DRAFT GUIDANCE OF EFSA

Draft Guidance of EFSA on clustering and ranking of emissions of active substances of plant protection products and transformation products of these active substances from protected crops (greenhouses and crops grown under cover) to relevant environmental compartments[1]

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ABSTRACT

EFSA was asked by the Commission to prepare a Guidance of EFSA on clustering and ranking of emissions of plant protection products (PPPs) and transformation products of these active substances from protected crops (greenhouses and crops grown under cover) to relevant environmental compartments. This EFSA Guidance Document provides guidance for users on how to assess these emissions when performing risk assessments according to Regulation EC no 1107/2009 of the European Parliament and the Council.

KEY WORDS

Risk assessment, protected crop, covered crop, environmental fate, pesticide, glasshouse, environmental receptor

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SUMMARY

A number of EU Member States (MSs) requested guidance on how to carry out environmental risk assessment of Plant Protection Products (PPPs) emitted from protected crops in response to EFSA's consultation of Member States. EFSA was asked by the Commission to prepare a Guidance of EFSA on clustering and ranking of emissions of PPPs and transformation products of these active substances from protected crops (greenhouses and crops grown under cover) to relevant environmental compartments. This guidance also addresses elements that should be considered in deriving exposure scenarios to be used in risk assessment, for both soil-bound and soil-less production systems in greenhouses following the Panel's recommendations (EFSA, 2012).

Receptor soil

For all structures that can be considered non-permanent, risk assessment for the soil compartment should be performed using the approaches for open field. For permanent structures a risk assessment is only necessary for persistent substances (DegT90>1 year from Uniform principles (Regulation (EU no 546/2011)).

Receptor groundwater

Leaching to groundwater from protected crop systems may occur, depending on environmental conditions, the construction technology of the system and the substance properties. For all protection structures mentioned in table 1, except walk-in tunnels and greenhouses, it is proposed to use current open field approaches for exposure of groundwater. For walk-in tunnels and greenhouses example scenarios are given.

Receptor air

For all protection structures mentioned in table 1 it is proposed to use the current approaches according to FOCUS Air (SANCO/10553/2006 Rev 2 June 2008).

Receptor surface water

For all structures mentioned in table 1, except walk-in tunnels, closed buildings and greenhouses, the same approach as for open field should be used as the situation is similar to the open field. For walk-in tunnels it is proposed that the FOCUS surface water drainage scenarios be used. For greenhouses drainage example scenarios are presented in this guidance.

The full listing of the example scenarios can be found on EFSA website after the finalisation of the guidance.

It is recommended to develop representative exposure scenarios for greenhouses and walk-in tunnels with regard to groundwater and surface water and the example scenarios are replaced by these.

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BACKGROUND AS PROVIDED BY EFSA

During a general consultation of Member States, through the Standing Committee on the Food Chain and Animal Health, on needs for updating existing Guidance Documents and developing new ones, a number of EU Member States (MSs) requested environmental fate and behaviour guidance on how to carry out environmental risk assessment of PPPs emitted from protected crops,

Based on the Member State responses and the Opinions prepared by the PPR Panel (EFSA 2010 and 2012) the Commission tasked EFSA to prepare a Guidance of EFSA on clustering and ranking of emissions of PPPs and transformation products of these active substances from protected crops (greenhouses and crops grown under cover) to relevant environmental compartments in letter of 31 July 2012. EFSA accepted this task in response to the Commission in letter dated 9 October 2012. The Commission requests this scientific and technical assistance from EFSA according to Article 31 of Regulation (EC) no 178/2002 of the European Parliament and of the Council.

Following public consultations on the Opinion (EFSA, 2012), Member States and other stakeholders requested “an *easy to use Guidance Document”* to facilitate the use of the proposed guidance and methodology for the evaluation of PPPs according to Regulation (EC) No 1107/2009.

Once this Guidance Document is delivered, the Commission will initiate the process for the formal use of the Guidance Documents within an appropriate time frame for applicants and evaluators.

TERMS OF REFERENCE AS PROVIDED BY THE COMMISSION

EFSA, and in particular the Pesticides Unit, is asked by the Commission (DG SANCO) to draft an EFSA Guidance Documents as mentioned below:

1) EFSA Guidance Document on clustering and ranking of emissions of active substances of PPPs and transformation products of these active substances from protected crops (greenhouses and crops grown under cover) to relevant environmental compartments.

The EFSA Guidance Documents should respect the science proposed and methodology developed in the two adopted PPR opinions mentioned in this document (EFSA 2010, EFSA 2012).

EFSA is requested to organise public consultations on the draft Guidance Documents, to ensure the full involvement of Member States and other stakeholders. To support the use of the new guidance, EFSA is requested to organise training of Member State experts, applicants and other relevant stakeholders.

CONTEXT OF THE SCIENTIFIC OUTPUT

To address the Terms of References as provided by the Commission.

ASSESSMENT

1. Introduction

This guidance is intended for the risk assessment of plant protection products (PPPs) active substances and their transformation products (metabolites). Guidance is provided for when the same methodology as for open field can be used and be considered representative or conservative, and when special, approaches are more appropriate. Outlined in the table below is a summary of the structures and the proposed approaches that are further discussed in chapter 3.

Table 1: Summary of structures and proposed approaches for exposure assessment

Structure/System	Groundwater	Surface water	Soil	Air
Low net shelter	FOCUS all 9*	FOCUS all*	FOCUS*	FOCUSAIR*
Low plastic shelter	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
Low net tunnel	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
Low plastic tunnel	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
High net shelter	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
High plastic shelter	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
Shade house	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
Closed building	Not relevant	Not relevant	Not relevant	FOCUSAIR
Walk-in tunnel	Example leaching scenario concerning a soil-bound tomato crop in Italy *	FOCUS D*	FOCUS	FOCUSAIR
Greenhouse	Example leaching scenario (GW) concerning a soil-bound tomato crop in Italy * Example drainage scenario (SW) concerning a soil-bound chrysanthemum crop in the Netherlands Example scenario (SW) concerning a soilless cultivation in the Netherlands. For the receptor soil: assessment only for persistent substances			FOCUSAIR

*For further details on these abbreviations and meanings, please see chapter 3 and 4.

In EU regulation, protected crop systems (e.g. greenhouses and cultivations grown under cover) are considered as systems which prevent emission of PPPs after application. In article 3 point 27 of the mentioned EU regulation the following definition is given:

A 'greenhouse' means a walk-in, static, closed place of crops production with a usually translucent outer shell, which allows controlled exchange of material and energy with the surroundings and prevents release of plant protection products (PPPs) into the environment.

For the purpose of this Regulation, closed places of plant production where the outer shell is not translucent (for example for production of mushrooms or witloof) are also considered as greenhouses.

Nevertheless, there are indications from research reports and other literature (see, for example, Teunissen 2005) that emissions occur also in systems commonly recognised as "greenhouses". These systems do not fulfil the condition of preventing the release of PPPs into the environment and therefore do not fall under what would be defined as a "greenhouse" according to the definition of the Regulation (EC) 1107/2009. Therefore, it is necessary to clarify under which scenarios the different protected crops fall under the definition of greenhouse according to EU regulation and, consequently, under the provisions for mutual recognition foreseen in Art. 40(c) of that regulation. To this aim, and following the request of MSs to update guidance on how to carry out environmental risk assessment of PPPs emitted from protected crops, the Commission asked EFSA to develop a Guidance Document on clustering and ranking of emissions of active substances of PPPs and transformation products of these active substances from protected crops (greenhouses and crops grown under cover) to relevant environmental compartments.

For the development of the EFSA Guidance Document the Commission asked EFSA to respect the science proposed and methodology developed in the two adopted PPR opinions on emissions from protected crops (EFSA 2010, EFSA 2012).

In the first opinion (EFSA 2010), a survey of the covered crop systems was given and a classification system for structures was developed according to six major groups: low (mini) tunnels, plastic shelters, net shelters, shade houses, walk-in tunnels and greenhouses (low- and high tech types). Also the emission routes and the major receptors were defined in relation to the structure of the cover, the pesticide application method and the soil/soil-less growing system. This classification system is considered useful in describing the huge variability of the sector and is used throughout this Opinion as well.

The second opinion (EFSA 2012) addressed potential emission routes, their relevance to environmental receptors and their ranking. More specifically, the aim of the Opinion was to identify those situations for which scenario development was useful and/or necessary and to prioritise them. The approach was according to two aspects: 1) emission, and 2) spatial distribution. With regard to the emission aspect, estimations of emissions from selected covered crop systems to environmental receptors were compared to emissions from open field applications. With regard to the spatial distribution aspect, the distribution of covered cropping systems was compared to that of open field cropping systems as far as driving forces for emissions are concerned. In addition, the Opinion identified models that can be used for calculating emissions from covered crops and major aspects to be considered when actually developing scenarios.

In the second opinion (EFSA 2012), only emissions of PPPs applied to crops grown under cover were discussed. Exposure assessment in the environmental receptors as well as the ecological effect assessment were not addressed. In the Panel's earlier opinion on this subject (EFSA 2010), it was recognised that emissions from covered cropping systems might occur due to removal of crop remnants, harvested products, substrates and plastic materials. The PPR Panel did not consider these emissions in this Opinion because most Member States have dedicated regulations on these aspects, not related to Regulation 1107/2009. Assessment with regard to consumers, occupational and residential exposure was explicitly excluded from Opinion as this was not in the mandate.

Plant protection products (PPPs) of biological nature

The guidance in this document mainly concerns chemical PPPs, i.e. active substances and their metabolites. Microbial PPPs (any microbiological entity, including lower fungi and viruses, cellular or non-cellular, capable of replication or of transferring genetic material) are also subject to this Guidance. However, models used in the environmental risk assessment proposed for use in this Guidance are not always capable of, nor meant for, predicting fate and behaviour of such products in the environment (e.g. these methods do not consider the potential growth of microorganisms and therefore it cannot be guaranteed that they provide a realistic worst case exposure assessment when applied to them). For other active substances of biological nature like e.g. plant extracts or food or feed additives, this guidance applies in principle taking into account however, the respective approaches for these types of active substances as defined in other guidance.

