Environmental Indicator Crop Protection (EICP)

Documentation of calculation rules

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This document contains the methodological description of the environmental indicator crop protection (EICP). This indicator has been developed based on existing models and model components. The methodology is consistent with the European Food Safety Authority (EFSA) and Dutch Board for the Authorisation of Plant Protection Products and Biocides (Ctgb) guidelines and based on methodology as applied by the Ctgb and EFSA in the assessment of plant protection products (PPPs). The EICP calculates the impacts on six protection goals: Groundwater, Aquatic organisms, In-soil organisms, Non-target arthropods, Pollinators and Birds & Mammals.

Dit document bevat de methodologische beschrijving van de milieu-indicator gewasbescherming (MIG). Deze indicator is ontwikkeld op basis van bestaande modellen en modelcomponenten. De methodiek is consistent met de richtlijnen van de EFSA en het Ctgb en gebaseerd op de methodiek zoals gehanteerd door het College voor de Toelating van Gewasbeschermingsmiddelen en Biociden (Ctgb) en de Europese Autoriteit voor Voedselveiligheid (EFSA) bij de beoordeling van gewasbeschermingsmiddelen (PPP's). De EICP berekent de effecten op zes beschermingsdoelen: grondwater, waterorganismen, bodemorganismen, niet-doelwit arthropoden, bestuivers en vogels & zoogdieren.

Key words: Crop protection, pesticides, environmental impact, environmental indicator.

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Preface

How to make agriculture and horticulture more sustainable receives a lot of attention in both the societal debate and in discussions between public and private stakeholders. It is subject of research, and the market is demanding safe and environmentally friendly produced food and ornamental products. This creates the need for farmers and growers to apply tools that help them to produce sustainably. This also concerns their crop protection strategy.

A consortium of public and private stakeholders under the umbrella of the Top Sector for Horticulture & Starting Materials has commissioned a project to develop an environmental indicator for crop protection (EICP), which calculates the environmental impact of plant protection products that are applied by farmers and growers. This document contains a description of the methodology and calculation rules of the EICP.

The research team consisting of researchers from Wageningen Research, CLM and advisors of Nature & Environment wants to thank the team representing the consortium partners, the farmers, growers and stakeholders that participated in testing the EICP during the test and pilot phase, the international advisors and all other involved stakeholders that contributed to the development of the EICP for their comments and assistance.

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Summary

A consortium of public and private stakeholders under the umbrella of the Top Sector for Horticulture & Starting Materials has commissioned a project to develop an environmental indicator for crop protection (EICP), which calculates the environmental impact of plant protection products that are applied by farmers and growers. This document contains a description of the methodology and calculation rules of the EICP.

The EICP has been developed based on existing models and model components. The methodology is consistent with the European Food Safety Authority (EFSA) and the Dutch Board for the Authorisation of Plant Protection Products and Biocides (Ctgb) guidelines and based on methodology as applied by these entities in the assessment of plant protection products (PPPs). In the development of the EICP, all model calculations, i.e. emission, exposure and risk models for six protection goals, follow the principle that:

1. the same data is used in all calculations,
2. a risk assessment is carried out combining estimates for exposure and effect, and
3. only active ingredients and products are assessed that have been approved.

Furthermore, the following principles are applied:

- Differentiation: The variation in the input data (cultivation practices such as spraying schemes or mitigation measures) is translated into a realistic variation in the indicator scores.
- Modelling: Preference for state-of-the-art, scientifically substantiated and widely accepted modelling approaches.
- Data accessibility: Data must be accessible and easy to enter for users.
- Conservative-realistic exposures and effects: the environmental effect reflects a reasonable representation of reality but not an absolute worst case.
- Pragmatism: Calculations should not require too much computing time or secondary data.
- Tier level calculations: No higher tier assessment/calculations are included for the EICP, with one exception: Results from higher tier effect assessment are used, for example when using RAC values from aquatic risk assessment.
- Comparison with risk assessment: Result cannot be interpreted as absolute risk estimates, immediately comparable to risk estimates from registration, since calculation rules are too simplistic for that.

Available model components have been selected based on these principles and applied according to the concepts presented in Figure S1.

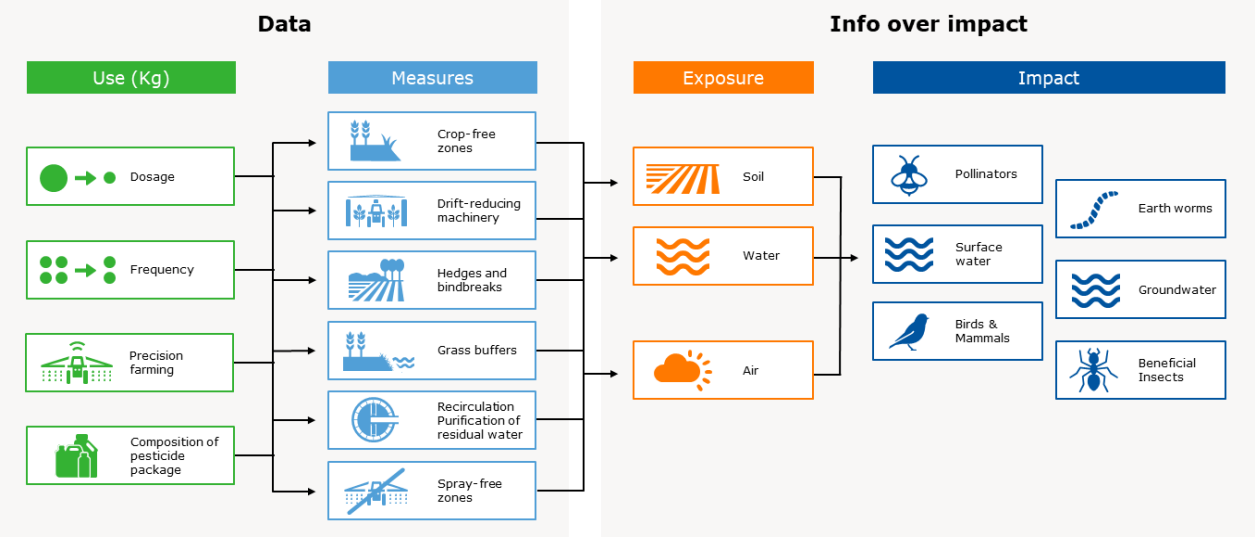


Figure S1 *Conceptual approach of the EICP*

The model components included in the EICP are as follows:

1. Emissions to air, surface water and soil, dependent on the cultivation system (protected cultivation or cultivation in the open field), the pesticides applied, the dosages, the application mode, the spraying equipment and the measures to prevent emission. Selected model components are:
   - The Greenhouse Emission Model (GEM, protected cultivation, see Wipfler et al., 2015)
   - The Nationale Milieuindicator (NMI, cultivation in the open field, see Kruijne et al., 2012)
2. Exposure of water organisms to pesticides is calculated by application of models such as WATERSTROMEN (Voogt et al., 2012), Substance Emission Model (Van der Linden et al., 2015), TOXSWA (Beltman et al., 2014) and meta-PEARL (Tiktak et al., 2012).
3. The EICP relates the *Relevant exposure concentration (REC)* as resulting from emission and exposure calculation steps to a specific toxicity threshold per protection goal. For the EICP, a range of appropriate toxicity thresholds are used per protection goal as effect threshold values (ETH). The risk indicator is expressed by an exposure toxicity ratio (ETR) per unit area of agricultural land.

The protection goals that are included in the EICP are:

- Groundwater
- Aquatic organisms (including fish, macrophytes and invertebrates)
- In-soil organisms
- Non-target arthropods
- Pollinators
- Birds & Mammals

Human health falls outside the scope of the EICP.

Possibilities for further developing the EICP include adding emission routes that have not yet been included, such as leaching via drainage, adding model components that enable application outside the Netherlands, such as leaching via runoff, and refining existing model components, such as incorporating the drift calculator to improve the calculation of emission via drift.

Samenvatting

Een consortium van publieke en private stakeholders binnen de Topsector Tuinbouw & Uitgangsmaterialen heeft opdracht gegeven voor een project om een milieu-indicator voor gewasbescherming (MIG) te ontwikkelen, die de milieu-impact berekent van gewasbeschermingsmiddelen die worden toegepast door boeren en telers. Dit document bevat een beschrijving van de methodiek en rekenregels van de MIG.

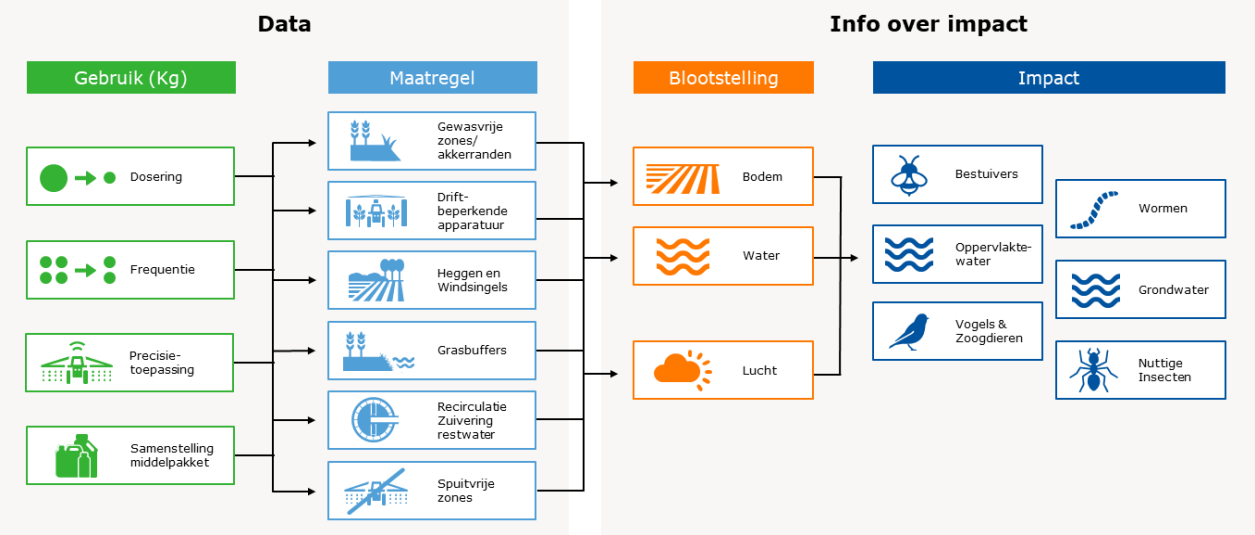
De MIG is ontwikkeld op basis van bestaande modellen en modelcomponenten. De methodiek is consistent met de richtlijnen van de EFSA en het Ctgb en gebaseerd op de methodiek zoals gehanteerd door het College voor de Toelating van Gewasbeschermingsmiddelen en Biociden (Ctgb) en de Europese Autoriteit voor Voedselveiligheid (EFSA) bij de beoordeling van gewasbeschermingsmiddelen (PPP's). In de ontwikkeling van de MIG volgen alle berekeningen van emissie, blootstelling en risico voor zes beschermingsdoelen, het principe dat:

1. dezelfde gegevens worden gebruikt in de berekeningen,
2. een risicobeoordeling wordt uitgevoerd waarbij schattingen voor blootstelling en effect worden gecombineerd, en
3. alleen actieve ingrediënten en producten worden beoordeeld die al zijn goedgekeurd.

Verder worden de volgende regels gehanteerd:

- Differentiatie: de variatie in de invoergegevens (teeltpraktijk) wordt vertaald in een realistische variatie in de indicatorscores, of anders geformuleerd: veranderingen in bespuitingsschema's of mitigerende maatregelen worden weerspiegeld door veranderingen in indicatorscores.
- Modellering: voorkeur voor state-of-the-art, wetenschappelijk onderbouwde en breed geaccepteerde modelleringsbenaderingen.
- Toegankelijkheid data: gegevens moeten toegankelijk en gemakkelijk in te voeren zijn voor gebruikers.
- Conservatief-realistische blootstellingen en effecten: het omgevingseffect geeft een redelijke weergave van de werkelijkheid weer, maar geen absoluut worst case scenario.
- Pragmatisme: berekeningen mogen niet te veel rekentijd of secundaire gegevens vergen.
- Niveau tier-berekeningen: er zijn geen hogere tier beoordeling/berekeningen opgenomen voor de EICP, met één uitzondering: resultaten van een hogere tier effectbeoordeling worden gebruikt, bijvoorbeeld bij gebruik van RAC-waarden van aquatische risicobeoordeling.
- Vergelijking met risicobeoordeling: het resultaat niet interpreteren als absolute risicoschattingen, direct vergelijkbaar met risicoschattingen uit registratie, daarvoor zijn rekenregels te simplistisch voor zijn.

Beschikbare modelcomponenten zijn geselecteerd op basis van deze regels en toegepast volgens de concepten gepresenteerd in figuur S1.



