PPP per crop and application type, applied mass in kg/ha per application, application timing, number of applications per year and interval between the applications as used in the impact assessment.

ID	ID name	Appl. type	Mass (kg)	Application timing	Times per year	Appl. Interval (d)
			Rose			
I1	Insecticide 1	Dripping	0.84	April	2	7
F1	Fungicide 1	Spraying	0.3	July, August	6	7
F2	Fungicide 2	Spraying	0.15	June, July	6	7
F3	Fungicide 3	Spraying	2.5	June, July	7	7
A5	Acaricide 5	Spraying	0.075	July, August, September	6	7
F8	Fungicide 8	Spraying	0.75	June	4	7
A1	Acaricide 1	Spraying	0.0135	June	3	7
A3	Acaricide 3	Spraying	0.12	February	2	7
I5	Insecticide 5	Spraying	0.096	June	3	7
A2	Acaricide 2	Spraying	0.144	June, August	4	7
			Sweet Pepper			
I1	Insecticide 1	Dripping	0.1568	April, June	2	61
I2	Insecticide 2	Spraying	0.1	July, August, September	6	7
I8	Insecticide 8	Spraying	0.0525	July, August	6	7
A1	Acaricide 1	Spraying	0.0135	January, December	4	7
A2	Acaricide 2	Spraying	0.144	July	2	7
I3	Insecticide 3	Spraying	0.625	July	3	7
I4	Insecticide 4	Dripping	0.115	June	3	7
			Tomato			
I1	Insecticide 1	Spraying	0.1568	July, September	2	62
I4	Insecticide 4	Spraying	0.12	May, May	2	7
A3	Acaricide 3	Spraying	0.18	April, April	2	7
F4	Fungicide 4	Spraying	0.6	September, September	2	7
F5	Fungicide 5	Spraying	1.59	April, May, July, August	4	7
A2	Acaricide 2	Spraying	0.144	May, May	2	7
F6	Fungicide 6	Spraying	0.75	August	3	7
I5	Insecticide 5	Spraying	0.144	July, August	6	7
F9	Fungicide 9	Spraying	0.5	September	4	7
A4	Acaricide 4	Spraying	0.165	June	3	15
			Ficus			
I1	Insecticide 1	Dripping	1.96	June	2	7
A1	Acaricide 1	Spraying	0.009	April, June, August, October	8	7
A2	Acaricide 2	Spraying	0.144	June	2	7
F7	Fungicide 7	Spraying	9	July	1	
PGR1	Plant Growth Regulator 1	Spraying	4.256	1. per month	12	30-31
I6	Insecticide 6	Spraying	0.14	September, October	3	20
A3	Acaricide 3	Spraying	0.12	December	2	7
I7	Insecticide 7	Spraying	0.1	June	2	7

3 Results

3.1 Example calculations

3.1.1 Sensitivity of water discharges to crop type

The WATERSTROMEN model provides the 3-hourly discharges from the greenhouse to the ditch, as the sum of filter discharge and sodium related discharge. Each crop has a specific discharge pattern. Also, the water flux patterns differ over simulated years due to meteorological events, such as different precipitation patterns and incoming radiation. For the four selected crops we calculated the discharge to surface water over the period 2000 to 2007, being the sum of the filter discharge and the sodium induced discharge.

In Table 3.1 the annual discharges are listed. Rose exhibits the highest annual discharges each year, up to 744 m^3 ha^{-1} in 2005, sweet pepper is the second highest together with ficus. The lowest annual discharges can be found for tomato of which the lowest value is 181 m^3 ha^{-1} in 2004. Rose and sweet pepper have high annual values, as well as a high number of extreme discharge events, while tomato and ficus show lower values and a negligibly small number of incidental discharges (Fig. 3.1 to 3.4).

Discharge patterns shown in the Figures 3.1. to 3.4 result from the regular discharges due to filter cleaning and the discharge peaks that are induced to prevent sodium accumulation above the threshold value. All discharges are calculated per ha. The filter discharge volume is below 4 m^3 d^{-1} for all crops. The volumes of sodium related discharged water may vary, with a maximum of 18 m^3 d^{-1} (rose). Over the simulated period of 7 years, the year 2003 shows discharge peaks most frequently. 2003 is known to be a dry year. In dry years the water demand is higher and hence sodium accumulates faster, which results in more discharge events.

Table 3.1
Annual discharge to surface water for the crops rose, sweet pepper, ficus and tomato.

Year	Annual discharge (m^3 ha^{-1} yr^{-1})			
	Rose	Sweet Pepper	Ficus	Tomato
2000	661	388	425	215
2001	663	398	446	220
2002	761	392	440	214
2003	913	729	413	182
2004	611	366	435	207
2005	744	411	440	215
2006	702	477	408	187
Mean annual discharge	722	452	429	206

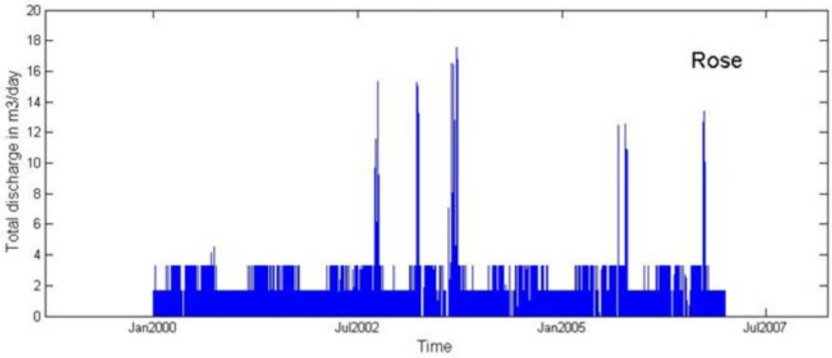

Figure 3.1 *Discharge pattern of rose over the simulated period of 1-1-2000 to 31-12-2006.*

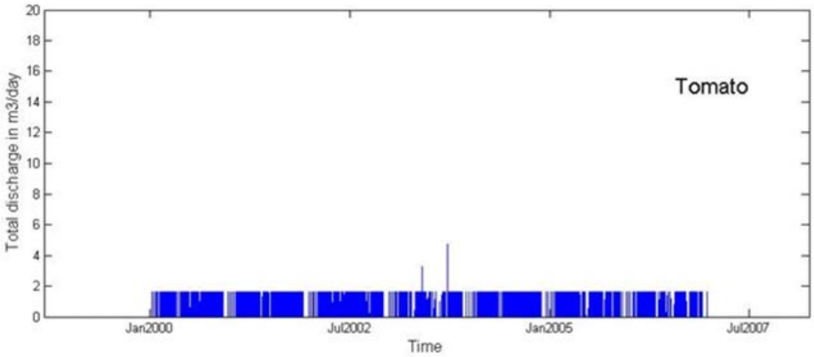

Figure 3.2 *Discharge pattern of tomato over the simulated period of 1-1-2000 to 31-12-2006.*

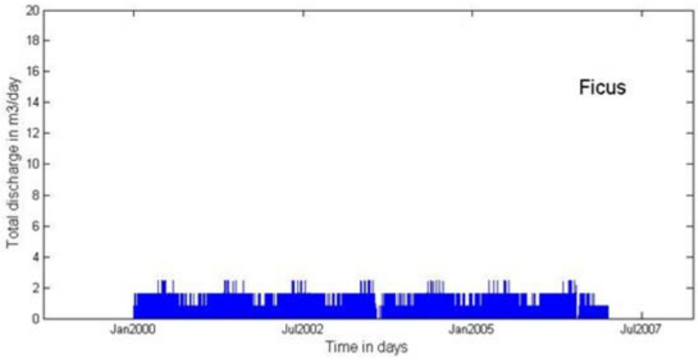

Figure 3.3 *Discharge pattern of ficus over the simulated period of 1-1-2000 to 31-12-2006.*

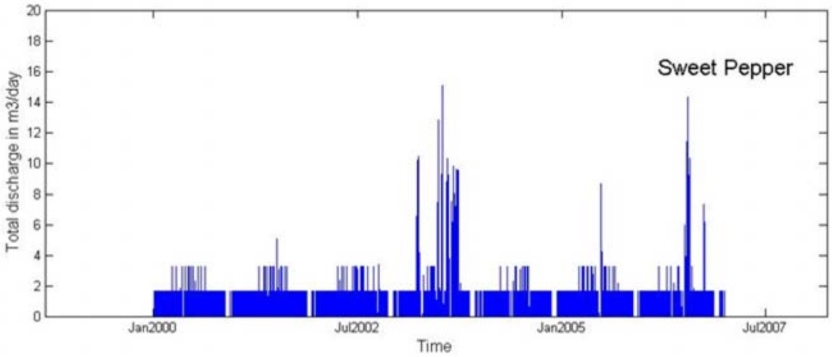

Figure 3.4 *Discharge pattern of sweet pepper over the simulated period of 1-1-2000 to 31-12-2006.*

As an example for the differences in discharge between two crops, Figure 3.5 shows the total discharge for rose and ficus over the period March- April 2003. Rose shows an irregular pattern which is dominated by discharge owing to sodium accumulation, ficus shows a regular discharge only owing to filter cleaning.

