Swedish University of
Agricultural Sciences

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Pesticides in surface water in areas with open ground and greenhouse horticultural crops in Sweden 2008

Open ground cultivation of horticultural crops during early spring (Photo: J. Kreuger)

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Swedish University of Agricultural Sciences ISRN SLU-VV-EKOHYD-117-SE
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Contents

1. Summary

Current environmental monitoring of pesticides (crop protection products) in Sweden mainly concentrates on investigating possible leaching of pesticides used within agriculture. However, there is a lack of knowledge on how these compounds behave in the environment after their use within horticultural production. In certain parts of southern Sweden there are extensive areas of outdoor fruit and vegetable crops, as well as greenhouse crops. Greenhouses have in some contexts been regarded as 'closed environments'. This has meant that the same high demands have not always been applied when assessing the risks of harmful effects to neighbouring waters of crop protection products used in greenhouses compared with those used in outdoor vegetable crops.

The aim of this investigation was to broaden our knowledge of possible leaching to water of pesticides used in field cultivation of horticultural crops and in greenhouses. The investigation, which was carried out in 2008, is the most comprehensive to date as regards the number of pesticides analysed in Swedish watercourses. The analyses comprised 126 different substances, 39 of which have not been investigated previously within Swedish environmental monitoring.

The investigation consisted of surface water sampling in six areas with extensive growing of horticultural crops. Field growing of berries occurred in the catchment area in SE Småland, vegetables in NE Skåne and fruit in SE Skåne. Greenhouse cultivation took place in the catchment area in W Skåne and NW Skåne. Some 10 samples per area were collected during the period May-October 2008. In addition, around 20 water samples were collected for analysis from one of the areas included in national environmental monitoring (area N34 in Halland). A few samples were also taken of the effluent water from greenhouses with recirculation systems.

A total of 78 of the 126 substances included in the investigation were encountered, with a range of between 24 and 44 substances detected in water from the individual areas. The highest numbers of substances and the highest concentrations were detected in the area with intensive vegetable growing in NE Skåne, in the area in Halland and in the two areas with greenhouse growing. Lower concentrations and fewer substances were found in water from the area in SE Småland with strawberry cultivation and from the area in SE Skåne with apple orchards.

The guideline value was exceeded in most of the samples collected from the area in NE Skåne and in all samples from the two greenhouse areas (W Skåne and NW Skåne), with the highest exceedences in the latter two areas. The insecticide imidacloprid was the substance that exceeded the guideline value most frequently in this investigation. Some of the substances encountered at elevated levels in water from the areas with greenhouse cultivation were also detected in the samples of effluent water taken from the greenhouses. Substances used widely in ornamental plant production in the greenhouse were also found in the watercourse in W Skåne. The results show that there is leaching of crop protection products from Swedish greenhouses. Future work should therefore aim to identify potential risk elements associated with crop protection operations in the greenhouse, with the aim of decreasing losses of crop protection products to neighbouring waters.

2. Introduction

National environmental monitoring in Sweden within the sub-programme Pesticides is directed at the use of crop protection products within agriculture. It is this sector that dominates in Sweden as regards the use of crop protection products (pesticides), but some degree of use also occurs within horticulture. In the type areas that form part of national pesticide monitoring, horticultural crops are only grown to a very limited extent (Adielsson *et al*., 2007). Horticultural crops are grown on 0.5% of Sweden's arable land. Sales statistics from the Swedish Chemicals Agency show that the use of crop protection products within fruit and vegetable growing represented approx. 2% of the amount used within agriculture in 2007 (KemI, 2008). Since a number of crop protection products are used specifically within horticulture, this means that these are not investigated within the current environmental monitoring programme for pesticides. Thus knowledge is very limited on possible leaching of these substances under Swedish conditions.

This report presents the results of a screening investigation carried out in summer 2008 involving sampling and analysis of crop protection products in water from areas of Sweden where horticultural crops are grown. The investigation was carried out by the Swedish University of Agricultural Science (SLU) at the behest of the Environmental Protection Agency (NV) (Contract 222 0810).

The aim of the investigation was to study possible leaching of crop protection products from areas with intensive outdoor cultivation of horticultural crops. The structure of the investigation generally matched that of the preparatory investigation carried out in winter 2007/2008 (Adielsson *et al*., 2008a), but also included additional water sampling from two areas with greenhouse cultivation of vegetables and ornamental plants. However, any leaching from outdoor cultivation of nursery plants was not included. The investigation comprised analyses of crop protection products of the types herbicides, fungicides and insecticides, but not plant growth regulators.

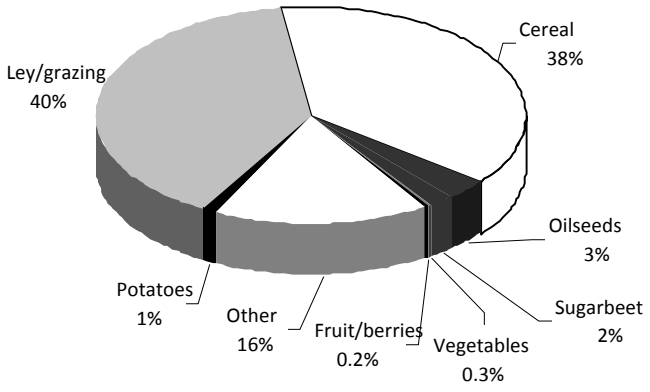

Figure 1. Relative acreage of different crop groups grown in Sweden, 2005.

Table 1. Regional distribution of cultivated area of vegetables, fruit and berries, and as a proportion of the total acreage of outdoor horticultural crops, 2005

County	Area (ha)			Proportion of total outdoor growing (%)
	Vegetables	Fruit	Berries	
Blekinge	166	135	301	5%
Dalarna	66	-	115	1%
Gotland	612	15	36	5%
Gävleborg	21	0,3	41	1%
Halland	364	10	108	4%
Jämtland	11	0,2	83	1%
Jönköping	45	78	105	2%
Kalmar	364	3	453	7%
Kronoberg	14	15	9	0%
Norrbotten	46	-	176	2%
Skåne	4 215	1 482	847	54%
Stockholm	54	32	62	1%
Södermanland	13	2	55	1%
Uppsala	21	13	42	1%
Värmland	34	23	98	1%
Västerbotten	68	-	28	1%
Västernorrland	25	3	47	1%
Västmanland	7	24	29	0%
Västra Götaland	442	19	361	7%
Örebro	99	11	30	1%
Östergötland	361	7	166	4%
Sweden as a whole	7047	1870	3190	

Source: SCB, 2006.

2.1 Background

Cultivation of fruit and vegetables is very limited in Sweden compared with *e.g*. cereals and ley, which are grown on a large proportion of Swedish arable land (**Figure 1**). However, although the total area of these horticultural crops in Sweden is small, locally they can comprise a considerable proportion of the cultivated area (SCB, 2006). The area with the most intensive cultivation of horticultural crops is the county of Skåne, where 54% of the total acreage is found (**Table 1**). This is followed by the counties of Kalmar and Västra Götaland, each of which have 7% of the total horticultural area. When the area of organic horticultural cultivation is excluded, Skåne's share of outdoor horticultural cultivation increases to 57%, while Kalmar and Västra Götaland retain the same share.

In Sweden, horticultural crops are usually divided into vegetables, fruit and berries. Within the vegetables, carrots are the largest crop in terms of area, followed by iceberg lettuce and onions (**Table 2**). Among the fruit, apples are the largest crop, while strawberry is the type of berry grown on the largest area. Table 2 also provides data on cereals and potatoes for the sake of comparison.

In the user survey carried out by Statistics Sweden (SCB) on behalf of the Swedish Board of Agriculture (SJV) referring to the 2005/2006 season, four horticultural crops were included; carrot, onion, apple and strawberry (SCB, 2007). These four are largest in terms of area and were identified as pesticide-intensive crops by experts within the area. The survey showed that between 80 and 90% of the area devoted to these crops was sprayed, which is of the same order of magnitude as for winter wheat and potatoes (**Table 3**). However, the amount of active ingredient applied per unit area sprayed differed greatly, with winter wheat receiving

Table 2. Total area of horticultural crops grown outdoors in Sweden, 2005

Vegetables	Cultivated area (ha)	**Fruits**	Cultivated area (ha)
Carrots	1 727	Apples	1 440
Iceberg lettuce	1 211	Pear	197
Onions	902	Cherry	139
White cabbage	370	Plum	94
Cauliflower	311		
Beetroot	288		
Broccoli	246	**Berries**	
Spinach	243	Strawberry	2 401
Cucumber	226	Blackcurrant	511
Parsnip	180	Raspberry	156
Dill	175	Other berries	123
Swedish turnip	163		
Maize	140		
Leek	127	**Comparison**[§]	
Kale, red cabbage	73	Cereals	1 023 976
Various others	665	Potatoes	22 081

Source: SCB. 2006. [§]Jordbruksstatistisk årsbok 2007. SJV

on average 0.6 kg active ingredient per hectare and the others in the order of 2-7 kg/ha. The number of sprayings varied between 5 and 20 per year for the horticultural crops and potatoes, whereas winter wheat is normally only sprayed on two occasions per year.

The use of different types of crop protection products varies between different crops, with the highest use in apples, followed by onions and strawberries (**Figure 2, Table 3**). The amount of herbicide needed does not differ greatly between the horticultural crops and instead it is their susceptibility to fungal diseases that is highly significant. Carrots are normally less susceptible to fungal attack, while onions, apples and strawberries require several sprayings. The quantities of insecticides used are small, which can partly be attributed to most insecticides being used in considerably lower doses than fungicides. As Figure 2 shows, spraying of horticultural crops is considerably greater than for winter wheat, while potato is also a relatively pesticide-intensive crop.

Within vegetable growing, it is common to use an agricultural sprayer for application of crop protection products (**Table 4**). This also applies to strawberry growing, although one-fifth of

Table 3. Area treated, dose of active ingredient (a.i.), amount used and number of spraying occasions per season for four horticultural crops and two other agricultural crops, 2005/2006

Crop	Treated area (ha)	Dose a.i. (kg/ha)	Amount used (ton)	No. of sprayings per yr *
Carrots	88%	2.05	2.9	5.0
Onions	80%	5.56	3.8	7.9
Strawberries	86%	5.27	10.8	7.8
Apples	89%	7.15	8.2	9.5
Winter wheat	94%	0.59	176.9	2.1
Potatoes	89%	3.42	61.2	7.5

* = Refers to spraying in growing crop, *i.e*. not including total weed killing or haulm destruction.
Source: SCB, 2007.

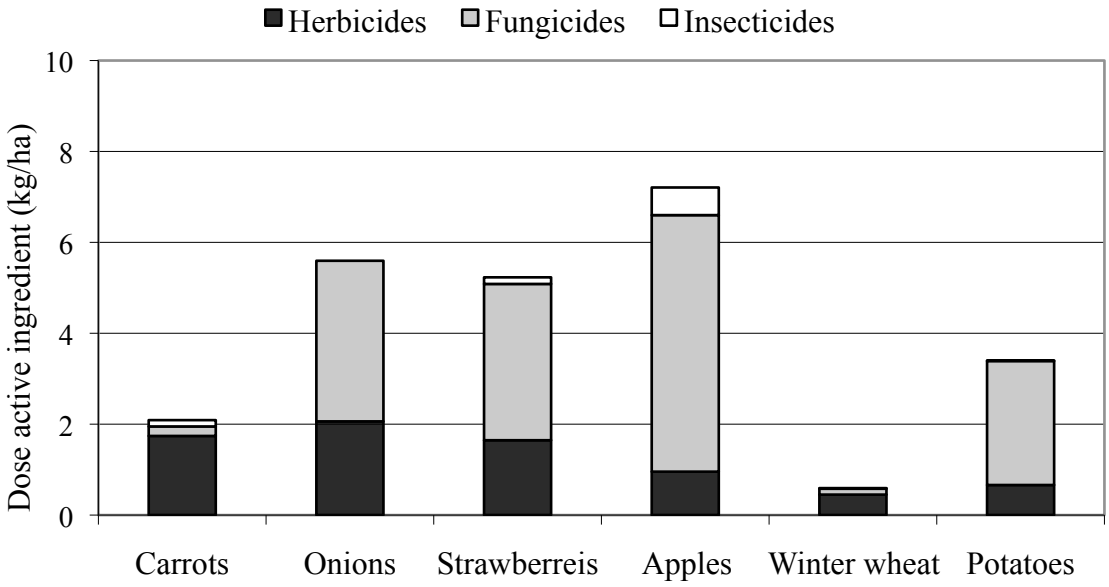

Figure 2. Amount of crop protection products applied to different crops, calculated as mean dose on the total area of that crop treated during one year (modified from SCB, 2007).

growers state that they use a band sprayer for pesticide application. However, fruit crops require specialist equipment, with a fan sprayer being the most common type of sprayer used within this type of enterprise. In general, around half the growers surveyed reported using a sprayer that was more than 10 years old (SCB, 2007). The growers were also asked about where they refilled their sprayer. The most common practice was to position the equipment on a concrete pad (~50%), while ~20% used a biobed for the purpose and 10% reported that they refilled their sprayer in the farmyard. The remaining 20% used biologically active land. Data given by the horticultural growers on the age of the equipment and the refilling site are comparable with data provided by other farmers (SCB, 2007).

