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Dutch Environmental Risk Indicator for Plant Protection Products

Appendices NMI 3

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R. Kruijne, A.M.A. van der Linden, J.W. Deneer, J.G. Groenwold and E.L. Wipfler

Dutch Environmental Risk Indicator for Plant
Protection Products

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Appendices NMI 3

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Abstract

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The NMI 3 focusses on indicators for emissions to surface water and the related aquatic risk resulting from agricultural use of pesticides in the Netherlands. The risk indicator is the exposure toxicity ratio. The model also considers the risk to groundwater, soil organisms and the terrestrial ecosystem. The model calculates indicators for emission to surface water resulting from atmospheric deposition, spray drift, drainage flow, point sources, discharge from greenhouses. The model combines a wide range of information about pesticide sales, usage, spray drift mitigation, emission factors, crop maps, surface water, soil, climate, and substance properties. The primary goal is to compare on a relative scale the annual risk at national scale at the starting and end year of the policy period. The results can be used for ranking, for comparing applications of similar type and for visualisation of spatial patterns of indicators. The result cannot be translated into a risk at a specific location and time.

Keywords: risk indicator, environment, sustainable use, pesticides, policy evaluation, NMI.

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Wageningen, January 2012

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Appendix 1 Surface water dimensions and maps

Surface water maps (resolution 250 x 250 m²)

1. Length of large field ditches with pipe drain outlet (m ha⁻¹)
2. Length of medium size field ditches with pipe drain outlet (m ha⁻¹)
3. Length of small field ditches with pipe drain outlet (m ha⁻¹)
4. Total water volume per unit area (1 ha) agricultural land (m³ ha⁻¹)
5. Average water volume in field ditches, per m ditch length (m³ per m)
6. Average width of the water body in field ditches (m)
7. Average ratio width of the water body : water volume per m ditch length (m⁻¹)

The average dimensions shown in maps 5, 6, 7 are calculated from the length, the cross-sectional dimensions and the water depth per ditch class (maps 1, 2, 3).

Field ditch dimensions

Field ditch dimensions are used in emission and exposure calculations. The length L and volume of water V are used in the equations in the main report and expressed per unit of 1 ha agricultural land per ha.

The total length of field ditches per unit area of agricultural land in the plot:

$$L = \sum_{s=1}^3 (L_s) \quad (\text{Eq. 1})$$

- L_s length of field ditches per unit area of agricultural land in the plot (m ha⁻¹)
 L total length of field ditches per unit area of agricultural land in the plot (m ha⁻¹)
 s watercourse class index ($1 \leq s \leq 3$)

The average width of the water body is used for calculating the atmospheric deposition and spray drift deposition, and for calculating the volatilisation rate coefficient:

$$B = \frac{\sum_{s=1}^3 (B_s L_s)}{L} \quad \text{Eq. (2)}$$

- B average width of the water body in field ditches in the plot (m)
 B_s width of the water body in the field ditch (m)
 L_s length of field ditches per unit area of agricultural land in the plot (m ha⁻¹)
 L total length of field ditches per unit area of agricultural land in the plot (m ha⁻¹)
 s watercourse class index ($1 \leq s \leq 3$)

The water volume is used for calculating the peak concentration in the field ditch:

$$V = \sum_{s=1}^3 (L_s v_s) \quad \text{Eq. (3)}$$

$$v_s = b_s d_s + z_s d_s^2 \quad \text{Eq. (4)}$$

- V total volume of water in field ditches per unit area of agricultural land in the plot ($\text{m}^3 \text{ha}^{-1}$)
 L_s length of field ditches per unit area of agricultural land in the plot (m ha^{-1})
 v_s volume of water per unit length ($\text{m}^3 \text{m}^{-1}$)
 b_s bottom width (m)
 d_s water depth (m)
 z_s side slope factor (h : v)
 s watercourse class index ($1 \leq s \leq 3$)

The volume of water per unit length is used for calculating the volatilisation rate coefficient:

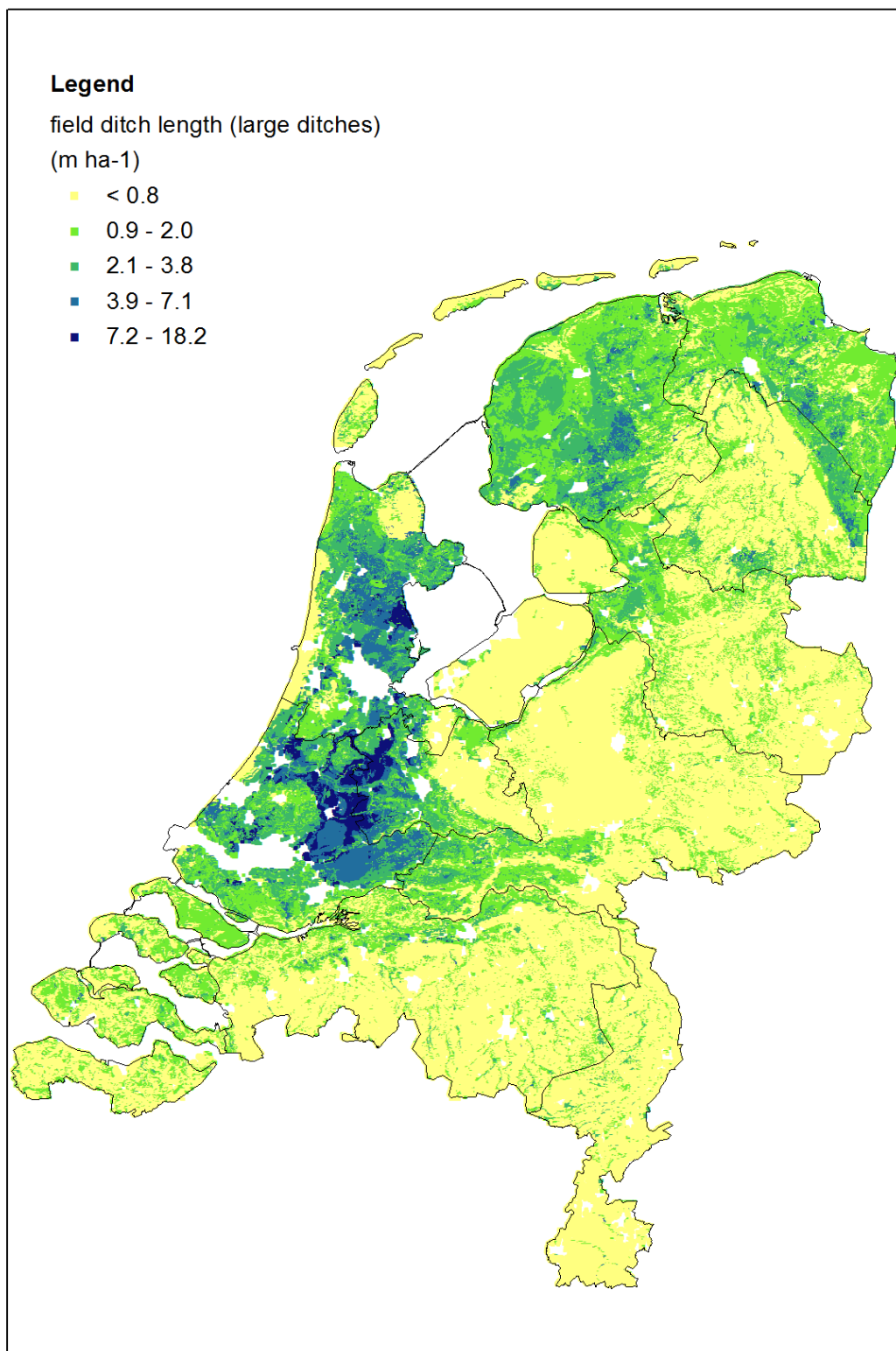
$$v = \frac{V}{L} \quad \text{Eq. (5)}$$