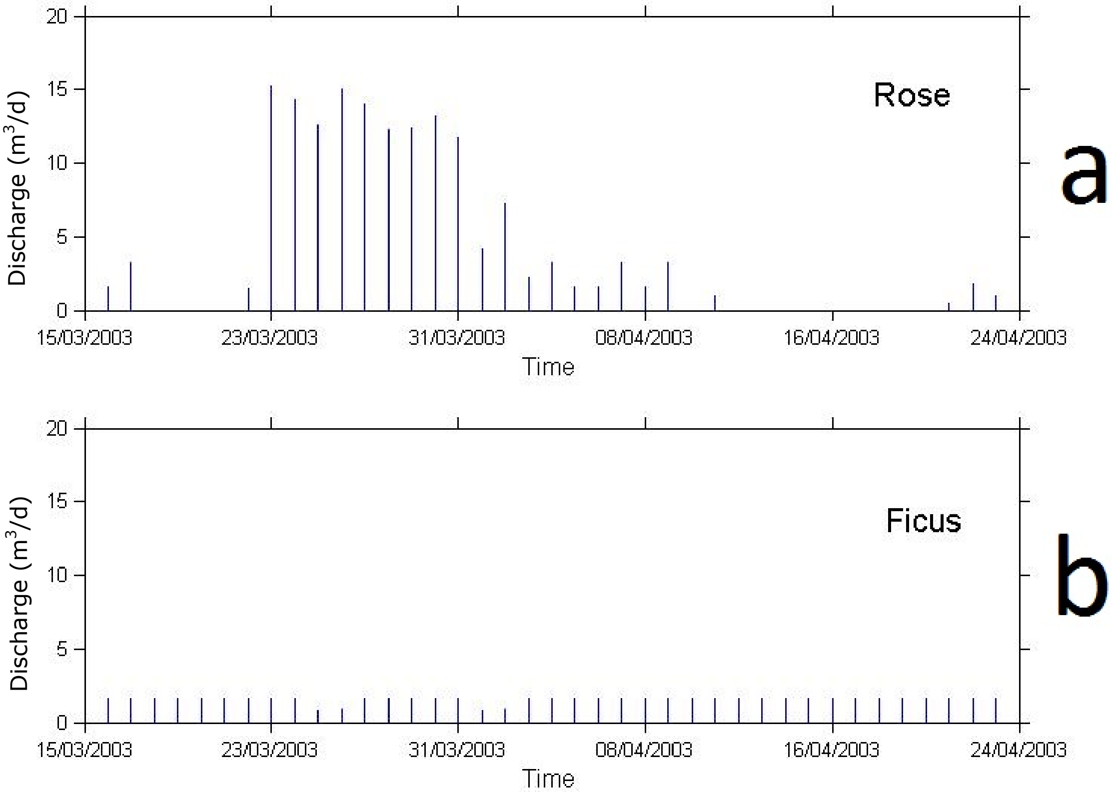

Figure 3.5 *Discharge patterns in a selected period (March / April 2003) for (a) rose and (b) ficus.*

3.1.2 Mass discharge and concentrations in the ditch

Four example cases were studied to explore the sensitivity of the model. The characteristics of these cases are summarised in Table 3.2. In all cases the applied PPP was Insecticide 1. The half-life of Insecticide 1 due to hydrolysis is 1000 d and the log(K_{ow}) is 0.57, which gives a selectivity factor for plant uptake of 0.42.

Table 3.2
Main characteristics of the example cases. The applied PPP is Insecticide1.The applied mass is given per application.

Case	PPP ID	Application type	Timing	Applied Mass (kg/ha)	Crop
1	I1	Dripping	8. April, 15. April	0.84	Rose
2	I1	Dripping	1. April, 1. June	0.84	Rose
3	I1	Dripping	1. April, 1. June	0.84	Tomato
4	I1	Spraying	8. April, 15. April	0.84	Rose

3.1.2.1 The impact of the Application timing

We considered two different applications with respect to timing, of the PPP Insecticide 1 (I1) applied to rose; the total annual applied mass is the same for both cases. These are shown as case 1 and 2 in Table 3.2. Figure 3.6 and Figure 3.7 show the daily mass discharge of rose with Insecticide 1, for the Cases 1 and 2. Although, the same dose is given for both cases, the total discharged amount differs. E.g. in the year 2003 (the fourth peak in Fig. 3.6 and the seventh and eighth peak in Fig. 3.7), Case 1 has a lower peak as compared to the other years, whereas Case 2 shows a higher peak in 2003 as compared to the other years. We calculated for this year the total discharged mass. These were 142 g and 205 g for Case 1 and Case 2, respectively. Hence, the discharged mass of Case 2 is almost 1.5 times the discharge of Case 2.

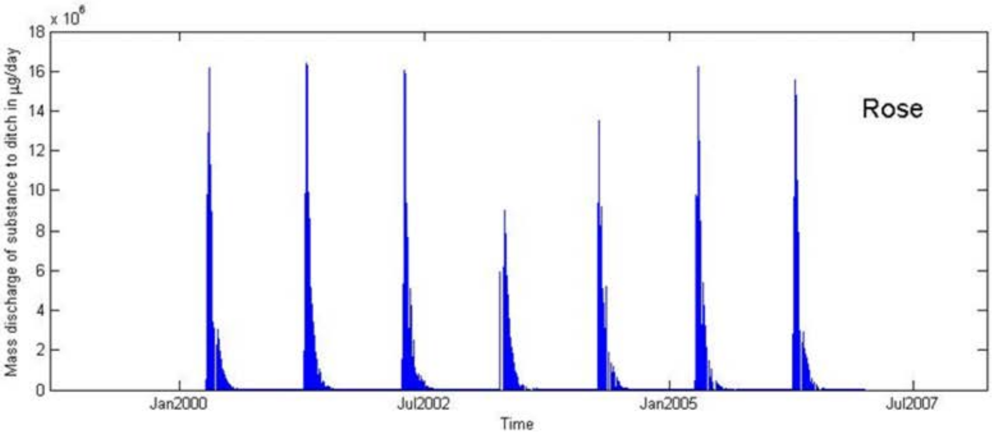

Figure 3.6 *Daily mass discharge from rose with the application of Insecticide 1 via dripping on 8 April and 15 April (Case 1).*

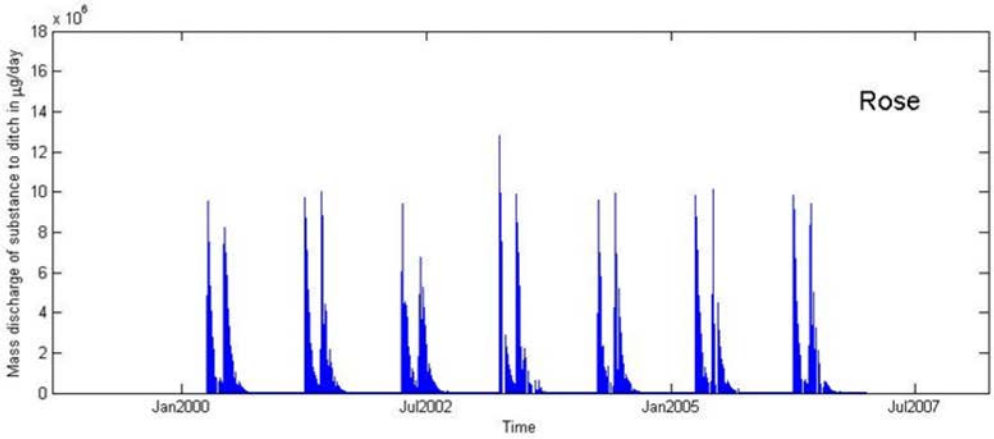

Figure 3.7 *Daily mass discharge from rose of Insecticide 1 applied via dripping on 1 April and 1 June (Case 2).*

In Table 3.3, the main mass balance terms are given for 2003. The discharged mass for Case 2 in 2003 is ca. 1.5 times that of Case 1. Plant uptake shows to have more impact on the discharged mass than degradation (i.e. transformed) as DegT50 used is 1000 days.

Table 3.3
Mass balance terms of Case 1 and 2 for 2003.

