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Acute Aquatic Risk Indicator for Pesticides

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ABSTRACT

Since the introduction of the Multi Year Crop Protection Plan in the Netherlands the amount of pesticides used in the Netherlands has decreased with approximately 50%. One of the questions raised some years ago was: does a substantial decrease of the amount of pesticides used by the farmers have a proportional enhancement in the quality of the aquatic environment. To answer the raised question an indicator for the acute risk of pesticides in the aquatic environment was developed. This indicator is the quotient of the predicted environmental concentration and the toxicity for a certain group of organisms, which is scaled for the area treated with a compound and includes all the pesticides used since 1984. The risk for algae and daphnids has declined by 40% and for fish by 15%. Less than 20 pesticides accounted for approximately 85% of the height of the indicator.

SAMENVATTING

De acute aquatische risico-indicator voor bestrijdingsmiddelen kan beschouwd worden als een indicator voor de toxische druk van bestrijdingsmiddelen op het aquatische milieu. De indicator is gebaseerd op alle bestrijdingsmiddelen die in Nederland gebruikt worden of werden sinds 1984. Voor elk bestrijdingsmiddel werd het quotiënt van de voorspelde concentratie (PEC) in het oppervlaktewater en de toxiciteit voor een bepaalde groep van waterorganismen, vermenigvuldigd met de relatieve oppervlakte waarop de stof werd toegepast (ten opzichte van al het met bestrijdings-middelen behandeld agrarisch areaal). De indicator is berekend voor elk jaar sinds het in werking treden van het MJPG. De druk op algen en daphnia's is verminderd met 40% en voor vissen met 15%. Minder dan twintig bestrijdingsmiddelen zijn verantwoordelijk voor ongeveer 85% van de hoogte van de indicator. De bestrijdingsmiddelen die met meer dan 10% bijdragen aan de indicator waarde zijn fentin-acetaat en monolinuron bij de algen, fentin-acetaat, ethyl-parathion en fosalone bij de daphnia's en captan en lambda-cyhalothrin bij de vissen. De grootste winst voor het aquatische milieu kan bereikt worden door deze bestrijdings-middelen niet meer te gebruiken en te vervangen door bestrijdingsmiddelen met een lagere PEC/TOX verhouding te hebben.

SUMMARY

The Acute Aquatic Risk Indicator for Pesticides can be considered as an indicator for the effects of pesticides on the aquatic ecosystem or on particular groups of species (e.g. algae, daphnids or fish). This indicator is based on all the pesticides that are used in the Netherlands or were used since 1984. For every compound the quotient of the predicted environmental concentration and the toxicity for a certain group of organisms is multiplied by the relative area treated with a compound. The indicator value is calculated for every year since the introduction of the Multi Year Crop Protection Plan in the Netherlands.

The risk for algae and daphnids has declined by 40% and for fish by 15%. Less than 20 pesticides accounted for approximately 85% of the height of the indicator. The pesticides that contributed in 1996 more than 10% to the indicator value for algae are fentin-acetate and monolinuron, for daphnids fentin-acetate, parathion (ethyl) and phosalone and for fish captan and lambda-cyhalothrin. The greatest benefit for the aquatic ecosystem can be obtained by abondoning the use of these pesticides, even in case other pesticides are used, provided that their PEC/TOX quotients are lower.

1. INTRODUCTION

Since the introduction of the Multi Year Crop Protection Plan in the Netherlands the amount of pesticides used in the Netherlands has decreased with approximately 50% (Figure 1). One of the questions raised some years ago was: does a substantial decrease of the amount of pesticides used by the farmers have a proportional enhancement in the quality of the aquatic environment. In the first instance two arguments were found that were pointing in another direction. First, the decline (50% according to the NEFYTO) in kilograms can be attributed for the main part to the decrease in use of two soil fumigants (metam-sodium and 1,3-dichloropropene). These fumigants are hardly influencing the quality of the adjacent surface water (ditches) because they are injected into the soil and have a high volatility. Second, old pesticides (mostly broad spectrum compounds with high dosages) are replaced by modern pesticides (more specific working mechanisms and relative highly toxic). To answer the raised question an indicator for the acute risk of pesticides in the aquatic environment was developed. This indicator is the quotient of the predicted environmental concentration and the toxicity for a certain group of organisms, which is scaled for the area treated with a compound:

$$\frac{PEC}{TOX} * \frac{\text{Area treated with 1 compound}}{\text{Area treated with all compounds}}$$

In 1997 this risk indicator was based on 31 of the pesticides used in the Netherlands (Milieubalans, 1997). In this report the risk indicator includes all the pesticides used since 1984.

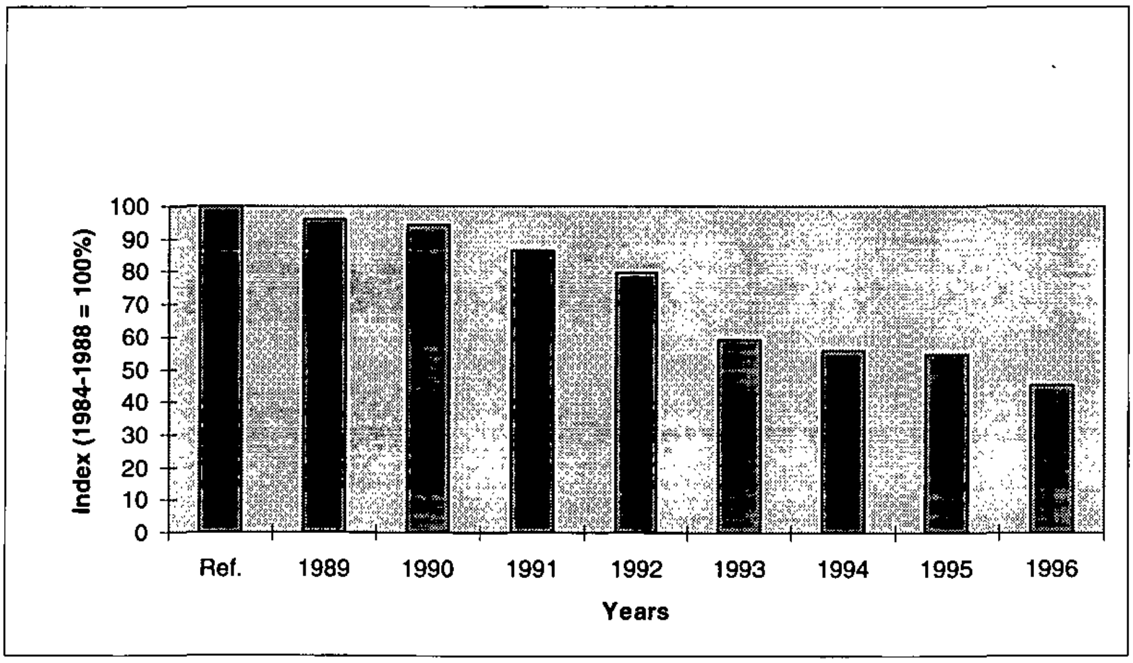

Figure 1 Total use of agricultural pesticides in the Netherlands according to the NEFYTO (see also chapter 2.4.). The reference period is defined as the average tonnage of 1984 to 1988, which is indexated at 100%.