- v water volume per unit field ditch length in the plot ($\text{m}^3 \text{m}^{-1}$)
 V total volume of water per unit area of agricultural land in field ditches in the plot ($\text{m}^3 \text{ha}^{-1}$)
 L total length of field ditches per unit area of agricultural land in the plot (m ha^{-1})

Assuming a rectangular cross-sectional profile, the depth of the water body in the field ditches;

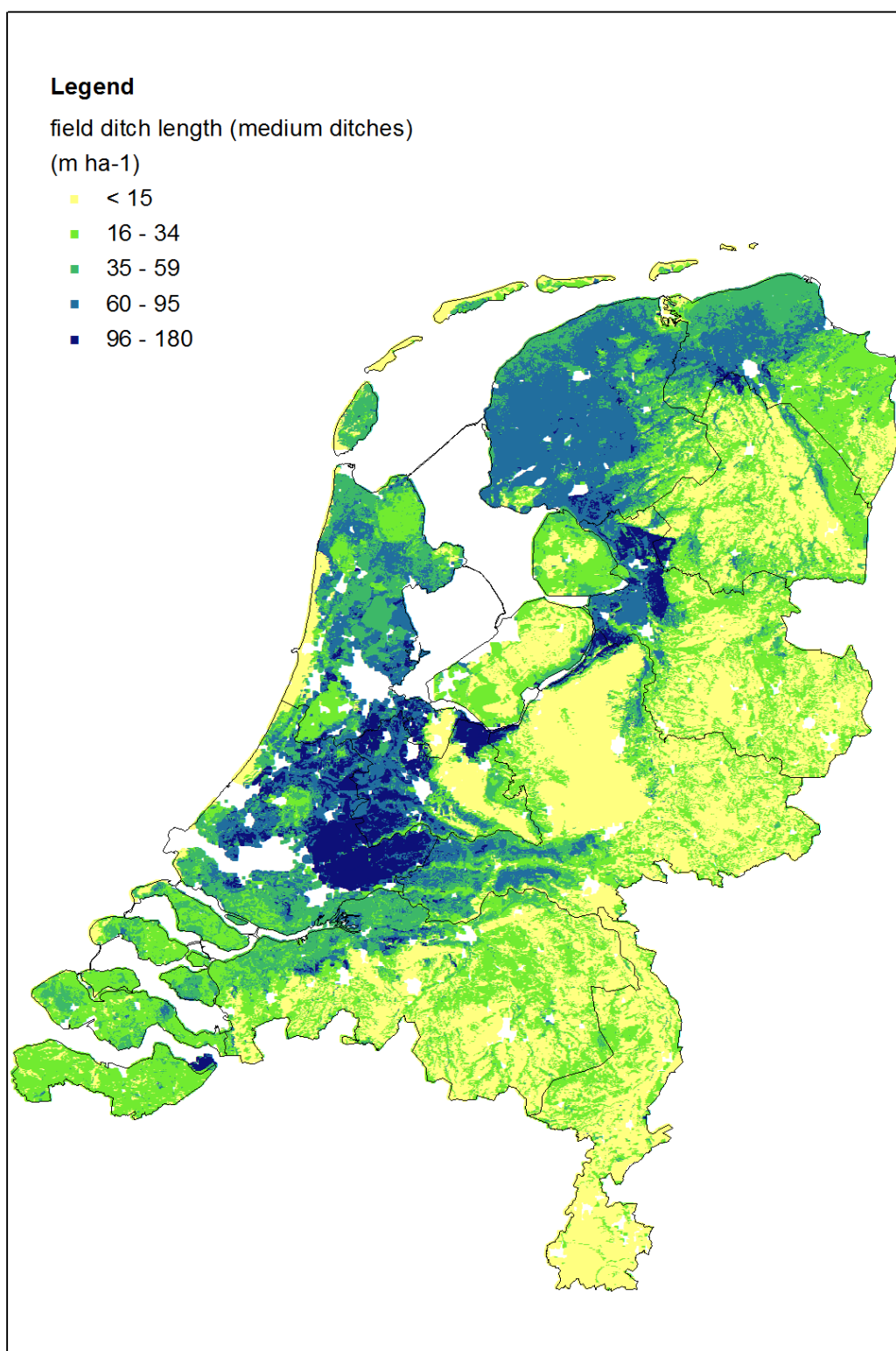
$$d = \frac{v}{B} \quad \text{Eq. (6)}$$

- d water depth in field ditches in the plot (m)
 v water volume per unit field ditch length in the plot ($\text{m}^3 \text{m}^{-1}$)
 B average width of the water body in field ditches in the plot (m)