Case	Applied mass (kg/ha)	Transformed (kg/ha)	(%)	Uptake (kg/ha)	(%)	Discharged (kg/ha)	(%)	Leakage (kg/ha)	(%)
1	1.68	0.0138	0.8	1.42	84.5	0.142	8.5	0.104	6.2
2	1.68	0.0145	0.9	1.37	81.6	0.205	12.2	0.089	5.3

Figure 3.8 and 3.9 zoom in on year 2003, for again Case 1 and Case 2. The figures A show the daily discharge volumes. The figures B show the discharged masses. One discharge peak occurs between 22.3.2003 and 02.04.2003 and a second peak occurs between 13.08.2003 and 24.09.2003. Hence, for Case 1 the first application occurs 6 days after the peak discharge event, whereas for Case 2, the first application is just during the peak discharge. Thus for Case 2, a considerable part of the PPP is immediately discharged to the surface water after being applied to the crop. The PPP has no time to dissipate significantly and is discharged in one event instead of being diluted, degraded or taken up by the crop.

The example calculations above show that differences in application timing affect the annual discharged mass as well as the annual peak discharged mass. A larger time-lag between application and discharge decreases the emitted mass as it allows for the PPP to be degraded or taken up by the plants.

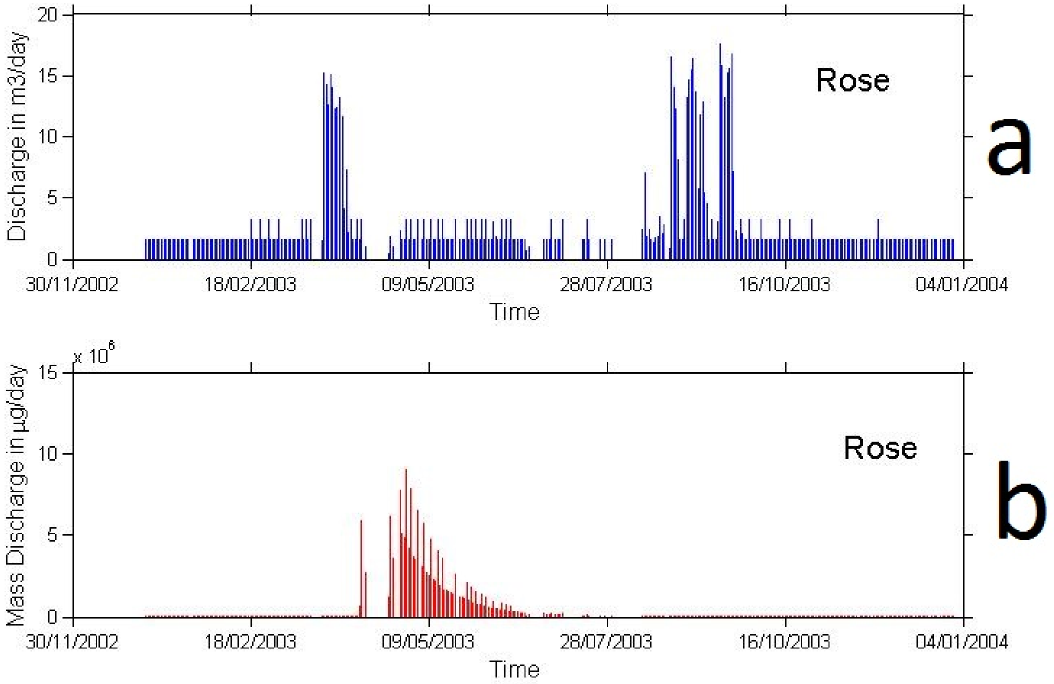

Figure 3.8 *Daily water discharge (a) and daily mass discharge (b) to the ditch in 2003. Insecticide 1 is applied via dripping on 8 April and 15 April to rose (Case 1).*

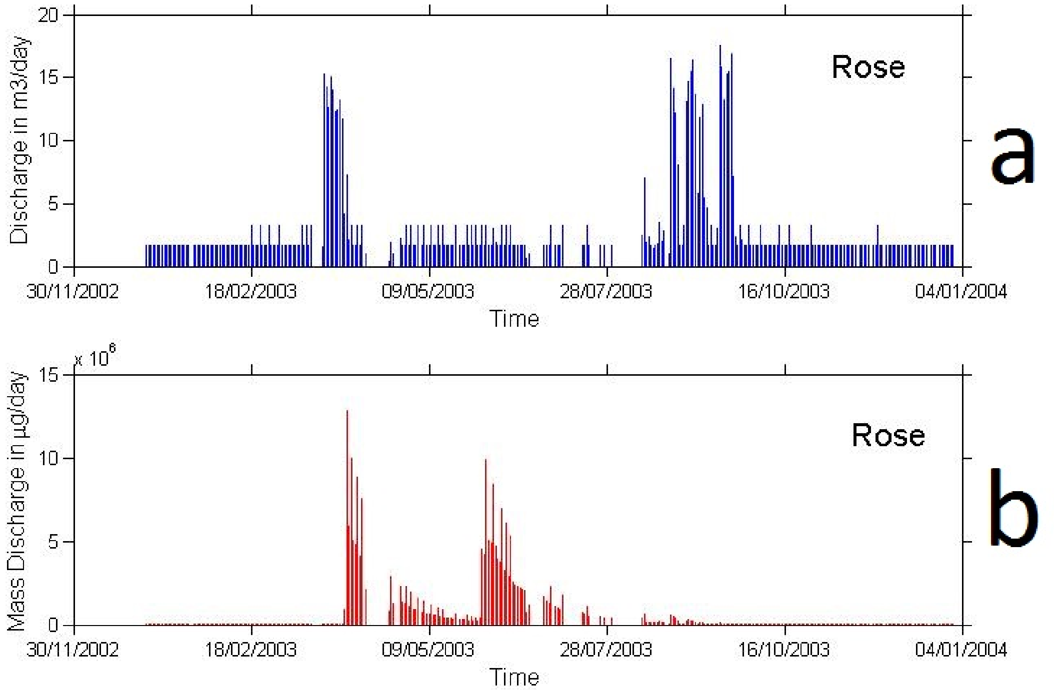

Figure 3.9 *Daily water discharge (a) and daily mass discharge (b) to the ditch in 2003. Insecticide 1 is applied via dripping on 1 April and 1 June to rose (Case 2).*

3.1.2.2 The Discharge Pattern

Rose and tomato are crops with different sodium tolerance levels. Rose has a low sodium tolerance level with frequent sodium related discharge events. Tomato belongs to the group of crops which have a higher sodium tolerance. To show the difference between both crops we simulated a third case, i.e. tomato with the same application scheme as for rose Case 2. In Figure 3.10, the water discharge and mass discharge from tomato is given for the year 2003. In comparison to rose, the discharged mass from tomato is much lower. We calculated the total discharged mass from tomato for the year 2003, which was only 66 g, this is more than 2 times lower than for rose (Note that the axes in Figure 3.10 differ from the axes of Figure 3.9). The maximum daily discharged mass was 12.4 g for rose and 4.1 g for tomato.