Where approved methods for risk assessment of PPPs of biological nature exist for open field applications and this Guidance indicates that open field methodology can be used for a specific application to a covered crop, then that method may be used for the specific application as well. For the time being, the use of tools available for chemicals to estimate environmental exposure to microorganisms should be considered on a case by case basis. In such cases, sufficient justification should be provided to demonstrate that a realistic worst case exposure has been assessed. In cases where only low confidence can be placed on such exposure assessment, applicants should consider providing additional experimental data that allow exposure to the microorganisms to be addressed. These additional data should be derived from studies performed under realistic worst case conditions representative of the proposed agricultural/horticultural practices proposed for the plant protection product containing the microorganism.

2. Details on structures

Various kinds of structures are currently used for protecting crops, including soil mulching with plastic or organic (e.g. straw) material or direct crop cover with non-woven fabric. A technical classification is proposed for protected crop systems by taking into consideration the nature of the emission routes for PPPs (EFSA 2010). The classification considers the structure (frame and covering) as well as the growing system, in particular the possibility to grow plants in media other than soil (soilless culture) and to recycle drainage water (from both soil-bound and soilless culture) in what are named "closed-loop systems". Protection structures may be categorized also considering the accessibility for the workers (i.e. low, inaccessible tunnels or accessible structures such as large tunnels and greenhouses) and whether they are permanent or temporary. The permeability of the covering material is another relevant criterion in regard to PPP emissions.

Based on these criteria, many kinds of protection structures can be identified (Figure 1); however, the main categories considered in this Guidance Document are low plastic tunnels, (high) plastic shelters or shade houses, walk-in tunnels and greenhouses (Table 2).

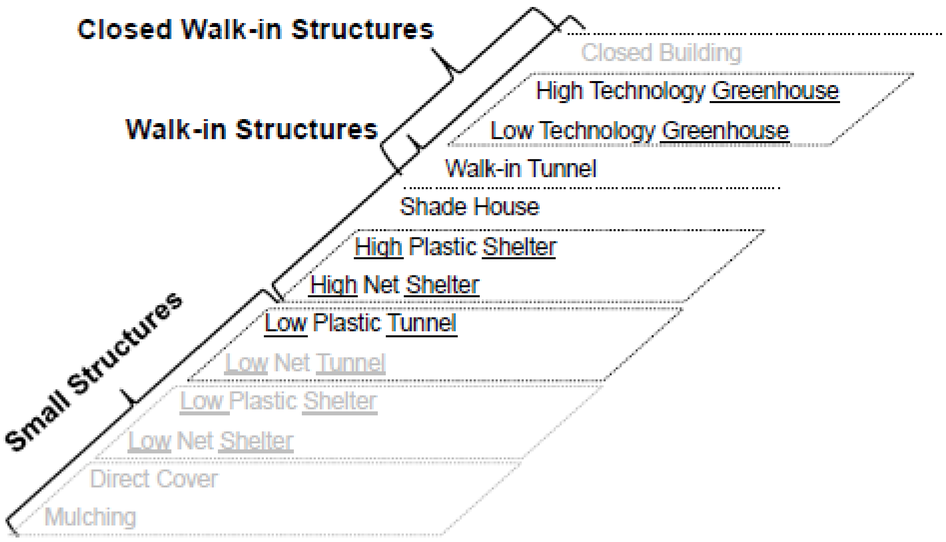

Figure 1: Main categories of protection structures (from EFSA 2010). Small structures are not accessible to the workers, and are generally temporary. Walk-in structures are large enough to work in the structure and may be closed at all sides with water-proof screens. Small structures and closed buildings with a non-translucent outer shell which are not explicitly addressed in this Guidance are shown in grey. The main structures focused on in this Guidance are shown in black.

Table 2: Classification criteria and main categories of protection structures

	Accessibility [(a)]	Temporary structure	Permeable cover [(b)]
Low plastic tunnel	No	Yes	No
(High) Plastic shelter	Yes	Yes	No
(High) Net shelter	Yes	Yes/No	Yes (net)
Shade house	Yes	Yes/No	Yes (net)
Walk-in tunnel	Yes	Yes	No
Greenhouse	Yes	No	No

(a): accessibility for operators
(b): permeable to water

2.1. Low (mini) tunnel

This is a simple plastic cover generally associated with mulching. It is a temporary cover, in that it is removed some weeks well before the harvest.

Figure 2: Examples of low tunnels (photos: Alberto Pardossi)

2.2. Plastic Shelter

A plastic shelter is generally used for fruit crops, such as table grape and strawberries, in order to protect them against cold or rain and to extend the harvest period. In some cases, the cover is discontinuous, that is the shelter is placed only above the crop row.

Figure 3: Plastic shelters used for table grape (left) or soilless-grown strawberry (right) in Italy (photos: Alberto Pardossi)

2.3. Net shelter and Shade house

A net shelter is used to protect vegetable or ornamental crops from excessive heat and/or light, wind, insects and birds; it may have the shape of a tunnel or small greenhouse, the only difference consisting of a permeable cover fabric. A shade house is a shading net in the shape of a tunnel or small greenhouse; it is generally used for ornamental crops.

Figure 4: Shade house for pot ornamentals in Italy (photo: Alberto Pardossi)

2.4. Walk-in tunnel

A Walk-in tunnel is an unheated structure used for growing plants. It usually consists of a single layer of plastic supported by plastic or metal arches or hoops. These structures are large enough to walk and work inside, and generally they are temporary, in that they or their coverings are generally removed at the end of cultivation.

Figure 5: Walk-in tunnels for soil cultivation of strawberry (photo: Alberto Pardossi)

2.5. Greenhouse

A greenhouse is described as a walk-in, static, closed place for crop production with a translucent outer shell in Regulation (EC) 1107/2009. Greenhouses can be classified according to the geometry (e.g. single span or multi-span) and the material used for the frame (wood, aluminium, steel, or a combination of them) and the shell (plastic, both rigid pans and films; glass). These structures range in size from small sheds to very large buildings. For example, newly built glasshouses in the Netherlands may have a cultivation area of up to 10 ha, with an average height of 8 m.

Following Pardossi et al. (2004), both low- and high technology greenhouses can be identified. Low-technology greenhouses have a very simple structure, with plastic covering and poor climate control; very often, they lack a heating system. Vegetables and low-value cut flowers are grown under this kind of shelter.

Figure 6: Examples of low-tech plastic greenhouse: the traditional low-cost 'parral' (left), which is widely used in the Southern Spanish region of Almeria, and the more innovative pre-fabricated arch-shaped multi-tunnel (photos: Alberto Pardossi)

High technology greenhouses have a metal structure, are covered by plastic (also rigid pans) or glass (obviously, the term 'glasshouse' refers to this kind of structure) and have an automatic climate control, which may include root zone heating, forced ventilation, evaporative cooling, light conditioning (shading and/or artificial lighting) and carbon dioxide enrichment. Soilless growing systems are often installed to maximise space-use efficiency and minimise hand labour. They are generally employed for high-value crops, such as out-of-season vegetables, cut flowers (e.g. roses), pot ornamentals and propagation materials (seedlings, cuttings, ex vitro plantlets, etc.).

Figure 7: Examples of high-tech glasshouse in Italy (left) and in the Netherlands (right) (photos: Alberto Pardossi)

3. Receptors

3.1. Conclusion for receptor section

The risk assessment proposed in this section includes and concerns both the active substance as well as all, for risk assessment purposes, relevant metabolites in PPPs. With regards to microbial plant protection products (e.g. micro-organisms, viruses and fungi, please see section 1 for further details.

Spatial distributions of open structures are considered to be evenly distributed (have no bias) within climatic zones with respect to both temperature and precipitation. This is approximately the same assumption as made for open field (tier 1), so the open field scenarios can be considered representative in the first tier.

This is not assumed for greenhouses and walk-in tunnels and the FOCUS scenarios for open field are considered not to be representative for these structures. Instead, separate scenarios have to be developed in the future.

Mulching and direct plastic cover were excluded in the scientific Opinion (EFSA 2010) and are not included in this table. The environmental risk assessment for open fields can be applied.

Table 3: Summary of structures and proposed approaches for exposure assessment.

Structure/System	**Groundwater**	**Surface water**	**Soil**	**Air**
Low net shelter	FOCUS all 9 [(1)]	FOCUS all [(2)]	FOCUS [(3)]	FOCUSAIR [(4)]
Low plastic shelter	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
Low net tunnel	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
Low plastic tunnel	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
High net shelter	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
High plastic shelter	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
Shade house	FOCUS all 9	FOCUS all	FOCUS	FOCUSAIR
Closed building	Not relevant	Not relevant	Not relevant	FOCUSAIR
Walk-in tunnel	Example leaching scenario concerning a soil-bound tomato crop in Italy [(5)]	FOCUS D [(6)]	FOCUS	FOCUSAIR
Greenhouse	Scenarios to be developed for receptors soil, surface water and groundwater. Open field approach in the meantime.			FOCUSAIR

(1): All 9 FOCUS (2000, 2009) groundwater scenarios: Châteaudun, Hamburg, Jokioinen, Kremsmünster, Okehampton, Piacenza, Porto, Sevilla and Thiva according to FOCUS groundwater scenarios in the EU review of active substances, Sanco/321/2000 rev.2 and other Sanco document

(2): All FOCUS (2001) surface water scenarios at Step 3: D1 (Lanna), D2 (Brimstone), D3 (Vredepeel), D4 (Skousbo), D5 (La Jailliere), D6 (Váyia, Thiva), R1 (Weiherbach), R2 (Valadares, Porto), R3 (Ozzano, Bologna) and R4 (Roujan) according to FOCUS Surface Water Scenarios in the EU Evaluation Process under 91/414/EEC, SANCO/4802/2001-rev.2 final (May 2003).

(3): PECsoil to be calculated according to Soil persistence models and EU registration, the final report of the work of the Soil Modelling Work group of FOCUS, 29.2.97.

(4): PESTICIDES IN AIR: CONSIDERATIONS FOR EXPOSURE ASSSESSMENT, Report prepared by the FOCUS Working Group On Pesticides in Air (FOCUS Air Group) SANCO/10553/2006 Rev 2 June 2008

(5): According to Appendix A

(6): FOCUS drainage scenarios at step 3: D1 (Lanna), D2 (Brimstone), D3 (Vredepeel), D4 (Skousbo), D5 (La Jailliere), D6 (Váyia, Thiva) according to FOCUS Surface Water Scenarios in the EU Evaluation Process under 91/414/EEC, SANCO/4802/2001-rev.2 final (May 2003).