Figuur S1 *Conceptuele aanpak van de MIG*

De modelcomponenten die in de MIG zijn opgenomen, zijn als volgt:

1. Emissies naar lucht, oppervlaktewater en bodem, afhankelijk van het teeltsysteem (beschermde teelt of teelt in de volle grond), de toegepaste bestrijdingsmiddelen, de doseringen, de toedieningswijze, de spuitapparatuur en de maatregelen ter voorkoming van emissie. Geselecteerde modelcomponenten zijn:
   - het Greenhouse Emission Model (GEM, beschermde teelt, zie Wipfler et al., 2015)
   - De Nationale Milieuindicator (NMI, teelt in de volle grond, zie Kruijne et al., 2012))
2. Blootstelling van waterorganismen aan bestrijdingsmiddelen wordt berekend door toepassing van modellen zoals WATERSTROMEN (Voogt et al., 2012), Substance Emission Model (Van der Linden et al., 2015), TOXSWA (Beltman et al., 2014) en meta-PEARL (Tiktak et al., 2012).
3. De MIG relateert de Relevante blootstellingsconcentratie (REC) als resultaat van emissie- en blootstellingsberekeningsstappen aan een specifieke toxiciteitsdrempel per beschermdoel. Voor de MIG worden als effectdrempelwaarden (ETH) per beschermdoel een reeks relevante toxiciteitsdrempels gebruikt. De risico-indicator wordt uitgedrukt in een blootstellingstoxiciteitsratio (ETR) per oppervlakte-eenheid landbouwgrond.

De beschermdoelen die zijn opgenomen in het MIG zijn:

- Grondwater
- Waterorganismen (met inbegrip van vis, macrofyten and invertebraten)
- Bodemorganismen
- Niet doelwit arthropoden
- Bestuivers
- Vogels & zoogdieren

De humane gezondheid valt buiten de scope van de MIG.

Mogelijkheden om de MIG door te ontwikkelen betreffen het toevoegen van emissieroutes die nu nog niet zijn meegenomen zoals uitspoeling via drainage, het toevoegen van modelcomponenten waarmee toepassing buiten Nederland mogelijk wordt, zoals uitspoeling via bovengrondse afvoer en het verfijnen van bestaande modelcomponenten zoals het inbouwen van de driftcalculator om de berekening van emissie via drift te verbeteren.

1 Introduction

1.1 Background

The social and environmental impacts associated with the use of pesticides can be significant, and efforts to measure and limit the use and impacts of pesticides have been pursued on many fronts. However, many of these methods can lead to a challenging setting for growers and fail to incentivise a reduction in *systematic* environmental impacts. A pesticide indicator is an objective measure of the systemic impacts of a plant protection regime across a set of parameters. An indicator is a simplification of a more complex reality, but an indicator is required that is scientifically sound and provides clear feedback for assessing different plant protection regimes (for example, integrated pest management relative to a more conventional pest management regime).

Across horticultural and arable value chains (fruit and vegetables, flowers, plants and arable products such as potato), there is a demand for an objective and reliable crop protection impact indicator that can provide scientifically credible feedback to all players across the value chain, from producers to buyers, retailers, and consumers. This project has developed a new method that is based on the most suitable existing models for each impact route. The environmental indicator crop protection (EICP) can be used by farmers and growers to make their crop protection strategy more sustainable by comparing the environmental impact of different spraying schemes. It can also be used by supply chain partners sourcing plants and plant products. They can compare the environmental impact of the pesticides applied in the production of the products they want to buy. The results will contribute to an improved debate on the impacts of pesticides use: broad support will ensure that this debate is impact-oriented as opposed to inputs-oriented. Furthermore, the debate will be more informed if the method can translate possible improvements in crop protection strategy into a changed impact (for example, the benefits of integrated pest management will be more transparent). Furthermore, the application of this indicator will ensure consistency in the implementation of policy, promote cooperation between all actors, and provide direction for the reduction of the environmental impact of crop protection products.

1.2 Requirements to the model

The environmental indicator crop protection (EICP) has been developed on the basis of a Scoping Paper (Helmes et al., to be published), in which the demarcation of the EICP has been described, and methods that can be used to develop the indicator have been assessed. The conclusion is that a method that is based on and consistent with the risk assessment methodology applied in the authorisation processes to register plant protection products and that can be applied by farmers and growers to reduce the environmental impact of their pesticide use is lacking. Nevertheless, models, or parts of models used to assess emissions or impacts can be applied in the EICP.

The environmental indicator crop protection (EICP) has been developed on the basis of existing models and model components. The methodology is consistent with the European Food Safety Authority (EFSA) and the Dutch Board for the Authorisation of Plant Protection Products and Biocides (Ctgb) guidelines, and based on methodology as applied by these entities in the assessment of plant protection products (PPPs). In the development of the EICP, all model calculations, i.e. emission, exposure and risk models for six protection goals, follow the principle that:

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- Comparison with risk assessment: Result cannot be interpreted as absolute risk estimates, immediately comparable to risk estimates from registration, since calculation rules are too simplistic for that.

Available model components have been selected based on these rules. For emission, exposure and risk modelling the chosen components are described in the subsequent chapters of this document. Scientific state-of-the-art methods are not available for all required model components, e.g. exposure modelling for pollinators and birds & mammals is performed based on generic, precalculated shortcut values. The first version of the EICP must be applicable in the Netherlands.

In the authorisation of plant protection products, products are approved by the Ctgb and EFSA at different refinement levels (tiers), depending on the risk assessment outcome at lower levels. If a substance is approved at a lower tier level, this means that the risk of an environmental impact (or health effect) is low, but since the method is conservative a substance that is not admissible at lower tiers, can be assessed at a higher tier, where refinement requires more extensive testing with test methods that simulate the field situation more closely and result in less conservative and smaller risk estimates. As a result, the level of information differs between the products, due to the tier at which they have been approved. We have chosen to use the information at the highest available tier level. We accept as a consequence of this some inconsistency in the calculation of the risk when aggregating and comparing PPPs. Higher tier information is almost exclusively used in the aquatic risk assessment. The single steps for the calculation of EICP values are shown in Figure 1.1. This figure shows selections that need to be made by a user, required information and data from databases and scenario definitions. The figure shows that two separate models have been developed: one for protected cultivation and one for open cultivation. The reason is that emission routes are quite different and require separate models. Furthermore, since not all protection goals are affected by pesticide use in protected cultivation, only the potentially affected protection goals are included in the model for protected cultivation.

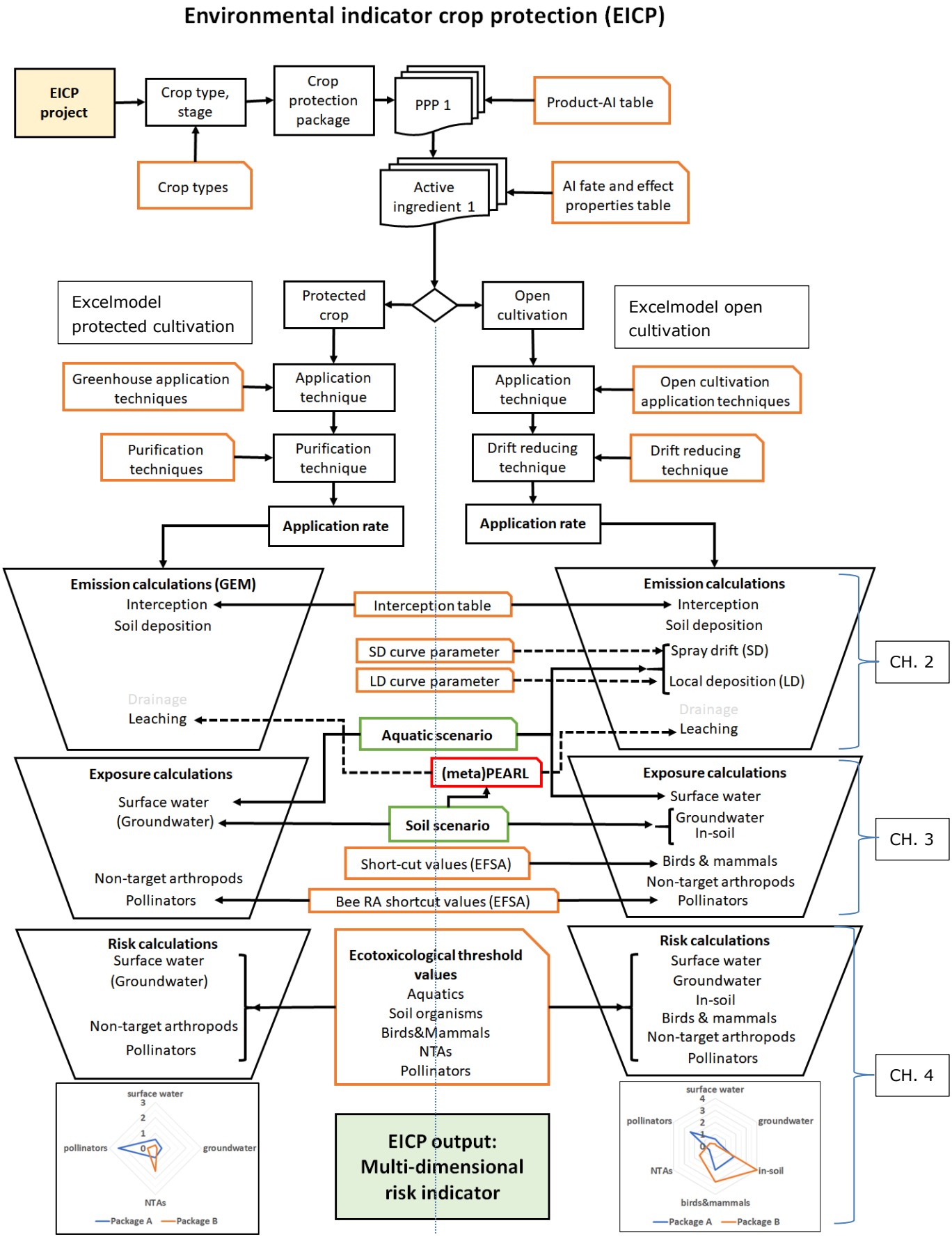

Figure 1.1 *Flow chart showing the data processing in the EICP. Scenario definitions are in green-edged boxes, input parameter table in orange-edged boxes, models in red-edged boxes. Groundwater for protected crop is only relevant for soil-bound cultivation*

The EICP definitions and calculation rules are based on and closely related to two existing modelling respective risk indicator calculation methods, which are the Nationale Milieuindicator, version 3 (NMI3) and the Greenhouse emission model (GEM). These methods are extensively documented (Kruijne et al., 2012; Vermeulen et al., 2010; Wipfler et al. 2015). For the EICP documentation in the following, we have repeated most relevant and critical elements but refer for details to the respective original documentation. A short discussion about the relation between EICP and NMI is given in Section 5.2. For more details and in-depth information, we recommend looking into the documents we refer to (especially Kruijne et al., 2012 for NMI and Wipfler et al. 2015 for GEM).

1.3 Overview of the development

In the scoping phase, the scope of the EICP has been elaborated in greater detail. Furthermore, a selection of relevant indicators and models has been assessed and a choice has been made which model components could be used for application in the EICP. Afterwards, the models for protected cultivation and cultivation in the open field have been developed by the project team in Excel. Then experts of consortium members have tested the first versions of the EICP. After that, adjustment pilots have been executed by potential users in practice and the feedback has been processed. On the basis of the adjusted models, a Minimal Viable Product version of software has been developed. However, this MVP is not ready for use in practice. The results have been delivered to the consortium.[1] A number of consortium partners have taken the lead to take next steps for release in practice, scheduled for the beginning of 2024. They make use of the recommendations made by the project team about further developments, completion of the pesticides properties database and future governance.

1.4 Reading guide

The EICP has been developed in Excel in two versions: one for crops cultivated in the open field and one for protected cultivation. The models in Excel serve as a basis for development of web-based software, which can be applied by the farmers and growers who will use the EICP. The main report (Chapter 2, 3 and 4) contains the description of the methodology. The appendices contain a short user manual, description of the data and background information about methodological considerations.

In this documentation, we have decided not to provide all formulas. Since the EICP is largely based on methods and models that are well described, we refer to the documents in which the formulas are described. In this report, we focus on the headlines. This document is structured as follows: In Chapter 2 emission calculations are described. In Chapter 3 the calculation of exposure endpoints is presented and Chapter 4 elaborates the risk indicator values for all endpoints. In Chapter 5, advantages and limitations, as well as future needs and aspects of international applicability are discussed.

The description of the Chapters 2, 3 and 4 in relation to the conceptual model is outlined in Figure 1.1 and 1.2.

[1] Contact person is Peter Knippels from LTO, email: pknippels@lto.nl.

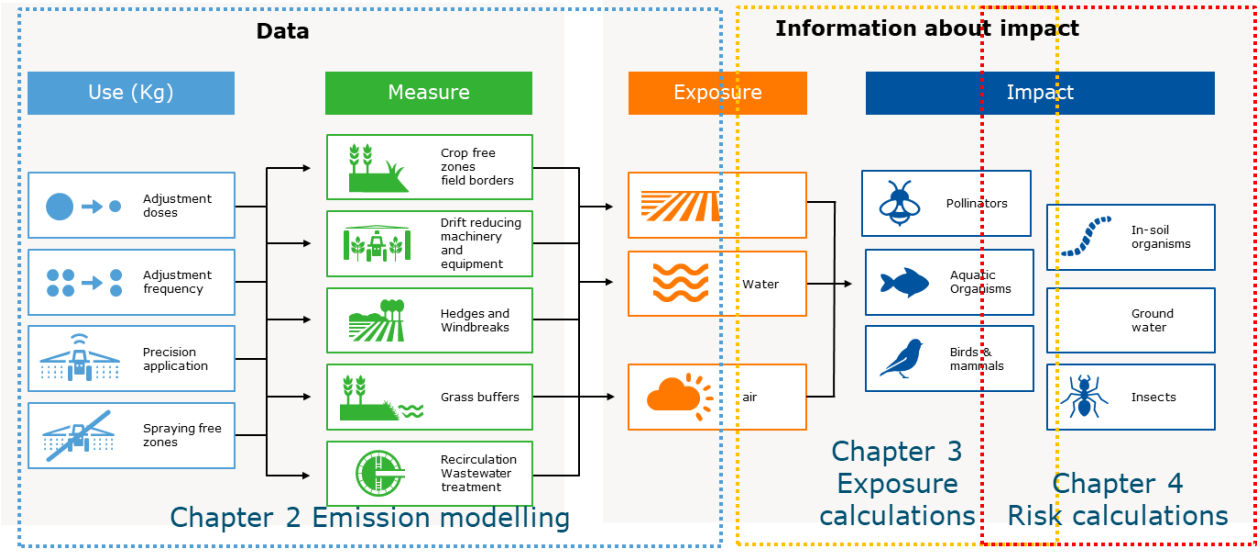

Figure 1.2 *Conceptual model of the EICP related to the chapters of this report*

2 Emission calculations

The calculations needed for the EICP are divided into emission, exposure and risk. For EICP calculations, the calculation of risk indicator values is done per crop, so that besides the definition of the crop the basic question is whether the crop is grown in protected or in open cultivation.