2. METHOD

2.1. Toxicity

Data were collected for algae (EC50), daphnids (E(L)C50) and fish (LC50). In principle the data available at the Centre of Substances and Risk assessment (CSR) of the National Institute of Public Health and the Environment were used (files, handbooks and reports). These data were complemented with data from the data base AQUIRE. When more than one data was available for one of the groups (e.g. algae) for one pesticide the geometric mean was used in the calculation of the risk indicators. Sometimes for algae only a NOEC value was available. This value was extrapolated to an EC50 value by using the following relationship: NOEC = EC50/3.
When no data were available for a certain pesticide the geometric mean of the chemical family (according to the Pesticide Handbook) was used (see compound x in Table 1) and when no data for the chemical family were available the geometric mean of the pesticide group was used (e.g. insecticide or fungicide, see compound y in Table 1).

Table 1 Example calculation for missing toxicity data.

Compound	Chemical family	Pesticide group	Reported value	Extrapolated value
Compound 1	Urea	Herbicide	25	-
Compound 2	Urea	Herbicide	47	-
Compound 3	Urea	Herbicide	34	-
Compound 4	Urea	Herbicide	112	-
Compound 5	Sulfonanilide	Herbicide	234	-
Compound 6	Sulfonanilide	Herbicide	345	-
Compound 7	Sulfonanilide	Herbicide	96	-
Compound x	Urea	Herbicide	??	46#
Compound y	Benzofuran	Herbicide	??	86*

= average value of ureas, * = average value of herbicides.

2.2 Drift and dosage

The DLO Winand Staring Centre (Wageningen, The Netherlands) provided estimates (calculated with ISBEST 3.0) of the mean drift percentage (see appendix) and the mean dosage for a number of pesticides. The calculation procedure takes into account the use on different crops (with different drift percentages), the use indoors (no drift to surface water) and the application methods and is not based on measurements.
The indicator is based on 297 pesticides that were or are still used in the Netherlands in the period 1984 to 1996. However, ISBEST 3.0 could only provide data for 206 pesticides. When no data were available for a pesticide (91 pesticides) this gap was filled in the same way as was done for the missing toxicity data. When no data were available for a certain compound the geometric mean of the chemical family (according to the Pesticide Handbook) was used and when no data for the chemical family were available the geometric mean of the pesticide group was used.

2.3. Predicted Environmental Concentration (PEC)

The percentage of drift was used to estimate the concentration in the Dutch standard ditch. The standard ditch is defined to be adjacent to the sprayed field, with a width and a depth of 1.0 and 0.25 meter, respectively. The dosage for the PEC calculation is expressed in mg/m^2. When the dosage is 20 mg/m^2 and the drift is 5% the PEC in the ditch will be (20 * 0.05) / 250 = 0.004 mg/l.

2.4. Sales data

Data on the amount of agricultural pesticides (kg) sold in the Netherlands are available at the Plant Protection Service (Wageningen, The Netherlands). These data are confidential. However, they can be used for calculations, but it is not allowed to publish them in this report. The sales data are partly provided by the NEFYTO. The period 1984 to 1988 is used as the starting point/reference period of the Multi Year Crop Protection Plan. Since 1992 the data of the NEFYTO are adjusted by the Plant Protection Service for the proportion of the market that is not represented by the NEFYTO (in 1992 9%, in 1993 15%, in 1994 18%, and in 1995 and 1996 16%). For the calculation of the acute aquatic risk indicator values the adjusted data are used.

2.5. Acute aquatic risk indicator

With the mean application rate and the sales data (kilograms sold in the Netherlands) it is possible to calculate the numbers of hectares that have been treated by one product in one year. No correction has been made for repeated applications. For every compound the PEC/L(E)C50 was calculated. This quotient was multiplied by the area treated with the compound divided by the area treated with all compounds (an example is given in Table 2). The indicator value was calculated for every year since the reference period (1984 to 1988) for daphnids, algae and fish. For the reference period the mean yearly value for this period was used and indexated at 100%. The other years (1989 to 1996) are expressed in percentages of this reference value.

Table 2 Description of the calculation of the Indicator value.

Compound 1	$(PEC_{c1} / LC50_{c1}) * (AREA_{c1} / AREA_{total}) = OUTCOME_{c1}$
Compound 2	$(PEC_{c2} / LC50_{c2}) * (AREA_{c2} / AREA_{total}) = OUTCOME_{c2}$
....	.... = +
Compound n	$(PEC_{cn} / LC50_{cn}) * (AREA_{cn} / AREA_{total}) = OUTCOME_{cn}$
Σ all compounds	= Indicator value

3. RESULTS

3.1. Toxicity data

For the 297 compounds causing drift (compounds with no drift to surface water were omitted) 5391 toxicity data were found: for algae 306 (69% of the compounds), for daphnids 1427 (90% of the compounds) and for fish 3658 (99% of the compounds, only two compounds were missing). On average the geometric means, the values used in the calculation for the risk indicators, for algae, daphnids and fish, are based on 0.8, 3.6 and 9.2 toxicity tests, respectively. In the appendix the number of toxicity studies found for each compound for algae, daphnids and fish are presented. A summary of this information can be found in Figure 2.

