Emissions of plant protection products to surface water from soilless greenhouse cropping systems

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The risk of emission from soilless cropping systems to surface water is not, or only marginally included in the current evaluation for pesticide authorisation in Europe. However, data from Dutch water boards indicate that the emission of plant protection products (PPPs) and biocides from glasshouse horticulture to surface water may be higher than assumed in the authorisation procedure. In 2008 a Dutch working group started unravelling the emission to surface water with the goal of creating an evaluation tool. An evaluation tool consists of an (modelled) approach for determining expected concentrations in surface water and a reference scenario per crop i.e. a description of an actual situation including the technical layout of the glasshouse, the climatological year and the receiving ditch.

Since data on emissions were not available, the working group analysed the issue of emission through the following steps:

1 **Understanding the nature of the emission:** Emission from soilless cultivation systems in a covered surrounding are expected to follow the water and air flows. This supposition justifies the identification of the routes of water and air leaving the system. This working group was interested in the emissions to surface water. Given that re-use of condensation water is compulsory in Dutch glasshouses, leakage will permeate to the surface water at relatively low rates and ventilation was not covered by this working group, the discharge of recirculation water and filter cleaning water constitute the most relevant flows.

2 **Identification and classification of cropping systems and pesticide application methods:** Three types of cropping systems were identified, being a drip irrigation system on substrate (for vegatables and flower crops), an ebb/flow system (for potplant production) and soil bound production. In terms of application method three systems were distinguished: application via the nutrient solution, spray or fogging and spray application on an ebb/flow system. The latter application method leads to fluid liquid partially being sprayed directly in the nutrient solution upon flow.

3 **Identifying the water fluxes in cultivation systems:** A model approach was used to quantify the water flows. One model was developed for quantifying the water flows describing discharge as a function of sodium accumulation in the recirculation water, while filter cleaning water is described as function of the volume of water filtered. A second model described substance fate after application, taking into account crop uptake, degradation, sorption (when relevant) leakage, evaporation and eventually discharge.

4 **Identification of discharge strategies in current practice and developing a reference strategy:** Until 2008 the only legal argument for discharge of recirculation water was the accumulation of sodium. However, in practice growers discharge recirculation water in case of e.g. irregularities in the nutrient composition of the water – so called un-balance, technical flaws in system components, daily flush of the piping system or observed stagnating growth. Since these reasons for discharge were either plant-physiologically unfounded, due to technical failing or otherwise unusable for modelling, the accumulation of sodium was used for further developing of the tool. Stakeholder engagement around this issue led to support for this approach. Since dealing with sodium accumulation in practice may mean a daily discharge of small volumes up to infrequent discharges of large volumes, an intermediate strategy for discharge was used.

5 **Clustering the diversity in crops:** Using Sodium accumulation as the driver for discharge, crops could be clustered by their sodium sensitivity (high / low) and evaporation rate (high / low). Examples of crops would be: roses (high – high), tomato (low – high), Phalaenopsis (high – low), Ficus (low – low).
Using the description of (an older) glasshouse type in The Netherlands the understanding of steps 1-5 was used to test run the models and get a first insight in the order of magnitude of emissions.

Table 1 - Calculated extremes in emissions caused by differences in rainfall, sizes of water basin and [Na+] in the water source for additional water, based on the chosen application scheme for PPPs for one example substance and one application scheme

Fate model	Calculated for model crop	Low end of emissions (% of application)	High end of emission (% of application)
Application via nutrient solution	Cucumber	0.03	11
	Pepper	0.02	10
	Rose	0.11	16
Crop application by spraying	Cucumber	0.01	0.5
Crop application in ebb/flow system	ficus	0.01	0.5

6 **Developing scenarios for the four crop clusters:** Sensitivity analyses of the models Waterstromen and substance fate showed that the emission to surface water was mainly determined by rainfall, evaporation (irradiation), size of rainwater collection basin (supply of sodium-free water), additional water sources (with their sodium content) and sodium concentrations in commercial fertilisers and disinfectants like sodium hypochlorite. Since the data on these aspects were not available experts were asked to describe technical realisations of glasshouses in terms of basin sizes, additional water sources and sodium concentrations in fertilisers in their regional distribution and in distribution over the crop clusters.

7 **Understanding the diversity in size of the receiving surface waters:** Using an overlay of glasshouse areas with the hydrological maps would give an acceptable estimation – analogue to the approach used in developing the open field scenario. However, glasshouses in The Netherlands are frequently connected to the sewage system – and obliged to use it. Since the actual data of the area connected to a sewer were not available, the coverage needed to be estimated by relevant experts. The impact of sewers to the concentration of pesticides in surface water (dilution and break down) has been shown to vary widely for different pesticides.

8 **Ordering the emission-risks to allow for a decision on the level of protection:** Per crop the diversity of glasshouse realisations combined with expected ditches and weather data of the past 20 years allows for a ranking on theoretical concentrations of pesticides in the receiving surface water. Each combination is considered a 'situation' that could be used as a reference. The situation at the desired level of emission (50%, 75% or the more common used 90% percentile highest level of emission) could be taken as reference scenario for the evaluation of pesticides.

Results indicate that emissions to surface water cannot be neglected (step 1). The modelled approach using 'Waterstromen' and a model for substance fate (step 3) and the selected strategy for discharge (step 4) allows evaluators to calculate concentrations and total annual volumes of pesticide emissions from glasshouses. The understanding of the crop clusters (step 5), the water-technical realisations of glasshouses (step 2 and 6) and the receiving ditches (step 7) was needed to develop scenarios that can be used as reference situation (step 8) for evaluating the emission of any given pesticide to surface water in The Netherlands.

KEY WORDS: Pesticides, covered crops, substrate cultivation, volatilisation, risk assessment

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