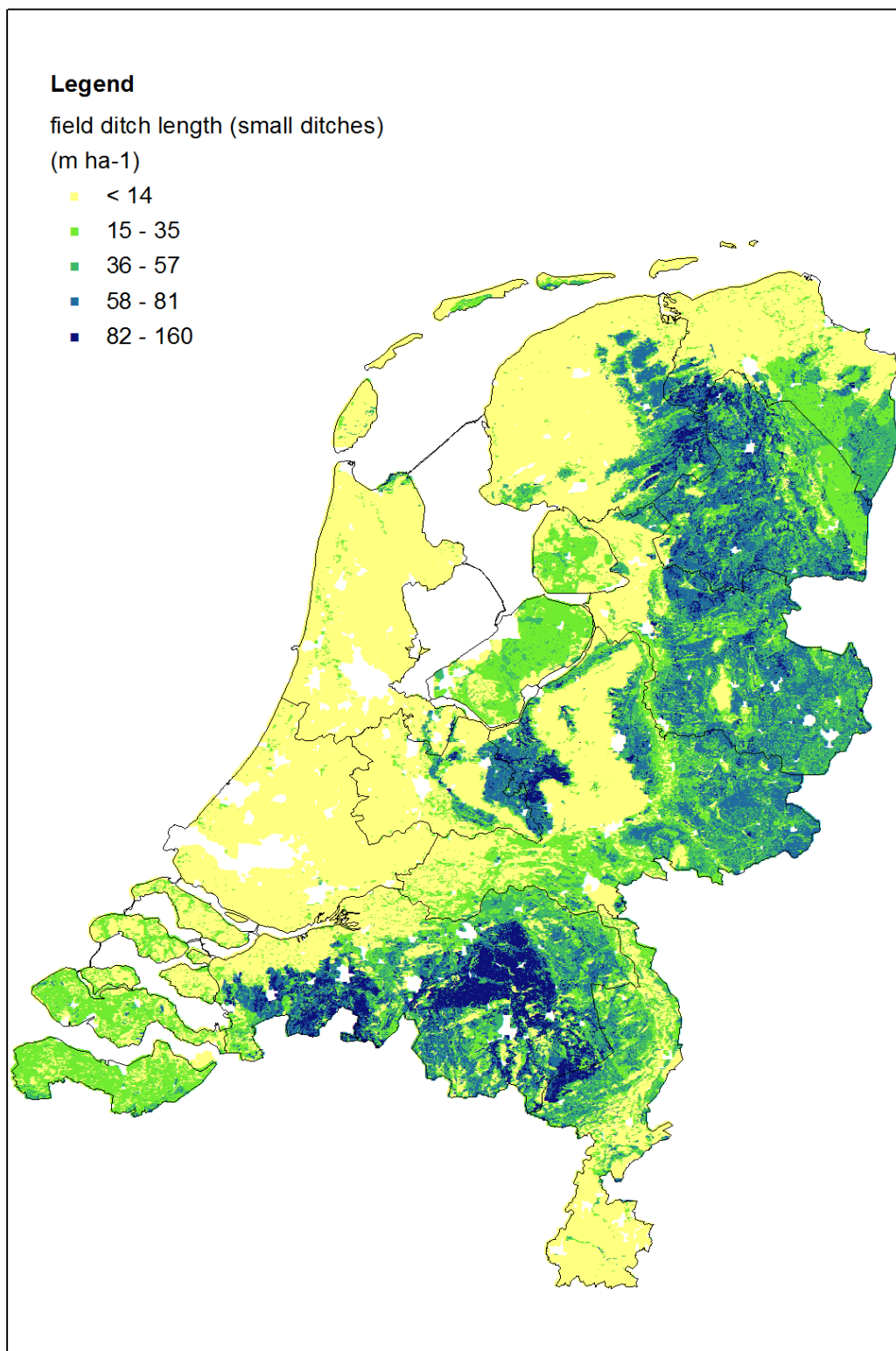
Map 1.1

Length of large field ditches with pipe drain outlet (m ha⁻¹).



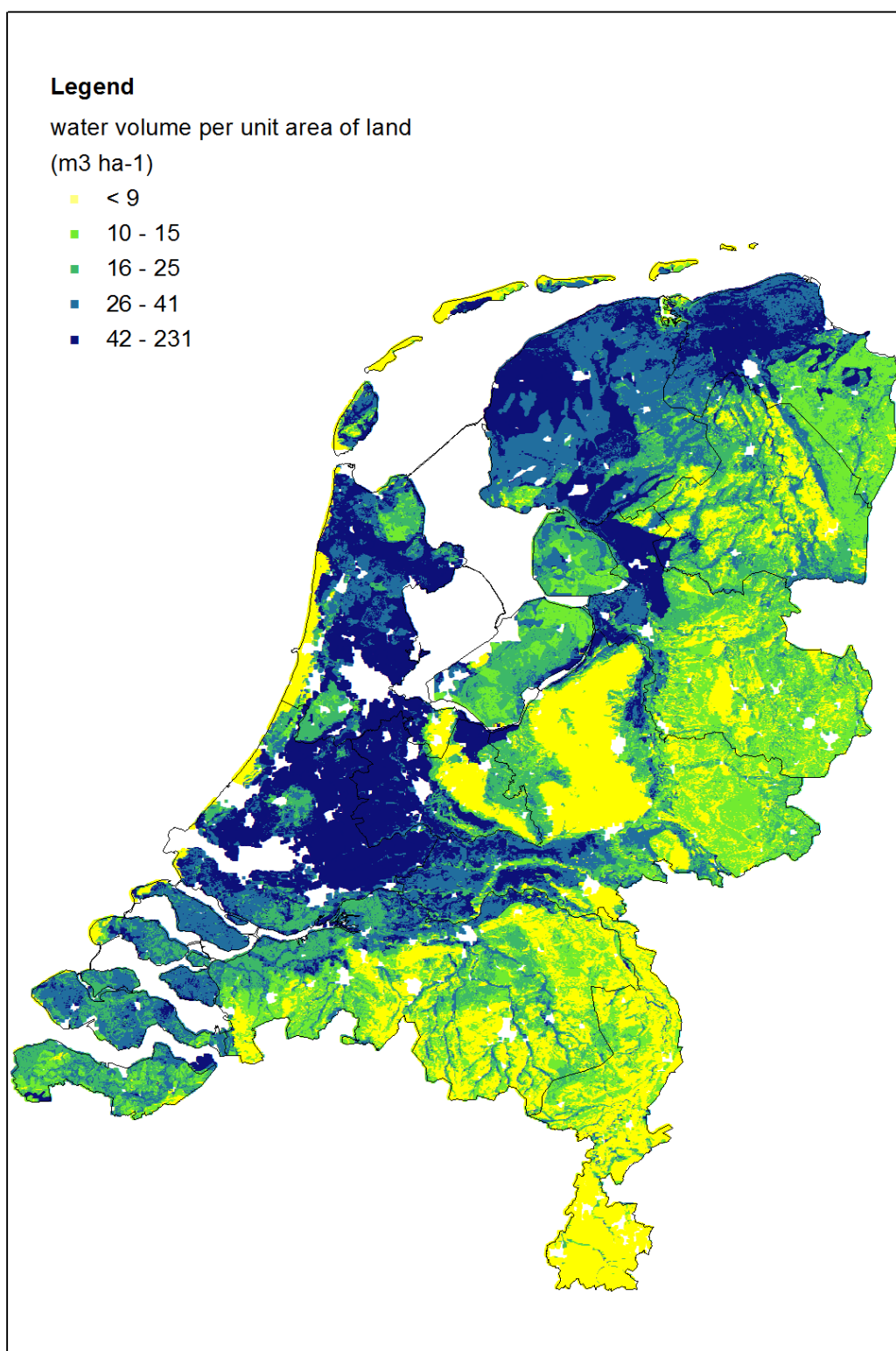
Map 1.2

Length of medium size field ditches with pipe drain outlet (m ha⁻¹).