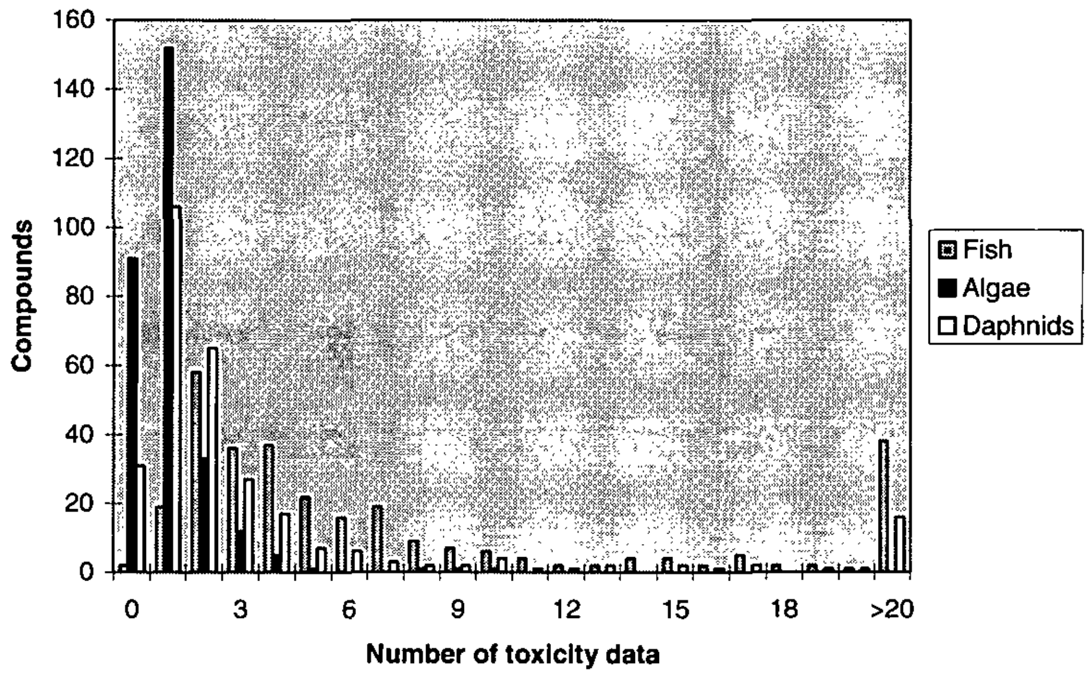

Figure 2 Number of available toxicity data for a compound for algae, daphnids and fish

In Table 3 the toxicity ranking (top 20 compounds) is presented for every group (algae, daphnids and fish). For algae the toxicity is ranging between 0.00087 mg/l for the most toxic pesticide (permethrin) and 30000 mg/l for TCA. For daphnids the most toxic pesticide is bifenthrin with 0.00013 mg/l and 4347 mg/l for TCA. For fish the most toxic pesticide is also bifenthrin with 0.00023 mg/l and 5946 for dikegulac-sodium.

For five of the 20 pesticides (cyhexatin, fenbutatinoxide, fentin-acetate, paraquat-dichloride and bromacil) with the highest toxicity for algae the toxicity value is extrapolated as described in the chapter 2.1.

Table 3 Geometric mean toxicity data for the 20 most toxic compounds for every group of organisms (* = estimated, no toxicity data for species group available).

Algae	mg/l	Daphnids	mg/l	Fish	mg/l
Permethrin	0.00087	Bifenthrin	0.00013	Bifenthrin	0.00023
Carbaryl	0.001	Alpha-cypermethrin	0.00017	Flucythirate	0.00047
Monolinuron	0.001	Esfenvalerate	0.00026	Lambda-cyhalothrin	0.00085
Cyhexatin*	0.002	Cyfluthrin	0.00030	Cyhalothrin	0.0009
Fenbutatinoxide*	0.002	Cyhalothrin	0.00034	Esvenfalerate	0.0014
Fentin-acetate*	0.002	Trichlorephon	0.00044	Cyfluthrin	0.0021
Fentin-hydroxide	0.002	Lambda-cyhalothrin	0.00046	Fenvalerate	0.0021
Metribuzin	0.0032	Fenpropathrin	0.00053	Deltamethrin	0.0022
Esfenvalerate	0.0051	Azamethiphos	0.00067	Alpha-cypermethrin	0.0028
Propyzamide	0.0055	Phosalone	0.00069	Fenpropathrin	0.0030
Diquat-dibromide	0.011	Fenvalerate	0.00073	Fluvalinate	0.0031
Paraquat-dichloride*	0.011	Terbuphos	0.00098	Trichlorophon	0.0047
Tri-allate	0.0112	Flucycloxuron	0.00109	Abamectine	0.0051
Bromacil*	0.012	Dichlorvos	0.00122	Endrin	0.0056
Lenacil	0.012	Chlorfenvinphos	0.00141	Permethrin	0.0066
Parathion (ethyl)	0.015	Azinphos-methyl	0.00146	Azocyclotin	0.0072
Diflubenzuron	0.015	Deltamethrin	0.00157	Dinoseb-acetate	0.0095
Chlorbromuron	0.017	Abamectine	0.00218	Dinoterb	0.0149
Methabenzthiazuron	0.018	Heptenophos	0.0022	Fenothrin	0.0175
Cyanazin	0.019	Permethrin	0.0024	Carbaryl	0.019

3.2. Size of application areas

In Table 4 the percentages of the total area treated with pesticides for a certain compound is given for the reference period and for 1996 (only the 15 compounds with highest % of the total area). The average 'total' area was 12.4 million hectares in the reference period (11.5 - 13.1 million hectares) and 14.6 million hectares in 1996. In practise the number of hectares are smaller, because sometimes a compound is used more than 1 time on a hectare and some hectares are treated with more than one active ingredient, either simultaneously or at different times in the year.

3.3. Acute aquatic risk indicators

In Figure 3 the aquatic risk indicator is presented for the acute local situation for fish, daphnids and algae. The risk for algae and daphnids has declined by 40% and the risk for fish only by 15%.

The sharp drop for fish in 1990 is caused by the ban of dinoseb in that year. The decrease over the years of the risk for daphnids and algae can be attributed to a drop in the use of fentin-acetate, but this pesticide is still contributing for approximately 35% to the height of the risk indicator for algae and daphnids. The two reasons for this are the relatively high PEC/L(E)C50 quotient and the large area in which fentin-acetate is used (11% of the total area in the reference period and 4% in 1996).

Table 4 The percentages of the 'total' area treated with pesticides (see chapter 3.2) for the 15 compounds with the highest % of the 'total' area (* = estimated, no mean dosage for compound available).