For crops in protected cultivation (greenhouses), the greenhouse emission model (GEM) is used with specific scenarios for soilless and soil-bound cultivation (Section 2.1). For both scenarios the input of PPPs to surface water is considered for the risk calculation. For soil-bound cultivation risk for groundwater is also part of the calculations.

For crops in open cultivation, the emissions of a PPP to the following compartments are considered (Section 2.2):

- Crop
- Soil
- Surface water
  - Local (atmospheric) deposition
  - Spray drift
  - Drainage flow
- Groundwater

2.1 Protected Cultivation

Two different production systems in protected cultivation (greenhouses) are part of the Greenhouse Emission Model (GEM): Greenhouses with soilless cultivation and greenhouses with soil bound cultivation. Emission routes to water in these systems differ and require different model calculations.

2.1.1 Emission to surface water from greenhouses with soilless cultivation

The GEM model approach for emission to surface water is used for calculating the environmental impact of pesticides used in Dutch greenhouses with soilless cultivation (Van der Linden et al. 2015). Discharge of recirculation water is the major emission route towards surface water in these cases. The driving forces behind these discharge events are the sodium content in the recirculated nutrient solution and the sodium tolerance of the greenhouse crop (Vermeulen et al., 2010). Hence, the quality of the irrigation water has a large effect on the total emitted mass of pesticides to surface water. Irrigation water quality is in its turn determined by the volume of the rainwater collector, total annual rainfall and the quality of the alternate irrigation water in case the rainwater collector has been depleted. These parameters are used to estimate the average discharge of water, and this average is implemented in GEM. In addition the application method, the size and timing of the application as well as substance degradation in the recirculated nutrient solution determine to a large extent the emission to surface water. The amount of discharged water as well as the effectivity of the purification systems (if used) are also relevant parameters to include. The GEM model for soilless cultivation consists of three submodels:

a. for applications to crops grown on mats by drip irrigation;
b. for spray/LVM applications to crops grown on such mats and
c. for spray/LVM applications to crops grown in pots in an ebb/flood system.

GEM includes the TOXSWA model to determine the fate dynamics and pesticide concentration in the ditch (as explained in the exposure section, Section 3.1).

2.1.2 Emission from greenhouses with soil bound cultivation.

The GEM model approach for soil-bound cultivation is used for calculating the environmental impact of pesticides in these production types (Wipfler et al., 2015). For soil bound cultivation the GEM model calculates emission to surface water for pesticides as well as leaching to groundwater; surface water as a habitat for aquatic organisms and groundwater as source of drinking water. The GEM model for soil bound cultivation is based on the scenario study of Wipfler et al. (2014). In this study calculations were first done with the greenhouse models KASPRO and WATERSTROMEN[2] for inside temperature, evapotranspiration and irrigation. The so-obtained climatic data and groundwater data obtained were then used as boundary conditions for the pesticide fate model PEARL.[3] Groundwater levels were obtained from the Dutch Hydrological Instrument (NHI) (De Lange et al., 2014). Soil properties were derived from generally available data sources. For the characterisation of the top 30 cm of the soil, data were derived from measurements in greenhouses. PEARL drain discharge was linked to a metamodel of TOXSWA[4] to calculate PPP concentrations in the discharge receiving ditch. Chrysanthemum was used as the model crop for both scenario derivations, being the major soil-bound crop grown in greenhouses. The scenarios were selected based on the 90th overall percentile of this distribution. Output of GEM for greenhouses with soil bound cultivation is the predicted concentration in surface water and in groundwater (further explained in the exposure section, Section 3.1).

2.2 Open cultivation

To calculate emissions of pesticides in open cultivation a number of scenarios, parameters and calculation rules are needed. Scenarios are introduced in Sections 2.2.1 and 2.2.2 and parameters and calculation rules are explained in Sections 2.2.3 and 2.2.4.

2.2.1 Aquatic scenarios

Aquatic scenarios are needed for the calculation of emissions to and exposure in surface water. Relevant characteristics of water bodies are the dimensions of ditches, with the surface water width being used for the calculation of spray drift and atmospheric deposition. The length and volumes of field ditches per unit area of agricultural land, and per watercourse class, are used for exposure calculations, and emission to water per surface area is related to the water volume. The aquatic scenarios for the Netherlands are based on available information, i.e. the STONE schematisation as used in NMI. For the 6,405 STONE plots (Kroon et al., 2001)[5] that cover the Netherlands, the hydrotype[6] (one of six classes of soil classified concerning hydrological parameters), and densities of narrow, medium and large water courses in units of length per hectare are provided. For EICP calculation, calculations for a specific location in the Netherlands are linked to the characteristics of the associated STONE plot, more details are given in Appendix 2. For other countries than the NL, scenarios with respective data on water body densities and properties are needed, where the spatial resolution of such information can vary, in an extreme case only one generic scenario for a whole region or country can be defined and used.

Drainage emissions are currently not included in the Ctgb pesticide registration, because related calculation methods are still under development. The release of the DRAINBOW tool is expected in the near future. To stay consistent with the Ctgb procedure, in the current EICP implementation, emissions to surface water via drainage are not considered. Future options for emission modelling via drainage are listed in Appendix 3.

[2] Dutch translation of 'Waterflows'.
[3] PEARL: Pesticide Emission Assessment at Regional and Local scales, state-of-art numerical pesticide leaching model; available at https://www.pesticidemodels.eu/pearl/pearl-model
[4] TOXSWA: TOXic substances in Surface Waters; state-of-art numerical pesticide fate model for surface water; available at https://www.pesticidemodels.eu/toxswa/home
[5] RIZA rapport 2001.017: Redesign STONE.
[6] Hydrotypes are resulting from a division of the Netherlands based on hydrological properties. See Appendix 2.

2.2.2 Soil scenarios

For the EICP calculations leaching concentrations in groundwater were calculated with a meta-model of PEARL. This meta-model is based on GeoPEARL calculations for a number of hypothetical substance applications varying in half-life and sorption constant (van den Berg et al., 2008). The meta-PEARL soil scenario for leaching considers the parameters local organic matter fraction in the topsoil, soil dry bulk density and soil pH.

2.2.3 Crop interception, volatilisation and net soil deposition

Crop interception values for combination of crops and application techniques are taken from the NMI Appendix 5 (pages 73, Kruijne et al., 2012). Net soil deposition is calculated based on interception and volatilisation following NMI documentation (formulas 1-18 on pages 26-30, Kruijne et al., 2012). An overview of the calculated state variable is given in Appendix 4.

For the calculations of emissions, in a first step crop interception, volatilisation and net soil deposition are calculated. Volatilisation during application as loss process is calculated with a fixed percentage (3%). Crop interception is assumed to be dependent on crop stage and application technique, Appendix 5 of the NMI3 documentation contains respective values, Table 2.1 contains an example.

Table 2.1 *Example for time-and application-dependent crop interception values*

2 Crop interception fractions for spraying applications to field crops in the NMI 2 (as used in the NMI 3) 1

crop	Sector	Mode of action	Application time (month number)											
			1	2	3	4	5	6	7	8	9	10	11	12
Onions (bulbs)	Akkerbouw (arable farming)		-	-	-	0.145	0.166	0.428	0.457	0.171	-	-	-	-
Onions			-	-	0.116	0.166	0.166	0.428	0.457	0.457	0.137	-	-	-
Peas			0.013	0.013	0.065	0.187	0.383	0.709	0.720	0.307	0.013	0.013	0.013	0.013
Field beans			-	-	-	-	0.175	0.750	0.900	0.788	-	-	-	-
Seed potatoes			0.002	0.002	0.002	0.060	0.315	0.632	0.843	0.780	0.002	0.002	0.002	0.002
Haricot beans			-	-	-	-	0.075	0.500	0.800	0.863	0.630	-	-	-

Source: Kruijne et al. (2012).

Initial soil deposition is calculated as the application rate (dosage in kg or l per ha) minus the volatilisation during application minus the fraction of the application rate intercepted by the crop (eq. 2, p.26). Part of the material initially deposited on the soil may evaporate, resulting in a decrease of the amount deposited onto the soil. Cumulative volatilisation from the soil surface is calculated using a regression equation (eq. 3, p.27 (Kruijne et al., 2012). The net soil deposition, S[N], needed in the calculation of leaching emissions and soil and terrestrial risk indicators is given by eq. 4 (p.27, Kruijne et al., 2012). The calculation of cumulative volatilisation is relatively complex and depends on soil pH, temperature and soil organic matter content (eqs. 5-18, Kruijne et al., 2012).

2.2.4 Emission to surface water

To calculate the input to surface water from air via spray drift (SD) and local deposition (LD) via air two predominant aspects need to be considered i) the distance of the spraying device from the water body (crop free zone; CFZ) and ii) the deposition input curves. The crop-free zone is composed of three parts: i) a generic minimum buffer zone (BZ), ii) an additional product-specific, mandatory BZ defined in the registration procedure, and iii) an additional voluntary distance implemented by the farmer to reduce the environmental impact. In the EICP implementation, the BZ is input of the user, which comprises all these three parts in one value. Note that no checks are done whether a given BZ complies with the relevant regulatory requirements.

The deposition input curve for LD depends on the vapour pressure and additional empirical parameters (p. 30-33 Kruijne et al., 2012). The deposition input curve for SD is independent from active ingredient characteristics, but depends on the application technique. Until the release of updated spray drift curves as

estimated in the Drift Calculator developed by Wageningen Plant Research, the simple method as used by Ctgb based on drift reducing technology (DRT) classes is used (described in Appendix 2).

Surface water- Local deposition

For calculating the deposition onto surface water bodies the width of these bodies is calculated using the distance between the crop and the near and far edge of the surface water (distance OB and OC in NMI Figure 13). These distances are taken from the STONE Hydrotype data ('insteek A_B') to which the width of the crop-free zone, as entered by the user, is added. This is done for three classes of surface water bodies as defined in the NMI (see Table 2.2).

Table 2.2 *Coefficients and formulae as used for the calculation of local deposition to surface water in EICP*

Eq. NMI3	Symbol	Explanation
EQ 19	Y	*the cumulative fraction of the dosage deposited during the first 24 h after application, defined as mass of PPP per unit surface area of water divided by mass of PPP per unit surface area of agricultural land (kg ha-1) / (kg ha-1)*
EQ 20a	Dep[pr]	*average deposition fraction between two points at distance OB and OC, primary system (large) (kg ha-1) / (kg ha-1)*
EQ 20b	Dep[sec]	*average deposition fraction between two points at distance OB and OC, secondary system (medium) (kg ha-1) / (kg ha-1)*
EQ 20c	Dep[ter]	*average deposition fraction between two points at distance OB and OC, tertiary system (small) (kg ha-1) / (kg ha-1)*
EQ 21a	Y[pr]	*deposition percentage over the full width, primary system (large)*
EQ 21b	Y[sec]	*deposition percentage over the full width, secondary system (medium)*
EQ 21c	Y[ter]	*deposition percentage over the full width, tertiary system (small)*
EQ 23	Esw[ad]	*emission to field ditches by local (atmospheric) deposition (kg ha-1)*

Source: Kruijne et al. (2012).

Surface water- Spray drift

In general, spray drift input into water bodies can be calculated based on spray-drift curves. These curves depend on application technique, crop type and spray-drift reducing techniques, in addition to the distance of the spraying device from the water body. Ideally, the calculation of spray drift input would be implemented in the EICP in a modular way, which allows to update or exchange specific spray drift curves in future versions of the EICP, also in adaptation to other countries.

Currently the implementation of drift is done in a simple way due to the fact that the drift calculator is not implemented in the risk assessment methodology as applied by the Ctgb. Parameters from such deposition curves would be needed to parameterise equation 24 (p. 38) of the NMI. Following a discussion with Ctgb, and based on their recommendation, values are calculated based on the activity degree and the registered application technique (values in Table 2.3). Using these values as drift percentages and the crop free zone that was given as input emission to surface water by drift is calculated according to an adapted equation 26 on page 39 of the NMI. The adaption is that the parameter $\bar{y}_{sd,s}$ (the average spray drift percentage for the three different watercourse classes) is replaced with the respective value from Table 2.4.

Spray drift input is, as for the LD, calculated based for three water course classes, and based on detailed information available from STONE (PLOT_OPWA).