2.2 Type areas within pesticide monitoring

Within the four ordinary type catchment areas included in national pesticide monitoring there is some growing of horticultural crops (Adielsson *et al*., 2007). The total area of horticultural crops grown annually within the four areas amounts to around 70 ha (**Table 5)**, which is equivalent to ~1.5 % of the total arable acreage within these areas. Most of the acreage lies within the type area in Halland (N34), where most of the crops included in Table 5 are grown, except strawberries and field beans. Field beans are grown almost exclusively in Västergötland (O 18) and are mainly produced without the use of crop protection products.

Table 4. Information on type of spraying equipment used and its age

	Type of spraying equipment			Proportion of growers with sprayer >10 yrs old
	Agric. sprayer	Band sprayer	Fan sprayer	
Carrots	96%	1%	1%	45%
Onions	91%	0%	2%	44%
Strawberries	71%	21%	2%	45%
Apples	5%	1%	95%	50%

Source: SCB, 2007.

Table 5. Combined area (ha) cropped with horticultural crops within the four type areas during the period 2002-2007

Crop	2002	2003	2004	2005	2006	2007
Strawberries	1.5	3.3	5.1	1.4	2.9	2.8
Onions	0.8	0.9	0.9	1.4	0.7	0.6
Maize	4.1	3.8	5.3	5.7		0.5
Carrots		24.1	15.7	27.2	10.0	6.6
Parsnip		6.0	6.4			
Beetroot			3.0	2.0	3.6	3.7
White cabbage			3.0	10.6	13.0	
Field beans	23.8	11.6	35.5	62.0	44.0	43.4
Vegetables*	20.7					
Total	50.9	49.7	74.9	110.3	74.1	57.6

* Detailed information on horticultural crops was not specified for all areas during the first year of the survey.

The compounds used specifically in horticultural production in the Halland area during the past three years are dimethoate, ioxynil, lambda-cyhalothrin and pendimethalin. Of these, dimethoate, lambda-cyhalothrin and pendimethalin have been analysed within national pesticide monitoring. Dimethoate has also been detected on some occasions in two years when it was only used in carrots and parsnips. These findings were at trace level where the limit of detection was 0.02 µg/l.

3. Selection of areas and sampling occasions

The search for suitable water courses was concentrated to areas that were likely to have the most intensive cultivation of horticultural crops. Using Swedish Board of Agriculture database with block data aggregated to sub-catchment level, a regional profile of the distribution in the country was drawn up with the aid of the GIS programme ArcInfo. A more careful resolution was then applied to those areas considered to be the most relevant. The block data were entered into the GIS programme and the distribution of different crops was studied using the terrain map as a base.

In order to relate any leaching of pesticides to the cultivation of horticultural crops, one of the search criteria was that the proportion of fruit, berry or vegetable growing had to comprise at least 15-20% of the arable land within the catchment area. The preferred size of catchment area was ~500-1500 ha, and the water course had to have water flow throughout the growing season. Initially, six different areas were selected as interesting. After a tour of inspection of these areas in April 2008, three were finally selected as the subject of further investigations (see also Chapter 5).

The growing season for the different crops varies widely, as does the time of treatment. **Figure 3** presents a schematic diagram of treatment times for the four main crops (apples, strawberries, onions and carrots) over the space of a normal year.

For fruit the treatment season starts with bud burst (April), when the first treatment is applied, and ends at harvest (September). For berries, mainly strawberries, the season starts with a weed treatment in March and continues with fungicide and insecticide treatments during May. For carrots and onions, weed treatment is carried out over a longer period at the beginning of the growing season since these crops are sensitive to competition at that time. Fungicide and insecticide treatments are then applied. Use of insecticides in onions is not very common. The period specified in the diagram for insecticide treatment of carrots only applies to areas that

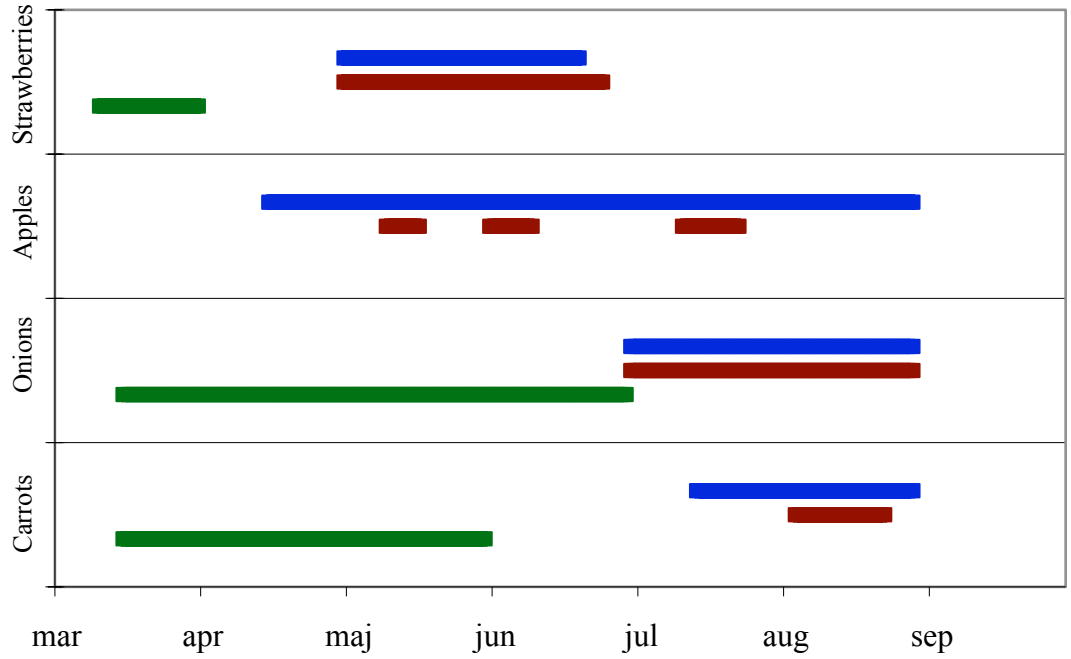

Figure 3. Main application periods for crop protection products in different crops. Green = herbicide; Brown = insecticide; Blue = fungicide.

are free from carrot psyllid, which is mainly found in the Örebro region and in parts of Halland. Treatment against carrot psyllid is normally carried out in June.

4. Selection of substances

The selection of substances to include in the analyses was based on a review of those registered for use in outdoor horticultural production in winter 2007/2008 (Adielsson *et al.*, 2008a). In the selection process, consideration was given to the amount used, the number of hectares that the amount sold could cover, the toxicity of the substance to the aquatic environment and the intrinsic properties of the substance. The final selection was based on whether the substance could be included in a general analytical method rather than requiring a customized method.

At the time of the selection process, the focus of the study was on outdoor cultivation of horticultural crops, so a number of substances of high relevance for greenhouse growing were not included in the selection process and thus not in the analyses (*e.g.* plant growth regulators, which make up a considerable proportion of the crop protection products used in greenhouse growing of ornamentals).

A review of the substances used within fruit and vegetable growing in Sweden (2007) is given below, with information on those already included in pesticide monitoring analyses, whether included in the present screening, the amount sold and the estimated area treated with the substance in question (**Tables 6-8**).

4.1 Herbicides

There were 22 herbicides (**Table 6**), of which 14 were included in the national environmental monitoring programme of pesticides during 2007, including the 10 compounds sufficient for

Table 6. Herbicides used within fruit and vegetable growing (according to Bekämpningsmedelsregistret, 2007 and Jordbruksverket, 2006a, b and c)

Active ingredient	Incl. in EM[1]	Incl. in present study	Amount sold[2] (ton)	Area[3] (ha)	Specific to hort.
aclonifen	X	X	27	29 348	
bentazone	X	X	20	49 405	
chloridazon	X	X	15	8 401	
clethodim		X	2	22 222	
clomazone		X	0.2	2 222	
clopyralid	X		9	55 333	
cycloxydim		X	5	22 800	
dichlorprop-P	X	X	9	20 000	
diquat dibromide			12	20 000	
glufosinate-ammonium			1	1 405	
glyphosate	X		536	451 875	
ioxynil		X	0.3	2 822	X
isoxaben		X	0.4	1 391	X
MCPA	X	X	204	585 089	
mecoprop-P	X	X	7	31 909	
metamitron	X	X	83	51 324	
metazachlor	X	X	30	40 533	
metribuzin	X	X	6	60 952	
pendimethalin	X	X	4	1 722	
phenmedipham	X	X	25	77 750	
propyzamide	X	X	2	844	
tepraloxydim		X	new substance 2007		

[1]Included in analyses within the national environmental monitoring programme (EM) of pesticides, 2007.
[2]Amount sold calculated as mean for the three-year period 2004-2006 (KemI, 2007).
[3]Area calculated from mean value for recommended dose according to Jordbruksverket, 2006a, b and c.

treatment of the largest number of hectares. Only two of the active substances are unique to horticultural production, while the rest are used in several areas. The amount of herbicides sold is generally higher than for insecticides. Glyphosate is the most sold compound, but since it is not used specifically in horticulture and in addition requires a customized analytical method, a decision was made to exclude glyphosate from the investigation.

4.2 Insecticides

Fifteen insecticides were approved for use within horticulture (**Table 7**), of which six are specific for this application. Eight of the compounds were included in the national environmental monitoring programme of pesticides in 2007. The amounts sold are relatively small, up to five tons per substance. Insecticides are applied in low doses, which means that the amount used can cover a relatively large area. Of the nine substances that could cover the largest area, eight were included in pesticide monitoring in 2007.

4.3 Fungicides

There were 18 fungicides approved for use within horticulture (**Table 8**), nine of which are also unique to this area of application. Other compounds are also used within agriculture. The amounts sold are smaller than for many herbicides, but generally greater than for insecticides. Five of the six substances spread on the largest area were included in the national environmental monitoring programme of pesticides in 2007.

Table 7. Insecticides used within fruit and vegetable growing (according to Bekämpningsmedelsregistret, 2007 and Jordbruksverket, 2006a, b and c)

Active ingredient	Incl. in EM[1]	Incl. in present study	Amount sold[2] (ton)	Area[3] (ha)	Specific to hort.
abamectin			<0.1	4 505	X
acetamiprid		X	0.1	2 000	X
alpha-cypermethrin	X	X	1.6	113 333	
beta-cyfluthrin	X	X	1.7	180 000	
cypermethrin	X	X	2.0	107 176	
deltamethrin	X	X	0.4	25 263	
diflubenzuron		X	0.4	2 564	
dimethoate	X	X	4.3	15 400	
esfenvalerate	X	X	2.5	135 000	
fenpyroximate		X	0.1	1 183	X
hexythiazox		X	0.1	1 143	X
lambda-cyhalothrin	X	X	<0.1	8 571	X
methiocarb		X	no data		X
pirimicarb	X	X	5.1	50 286	
pyrethrins		X	0.6	43 573	

[1]Included in analyses within the national environmental monitoring programme (EM) of pesticides, 2007.
[2]Amount sold calculated as mean for the three-year period 2004-2006 (KemI, 2007).
[3]Area calculated from mean value for recommended dose according to Jordbruksverket, 2006a, b and c.

Table 8. Fungicides used within fruit and vegetable growing (according to Bekämpningsmedelsregistret, 2007 and Jordbruksverket, 2006a, b and c)

Active ingredient	Incl. in EM[1]	Incl. in present study	Amount sold[2] (ton)	Area[3] (ha)	Specific to hort.
azoxystrobin	X	X	13	72 000	
boscalid		X	new substance 2007		X
cyprodinil	X	X	17	40 593	
dimethomorph		X	1.0	3 889	
dithianon			2.0	3 393	X
fenhexamid		X	1.6	2 133	X
fenpropimorph	X	X	29	20 533	
fluazinam	X	X	25	90 400	
fludioxonil		X	1.5	5 156	
fosetyl-aluminium			4.2	964	X
calcium polysulfide			0.2	211	X
kresoxim-methyl		X	0.3	2 182	
mancozeb			36	26 267	
mepanipyrim		X	new substance 2007		X
penconazole		X	0.1	357	X
propamocarb		X	16	7 545	
pyraclostrobin	X	X	13	77 612	
pyrimethanil		X	1.1	2 000	X

[1]Included in analyses within the national environmental monitoring programme (EM) of pesticides, 2007.
[2]Amount sold calculated as mean for the three-year period 2004-2006 (KemI, 2007).
[3]Area calculated from mean value for recommended dose according to Jordbruksverket, 2006a, b and c.