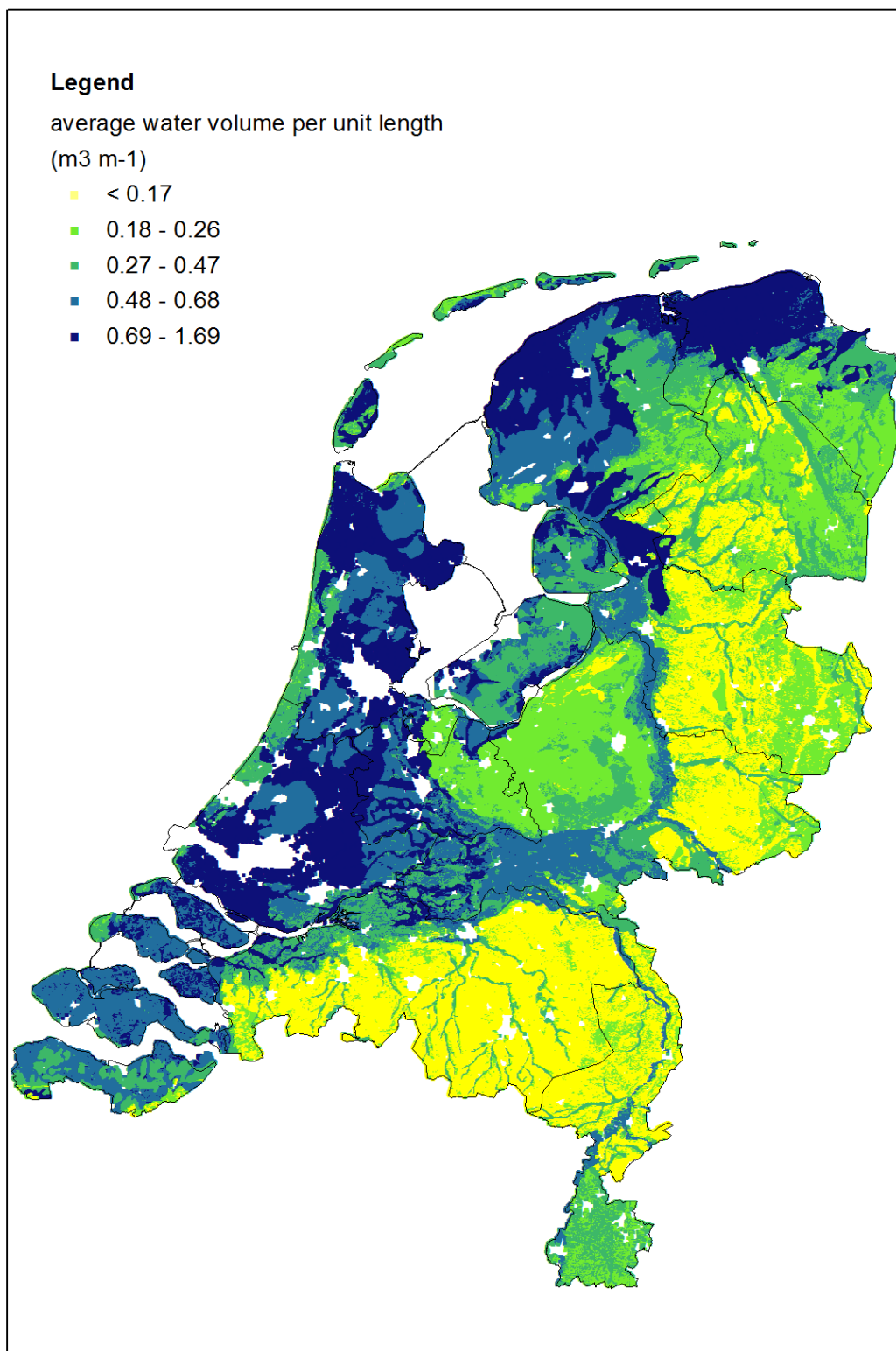
Map 1.3

Length of small field ditches with pipe drain outlet (m ha⁻¹).