Table 2.3 *Spray-drift input values*

							Large fruit (CFZ 3m)		Large fruit (CFZ 4.5m)				
							Bald (< 1 mei)	Leaves	Bald (< 1 mei)	Leaves			
	Seed treatment	Granulate	Spraying followed by working into the ..	Field sprayer	Backpack sprayer	Tree or fruit weed sprayer	Up or sideways spray		Up or sideways spray		Spills	erectors	high avenue trees
DRT - 0	0	0	2	2		1.2	16.6	8.6	10.3	6.3	0.76	2.8	5.8
DRT - 50	0	0	1	1		0.6					0.32	1.1	1.6
DRT - 75	0	0	0.5	0.5	0.014		8.3	2	5	1.2			1.4
DRT - 90	0	0	0.2	0.2	0.008		2.5	1	1	0.7	0.05	0.19	
DRT - 95	0	0	0.1	0.1			1.3	0.36	0.6	0.26			0.3
DRT - 97,5	0	0	0.05	0.05			1.3	0.13	0.6	0.1			
DRT - 99	0	0	0.02	0.02			0.65	0.05	0.23	0.04			

2.2.5 Groundwater

Emission to groundwater via leaching is calculated using a meta-modelling approach, where the GeoPEARL version 1 meta model, originally developed for the European Union in the HAIR instrument (Van der Linden et al., 2007, Kruijne et al., 2011) was applied. It is applicable EU-wide. The regression equation predicts both the nominal long-term average leaching fraction and the long-term average leaching concentration in the soil solution at 1 m depth, based on a set of simple soil properties and average soil moisture conditions, substance properties and annual precipitation.

The coefficients of the regression equation (Kruijne et al., 2012) p. 52, Equation 34) for the leaching concentrations in groundwater were obtained from results of GeoPEARL calculations for a number of hypothetical substances varying in half-life and sorption constant. From these results, median annual leaching concentrations were derived for each of the plots, using local conditions from STONE plot information. Regression coefficients were obtained using a robust linear regression technique, as reported in the NMI3 documentation (Kruijne et al., 2012) and taken as reported in Table 11 in the NMI3 documentation. Calculations are done based on the symbols as given in Table 2.4.

Table 2.4 *Coefficients and formulae as used for the calculation of leaching emissions in EICP*

Eq. NMI3	Symbol	Explanation
EQ 35	μ	*the first order rate coefficient as influenced by local temperature, (d-1)*
	X1	*variable used for the regression equation (eq. 34 in NMI documentation)*
	X2	*variable used for the regression equation (eq. 34 in NMI documentation)*
EQ 40	K[om,com]	*combined sorption constant, (dm3 kg-1), for substances with pH-dependent sorption behaviour, a combined sorption constant for the acidic molecule and its conjugated base is calculated*
EQ 41	E[gw]	*nominal leaching fraction at depth Lsoil, per unit soil deposition (kg ha-1) / (kg ha-1)*

3 Exposure

3.1 Protected cultivation

3.1.1 Exposure in soilless cultivation

In the protected soilless cultivation pesticide exposure in water is expressed as the pesticide concentration in surface water. This exposure is calculated using GEM. In GEM Crops grown on substrate were divided over four categories based on their water requirement and sodium tolerance and dominant growing system. Each of these categories has a specific discharge pattern to the nearby ditch. For each of these categories an exposure scenario was developed by Van der Linden et al. (2015). The endpoint of the exposure assessment, i.e. the Predicted Environmental Concentration (PEC), was defined as the target overall percentile annual peak concentration in a standard ditch with a length of 100 m. The target percentile can be either a 50th or a 90th percentile. A 90th percentile is used. The percentile is based on simulations during a 7-year period with an application date on June 15th.

To calculate the surface water concentrations in GEM, three models must be run in consecutive order. The WATERSTROMEN model calculates the water fluxes in the soilless greenhouse system as well as the discharged volumes. The Substance Emission Model calculates the PPP fate in the system and the discharged PPP mass. TOXSWA calculates the PPP concentrations in the receiving ditch while accounting for PPP fate processes such as dilution, degradation and sorption. The models are run over the time period 2000 to 2007 (in total seven years). The PEC is calculated as the target percentile of the seven annual peak surface water concentrations (Wipfler et al. 2015). Pesticide fate in the water body is simulated with the TOXSWA model (TOXic substances in Surface WAters, Adriaanse 1996, Beltman et al. 2014). The model was developed to calculate pesticide concentrations in surface water and sediment. TOXSWA considers transport, degradation, the formation of transformation products, sorption to sediment and suspended solids, and volatilisation. The transformation rates cover the combined effect of hydrolysis, photolysis and biodegradation. Transformation and volatilisation are assumed to be temperature-dependent. Sorption to sediment and suspended solids is described with the Freundlich equation. Application date has influence due to temperature and growing season effect (water use of plants). Using the models mentioned GEM gives the annual peak concentration in water (exposure) as output.

In the environmental indicator the predicted concentration in surface water is related to aquatic toxicity of the pesticide. The risk indicator for surface water is expressed by this exposure toxicity ratio (ETR) per unit area of agricultural land (see Chapter 4).

3.1.2 Exposure in soil-bound cultivation

In the protected soil-bound cultivation pesticide exposure is expressed as the pesticide concentration in surface water and in groundwater. This exposure is also calculated using GEM. One exposure assessment scenario was derived for all soil-grown crops, based on the model crop: chrysanthemum (Wipfler et al. 2014).

For surface water the endpoint of the assessments was defined as the 90th percentile annual peak concentration in an evaluation ditch with a length of 100 m. Based on simulations during a 7-year period with an application date on 15 June. Using GEM, three models must be run in consecutive order to calculate the surface water concentration. The SWAP model calculates the hydrology in the greenhouse soil, PEARL calculates the PPP fate in the greenhouse soil and emission to the drains and TOXSWA calculates the PPP concentration in the receiving ditch. The PEC is calculated as the 90th percentile of the seven annual peak surface water concentrations. In the environmental indicator the surface water PEC is compared to aquatic toxicity by calculating the ratio (see Chapter 4).

For groundwater leaching the endpoint of the assessments was defined as the 90th percentile annual average groundwater concentration at 1 m depth. Two models need to be run in consecutive order to calculate the groundwater leaching concentration. The SWAP model calculates the hydrology in the greenhouse soil, PEARL simulates the PPP fate in the greenhouse soil and calculates the groundwater concentrations (PEC). The scenario is considered representative for all soil-bound crops.

The groundwater PEC shows the environmental impact on this protection goal.

3.2 Open cultivation

3.2.1 Exposure to surface water

The consideration of emission pathways to surface water changes by application technique. Two application types, spraying with field sprayer boom and spraying followed by soil incorporation, are considered as relevant for surface water input, accounting for local deposition and spray drift as entry routes. Drainage is not yet considered here (see Section 2.2.1). For the calculation of exposure based on the emissions from local deposition and spray drift sources, the emissions (per 1 ha of agricultural land) are divided by the volume of surface water per 1 ha of agricultural land, resulting in an initial concentration. TWA concentrations are calculated for the 21 days after the pesticide application event, see Table 3.1 for an overview.

Table 3.1 *State variables as used for the calculation of exposure to surface water organisms in EICP*

Eq. NMI3	Symbol	Explanation
	PIEC[ad+sd]	*Maximum concentration by emissions from AD and SD (g/L)*
	TWA[ad+sd]	*Time-weighted average concentration for AD and SD, time window is 21 days (g/L)*
EQ 49	PIEC[sw]	*PIECsw: highest sw concentration (g/L))*
EQ 50	TWA[sw]	*TWAsw: time weighted average concentration (g/L)*

The final short-term exposure concentration in surface water is eventually calculated as the maximum peak concentration from local deposition and spray drift (eq. 57, p. 63). The long-term exposure is then calculated considering dissipation in water (Section 4.1.4). Spray drift or atmospheric deposition for seed treatment in arable crops is not considered as input for surface water.

3.2.2 Exposure to groundwater (leaching)

Exposure to groundwater is simply considered by using concentrations from the respective emission calculations using the meta-PEARL approach (SectionGroundwater 2.2.5. Groundwater).

3.2.3 Exposure for in-soil organisms

Exposure for soil-living organisms is calculated following Section 4.3 (p.65-70) of the NMI3 documentation (Kruijne et al., 2012), an overview is given in Table 3.2. Influence of soil moisture is left out from the calculations since correction does not result in significant changes (Kruijne et al., 2012). Exposure is expressed as total content of a substance in soil over a depth of 0.05 m based on net soil deposition, which depends on the nominal application rate, crop interception and an emission term. In the NMI, it is suggested to calculate soil content assuming long-term use of the substance on the treated field. Potential short-term effects are evaluated after the last treatment within the growing season; potential medium-term effects are evaluated two years after the last treatment and potential long-term effects are evaluated seven years after the last treatment (Van der Linden et al., 2008a,b). The relevant soil depths for the calculations are taken as 0.05 m for spraying and soil injection applications, but is assumed to be 0.2 m when the product is incorporated into the soil. The exposure level used for the calculation of potential acute effects is the maximum of the soil content immediately after each application in the series. If an application series consists of a single application, the exposure level is calculated as the sum of the plateau concentration and the

concentration resulting from a single application (eq. 72, NMI3, p. 67), otherwise a final plateau concentration is considered (eq. 76, NMI3, p. 68).

Table 3.2 *Coefficients and variables as used for the calculation of exposure for soil organisms in EICP*

Eq. NMI3	Symbol	Explanation
EQ 68	k[soil,ref]	*first order transformation rate coefficient at reference conditions (d-1)*
EQ 69	f[T,an]	*function taking account of temperature effects (-)*
EQ 66	S[N,tot]	*total net soil deposition within one growing season as results from an application series (kg ha-1)*
EQ 67	M[S,plateau]	*amount in the soil one year after the last application series of a long term treatment series (kg ha-1*
EQ 71	C[S,plateau]	*content of the substance per kg soil resulting from long term applications, (kg kg-1)*
EQ 73	C[S,I]	*initial soil concentration resulting from the recent application (kg kg-1)*
EQ 72	C[S,A]	*initial soil concentration after the application (kg kg-1)*
	C[S,Final]	*maximum of all C[S,I] values in an application series (kg kg-1)*
EQ 77	PIEC[soil]	*peak concentration in soil (mg kg-1)*
EQ 78	TWA[soil]	*Time Weighted Average environmental concentration in soil, (mg kg-1)*
EQ 81	PEC[soil,2y]	*predicted environmental concentration in the soil two years after the last application (mg kg-1)*
EQ 82	PEC[soil,7y]	*total net soil deposition within one growing season as results from an application series (kg ha-1)*

3.2.4 Exposure for non-target arthropods

Impact on NTA is only assessed in-field in the EICP calculations. The most recent document on ERA for NTAs is the EFSA 'Scientific Opinion addressing the state of the science on risk assessment of plant protection products for non-target arthropods' (EFSA PPR Panel, 2015). Within this document, a number of recommendations for a guidance document are made. Most relevant for the EICP, in Chapter 2 a review of the current risk assessment procedures for NTAs is given. Basically, the current regulatory NTA risk assessment, performed in accordance with the recommendations of the 'Guidance Document on Terrestrial Ecotoxicology', as provided by the Commission Services (SANCO/10329/2002 rev.2 (final), 17 October 2002), and in consideration of the recommendations of the ESCORT 2 guidance document requires two standard test species for assessing the risk of spray applications towards NTAs in TIER 1 being the parasitoid wasp *Aphidius rhopalosiphi* and predatory mite *Typhlodromus pyri* (p. 18/19 in EFSA 2015). For these 'standard indicator species', risk quotients can be calculated using LR50 values tested on glass plates. The LR50 is the application rate which is leading to 50% mortality in the tests, and is expressed as mass per area, i.e. often g/ha. Using this approach also for EICP calculations, application rates (reduced by crop interception from the NMI tables) results in soil deposition in units of mass per area, the net soil deposition S[N], as defined above in Section 2.2.3., which can be directly used for the calculations of NTA risk.

3.2.5 Exposure for birds and mammals

The first tier risk assessment procedure for birds and mammals as used by Ctgb is following EFSA guidance (2009). Basically, the conservative assumption is that spraying with a pesticide is leading to exposed food items for birds and mammals, and in the lowest tier (most conservative) exposure assessment, it is assumed that organism are feeding exclusively on that food item, resulting in an daily dietary dose (DDD). For the selection of the relevant food item, a combination of crop type and species group is considered. If the treated crop is not edible (e.g. apple trees) for birds and mammals, the route of exposure is assumed via ingestion of contaminated plant material from secondary vegetation (e.g. grass in the apple orchard). Specifications in the EFSA guidance document for birds and mammals (EFSA GD 2009) provide tabulated information about the relevant factors for the calculation of the daily dietary dose (DDD), based on food intake derived from an active substance's application rate (AR), body weight (BW), daily energy requirements (DEE), food energy content (FE), the residue unit dose (RUD) and the proportion of food taken from treated fields (PT), which is assumed to be always 100% for EICP calculations. A time-weighted average dose of the DDD can be used to estimate the doses that the organisms receive due to long-term exposure (EFSA GD 2009). For other applications than spraying, i.e. granular or seed treatments, in the NMI standard values for the exposure

calculation are provided for birds (P. 71-73), e.g. the acute factor for generic focal species, $f_{gr,a}$ = 5,500, but no counterpart for small mammals is available (Table 3.3). Hence, it was decided to use the default values for granular application that are defined for birds and for small mammals. Food intake rates, as used for seed treatment assessment, are available from the EFSA guidance also for small mammals. The following Table 3.3 gives an overview about the values used.