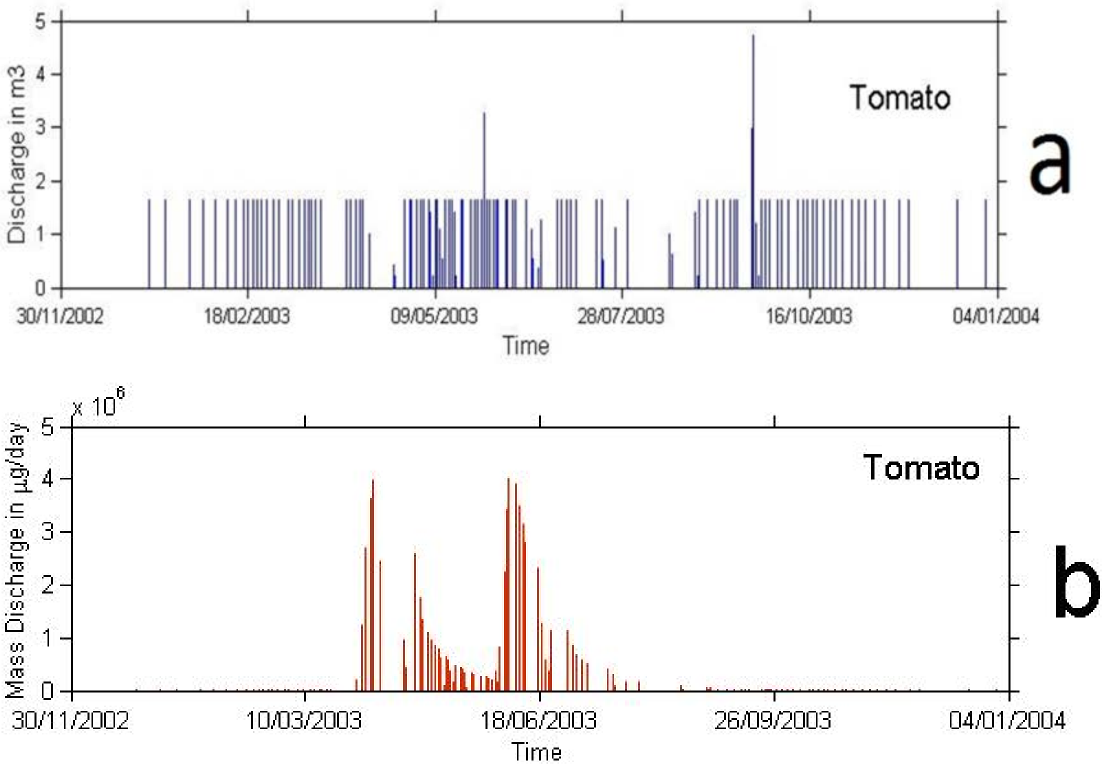

Figure 3.10 *Daily water discharge (a) and daily mass discharge (b) to the ditch in 2003. Insecticide 1 is applied via dripping on 1 April and 1 June to tomato (Case 3).*

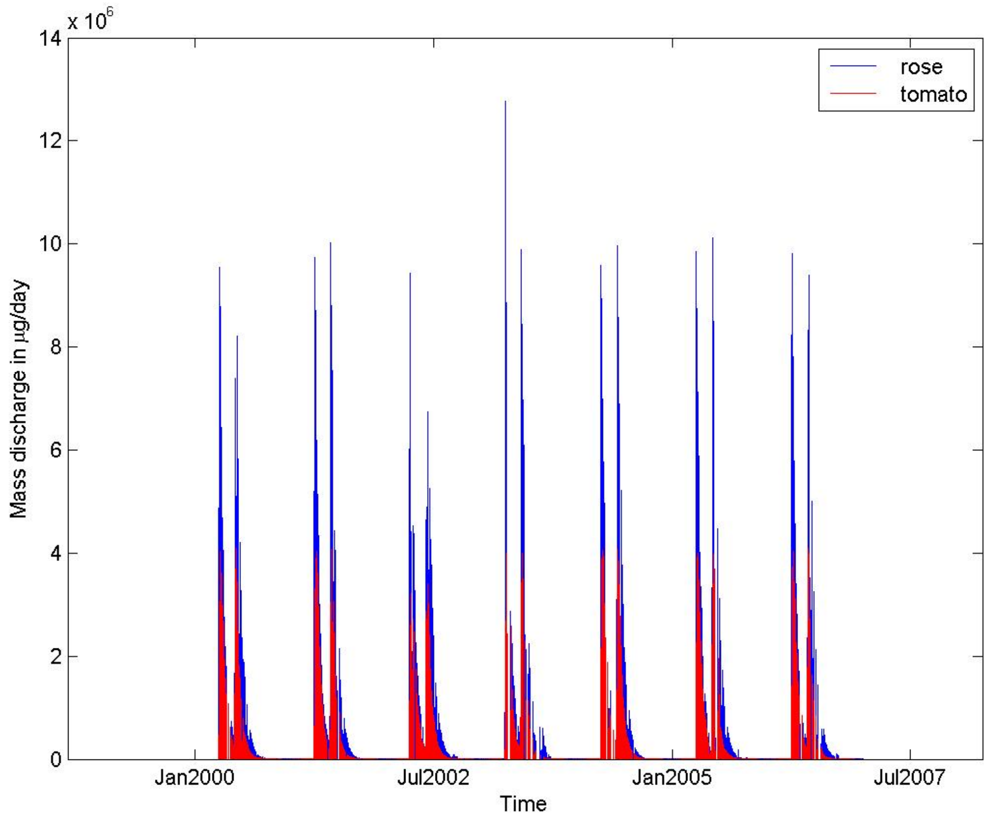

Figure 3.11 *Mass discharge to surface water from rose (Case 2, blue line) and tomato (Case 3, red line). Insecticide 1 is applied via dripping on 1 April and 1 June.*

Figure 3.11 shows the mass discharge of Insecticide 1 for Case 2 and 3, i.e. rose and tomato, respectively with the same application scheme. Discharge peaks for both crops occur at the same time. The mass discharges from rose (blue) last longer and are higher than from tomato. A number of processes cause this difference. The first one is that the residence time of water for tomato is longer, hence the time for degradation and plant uptake is also longer. In addition, the ratio between water supply and crop uptake of rose is 1.5 and for tomato only 1.25 (See Table 2.1). This implies that relatively more water is taken up by tomato than by rose. In Table 3.4 the mass balances of all cases are given. Comparison between case 2 and 3 reveals that the plant uptake by tomato crops dissipates 90% of the total applied mass, whereas rose dissipates only 80%. The effect of degradation for both cases is very low as the DegT50 used in the calculations is 1000 d. Plant uptake therefore has more effect on the discharged concentration.

3.1.2.3 Application type

PPP may be applied via the nutrient solution or via spraying or fogging. To show the effect of the way PPP is applied two cases are compared with application via the nutrient solution (Case 1) or via spraying (Case 4). In Table 3.4 the mass balances are given. For Case 4, *Applied mass* refers to the total mass that enters the recirculation system via the collection and use of condensation water. This is only 126 g, 1/13 of the total applied mass (1.68 kg). Note that the percentages transformed, uptake and discharge are approximately the same for both cases.

Table 3.4
Mass balance terms of Case 1 to 4 (averaged over 7 years).

Case	Applied mass (kg/ha)	Transformed (kg/ha)	(%)	Uptake (kg/ha)	(%)	Discharged (kg/ha)	(%)	Leakage (kg/ha)	(%)
1	1.68	0.013	0.8	1.36	81.2	0.205	12.2	0.097	5.8
2	1.68	0.0141	0.8	1.35	80.5	0.22	13.1	0.094	5.6
3	1.68	0.0105	0.6	1.51	90.1	0.08	4.9	0.074	4.4
4	0.126*	0.001	0.9	0.10	81.4	0.015	12.1	0.007	5.6

* This is not the applied mass. It is the mass that comes into the recirculation water after spraying. The percentiles are given relative to this mass.

3.1.2.4 The Dynamics of the Receiving Ditch

The receiving ditch is simulated as a water body with a length of 100 m and an upstream flow which varies driven by the weather conditions. Dry or wet spells lead to water level and water velocity fluctuations in the ditch and therefore affect the concentration of PPP in the water body.

Figure 3.12a shows the mass of the Insecticide 1 thatis discharged daily to the ditch in case of a rose cultivation (Case 1). The figure shows a series of paired peaks. The 4th peak (year 2003) presents the maximum value in 2003 and coincides with the discharge events from 13.08.2003 to 24.09.2003. Note that the corresponding maximum hourly discharged flux is higher than the daily discharge.

Figure 3.12b shows the concentration of Insecticide 1 in the ditch averaged over 1 day. The number of peaks of concentration are the same and appear at the same time as the peaks of mass discharge. The concentrations show a bigger variation than the mass discharge peaks. This is due to the flushing/ dilution and due to the highly fluctuating upstream water discharges. The first three peaks in Figure A are of similar height and width. In contrast, the first three peaks in Figure B show differences in their maximum values up to a factor 2 between 2001 and 2002. The dynamics of the ditch discharge and the water level fluctuations cause additional dynamics in the PPP concentration due to dilution and transport processes.