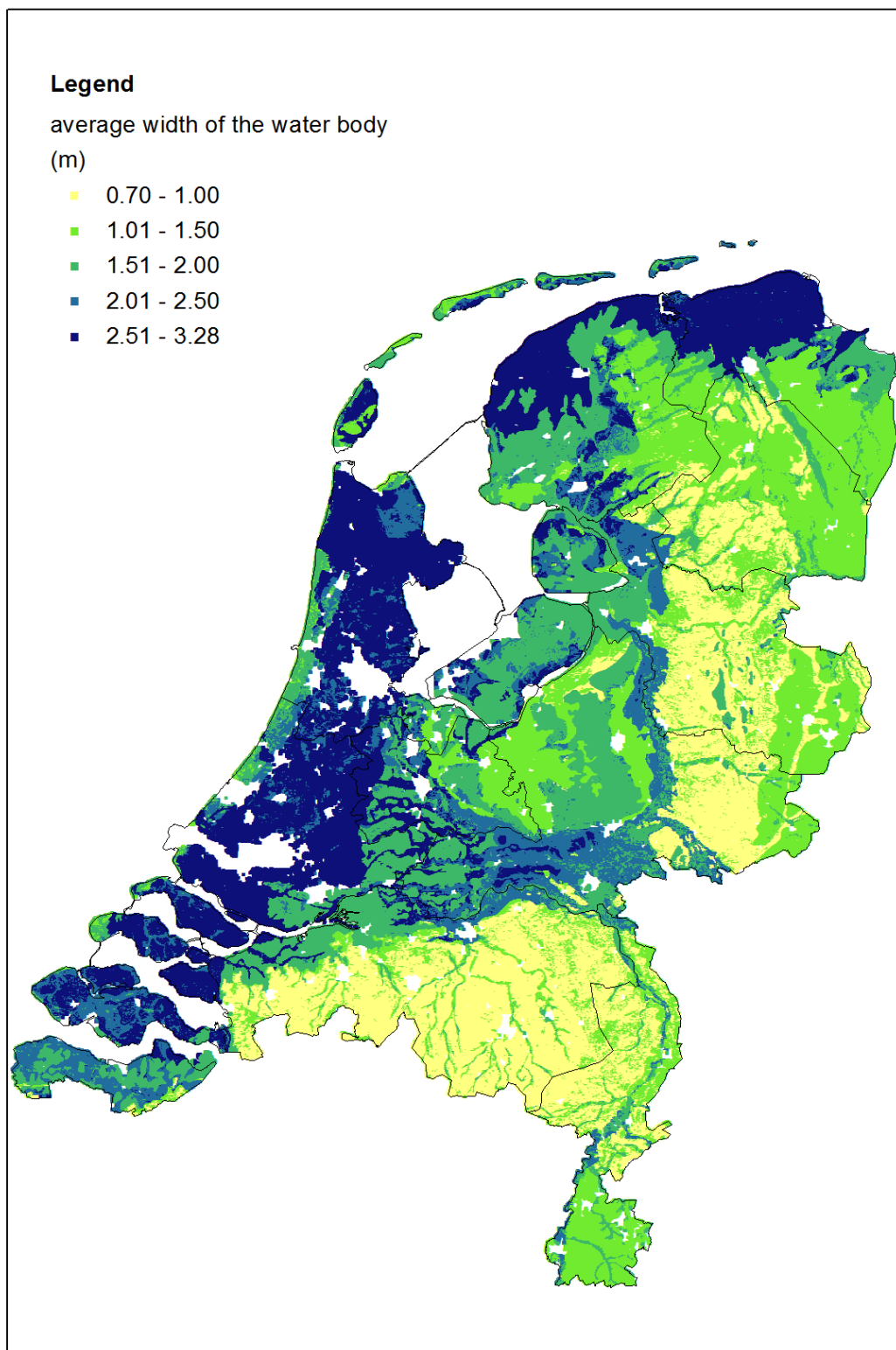
Map 1.4

Total water volume per unit area (1 ha) agricultural land (m³ ha⁻¹).

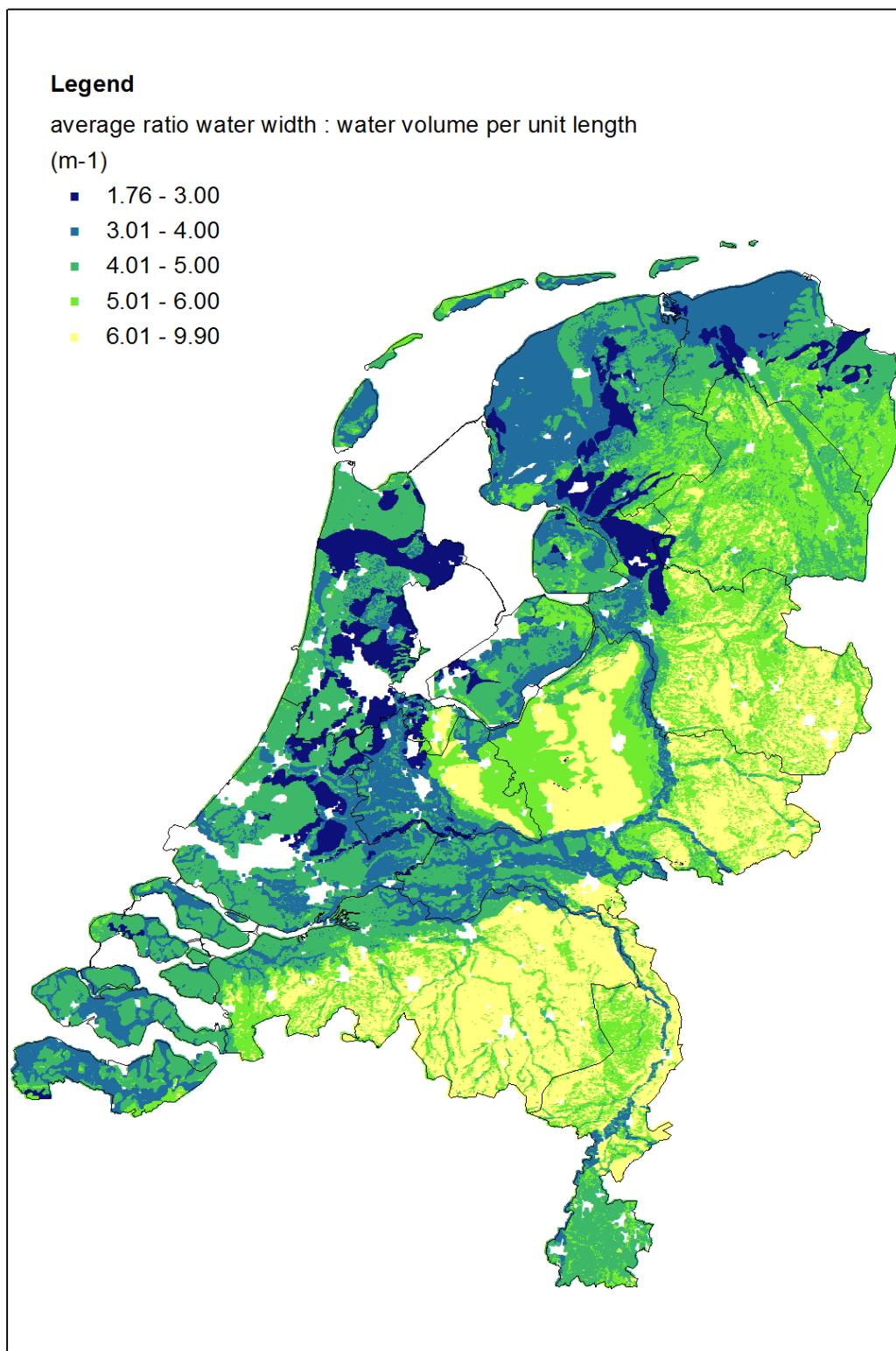


Map 1.5

Average water volume in field ditches, per m ditch length (m³ per m).



Map 1.6
Average width of the water body in field ditches (m).



Map 1.7

Average ratio width of the water body : water volume per m ditch length (m¹).

Appendix 2 Implementation drift reducing measures

Brongegevens NMI 3 : Implementatiegraden per combinatie van gewas, techniek en teeltvrije zone (per jaar, sector)

Klasse (alle 6 sectoren)

- Neerwaarts spuiten (NMI code HERB for downwards spraying)
- Zijwaarts en opwaarts spuiten (NMI code INFU for side- and upwards spraying)

Aanvulend voor de fruitteelt (windhaag)

- Kaal is windhaag in bladloos stadium (dormant stage of wind shield)
- Volblad is windhaag in volblad stadium – mei t/m oktober (full leaf stage of wind shield)

Toelichting: zie Appendix 3.