Table 3.3 *Factors and parameters used for the exposure calculations for birds and mammals*

Symbol	Value	explanation	Unit	Reference
f[TWA]	0.53	*factor for conversion of acute exposure into a time weighted average exposure (21d)*	(-)	NMI doc. P.71
f[gr,a]	5500	*factor acute for generic focal species, RA granular application for birds*	(mg a.i. (kg bw)-1 d-1) / (kg a.i ha-1)	NMI doc. P.72
f[gr,ch]	3500	*factor chronic for generic focal species, RA granular application for birds*	(mg a.i. (kg bw)-1 d-1) / (kg a.i ha-1)	NMI doc. P.72
NAR	10^6	*nominal application rate (NAR), (corr. to 10 kg seed ha-1 at application rate = 1 kg a.i. ha-1), for seed treatment RA*	(mg a.i.) / (kg seed)	NMI doc. P.73
FIR/bw [bird,large]	0.96	*FIR/bw values for large birds (thrush), exposed to pesticide residues via ingestion of plant seedlings or by granules sticking to earthworms*		EFSA B&M 2009, Table 14
FIR/bw [bird,small]	2.26	*FIR/bw values for small birds (lark), exposed to pesticide residues via ingestion of granules sticking to leaves*		EFSA B&M 2009, Table 15
FIR/bw [mammal,large]	1.34	*FIR/bw values for large mammals (mouse), exposed to pesticide residues via ingestion of plant seedlings or by granules sticking to earthworms*		EFSA B&M 2009, Table 16
FIR/bw [mammal,small]	1.68	*FIR/bw values for small mammals (shrew), exposed to pesticide residues via ingestion of granules sticking to leaves*		EFSA B&M 2009, Table 17

3.2.6 Exposure for bees

The current guidance from EFSA (EFSA, 2013) is used for EICP calculations. This EFSA guidance is currently under revision, but it is expected that the screening level approach, which is most relevant for the EICP, will remain more or less unchanged. This screening level exposure and risk assessment provides a pragmatic, but still science-based approach which links an application rate (AR) of a pesticide to a certain risk, within a certain crop.

In the EFSA approach, 5 exposure scenarios are basically considered:
1. Treated crop
2. Weeds in treated crops
3. Plants in field-margins (spray drift)
4. Adjacent crops (spray-drift)
5. Succeeding crops (residues)

Of those exposure routes, 1 and 2 are considered to contribute most to environmental exposure. Per scenario, the EFSA guidance provides the means to calculate an exposure estimate based on the AR and so-called short-cut values (SVs). The SVs were derived considering information on feed (nectar and pollen) consumption and worst-case pesticide residue levels (RUDs or default 1 mg/kg) of the feed items. SVs were calculated separately for adults and larvae of honey bees (HB), bumble bees (BB) and solitary bees (SB) and application techniques. These SVs can be looked up (Table J3 in EFSA 2013), taking into account whether a crop is attractive for the specific bee type for pollen and/or nectar, what the crop management is (application technique), and whether pollen and/or nectar are available at the timepoint of application (Appendix J of EFSA 2013). Resulting exposure levels, called *screening-level pollinator exposure assessment factors* (SLPEA) quantify individual level exposure of the different bee types and life stages, and allow for a

comparison with effect threshold from acute (LD50oral) or chronic (10d LDD50) tests. Respective calculation rules and shortcut values are given in Table 3.4 and 3.5.

Since toxicity threshold values are mainly available for adult honeybees, the EICP calculations are restricted to those. In more detail, toxicity threshold values are available for acute oral uptake, acute contact and for chronic exposure (often 10d). The EICP considers these toxicity endpoints and provides exposure estimates according to EFSA calculation rules. According information was collected for contact exposure assessment for spray applications (EFSA 2013, p. 17), oral exposure assessment for spray applications (EFSA 2013, Section 3.2.2), and risk assessment schemes for solid formulations (EFSA 2013, Section 3.3.).

Table 3.4 *Screening step calculation rules and shortcut values for spray active ingredients and oral exposure. The shortcut value is used to calculate the exposure for a specific pathway. Please note that SV values are modified in comparison to the EFSA Tables 2 and 3, since they have been multiplied with the inverse of the trigger values to allow to use the same approach for oral and contact evaluation. It is calculated from mechanistic calculation rules for a number of scenarios. These SV are pre-calculated in order to simplify the calculation of exposure and potential effect*

Type of assessment	Formula	Endpoint	Application rate AR	Shortcut value – downward	Shortcut value – sideward
Acute oral exposure adult bees	ETRacute adult oral,spray = AR * SV/LD50oral	Acute oral LD50 µg a.s./bee	kg a.s./ha	38 a)	53 a)
Chronic oral exposure adult bees	ETRchronic adult oral, spray = AR * SV/10 d LDD50	Chronic oral 10 d LDD50 b) µg a.s./bee per day	kg a.s./ha	253 a)	353 a)
Contact exposure for spray applications	HQcontact,spray = AR*SV*/LD50 contact	Acute contact LD50 µg a.s./bee	kg a.s./ha	23.8 c)	11.8 c)

a) Note that the SV values are modified in comparison to the EFSA Tables 2 and 3, since they have been multiplied with the inverse of the trigger values to allow to use the same approach for oral and contact evaluation; b) The chronic 10-d endpoint is expressed in terms of µg a.s./bee (lethal dietary dose). The same endpoint is in literature often referred to as 10-d LC50; c) Note that the SV was created by division of 1,000 (to account for g to kg conversion of the AR) by the HQ trigger values.

Table 3.5 *Screening step calculation rules and shortcut values for granular and seed treatments. Please note that SV values are modified in comparison to the EFSA Tables 2 and 3, since they have been multiplied with the inverse of the trigger values to allow to use the same approach for oral and contact evaluation*

Type of assessment	Formula	Endpoint	Application rate AR	Shortcut value a)
Contact exposure for granular applications	HQcontact,gr = AR* SV/LD_{50} contact	Acute contact LD50 µg a.s./bee	kg a.s./ha	7.1
Contact exposure for seed treatments	HQcontact,st = AR* SV/LD_{50} contact	Acute contact LD50 µg a.s./bee	kg a.s./ha	71.4
Acute oral exposure granular applications	ETRacute adult oral, gr = AR * SV/LD50 oral	Acute oral LD50 µg a.s./bee	kg a.s./ha	11.4
Chronic oral exposure granular applications	ETRchronic adult oral, gr = AR * Ef * SV/10 d LDD50	Chronic oral 10 d LDD50 b) µg a.s./bee per day	kg a.s./ha	75.9
Acute oral exposure seed treatment	ETRacute adult oral,st = AR * SV/LD50 oral	Acute oral LD50 µg a.s./bee	kg a.s./ha	3.5
Chronic oral exposure seed treatment	ETRchronic adult oral, st = AR * SV/10 d LDD50	Chronic oral 10 d LDD50[b] µg a.s./bee per day	kg a.s./ha	23.3

a) Note that the SV values are modified in comparison to the EFSA Tables 6 and 7, since they have been multiplied with the inverse of the trigger values to allow to use the same approach for oral and contact evaluation; b) The chronic 10-d endpoint is expressed in terms of µg a.s./bee (lethal dietary dose). The same endpoint is in literature often referred to as 10-d LC50.

4 Risk indicator calculation

4.1 Principle

A risk indicator relates the *Relevant exposure concentration (REC)* as resulting from emission and exposure calculation steps to a specific toxicity threshold per protection goal. For the EICP, a range of appropriate toxicity thresholds are used per protection goal as effect threshold values (ETH). We follow for the EICP the principle that the risk indicator is expressed by an exposure toxicity ratio (ETR) per unit area of agricultural land. The calculation of risk indicators is executed per protection goal, as given in Table 4.1. A more detailed table (Table 4.2) lists all specific calculation options per protection goal. It should be noted that not for all active ingredients all indicator values can be calculated since threshold values may be missing. All available values are aggregated per protection goal in case more than one endpoint is available by taking the maximum of the available ETR values.

Table 4.1 *Overview of protection goals considered or the risk indicator calculations and related relevant exposure compartment*

Protection goal	Relevant exposure
Groundwater	Groundwater
Aquatic organisms (including fish, macrophytes and invertebrates)	Surface water, based on spray drift and local deposition
In-soil organisms	Soil concentration, deposition distributed within a certain soil volume
Non-target arthropods	Applied mass per area (net soil deposition)
Pollinators	Treated crop, Weeds in treated crops. Application rate & shortcut values
Birds & Mammals	Relevant food item, Daily dietary dose (DDD)

Table 4.2 *Details of protection goals, exposure units and related risk thresholds*

Protection goal	Temporal dimension	Exposure unit	Unit	Risk threshold	Risk indicator protection goal
Groundwater	-	C[gw]	Ug L-1	0.1 (ug/L)	**Groundwater**
Aquatic organisms	Acute	PIEC[sw]	mg dm-3	Lowest LC50	**Aquatic**
	Chronic	TWA[sw]	mg dm-3	Lowest NOEC	
	RAC	PIEC[sw]	mg dm-3	RAC	
In-soil organisms	Acute	PIEC[soil]	mg kg-1	LC50	**Soil**
	Chronic	TWA[soil]	mg kg-1	NOEC	
	Medium term toxicity	PEC[soil,2y]	mg kg-1	NOEC	
	Long term toxicity	PEC[soil,7y]	mg kg-1	NOEC	
NTA	Acute	S[N]	kg ha-1	LR50 (g/ha)	**NTA**
Pollinators	Acute	SLPEA[acute]	µg /bee	Oral acute 48hr LD50	**Pollinators**
	Chronic	SLPEA[chronic]	µg /bee	Oral chronic 10d LC50	
	Contact	SLPEA[contact]	µg /bee	Acute contact LD50	
Birds	Acute	DDD[bird,ac]	mg/kg	Acute LD50	**Birds & Mammals**
	Chronic	DDD[bird,ch]	mg/kg	Short term Dietary LC50/LD50	
Mammals	Acute	DDD[ma,ac]	mg/kg BW/day	Acute Oral LD50	
	Chronic	DDD[ma,ch]	mg/kg	Short Term Dietary NOEL	

4.2 Collection, storage and update of ecotoxicological threshold values

Threshold values were defined per protection goal (Table 4.2) and were collected by Ctgb from the EFSA databases for 122 active ingredients. A protocol for data collection was developed and used. Threshold values for the 122 active ingredients are presented in the table that can be accessed via the link in Appendix 2.

4.3 Sensitivity analyses of exposure-toxicity values.

A sensitivity analysis of the risk indicators values was performed for 45 active ingredients for application on all 6,405 STONE plots. Local STONE plot properties have an impact on ETRs for aquatics, groundwater and soil only. The maximum application rate as available from the label information per product was used, and one application in spring and one in autumn was simulated. The resulting exposure and risk indicator values were analysed, presented here only for spring applications. Raw indicator values were found to differ marginally between spring and autumn applications, but differ significantly between the single protection goals. In order to be able to compare risks indicator values between protection goals it was decided to scale these values by the 90th percentile of all risk indicator values (across all AIs and all STONE plots) per protection goal. This percentile has been selected to serve as a reference value for pesticides with relative high toxicity. The respective scaling values (also median values for comparison) are given in Table 4.3.

Table 4.3 *Scaling values (90th percentiles of sensitivity analyses, additionally median values for comparison)*

	Median	Scaling values (90th percentile)
Groundwater	53.25	1040.03
Aquatic	134.26	3394.53
Soil	0.0671	2.118
NTA	0.000757	0.0227
Pollinators	0.0764	19.83
B&M	0.322	10.018

The resulting scaled indicator values for 45 active ingredients and a single application in spring are shown in the following figures (Figure 4.1, Figure 4.2, Figure 4.3), where for groundwater, aquatic, and soil scaled risk indicator values are shown with boxplots, reflecting the variation across the 6,405 STONE plots. For NTA, pollinators and birds & mammals no local characteristics were included in the calculations, hence these values show no spatial variation. When for single AIs no threshold values could be found, the active ingredients are given in the top of the figures without plotted values in the diagram, e.g. dimethoate and bifenazate for NTA. The plotted values show a reasonable distribution of the scaled indicator values across AIs, with about 5 of the overall 45 AIs showing values larger than 1 (90th percentile), the other values ranging down to 10^{-5} and lower. For the application of the EICP, scaled risk indicator values are calculated using the scaling factors as given in Table 4.3. Resulting values can be interpreted as risk relative to the 90th percentile of the 45 tested active ingredients, hence rendering values larger than 1 belonging to the most toxic active ingredients for a specific protection goal. Most importantly, the scaling results in a direct comparability of values between the different protection goals.