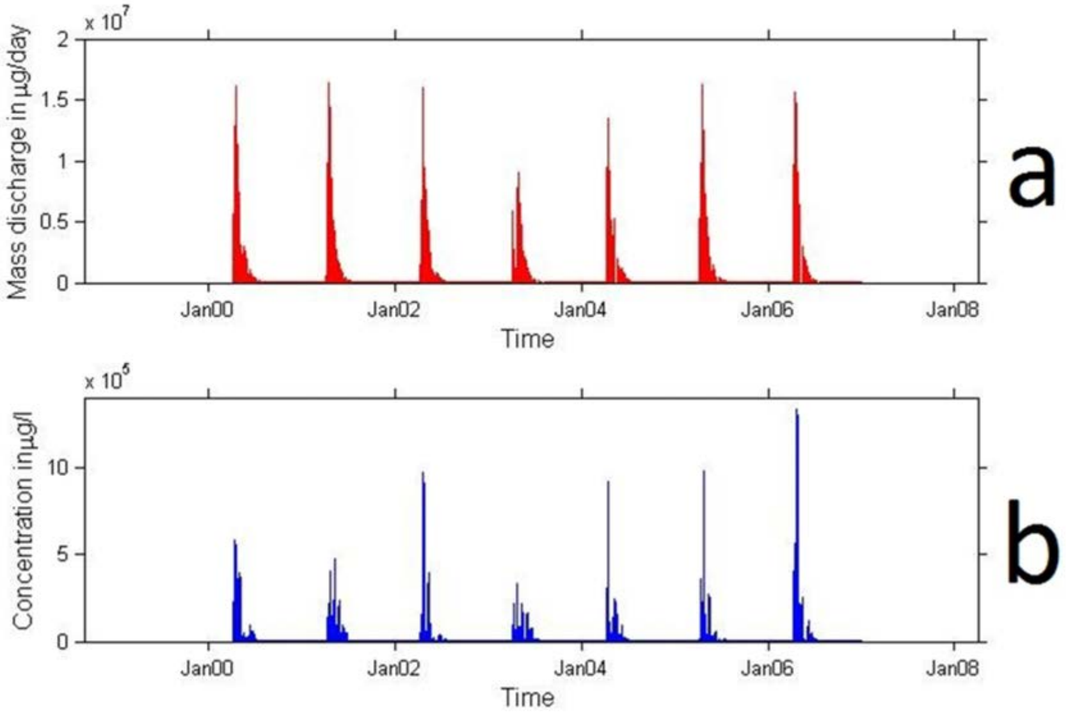

Figure 3.12 *Comparison of daily mass discharge (a) and Insecticide 1 concentration averaged over 24 hr (b) in the ditch for rose, Case 1.*

3.2 Impact of the new scenarios

The impact of the new scenarios was assessed by comparing the Predicted Environmental Concentration, being the 50th or 90th percentile peak concentration in surface water, to the authorisation criterion. In Table 3.5, all considered PPP-crop combinations are given with their 50th and 90th percentile concentrations, the reference effect concentrations (NOEC or EC50), the assessment factors used and the authorisation criterion. In the 7th column the ratio between the 90th percentile concentration and the authorisation criterion is given.

For most of the PPPs considered, the calculated concentration, hereafter referred to as Predicted Environmental Concentration (PEC), is above the authorisation criterion. In the Figures 3.13 and 3.14, the ratio between the authorisation criterion and the PEC is given for the PEC being the 50th and 90th percentile concentration, respectively. From the total of 35 combinations, only 8 have a PEC below the authorisation criterion in case a 90th percentile concentration is selected. The 50th percentiles are between a factor 1.1 to 6.5 lower than the 90th percentile concentrations. Although the PEC values for the 50th percentile lie below the values for the 90th percentile, only five of the considered combinations drop below the authorisation criterion, when changing the percentile from 90th to 50th.

Table 3.5 also gives the end-of-pipe reduction that would be needed to meet the level of the authorisation criterion for a 90th percentile PEC (concentration in the ditch). A linear relationship between discharged mass and PEC was assumed to derive the reduction. The needed reduction ranges from 0 to 100 percent. 17 of the 35 considered combinations required end-of-pipe treatment larger than 90 percent.

The PEC was calculated averaged over 100 m of ditch. To indicate the effect of ditch length, for rose with the application of I1 (see first row in Table 2.3) with a ditch length of 50 m the 90th percentile concentration was calculated, being 2094.2 µg/L. This is a factor 1.5 higher than for a 100 m ditch. For the other cases a decrease of the length of the considered ditch will presumably lead to a similar increase of calculated concentration.

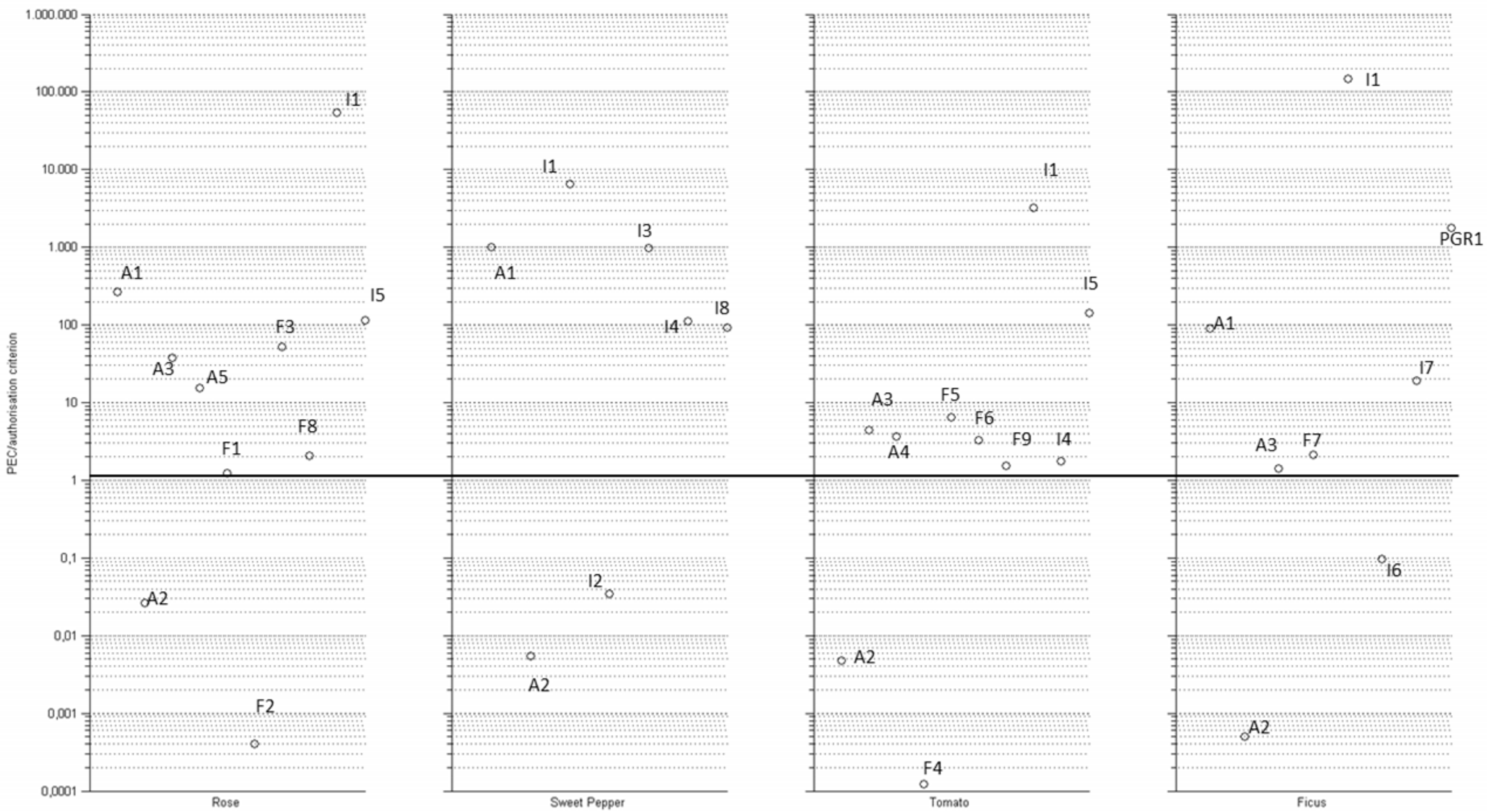

Figure 3.13 *Ratio between the predicted environmental concentration (PEC) and the authorisation criterion of all modelled crops for the 90th percentile concentration of annual peak values. The line distinguishes between PPPs which exceed the authorisation criteria and PPPs below the authorisation criterion (the IDs of the different PPPs can be found in Table 2.3.1).*