Document versie: Implementatiegraden NMI3 V3.docx dd. 10-06-2011

Fruit orchards

1998		APPELEN			PEREN		
	Teelt vrije zone (m)	dop-12.5	kaal	volblad	dop-12.5	kaal	volblad
		neer- waarts	zij/op- waarts	zij/op- waarts	neer- waarts	zij/op- waarts	zij/op- waarts
dwarsstroomspuit met windsingel	3		45	45		45	45
dwarsstroomspuit in open perceel	3		52	52		54	54
onkruidspuit	0.75	55			55		
onkruidspuit in combinatie met een windsingel	0.75	45			45		
tunnelspuit in open perceel	3		3	3		1	1
Totaal		100	100	100	100	100	100

Fruit orchards

2004		APPELEN			PEREN		
	Teelt vrije zone (m)	dop-12.5	kaal	volblad	dop-12.5	kaal	volblad
		neer- waarts	zij/op- waarts	zij/op- waarts	neer- waarts	zij/op- waarts	zij/op- waarts
dwarsstroomspuit met windsingel	3.0		94.7	94.7		83.9	83.9
dwarsstroomspuit in open perceel	3.0		5.3	5.3		16.1	16.1
handspuitboom met standaard dop en vanggewas	1.5				8.7		
onkruidspuit	1.5	5.2					
onkruidspuit in combinatie met een emissiescherm	1.5				82.2		
onkruidspuit in combinatie met een vanggewas	1.5	94.8					
rijenspuit met vanggewas	1.5				9.1		
Totaal		100	100	100	100	100	100

Fruit orchards

2008		APPELEN			PEREN		
	Teelt vrije zone (m)	dop-12.5	kaal	volblad	dop-12.5	kaal	volblad
		neer- waarts	zij/op- waarts	zij/op- waarts	neer- waarts	zij/op- waarts	zij/op- waarts
axiaalspuit in open perceel	3		1	1		2	2
axiaalspuit in open perceel met venturidop	3		10	10		10	10
axiaalspuit met reflectie- en emissiescherm	3		1	1		1	1
axiaalspuit met reflectiescherm	3		1	1		1	1
axiaalspuit met windsingel	3		10	10		10	10
dwaarsstroomspuit met windsingel	3		31	31		29	29
dwaarsstroomspuit in open perceel	3		4	4		6	6
dwaarsstroomspuit in open perceel met venturidop	3		30	30		30	30
dwaarsstroomspuit met reflectie- en emissiescherm	3		4	4		4	4
dwaarsstroomspuit met reflectiescherm	3		4	4		4	4
onkruidspuit	1.5	28			18		
onkruidspuit in combinatie met een emissiescherm	1.5	36			43		
onkruidspuit in combinatie met een vanggewas	1.5	36			39		
tunnelspuit in open perceel	3		4	4		3	3
Totaal		100	100	100	100	100	100

Flower bulbs

		GLADIOLLEN		HYACINTEN		IRISSEN		LELIES		NARCISSEN		TULPEN	
1998	Teelt	dop-12.5		dop+0		dop+0		dop+0		dop+0		dop+0	
	vrije zone (m)	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts
handspuitboom met standaard dop	0.75	1	1	1	1	1	1	1	1	1	1	1	1
veldspuit met luchtondersteuning en standaard dop in open perceel	0.75	10	10	10	10	10	10	10	10	10	10	10	10
veldspuit met standaard dop in open perceel	0.75	89	85	89	85	89	85	89	85	89	85	89	85
vliegtuigspuit in open perceel	0.75		4		4		4		4		4		4
Totaal		100	100	100	100	100	100	100	100	100	100	100	100

Flower bulbs

		GLADIOLEN		HYACINTEN		IRISSEN		LELIES		NARCISSEN		TULPEN	
2004	Teelt	dop-12.5		dop+0		dop+0		dop+0		dop+0		dop+0	
	vrije zone (m)	neer-waarts	zij-/op-waarts	neer-waarts	insect/fung	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts
veldspuit met 50% dop en vanggewas	1.5											9.8	9.8
veldspuit met 50% dop in open perceel	1.5	38.1	38.1	18.0	16.3	16.8	16.8	27.0	24.6	57.2	57.2	29.3	29.3
veldspuit met 75% dop in open perceel	1.5	23.3	23.3		4.3			35.7	32.5	19.3	19.3	13.1	13.1
veldspuit met 90% dop en vanggewas	0.5											9.3	9.3
veldspuit met 90% dop in open perceel	1	7.3	7.3	20.1	18.1	15.7	15.7	13.6	12.4			28.1	28.1
veldspuit met luchtondersteuning en 50% dop in open perceel	1	13.5	13.5	22.5	20.3	24.8	24.8	10.2	9.3				
veldspuit met luchtondersteuning en 75% dop in open perceel	1	8.3	8.3		5.4			13.5	12.3				
veldspuit met luchtondersteuning en 90% dop in open perceel	0.5			24.9	22.5	23.1	23.1		4.7				
veldspuit met luchtondersteuning en standaard dop in open perceel	1.5			8.0	7.3	11.6	11.6						
veldspuit met standaard dop in open perceel	1.5	9.6	9.6	6.4	5.8	7.9	7.9		4.2	23.5	23.5	10.3	10.3
Totaal		100	100	100	100	100	100	100	100	100	100	100	100

Flower bulbs

		GLADIOLEN		HYACINTEN		IRISSEN		LELIES		NARCISSEN		TULPEN	
2008	Teelt	dop-12.5		dop+0		dop+0		dop+0		dop+0		dop+0	
	vrije zone (m)	neer-waarts	zij-/op-waarts	neer-waarts	insect/fung	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts
veldspuit met 50% dop en vanggewas	1.5											8	8
veldspuit met 50% dop in open perceel	1.5	25	25	7	7	8	8	15	15	44	44	16	16
veldspuit met 75% dop in open perceel	1.5	20	20	8	8	8	8	25	25	18	18	10	10
veldspuit met luchtondersteuning en 50% dop in open perceel	1	12	12	20	20	20	20	7	7	2	2	2	2
veldspuit met luchtondersteuning en 75% dop in open perceel	1	7	7					10	10	3	3	3	3
veldspuit met luchtondersteuning en 90% dop en vanggewas	0.5											9	9
veldspuit met luchtondersteuning en 90% dop in open perceel	0.5	36	36	60	60	56	56	43	43	33	33	52	52
veldspuit met luchtondersteuning en standaard dop in open perceel	1.5			5	5	8	8						
Totaal		100	100	100	100	100	100	100	100	100	100	100	100

- Tree nurseries

		BLOEM KWEKERIJ		BOS_HAAG PLANTSN		LAAN_PARKBOMEN			ROZEN STRUIKEN		SIER CONIFEREN		VASTE PLANTEN		VRUCHT BOMEN	
1998	Teelt vrije zone (m)	dop-12.5		dop-12.5		dop-12.5		opzetters	dop-12.5		dop-12.5		dop-12.5		dop+0	
		neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts
axiaalspuit in open perceel	2							100								
handspuitboom met standaard dop	0.5	1	1	40	50											
	0.75								40	50	40	50	40	50	40	50
onkruidspuit	0.5			10												
	0.75					84			10		10		10		10	
onkruidspuit in combinatie met een windsingel	0.75					16										
veldspuit met luchtondersteuning en standaard dop in open perceel	0.5	10	10	10	10											
	0.75								10	10	10	10	10	10	10	10
veldspuit met standaard dop in open perceel	0.5	89	89	40	40											
	0.75								40	40	40	40	40	40	40	40
Totaal		100	100	100	100	100		100	100	100	100	100	100	100	100	100