1984-1988	% of area	1996	% of area
Fentin-acetate	11.1	Fluazinam	5.3
Maneb	8.8	Mancozeb	4.3
Phenmedipham	6.6	Phenmedipham	4.1
Metamitron	5.0	Maneb	4.0
Mecoprop*	4.3	Fentin-acetate	4.0
Parathion (ethyl)	2.5	Captan	3.5
Captan	2.4	Glyphosate	3.4
TCA*	2.2	Dimethoate	3.4
Dinoseb*	2.1	Cymoxanil	3.3
Atrazin	1.9	Ethofumesate	3.1
Ethofumesate	1.8	Metamitron	3.0
Bentazon	1.7	Esfenvalerate	2.8
Pirimicarb	1.7	Deltamethrin	2.7
Triadimefon	1.6	MCPA	2.4
Dalapon*	1.5	Carbendazim	2.2

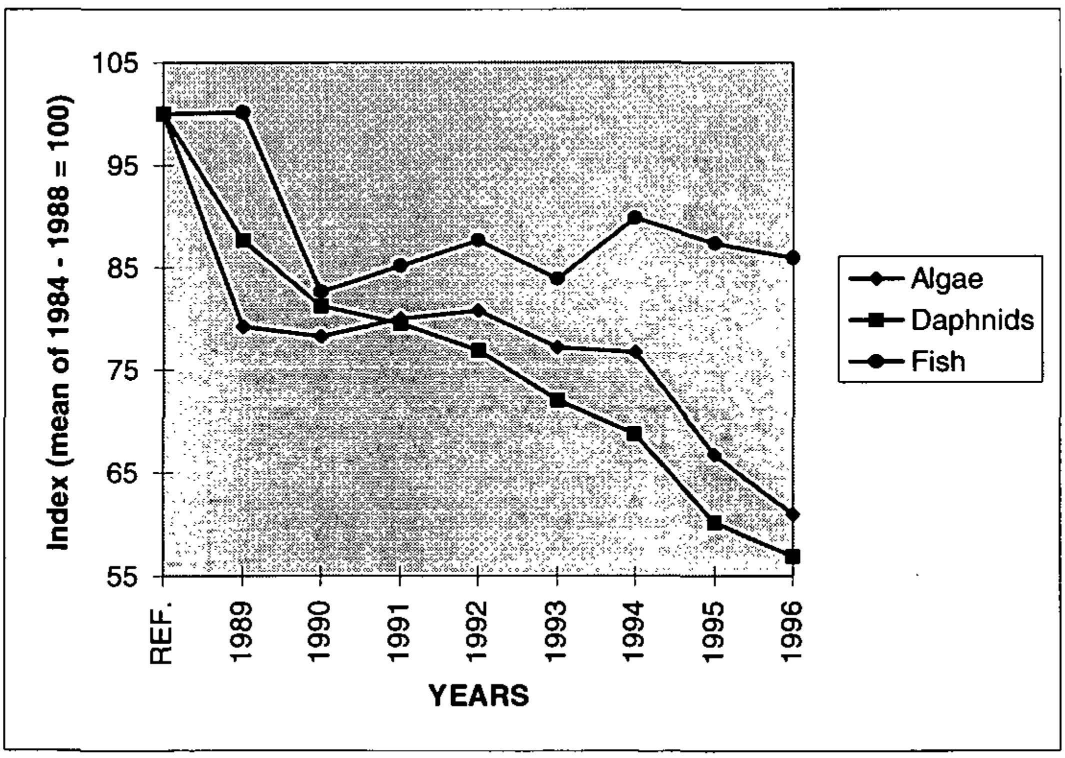

Figure 3 Acute aquatic risk indicators for algae, daphnids and fish.

The line for fish may suggest that the aquatic risk is higher for fish than for the two other groups, because the line for fish is above the other two lines, but the contrary is true. The absolute figure for fish is a factor ten lower than for algae and daphnids as can be seen in figure 4. In the figure a "no effect line" is presented. This line represents the level where for each compound the predicted environmental concentration equals the no effect concentration for the aquatic ecosystem (PEC/NECeco = 1). The NECeco is defined as the L(E)C50 divided by 100 (10 for the step of 50% effect to no effect (NOEC) and 10 for the step one species to more and other species).

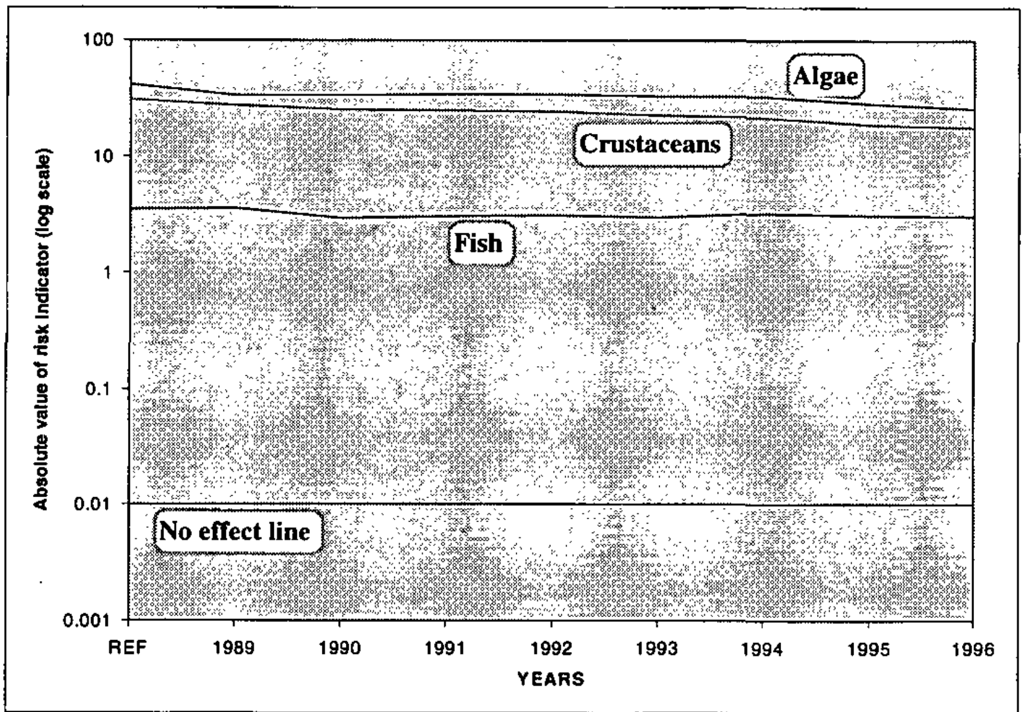

Figure 4 Absolute values of indices for Algae, Daphnids and Fish and the "No effect line".

3.4. The most important compounds

3.4.1. Algae

In Table 5 the compounds which contribute 1 or more percent to the acute index value for algae for the reference period and 1996 are presented. Only 12 or 13 compounds contribute more than 1%. For both periods fentin-acetate is the highest contributor: in the reference period 65.4 % and in 1996 40.6%. Note that for four of the compounds mentioned in this table no toxicity data are available for algae, which probably will increase the uncertainty.