3.2. Receptor soil

For all structures that can be considered non-permanent, risk assessment for the soil compartment should be performed using the approaches for open field. The following assumptions are made for receptor soil:

- net precipitation is assumed not to be changed / hardly influenced
- precipitation pattern is not changed
- wash-off from crop is not changed (at least not becoming larger)
- temperature is on the average not lower than open field (where average temperature would be higher the open field can be considered conservative)
- soil has not been changed (at least %OM is not lower)

With regard to covered cropping systems, the PPR Panel made an earlier recommendation not to develop a separate risk assessment methodology for the receptor soil (EFSA 2010). If the estimation of exposure in soil, either inside or outside the covered cropping system, is subsequently required, as a first approximation risk assessment methodology for the open field could be applied, taking into account the boundary conditions of the covered cropping system.

In the open structures the soil has not been changed or replaced in such way that open field scenarios cannot be considered representative. If soil has been amended with organic materials to enlarge soil organic matter content, this will lower the pore water concentrations. Also for this situation the open field approach can be applied as it can be considered protective for open structures.

For the soil compartment in permanent structures the relevance of a risk assessment for soil may be doubted, as in permanent systems the soils can hardly be considered similar to field soils. If an assessment for an outdoor application of a substance results in an acceptable risk there is no reason to assume any difference for the use in protected crops (EFSA 2010, PROTEA). If the intended use is for permanent structures only, the changes to the soil parameters and the soil organism community can be considered such that a risk assessment for soil organisms is not relevant. However for persistent substances (DegT90>1 year from Uniform principles (Regulation (EU no 546/2011)) an assessment as it was open field is required with regard to their residues, to account for possible change of destination of the soil within structure (eg if the soil is removed and used outside and/or the structure is removed),

3.3. Receptor groundwater

For all protection structures mentioned in table 2 except walk-in tunnels and greenhouses it is proposed to use current open field approaches for exposure of groundwater. Leaching to groundwater of active substances depends amongst others on soil properties. Soil properties are considered to be not different for protection structures. For some other properties influencing risk and amount of leaching though soil a more detailed description for comparison is described below.

The following assumptions are made for all open structures except greenhouses and walk-in tunnels:

- net precipitation is assumed not to be changed / hardly influenced
- precipitation pattern is not changed
- wash-off from crop is not changed (at least not becoming larger)
- temperature is on the average not lower than open field (where average temperature would be higher the open field can be considered conservative)
- drip irrigation is not covered, as is for open field (EFSA, 2012)
- soil has not been changed (at least %OM is not lower)

Considering the receptor groundwater, the major factors, besides substance properties, influencing the risk for leaching can be considered the amount of active ingredient reaching the soil (determined by interception mainly) and the climatic conditions. Looking at the protection structures (table 2) it can be concluded that the amount of active ingredient reaching the soil will be comparable to open field for high and low net shelters and shade houses. This conclusion is based on the fact that the application technique used for the application of the PPP is the same in greenhouses then in open field.

In low plastic shelters and low net shelters application to the crop by spraying during coverage is not considered relevant. Application to soil or seed has zero interception, the same as for field applications to soil or seed. After the cover is removed the situation becomes identical to open field. If the cover is put back in place after application, it is assumed that the open field assessment is conservative. For these structures the changes in driving forces on leaching to ground water are assumed to have no significant effect on leaching, as compared to the open field under otherwise comparable conditions. If the covering on the structure is permeable or semi-permeable to rain, this will supplement any irrigation and thus the emission towards groundwater is certainly no less than the emission under open-field conditions.

For low plastic tunnels and low net tunnels spray application of PPP during covering can be by a pulled spray boom system that is within the structure. In the current approach it is assumed that this system is comparable to field spray booms and the interception is the same.

In high net tunnels and high plastic tunnels spray application of PPP to the crop can be comparable to spray application in open field. The interception values from the crop will also be comparable to open field.

Leaching to groundwater in crops grown under cover will be influenced by the amount of water (rainfall and/or irrigation) reaching the soil after application of PPPs.

Water supply to covered crops (low plastic tunnels, low plastic shelters, net shelters and shade houses (high net shelters) is usually not different from water supply to crops in the open field, i.e. via precipitation (EFSA 2012). So for these constructions, no effect of water supply on leaching is expected. If there is coverage after application, in some cases water may infiltrate at locations where PPPs were not applied. Open field approach is therefore considered conservative.

Especially for high and low net shelters, and net tunnels, the amount of rainfall reaching the soil can be considered to be not different from open field for the purposes of this guidance. Irrigation may be restricted to within the structure but will follow the same procedures as irrigation in open field.

For low plastic shelters and –tunnels the amount of rain reaching the soil could be lower. Furthermore irrigation in low plastic shelters is not considered relevant as long as the cover is present. Irrigation, in low plastic tunnels could be by drip irrigation. In that case soil leaching may be subject to so called “fingering”. Such uneven water supply, via drip irrigation or furrow irrigation, cannot be handled with models currently used in risk assessment. However, such watering systems are used not only in covered crops, but in open field as well. Leaching may be affected in both a positive (less leaching) and negative (more leaching) sense, depending on the way the PPP is applied. Comparing evenly distributed water supply and drip irrigation, leaching may be higher up to an order of magnitude (Leistra 1985). Currently no models (generally accepted for risk assessment purposes) are available covering for this phenomenon. As it may be expected that at a depth of 1 m (groundwater level in leaching models) the fingering process has smoothed, potential leaching can be described using open field approach.

For walk-in tunnels and greenhouses, example scenarios are provided (see section 4.2). It is unknown whether these scenarios represent realistic worst case conditions. Notifiers may use these scenarios or construct their own scenario until representative scenarios have been developed and accepted. In both cases, the use of the scenario has to be justified with respect to the vulnerability to leaching.

3.4. Receptor air

For all protection structures mentioned in table 2 it is proposed to use the current approaches according to FOCUS Air (SANCO/10553/2006 Rev 2 June 2008).

Using the experimental data and taking into account the potential uncertainties of volatilisation and vapour pressure (VP) measurements, the following conservative values are proposed by the FOCUS Air group to establish whether a substance has the potential to reach the air:

VP ≥ 10-4 Pa (20°C) for volatilisation from soil and

VP ≥ 10-5 Pa (20°C) for volatilisation from plants

The FOCUS Air group also proposes that a long-range transport trigger of a DT50air in air of > 2 days be used to identify substances that require further evaluation for long-range transport. It is assumed that this trigger refers to transformation only.

For plastic shelters, net shelters and shade houses the emissions to air of active ingredients from volatilisation and drift can be assumed to be comparable to open field based on the high ventilation rate. For low plastic tunnels and low shelters the crop protection products will not often be applied when the cover is in place, hence the approach for open field can be used. If the cover is removed during application and replaced immediately after, the open field approach can be considered conservative for the covered crop application.

For closed buildings, data on emissions to air is scarce. No general recommendation on emissions from warehouses is given in FOCUS Air as there is only one study on potential air contamination by contact insecticides during and after warehouse fogging.

Emissions to air from greenhouse and walk-in tunnel covered crop systems do occur; even from relatively closed systems such as greenhouses (EFSA, 2012). The driving force is the necessary ventilation of the system and factors influencing the volatilisation, e.g. the factors influencing the Henry coefficient of the substance. Calculated emissions from greenhouses, both high-tech greenhouses in the central zone and multi-span greenhouses in the southern zone, indicate that the levels might be as high as or higher than for the open field. However, no currently used models are available to cover these emissions and until developed, open field approach should be used.

3.5. Receptor surface water

For all structures except walk-in tunnels, closed buildings and greenhouses, the same approach as for open field should be used as the situation is similar to the open field. Small (resulting in lower emissions) to negligible effects are expected on emissions to air and drift for plastic shelters, net shelters and shade houses so current approaches for open field can be considered repersentative or conservative. Nets are known to have an effect on drift deposition on surface water, dependent on the mesh (although the mesh-size will often be such that the effect can be considered negligible). Drift deposition on surface water can also be lower for shade houses, depending on the structure of the side walls of the construction but probably this effect is small. Short-range atmospheric deposition to surface water is assumed to be not different from open field use.

The following assumptions are made for all structures except closed buildings, greenhouses and walk-in tunnels:

- net precipitation is assumed not to be changed / hardly influenced
- precipitation pattern is not changed
- wash-off from crop is not changed (at least not becoming larger)
- temperature is on the average not lower than open field (where average temperature would be higher the open field can be considered conservative)
- drip irrigation is not covered, as is for open field (EFSA, 2012)
- soil has not been changed (at least %OM is not lower)

Additionally, with regard to spray-drift the following assumptions are made for all covered structures except closed buildings, greenhouses and walk-in tunnels:

- the distance to the receptor surface water is not less, i.e. for respectively upward/sideways and downward spraying (which should be known from the application) there are no differences in the distance between the surface water and the last row of the crop
- the wind speed during application is not higher
- the boom height above canopy (downward spraying only) is at least not higher
- the speed of machine during application is not worse with regard to drift
- if applicable, the same drift reducing technology and /or distance to the non-target object (eg surface water) as for the open field is assumed.

For closed buildings, volatile substances might be transported to adjacent surface water bodies. Outdoor exposure after warehouse use depends on parameters that have not been quantified, FOCUS Air (2008) gives no general recommendation on emissions from closed buildings and the previous Opinion of EFSA (2010) did not consider this situation. Currently insufficient information is available to address this issue properly. For practical purposes emissions to surface water are not assessed.

For walk-in tunnels it is proposed that the drainage scenarios in FOCUS surface water step 3 are used. In the tunnels, emissions to surface water are expected from drift and drainage. Run-off is not considered a major route as the structure will present overland flow. The three major characteristics of importance to discharge to surface water via run-off are temperature, slope and rainfall. As walk-in tunnels have higher temperature (which is best case) and are protected from rainfall, the main routes are expected to be drift and drainage. Drift in walk-in tunnels may be almost absent if the cover is continuous but may be comparable to drift emission from open field when holes are present, or the side walls are rolled-up (Beulke, 2011). See further chapter 4.2.

For greenhouses, the relevant emission routes to surface water are drainage, condensation (and the following deposition onto surface water) and discharge of (recirculation) water. Emissions to air from greenhouses shortly after application can be reduced if ventilation is limited for some time. Drift emission from greenhouses is negligible when openings are closed during application. In soil-less cultivation the main driving factor with regard to emissions to surface water is the necessity to discharge deteriorated nutrient solution, for soil-bound crops it is the amount of supplied water. See further chapter 4.2.

