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Reducing pesticide emission from greenhouses: a joint agenda setting

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Abstract Despite a high degree of IPM in the Netherlands, pesticides used in greenhouse horticulture are exceeding environmental quality standards for surface water. In this paper the joint fact finding en agenda setting by stakeholders are described. An overview is given of the emission routes in hydroponic growing systems and emission reducing measures and remaining questions are discussed.

Key words: IPM, discharge, hydroponic growing systems, reuse, joint fact finding

Introduction

Over the years much research effort has been put into the development of biological control and IPM. In the Netherlands in greenhouses IPM is common practice, be it at a higher level in fruit vegetables than in ornamentals. The main driving forces are retail demands for residue-free vegetables, resistance development to pesticides, and societal and governmental pressure towards sustainable production. In the last decade the Dutch government aimed at making crop protection more sustainable. By 2010 the environmental burden due to pesticides had to be reduced by 95% compared to 1998. This resulted in stimulation of the development of biological control and IPM, by funding research and knowledge transfer projects, like *Farming with Future* (De Buck & Beerling, 2005).

In 2005 an underestimated problem was revealed by Teunissen (2005): the water quality in greenhouse horticulture areas was still below the environmental quality standard for surface water. This was due to pesticides, despite the high degree of IPM and reduction in pesticide use. This led to a shift in focus of *Farming with Future* from IPM toward water quality. In this paper our analysis of the problem and subsequent approach to solve it are described.

Analysis of the problem

In the Netherlands 75% of the greenhouse crops are grown in soilless, or hydroponic, growing systems. In hydroponics, nutrient solutions recirculate with the possibility of a 100% closed water and nutrient cycle. These systems are in theory better equipped to minimize emissions of nutrients and pesticides than soil-grown crops, where leaching of nutrients and pesticides to ground and surface water are difficult to prevent. Nevertheless, the emissions of pesticides from hydroponic systems are significant, as was stated by Teunissen (2005).

Joint fact finding

The first step the project *Farming with Future* took was discussing the problem with the growers' organisation, water boards, agrochemical industry, and supply and advice organisations. In subsequent multi-stakeholder meetings the technique of joint fact finding was applied. The search for common interests in situations like these helps to focus on solutions instead of disagreements. But also the interests of the individual stakeholder should be acknowledged, since these will motivate him or her to come into action. In our case, it is in the interest of the agrochemical industry, supply organisations and growers to prevent pesticides being banned and retain the societal ‘licence to operate’. But it is in the interest of water boards to have a better water quality. Instead of disagreeing about whether pesticides should be banned, the stakeholders are now focussing on their common interest and join forces to lower the levels of pesticides in surface waters to meet the quality standards.

The stakeholders agreed on an agenda with the following actions: 1) Raise the awareness among growers and advisors, to make them receptive for advises to reduce the emissions. At the same time, find out 2) what the emission routes of the pesticides to the surface waters are, and 3) how the emission via these routes can be reduced.

Raising the awareness

For hydroponic cultures reuse is the prevailing standard, but drain water is easily discarded when there is only the slightest doubt about the quality for cultivation. Growers tend to avoid risks, especially since costs and other consequences are still low. Due to a joint effort of stakeholders the awareness of upcoming consequences is now growing.

Water boards initiated studies focusing on greenhouses (*i.e.*, Kruger, 2008; Tolman, 2010) and communicated to growers their water quality figures. The growers’ organisation together with the other stakeholders started to communicate the necessity to reach a ‘practically zero emission greenhouse for water by the year of 2027’, as was agreed upon with the water boards and the national government (*Glami* Agreement 2006-2010, succeeded by *Platform Sustainable Greenhouse Horticulture* and its sustainability agenda 2011-2015). This was a result of the obligation to implement the EU Water Framework Directive2000/60/EC.

In the meantime the government realised that the registration procedure for pesticides was based on wrong assumptions. The current procedure uses a fixed emission percentage of 0.1% of the applied pesticides, which appeared to be a 2 to 50 fold underestimation of the actual emissions (Vermeulen *et al*., 2010). Already in 2013 the Dutch registration procedure will be adapted to these insights. When the emission does not decrease significantly, this is likely to result in the banning of pesticides and less new ones to be registered. The stakeholders communicate also these new insights and consequences.

These new findings appears to be an impulse for growers to accelerate the reduction of pesticide emission via water flows. But it is essential to involve advisers in the development of emission reducing strategies, since many growers are influenced by their adviser who generally is more conservative and risk-avoiding.

Emission routes

In hydroponics the emission of pesticides to surface water is assumed to follow the water flows (see Figure 1) and can therefore be used to determine the significance of the emission routes (Vermeulen *et al.*, 2010). In general, the largest contribution is discharge of recirculation water directly to the surface waters or indirectly via the sewage. The amount discharged however may vary from almost 0 to more than 3000 $m^3.ha^{-1}.year^{-1}$, with large variations between, but also within crops (Van Paassen & Welles, 2010). The pesticides detected in drain and discharged water are not only applied via drip irrigation, but also via spray and space treatments (Kruger, 2008).