3.4.2. Daphnids

In Table 6 the compounds which contribute 1 or more percent to the height of the acute index value for daphnids for the reference period and 1996 are presented. In the reference period only 5 and in 1996 only 11 compounds contribute more than 1%. For both periods fentin-acetate is the highest contributor: in the reference period 55.4 % and in 1996 35.1%.

Table 5 Compounds that contribute more than 1% to the index value for Algae (* = estimated, no toxicity data available).

1984-1988	%	1996	%
Fentin-acetate*	65.4	Fentin-acetate*	40.6
Monolinuron	7.6	Monolinuron	19.6
Metribuzin	3.8	Metribuzin	5.6
Paraquat-dichloride*	3.3	Diquat-dibromide	5.2
Fentin-hydroxide	2.8	Carbaryl	4.6
Methabenzthiazuron	2.1	Paraquat-dichloride*	3.4
Parathion (ethyl)	2.0	Parathion (ethyl)	2.2
Permethrin	1.8	Fentin-hydroxide	2.0
Diquat-dibromide *	1.5	Atrazin	1.9
Atrazin	1.5	Propachlor	1.7
Fenbutatinoxide*	1.3	Permethrin	1.5
Carbaryl	1.3	Tri-allate	1.4
		Cyhexatin*	1.0

Table 6 Compounds that contribute more than 1% to the height of the index value for Daphnids.

1984-1988	%	1996	%
Fentin-acetate	55.4	Fentin-acetate	35.1
Parathion (ethyl)	12.4	Parathion (ethyl)	13.3
Maneb	10.4	Phosalone	10.4
Chlorfenvinphos	6.5	Esfenvalerate	7.9
Azinphos-methyl	5.0	Maneb	7.9
		Chlorfenvinphos	4.2
		Lambda-cyhalothrin	3.6
		Azinphos-methyl	3.2
		Deltamethrin	1.4
		Fluazinam	1.3
		Carbaryl	1.1

3.4.3. Fish

In Table 7 the compounds which contribute 1 or more percent to the height of the acute index value for fish for the reference period and 1996 are presented. In the reference period 14 and in 1996 16 compounds do contribute more than 1%. In the reference period dinoseb, dinoseb-acetate and captan are the highest contributors: between 15 and 20%. In 1996 captan is the highest contributor with 22.8% and the lambda-cyhalothrin (new on the market since 1992) on the second place with 11.5%. Dinoseb and dinoseb-acetate are not mentioned in the table of 1996 because both products are not sold anymore in the Netherlands.

Table 7 Compounds that contribute more than 1% to the height of the index value for Fish.

1984-1988	%	1996	%
Dinoseb	19.3	Captan	22.8
Dinoseb-acetate	15.9	Lambda-cyhalothrin	11.5
Captan	14.6	Tolylfluanide	9.6
Dinoterb	9.7	Dinoterb	9.2
Fentin-acetate	4.9	Esfenvalerate	8.4
Thiram	4.9	Fluazinam	6.0
Maneb	3.5	Deltamethrin	5.9
Tolylfluanid	3.3	Thiram	4.5
permethrin	2.8	Folpet	2.6
Fenvalerate	2.3	Fentin-acetate	2.1
Fentin-hydroxide	2.0	Carbaryl	2.0
Azinphos-methyl	1.6	Maneb	1.8
Quintozeen	1.3	Permethrin	1.6
Deltamethrin	1.1	Carbendazim	1.3
		Mancozeb	1.2
		Propachlor	1.2

4. DISCUSSION

In this report aquatic risk indicators are calculated for three groups of organisms, algae, daphnids and fish, the traditional species tested for legislative purposes. But it is also possible to perform this calculation with an "L(E)C50" for the ecosystem by using either the 95th percentile (according to Aldenberg and Slob, 1993) of all the available acute data (not only algae, daphnids and fish) or by using the lowest available value divided by ten or hundred.
When a critical concentration for aquatic ecosystems is defined as the lowest value that is calculated for either algae, daphnids or fish, then the risk for the aquatic ecosystem has declined by approximately 35% (see Figure 5) since the reference period 1984 to 1988. Please note that by using an index it is not necessary to define an extrapolation factor, because of the relative scale. Figure 5 should be considered with caution, because only three different species groups are included in the calculation.
In 1996 only 18 of the 223 pesticides that were causing drift to surface water did contribute for more than 1% to the index value for the aquatic ecosystem, together they account for ± 86% (Table 8). The five pesticides with the highest score are fentin-acetate, monolinuron, parathion (ethyl), carbaryl and phosalone. The Centre for Agriculture and Environment in Utrecht developed the "Milieumeetlat" and although they are using a different method (fixed dosage of 1 kg/ha and fixed drift percentage of 1% for each pesticide) fentin-acetate was also one of their top five pesticides (Reus and Faasen, 1995).

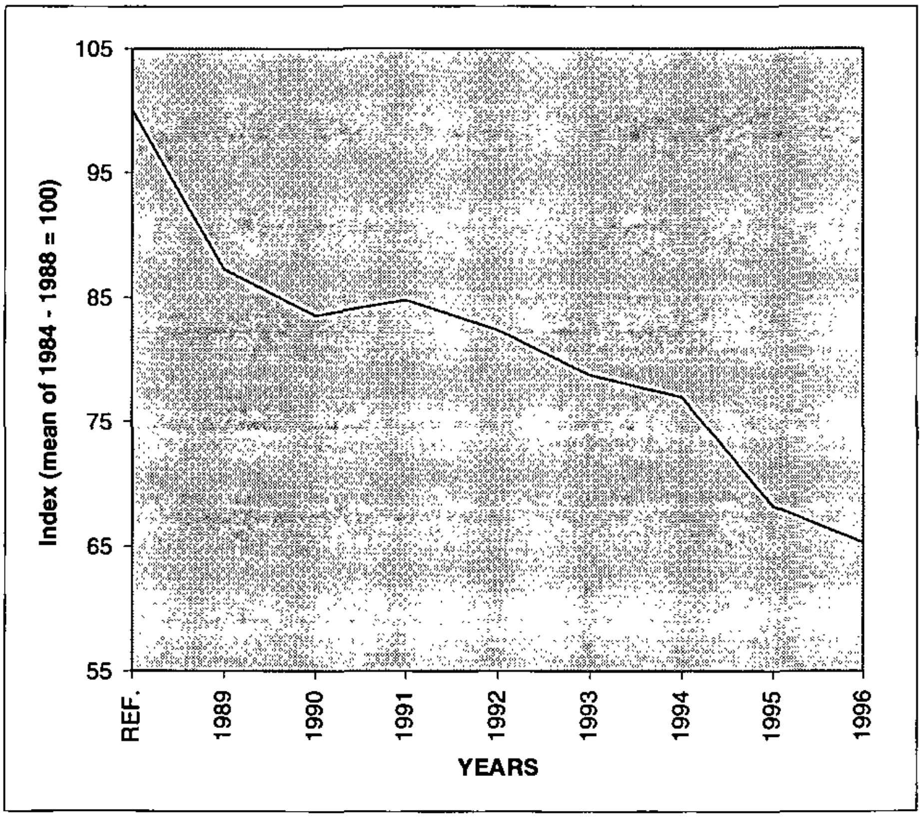

Figure 5 Acute risk indicators for the aquatic ecosystem.