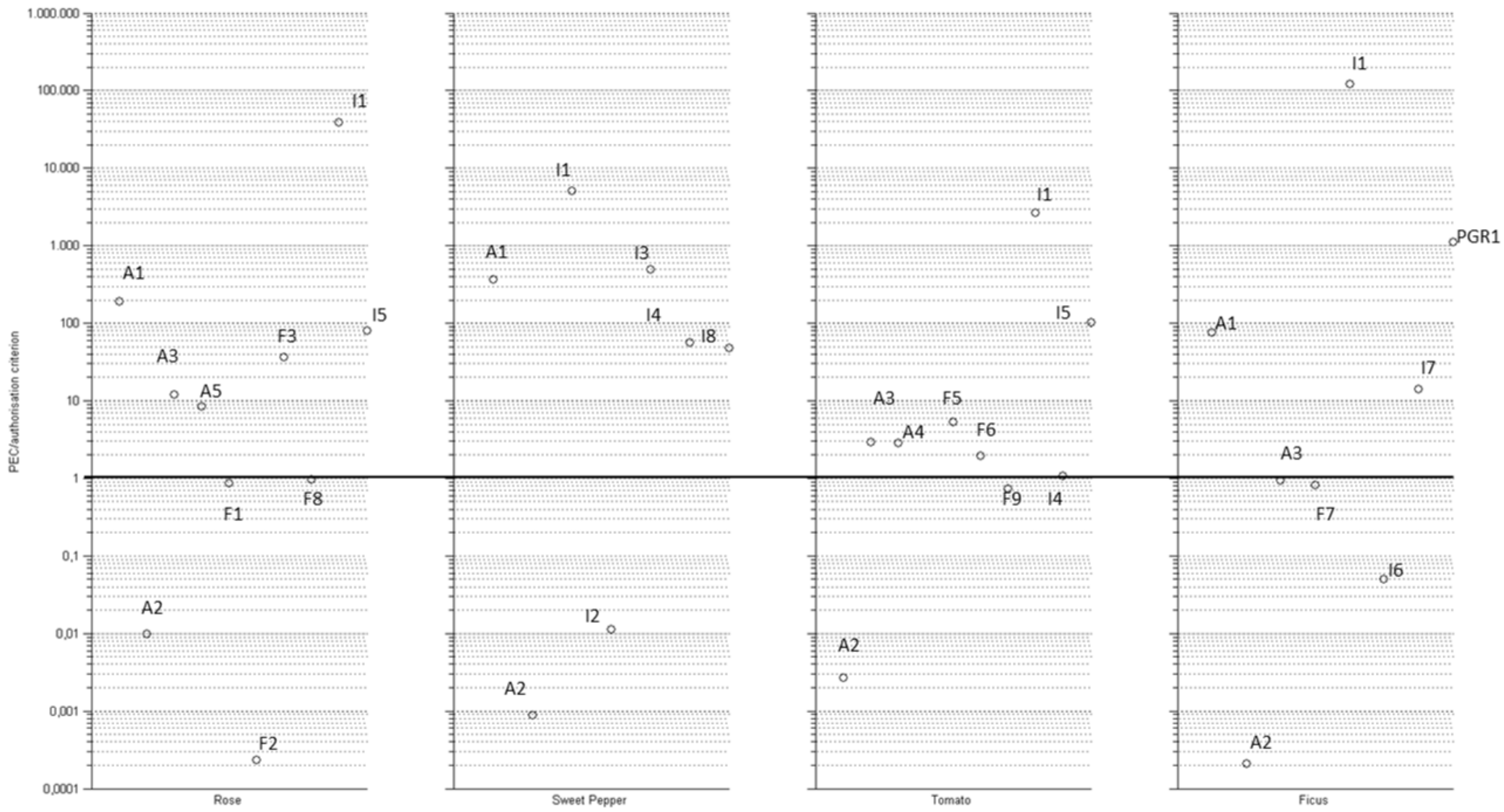

Figure 3.14 *Ratio between the predicted environmental concentration (PEC) and the authorisation criterion of all modelled crops for the 50th percentile concentration of annual peak values. The line distinguishes between PPPs which exceed the authorisation criteria and PPPs below the authorisation criterion (the IDs of the different PPPs can be found in Table 2.3.1).*

Table 3.4
50th and 90th percentile concentrations for all crop-PPP combinations, as well as the reference effect concentrations (NOEC or EC50), the assessment factors used, the ratio between the 90th percentile concentration and the reference effect concentrations. The last column shows the end-of-pipe reduction needed to meet the authorisation criterion (i.e. reference effect concentration times assessment factor). The percentile concentration is the peak concentration averaged over 1 hr.

ID	PPP Identification name	50th perc. (µg/L)	90th perc. (µg/L)	Reference effect concentrations (µg/L)	Assessment Factor	PEC/auth 90th perc.	% needed end of pipe red.
				Rose			
I1	Insecticide 1	1047.300	1471.960	0.027	1	54517.04	100
F1	Fungicide 1	10.940	15.620	125	0.1	1.25	20
F2	Fungicide 2	2.329	4.026	100000	0.1	0.00	0
F3	Fungicide 3	293.600	420.600	80	0.1	52.58	98
A5	Acaricide 5	0.110	0.202	1.3	0.01	15.55	94
F8	Fungicide 8	9.693	20.810	100	0.1	2.08	52
A1	Acaricide 1	0.195	0.268	0.01	0.1	267.56	100
A3	Acaricide 3	0.301	0.941	0.25	0.1	37.65	97
I5	Insecticide 5	10.610	15.108	1.3	0.1	116.22	99
A2	Acaricide 2	0.017	0.045	17	0.1	0.03	0
				Sweet Pepper			
I1	Insecticide 1	137.700	176.320	0.027	1	6530.37	100
I2	Insecticide 2	0.029	0.090	26	0.1	0.03	0
I8	Insecticide 8	12.020	23.126	2.5	0.1	92.50	99
A1	Acaricide 1	0.373	0.993	0.01	0.1	993.10	100
A2	Acaricide 2	0.001	0.009	17	0.1	0.01	0
I3	Insecticide 3	44.580	87.658	0.9	0.1	973.98	100
I4	Insecticide 4	143.500	277.840	25	0.1	111.14	99
				Tomato			
I1	Insecticide 1	72.880	87.490	0.027	1	3240.37	100
I4	Insecticide 4	2.702	4.405	25	0.1	1.76	43
A3	Acaricide 3	0.074	0.111	0.25	0.1	4.46	78
F4	Fungicide 4	0.002	0.012	940	0.1	0.00	0
F5	Fungicide 5	3376.800	4036.560	6300	0.1	6.41	84
A2	Acaricide 2	0.005	0.008	17	0.1	0.00	0
F6	Fungicide 6	19.890	32.918	101	0.1	3.26	69
I5	Insecticide 5	12.240	17.268	1.2	0.1	143.90	99
F9	Fungicide 9	10.070	20.816	135	0.1	1.54	35
A4	Acaricide 4	0.014	0.017	0.047	0.1	3.69	0
				Ficus			
I1	Insecticide 1	3333.800	3974.980	0.027	1	147221.48	100
A1	Acaricide 1	0.077	0.090	0.01	0.1	90.09	99
A2	Acaricide 2	0.000	0.001	17	0.1	0.00	0
F7	Fungicide 7	749.600	1939.800	9100	0.1	2.13	53
PGR1	Plant Growth Regulator 1	2259.600	3599.460	200	0.01	1799.73	100
I6	Insecticide 6	15.520	29.756	3100	0.1	0.10	0
A3	Acaricide 3	0.024	0.036	0.25	0.1	1.44	30
I7	Insecticide 7	14.200	18.958	10	0.1	18.96	95

4 Discussion, conclusions and recommendations

The impact was assessed of new Dutch exposure scenarios for the environmental risk assessment of plant protection products used in soilless horticulture. The new scenarios are intended to be used in the Dutch PPP registration process. The selected crops were rose, tomato, sweet pepper and ficus. For each crop 7-11 plant protection products were selected. Three parameterized models were used consecutively to calculate the water fluxes inside the greenhouse (WATERSTROMEN), the PPP fate in the greenhouse (Substance Emission Model), and the concentration in the receiving ditch (TOXSWA). The predicted environmental concentration was either the 50th percentile or the 90th percentile peak concentration in surface water. Both percentiles were used in the assessment as the risk managers have not decided yet on the percentile to be used. The calculated concentration was compared to the authorisation criterion of each PPP. The authorisation criterion was based on first tier effect concentrations.

Additionally to the impact assessment, model sensitivity was assessed by analysing a number of example cases, while using the new exposure scenarios. The sensitivity to PPP properties has not been investigated, but it may be expected that emissions to surface water, and consequently the concentrations in surface water, will become lower when transformation in the recirculation water is faster.

4.1 Example calculations

The example calculations showed that:

Discharge towards nearby ditches was due to both filter cleaning and sodium control. The discharge patterns varied between crops. The differences were mainly caused by different water demand and different sodium tolerance levels. The crop with the highest annual and daily discharge was rose, while ficus had the lowest annual discharge. Rose is a crop with a relatively high water demand (8250 m^3/ha/yr) and a low sodium tolerance (4 mmol/L), whereas ficus has a lower water demand of 4640 m^3/ha/yr and a sodium tolerance of 6 mmol/L. During dry years the discharge to surface water was higher than in the other years.

Discharged mass was higher for application right before or during a discharge event. The longer PPP remains in the greenhouse circulation water, the less the discharged mass became. Plant uptake was the process reducing the discharge most. Degradation is expected to play a role here, but for the example substances degradation rates were negligible.