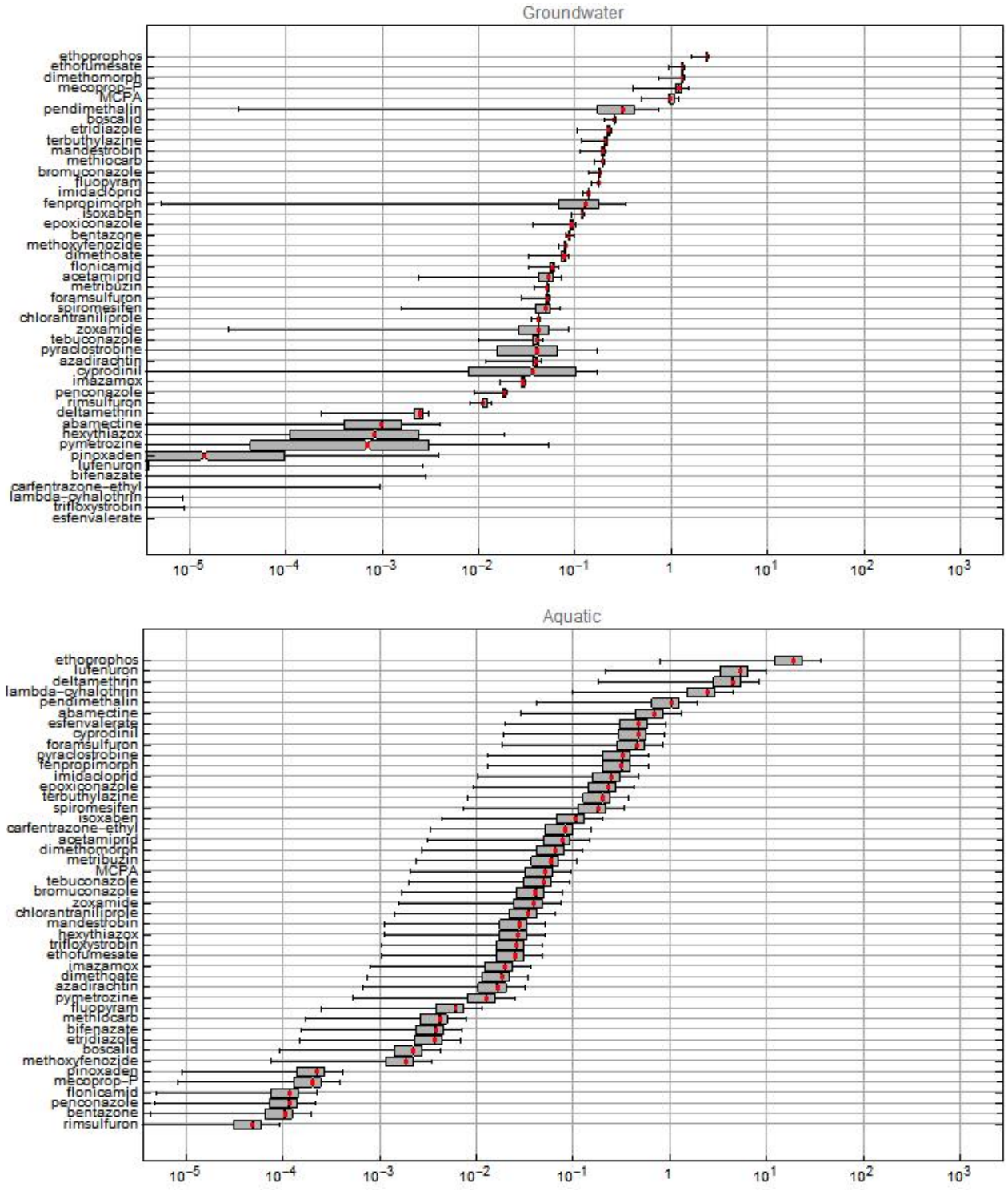

Figure 4.1 *Scaled indicator values for 45 active ingredients and a single application in spring, for groundwater (top), and aquatic organisms (bottom). EICP risk indicator values are shown with boxplots, reflecting the variation across the 6,405 STONE plots*

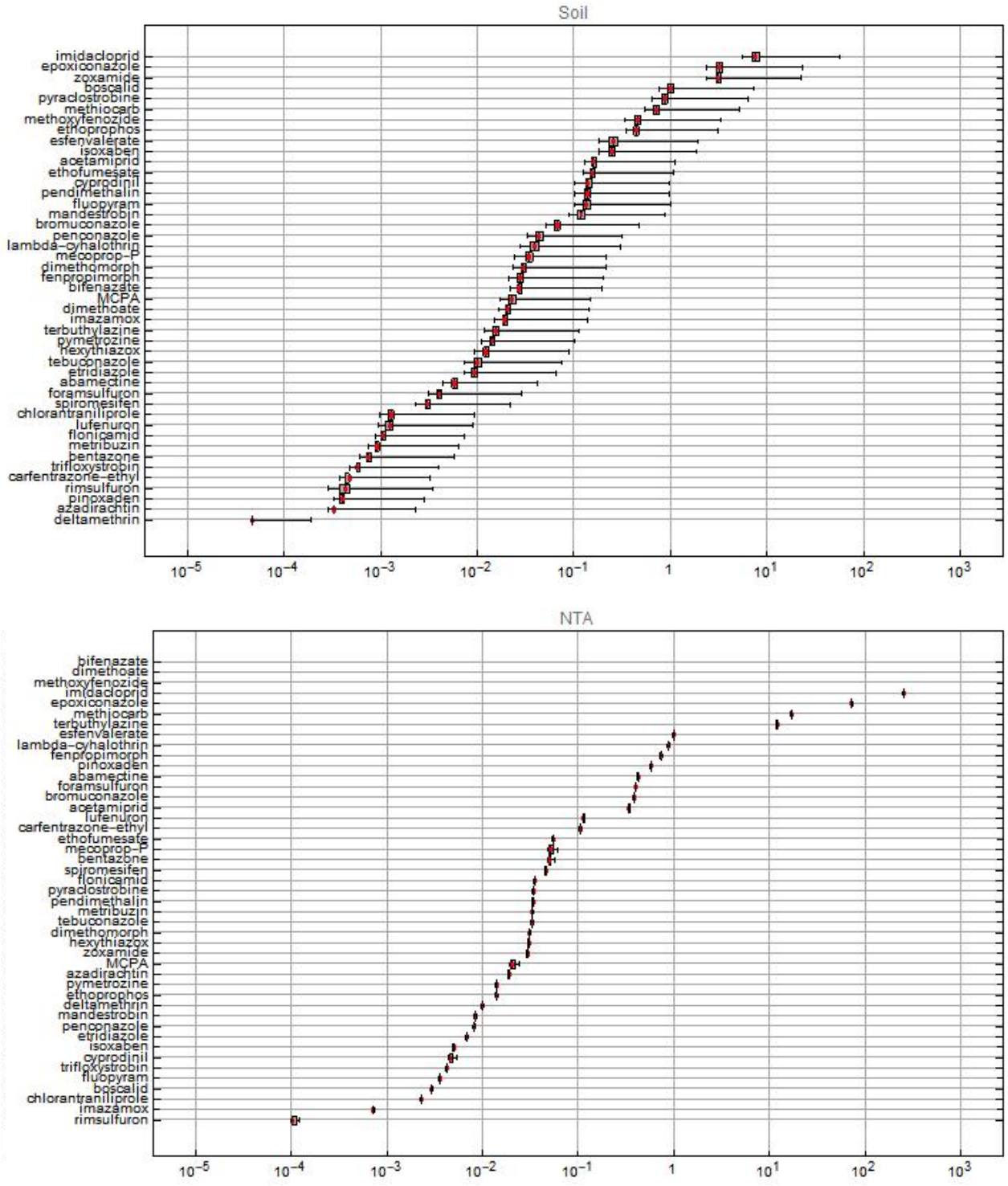

Figure 4.2 *Scaled indicator values for 45 active ingredients and a single application in spring, for soil organisms (top), and NTA (bottom). EICP risk indicator values for soil are shown with boxplots, reflecting the variation across the 6,405 STONE plots*

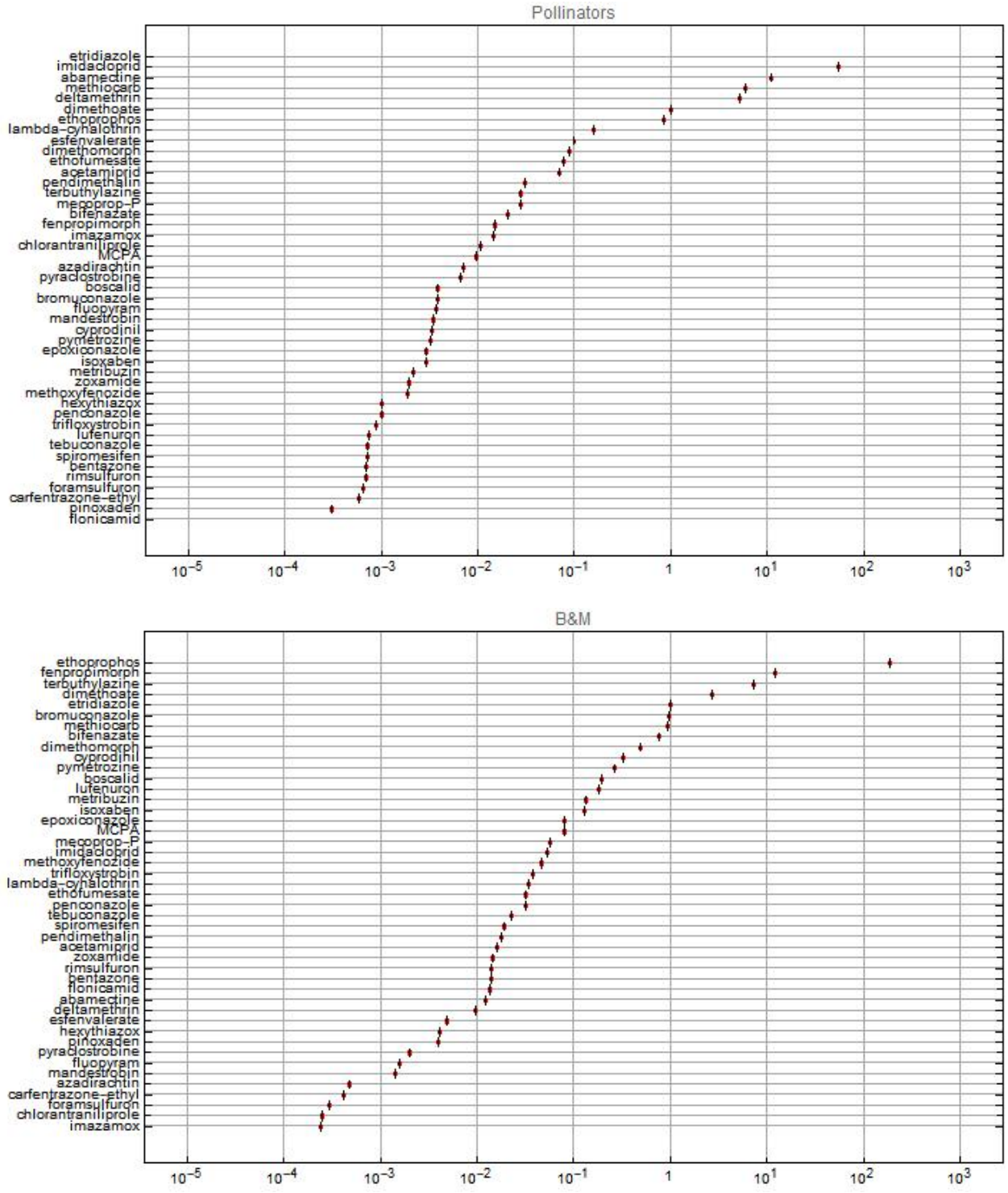

Figure 4.3 *Scaled indicator values for 45 active ingredients and a single application in spring, for pollinators (top), and birds & mammals (bottom). EICP risk indicator values for soil are shown with boxplots, reflecting the variation across the 6,405 STONE plots*

4.4 Calculation of risk indicator values and aggregation of pesticide packages

4.4.1 Evaluation of crop protection packages

A crop protection package can consist of a number of pesticide product applications, each of the products can contain a number of one or more active ingredients (AI). For the evaluation of a crop protection package, the user fills in a list with products, which are translated to their respective active ingredients. This list is evaluated AI by AI, and calculation rules are applied for repeated applications of AIs resulting from repeated application of the same or different products. Resulting indicator values are added up. By this procedure, resulting risk indicator values for a whole crop protection package depend on the number of applied products and applications.

4.4.2 Definition of risk indicator values

The basic principle of the risk indicator is the calculation of ETRs per protection goal, as resulting from the division of the relevant environmental concentration (REC) by the related effect threshold (ETH):

$$ETR_{i,raw,PG} = \frac{REC_i}{ETH_{i,pg}}$$

The REC is here the relevant exposure quantity, which can be PIEC or TWA for surface water and soil, or net soil deposition for NTA, or other exposure units for the other protection goals (see column exposure unit in Table 4.2), *PG* is the protection goal (Table 4.1) and *i* refers to an active ingredient.

The ETR values are not constrained in their absolute values and difficult to interpret, hence they are used in a scaled format, which is achieved by using the results from the sensitivity analyses (SA) as explained in Section 4.3. In the SA, ETR values for the current selection of 45 active ingredients were calculated for the six protection goals. For open cultivation these calculations were executed per STONE plot. Using scaling factors (SF_{pg}) as given in Table 4.3, ETR results were scaled per protection goal: $ETR_{i,pg}$.

The scaling for the protected crops is based upon the impact of the active ingredients taken into account in the pre runs with the GEM model. The impact of 1 kg of active ingredient applied in a greenhouse crop is calculated as the concentration in water calculated by GEM divided by the RAC value. The 90th percentile score of the impact is used as the scaling variable. The value of the scaling variable is calculated for each crop separately.