4. Existing and proposed procedures and models

4.1. Existing procedures and models

In the current risk assessment for active substances in the EU process it has been common practice in the past to assume that the emissions to the environment from closed structures like greenhouses and walk-in tunnels can be considered negligible. In the last years it has become more and more common to assume a deposition value of 0.1 % of the dose rate as drift input to surface water. (Linders and Jager, 1997). For more open structures the exposure assessment in the peer review process has often been on a case by case basis. In case the technology of the structure was unclear from the proposed table of uses, risk assessment as for open field use was usually considered as a worst case.

4.1.1. Receptor soil

Estimates of PECsoil is made with simple models and calculations according to FOCUS (1997) using a step-wise approach. The guideline details methods for estimating initial and time-weighted average concentrations of pesticide concentrations in soil following single and/or multiple applications, as well as calculations of plateau concentrations.

4.1.2. Receptor groundwater

Estimating concentrations in groundwater is done according to FOCUS (2000, 2009) where nine groundwater scenarios have been defined, which are considered to be realistic worst-case and to collectively represent agriculture in the EU, for the purposes of a Tier 1 EU-level assessment of the leaching potential of active substances and their metabolites. The scenario definitions are lists of properties and characteristics which exist independently of the simulation models. These scenario definitions have also been used to produce sets of model input files. Input files corresponding to all nine scenarios have been developed for use with the simulation models PEARL, PELMO and PRZM, whilst input files for a single scenario as well as some national scenarios have also been developed for the model MACRO. The scenarios as defined do not mimic specific fields, nor should they be viewed as representative of the agriculture in the Member States where they are located. Instead the nine scenarios should be viewed as representing major agricultural areas in the EU. The nine scenarios are Châteaudun, Hamburg, Jokioinen, Kremsmünster, Okehampton, Piacenza, Porto, Sevilla and Thiva.

4.1.3. Receptor air

For estimating concentrations of pesticides in air, FOCUS (2008) is used. This document describes a short-range exposure assessment scheme which uses a vapour pressure trigger to identify substances of potential concern. The trigger is 10^{-5} Pa (at 20 ºC) if a substance is applied to plants and 10^{-4} Pa (at 20 ºC) if the substance is applied to soil. Substances that exceed these triggers, and require drift mitigation in order to pass the terrestrial or aquatic risk assessment, need to have deposition following volatilisation quantified and added to deposition from spray drift. Quantification is firstly done by modelling, if safety cannot be demonstrated by this means then further experimental data are required. The guidance also recommends a trigger of a DT_{50} in air of 2 days to identify substances of potential concern for long-range transport. Substances having a longer DT_{50} are considered to require further evaluation to assess their potential impact on the environment. It is assumed that this trigger refers to transformation only.

Medium-range transport is not included. No general models that are in common regulatory use for assessing the effects of medium and / or long-range transport exist. Also, a specific protection goal for the receptor air is not defined.

4.1.4. Receptor surface water

Predicted concentrations in surface water are calculated according to FOCUS (2001). The procedure consists of four steps, whereby the first step represents a very simple approach using simple kinetics, and assuming a loading equivalent to a maximum annual application. The second step is the estimation of peak and time-weighted concentrations taking into account a sequence of loadings, and the third step focuses on more detailed modelling taking into account realistic "worst case" amounts entering surface water via relevant routes (run-off, spray drift and drainage). The last (4th) step considers substance loadings as foreseen in Step 3, but it also takes into account the range of possible uses and measures to mitigate exposure. The uses are therefore related to the specific and realistic combinations of cropping, soil, weather, field topography and aquatic bodies adjacent to fields.

The models chosen by FOCUS were MACRO for estimating the contribution of drainage, PRZM for the estimation of the contribution of runoff and TOXSWA for the estimation of the final PECs in surface waters. The models include ten scenarios, considered realistic worst-case on the basis of expert judgement. Collectively, these scenarios represent agriculture across Europe, for the purposes of Step 1 to 3 assessments at the EU level. Six of the scenarios characterise inputs from drainage and spray drift ("D-scenarios) whilst four characterise inputs from runoff and spray drift ("R-scenarios"). The field sites chosen to represent each scenario are:

D scenarios:

D1 Lanna

D2 Brimstone

D3 Vredepeel

D4 Skousbo

D5 La Jailliere

D6 Váyia, Thiva

R scenarios:

R1 Weiherbach

R2 Valadares, Porto

R3 Ozzano, Bologna

R4 Roujan

4.2. Proposed procedures and models

Current scenarios for open field applications may be too conservative for walk-in tunnels and greenhouses with respect to risk assessment for soil and especially groundwater and surface water.

4.2.1. Receptor soil

For closed buildings (if relevant) and greenhouses, the (top) soil may have been altered such that open field procedures may not be appropriate. For these situations, it is proposed that PPP soil concentrations are assessed in view of a change of function of the soil at the location. In want of appropriate assessment methodology, the procedure as proposed by Van der Linden et al. (2008) is proposed for persistent PPP.

4.2.2. Receptor groundwater

Current risk assessment procedures for the receptor groundwater may be too eonservative for Walk-in tunnels and greenhouses, while they are not applicable to closed buildings. It is therefore proposed not to assess impacts on groundwater for closed buildings and to assess impact on groundwater for Walk-in tunnels and Greenhouses using specific scenarios (see further chapter 5).

4.2.3. Receptor air

It is proposed to use open field methodology for assessing the impact on air for all applications. This means that, for walk-in tunnels and greenhouses, deposition on surface water and long range transport via air is assessed.

4.2.4. Receptor surface water

Current scenarios for surface water may be too conservative for walk-in tunnels and greenhouses, while other regulation may exist for closed buildings. It is proposed to assess applications in walk-in tunnels and greenhouses according to the procedures proposed in chapter 5 for these covered crop situations.

5. Assessments for Walk-in tunnels and greenhouses

5.1. Receptor air

See previous chapter 4.1.3, not different from open field.

5.2. Receptor soil

See previous chapter, open field for walk-in tunnel, not relevant for GH except for persistent substances (DegT90>1 year, see Uniform principles (Regulation (EU no 546/2011)) in view of potential change of function of the location where the GH is situated, with assessment for example following the methodology as described in Van der Linden et al. (2008). EFSA is working on a Guidance Document on assessments for soil which may have impact on current procedures, for open fields and covered crops as well.

5.3. Receptors groundwater and surface water

FOCUS (2000, 2001, 2009) provides scenarios for groundwater and surface water environmental risk assessment for applications of PPPs to open field crops. Such representative and generally accepted scenarios are not yet available for greenhouses and walk-in tunnels. This section describes what information is required to construct scenarios for these growing systems and associated appendices give typical examples of such scenarios. It should be noted however that their representativeness is not known and therefore should be regarded as examples only.

The example scenarios are:

1. A leaching scenario for a soil bound tomato crop at a location in Italy
2. A drainage scenario relevant for surface water for a soil bound chrysanthemum crop at a location in the Netherlands
3. A soilless cultivation scenario for a rose crop (cut flower) at a location in the Netherlands with discharge to surface water.

The example scenarios are described in detail in the appendices. This section gives a summary description and highlights the main information that is required for constructing scenarios.

Soil-bound crops, leaching and drainage scenarios

The models generally used to calculate leaching and drainage from open field cultivation can equally well be used to calculate leaching and drainage from walk-in tunnels and greenhouses if appropriate scenarios are available. As stated above, representative and generally accepted scenarios for risk assessment are lacking for soil-bound greenhouse crops, so for the time being, scenarios have to be constructed and their parameterisation justified.

A scenario requires specification of crop and soil parameters as well as soil management information and (in-system) climatic conditions. The following text gives a short summary of the required information; further information and examples are given in Appendices A and B. The reader is referred to FOCUS (2000, 2001, 2009) for full descriptions. Relevant emission routes are leaching (for the receptor groundwater) and drainage and occasionally condensation discharge (for the receptor surface water). In addition, drift can be taken into account for walk-in tunnels (see also Beulke et al, 2011) and section 4.2. In general, run-off will not occur due to the construction preventing overland flow of water.

Crop information consists of:

- Crop stage as a function of time, at least dates of emergence (or transplanting date), maximum LAI, senescence (canopy closure) and harvest (crop removal) should be known.
- The rooting depth and crop height, the value of maximum LAI.
- Typical values of the crop water withdrawal function (besides others for example the wilting point, see for details page 201 of Appendix E of FOCUS 2000).

Soil information consists of:

- Soil texture
- Soil bulk density
- Soil organic matter or soil organic carbon
- Soil pH
- Soil hydraulic properties

of all layers (or horizons) of the soil profile.

Soil management information includes the date(s) of soil tillage and the depth(s) to which the soil is tilled.

The weather information should include at least the temperature (°C) inside the greenhouse and the amounts of irrigation (mm water layer) in course of time, on an hourly or daily basis. Information on radiation, humidity, wind speed and potential evapotranspiration should be available dependent on calculation options and/or might be used to derive the necessary information for the calculations using external models.

In principle, all necessary substance parameters are available from the dossier. Sometimes, default values may be used if substance specific information is not available, e.g. the plant uptake factor. The substance information includes molar mass, solubility in water, saturated vapour pressure, sorption constant and transformation constants in soil and water. Also from the dossier is the substance application scheme (including the amount(s) and the time(s) of application or the growth stage(s) of the crop at which the substance is applied). It may be necessary to translate growth stage(s) into calendar information. Relevant EU guidance should be consulted on use in exposure assessment of the above mentioned default values, application scheme information and growth stage/calendar information.

Appendix A gives an example of a leaching scenario concerning a soil-bound tomato crop in a greenhouse in Italy. Appendix B gives a drainage scenario concerning a chrysanthemum crop in a greenhouse in the Netherlands.

soilless crops

The currently available model for calculating emissions from soilless cultivations (GEM) actually is a combination of a model for calculating the water demand of, and water supply to, the crop (the model WATERSTREAMS, Voogt et al. 2012) and a model for calculating fate and behaviour of substances in the system and discharge (emission) from the system to surface water. The discharge can be input to a surface water simulation model in order to calculate exposure concentrations in the surface water. A software package containing GEM and TOXSWA has been established but not released yet.

Figure 8 gives a schematic representation of a soilless crop system and the water and substance flows in the system.