Sodium sensitive crops had a higher total discharged mass as well as a higher maximum daily mass discharge than sodium tolerant crops. As the residence time of sensitive crops was shorter, the effect of degradation and plant uptake was less. A lower water supply-plant uptake ratio increased the effect of plant uptake and degradation.

Applying PPP by spraying showed a 92% lower emission to surface water in the average mass balance as compared to application to the nutrient solution in the example calculations. A lower percentage was expected because the substance is entering the system only via redistribution into condensation water.

Water level and flow dynamics in the ditch varied independently of the greenhouse processes. This may lead to additional concentration dynamics in the water body, even if the amounts of discharged mass are the same.

4.2 Impact

27 of the 35 PPP-crop combinations had a 90^{th} percentile PEC that exceeded the authorisation criterion. 22 of these combinations had a 50^{th} percentile PEC that exceeded the authorisation criterion. For the PPPs that exceed the authorisation criterion (reference is 90^{th} percentile) a corresponding minimally required end-of-pipe reduction percentage was calculated that amounted to nearly 100%. For 17 of the 35 considered combinations a reduction percentage larger than 90% would be needed.

The results indicate that the calculations with the degradation only based on hydrolysis show that, if no end-of-pipe treatment is considered, the implementation of the new scenarios in the registration process could lead to exclusion of a large number of PPPs. The decision of the percentile to be used appears to have no big impact on the calculated PEC. The authorisation criterion used is based on first tier effect concentrations. Higher tier effect concentrations may increase the number of PPPs that pass the authorisation criterion. The working group decided however, to assess the impact while considering a similar reference level for all substances, being the first tier effect concentration with corresponding assessment factor. Higher tier information on degradation in the recirculation water may also lead to a larger number passing.

The PEC is sensitive to the ditch length that is used for calculating the annual peak concentration. However, it will have limited impact on the available PPP for use in soilless horticulture.

In the calculations it was assumed that degradation in greenhouses only occurs due to hydrolysis. This is a conservative assumption as Matser *et al.* (1997) already showed that degradation may be enhanced due to microbial activity around plant roots of full grown plants. The working group recommends investigating the use of more realistic degradation rates. A proper method should be developed to derive degradation rates in greenhouses, optionally as function of the crop development stages. This may decrease the concentrations in the discharge water as well as in the ditch.

Sorption to substrate was not included in the scenarios. This is also a conservative assumption as Matser *et al.* (1997) showed that sorption may play a role in rockwool systems. Although it is expected that degradation in the recirculating water has a larger effect, it is recommended to further assess the role of sorption to substrate and to include sorption in the calculations.

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Annex 1 Substance properties

For substrate the degradation rate in soil was taken. For sediment organisms the exposure concentration of water was assumed to be representative.

Acaricide 1

Property	Value	Unit	Comment
Molar mass	859.1	$g.mol^{-1}$	
Half-life transformation in water	2.4	d	Measured at 20 °C
Half-life transformation in sediment	99	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	0.1	d	Measured at 20 °C
Half-life transformation in substrate	28.7	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	129	$L.kg^{-1}$	Kom
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.9	-	
Saturated vapour pressure	3.7E-6	Pa	Measured at 25 °C
Water solubility of substance	1.21	$mg.L^{-1}$	Measured at 25 °C
Octanol-water partition coefficient	25118.9	$m^2.d^{-1}$	
Reference effect concentration	0.01	$\mu g.L^{-1}$	NOEC daphnia

Acaricide 2

Property	Value	Unit	Comment
Molar mass	300.4	$g.mol^{-1}$	
Half-life transformation in water	0.25	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	0.8	d	Measured at 25 °C
Half-life transformation in greenhouse air	100	d	Measured at 20 °C
Half-life transformation in substrate	1	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	1046	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	1	-	
Saturated vapour pressure	1.33E-5	Pa	Measured at 25 °C
Water solubility of substance	2.06	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	2511.9	$m^2.d^{-1}$	
Reference effect concentration	170	$\mu g.L^{-1}$	NOEC fish

Acaricide 3

Property	Value	Unit	Comment
Molar mass	370.49	$g.mol^{-1}$	
Half-life transformation in water	2	d	Measured at 20 °C
Half-life transformation in sediment	8	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	107.3	d	Measured at 20 °C
Half-life transformation in greenhouse air	0.1	d	Measured at 20 °C
Half-life transformation in substrate	13.8	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	17923.43	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	1	-	
Saturated vapour pressure	7.E-6	Pa	Measured at 20 °C
Water solubility of substance	0.13	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	35645	$m^2.d^{-1}$	
Reference effect concentration	0.25	$\mu g.L^{-1}$	NOEC daphnia

Acaricide 4

Property	Value	Unit	Comment
Molar mass	364.9	$g.mol^{-1}$	
Half-life transformation in water	45.3	d	Measured at 20 °C
Half-life transformation in sediment	45.3	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	0.2	d	Measured at 20 °C
Half-life transformation in substrate	71.8	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	38574	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.953	-	
Saturated vapour pressure	1.E-6	Pa	Measured at 20 °C
Water solubility of substance	0.022	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	2355229	$m^2.d^{-1}$	
Reference effect concentration	0.047	$\mu g.L^{-1}$	NOEC mysidopsis

Acaricide 5

Property	Value	Unit	Comment
Molar mass	511.2	$g.mol^{-1}$	
Half-life transformation in water	112	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 20 °C
Half-life transformation in greenhouse air	1.03	d	Measured at 20 °C
Half-life transformation in substrate	185	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	23887.5	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.982	-	
Saturated vapour pressure	4.E-6	Pa	Measured at 25 °C
Water solubility of substance	0.046	$mg.L^{-1}$	Measured at 25 °C
Octanol-water coefficient	131825	$m^2.d^{-1}$	
Reference effect concentration	1.3	$\mu g.L^{-1}$	EC50 daphnia

Fungicide 1

Property	Value	Unit	Comment
Molar mass	343.21	$g.mol^{-1}$	
Half-life transformation in water	9	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	1.1	d	Measured at 20 °C
Half-life transformation in substrate	232	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	447.5	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.86	-	
Saturated vapour pressure	7.2E-7	Pa	Measured at 20 °C
Water solubility of substance	4.6	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	912	$m^2.d^{-1}$	
Reference effect concentration	125	$\mu g.L^{-1}$	NOEC fish

Fungicide 2

Property	Value	Unit	Comment
Molar mass	313.3	$g.mol^{-1}$	
Half-life transformation in water	9	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	821.8	d	Measured at 25 °C
Half-life transformation in greenhouse air	0.28	d	Measured at 20 °C
Half-life transformation in substrate	0.6	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	178.65	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.975	-	
Saturated vapour pressure	2.3e-6	Pa	Measured at 20 °C
Water solubility of substance	2.0	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	2512	$m^2.d^{-1}$	
Reference effect concentration	>100000	$\mu g.L^{-1}$	NOEC fish

Fungicide 3

Property	Value	Unit	Comment
Molar mass	281.5	$g.mol^{-1}$	
Half-life transformation in water	1	d	Measured at 20 °C
Half-life transformation in sediment	204.	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 20 °C
Half-life transformation in greenhouse air	100	d	Measured at 20 °C
Half-life transformation in substrate	41	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	14617	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.855	-	
Saturated vapour pressure	0.00048	Pa	Measured at 20 °C
Water solubility of substance	100	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	39811	$m^2.d^{-1}$	
Reference effect concentration	80	$\mu g.L^{-1}$	NOEC daphnia

Fungicide 4

Property	Value	Unit	Comment
Molar mass	199.28	$g.mol^{-1}$	
Half-life transformation in water	14.6	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 20 °C
Half-life transformation in greenhouse air	0.1	d	Measured at 20 °C
Half-life transformation in substrate	34.3	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	301	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.868	-	
Saturated vapour pressure	1.1e-3	Pa	Measured at 20 °C
Water solubility of substance	0.121	$mg.L^{-1}$	Measured at 25 °C
Octanol-water coefficient	691	$m^2.d^{-1}$	
Reference effect concentration	940	$\mu g.L^{-1}$	NOEC daphnia

Fungicide 5

Property	Value	Unit	Comment
Molar mass	224.7	$g.mol^{-1}$	
Half-life transformation in water	11.8	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	0.3	d	Measured at 20 °C
Half-life transformation in substrate	22.4	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	113.97	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.865	-	
Saturated vapour pressure	1.66e-3	Pa	Measured at 25 °C
Water solubility of substance	600	$mg.L^{-1}$	Measured at 25 °C
Octanol-water coefficient	0.063	$m^2.d^{-1}$	
Reference effect concentration	>6300	$\mu g.L^{-1}$	NOEC fish