5. Description of areas

Water sampling was carried out in summer 2008 in four water courses that drain catchment areas with relatively intensive outdoor cultivation of horticultural products (**Table 9**). The areas varied in size between ~5 and 19 km^2. The proportion of the available arable area

Table 9. Background information on the study catchments with outdoor cultivation of horticultural crops

Catchment	Total area (ha)	Arable area (ha)	Proportion of horticulture
SE Småland	1 036	643 (62%)	11%
NE Skåne	1 864	1 545 (83%)	36%
SE Skåne	546	410 (75%)	21%
Halland (N34)*	1 460	1 275 (87%)	15%

* Figures refer to the 2007 grower survey in the area.

devoted to outdoor cultivation of horticultural crops varied between 11 and 36%, with the largest proportion in NE Skåne.

The water course in Halland (N34) is largely a piped water course that has been included in the national pesticide monitoring programme since 2002. Within this catchment, vegetables are grown on ~15% of the arable area. Two areas with extensive fruit and vegetable growing, situated in SE and NE Skåne, were included in the investigation. The fruit orchards in SE Skåne are situated along the lower reaches of an open water course that discharges into Hanöbukten. The water course in NE Skåne is relatively narrow and mainly runs open alongside neighbouring crops, including vegetable crops. On visits to the area, buffer zones were noted along parts of the water course (**Figure 4**). The water course in SE Småland also runs open along neighbouring crops of *e.g.* strawberries. For an overview of the main land uses in the different catchment areas see **Table 10**.

The investigation also included sampling of water courses emerging from two areas with extensive greenhouse production, one in W Skåne and one in NW Skåne. In W Skåne five greenhouses are located, two of them with ornamental plants and three with cucumbers. Any drainage water and excess water from the area is carried via a stream to the river Råån. The samples were taken just before the stream discharges into Råån. This total catchment area amount to 440 ha in size and consists of arable land and areas of detached houses, including the greenhouse area of 55 000 m^2 (5.5 ha).

In NW Skåne four greenhouses are located, two of them with tomatoes and two with cucumbers. The greenhouses have an internal collection system to which effluent water from the greenhouses is diverted to ponds and cisterns. This water is used for irrigation of crops on neighbouring fields during dry weather periods. One nearby water course, including a smaller tributary (sampled once), was selected in this area in order to assess the risk of flow to the water course from drainage water or from ponds when the capacity of the collection system was exceeded, *e.g.* after heavy rainfall. The greenhouses with tomatoes did not drain to the stream and are therefore only relevant for samples from the collection systems. The total catchment area comprises 1 820 ha and this area also mainly consists of arable land. The total greenhouse area is 63 000 m^2 (6.3 ha).

Table 10. Crops grown on horticultural land in the different catchment areas

Catchment	Crops grown (horticultural)
Outdoors	
SE Småland	Strawberries, also cucumber and potatoes
NE Skåne	Carrots, also onions, potatoes and strawberries
SE Skåne	Apples
Halland (N34)	Vegetables
Greenhouses	
W Skåne	Greenhouses with ornamental plants and cucumber
NW Skåne	Greenhouses with cucumber and tomatoes

Figure 4. Buffer zone along the water course in NE Skåne.

5.1 Use of crop protection products

Information on the use of crop protection products within the study areas was collected through general interviews with a few growers within each area. These interviews were targeted at growers of horticultural crops in the respective area. The aim was to document the commercial pesticides normally used on the relevant crops (**Appendix 1**). In the greenhouse areas information on pesticide use could only be obtained from the growers of cucumbers.

6. Sampling

Sampling started in the beginning of May 2008 in the four areas with outdoor vegetable growing and at the end of June in the two areas with greenhouse growing (**Table 11**). The duration of sampling was adjusted to include the main period of use of crop protection products in the dominant crops in the area and the period immediately after this (see **Figure 3**). The last samples arrived at the laboratory in the middle of October.

The samples were collected around every 14 days as instantaneous samples, with the help of local personnel from the Rural Economy and Agricultural Society and the Environmental and Health Protection offices in all areas except Halland (N34), which is included in national environmental monitoring. On each sampling occasion, a 1-litre glass bottle and a 1-litre plastic bottle were filled. In Halland, sampling was carried out using an automated sampler, which gives time-integrated samples collected weekly, with one sub-sample taken every 80 minutes during the week. The samples are stored in a refrigerator during the sampling week. All samples were sent to the laboratory by business post (delivery within 24 hours) in boxes with freezer packs. The samples were either extracted on the day of arrival at the laboratory or they were placed in the freezer.

Table 11. Sampling period and number of samples in the different catchment areas

Catchment	Sampling period	Number of samples
Outdoors		
SE Småland	6 May – 25 Aug	9
NE Skåne	14 May – 8 Sep	11
SE Skåne	4 May – 24 Aug	11
Halland (N34)	5 May – 20 Oct	21
Greenhouses		
W Skåne	25 Jun – 14 Oct	7
NW Skåne	7 Jul – 30 Sep	9*
Total number of samples		68

*Of which four were samples of overflow water from ponds and cisterns.

The flow in water courses was generally low in all areas during summer 2008, when very little rain fell during the early part of the summer (**Table 12**). SE Småland was affected by drought in early summer, with practically stationary water during June. SE Skåne had higher flow during May than later in the summer, when it ran rather slowly before increasing again at the end of August. The same general flow pattern also applied in NE Skåne, with the exception of two days in August with considerable rainfall (~35mm) when the flow increased sharply. Flow in the water course in W Skåne was low during the entire sampling period, with the greatest depth (14 cm) in August and the least (2 cm) in October. NW Skåne had early summer drought that did not affect the water course substantially. Flow increased on one occasion in August after a shower of rain.

The sampling occasions in each of the four areas with outdoor vegetable growing in relation to rainfall during summer 2008 are shown in **Figures 5-8**.

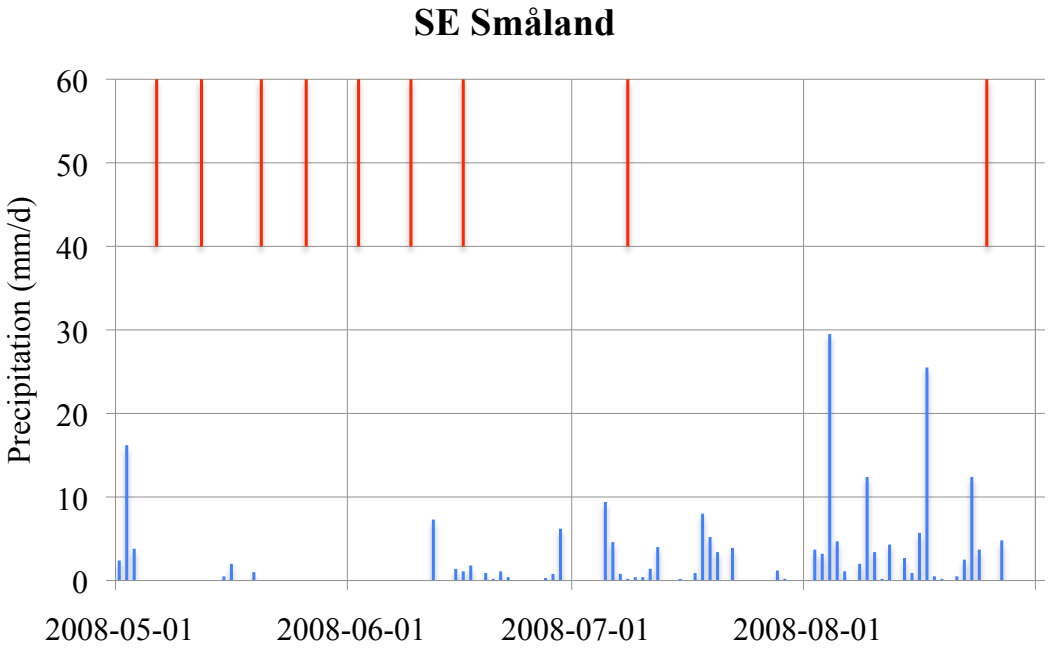

Figure 5. Daily rainfall in summer 2008 in SE Småland, with sampling occasions marked as red bars along the top of the diagram.

Table 12. Monthly rainfall measured in summer 2008 in the different regions

Catchment	Precipitation (mm)					
	Maj	Jun	Jul	Aug	Sep	Total
SE Småland	26	22	44	124	46	262
NE Skåne	3	34	53	125	43	258
SE Skåne	18	34	23	136	92	302
Halland (N34)	23	72	134	169	72	470
W Skåne	25	36	45	179	35	320
NW Skåne	17	22	78	158	50	325

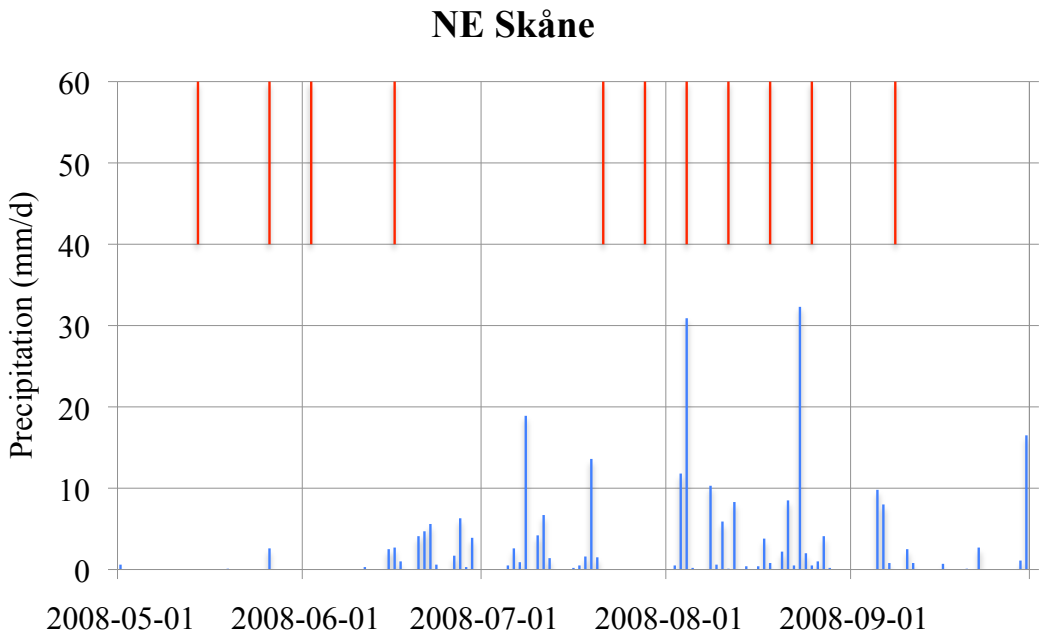

Figure 6. Daily rainfall in summer 2008 in NE Skåne, with sampling occasions marked as red bars along the top of the diagram.

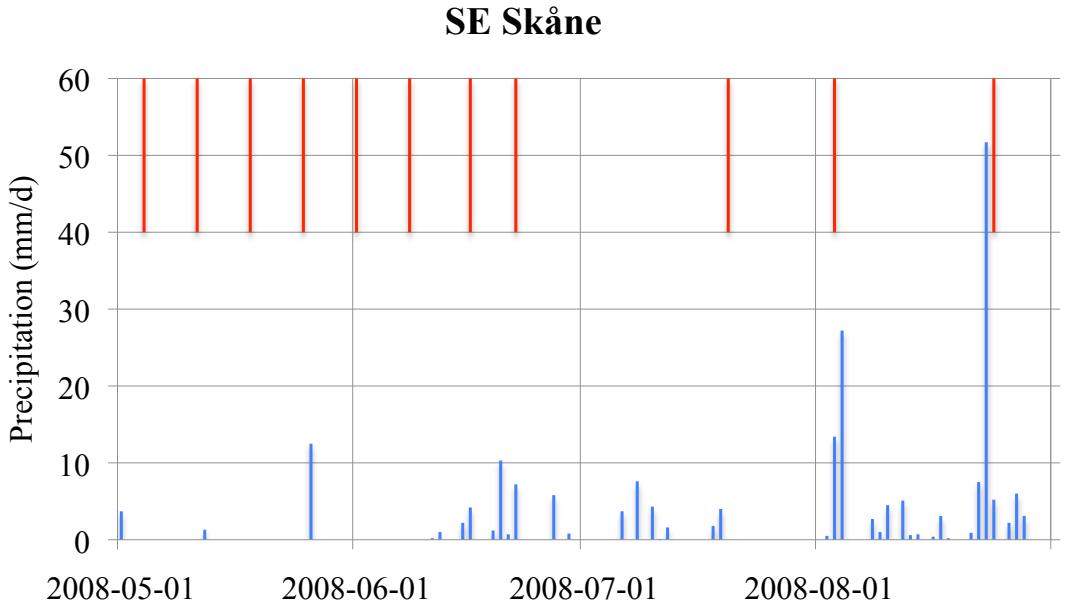

Figure 7. Daily rainfall in summer 2008 in SE Skåne, with sampling occasions marked as red bars along the top of the diagram.