Table 8 Compounds that contribute more than 1% to the index value for the aquatic ecosystem (* = estimated, no toxicity data available).

1996	%		
Fentin-acetate*	26.3	Paraquat-dichloride*	2.3
Monolinuron	12.6	Captan	2.0
Parathion (ethyl)	7.0	Chlorfenvinfos	1.9
Carbaryl	6.0	Lambda-cyhalothrin	1.6
Phosalone	4.6	Atrazin	1.5
Diquat-dibromide	4.0	Azinfos-methyl	1.4
Maneb	4.0	Permethrin	1.2
Metribuzin	3.6	Propachloor	1.2
Esfenvaleraat	3.5	Fentin-hydroxide	1.2

In this report it was decided to calculate the indices for all the compounds that were in one way or another causing drift to the adjacent ditch. It is also possible to perform these calculations for a specific group of compounds, e.g. fungicides or herbicides. In Figure 6 the relative contribution of five pesticide groups (herbicides, acaricides, fungicides, insecticides and others) are presented.

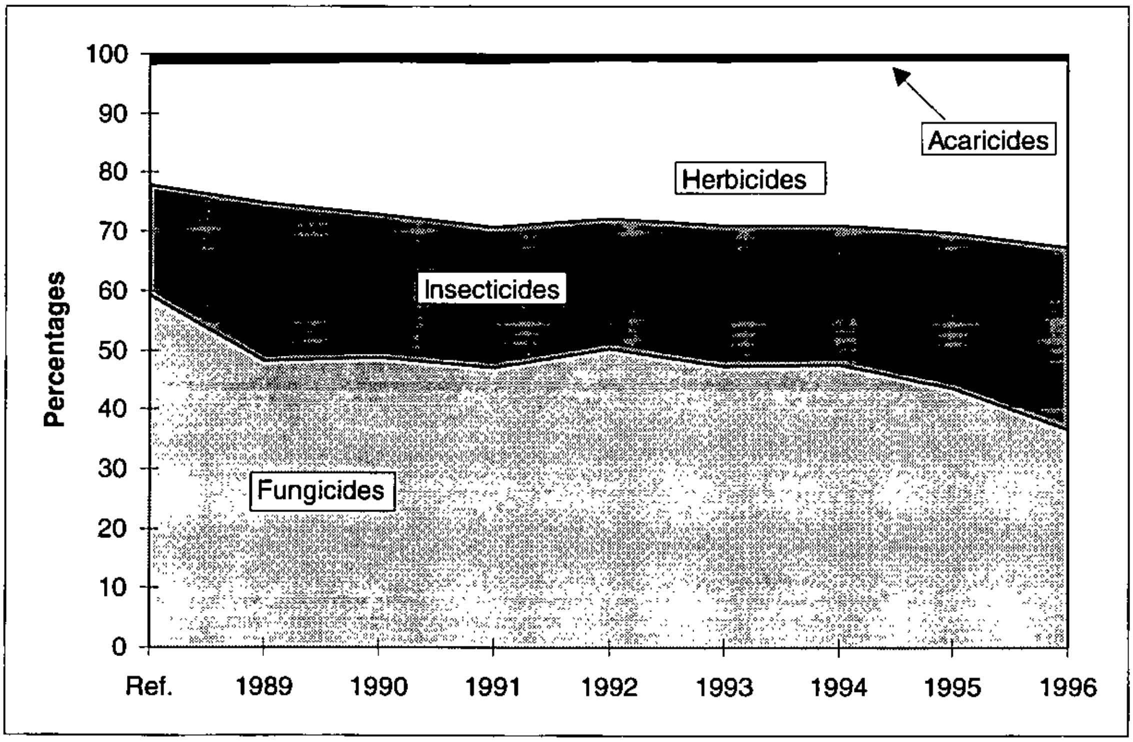

Figure 6 The contribution of four pesticide groups to the index for a particular year.

In the period under consideration the contribution of fungicides has dropped from 59% to 37% and has raised for insecticides and herbicides from approximately 20% to 31%. Acaricides only contribute for 1 or 2% to the index. Pesticides not belonging to these four groups contribute less than 1%.

Till now it is assumed that application methods and management methods did not change over the period. This resulted in the use of a standard set of drift data which did not change since the reference period. In the past few years much attention has been paid to drift reduction. Better application and management methods are becoming available as well as protective measures like spray free zones or windbreaks. The method described in this report is able to cope with changes in drift percentages.

The index described in this report does not give any information about the quantity of surface water that is contaminated by pesticides. This depends on the total area of agricultural use and on the water/land ratio.

5. CONCLUSIONS

A) The risk for the aquatic ecosystem (acute situation) has declined by approximately 35% in surface water influenced by drift of pesticides since the reference period 1984 - 1988.
The risk for algae and daphnids has declined by 40% and for fish by 15%.

B) In 1996 only 18 pesticides from the 223 pesticides that were causing drift to surface water contributed more than 1% to the index value for the aquatic ecosystem, together they accounted for 86%. The same holds for the individual groups of organisms (algae, daphnids and fish)

C) The pesticides that contributed in 1996 more than 10% to the index value for the aquatic ecosystem are fentin-acetate 26% and monolinuron 13%. For algae these pesticides are fentin-acetate 41% and monolinuron 20%, for daphnids fentin-acetate 35%, parathion (ethyl) 13% and phosalone 10% and for fish captan 23% and lambda-cyhalothrin 12%.

D) The greatest benefit for the aquatic ecosystem can be obtained by abondoning the use of these pesticides, even incase other pesticides are used, provided that their PEC/TOX quotients are lower.

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APPENDIX

In this appendix the average drift percentages as provided by the DLO Winand Staring Centre are presented and the number of toxicity studies found for the three different species groups (algae, daphnids, and fish). Due to the confidential nature of the sales data it is also not possible to present the mean dosage for each pesticide.