Fungicide 6

Property	Value	Unit	Comment
Molar mass	302.2	$g.mol^{-1}$	
Half-life transformation in water	4.92	d	Measured at 20 °C
Half-life transformation in sediment	18.4	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 20 °C
Half-life transformation in greenhouse air	0.31	d	Measured at 20 °C
Half-life transformation in substrate	0.27	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	376.58	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.86	-	
Saturated vapour pressure	4e-7	Pa	Measured at 20 °C
Water solubility of substance	0.024	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	3236	$m^2.d^{-1}$	
Reference effect concentration	101	$\mu g.L^{-1}$	NOEC fish

Fungicide 7

Property	Value	Unit	Comment
Molar mass	279.3	$g.mol^{-1}$	
Half-life transformation in water	47.2	d	Measured at 20 °C
Half-life transformation in sediment	47.2	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 20 °C
Half-life transformation in greenhouse air	0.25	d	Measured at 20 °C
Half-life transformation in substrate	20	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	237	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	1	-	
Saturated vapour pressure	3.3e-3	Pa	Measured at 25 °C
Water solubility of substance	26000	$mg.L^{-1}$	Measured at 25 °C
Octanol-water coefficient	51.28	$m^2.d^{-1}$	
Reference effect concentration	9100	$\mu g.L^{-1}$	

Fungicide 8

Property	Value	Unit	Comment
Molar mass	316.42	$g.mol^{-1}$	
Half-life transformation in water	42.3	d	Measured at 20 °C
Half-life transformation in sediment	42.3	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	30	d	Measured at 20 °C
Half-life transformation in greenhouse air	1	d	Measured at 20 °C
Half-life transformation in substrate	71.8	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	1091.6	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.941	-	
Saturated vapour pressure	5.7E-5	Pa	Measured at 20 °C
Water solubility of substance	13.06	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	3.68	$m^2.d^{-1}$	
Reference effect concentration	100	$\mu g.L^{-1}$	NOEC fish

Fungicide 9

Property	Value	Unit	Comment
Molar mass	396.7	$g.mol^{-1}$	
Half-life transformation in water	1000	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 20 °C
Half-life transformation in greenhouse air	0.86	d	Measured at 20 °C
Half-life transformation in substrate	107.8	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	161.77	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.827	-	
Saturated vapour pressure	1.6e-6	Pa	Measured at 20 °C
Water solubility of substance	16	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	1995.26	$m^2.d^{-1}$	
Reference effect concentration	135	$\mu g.L^{-1}$	NOEC fish

PGR 1

Property	Value	Unit	Comment
Molar mass	160.2	$g.mol^{-1}$	
Half-life transformation in water	1	d	Measured at 20 °C
Half-life transformation in sediment	1	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	0.25	d	Measured at 20 °C
Half-life transformation in substrate	1	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	10.7	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.9	-	
Saturated vapour pressure	1.27e-5	Pa	Measured at 21.6 °C
Water solubility of substance	180000	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	0.030789	$m^2.d^{-1}$	
Reference effect concentration	200	$\mu g.L^{-1}$	LC50 daphnia

Insecticide 1

Property	Value	Unit	Comment
Molar mass	255.7	$g.mol^{-1}$	
Half-life transformation in water	7	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	0.85	d	Measured at 20 °C
Half-life transformation in substrate	118	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	131	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.9	-	
Saturated vapour pressure	4.E-10	Pa	Measured at 20 °C
Water solubility of substance	613	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	3.71	$m^2.d^{-1}$	
Reference effect concentration	0.027	$\mu g.L^{-1}$	

Insecticide 2

Property	Value	Unit	Comment
Molar mass	527.84	$g.mol^{-1}$	
Half-life transformation in water	1.9	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	100	d	Measured at 20 °C
Half-life transformation in substrate	150	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	5152	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.9	-	
Saturated vapour pressure	6.0e-5	Pa	Measured at 25 °C
Water solubility of substance	0.2	$mg.L^{-1}$	Measured at 25 °C
Octanol-water coefficient	44668.4	$m^2.d^{-1}$	
Reference effect concentration	26	$\mu g.L^{-1}$	NOEC sediment organismen

Insecticide 3

Property	Value	Unit	Comment
Molar mass	283.3	$g.mol^{-1}$	
Half-life transformation in water	45.5	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 20 °C
Half-life transformation in greenhouse air	100	d	Measured at 20 °C
Half-life transformation in substrate	100	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	168.2	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.95	-	
Saturated vapour pressure	4.3e-7	Pa	Measured at 25 °C
Water solubility of substance	3600	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	50.12	$m^2.d^{-1}$	
Reference effect concentration	0.9	$\mu g.L^{-1}$	NOEC daphnia

Insecticide 4

Property	Value	Unit	Comment
Molar mass	217.2	$g.mol^{-1}$	
Half-life transformation in water	6	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	12	d	Measured at 25 °C
Half-life transformation in greenhouse air	1.125	d	Measured at 20 °C
Half-life transformation in substrate	14	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	1302	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.9	-	
Saturated vapour pressure	4.2e-6	Pa	Measured at 25 °C
Water solubility of substance	320	$mg.L^{-1}$	Measured at 25 °C
Octanol-water coefficient	0.5754	$m^2.d^{-1}$	
Reference effect concentration	25	$\mu g.L^{-1}$	NOEC daphnia

Insecticide 5

Property	Value	Unit	Comment
Molar mass	255.7	$g.mol^{-1}$	
Half-life transformation in water	7	d	Measured at 20 °C
Half-life transformation in sediment	1000	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	0.85	d	Measured at 20 °C
Half-life transformation in substrate	118	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	131	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.9	-	
Saturated vapour pressure	4.E-10	Pa	Measured at 20 °C
Water solubility of substance	613	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	3.71	$m^2.d^{-1}$	
Reference effect concentration	0.027	$\mu g.L^{-1}$	

Insecticide 6

Property	Value	Unit	Comment
Molar mass	229.16	$g.mol^{-1}$	
Half-life transformation in water	39.5	d	Measured at 20 °C
Half-life transformation in sediment	39.5	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	13.7	d	Measured at 20 °C
Half-life transformation in substrate	1	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	3.42	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	1	-	
Saturated vapour pressure	9.43e-7	Pa	Measured at 20 °C
Water solubility of substance	5200	$mg.L^{-1}$	Measured at 20 °C
Octanol-water coefficient	0.5754	$m^2.d^{-1}$	
Reference effect concentration	3100	$\mu g.L^{-1}$	NOEC daphnia

Insecticide 7

Property	Value	Unit	Comment
Molar mass	291.7	$g.mol^{-1}$	
Half-life transformation in water	35.5	d	Measured at 20 °C
Half-life transformation in sediment	35.5	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	0.1	d	Measured at 20 °C
Half-life transformation in substrate	31.3	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	34.8	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.87	-	
Saturated vapour pressure	6.6e-9	Pa	Measured at 25 °C
Water solubility of substance	41000	$mg.L^{-1}$	Measured at 25 °C
Octanol-water coefficient	0.741	$m^2.d^{-1}$	
Reference effect concentration	0.1	$\mu g.L^{-1}$	Chronic sediment organism

Insecticide 8

Property	Value	Unit	Comment
Molar mass	483.15	$g.mol^{-1}$	
Half-life transformation in water	170	d	Measured at 20 °C
Half-life transformation in sediment	170	d	Measured at 20 °C
Half-life transformation in recirculation water, including the disinfection tank	1000	d	Measured at 25 °C
Half-life transformation in greenhouse air	1	d	Measured at 20 °C
Half-life transformation in substrate	1378	d	
Coefficient of equilibrium sorption in substrate, sediment and suspended solids	174.6	$L.kg^{-1}$	
Reference concentration in liquid phase in sediment/ suspended solids	1	$mg.L^{-1}$	
Freundlich exponent in sediment/ suspended solids	0.95	-	
Saturated vapour pressure	6.3e-12	Pa	Measured at 25 °C
Water solubility of substance	0.88	$mg.L^{-1}$	Measured at 25 °C
Octanol-water coefficient	724.4	$m^2.d^{-1}$	
Reference effect concentration	100	$\mu g.L^{-1}$	NOEC fish

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The mission of Wageningen UR (University & Research centre) is 'To explore the potential of nature to improve the quality of life'. Within Wageningen UR, nine specialised research institutes of the DLO Foundation have joined forces with Wageningen University to help answer the most important questions in the domain of healthy food and living environment. With approximately 30 locations, 6,000 members of staff and 9,000 students, Wageningen UR is one of the leading organisations in its domain worldwide. The integral approach to problems and the cooperation between the various disciplines are at the heart of the unique Wageningen Approach.

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