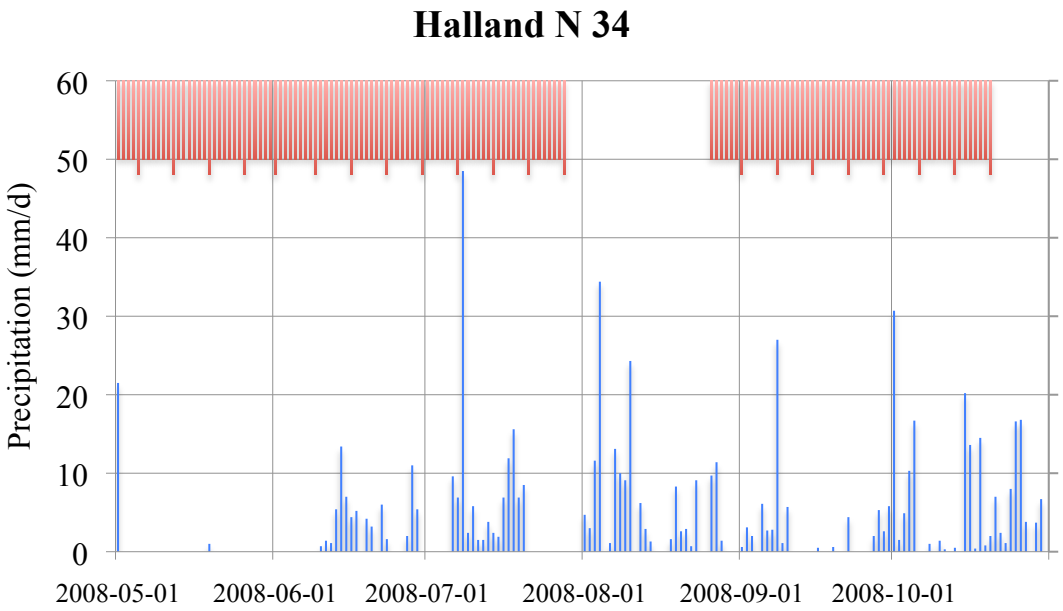

Figure 8. Daily rainfall in summer 2008 in Halland, with sampling occasions marked as red bars along the top of the diagram. Time-integrated sampling was carried out with an automatic water sampler; the longer red bars mark changes of sampling bottles.

7. Analyses

In this study, crop protection products were analysed in surface water from streams and rivers running alongside outdoor vegetable crops and greenhouses at different locations in Sweden. All analyses were carried out at the Section for Organic Environmental Chemistry (OMK), Department of Aquatic Sciences and Assessment, SLU. Reliability in results is of fundamental importance and is based on good quality work routines and careful method validation. To assess whether the analyses meet the quality criteria, the laboratory is regularly inspected by an external authority, SWEDAC. When that authority decides that activities meet the requirements, an accreditation certificate is issued. One of the requirements set by SWEDAC is regular participation proficiency testing studies. At the present time, OMK is accredited for several different analytical methods.

A total of 126 substances are dealt with in this report (**Appendix 2**). To cover all these, several different method applications were required. **Appendix 2** (summary of normal detection limits used in 2008) shows the methods used for the different substances and areas. The following description applies to samples from all areas except type area Halland (N34):

For 23 of the substances, liquid-liquid extraction with dichloromethane was used, followed by gas chromatographic identification and quantification with mass spectrometric detection (GC-MS). This method is called OMK 51:5 and is accredited by SWEDAC. The method involves addition of an internal standard to samples to compensate for any variations in volume, injection errors and losses during sample handling. During the sampling season a number of trials were carried out involving addition of all component substances in a 'reference water sample', which formed the basis for determination of quantification limits.

The other 103 substances were analysed using a newly developed analytical method – liquid chromatography with tandem mass spectrometry detection (LC-MS/MS) with on-line sample extraction. This method is called OMK 57:0 and will partly or completely replace some

previous methods used at the laboratory. The method was accredited by SWEDAC in spring 2009 and is described in detail by Jansson & Kreuger (2010).

In sample preparation for method OMK 57:0, two sub-portions were taken from every water sample and the pH was adjusted to 5.0 and 3.5. Internal standard was added with the aim of correcting for any variations in injection volume and the samples were then passed through an injection filter. On each analysis occasion new standard solutions were prepared to cover a limited area of concentrations. During preparation of the standard solutions, tests were also performed in which all constituent substances were added to randomly selected water samples. The recovered concentrations of the added substances formed the basis for determination of quantification limits.

For type area Halland (N34), method OMK 57:0 was only used for newly occurring substances within environmental monitoring. For other substances three different methods were used, all of which are accredited. For determination of non-polar and semi-polar substances method OMK 51:5 (described above) was used. Sulfonylurea herbicides were analysed by acidification of the sample followed by solid-phase extraction (method OMK 49:6). Final determination was made by liquid chromatography with mass selective detector (LC-MS). In analysis of acidic herbicides (method OMK 50:8), the sample was acidified and the substances were then extracted using solid-phase technique. After derivatisation, quantification was carried out by gas chromatograph coupled to mass selective detector (GC-MS).

A feature shared by all methods was that they were based on the same samples, which were allocated a specific numerical code on arrival at the laboratory. The first sampling was on 4 May 2008 and the last on 20 October 2008. Sample preparation and analysis with method OMK 57:0 (excluding data evaluation) of all samples received was carried out between 16 October 2008 and 19 November 2008 on water samples that had been stored in the freezer (-20°C). For the other methods the samples were extracted continuously upon arrival at the laboratory. The extracts were then stored in the freezer (-20°C) for one to six months before analysis, which took place on a number of occasions in the period May-November 2008.

When the measured concentration of any substance exceeded the highest concentration in the standard series, the sample was diluted so that on re-analysis the concentration fell within the calibration area. In order for the concentration to be specified, it had to lie above the limit of quantification (LOQ). This limit generally means that the signal from the target substance is at least 10-fold higher than the background noise. The concentrations that fell below this limit, but above the limit of detection (LOD), are stated as ‘trace’. This means that the substance was shown to be present in the sample, but that the concentration was too low to be determined with the required precision. This limit generally means that the signal from the target substance is at least three-fold higher than the background noise. Both the quantification limit and detection limit can vary somewhat between different analysis occasions and also depending on the chemical properties of the water sample. The analysis records state the sample-specific relevant limits for each substance. **Appendix 2** lists the 126 substances determined and the analytical method used.

With all analytical methods, addition of internal standard was used to check the recovery. During the season, regular addition tests were also carried out at trace analysis level to establish and monitor reproducibility and recovery. The analyses included a number of degradation products (or by-products). The abbreviations used for some of these degradation products are explained in Chapter 10.

Table 13. Number of substances detected, frequency of detection and highest concentration in water from the six study areas. Frequency of detection is given as a percentage of the total possible number of detections (*i.e.* the number of samples multiplied by the number of substances analysed)

Catchment	Substances		Detections (incl. trace)		Max conc. single substance	Max cumulative conc.
	Number	Frequency	Number	Frequency	(µg/l)	(µg/l)
Outdoors						
SE Småland	25	20%	89	8%	0.3	0.4
NE Skåne	44	35%	193	14%	4.4	4.7
SE Skåne	24	19%	79	6%	0.05	0.2
Halland (N34)	44	35%	311	12%	4.0	5.8
Greenhouses						
W Skåne	43	34%	194	22%	9.6	17.3
NW Skåne (streams)	40	32%	99	16%	15	19.9
- Effluent water	22	17%	39	8%	89	94.1

8. Results

A total of 68 water samples were taken in the six areas investigated and the number of individual measurements amounted to 8 486. The concentrations of substances detected in all samples are shown by area in **Appendix 3.** In surface water from the individual areas 24-44 substances were detected (**Table 13**). The detection rate as a percentage of the total possible number of detections was 6-22% for the areas, with the highest detection frequency in the water course draining the greenhouse area in W Skåne.

In total, 78 different substances were detected, including 33 herbicides, 24 fungicides, 13 insecticides and 7 degradation products (**Table 14**). The substances most commonly encountered in concentrations above the limit of quantification were (in descending order): bentazone, boscalid, azoxystrobin, BAM, propamocarb, mecoprop, metalaxyl, imidacloprid, metamitron and MCPA (**Table 14**). The two fungicides boscalid and propamocarb were the only substances found in all six study areas. Boscalid has broad applications within field-grown horticultural crops, but is also used under permit in greenhouses (ornamental plants). Propamocarb is used on potatoes, lettuce and greenhouse crops (cucumbers, tomatoes and ornamental plants).

Within national environmental monitoring, the herbicide bentazone is again the substance encountered most frequently, being detected in all areas and in practically all samples. In the present investigation no bentazone residues were found in the area in SE Skåne (apple orchards) or in the area in W Skåne dominated by greenhouse cultivation (ornamental plants and cucumber). Note that glyphosate, which is the most widely used herbicide in Sweden, was not included in the present investigation (see Chapter 4).

The lowest number of substances and the lowest concentrations were observed in water from the areas with fruit and berry cultivation (SE Småland and SE Skåne) (**Table 13**). The highest cumulative concentration in an individual sample in these two areas was 0.4 µg/l and 0.2 µg/l, respectively. Greater numbers of substances and higher concentrations were found in water from the area with vegetable growing (NE Skåne) and from the area in Halland (N34). The highest cumulative concentration in an individual water sample in these areas was 4.7 µg/l and 5.6 µg/l, respectively (**Table 13**).

Table 14. Substances detected in water samples from six water courses draining areas with horticultural crops in 2008 (not effluent water). Frequency of detection is given as a percentage of the number of samples analysed

Substance (type)	No. detect. ≥ LOD	No. detect. ≥ LOQ	Max conc (µg/l)	Freq. det. ≥ LOQ	No. of areas ≥ LOQ
acetamiprid (I)	7	6	0.41	9%	2
aclonifen (H)	2	1	0.07	2%	1
alpha-cypermethrin (I)	6	0	trace	0%	0
amidosulfuron (H)	3	1	0.07	2%	1
atrazine (H)	37	14	0.02	22%	4
DEA (D)	28	8	0.007	13%	3
DIPA (D)	3	0	trace	0%	0
azoxystrobin (F)	34	32	3.9	50%	5
BAM (D)	53	30	0.05	47%	5
bentazone (H)	44	40	0.28	63%	4
bitertanol (F)	2	2	0.04	3%	1
boscalid (F)	37	37	4.9	58%	6
carbofuran (D)	1	1	0.008	2%	1
carfentrazone acid[#] (D)	1	1	0.09	2%	1
chloridazon (H)	9	1	0.01	2%	1
chlorpyrifos (I)	3	0	trace	0%	0
clethodim (H)	1	1	0.003	2%	1
clopyralid (H)	5	1	0.84	5%	1
cyanazine (H)	2	2	0.009	3%	1
cyazofamid (F)	3	0	trace	0%	0
cyprodinil (F)	15	3	0.37	5%	2
dichlorprop (H)	8	6	0.29	9%	2
diflufenican (H)	16	3	0.02	5%	2
dimethoate (I)	3	3	0.01	5%	1
dimethomorph (F)	8	8	1.5	13%	2
diuron (H)	5	4	0.01	6%	2
endosulfan-alpha (I)	10	2	0.004	3%	2
endosulfan-beta (I)	10	6	0.01	10%	2
endosulfan sulfate (D)	12	9	0.06	14%	2
esfenvalerate (I)	5	0	trace	0%	0
ethofumesate (H)	11	4	0.04	6%	3
fenhexamid (F)	1	1	0.008	2%	1
fenpropimorph (F)	11	4	0.53	6%	2
fluazinam (F)	6	1	0.01	2%	1
fludioxonil (F)	3	2	0.07	3%	1
flupyrsulfuron-methyl (H)	1	1	0.15	2%	1
fluroxypyr (H)	16	10	0.13	16%	4
flurtamone (H)	5	4	0.04	6%	2
hexythiazox (I)	11	11	0.13	17%	3
imazalil (F)	16	12	1.0	19%	3
imidacloprid (I)	23	23	15	36%	4
isoproturon (H)	33	18	0.28	28%	5
isoxaben (H)	6	1	0.12	2%	1
kresoxim-methyl (F)	12	9	0.13	14%	3
MCPA (H)	33	19	0.23	30%	5
mecoprop (H)	41	28	0.68	44%	5
mepanipyrim (F)	1	1	0.01	2%	1
metalaxyl (F)	44	24	0.20	38%	5
metamitron (H)	25	22	4.4	34%	4
metazachlor (H)	22	18	0.15	28%	5
methabenzthiazuron (H)	10	5	0.006	8%	2

Substance (type)	No. detect. ≥ LOD	No. detect. ≥ LOQ	Max conc (µg/l)	Freq. det. ≥ LOQ	No. of areas ≥ LOQ
methiocarb (I)	6	4	0.07	6%	1
metribuzin (H)	32	17	4.0	27%	3
metsulfuron-methyl (H)	1	0	trace	0%	0
penconazole (F)	4	1	0.02	2%	1
phenmedipham (H)	3	3	0.23	5%	2
picoxystrobin (F)	10	9	0.70	14%	4
pirimicarb (I)	14	11	0.14	17%	4
prochloraz (F)	8	4	2.9	6%	2
propamocarb (F)	37	30	4.5	47%	6
propiconazole (F)	16	7	0.22	11%	4
propoxycarbazone-Na (H)	2	2	0.02	3%	1
prosulfocarb (H)	10	7	1.9	11%	4
prothioconazole (F)	3	1	0.04	2%	1
prothioconazole-desthio (D)	6	5	0.10	8%	3
pyraclostrobin (F)	4	3	0.006	5%	1
pyrimethanil (F)	12	10	1.6	16%	2
quinmerac (H)	15	14	0.09	22%	4
rimsulfuron (H)	1	1	0.06	2%	1
simazine (H)	11	1	0.14	2%	1
terbuthylazine (H)	19	12	0.04	19%	3
DETA (D)	34	11	0.08	17%	3
thiacloprid (I)	1	0	trace	0%	0
thiamethoxam (I)	4	2	0.16	3%	1
thifensulfuron-methyl (H)	2	1	0.04	2%	1
tolylfluanid (F)	5	0	trace	0%	0
tribenuron-methyl (H)	1	0	trace	0%	0
vinclozolin (F)	6	5	0.005	*	1

H = Herbicide; F = Fungicide; I = Insecticide; D = Degradation product (where possible subdivided under parent substance). # = chloropropionic acid * = vinclozolin was analysed in a limited number of samples.