- Tree nurseries

		BLOEM KWEKERIJ		BOS_HAAG PLANTSN		LAAN_PARKBOMEN			ROZEN STRUIKEN		SIER CONIFEREN		VASTE PLANTEN		VRUCHT BOMEN	
2004	Teelt vrije zone (m)	dop-12.5		dop-12.5		dop-12.5		opzetters	dop-12.5		dop-12.5		dop-12.5		dop-12.5	
		neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts
axiaalspuit in open perceel	5							50.0								
axiaalspuit met windsingel	5							6.8								
dwarsstroomspuit in open perceel	0.5		8.7		6.5											
	1.5									9.1				12.4		
handspuitboom met standaard dop	0.5	37.7	34.4	16.7	15.6											
	1.5					18.0	11.2				24.6	24.6	26.3	23.0		
onkruidspuit in combinatie met een vanggewas	1.5					22.1										
Rijenspuit	1								10.8	9.8	21.3	21.3	22.4	19.6		
	1.5					34.1	21.2									
veldspuit met 50% dop en vanggewas	0.5			9.0	8.4											
	1.5								7.2	6.5						
veldspuit met 50% dop in open perceel	0.5	9.9	9.1	39.7	37.1											
	1.5					8.6			28.4	25.8	30.9	30.9	23.8	20.8	26.2	26.2
veldspuit met 75% dop in open perceel	1.5					17.3	10.7				10.0	10.0				
veldspuit met 90% dop in open perceel	0.5	11.1	10.2													
	1														18.6	18.6
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5			8.4	7.9											
	1														24.1	24.1
veldspuit met luchtondersteuning en 90% dop in open perceel	0.5														17.0	17.0
veldspuit met luchtondersteuning en	1.5														6.8	6.8

		BLOEM KWEKERIJ		BOS_HAAG PLANTSN		LAAN_PARKBOMEN			ROZEN STRUIKEN		SIER CONIFEREN		VASTE PLANTEN		VRUCHT BOMEN	
2004	Teelt vrije zone (m)	dop-12.5		dop-12.5		dop-12.5		opzetters	dop-12.5		dop-12.5		dop-12.5		dop-12.5	
		neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts
standaard dop in open perceel																
veldspuit met standaard dop en vanggewas	1.5								10.8	9.8						
veldspuit met standaard dop in open perceel	0.5	41.2	37.7	26.2	24.5											
	1.5								42.8	38.9	13.3	13.3	27.5	24.1	7.4	7.4
Totaal		100	100	100	100	100	43	57	100	100	100	100	100	100	100	100

- Tree nurseries

		BLOEMKWEKERIJ		BOS_HAAGPLANTSJEN		LAAN_PARKBOMEN			ROZENSTRUUKEN		SIERCONIFEREN		VASTE_PLANTEN		VRUCHTBOMEN	
2008	Teelt	dop-12.5		dop-12.5		dop-12.5		opzetters	dop-12.5		dop-12.5		dop-12.5		dop+0	
	vrije zone (m)	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts
axiaalspuit in open perceel	5							78								
axiaalspuit in open perceel met venturidop	5							2								
axiaalspuit met windsingel	5							10								
dwarsstroomspuit met windsingel	0.5	6	6	5	5											
	1								2	2						
dwarsstroomspuit in open perceel	0.5	5	5													
	1.5								9	9			5	5		
	5							10								
handspuitboom met standaard dop	0.5	28	28	8	8											
	1.5					8					25	25	25	25		
onkruidspuit in combinatie met een vanggewas	1.5					10										
Rijenspuit	0.5	10	10	18	18											
	1								18	18	18	18	15	15	3	3
	1.5					18										
veldspuit met 50% dop in open perceel	0.5	25	25	59	59											
	1.5					19			25	25	46	46	40	40	46	46
veldspuit met 75% dop in open perceel	1.5					20			16	16	10	10				
veldspuit met 90% dop in open perceel	0.5	11	11													
	1								14	14			10	10	9	9
	1.5					25										

		BLOEMKWEKERIJ		BOS_HAAGPLANTSEN		LAAN_PARKBOMEN			ROZENSTRIJKEN		SIERCONIFEREN		VASTE_PLANTEN		VRUCHTBOMEN	
2008	Teelt	dop-12.5		dop-12.5		dop-12.5		opzetters	dop-12.5		dop-12.5		dop-12.5		dop+0	
	vrije zone (m)	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5	15	15	10	10											
	1								13	13	1	1	5	5	21	21
veldspuit met luchtondersteuning en 90% dop in open perceel	0.5								3	3					21	21
Totaal		100	100	100	100	100		100	100	100	100	100	100	100	100	100

- Vegetables (a)

1998		AARDBEIEN		ASPERGES		PREI		SCHORSENEREN		SLUITKOOL	
	Teelt vrije zone (m)	dop-12.5		dop+0		dop-12.5		dop+25		dop+25	
		neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts
handspuitboom met standaard dop	0.75	4.1	4.1	0.9	0.9						
handspuitboom met standaard dop en windsingel	0.75	0.9	0.9	0.1	0.1						
Rijenspuit	0.75	27.1	27.1			9	9				
rijenspuit met windsingel	0.75	5.9	5.9								
veldspuit met luchtondersteuning en standaard dop en windsingel	0.75	3.1	3.1	0.5	0.5						
veldspuit met luchtondersteuning en standaard dop in open perceel	0.5									2	2
	0.75	13.9	13.9	6.5	6.5	8	8	5	5		
veldspuit met standaard dop en windsingel	0.75	8.1	8.1	6.4	6.4						
veldspuit met standaard dop in open perceel	0.5									98	98
	0.75	36.9	36.9	85.6	85.6	83	83	95	95		
Totaal		100	100	100	100	100	100	100	100	100	100

- Vegetables (b)

1998 (vervolg)		SPRUITKOOL		STAMBONEN		WAS_BOSPEEN		WINTERPEEN		WITLOFWORTEL	
	Teelt vrije zone (m)	dop-12.5		dop+25		dop+25		dop-12.5		dop+25	
		neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts
handspuitboom met standaard dop	0.75										
handspuitboom met standaard dop en windsingel	0.75										
rijenspuit	0.75							6	6		
rijenspuit met windsingel	0.75										
veldspuit met luchtondersteuning en standaard dop en windsingel	0.75										
veldspuit met luchtondersteuning en standaard dop in open perceel	0.5	2	2	3	3					8	8
	0.75					2	2	3	3		
veldspuit met standaard dop en windsingel	0.75										
veldspuit met standaard dop in open perceel	0.5	98	98	97	97					92	92
	0.75					98	98	91	91		
Totaal		100	100	100	100	100	100	100	100	100	100

- Vegetables (a)