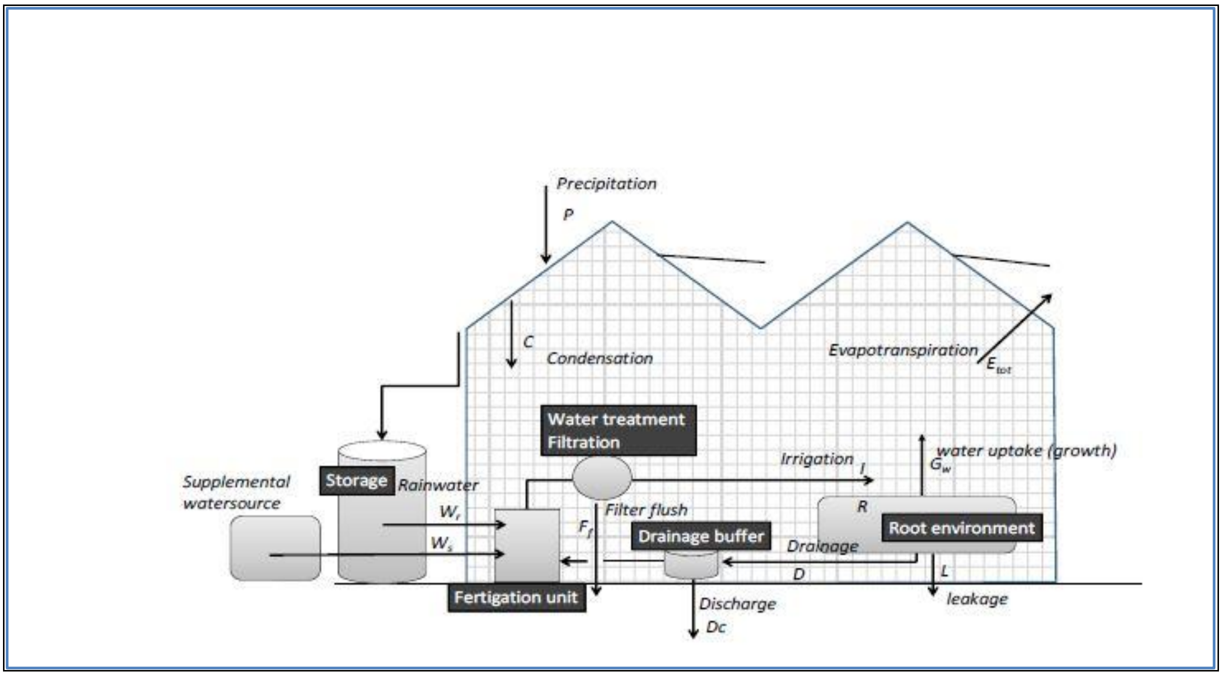

Figure 8: Schematic overview of a soilless growing system. Source: Voogt et al. (2012).

The WATERSTREAMS model calculates the crop water demand based on climatic conditions outside the greenhouse and greenhouse management parameters like greenhouse temperature and humidity. Water is taken from a rainwater storage basin or alternative water source and pumped around in excess of the crop water requirement. In recirculation systems, the excess water is returned to the fertigation unit and mixed with fresh water unless there is a need for discharge. In non-recirculating systems, the excess water is discharged directly. Besides flows of water, the model takes account of nutrients and salts in the system reservoirs. GEM accounts for PPP present in the system and calculates concentrations in various reservoirs and degradation and uptake of PPP. PPP may enter the system via addition to the recirculating water or via application the crop by e.g. spraying, fogging or fumigation. In the latter situation, the PPP may enter the system after partitioning into condensation water, which is collected and added to the recirculating water.

PPPs may leave the system via air exchange, leakage, filter rinsing and discharge. Under recirculating conditions, ions not taken up by the crop may accumulate. The speed of accumulation is dependent on the concentrations of these ions in the water sources and fertilisers and the uptake. If concentration levels exceed tolerance levels, part of the recirculating is discharged and replenished with fresh water. In WATERSTREAMS discharge is governed by the sodium level of the system. Other management decisions may add to the discharge.

For the development of a scenario, WATERSTREAMS needs the following major information (see Voogt et al. 2012 for details).

- Weather conditions of the area (daily or hourly values), see example.
- The size of the rainwater storage basin.
- The sodium concentration in the various water sources, for example rain water near the coast 0.5 mmol/l, reverse osmosis water 0.1 mmol/l, tap water 1.8 mmol/l. It is assumed that rainwater is preferentially used and that other sources are used only when the rainwater basin is empty.
- The sodium concentration in the fertilisers.

- Crop and its growth parameters, including the maximum sodium concentration tolerated by the crop.
- Indoor climatic set points like minimum temperature.
- The drainage fractions, i.e. the amount of water in excess of the crop requirement.
- Management information on the filter system and how that is handled.
- Any other information on crop management, for example periods of operating without recirculation.

In order to calculate fate and behaviour of a PPP in the system, the following information needs to be available from the dossier or otherwise, for parent and metabolites:

- Physic-chemical parameters like molar mass, water solubility, saturated vapour pressure and the octanol water partition coefficient. The latter is necessary to calculate the plant uptake of the substance (Briggs's method).
- The sorption constant Koc or Kom, in case of dissociating (weak acidic) substances also pK_a and the sorption constants for the acid as well as the conjugated base. This information is necessary only in case the substance is applied to pot plants.
- The degradation constant in water or nutrient solution. In addition, degradation constants applicable to the water treatment unit can be used by the model. When available, substance specific values of the Arrhenius activation energy (or Q10 value) can be taken into account.

For pot plant systems, the relative area of the pots has to be provided in case of a spraying (or equivalent) application.

Finally, of course, the application scheme, the application amounts and the application method has to be known. Together with the growth system, the application method defines which model options apply. Application to the nutrient solution and spraying require different options, because different routes of substance flows are taken into account. A third option is available for a spray application to pot plants in ebb/flow systems.

The TOXSWA model may be used to calculate exposure concentrations in surface water. A special version is needed because discharge from a greenhouse has to be regarded a point source rather than a diffuse source. Required information to run the TOXSWA model is the same as the information required for running the open field applications with the TOXSWA model (see FOCUS 2001).

Appendix C gives typical input and set-points for a rose crop in a glasshouse. Total volumes (average yearly values of water supply, discharge, etc are given as well.

CONCLUSION AND RECOMMENDATIONS

EFSA was asked by the Commission to prepare a Guidance of EFSA on clustering and ranking of emissions of PPPs and transformation products of these active substances from protected crops (greenhouses and crops grown under cover) to relevant environmental compartments. This EFSA Guidance Document provides guidance for users on how to assess these emissions when performing risk assessments according to Regulation EC no 1107/2009 of the European Parliament and the Council. In this Guidance Document risk assessment methodology is assigned to all covered crop structures except greenhouse and walk in tunnels for which only examples are given.

It is recommended to develop representative exposure scenarios for greenhouses and walk-in tunnels with regard to groundwater and surface water. It is also recommended to develop further guidance to estimate environmental exposure from protected crops to microbial PPPs. The same is valid for other environmental exposure assessment tools (aquatic and terrestrial), i.e. for open field applications.

REFERENCES

EFSA Panel on Plant Protection Products and their Residues (PPR), 2010. Scientific Opinion on emissions of plant protection products from greenhouses and crops grown under cover: outline for a new guidance. EFSA Journal 2010; 8(4):1567. [44 pp]. doi:10.2903/j.efsa.2010.1567. Available online: www.efsa.europa.eu

EFSA Panel on Plant Protection Products and their Residues (PPR), 2012. Scientific Opinion on clustering and ranking of emissions of plant protection products from protected crops (greenhouses and crops grown under cover) to relevant environmental. EFSA Journal 2012; 10(3):2611. [87 pp]. doi:10.2903/j.efsa.2012.2611. Available online: www.efsa.europa.eu

FOCUS, 1997. Soil Persistence Models and EU Registration, European Commission Document No. 7617/VI/96. URL: http://europa.eu.int/comm/food/plant/protection/evaluation/focus_en.htm

FOCUS 2000. Appendix E. Parameterisation of PEARL. Available at: http://viso.ei.jrc.it/focus/gw/index.html

FOCUS, 2000 “FOCUS groundwater scenarios in the EU review of active substances” – The report of the work of the Groundwater Scenarios Workgroup of FOCUS (Forum for the Co-ordination of pesticide fate models and their Use), Version1 of November 2000. EC Document Reference Sanco/321/2000 rev.2, 202 pp.

FOCUS, 2001. FOCUS Surface Water Scenarios in the EU Evaluation Process under 91/414/EEC Report of the FOCUS Working Group on Surface Water Scenarios, EC Document Reference SANCO/4802/2001-rev.2, 245 pp.

FOCUS, 2002. Generic guidance for FOCUS groundwater scenarios, Version 1.1, April 2002, 61 pp.

FOCUS, 2003. FOCUS Surface Water Scenarios in the EU Evaluation Process under 91/414/EEC Report prepared by the FOCUS Working Group on Surface Water Scenarios, EC Document Reference SANCO/4802/2001-rev.2 final (May 2003), 245 pp.

FOCUS, 2008. Pesticides in air: considerations for exposure assessment. Report prepared by the FOCUS Working Group on Pesticides in Air (FOCUS Air Group), EC Document Reference SANCO/10553/2006 Rev.2 June 2008 328 pp.

FOCUS, 2009. Assessing Potential for Movement of Active Substances and their Metabolites to Ground Water in the EU. Report of the FOCUS Ground Water Work Group, EC Document Reference Sanco/13144/2010 version 1, 604 pp.

Boesten JJTI, Van der Linden AMA, Beltman WHJ, Pol JW. 2012. Leaching of plant protection products and their transformation products. Proposals for improving the assessment of leaching to groundwater in the Netherlands. Alterra report 2264. ISSN 1566-7196.

EU, 2009. Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC. Official Journal of the European Union L 309/1.

EU, 2011. Commission Regulation (EU) No 546/2011 of 10 June 2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards uniform principles for evaluation and authorisation of plant protection products. Official Journal of the European Union L 155/127-175.

Pardossi A, Tognoni F and Incrocci L, 2004. Mediterranean Greenhouse Technology. Chronica Hortic. 44 (2), 28-34.

Linden AMA van der, Boesten JJTI, Brock TCM, Eekelen GMA van, Horst MMS ter, Jong FMW de, Montforts MHMM, Pol JW. 2008. Revised proposal for the risk assessment of persistence of plant protection products in soil. Bilthoven, RIVM, report 601712003.

Linders JBHJ, Jager DT (eds.), 1997. USES 2.0, The Uniform System for the Evaluation of Substances, version 2.0; supplement to EUSES. RIVM Rapport 679102037 (216 pages).