The highest concentrations were found in surface water from the two greenhouse areas (W Skåne and NW Skåne), with the highest cumulative concentration of up to 19.9 µg/l in water from NW Skåne, in a small tributary to the main stream, which was sampled on one occasion at the beginning of July (**Appendix 3**). The water course draining the ~400 ha large catchment area in W Skåne, which had extensive greenhouse growing, also had elevated concentrations of certain substances, with a highest cumulative concentration of 17.3 µg/l (**Table 13**). At most, 31 different substances were detected in a single water sample from this area.

These results show that a range of different crop protection products is found in stream water draining areas with greenhouse cultivation. For example, imidacloprid (Confidor) and propamocarb (Previcur) were detected in all seven water samples taken during the period 25 June - 14 October in the stream draining the area in W Skåne. The highest concentration of imidacloprid was 9.6 µg/l and the highest concentration of propamocarb 4.5 µg/l (**Appendix 3**). The concentrations of these two substances were substantially lower in water from the area in NW Skåne with outdoor cultivation of vegetables. The compound boscalid (Signum, which among other things is used under permit in greenhouses) was detected in elevated concentrations in stream water from the greenhouse area in W Skåne, with the highest concentration being 4.9 µg/l.

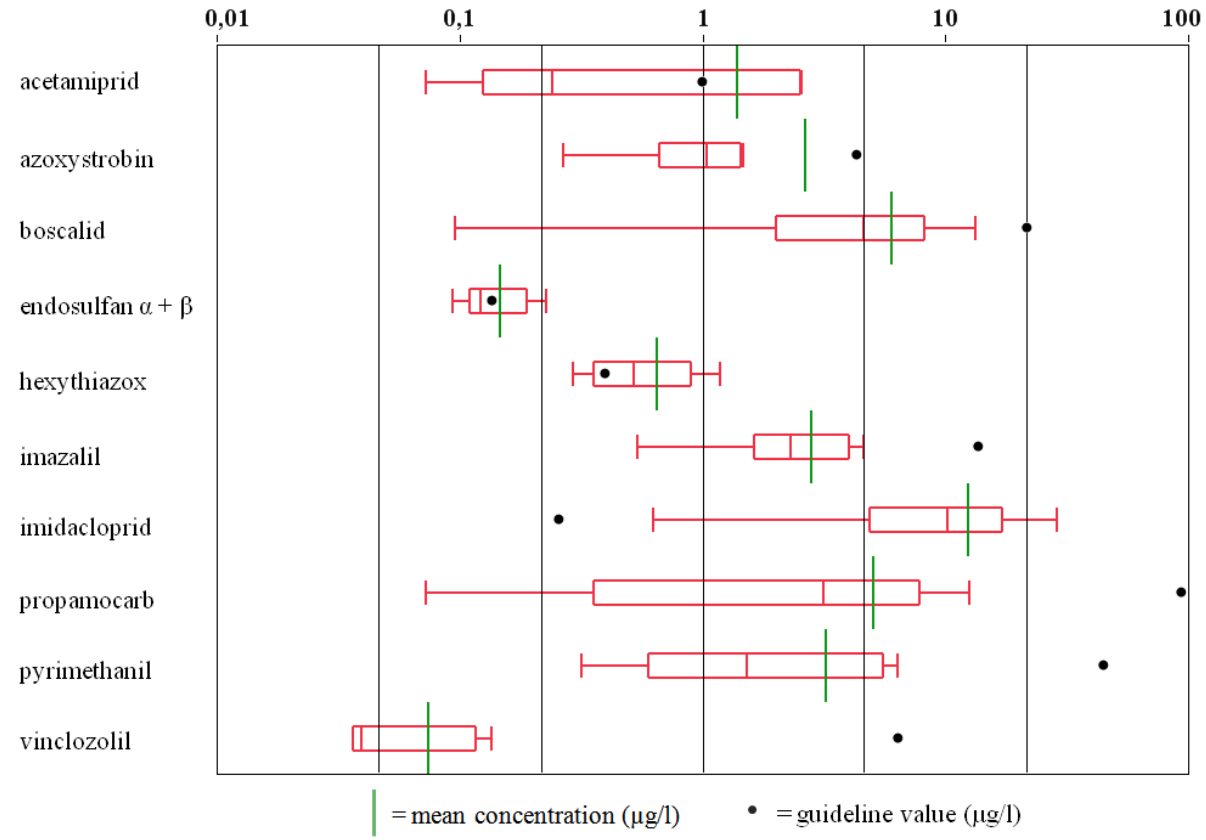

Figure 9. Range of measured concentrations (µg/l) of some crop protection products in water courses draining areas with greenhouse cultivation (W Skåne and NW Skåne) in relation to their guideline values.

In the stream draining the area with greenhouses in NW Skåne, some substances that can be attributed to greenhouse cultivation were detected during the entire season 7 July - 30 September (5 samples, one from a small tributary). The highest concentration of imidacloprid was 15 µg/l in the small tributary and 1.5 µg/l in the main water course. For propamocarb the highest concentration was 1.6 µg/l in the main water course. In this area, samples were also taken from greenhouse effluent water collected in ponds or cisterns for subsequent use in irrigation of neighbouring fields. The results showed that some of the highest concentrations of crop protection products, used on greenhouse crops, detected in this investigation were present in the effluent water leaving the greenhouses.

A somewhat unexpected finding was the detection of the insecticide endosulfan, including its degradation product endosulfan sulfate, and the fungicide vinclozolin in water from the greenhouse areas (**Appendix 3**). The registration of both endosulfan (Cyclodan) and vinclozolin (Ronilan) in Sweden was discontinued over 10 years ago (1995 and 1996, respectively) and are now also banned within the EU. Both substances occur regularly in the rainwater samples taken within national environmental monitoring (Adielsson *et al*., 2008b). The concentrations detected in the present investigation were consistently higher than those reported in rainwater. It was primarily in the water course draining the area in W Skåne with greenhouse cultivation of ornamental plants that elevated concentrations of these two obsolete substances were detected. A possible explanation for these findings is import of seedlings/small plants from countries where the two compounds are still approved for use.

Table 15. Substances that exceeded the relevant guideline value in water samples from horticultural areas during 2008 (not effluent water), with information on current guideline values, the general limit of detection (LOD) of analytical methods, the number of times the substance reached or exceeded the guideline value (GV), the max concentration detected, and the ratio of max concentration to guideline value

Substance	Guideline value (µg/l)	LOD (µg/l)	No. of times ≥ GV	Max conc. (µg/l)	Ratio
acetamiprid (I)	0.1	0.001	2	0.41	4
alpha-cypermethrin (I)	0.001	0.001	2	trace	
azoxystrobin (F)	0.9	0.001	1	3.9	4
cyprodinil (F)	0.2	0.005	1	0.37	2
diflufenican (H)	0.005	0.002	7	0.02	4
endosulfan-beta (I)	0.005	0.0001	3	0.01	2
endosulfan sulfate (D)	0.005	0.0002	8	0.06	12
esfenvalerate (I)	0.0001	0.0005	5	trace	
fenpropimorph (F)	0.2	0.002	1	0.53	3
flupyrsulfuron-methyl (H)	0.05	0.002	1	0.15	3
hexythiazox (I)	0.025	0.001	7	0.13	5
imidacloprid (I)	0.013	0.01	21	15	1154
kresoxim-methyl (F)	0.1	0.001	1	0.13	1
methiocarb (I)	0.016	0.001	3	0.07	4
metribuzin (H)	0.08	0.001	1	4.0	50
picoxystrobin (F)	0.01	0.01	3	0.70	7
pirimicarb (I)	0.09	0.002	2	0.14	2
prochloraz (F)	1.3	0.002	1	2.9	2
prosulfocarb (H)	0.9	0.002	1	1.9	2
prothioconazole-desthio (D)	0.07	0.002	1	0.10	1
rimsulfuron (H)	0.01	0.003	1	0.06	6
terbuthylazine (H)	0.02	0.002	2	0.04	2
DETA (D)	0.02	0.002	1	0.08	4

H = Herbicide; F = Fungicide; I = Insecticide; D = Degradation product (where possible subdivided under parent substance).

The results from this initial investigation of a screening nature show that there is leaching of crop protection products that can be attributed to their use in Swedish greenhouses. Work should therefore be carried out to identify potential risk elements in conjunction with plant protection operations in the greenhouse, with the aim of decreasing losses of crop protection products to neighbouring waters. See also the review carried out by Löfkvist *et al*. (2009) in which a number of risk elements are identified and suitable countermeasures discussed.

9. Assessment according to guidelines for surface water

In Sweden, the Chemicals Agency has produced guidelines for crop protection products in surface water. This list includes around 100 active substances and degradation products (Kemikalieinspektionen, 2009). The guideline value specifies the highest concentration at which no negative effects of a crop protection chemical in surface water can be expected. These values should be regarded as a tool in assessing the environmental quality of Swedish water courses. In 2008 a new EU Directive was issued regarding environmental quality standards within the area of water policy, including norms for *e.g.* 10 crop protection products (EU, 2008).

Table 16. Number of samples in which the guideline value for an individual substance was exceeded in water from the different areas

	Outdoors				Greenhouses		
Substance	SE Småland (n = 9)	NE Skåne (n = 11)	SE Skåne (n = 11)	Halland (n = 21)	W Skåne (n = 7)	NW Skåne (n = 5)	NW Skåne effluent (n = 4)
acetamiprid					2		
alpha-cypermethrin					1	1	1
azoxystrobin						1	2
cyprodinil				1			
diflufenican	2	1			2	2	
endosulfan-beta					3		
endosulfan sulfate					7	1	
esfenvalerate				3	2		
fenpropimorph				1			
flupyrsulfuron-methyl						1	
hexythiazox					6	1	3
imazalil							1
imidacloprid		8	1		7	5	2
kresoxim-methyl						1	
methiocarb					3		
metribuzin				1			
picoxystrobin				3			
pirimicarb				1	1		
prochloraz				1			
prosulfocarb		1					
prothioconazole-desthio				1			
rimsulfuron				1			
terbuthylazine		1			1		
DETA					1		

Since Swedish guideline values are based on the lowest concentration in comparisons of acute and chronic ecotoxicological values, the same method was used in selection of the values from this list. However, for some of the substances included in this investigation there is no Swedish or EU guideline value and therefore guidelines for these were taken from the Netherlands in the first instance, or temporary Swedish guidelines were drawn up. All values used in this investigation and their sources are shown in **Appendix 4**. Of the substances detected on some occasion in this investigation, only mepanipyrim had no guideline value.

For most of the substances investigated the limit of detection was lower than guideline value, *i.e.* below the level at which negative effects of the compound in question can be expected. However, for some substances the limit of detection was higher than the guideline value, which means that for these substances the risk of possible negative effects cannot be stated with complete certainty. In this investigation, the pyrethroids beta-cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, permethrin and tau-fluvalinate, and also fenithrotion, were the compounds with a higher detection limit than their respective guideline (5- to 25-fold higher).

A total of 23 substances (6 herbicides, 6 fungicides, 8 insecticides and 3 degradation products) were detected in the water courses investigated at concentrations above the guideline value on some occasion (**Table 15**). An additional substance (the fungicide imazalil) exceeded the guideline value on one occasion in the greenhouse effluent water tested (**Table 16**).