Compound	Average drift (%)	Number of toxicity studies Algae	Daphnids	Fish
1-naftylacetic acid	6.80	1	1	3
2,4-D	4.40	1	10	48
abamectin	0.10	no data	2	3
acephate	1.80	1	3	16
aclonifen	5.00	1	1	2
alachlor	no data	2	5	10
alpha-cypermethrin	no data	1	1	2
alloxydim	no data	no data	2	1
amitraz	7.30	1	1	3
amitrole	0.20	2	2	5
ammonium sulfamate	no data	no data	no data	3
anilazine	5.00	2	5	6
anthraquinone	no data	no data	1	2
asulam	5.00	no data	2	9
atrazine	5.00	10	7	25
azaconazole	17.00	1	1	6
azamethiphos	no data	no data	1	11
azinphos-methyl	9.10	3	5	70
azocyclotin	7.80	no data	1	3
Bacillus thuringiensis	no data	no data	no data	2
benazolin	5.00	no data	1	4
bendiocarb	no data	1	4	4
benfuracarb	no data	1	1	2
benodanil	no data	no data	no data	2
benomyl	1.00	1	4	37
bentazone	5.00	2	2	3
benzoylprop-ethyl	no data	no data	no data	2
bifenox	5.00	1	3	6
bifenthrin	0.10	2	4	2
bioallthrin	no data	no data	4	33
bitertanol	3.20	1	4	6
borax	no data	no data	1	2
bromacil	no data	no data	1	6
bromophos	no data	no data	no data	2
bromophos-ethyl	no data	1	1	1
bromoxynil	5.00	1	25	7
bromuconazole	no data	2	1	2
broomfenoxim	5.00	2	2	6
broompropylate	8.80	1	1	3
buminaphos	5.00	2	2	no data
bupirimate	2.30	1	1	4
buprofezin	0.10	1	2	2
butocarboxim	0.10	1	2	3
butoxycarboxim	no data	no data	1	2
captafol	no data	1	4	14
captan	7.30	1	3	23
carbaryl	7.10	1	51	160
carbendazim	3.50	2	6	24
carbetamide	5.00	2	1	1
carbofuran	1.30	2	30	45
carbophenothion	no data	no data	4	11

Compound	Average drift (%)	Number of toxicity studies Algae	Daphnids	Fish
carboxin	no data	2	1	2
chlofentezin	3.70	1	2	4
chloralhydrate	no data	1	no data	no data
chlorbromuron	5.00	1	1	15
chlorfenvinphos	4.00	3	5	10
chlorflurenol (methyl)	no data	no data	no data	3
chloridazon	4.40	1	2	7
chlormequat	5.20	no data	1	6
chlorothalonil	4.10	no data	4	31
chlorotoluron	5.00	2	1	13
chloroxuron	no data	2	2	7
chlorpropham	5.00	1	1	3
chlorpyrifos	3.40	no data	8	72
chlorthal	no data	no data	1	3
chlorthiamid	no data	no data	no data	1
clodinafop	5.00	3	1	4
clopyralid	5.00	2	1	2
cloquintoceet	5.00	4	2	4
copper-hydroxide	no data	1	1	3
copper-oxychloride	13.00	no data	2	7
crimidine	no data	no data	no data	1
cyanazine	5.00	2	10	20
cycloate	no data	no data	2	1
cycloxydim	5.00	1	2	2
cyfluthrin	no data	2	6	7
cyhalothrin	5.00	1	6	5
cyhexatin	3.60	no data	3	17
cymoxanil	5.00	1	1	3
cypermethrin	6.90	no data	6	18
cyproconazole	5.00	1	1	6
cyprofuram	no data	1	1	2
cyromazine	0.20	2	2	5
dalapon	no data	no data	4	14
daminozide	1.10	2	3	3
deltamethrin	4.90	1	16	9
desmedipham	0.10	1	1	2
desmetryn	5.00	1	2	4
diallate	no data	no data	no data	2
diazinon	2.10	1	29	64
dicamba	4.90	3	5	9
dichlobenil	0.10	1	10	34
dichlofenthion	no data	no data	6	12
dichlofluanid	6.50	1	1	4
dichlorprop	no data	1	no data	1
dichlorprop-p	5.00	no data	no data	2
dichlorvos	0.20	1	20	30
dichloran	no data	1	1	4
dicofol	5.00	1	3	17
dienochlor	0.20	1	2	4
diethofencarb	2.70	1	2	2
difenoconazole	7.70	no data	1	1

Compound	Average drift (%)	Number of toxicity studies Algae	Daphnids	Fish
difenoxuron	5.00	2	1	2
difenzoquat	no data	1	1	2
diflubenzuron	5.00	4	12	10
diflufenican	5.00	1	1	4
dikegulac	0.10	no data	no data	4
dimethachlor	no data	1	1	4
dimethoate	5.00	4	24	35
dimethomorph	no data	no data	2	2
dinocap	no data	no data	1	5
dinoseb	no data	2	2	50
dinoseb-acetate	no data	1	1	2
dinoterb	5.00	1	1	3
diquat-dibromide	4.90	1	4	16
dithianon	9.50	1	2	7
diuron	0.70	1	11	26
DNOC	5.00	no data	7	17
dodemorph	0.20	1	1	2
dodine	no data	1	3	3
endosulfan	no data	no data	85	132
endothal	no data	no data	3	17
endrin	no data	no data	50	94
epoxyconazole	5.00	1	1	3
EPTC	5.00	1	5	25
esfenvalerate	5.00	1	2	9
ethephon	0.50	no data	1	2
ethiofencarb	5.00	no data	1	5
ethirimol	no data	2	1	2
ethofumesate	5.00	no data	2	5
etridiazole	0.10	1	1	2
etrimfos	6.70	1	2	7
fenaminosulf	no data	1	3	5
fenarimol	1.30	1	2	7
fenbutatin oxide	3.50	no data	2	15
fenchlorazole (ethyl)	5.00	1	1	3
fenfuram	no data	no data	no data	1
fenitrothion	no data	8	38	223
fenmedifam	5.00	1	3	4
fenothrin	no data	no data	no data	2
fenoxaprop-P-ethyl	5.00	1	2	5
fenoxycarb	6.80	1	3	8
fenpiclonil	no data	1	1	4
fenpropathrin	0.20	3	1	5
fenpropimorph	5.00	1	1	6
fentin acetate	5.00	no data	2	2
fentinhydroxide	5.00	1	8	18
fenvalerate	4.90	1	15	49
ferbam	no data	1	1	1
fluazifop-butyl	no data	no data	no data	3
fluazifop-p-butyl	5.00	2	2	2
fluazinam	4.80	1	2	2
flucycloxuron	0.10	1	2	2