For the evaluation of the application of all active ingredients used for one crop protection scheme, scaled ETR values are added up per protection goal:

$$EICP_{PG,j} = \sum_{i=1}^{n} ETR_{i,PG} = \sum_{i=1}^{n} \frac{ETR_{i,raw,PG}}{SF_{PG}}$$

where *n* is the number of PPPs in the crop protection package *j and SFpg refers to the scaling factor for the protection goal.*[7]

4.4.3 Presentation of resulting indicator

This procedure results in EICP values for a specific crop for at maximum six protection goals for open cultivation, and a maximum of four protection gaols for protected cultivation, while it might be that for some

[7] We have considered to use a log-scale for the presentation of the results, but it appeared to be too difficult to interpret the results in practice. Methodological considerations are provided in Appendix 5.

PGs the ETR values cannot be calculated due to missing data. One recommended option to communicate the risk indicator values in a differentiated form is the use of radar plots, with one axis per protection goal.

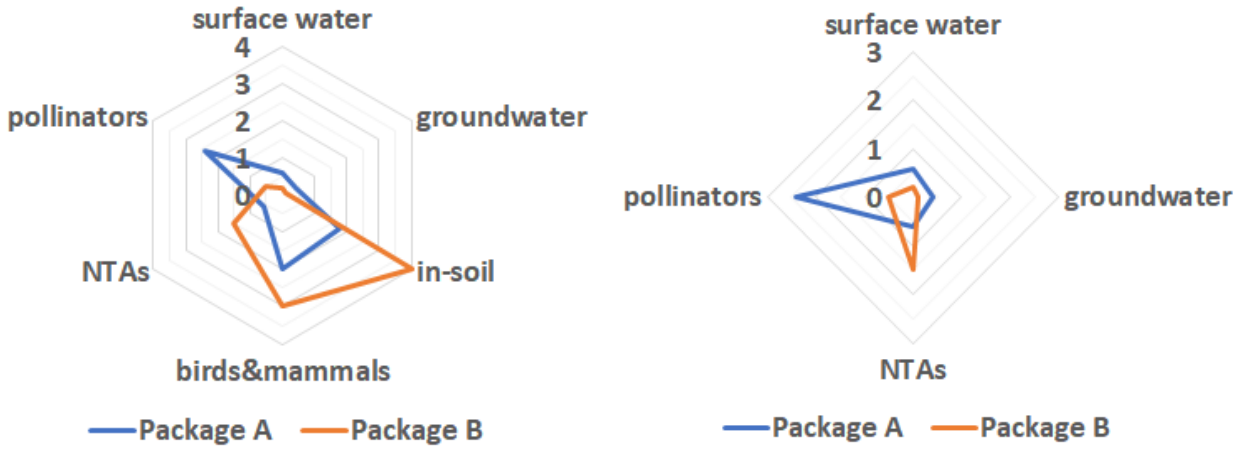

Figure 4.4 *The figure shows an example output as it could result from EICP calculations for open (left) or protected (right) cultivation on substrate: Per organism group one indicator value is shown on its own axis. These values can be larger than 1, since they stem from the full crop protection package, so it might contain several products, for each of which indicator values are calculated separately and summed up in the end*

5 Discussion

5.1 Application of the EICP in the NL

One of the principles in the development of the EICP regards the consistency of the conceptual approach with the risk assessment methodology as applied in the procedure of authorities registering PPPs, such as the Ctgb. The reason for this compliance is that we need to prevent that results will be questioned with the argument that the results deviate from the decision to register the applied PPPs. This principle has the consequence that pathways for emission which are not included in the registration procedure are not included in the EICP. An example is drainage as a pathway to surface water. Furthermore, simplification has been applied in certain models, such as the model for leaching (Section 2.2.2). With respect to emission modelling, we have implemented the simple method as used by Ctgb based on drift reducing technology (DRT) classes is used (Section 2.2.4) This is not only because of consistency, but the application of spray reducing technology is tailored to this method. As soon as updated spray drift curves developed by Wageningen Plant Research will be available, and implemented in Ctgb risk assessment methodology, the EICP can be adjusted.

5.2 Analysis of relative contribution of single AIs or products to EICP values

The test implementation of the EICP provides theoretically the option to analyse the relative contribution of single AIs or products to the EICP risk indicator values for whole crop protection packages. For example, this could be done by calculation of the indicator values for the full crop protection package, and once the package except one AI or one crop protection product, the difference in indicator values per protection goal is then obviously the contribution of that single AI or product. This analysis would provide the option to indicate to the crop producer how the overall environmental of the chosen crop protection package is built up, and to identify immediately most impactful products or AIs. This option is not implemented in the current EICP test version, but would ideally be implemented in later versions since it would increase the benefit for EICP users.

5.3 Commonalities and differences between EICP and NMI

Calculations of emissions, exposure and risk for the milieu-indicator gewasbescherming (EICP) are in good parts taken from the documentation of the nationale milieu-indicator (NMI) (Kruijne et al., 2012). The NMI methodology was developed over years by an expert team of pesticide fate modellers from WUR, RIVM and PBL, and was continuously adjusted with the responsible ministries. The NMI methodology is also consistent with the pesticide registration procedures in the Netherlands and the EU, as it follows a separation of exposure and effect assessment, and is using process-based mathematical models to analyse emissions and exposure of pesticides in the environment.

In the opposite, the aims of the NMI and the EICP are different. The NMI was mainly developed for supporting pesticide registration policy evaluation for all pesticides on the scale of the whole Netherlands, whereas the aim of the EICP is to calculate environmental risk indicator values for the pesticide package used for the production of a certain crop by a certain farmer/grower. These differences in the aims have some implications, see Table 5.1.

Table 5.1 *Comparison of NMI and EICP*

NMI	EICP	Implication
Calculations are performed for a large number (N=6405) of spatial units for the whole of the NL, results are aggregated from all locations to a national scale indicator	Calculations consider a local environmental situation, but the location can be anywhere (in the NL or another country)	Environmental conditions need to be appropriately represented in a spatial schematisation for the whole country, but one EICP application is restricted to one location
Calculations are performed for all individually registered pesticides	Calculations consider the package of pesticides used for the production of a specific crop	Entry point for the EICP calculations: Definition of pesticide package used for a product and selection of a specific local scenario
Main uncertainty for the calculation of NMI values lies in the usage information	Precise pesticide usage information is provided by the user	Uncertainty in EICP values reduced
Emission to surface water can come from open and protected crops	One product is grown either in open or protected cultivation	Calculation of EICP values can be separated between open and protected cultivation, emissions form protected crops are not relevant for open cultivation EICP calculations

5.4 Requirements for applying the EICP in new countries

The calculation rules for emissions, exposure and risk for the open cultivation are independent of country-specific aspects. Effort is needed when the EICP should be applied for another country than the NL for the provision of the required data. Different input information could be obtained from different sources. The registration of PPP and the prescription of product specific mitigation measures is as country specific as the choice of the crops which are produced. Hence, the list of possible crops and registered products needs to be adapted for any new country where the EICP would be applied. Respective information will be available from the respective registration authority. As part of this, usually a data package with physico-chemical properties, usage information, and ecotoxicological endpoints (in Europe: RAC values) can be obtained and used in EICP.

In addition to this, environmental information including characteristics of water courses and soil information is required for emission and exposure calculations. Availability of such data will differ per country, but the EICP is flexible in this context and can be calculated based on information based on expert judgement. The potential leaching to groundwater and exposure of surface water by drainage is based on runs of the PEARL model, which need to be done for new scenarios and/or new PPPs in other countries.

As variation in temperature and precipitation (long-term averages) is not very large for the Netherlands, it was decided not to differentiate and derive only one equation for the whole of the Netherlands.

(Ideally, the EICP would provide the possibility to run the PEARL model based on scenario definitions in a (semi-)automated way).

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Appendix 1 User guidance

Start:

User fills in input mask

Input	Data type	Links to
Pesticide application event	Integer	
Date	Date	
Location	Name, needs translation into LAT/LON	
Crop	Selection list	Interception
Product number/Product name	Selection list	AI
Application rate	(L or KG /Ha)	
Crop free zone	Metre	
Application technique (type of sprayer)	Selection list	
Drift reducing measures (nozzles etc.)	Selection list	

One EICP evaluation will usually consist of a list of pesticide applications. It will be for one location, and for one crop, but at different time points and hence crop stages. Any applied single pesticide product can be composed of a number of one or more active ingredients. The EICP evaluations will therefore be done for one location, one crop, at different time points/crop stages. Location specific data such as the relevant STONE plot for setting the aquatic scenario, the hydroregion, soil properties and the representative PEARL/soil scenarios for leaching and drainage will be defined in the beginning of a EICP evaluation run and written into the sheet 'Input_location'. Crop stage specific values such as the crop interception will be updated per evaluation step, respectively pesticide application event.

For all items in the pesticide application list, the product will be first translated into the contained AIs. Per AI, the required physico-chemical data and toxicity information will be extracted from the EICP pesticide property database and written into the sheet 'input_AI'. In the next step, emissions, exposure and risk indicators will be calculated for the AI. The results of the calculations will be stored (not all single calculation steps, but emission, exposure and risk) and the next AI will be evaluated. All pesticide application events will be evaluated in that way, all results are stored.

In consequence of this calculation flow and the specific purpose of the EICP calculations, all aspects of multiple applications in the calculation rules as laid down in the NMI documentation will be dismissed. Open question: What if the same product/ an AI is applied repeatedly? Concentrations would add up.

Finally, all risk indicators will be added per protection goal, following the assumption of effect addition. Further analyses concerning main drivers for the risk are possible, including the option to analyse the contributions of single products to the overall risk.

Appendix 2 Input data and scenarios

Definition of data tables

Data table	Source	Remarks
Crop	NMI, CLM (MML)	
Product active ingredients	Ctgb	Translation Product (choice of EICP user) into active ingredients (calculations in EICP)
Crop protection package	Consortium	
Pesticide properties	Ctgb/EFSA/PPDB	
Application technique	NMI	
Spray drift reducing techniques	Ctgb	to be matched with Spray drift calculations
Buffer zones	Ctgb	Crop-specific BZ and product-specific BZ
Interception table	NMI, Appendix	To be checked for completeness according to crop types, application techniques
Spray drift	WPR	To be extended with spray drift calculator
Atmospheric deposition	NMI	Parameters for AD are available
Food item data	EFSA GD	For B&M RA
Bee RA shortcut values	EFSA GD	For Bee RA
RAC values	Ctgb	Now 50 pesticides available. Further pesticides to be collected

Crop types

A predefined list with arable and horticultural crops is included. The user has to select one crop.

Pesticide properties

Property		Unit
Vapour pressure		(mPa)
Molar_1 enthalphy		(kJ mol -1)
Freundlich exponent		
Water solubility		(mg L -1)
Half life_1	water	
Half life_2	SED	
Half life_3	Water-SED	(days)
Half life_4	pKa	
Half life_5	PH dependent sorption	
Half life_6	KOM,BASE	
Half life_7	KOM, ACID	
Half life soil	DT50	(days)
Binding capacity	Kom	(l/kg)
Metabolite I	DT50	(dagen)
	Kom	(l/kg)
	correction factor	
Metabolite II	DT50	(days)
	Kom	(l/kg)
	correction factor	

Ecological Threshold values: see table below.

Application techniques
The following techniques can be selected:
1. Seed treatment
2. Granulate
3. Spraying followed by tillage
4. Field sprayer
5. Knapsack sprayer
6. Orchard herbicide sprayer
7. Upwards or sideways sprayer

Drift reduction class
Dependent on the application technique applied the drift reduction class can be selected. The following drift reduction percentages can be chosen: 0, 50, 75, 90, 95, 97,5, 99%.

Crop and spray free zones
The user has to indicate the distance to the edge of the plot that will not be sprayed.

Interception table
This table contains the Leaf Area Index (LAI) per crop per month as an indicator of the percentage interception.

STONE plot information
All necessary information for the calculation of spray drift and atmospheric deposition into surface water bodies are available for the 6,405 STONE plots. Also, for the definition of relevant soil information the STONE data is used. The spatial information is linked to the calculation based on the user selection of a location via the Dutch postcode.

A dataset resulting from the different tables in the STONE database as used for the EICP calculations is given in Table A2.1.