Table 17. Breakdown by area of the number of substances detected, number of individual detections and number of samples that exceeded the guideline values for crop protection products in surface water in 2008

	Outdoors				Greenhouses		
Substance	SE Småland	NE Skåne	SE Skåne	Halland	W Skåne	NW Skåne	NW Skåne effluent
Total no. of substances ≥ guideline value	1	4	1	9	12	8	5
Total no. of detections# ≥ guideline value	2 (0.2%)	11 (0.8%)	1 (0.1%)	13 (0.5%)	36 (4.1%)	13 (2.1%)	9 (1.8%)
Total no. of samples ≥ guideline value	2 (22%)	9 (82%)	1 (9%)	6 (29%)	7 (100%)	5 (100%)	4 (100%)

Number of possible detections = no. of samples x no. of substances investigated

The substances most commonly detected in concentrations above the guideline value were (in descending order): imidacloprid, endosulfan sulfate, diflufenican, hexythiazox and esfenvalerate (**Table 15**). Imidacloprid was the individual substance that most commonly exceeded the guideline value (0.013 µg/l) in this investigation, exceeding it in all samples from the two greenhouse areas (W Skåne and NW Skåne) (**Figure 9**) and in eight of 11 samples from areas with vegetable crops (NE Skåne) (**Table 16**). Since the entire catchment area was not inventoried in detail, the possibility cannot be excluded that this area (NE Skåne) contained one or several small greenhouse enterprises that could have contributed to the detection of imidacloprid in water from this area during most of the sampling period.

There was a greater number of detections above the guideline value in water from the two greenhouse areas (2-4%) than in water from the four areas that included outdoor vegetable growing (0.1-0.8%) (**Table 17**). All samples of water from the greenhouse areas contained one or more substances at concentrations above the guideline value. In the area with vegetable growing (NE Skåne), the compound imidacloprid made a higher percentage contribution than in the other outdoor vegetable growing areas.

10. Abbreviations

BAM = 2,6-dichlorobenzamide, degradation product of the herbicide dichlobenil.
By-product = substance present in a pesticide in addition to the active ingredient.
DEA = deethylatrazine, degradation product of the herbicide atrazine.
DETA = deethylterbuthylazine, degradation product of the herbicide terbuthylazine.
DIPA = deisopropylatrazine, degradation product of the herbicide atrazine.
Fungicide = product to control fungal diseases.
HCH = hexachlorocyklohexan, group including lindane (gamma-HCH) and its by-product alpha-HCH.
Herbicide = product to control weeds.
Insecticide = product to control insect attacks.
MCPA = active ingredient registered under that name (chemical name is [4-chloro-2-methylphenoxy]acetic acid).
Degradation product = a chemical product formed upon the breakdown of a pesticide.
Trace = substance found in a concentration above the limit of detection (LOD), but below the limit of quantification (LOQ) and therefore not quantified with the normal accuracy.
Plant growth regulator = product to regulate the physiological processes of plants.

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13. Appendices

Appendix 1. Crop protection products used in the different study areas, their active ingredients and type of use.

Appendix 2. Summary of normally applied detection limits in analyses of water samples in 2008.

Appendix 3. Concentrations (µg/l) of pesticide residues detected in horticultural streams, 2008, listed by catchment area and sampling date.

Appendix 4. Guideline values in aquatic environments for the crop protection products analysed.

Appendix 5. Physical-chemical properties of some active ingredients used in fruit and vegetable growing.

Appendix 1. Crop protection products used in the different study areas, their active ingredients and type of use

Area	Product	Active ingredient	Type
SE Småland *(strawberries, cucumber, potatoes)*			
	Acrobat WG	mancozeb #	F
		dimethomorph	
	Aliette 80 WG	fosetyl-aluminium #	F
	Amistar	azoxystrobin	F
	Basta	glufosinate-ammonium #	H
	Betanal SC	phenmedipham	H
	Centium 36 CS	clomazone	H
	Decis	deltamethrin	I
	Epok 600 EC	fluazinam	F
		metalaxyl-M	
	Fastac 50	alpha-cypermethrin	I
	Fenix	aclonifen	H
	Focus Ultra	cycloxydim	H
	Gallery	isoxaben	H
	Goltix WG	metamitron	H
	Matrigon	clopyralid #	H
	Ranman	cyazofamid	F
	Reglone	diquat dibromide #	H
	Round Up	glyphosate #	H
	Rovral 75 WG	iprodion	F
	Select	clethodim	H
	Sencor	metribuzin	H
	Signum	boscalid	F
		pyraclostrobin	
	Switch 62.5 WG	cyprodinil	F
		fludioxonil	
	Teldor WG 50	fenhexamid	F
	Vertimec	abamectin #	I
NE Skåne *(carrots)*			
	Amistar	azoxystrobin	F
	Danadim Progress	dimethoate	I
	Fenix	aclonifen	H
	Roundup	glyphosate #	H
	Signum	boscalid	F
		pyraclostrobin	F
	Stomp SC	pendimethalin	H
SE Skåne *(apples)*			
	Candit	kresoxim-methyl	F
	Delan WG	dithianon #	F
	Scala	pyrimethanil	F
	Signum	boscalid	F
		pyraclostrobin	
	Topsin WG	thiophanate-methyl #	F
W Skåne *(cucumber)*			

Area	Product	Active ingredient	Type
	Confidor WG 70*	imidacloprid	I
	Fungazil 100	imazalil	F
	Previcur N*	propamocarb	F
NW Skåne *(cucumber)*			
	Amistar	azoxystrobin	F
	Confidor WG 70*	imidacloprid	I
	Conserve*	spinosad #	I
	Fungazil 100	imazalil	F
	Nissuron*	hexythiazox	I
	Previcur N*	propamocarb	F
	Scala*	pyrimethanil	F
	Warrant 700 WG*	imidacloprid	I
Halland, N 34 *(onions)*			
	Pyramin DF	chloridazon	H
	Stomp	pendimethalin	H
	Totril	ioxynil	H

= This substance was not included in the analyses.
* = This product is mainly used within greenhouse production (KemI. 2009)
F = Fungicide; H = Herbicide; I = Insecticide.

Appendix 2. Summary of normally applied detection limits in analyses of water samples in 2008

	Limit of detection (LOD) (µg/l) Analytical method no.				Method applied (OMK no.)	
Substance	OMK 49	OMK 50	OMK 51	OMK 57	Area N 34	All other areas
acetamiprid	-	-	-	0.001	57	57
aclonifen	-	-	0.005	-	51	51
alaklor	-	-	0.005	0.01	51	57
alpha-cypermethrin	-	-	0.001	-	51	51
amidosulfuron	0.007	-	-	0.002	49	57
atrazine	-	-	0.003	0.001	51	57
DEA	-	-	0.004	0.002	51	57
DIPA	-	-	-	0.003	57	57
azoxystrobin	-	-	0.01	0.001	51	57
BAM	-	-	0.007	0.003	51	57
benazolin	-	0.005	-	0.01	50	57
bentazone	-	0.004	-	0.003	50	57
beta-cyfluthrin	-	-	0.002	-	51	51
bitertanol	-	-	0.008	0.01	51	57
boscalid	-	-	-	0.001	57	57
carbofuran	-	-	0.004	0.001	51	57
carfentrazone-ethyl	-	-	-	0.002	57	57
carfentrazone acid[#]	0.01	-	-	0.003	49	57
chlorfenvinphos	-	-	0.0002	0.003	51	57
chloridazon	-	-	0.01	0.003	51	57
chlorpyrifos	-	-	0.0002	-	51	51
chlortoluron	-	-	-	0.002	57	57
clethodim	-	-	-	0.001	57	57
clomazone	-	-	-	0.001	57	57
cyanazine	-	-	0.008	0.003	51	57
cyazofamid	-	-	-	0.003	57	57
cycloxydim	-	-	-	0.001	57	57
cyflutrin	-	-	0.001	-	51	51
cypermethrin	-	-	0.003	-	51	51
cyprodinil	-	-	0.002	0.005	51	57
2,4-D	-	0.004	-	0.01	50	57
deltamethrin	-	-	0.002	-	51	51
dichlorprop	-	0.004	-	0.003	50	57
diflubenzuron	-	-	-	0.001	57	57
diflufenican	-	-	0.002	0.002	51	57
dimethoate	-	-	0.009	0.002	51	57
dimethomorph	-	-	-	0.001	57	57
diuron	-	-	0.004	0.002	51	57
endosulfan-alpha	-	-	0.0001	-	51	51
endosulfan-beta	-	-	0.0001	-	51	51
endosulfan sulfate	-	-	0.0002	-	51	51
epoxiconazole	-	-	-	0.003	57	57
esfenvalerate	-	-	0.0005	-	51	51
ethofumesate	-	-	0.005	0.003	51	57
fenarimol	-	-	-	0.01	57	57
fenhexamid	-	-	-	0.001	57	57
fenitrothion	-	-	0.01	0.01	51	57
fenoxaprop-P	-	0.008	-	0.003	50	57
fenpropimorph	-	-	0.004	0.002	51	57

Substance	Limit of detection (LOD) (µg/l) Analytical method no.				Method applied (OMK no.)	
	OMK 49	OMK 50	OMK 51	OMK 57	Area N 34	All other areas
fenpyroximate	-	-	-	0.01	57	57
flamprop	-	0.005	-	0.005	50	57
florasulam	0.025	-	-	0.001	49	57
fluazinam	0.001	-	-	0.002	49	57
fludioxonil	-	-	-	0.003	57	57
flupyrsulfuron-methyl	0.006	-	-	0.002	49	57
fluroxypyr	-	0.006	-	0.01	50	57
flurtamone	-	-	0.01	0.001	51	57
flusilazol	-	-	-	0.002	57	57
flutriafol	-	-	-	0.002	57	57
fuberidazol	-	-	0.007	0.003	51	57
hexazinon	-	-	-	0.001	57	57
hexythiazox	-	-	-	0.001	57	57
imazalil	-	-	0.04	0.003	51	57
imidacloprid	-	-	0.5	0.01	51	57
iodsoulfuron-methyl-Na	0.006	-	-	0.002	49	57
ioxynil	-	-	-	0.001	57	57
iprodion	-	-	0.01	-	51	51
isoproturon	-	-	0.006	0.001	51	57
isoxaben	-	-	-	0.001	57	57
kresoxim-methyl	-	-	-	0.001	57	57
lambda-cyhalothrin	-	-	0.0005	-	51	51
lindane	-	-	0.003	-	51	51
HCH-alpha	-	-	0.0002	-	51	51
linuron	-	-	-	0.003	57	57
MCPA	-	0.004	-	0.003	50	57
mecoprop	-	0.004	-	0.003	50	57
mepanipyrim	-	-	-	0.003	57	57
mesosulfuron-methyl	-	-	-	0.003	57	57
metalaxyl	-	-	0.01	0.002	51	57
metamitron	-	-	0.02	0.001	51	57
metazachlor	-	-	0.005	0.002	51	57
methabenzthiazuron	-	-	-	0.001	57	57
methiocarb	-	-	-	0.001	57	57
metribuzin	-	-	0.005	0.001	51	57
metsulfuron-methyl	0.007	-	-	0.002	49	57
penconazole	-	-	-	0.003	57	57
pendimethalin	-	-	0.006	0.01	51	57
permethrin	-	-	0.01	-	51	51
phenmedipham	-	-	0.08	0.001	51	57
picoxystrobin	-	-	0.01	0.002	51	57
pirimicarb	-	-	0.004	0.002	51	57
prochloraz	-	-	0.01	0.002	51	57
procymidon	-	-	-	0.01	57	57
prometryn	-	-	-	0.002	57	57

Substance	Limit of detection (LOD) (µg/l) Analytical method no.				Method applied (OMK no.)	
	OMK 49	OMK 50	OMK 51	OMK 57	Area N 34	All other areas
propamocarb	-	-	-	0.001	57	57
propiconazole	-	-	0.009	0.003	51	57
propoxycarbazone-Na	-	-	-	0.001	57	57
propyzamide	-	-	0.004	0.003	51	57
prosulfocarb	-	-	0.007	0.002	51	57
prothioconazole	-	-	-	0.01	57	57
prothioconazole-desthio	-	-	-	0.002	57	57
pyraclostrobin	0.006	-	-	0.002	49	57
pyrethrins	-	-	-	0.01	57	57
pyrimethanil	-	-	-	0.002	57	57
quinmerac	-	0.006	-	0.005	50	57
rimsulfuron	0.006	-	-	0.003	49	57
silthiofam	-	-	-	0.003	57	57
simazine	-	-	0.004	0.002	51	57
spiroxamine	-	-	-	0.002	57	57
sulfosulfuron	0.01	-	-	0.002	49	57
tau-fluvalinate	-	-	0.005	-	51	51
tepraloxydim	-	-	-	0.001	57	57
terbuthylazine	-	-	0.003	0.002	51	57
DETA	-	-	0.002	0.002	51	57
terbutryn	-	-	0.005	0.005	51	57
thiacloprid	-	-	-	0.002	57	57
thiamethoxam	-	-	-	0.003	57	57
thifensulfuron-methyl	0.01	-	-	0.003	49	57
tolclofos-methyl	-	-	0.007	-	51	51
tolylfluanid	-	-	-	0.005	57	57
tribenuron-methyl	0.01	-	-	0.002	49	57
trifloxystrobin	-	-	-	0.002	57	57
trifluralin	-	-	0.002	-	51	51
triflusulfuron-methyl	0.01	-	-	0.001	49	57
triticonalzole	-	-	-	0.002	57	57
vinclozolin	-	-	0.0001	-	51	51

[#] = chloropropionic acid.