Discharge of filter water is only recently recognised as the second significant emission route; daily cleaning of the filters may add up to a yearly discharge of approximately 450 m^3 filter water per ha. Some minor emission routes of pesticides to the environment are leakages in the water system (but this is considered not to reach surface water), and overspill of drain

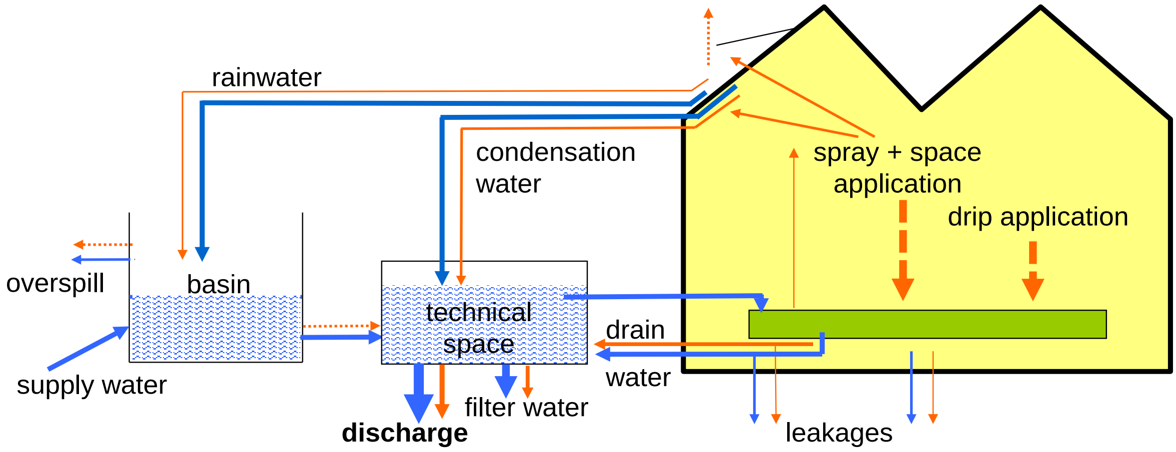

Figure 1. Water flows (▬) and pesticides emission routes (▬) in a hydroponic growing system.

water silos, or rainwater basins after first flush (this is the compulsory collection of the first 2 mm of rain after 48h of dryness).

Emission of pesticides to the air will occur during spray and space applications (drift), but also afterwards due to volatilisation. Part of it will end up via the cover in the condensation water. When condensation water is not reused, this flow is very significant (estimated at ca. 1000 m^3 per ha per year; Vermeulen *et al.*, 2010), but reuse is obligatory and common practice in the Netherlands.

Emission reducing measures

The size of the emission routes implies that most gain is in preventing discharge. One of the main reasons for discharge is the accumulation of sodium in the recirculation water, since certain levels of sodium cause damage to the crops. The supply water and fertilizers should therefore be low in sodium, and growers are advised to have sufficient storage for rainwater (a minimum of 500 m^3 per ha is obliged). The additional water needed in dry periods is preferably reversed osmosis water (filtered ground water), since surface and tap water are both higher in sodium.

The occurrence of root zone diseases or viruses is also a reason to stop reusing the nutrient solution. The recirculating water can be disinfected effectively by heat treatment or UV radiation. Fear for spreading a disease is generally not justified, on the condition that enough attention is paid to maintenance and adequate capacity of the disinfector.

Discharge also occurs unintentionally due to system failures or damage like leakage. For example, failure of the disinfector may cause significant emission (20-40 $m^3.ha^{-1}.day^{-1}$). This can be prevented with sufficient storage of drain water and rapid repair. Also mismanagement may cause unintentional discharge. Suboptimal water en nutrient management may result in small amounts of daily discharge, or flooding of drain silos. Also discharge of filter water, the second largest emission flow, falls in the category of preventable emissions. Awareness of the amount of discarded water and nutrients already stimulates growers to reuse this water.

Another approach in reducing the emission of pesticides is the optimisation of the application itself. Especially with drip applications there are several measures that help not only to increase the effectiveness of the product, but also decrease its emission. The timing of the application should be such that maximum uptake by the plant is ensured. Furthermore, the water should be reused at least 3 weeks in the summer or 6 weeks in wintertime before any discharge. This is particularly important for slow degrading pesticides.

Further steps in reducing emission

The decision to discharge is repeatedly not based on solid sodium figures, but on the grower's experience and feelings about the 'state of the crop'. Recently it is demonstrated in the laboratory that growth hampering in rose is caused by the accumulation of a not-yet identified organic substance, which can be broken down with advanced oxidation (UV-activated H_2O_2; Van Os *et al.*, 2010). This is now subject for further study in rose and other crops.

Starting from the assumption that not always all discharge can be prevented, also an 'end of pipe' solution should be available. For this purpose several techniques are being evaluated in cooperation with the waste and drinking water industries. Because of the urgency (2013!) of reducing the pesticide emission, this receives special attention. In addition, purification techniques for additional reuse of water and nutrients are being developed.

Conclusions

Pesticide related challenges in greenhouse horticulture have much in common with the challenges in waste management, for which a management tool called *The Ladder of Lansink* was developed by the Dutch Government in 1980. The hierarchical steps in this ladder are: 1) prevention, 2) reuse (of products), 4) recycling (of materials), 5) incineration (with energy production) and 6) landfilling as the last option. In analogy with this, a 'pesticide emission ladder' then could be: 1) prevention: prevent the need for pesticides and use alternatives, 2) reuse: prevent emission of pesticides by maximising reuse of water, 3) optimise use: apply pesticides with minimal emission, 4) purification: eliminate pesticides from discharged water.

In order to reduce the emission of pesticides it is necessary to battle on all these fronts. In the past the alternatives for pesticides received most, if not all attention. From the perspective of sustainability and the 'pesticide emission ladder' this is sensible. But in the meantime, as long as growers consider pesticides indispensable and use them, also considerable attention should be paid to the next steps of the ladder. This is in particular important for meeting the short term goals of reducing pesticide emission, but also from the perspective of sustainable water use.

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