Voogt W, Swinkels G-J, Van Os E. 2012. 'WATERSTREAMS': a model for estimation of crop water demand, water supply, salt accumulation and discharge for soilless crops. Proc. IVth IS on HortiModel 2012. Eds.: Weihong Luo et al., Acta Hort. 957, ISHS 2012.

GLOSSARY AND ABBREVIATIONS

2D	two dimensional
cdf	cumulative (probability) density function
drift	small droplets that settle readily on surfaces (e.g. soil and surface water)
EC	European Community
EEC	European Economic Community
EFSA	European Food Safety Authority
emission	technical term signifying the transfer of a substance over a boundary
ERA	Environmental Risk Assessment
EU	European Union
FOCUS	FOrum for the Co-ordination of pesticide fate models and their USe
GIS	Geographical Information System
GPFM	Greenhouse Pesticide Fate Mode
GW	groundwater
MACRO	leaching model, specifically developed for addressing macroporous water flow in soils
metabolite	See transformation product
MS	member state of the European community
OC	Organic carbon
OM	Organic matter
PEARL	Pesticide Emission At Regional and Local Scale. Model for calculating fate and behaviour of substances in soil
PEC	Predicted Environmental Concentration
PECair	PEC in air
PECsoil	PEC in soil
PECsw	PEC in surface water
PELMO	PEsticide Leaching MOdel. Model for calculating fate and behaviour of substances in the soil
PPP	plant protection product
PPR	Panel on Plant Protection Products and their Residues
protection	The word „protection‟ is often used to refer to physical barriers (i.e. plastic, glass or netting) or to refer to chemical / biological products that are applied to the crop (e.g. pesticides or plant growth regulators). Since this term could be ambiguous, we have chosen to use the term „PPPs‟ to refer to products (Plant Protection Products). When the word „protection‟ or „protected‟ appears, it refers to the physical barriers.
PRZM	Pesticide Root Zone Model. Model for calculating fate and behaviour of substances in the unsaturated zone of the soil
receptor	For the purpose of this opinion, a receptor is an environmental compartment receiving emissions, such as surface water, air, soil and groundwater.
SE	South East
solids	For the purpose of this opinion, solids are defined as solid materials such as plastic covers, plant residues, soil and substrate that can be removed from the protected structure.
substrate	any material, not in connection with subsoil, used for growing plants on
SWAP	Soil Water Atmosphere Plant model. Model for calculating water and heath transport in soil.
TOXSWA	TOXic substances in Surface WAters. Model for calculating fate and behaviour of substances in water courses
Transforma-tion product	For the purpose of this Guidance Document a transformation product means any metabolite or a degradation product of an active substance, safener or synergist formed either in organisms or in the environment in agreement with Regulation

	(EC) 1107/2009
WG	Working Group

APPENDICES

APPENDIX A: EXAMPLE LEACHING SCENARIO CONCERNING A SOIL-BOUND TOMATO CROP IN ITALY

The scenario in this Appendix gives an example scenario for leaching to groundwater. The representativeness of the scenario has not been established. It is unknown how data rank in the cumulative distributions of soil and climatic data, not in Italy nor in the rest of Europe. In order to establish a representative scenario, a proper selection has to be performed (EFSA 2012).

The following sections describe necessary parameters to construct the scenario.

The crop for this scenario is tomatoes. Although sometimes two tomato crops may be grown in one year in greenhouses, parameterisation in the example scenario is for a single crop. Tables A 1 and A 2 give the crop parameters. Table A 3 and A 4 give the soil parameters. For this scenario, soil parameters have been taken from the FOCUS Piacenza leaching scenario (FOCUS 2009). Table A 5 gives a summary overview of climatic conditions in the greenhouse, while Table A 6 gives the first few records of the detailed climate file. (Detailed files for the various models will be made available when the guidance is finalised and made publicly available).

From figures A 1 - 4 it is clear that the daily average temperature inside the greenhouse is mostly slightly higher than the outside temperature during the summer period, but considerably higher in spring and autumn. These later differences are due to the heating on the systems in those periods of the year. In contrast, the daily global radiation is almost always slightly to substantially lower than outside.

Table A 1: Crop parameters of the Italian greenhouse scenario

crop	growth stage#				max LAI		root depth$
		planting	scenescense	harvest	($m^2\ m^{-2}$)$	(dd/mm)#	(m)
		(dd/mm)	(dd/mm)	(dd/mm)			
tomatoes		18/03	22/07	22/08	6.0	20/06	1.0

@ day of transplanting from seedbed
# Data provided by A Pardossi, University of PISA
$ Data from FOCUS (2009)

Table A 2: Crop Kc-factors of the Italian greenhouse scenario

crop	Kc factor as a function of cropping periods (expressed in dd/mm-dd/mm)							
	harvest to emergence#		emergence to maximum LAI		maximum LAI to senescence		senescence to harvest	
	period	Kc$	period	Kc$	period	Kc$	period	Kc$
tomatoes	25/12-17/03	1.00	18/03-19/06	1.05	20/06-21/07	1.10	22/07-22/08	0.85

transplantation from seedbed
$ After FOCUS (2009)

Table A 3: Soil parameter of the Italian greenhouse scenario (after FOCUS 2009)

horizon	depth	classification	pH	pH	texture			om	oc	dry bulk density	depth factor
	(cm)		(H_2O)[@]	(KCl)[#]	(%)			(%)	(%)	(g cm^{-3})	(-)
					<2 µm	2-50 µm	>50 µm				
Ap	0-30	loam	7.0	6.4	15	45	40	2.17	1.26	1.3	1.0
Ap	30-40	loam	7.0	6.4	15	45	40	2.17	1.26	1.3	0.5
Bw	40-60	silt loam	6.3	5.6	7	53	40	0.80	0.47	1.35	0.5
Bw	60-80	silt loam	6.3	5.6	7	53	40	0.80	0.47	1.35	0.3
2C	80-100	sand	6.4	5.7	0	0	100	0	0	1.45	0.3
2C	100-170	sand	6.4	5.7	0	0	100	0	0	1.45	0.0

[@] Measured at a soil solution ratio of 1:2.5
[#] These values are estimated for the measured water values according to Boesten et al. (2012)
The depth factor indicates the relative transformation rate in the soil layer.
The depth of the groundwater is 1.5 m (range 1.3–0.7 m)

Table A 4: Soil hydraulic properties of the Italian greenhouse leaching scenario (after FOCUS 2009)

Depth	θs	θr	α	n	m	water content		Ksat	λ	AW[@]
						10 kPa	1600 kPa			
(cm)	(m^3 m^{-3})	(m^3 m^{-3})	(m^{-1})	(-)	(-)	(m^3 m^{-3})	(m^3 m^{-3})	m s^{-1} *10^{-6}	(-)	(mm)
0-30	0.4622	0.0100	3.13	1.238	0.1993	0.341	0.113	4.269	-2.037	68.4
30-40	0.4622	0.0100	3.13	1.238	0.1993	0.341	0.113	4.269	-2.037	22.8
40-60	0.4543	0.0100	2.31	1.3531	0.261	0.317	0.065	6.138	0.109	50.4
60-80	0.4543	0.0100	2.31	1.3531	0.261	0.317	0.065	6.138	0.109	50.4
80-100	0.31	0.0150	2.812	1.6060	0.3773	0.163	0.022	28.330	0.500	28.2
100-170	0.31	0.0150	2.812	1.6060	0.3773	0.163	0.022	28.330	0.500	

@ Plant available water in the soil layer
Plant available water in top meter is 220.2 mm.

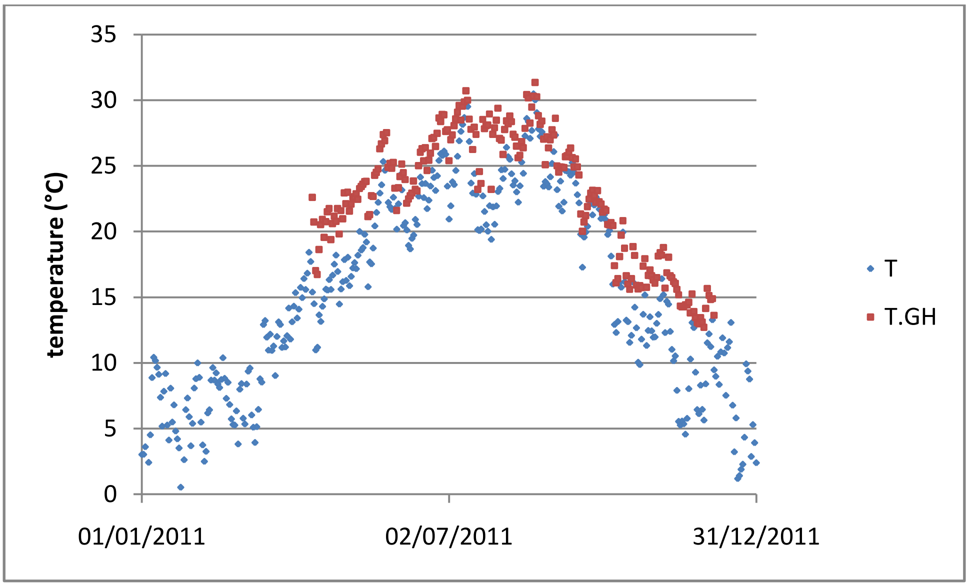

Figure A 1: Average daily temperature at Pistoia (Italy). T temperature outside greenhouse, T.GH temperature inside greenhouse

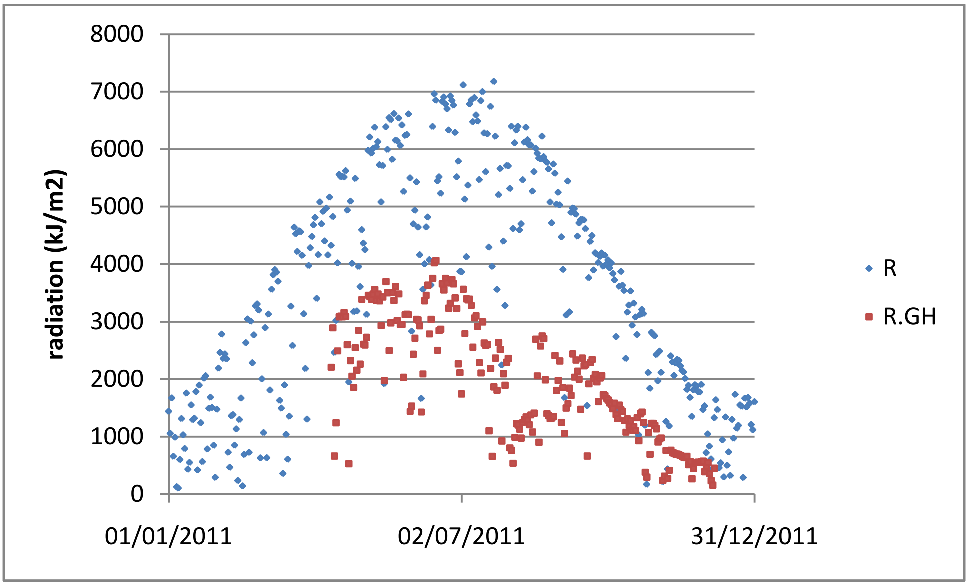

Figure A 2: Daily global radiation at Pistoia (Italy). R radiation outside greenhouse, R.GH radiation inside greenhouse