Appendix 3. Concentrations (µg/l) of pesticide residues detected in horticultural streams, 2008, listed by catchment area and sampling date. Concentrations apply for the date given in all areas except Halland (N 34) where average concentrations during the preceding week are given. Concentrations stated in **bold** equal or exceed the aquatic guideline value (compare **Appendix 4**) and concentrations in *italic* specify a trace value derived using analytical method OMK 57 (compare Chapter 10 and **Appendix 2**). The term "trace" refer to a trace value derived using analytical methods OMK51:5, OMK49:6 and OMK50:8 (compare Chapter 10 and **Appendix 2**). Added concentrations are calculated excluding trace values

Catchment SE Småland (**berries**, mainly strawberries, but also some cucumber and potatoes)

Substance	6 May	12 May	20 May	26 May	2 Jun	9 Jun	16 Jun	8 Jul	25 Aug
atrazine								*0.001*	
DIPA		*0.003*							
azoxystrobin	0.003		0.004	0.005	0.004	*0.002*	0.004	0.04	0.01
BAM	0.01	0.03	0.02	0.05	0.05	0.02	0.05	*0.008*	
bentazone	0.02	0.05	0.02	0.04	0.06	*0.009*	0.06	*0.003*	
boscalid			0.009	0.009	0.007				0.009
clethodim									0.003
cyanazine	0.009		0.006						
diflufenican								***0.009***	***0.009***
fenhexamid			0.008						
fenpropimorph				*0.002*					
imazalil								0.03	*0.007*
isoproturon	0.28	0.10	0.12	0.06	0.04	0.008	0.03	0.02	0.009
isoxaben	*0.001*	*0.001*	*0.002*	*0.001*					0.12
MCPA								*0.005*	0.08
mecoprop	*0.003*	*0.003*			*0.003*	0.008	*0.003*		
mepanipyrim			0.01						
metalaxyl	0.005		0.005					0.003	0.04
metamitron	0.007	0.004	0.006						0.14
metazachlor	0.01	0.03	0.03	0.06	0.08	0.01	0.03		
picoxystrobin						0.002	0.004	0.002	
propamocarb									0.002
prosulfocarb						0.01			*0.006*
prothioconazole-desthio							0.01	0.005	
quinmerac		0.01	0.01	0.04	0.04		0.02		
Added conc. (µg/l)	0.34	0.22	0.25	0.26	0.28	0.06	0.21	0.10	0.41
No. detetctions	10	9	13	9	8	8	9	11	12

Appendix 3 (ctnd)

Catchment NE Skåne (**vegetables**, mainly carrots, but also some onions, strawberries and potatoes)

Substance	14 May	26 May	2 Jun	16 Jun	21 Jul	28 Jul	4 Aug	11 Aug	18 Aug	25 Aug	8 Sep
aclonifen				0.07							
atrazine			0.003	0.003	0.002	0.003	*0.001*	0.002	0.003	*0.001*	0.004
DEA							0.002		0.003		
azoxystrobin	0.02	0.05	0.003	0.008	0.01	0.02	0.09	0.01	0.008	0.02	0.57
BAM	0.01		0.02	0.02	0.01	0.02	*0.008*	0.01	0.02	0.01	0.02
bentazone	0.06	0.06	0.08	0.08	0.05	0.09	0.02	0.04	0.08	0.04	0.07
boscalid	0.02	0.17	0.36	0.01	0.05	0.01	0.03	0.03	0.01	0.04	0.02
chloridazon				*0.007*					*0.004*	*0.003*	
chlorpyrifos									*0.001*		
cyazofamid							*0.02*				
cyprodinil		0.06	0.06	*0.01*	*0.006*						
diflufenican					*0.004*			***0.005***		*0.004*	
dimethoate							0.01	0.004		0.01	
diuron				0.008	*0.003*		0.006		0.01		
ethofumesate					0.03						
fluazinam					*0.004*		0.01			*0.004*	
fludioxonil		0.07	0.04	*0.004*							
fluroxypyr	0.01			0.02						0.05	
flurtamone								0.01	0.005		
hexythiazox						0.003	0.005				
imazalil									*0.005*		
imidacloprid		0.01	**0.01**	**0.01**	**0.02**	**0.02**	**0.68**	0.01	**0.01**	**0.02**	**0.01**
isoproturon	*0.002*	*0.001*	*0.002*	0.005	0.02			*0.003*		*0.002*	*0.002*
isoxaben										*0.001*	
MCPA		0.007	0.01	0.18	*0.007*	*0.004*	0.02		0.02		*0.005*
mecoprop				*0.003*			*0.004*				
metalaxyl			0.003	0.003	0.008	0.006	0.008	0.004	0.004	0.004	0.004
metamitron		0.004	0.14	0.02	4.4	0.09	0.12	0.15	0.07	0.12	0.09
metazachlor											0.005
methabenzthiazuron		*0.002*	*0.002*	*0.002*	*0.002*	*0.002*	0.003				
metribuzin	0.005	0.02	0.02	0.02	0.02	0.01	0.009	0.01	0.01	0.01	0.01
penconazole		*0.003*									0.02
phenmedipham					0.01		0.01				
propamocarb				*0.001*	0.004	0.03	0.07	0.003	0.003	0.003	*0.001*
propiconazole											*0.01*
prosulfocarb		0.10	**1.9**	0.06	0.09						*0.009*
prothioconazole-desthio				0.006							
pyraclostrobin		0.005	0.006				0.006	*0.002*			
pyrimethanil								*0.003*			
simazine							0.14				
terbuthylazine				0.008	0.003		**0.04**	*0.002*	0.002		
DETA				0.007	*0.002*		0.009		*0.002*	*0.002*	
thiacloprid							*0.002*				
tolylfluanid							*0.005*	*0.005*			
Added conc. (µg/l)	0.13	0.56	2.66	0.52	4.73	0.30	1.29	0.28	0.26	0.33	0.82
No. detections	7	14	16	24	22	13	26	18	19	18	16

Appendix 3 (ctnd)

Catchment SE Skåne (**fruit**, mainly apples)

Substance	4 May	11 May	18 May	25 May	1 Jun	8 Jun	16 Jun	22 Jun	20 Jul	3 Aug	24 Aug
acetamiprid		*0.001*						*0.001*			
atrazine		0.002		*0.002*	0.003		0.003			0.004	
DEA				0.004	0.007	0.002	0.004			0.007	
DIPA				*0.003*							
azoxystrobin									0.006	0.003	*0.001*
BAM	0.01	0.01	0.01		0.02	*0.007*	*0.009*	*0.008*	*0.009*	0.01	0.01
boscalid	0.004		0.003	0.006	0.005		0.003		0.003	0.005	0.03
chloridazon				*0.009*							*0.004*
dichlorprop	0.005	0.006		0.02						*0.003*	0.007
diuron									0.005		
endosulfan sulfate											trace
fluroxypyr											0.01
imazalil									*0.003*		
imidacloprid											**0.03**
kresoxim-methyl					0.006		*0.003*	*0.003*	0.006		
MCPA			0.03	0.02							0.05
mecoprop	0.008	*0.004*	*0.003*	0.007	*0.003*			*0.003*			*0.003*
penconazole							*0.003*				
pirimicarb											0.002
propamocarb											0.01
propiconazole					0.05	0.02	*0.006*				
prosulfocarb						0.05					
pyrimethanil	0.01				0.004			0.004			
simazine	*0.003*	*0.003*	*0.002*	*0.002*	*0.002*		*0.002*	*0.003*		*0.004*	*0.002*
Added conc. (µg/l)	0.04	0.02	0.04	0.06	0.10	0.07	0.01	0.004	0.02	0.03	0.15
No. detections	6	6	5	9	9	4	8	6	6	7	13

Appendix 3 (ctnd)

Catchment Halland (N 34, **vegetables**)

Substans	5 May	12 May	19 May	26 May	1 Jun	9 Jun	16 Jun	23 Jun	30 Jun	7 Jul	14 Jul
aclonifen								trace			
amidosulfuron				trace	0.07						
atrazine	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace
DEA	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace
DIPA											
BAM		trace	trace		trace	trace	trace	trace	trace	trace	trace
bentazone	0.04	0.03	0.04	0.05	0.16	0.28	0.04	0.04	0.06	0.04	0.04
boscalid									0.005		
carfentrazone acid					0.09						
chloridazon										trace	trace
chlorpyrifos											
cyazofamid											
cyprodinil		**0.37**	trace	trace	trace	trace	trace	trace	trace	trace	trace
diflufenican	trace						trace	trace			trace
dimethomorph											
esfenvalerate						**trace**	**trace**		**trace**		
ethofumesate				trace	trace	trace	trace	trace	trace		trace
fenpropimorph				0.13	**0.53**	trace	trace	trace	0.09	trace	trace
fluazinam									0.10	0.007	0.007
fluroxypyr		0.13	trace	0.03	0.04	trace	0.06	trace	trace	trace	trace
isoproturon	0.13			trace			trace				
MCPA			0.04	trace	0.02	0.02	0.18	0.11	0.04	trace	trace
mecoprop	0.19	0.25	0.30	0.34	0.58	0.68	0.41	0.34	0.50	0.45	0.28
metalaxyl	trace	trace	trace	trace	trace	trace	trace	trace	0.20	trace	0.07
metamitron		0.06	0.05			0.08	3.0	0.05	trace		trace
metazachlor											
metribuzin	trace	trace	trace	trace	**4.0**	0.07	trace	0.05	trace	trace	0.08
phenmedipham							0.23				
picoxystrobin						**0.20**		**0.70**	**0.10**	trace	
pirimicarb							trace	trace	**0.14**	trace	
prochloraz								**2.9**	0.46	trace	trace
propamocarb	*0.001*							0.81	0.01	0.02	0.008
propiconazole		0.13		0.09	0.22	trace	trace	trace	trace		trace
prosulfocarb											
prothioconazole						trace					
prothioconazole-desthio						**0.10**	0.01				
pyrimethanil											
quinmerac											
rimsulfuron						**0.06**					
terbuthylazine	trace							trace	trace		trace
DETA	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace
thifensulfuron-methyl					0.04		trace				
tolylfluanid					*0.008*						
tribenuron-methyl					trace						
Added conc. (µg/l)	0,36	0,97	0,43	0,64	5,75	1,49	3,93	5,00	1,71	0,52	0,49
No. detections	11	12	12	15	19	20	22	22	23	18	21

Appendix 3 (ctnd)

Catchment Halland (N 34, **vegetables**)

Substance	21 Jul	28 Jul	1 Sep	8 Sep	15 Sep	22 Sep	29 Sep	6 Oct	13 Oct	20 Oct
aclonifen										
amidosulfuron										
atrazine	0.02	0.02	trace	trace	trace	trace	trace	trace	trace	trace
DEA	trace	trace		trace	trace	trace	trace	trace	trace	trace
DIPA		*0.004*								
BAM	trace	trace				trace	trace			
bentazone	0.04	0.04	0.06	0.04	0.03	0.03	0.03	0.03	0.04	0.03
boscalid					0.007		0.004			0.002
carfentrazone acid										
chloridazon										
chlorpyrifos								trace		
cyazofamid		*0.004*	*0.01*							
cyprodinil	trace									
diflufenican	trace							trace		trace
dimethomorph							0.009			
esfenvalerate										
ethofumesate	0.03									
fenpropimorph								trace		
fluazinam										
fluroxypyr										
isoproturon									trace	0.20
MCPA	trace	trace	0.09	0.02						
mecoprop	0.32	0.32	0.13	0.26	0.24	0.36	0.33	0.13	0.13	0.10
metalaxyl	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace
metamitron								trace		
metazachlor				trace	trace			0.06	trace	trace
metribuzin	0.05	trace	trace	trace	trace	trace		trace	trace	trace
phenmedipham										
picoxystrobin										
pirimicarb										
prochloraz	trace									
propamocarb	0.02	0.004	0.003	trace	0.005	trace	0.02	trace	trace	0.02
propiconazole										
prosulfocarb										trace
prothioconazole		0.04	trace							
prothioconazole-desthio										
pyrimethanil							trace			
quinmerac								0.07	trace	0.06
rimsulfuron										
terbuthylazine	trace									
DETA	trace	trace	trace	trace	trace	trace	trace	trace		trace
thifensulfuron-methyl										
tolylfluanid										
tribenuron-methyl										
Added conc. (µg/l)	0.48	0.42	0.28	0.32	0.28	0.39	0.39	0.29	0.17	0.41
No. detections	15	13	10	10	10	9	11	14	10	14

Appendix 3 (ctnd)

Catchment W Skåne (**greenhouses** with ornamental plants and cucumber)