Compound	Average drift (%)	Number of toxicity studies Algae	Daphnids	Fish
flucythrinate	no data	no data	1	5
fluorchloridon	no data	1	1	4
flurenol	no data	no data	2	7
fluroxypyr	5.00	1	2	6
flutolanil	4.90	1	1	2
tau-fluvalinate	no data	no data	3	6
folpet	4.90	2	2	15
formaldehyde	0.10	2	1	9
formothion	5.00	1	2	4
fosetyl-aluminium	3.70	1	1	2
fuberidazole	no data	no data	1	2
furalaxyl	1.10	1	1	4
glufosinate-ammonium	2.00	1	2	4
glyphosate	4.40	3	3	19
glyphosate-trimesium	4.90	no data	no data	2
guazatine	no data	no data	1	1
haloxyfop_ethoxyethyl	4.80	1	2	5
heptenophos	2.80	no data	1	3
hexazinone	no data	no data	3	21
hexythiazox	1.30	no data	2	3
imazalil	0.20	1	2	3
imazamethabenz	no data	1	1	2
imidacloprid	no data	1	1	2
ioxynil	5.00	1	2	2
iprodione	4.80	2	2	5
isofenphos	no data	1	3	6
isoproturon	5.00	no data	1	8
kasugamycin	6.10	no data	1	2
lambda-cyhalothrin	5.00	1	4	4
lenacil	4.30	1	1	3
lindane	5.00	3	50	132
linuron	4.80	4	4	6
malathion	0.40	1	53	142
maleic-hydrazide	5.00	no data	no data	4
mancozeb	5.00	1	1	10
maneb	5.00	1	3	12
MCPA	4.80	1	4	7
mecoprop	no data	no data	1	3
mecoprop/mecoprop-P	4.90	2	1	5
mefluidide	no data	no data	no data	2
mepiquat.chloride	no data	no data	1	1
metalaxyl	1.90	1	2	3
metaldehyde	no data	no data	no data	1
metamitron	4.90	no data	2	2
metazachlor	4.80	1	1	3
methabenzthiazuron	5.00	1	1	3
methamidophos	0.10	no data	2	7
methiocarb	0.10	no data	3	14
methomyl	0.20	3	17	59
methoxychlor	no data	no data	22	45
metiram	6.10	1	1	4

Compound	Average drift (%)	Number of toxicity studies Algae	Daphnids	Fish
methidathion	8.80	2	4	8
metobromuron	5.00	1	1	17
metolachlor	5.00	2	3	6
metoxuron	5.00	1	2	4
metribuzin	5.00	1	4	9
metsulfuron-methyl	5.00	1	1	2
mevinphos	4.40	1	15	8
monolinuron	5.00	1	3	7
myclobutanil	6.80	1	1	2
nitrothal-isopropyl	no data	1	1	2
nuarimol	6.80	1	1	4
omethoate	3.50	2	2	7
oxadixyl	no data	1	2	4
oxamyl	0.20	1	2	7
oxycarboxin	no data	no data	1	2
oxydemeton-methyl	5.10	no data	5	8
paclobutrazol	0.10	no data	1	1
paraquat-dichloride	4.80	no data	7	22
parathion (ethyl)	4.70	1	47	57
penconazole	4.80	1	3	7
pencycuron	5.00	1	2	4
pendimethalin	5.00	1	1	4
pentachlorphenol	no data	9	91	140
permethrin	3.80	1	50	55
phosalone	6.10	1	2	8
phosphmidon	5.00	1	24	23
phosmet	no data	1	13	64
phoxim	no data	no data	2	11
piperonyl butoxide	1.00	2	10	11
pirimicarb	5.30	1	3	4
pirimiphos-methyl	1.40	1	1	7
plifenate	no data	no data	no data	1
prochloraz	3.20	1	2	3
procymidone	4.30	1	no data	3
propham	5.00	3	9	8
profenofos	no data	no data	no data	3
prometryn	5.00	1	3	10
propachlor	5.00	3	2	4
propamocarb-hydrochloride	2.50	1	no data	4
propaquizafop	5.00	1	1	3
propazine	5.00	1	2	5
propetamphos	no data	3	3	4
propiconazole	5.00	1	3	8
propoxur	5.60	1	13	28
propyzamide	5.00	1	1	3
prosulfocarb	5.00	1	1	3
pyrazophos	4.50	1	4	7
pyrethrins	1.00	no data	1	2
pyridaben	0.10	1	1	4
pyridate	5.00	no data	1	4

Compound	Average drift (%)	Number of toxicity studies Algae	Daphnids	Fish
pyrifenox	6.70	no data	no data	1
pyrimethanil	no data	1	1	3
quinmerac	5.00	1	1	2
quintozene	no data	no data	1	2
quizalofop-ethyl	5.00	1	1	7
rimsulfuron	5.00	1	1	4
S-methopren	no data	no data	2	13
sethoxydim	5.00	no data	1	5
simazine	2.00	1	9	25
sodiumdimethyldithiocarbamate	no data	2	1	4
sulfotep	no data	no data	2	7
TCA	no data	1	3	8
tebuconazole	5.00	1	2	6
teflubenzuron	0.30	1	1	2
terbufos	no data	1	6	30
terbutryn	5.00	5	4	15
terbutylazin	5.00	3	2	9
tetrachlorvinphos	no data	no data	no data	6
tetramethrin	no data	no data	no data	4
thiabendazole	no data	no data	2	1
thiocyclam	0.10	1	1	5
thiodicarb	no data	1	1	5
thiofanox	no data	no data	no data	2
thiometon	5.00	1	1	10
thiophanate-methyl	3.80	1	2	3
thiram	7.50	4	19	14
tolclofos-methyl	4.60	2	1	5
tolylfluanid	7.00	1	2	2
tri-allate	5.00	1	3	5
triadimefon	8.70	no data	2	3
triadimenol	5.50	1	1	2
triazophos	6.00	1	1	2
trichlorfon	0.10	no data	39	94
trichloronate	0.10	no data	no data	5
triclopyr	4.90	1	3	19
tridemorph	5.00	1	1	2
triflumizole	0.20	1	no data	4
trifluralin	no data	1	17	45
triforine	3.30	no data	1	2
validamycin	5.00	no data	no data	1
vamidothion	7.40	1	1	1
vinclozolin	4.60	1	1	5
zineb	5.00	1	2	5