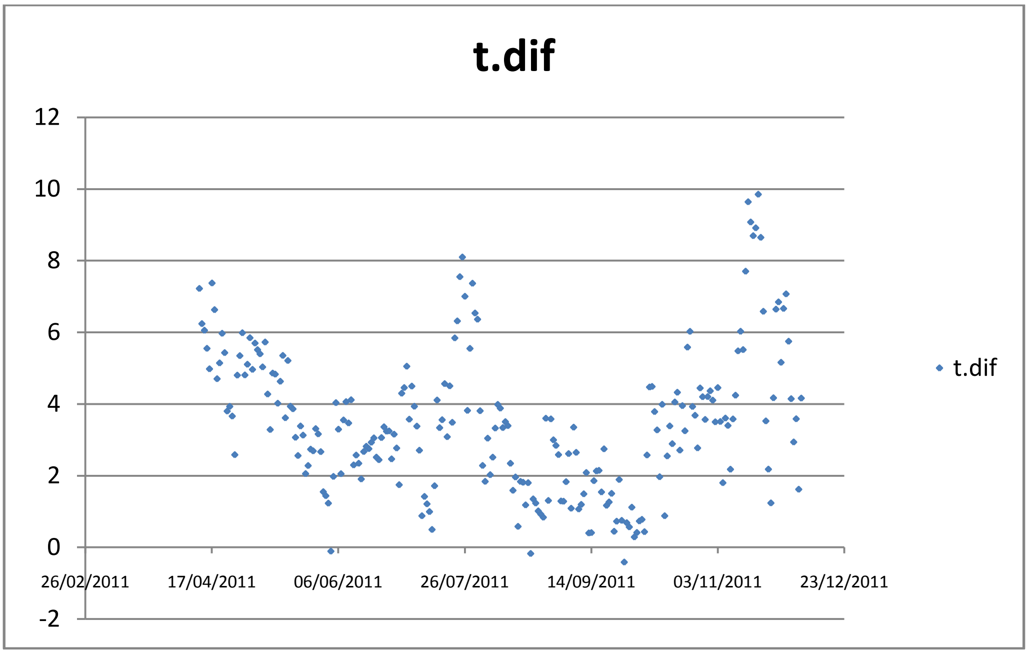

Figure A 3: Difference in temperature (temperature in greenhouse – temperature outside)

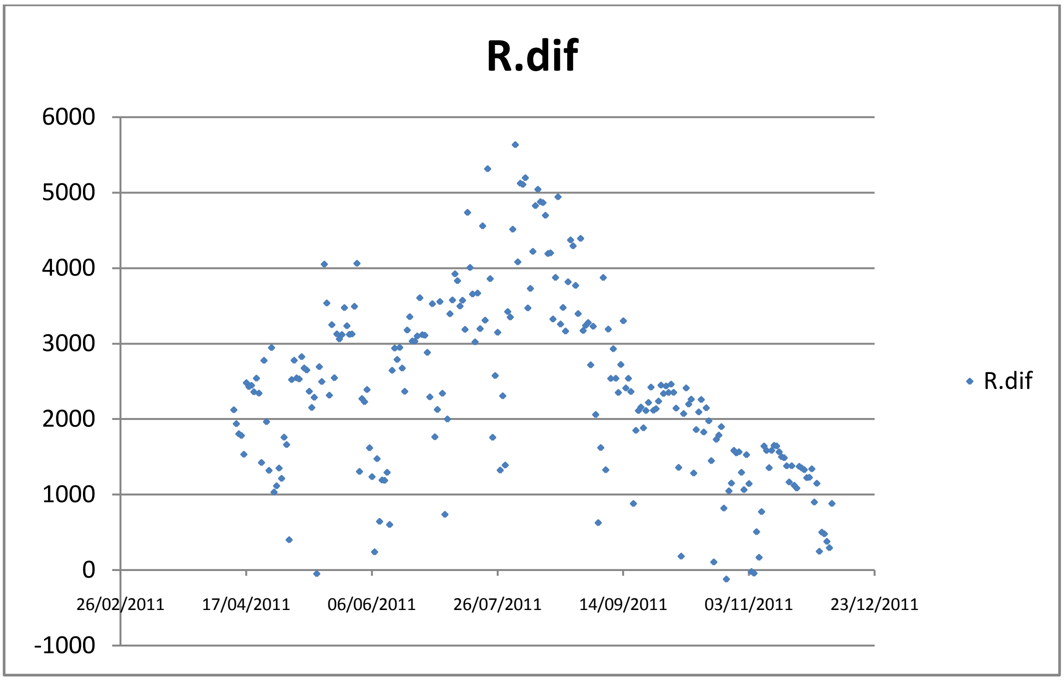

Figure A 4: Difference in radiation (radiation outside – radiation in greenhouse)

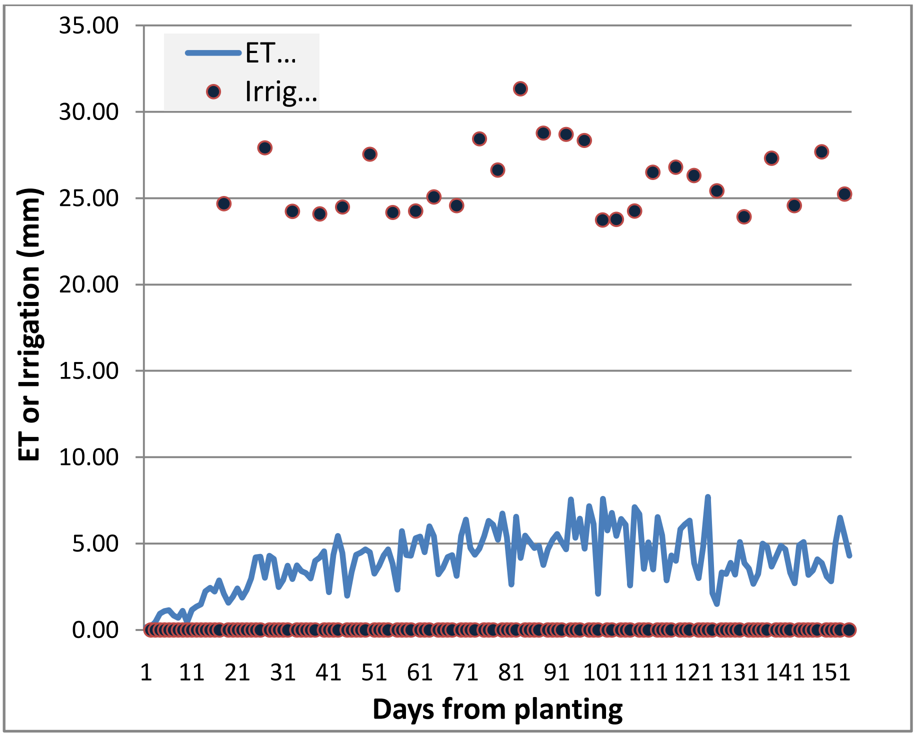

Figure A 5: Daily evapotranspiration and water irrigation in the Italian tomato scenario. Irrigation takes place after the total water deficit has exceeded the value of 20 mm (management decision)

Table A 5: Monthly average weather data of the Italian tomato greenhouse scenario

month	Avg radition (MJ/m2)	Avg temperature (°C)	Avg ET (mm)	Irrig sum (mm)	drainage sum (mm)
4	7.8	18.8	1.46	25	3.8
5	10.4	20.8	3.70	128	19.6
6	9.6	23.7	4.82	184	28.1
7	7.8	27.9	5.4	184	28.1
8	7.6	24.9	4.13	154	23.5
9	7.8	24.6	4.18	53	8.1

Table A 6 gives the first few lines of the necessary meteofile (example of PEARL meteofile) to run the calculations.

Table A 6: Partial example of meteofile of Italian GH tomato scenario (in this case on daily basis)

Date	Indoor radiation (MJ/m2)	Indoor air temperature (°C)	Crop evapotranspiration (ET; mm)	Daily soil water deficit (WD; mm)	Cumulated WD (mm)	Irrigation (I; mm)	Drainage (D; mm)
29-03-06	8.55	18.43	0.17	0.17	0.17		
10-04-06	2.84	17.28	0.20	0.20	0.37		
11-04-06	8.66	16.94	0.47	0.47	0.83		
12-04-06	7.55	16.16	0.95	0.95	1.78		
13-04-06	10.33	17.42	1.10	1.10	2.88		
14-04-06	10.58	18.47	1.15	1.15	4.03		
15-04-06	7.22	18.34	0.83	0.83	4.86		
16-04-06	4.74	18.25	0.70	0.70	5.56		
17-04-06	9.33	18.95	1.11	1.11	6.67		
18-04-06	3.72	18.03	0.45	0.45	7.12		
19-04-06	10.36	19.90	1.17	1.17	8.30		
20-04-06	8.58	19.12	1.36	1.36	9.65		
21-04-06	6.38	18.65	1.49	1.49	11.14		
22-04-06	10.93	20.02	2.24	2.24	13.38		
23-04-06	10.86	20.03	2.45	2.45	15.83		
24-04-06	10.26	20.26	2.22	2.22	18.05		

25-04-06	9.39	20.87	2.87	2.87	20.92		
26-04-06	6.20	19.84	2.10	2.10	2.10	**24.69**	**3.77**

Station	**DD**	**MM**	**YYYY**	**RAD**	**Tmin**	**Tmax**	**HUM**[#]	**WIND**[#]	**RAIN**	**ETref**
ex_I	12	4	1901	2207	22.60	22.60	-99.00	-99		
ex_I	13	4	1901	2891	20.73	20.73	-99.00	-99		
ex_I	14	4	1901	661	17.02	17.02	-99.00	-99		
ex_I	15	4	1901	1241	16.73	16.73	-99.00	-99		
ex_I	16	4	1901	2490	18.62	18.62	-99.00	-99		
ex_I	17	4	1901	3081	20.51	20.51	-99.00	-99		
ex_I	18	4	1901	3093	20.92	20.92	-99.00	-99		
ex_I	19	4	1901	3080	19.56	19.56	-99.00	-99		
ex_I	20	4	1901	3157	20.74	20.74	-99.00	-99		
ex_I	21	4	1901	3086	21.50	21.50	-99.00	-99		
ex_I	22	4	1901	2599	21.75	21.75	-99.00	-99		

[#] Humidity and wind speed are not available in this file; these parameters are necessary dependent on options of the SWAP model

Appendix B: Example drainage scenario concerning a soil-bound chrysanthemum crop in a high tech greenhouse in the Netherlands

The crop for this scenario is chrysanthemum, up till now almost always a soil bound cultivation. In a greenhouse, chrysanthemum is grown more or less continuously, i.e. beds of chrysanthemum of different age are lying next to each other. On the same spot, approximately five crops can be grown in one year. In such a greenhouse, crop protection (application of fungicides and/or insecticides) will be on plants of different age as, in general, a full compartment of a greenhouse has to be treated. This is reflected in assuming average plant characteristics all year round. Table B 1 and B 2 give the crop parameters.