Substans	25 Jun	2 Jul	28 Jul	19 Aug	10 Sep	23 Sep	14 Oct
acetamiprid			0.002	0.01	**0.41**	**0.40**	0.007
alpha-cypermethrin		**trace**		trace	trace	trace	
azoxystrobin	0.12	0.18	0.16	0.13	0.10	0.05	0.07
BAM	*0.009*	0.01	*0.005*	0.02	0.03	0.01	0.03
bitertanol				0.02		0.04	
boscalid	1.0	1.1	4.9	3.4	0.88	1.0	2.0
chloridazon			*0.003*				
chlorpyrifos				trace			
DEA					0.003		
diflufenican			**0.01**				**0.02**
dimethomorph	0.05	0.05	0.01	0.03	0.15	1.5	0.17
endosulfan-alpha	trace	trace	trace	trace	trace	0.004	trace
endosulfan-beta	0.004	trace	trace	**0.006**	**0.009**	**0.01**	0.004
endosulfan sulfate	**0.01**	**0.009**	**0.01**	**0.03**	**0.06**	**0.05**	**0.03**
esfenvalerate			**trace**			**trace**	
fenpropimorph			0.006				
hexythiazox	**0.08**	**0.10**	**0.13**	**0.03**	0.02	**0.03**	**0.04**
imazalil	0.76	1.0	0.81	0.53	0.26	0.21	0.25
imidacloprid	**3.9**	**4.2**	**9.6**	**7.7**	**5.2**	**1.7**	**2.6**
isoproturon	*0.002*	0.005	*0.004*	*0.003*	*0.004*	*0.003*	0.09
kresoxim-methyl	0.03	0.05	0.09	0.04	*0.002*	0.04	0.04
MCPA			*0.009*	*0.004*			*0.004*
mecoprop	*0.003*	0.005					*0.004*
metalaxyl	*0.002*	0.003		0.04	0.01	0.003	0.002
metazachlor	0.006	0.01	0.003	0.01	0.03	0.05	0.02
methabenzthiazuron	0.003	0.006	0.003				0.006
methiocarb	**0.02**	**0.07**	*0.001*	**0.04**	0.005		*0.001*
penconazole		*0.003*					
picoxystrobin	0.005	0.002					
pirimicarb	0.006	0.02	0.01	0.03	**0.10**	0.01	0.03
prochloraz	0.04	0.02		*0.005*			
propamocarb	0.37	0.22	0.75	2.6	1.2	2.4	4.5
propiconazole	*0.003*	*0.005*	0.02				
prosulfocarb							0.12
prothioconazole-desthio			*0.004*				
pyrimethanil	0.02	0.05	0.79	0.19	0.11	1.3	1.6
quinmerac	0.02	0.03	0.01		0.04	0.04	0.09
simazine					*0.002*		
terbuthylazine	0.002		0.004	0.005	**0.04**	0.003	0.005
DETA	0.004	0.003	0.02	0.009	**0.08**	0.005	0.009
thiamethoxam				0.16	0.04	*0.005*	
tolylfluanid			*0.008*				
vinclozolin	0.005	0.003	trace	-	0.0007	0.0007	0.0008
Added conc. (µg/l)	6.46	7.15	17.34	15.03	8.78	8.86	11.73
No. detections	27	28	31	28	27	26	28

- = Not analysed.

Appendix 3 (ctnd)

Catchment NW Skåne (**greenhouses** with cucumber and tomatoes)

Substans	7 Jul #	17 Jul	12 Aug	27 Aug	30 Sep
alpha-cypermethrin	**trace**		trace		
amidosulfuron				*0.003*	
atrazine			0.002		
azoxystrobin	**3.9**	0.42	0.06	0.01	0.03
BAM	*0.007*	*0.009*	0.02	0.02	0.02
bentazone		0.01	0.01	*0.01*	*0.01*
boscalid			0.003	0.37	0.04
carbofuran				0.008	
chloridazon				0.01	
dichlorprop			0.29	0.007	*0.004*
diflufenican		***0.008***	**0.01**		
endosulfan-alpha			trace	trace	0.004
endosulfan-beta			trace	trace	0.003
endosulfan sulfate		0.003	trace	trace	**0.006**
ethofumesate			0.04		0.04
flupyrsulfuron-methyl					**0.15**
fluroxypyr			0.03	0.07	
flurtamone			0.002	*0.001*	0.04
hexythiazox	**0.05**			0.016	
imazalil	0.88	0.07	0.04	0.35	*0.02*
imidacloprid	**15**	**0.94**	**1.5**	**0.12**	**0.05**
isoproturon		*0.003*	0.01	0.007	0.01
kresoxim-methyl				**0.13**	
MCPA		*0.005*	0.23	0.01	*0.004*
mecoprop			0.26	0.006	0.007
metalaxyl		0.003	0.008	0.01	0.003
metamitron			0.07	0.06	0.13
metazachlor				0.002	0.15
metribuzin				0.005	
metsulfuron-methyl			*0.002*		
picoxystrobin			0.002		
pirimicarb			0.003	0.002	
propamocarb	0.002	0.02	1.6	0.02	0.02
propiconazole			0.009		
propoxycarbazone-Na			0.02	0.005	
quinmerac					0.07
terbuthylazine	0.003				0.003
DETA	0.004				0.005
thiamethoxam			*0.003*		
tolylfluanid			*0.005*		
Added conc. (µg/l)	19.84	1.46	4.22	1.24	0.78
No. detections	9	11	29	27	23

The sample on 7 July was collected in a small tributary to the main water course (i.e. closer to three of the greenhouses).

Appendix 3 (ctnd)

Catchment NW Skåne (**effluent water** from greenhouses)

	Pond A	Pond Ba	Pond Bb	Cistern
	7	7	12	12
Substance	Jul	Jul	Aug	Aug
alpha-cypermethrin	**0.01**			
azoxystrobin	**19**	0.20	0.009	**2.5**
BAM				0.01
boscalid			0.004	
clomazone			*0.001*	
fenpropimorph	0.007			
hexythiazox	**0.06**	**0.05**	0.008	**0.07**
imazalil	**17**	0.27		2.0
imidacloprid	**34**			**89**
isoproturon			*0.001*	
linuron			0.01	
MCPA			0.01	trace
metalaxyl			0.02	
metazachlor		0.003	0.03	
propamocarb	0.006		*0.001*	0.52
prothioconazole-desthio			*0.004*	
pyrimethanil		0.05	0.07	
spiroxamin	*0.002*			
terbuthylazine			0.003	0.006
DETA			0.01	0.005
tolylfluanid			*0.005*	
vinclozolin	-	trace	-	trace
Added conc. (µg/l)	70.08	0.57	0.17	94.11
No. detections	8	6	15	10

- = Not analysed.

Appendix 4. Guideline values for plant protection products in the aquatic environment. If not otherwise stated the value presented is the one given by the Swedish Chemicals Agency (Kemikalieinspektionen, 2009)

Substance	Guideline value (µg/l)
acetamiprid [a]	0.1
aclonifen	0.2
alaklor*	0.3
alpha-cypermethrin	0.001
amidosulfuron	0.2
atrazine*	0.6
DEA [f]	0.6
DIPA [a]	0.1
azoxystrobin	0.9
BAM [b]	1000
benazolin [b]	325
bentazone	30
beta-cyfluthrin	0.0001
bitertanol	0.3
boscalid [a]	10
carbofuran	0.3
carfentrazone-ethyl	0.06
carfentrazone acid [d]	0.8
chlorfenvinphos*	0.1
chloridazon	10
chlorotoluron	missing
chlorpyrifos*	0.03
clethodim	10
clomazone [a]	5
cyanazine	1
cyazofamid	1
cycloxydim [b]	2.6
cyflutrin [b]	0.0014
cypermethrin	0.0002
cyprodinil	0.2
2,4-D [b]	26
deltamethrin	0.0002
diflubenzuron	0.004
diflufenican	0.005
dichlorprop	10
dimethoate	0.7
dimethomorph	2
diuron*	0.2
endosulfan*#	0.005
endosulfan sulfate [f]	0.005
epoxiconazole	missing
esfenvalerate	0.0001
ethofumesate	30
fenarimol	missing
fenhexamid	10
fenitrothion	0.009
fenoxaprop-P	2
fenpropimorph	0.2
fenpyroximate	missing
flamprop [c]	19
florasulam	0.01
fluazinam	0.4
fludioxonil	0.98
flupyrsulfuronmetyl	0.05
fluroxypyr (acid)	100
flurtamone	0.1

Substance	Guideline value (µg/l)
flusilazol	missing
flutriafol	missing
fuberidazol	missing
hexazinon [b]	0.56
hexythiazox [b]	0.025
imazalil	5
imidacloprid [b]	0.013
iodsoulfuron-methyl-Na [b]	24
ioxynil [b]	0.044
iprodion	0.2
isoproturon*	0.3
isoxaben	0.7
kresoxim-methyl	0.1
lambda-cyhalothrin	0.006
lindane (HCH) * #	0.02
MCPA	1
mecoprop	20
mepanipyrim	missing
mesosulfuron-methyl [a]	0.006
metalaxyl	60
metamitron	10
metazachlor	0.2
methabenzthiazuron	1
methiocarb [b]	0.016
metribuzin	0.08
metsulfuron-methyl	0.02
penconazole	0.7
pendimethalin	0.1
permetrin [b]	0.0003
phenmedipham	2
picoxystrobin [a]	0.01
pirimicarb	0.09
prochloraz [b]	1.3
procymidon	missing
prometryn	missing
propamocarb	90
propiconazole	7
propoxycarbazone-Na [b]	53
propyzamide	10
prosulfocarb	0.9
prothioconazole [a]	10
prothioconazole-desthio [a]	0.3
pyraclostrobin [a]	0.01
pyrethrins [b]	0.25
pyrimethanil	30
quinmerac	100
rimsulfuron	0.01
silthiofam [a]	9
simazine*	1
spiroxamine	0.03
sulfosulfuron	0.05
tau-fluvalinate	0.0002
tepraloxydim [a]	70
terbuthylazine	0.02
DETA [f]	0.02
terbutryn [b]	0.05

Substance	Guideline value (µg/l)
thiacloprid [b]	0.025
thiamethoxam [a]	0.2
thifensulfuron-methyl	0.05
tolclofos-methyl	1
tolylfluanid	0.2
tribenuron-methyl	0.1
trifloxystrobin [b]	0.054
trifluralin*	0.03
triflusulfuron-methyl	0.03
triticonalzole	1
vinclozolin [b]	1.6

* = Environmental Quality Standard (EQS) expressed as an annual average value (AA-EQS) for inland surface waters according (EU, 2008). The maximum allowable concentration (MAC-EQS) is normally 2-5 times higher.

= Applies to the total concentration of all isomers.

[a] = Temporary guideline value according to Andersson et al., 2009.

[b] = Dutch guideline value according to Otte & Evers, 2005, and Schraps *et al*., 2006.

[c] = Norwegian guideline value according to Ludvigsen & Lode, 2005.

[d] = Chloropropionic acid.

[f] = In the absence of any guideline value given by the above sources it was assumed that the degradation product has the same guideline value as the mother compound according to Asp & Kreuger, 2005.

Appendix 5. Physical-chemical properties of some active ingredients used in fruit and vegetable growing (those not included in the national monitoring programme)

Substance	Type	CAS nr	Water solubility (mg/l)	log P_{ow}	Vapour pressure (mPa)	Soil DT_{50} field (days)	K_{oc} (ml/g)
acetamiprid	I	135410-20-7	2950	0.8	0.0002	3	107
boscalid	F	188425-85-6	4.6	3.0	0.0007	200	809
cyazofamid	F	120116-88-3	0.1	3.2	0.01	5	1780
cycloxydim	H	101205-02-1	53	1.4	0.01	5	59
diflubenzuron	I	35367-38-5	0.08	3.9	0.0001	3	4620
dimethomorph	F	110488-70-5	29	2.7	0.001	44	348
fenhexamid	F	126833-17-8	20	3.5	0.0004	1	475
fenpyroximate	I	134098-61-6	0.02	5.0	0.01	4	52067
fludioxonil	F	131341-86-1	1.8	4.1	0.0004	21	75000
hexythiazox	I	78587-05-0	0.1	2.7	0.001	18	6188
isoxaben	H	82558-50-7	1.0	3.9	0.0006	123	354
clethodim	H	99129-21-2	5450	4.1	0.01	3	40
clomazone	H	81777-89-1	1102	2.5	19.2	43	287
kresoxim-methyl	F	143390-89-0	2	3.4	0.002	16	308
mepanipyrim	F	110235-47-7	2.1	3.3	0.02	57	874
methiocarb	I	2032-65-7	27	3.2	0.02	35	660
pyrethrins	I	8003-34-7	0.001	5.9	0.001	12	100000
pyrimethanil	F	53112-28-0	121	2.8	1.1	30	301
tepraloxydim	H	149979-41-9	430	0.2	0.01	63	20
thiacloprid	I	111988-49-9	184	1.3	0.0000003	18	615

Source: PPDB, 2009.

Apple orchard (Photo: Sven-Axel Svensson)

Distribution

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