Table A2.1 *Dataset as used for the EICP calculations dataset resulting from STONE database*

Symbol	Explanation	Unit	Reference table
STONE_ID	*ID of the STONE plot for the selected location*	(-)	Locations
HYDROTYPE_ID	*ID of the relevant hydrotype*	(-)	PLOT_OPWA
HYDROREGION_ID	*ID of the relevant hydroregion, basis for selection of the soil scenario for PEARL runs for drainage and leaching*	(-)	
f[om,5]	*local organic matter fraction in the topsoil (upper 5 cm),*	kg kg-1	PLOT_BODEM
ρ5	*soil dry bulk density (5 cm)*	kg dm-3	PLOT_BODEM
pH	*soil pH (upper 5 cm)*	(-)	PLOT_BODEM
T[a]	*local long-term annual average temperature (K)*	K	JAARTEMP
OB_PRIM	*distance between the crop edge and the 1st surface water boundary (m), primary system (large)*	m	HYDROTYPES
OC_PRIM	*distance between the crop edge and the 2nd surface water boundary (m), primary system (large)*	m	HYDROTYPES
OB_SEC	*distance between the crop edge and the 1st surface water boundary (m), secondary system (medium)*	m	HYDROTYPES
OC_SEC	*distance between the crop edge and the 2nd surface water boundary (m), secondary system (medium)*	m	HYDROTYPES
OB_TERT	*distance between the crop edge and the 1st surface water boundary (m), tertiary system (small)*	m	HYDROTYPES
OC_TERT	*distance between the crop edge and the 2nd surface water boundary (m), tertiary system (small)*	m	HYDROTYPES
SWLEN_PRIM_m_ha	*Slootdichtheid van het primair systeem (breed); Lengte kavelsloten per eenheid landoppervlak.*	m/ha	PLOT_OPWA

Symbol	Explanation	Unit	Reference table
SWLEN_SEC_m_ha	*Slootdichtheid van het secundair systeem (gemiddelde breedte); Lengte kavelsloten per eenheid landoppervlak*	m/ha	PLOT_OPWA
SWLEN_TERT_m_ha	*Slootdichtheid van het tertiair systeem (smal); Lengte kavelsloten per eenheid landoppervlak*	m/ha	PLOT_OPWA
BodemBreedte_m_PRIM	*bottom width, primary system*	m	HYDROTYPES
BodemBreedte_m_SEC	*bottom width, secondary system*	m	HYDROTYPES
BodemBreedte_m_TERT	*bottom width, tertiary system*	m	HYDROTYPES
WaterDiepte_m_PRIM	*water depth, primary system*	m	HYDROTYPES
WaterDiepte_m_SEC	*water depth, secondary system*	m	HYDROTYPES
WaterDiepte_m_TERT	*water depth, tertiary system*	m	HYDROTYPES
TaludFactor_h_v_PRIM	*slope ratio of river bank, primary system*	-	HYDROTYPES
TaludFactor_h_v_SEC	*slope ratio of river bank, secondary system*	-	HYDROTYPES
TaludFactor_h_v_TERT	*slope ratio of river bank, tertiary system*	-	HYDROTYPES
q	*the volume flux of water at depth Lsoil,*	(m d-1)	PLOT_BODEM
ρ100	*soil dry bulk density (100 cm)*	kg dm-3	PLOT_BODEM
Θ100,spring	*the long term average soil water content in spring, at 100 cm depth*	dm3 dm-3	PLOT_BODEM
Θ100,autumn	*the long term average soil water content in autumn, at 100 cm depth*	dm3 dm-3	PLOT_BODEM
f[om,100]	*local organic matter fraction in the topsoil (100 cm)*	kg kg-1	PLOT_BODEM
volume_PRIM	*water volume, primary system*	m3 ha-1	
volume_SEC	*water volume, secondary system*	m3 ha-1	
volume_TERT	*water volume, tertiary system*	m3 ha-1	
volume_TOTAL	*water volume, total system*	m3 ha-1	
STONE_METEO	*ID of the meteo station associated with the STONE plot*	-	

Details about the tables can be found in Kroon et al. (2001).

Hydrotypes

The hydrotypes map is a classification of the Netherlands based on hydrological properties. Hydrotypes are clustered into hydroregions (Figure 8.2). The variation of the drainage characteristics of the hydrotypes within the same region is usually less than between different regions. The NMI used hydrotypes and not hydroregions. The cross section sizes are available for 22 hydrotypes and 3 ditch types. To this is added the cross section of the old Dutch standard ditch (a kind of reference value for the drift figures in NMI 3): which results in 67 =(22 x 3) + 1 classes.

Table A2.2 *Clustering of hydrotypes to hydroregions*

Hydro region	ID	Hydrotype
Stream valleys	13	Singraven-stream valley
Dune strip	4	Dune strip
Sandy area	3	Cover sand profile
Sandy area	5	Loam and/or bolder clay profile
Sandy area	6	Bolder clay profile
Sandy area	7	Bolder clay-Peelo profile
Sandy area	8	Loss profile
Sandy area	9	Nuenen group profile
Sandy area	10	East-Netherlands profile
Sandy area	11	Open profile
Sandy area	12	Peelo profile
Sandy area	14	Moraine profile
Sandy area	15	Tegelen/Kedichem profile
River clay area	1	Betuwe-basin clay soil
River clay area	2	Betuwe-streamridge-over-basin clay soil
Sea clay area	16	Westland-C-profile
Sea clay area	17	Westland-D-profile
Sea clay area	18	Westland-DC-profile

Hydro region	ID	Hydrotype
Sea clay area	19	Westland-DH-profile
Sea clay area	20	Westland-DHC-profile
Peat area	21	Westland-H-profile
Peat area	22	Westland-HC-profile

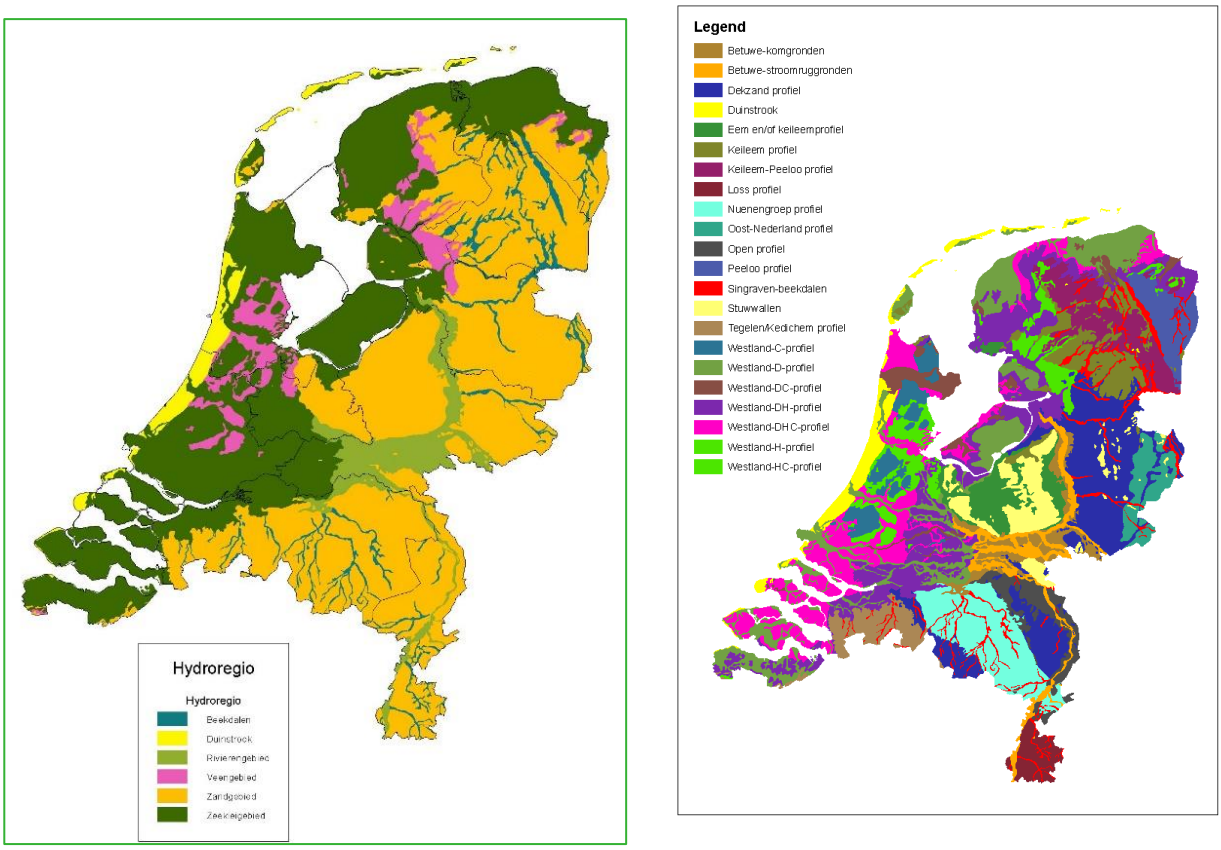

Figure A2.1 *Hydroregio chart and Hydrotype chart of the Netherlands*

Table A2.3 *Ecotoxicological threshold values for water organisms, algae*

The data that support the findings of this study are openly available in [repository name: Zenodo] at https://doi.org/10.5281/zenodo.7716478 , reference number [DOI: 10.5281/zenodo.7716478].

Table A2.4 *Ecotoxicological threshold values for water organisms, aquatic invertebrates*

The data that support the findings of this study are openly available in [repository name: Zenodo] at https://doi.org/10.5281/zenodo.7729530 reference number [DOI: 10.5281/zenodo.7729530]

Table A2.5 *Effect thresholds for aquatic organisms, fish*

The data that support the findings of this study are openly available in [repository name: Zenodo] at https://doi.org/10.5281/zenodo.7732524 reference number [DOI: 10.5281/zenodo.7732524]

Table A2.6 *Ecotoxicological threshold values water organisms, higher plants*

The data that support the findings of this study are openly available in [repository name: Zenodo] a https://doi.org/10.5281/zenodo.7732755 reference number [DOI: 10.5281/zenodo.7732755]

Table A2.7 *Ecotoxicological threshold values mammals*

The data that support the findings of this study are openly available in [repository name: Zenodo] a https://doi.org/10.5281/zenodo.7732803 reference number [DOI: 10.5281/zenodo.7732803]

Table A2.8 *Ecotoxicological threshold values birds*

The data that support the findings of this study are openly available in [repository name: Zenodo] a https://doi.org/10.5281/zenodo.7732861 reference number [DOI: 10.5281/zenodo.7732861]

Table A2.9 *Ecotoxicological threshold values pollinators*

The data that support the findings of this study are openly available in [repository name: Zenodo] a https://doi.org/10.5281/zenodo.7733309 reference number [DOI: 10.5281/zenodo.7733309]

Table A2.10 *Ecotoxicological threshold values soil organisms*

The data that support the findings of this study are openly available in [repository name: Zenodo] a https://doi.org/10.5281/zenodo.7733312 reference number [DOI: 10.5281/zenodo.7733312]

Table A2.11 *Ecotoxicological threshold values non-target Arthropods (NTAs)*

The data that support the findings of this study are openly available in [repository name: Zenodo] a https://doi.org/10.5281/zenodo.7733315 reference number [DOI: 10.5281/zenodo.7733315]

Appendix 3 Drainage emission modelling

Future options to be considered to achieve emission calculations to surface water via drainage in the EICP are:

1. Meta-model: Based on available drainage emissions factors, which have been calculated for the NMI3, a metamodel can be calibrated which connects physicochemical properties of the active ingredients and soil priorities with drainage emission factors. After calibration of a number of different empirical models, the best model can be selected and used for calculating drainage emission factors also for new active ingredients.
2. Simplified drainage model: A simplified drainage model was implemented in the scope of a master thesis at CLM (van der Laan 2019).

Appendix 4 Coefficients and formulae as used for the calculation of crop interception, volatilisation and net soil deposition in EICP

Eq. NMI3	Symbol	Explanation
EQ 1	E[air,app]	*emission to air during application, (kg ha-1)*
EQ 2	S[init]	*initial soil deposition (kg ha-1)*
EQ 3	CV[soil]	*cumulative volatilisation from the soil surface (% of amount reaching the soil).*
EQ 4	S[N]	*net soil deposition (kg ha-1)*
EQ 5	FP[gas]	*fraction of substance in the gas phase, (-)*
EQ 6	ε[gas]	*volumetric gas fraction*
EQ 7	ε[solid]	*volumetric solid fraction (volume solid parts per volume soil)*
EQ 8	ρ[solid]	*density of the solid phase (kg dm-3);*
EQ 9	FP[gas] (Weakly acidic PPP)	*fraction of substance in the gas phase, (-)*
EQ 10	f[nd,soil]	*fraction of substance at the soil surface, modification assuming that an ion has a saturated vapour pressure equal to zero (-)*
EQ 11	K[sl]	*partitioning of the substance over the solid phase and the liquid phase ()*
EQ 12	K[sl] PH dependent sorption	*partitioning of the substance over the solid phase and the liquid phase,for substances with pH-dependent sorption behaviour ()*
EQ 13	K[lg]	*liquid to gas partitioning coefficient ()*
EQ 14	K[H]	*dimensionless Henry coefficient (-)*
EQ 15	P[sat]	*saturated vapour pressure (mPA)*
EQ 16	f[T1]	*temperature correction factor (-)*
EQ 17	S	*solubility in water (?)*
EQ 18	f[T2]	*temperature correction factor (?)*

Appendix 5 Discussion of the Log-scale approach

Resulting $ETR_{i,pg}$ values are distributed on a log-scale across more than five orders of magnitude, hence an additional endpoint is calculated, in a sort of scoring approach.

$$EICP_{PG,score,j} = Max(0;\ 5 + \log(EICP_{PG,j}))$$

Resulting $EICP_{pg,score}$ values range from 0 to >5, where the values quantify the transformed order of magnitude of the scaled ETR of the AI. The choice of 5 can also be changed, it solely quantifies the level of ETR below which the added risk is not considered relevant. That means, for the choice of 5, an ETR of <0.0001 is not further considered.

It is suggested to consider to use $EICP_{PG}$ and $EICP_{pg,score}$ in parallel. Both calculation methods have their specifics: The original EICP values give continuous values of the risk indicators. The overall evaluation of a crop protection package will be dominated, however, by a few dominating active ingredients. If such dominant active ingredients, which are close or above the 90th percentile of all indicator values for a AI/product, are contained in a crop protection package, the overall impact will be large, otherwise the impact will be low. To allow farmers also to get rewards for a reduction of the number of pesticide products, also from the medium impact range, EICP score values are more suitable, since they use values based on the order of magnitude of the respective scaled exposure-toxicity ratio. Experience needs to be collected in case studies and test runs in how far these two suggested indicators can prove their usefulness in practice.

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