Table B 1: Crop parameters of the Dutch chrysanthemum greenhouse scenario

crop	growth stage				max LAI		root depth
	planting	emergence	scenescense	harvest	(m^2 m^{-2})	(dd/mm)	(m)
	(dd/mm)	(dd/mm)	(dd/mm)	(dd/mm)			
chrysanthemum	not relevant in chosen parameterisation, averaged over year				12.0		0.3

Table B 2: Crop Kc-factors of the Dutch chrysanthemum greenhouse scenario

crop	Kc factor as a function of cropping periods (expressed in dd/mm-dd/mm)			
	harvest to emergence	emergence to maximum LAI	maximum LAI to senescence	senescence to harvest
	periodKc	period Kc	period Kc	period Kc
chrysanthemum	1.00	1.00	1.00	1.00

Table B 3 and B 4 give the soil parameters. From the given parameters, it is clear that the top 25 cm of the soil profile differs substantially from the deeper layers. The deeper layers represent the original soil at the site, while the top layer is changed / replaced such that it is optimal for the growth and the handling of the crop. Soil management practices are such that these conditions are maintained.

Table B 3: Soil parameter of the Dutch chrysanthemum greenhouse scenario

horizon	depth	classification	pH	pH	texture			om	oc	dry bulk density	depth factor
	(cm)		(H_2O)[@]	(KCl)[#]	(%)			(%)	(%)	(g cm^{-3})	(-)
					<2 µm	2-50 µm	>50 µm				
Ap	0-25	sandy clay loam	-99	-99	22.5	0	77.5	13.7	7.95	0.893	1.0

B	25-30	clay	-99	-99	63.5	0	36.5	1.5	0.87	1.462	0.5
B	30-60	clay	-99	-99	63.5	0	36.5	1.5	0.87	1.462	0.5
B	60-100	clay	-99	-99	63.5	0	36.5	1.5	0.87	1.462	0.3
C	100-200	clay	-99	-99	63.5	0	36.5	1.5	0.87	1.462	0.0

The depth of the groundwater is 0.8 m (artificial drains)

Table B 4: Soil hydraulic properties of the Dutch chrysanthemum greenhouse scenario

Depth	θs	θr	α	n	m	water content		Ksat	λ
						10 kPa	1600 kPa		
(cm)	(m^3 m^{-3})	(m^3 m^{-3})	(m^{-1})	(-)	(-)	(m^3 m^{-3})	(m^3 m^{-3})	m s^{-1} $*10^{-6}$	(-)
0-25	0.53	0.0100	0.0242	1.280	0.219	0.427	0.2	9.407	-1.476
25-30	0.57	0.0	0.0194	1.089	0.0817	0.53	0.386	4.269	-5.955
30-60	0.57	0.0	0.0194	1.089	0.0817	0.53	0.386	4.269	-5.955
60-100	0.57	0.0	0.0194	1.089	0.0817	0.53	0.386	4.269	-5.955
100-200	0.57	0.0	0.0194	1.089	0.0817	0.53	0.386	4.269	-5.955

Table B 5 gives an overview of climatic conditions in the greenhouse. Daily temperature data of this scenario are shown in Figure B 1. From the figure it is clear that temperature is controlled by heating during winter time. Table x6 Crop parameters of the Dutch chrysanthemum greenhouse scenario.

Table B 5: Monthly average weather data of the Dutch chrysanthemum greenhouse scenario (period 1980 – 2000)

Month	Temperature	Rain	evap.trans	radiation	wind speed	humidity
	°C	mm/d	mm/d	kJ/m2	m/s	kPa
Jan	18.8	1.6	1.1	8200.5	0.7	2.1
Feb	18.9	1.9	1.4	8336.6	0.8	1.4
Mar	20.1	2.6	1.9	12234.8	1.2	1.4
Apr	20.5	3.5	2.5	14059.1	1.6	1.4
May	25.0	4.2	2.8	20001.9	2.3	1.3
Jun	25.7	4.3	2.8	19815.4	2.8	1.6
Jul	30.2	3.7	2.7	23452.0	3.1	1.6
Aug	26.6	3.8	2.5	18743.0	3.2	1.5
Sep	22.4	2.8	2.0	17372.0	2.5	1.8
Oct	19.6	1.9	1.5	11430.5	2.0	1.8
Nov	18.8	1.6	1.1	10346.6	1.1	1.6
Dec	18.7	1.5	1.0	8937.1	1.0	1.4
year	22.1	2.8	1.9	14446.0	1.9	1.6

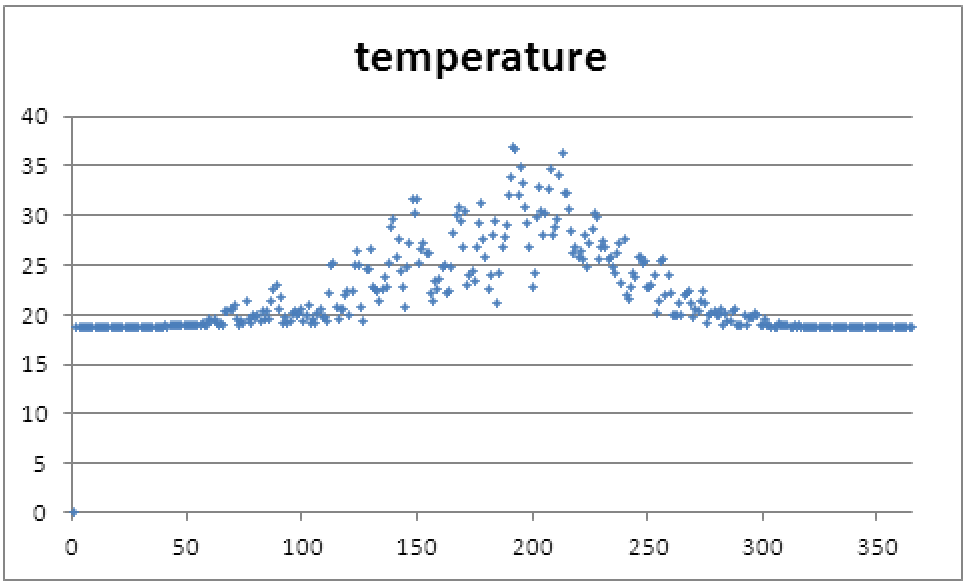

Figure B 1: A typical temperature (°C) sequence during a year for the greenhouse chrysanthemum crop in the Netherlands

APPENDIX C: EXAMPLE OF A SOILLESS ROSE SCENARIO IN A HIGH TECH GREENHOUSE IN THE NETHERLANDS

The crop for this scenario is rose, as a cut flower, grown in a soilless system. The crop is grown for several years, but only the sequence of one year is given. In such a growing system, crop protection (application of fungicides and/or insecticides) can be by treatment of the shoots (spraying, fogging or fumigation) or application to the recirculating nutrient solution (either to treat the roots or to apply systemic substances). The Waterstreams model calculates water fluxes to and from the plants based on management set points, the size of the rainwater collection basin and the secondary (and tertiary) water sources and the salt (sodium) contents of these water sources (see Tables C 1). The drainage fraction indicates the excess water supply to the plants; this water is recirculated unless discharged. Table C 2 gives long term average amounts of water amounts, characteristic of the systems. In this particular case, it is not necessary to discharge because of the abundance of water of good quality (secondary source is reverse osmosis water). In this case filter rinsing water is the only potential source of emission of PPP to surface water. Table C 3 gives the initial lines of the output of the Waterstreams model / input of the GEM model to calculate the fate of the PPP in the system and the discharge to surface water. The discharge, both water and substances (PPP and, if applicable, metabolites) can be used as input to the TOXSWA model.

Table C 1: Characteristics and management settings of the soilless growing system and sodium contents of the water sources

Characteristics of system		
crop	rose	
heating	high	min temp 20 °C
light	12000	lux/m2
rainwater basin	1500	m3/ha
drain fraction	0.5	-
water sources		
number	type	[Na] (mmol/l)
1	rainwater	0.1
2	osmosis water	0.1
3	tapwater	1.5

Table C 2: Long term average amounts of water in the soilless rose growing system

waterstream	m3/ha
rain	8671.6
water supply to crop	19188
crop uptake	9978
drainwater	9978
condensation	1626
discharge	0
filter rinsing	217
leakage	299
basin water	7463
osmosis water	1398
tap water	7

Table C 3: Partial file of daily water flows (m^3) in the system. Condensation is reused

date	water supply	crop uptake	condensation	discharge
1-1	29.35	14.67	8.25	0.00
2-1	28.72	14.36	8.08	0.00
3-1	28.40	14.20	7.99	0.00
4-1	27.50	13.75	7.71	0.00
5-1	29.48	14.74	8.26	0.00
6-1	30.16	15.08	8.46	0.00
7-1	30.38	15.19	8.52	0.00
8-1	26.48	13.24	7.42	0.00
9-1	27.62	13.81	7.74	0.00
10-1	27.70	13.85	7.76	0.00