		AARDBEIEN		ASPERGES		BLOEMKOOL		PREI		SCHORSENEREN		SLUITKOOL	
2004	Teelt	dop-12.5		dop+0		dop-12.5		dop-12.5		dop+25		dop+25	
	vrije zone (m)	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts
beddenspuit met overkapping in open perceel	1			20.1	20.1								
handspuitboom met standaard dop	1.5	6.6	6.2										
rijenspuit	1	17.5	16.5	32.3	32.3								
veldspuit met 50% dop en vanggewas	1.5							6.0	6.0				
veldspuit met 50% dop in open perceel	0.5					63.1	63.1					29.3	29.3
	1.5	33.6	31.6	32.1	32.1			51.9	51.9	27.4	27.4		
veldspuit met 75% dop in open perceel	0.5					5.9	5.9					38.0	38.0
	1.5		5.8	8.3	8.3			17.9	17.9	13.6	13.6		
veldspuit met 90% dop en vanggewas	0.5												
veldspuit met 90% dop in open perceel	0.5											17.3	17.3
	1									35.0	35.0		
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5					8.1	8.1						
	1	23.6	22.2					9.0	9.0				
veldspuit met luchtondersteuning en standaard dop in open perceel	1.5	7.7	7.3										
veldspuit met standaard dop in open perceel	0.5					22.9	22.9					15.4	15.4
	1.5	11.0	10.4	7.1	7.1			15.2	15.2	24.0	24.0		
Totaal		100	100	100	100	100	100	100	100	100	100	100	100

- Vegetables (b)

		SPRUITKOOL		STAMBONEN		WAS_BOSPEEN		WINTERPEEN		WITLOFWORTEL	
2004 (vervolg)	Teelt vrije zone (m)	dop-12.5		dop+25		dop+25		dop-12.5		dop+25	
		neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts
beddenspuit met overkapping in open perceel	1										
handspuitboom met standaard dop	1.5										
rijenspuit	1										
veldspuit met 50% dop en vanggewas	1.5										
veldspuit met 50% dop in open perceel	0.5	35.4	35.4	45.2	45.2					34.7	34.7
	1.5					38.0	38.0	23.8	23.8		
veldspuit met 75% dop in open perceel	0.5	23.5	23.5	27.9	27.9					26.0	26.0
	1.5					23.2	23.2	21.6	21.6		
veldspuit met 90% dop en vanggewas	0.5							6.0	6.0		
veldspuit met 90% dop in open perceel	0.5	23.7	23.7	9.3	9.3					24.4	24.4
	1					14.4	14.4	29.3	29.3		
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5	7.0	7.0								
	1										
veldspuit met luchtondersteuning en standaard dop in open perceel	1.5										
veldspuit met standaard dop in open perceel	0.5	10.4	10.4	17.6	17.6					14.8	14.8
	1.5					24.4	24.4	19.3	19.3		
Totaal		100	100	100	100	100	100	100	100	100	100

- Vegetables (a)

		AARDBEIEN		ASPERGES		BLOEMKOOL		PREI		SCHOR SENEREN		SLUITKOOL	
2008	Teelt	dop-12.5		dop+0		dop-12.5		dop-12.5		dop+25		dop+25	
	vrije zone (m)	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	zij-/op-waarts	neer-waarts	neer-waarts
beddenspuit met overkapping in open perceel	1			10	10								
dwaarsstroomspuit in open perceel	1.5			1	1								
handspuitboom met standaard dop	1.5	4	4										
rijenspuit	1	20	20	33	33								
veldspuit met 50% dop en vanggewas	1.5							10	10				
veldspuit met 50% dop in open perceel	0.5					65	65					33	33
	1.5	31	31	30	30			48	48	38	38		
veldspuit met 75% dop in open perceel	0.5					16	16					41	41
	1.5	5	5	12	12			28	28	22	22		
veldspuit met 90% dop en vanggewas	0.5												
veldspuit met 90% dop in open perceel	0.5					11	11					21	21
	1	5	5					5	5	40	40		
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5					8	8					5	5
	1	25	25	6	6			9	9				
veldspuit met luchtondersteuning en standaard dop in open perceel	1.5	10	10										
veldspuit met zakpijpen	1.5			8	8								
Totaal		100	100	100	100	100	100	100	100	100	100	100	100

— Vegetables (b)

		STAMBONEN		WAS_BOSPEEN		WINTERPEEN		WITLOF WORTEL		WITLOF WORTEL	
2008 (vervolg)	Teelt vrije zone (m)	dop+25		dop+25		dop-12.5		dop+25		dop+25	
		neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts
beddenspuit met overkapping in open perceel	1										
dwaarsstroomspuit in open perceel	1.5										
handspuitboom met standaard dop	1.5										
rijenspuit	1										
veldspuit met 50% dop en vanggewas	1.5										
veldspuit met 50% dop in open perceel	0.5	40	40					35	35	65	65
	1.5			41	41	30	30				
veldspuit met 75% dop in open perceel	0.5	42	42					30	30	16	16
	1.5			37	37	25	25				
veldspuit met 90% dop en vanggewas	0.5					4	4				
veldspuit met 90% dop in open perceel	0.5	13	13					15	15	11	11
	1			16	16	35	35				
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5	5	5					20	20	8	8
	1			6	6	6	6				
veldspuit met luchtondersteuning en standaard dop in open perceel	1.5										
veldspuit met zakpijpen	1.5										
Totaal		100	100	100	100	100	100	100	100	100	100

- Arable crops (a)

1998		AARDAPP_CONS		AARDAPP_FABR		AARDAPP_POOT		BRUINE_BONEN		CICHOREI		ERWTEN_GROEN	
	Teelt	dop-12.5		dop-12.5		dop-12.5		dop+25		dop-12.5		dop+25	
	vrije zone (m)	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts	neerwaarts	zij/opwaarts
rijenspuit	0.5									1	1		
	0.75	2	2	2	2	2	2						
veldspuit met luchtondersteuning en standaard dop in open perceel	0.25												
	0.5							3	3	14	14	3	3
	0.75	10	10	10	10	10	10						
veldspuit met standaard dop in open perceel	0.25												
	0.5							97	97	85	85	97	97
	0.75	88	86	88	88	88	84						
vliegtuigspuit in open perceel	0.75		2				4						
Totaal		100	100	100	100	100	100	100	100	100	100	100	100

- Arable crops (b)

1998 (vervolg)		GRASZAAD		POOT_ PLANTUIEN		SUIKER BIETEN		VELDBONEN		WINTER TARWE		ZAAIUIEN		ZOMER GERST	
	Teelt	dop+25		dop+0		dop+25		dop+25		dop+25		dop+0		dop+25	
	vrije zone (m)	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts
rijenspuit	0.5					13	13								
	0.75														
veldspuit met luchtondersteuning en standaard dop in open perceel	0.25	10	10							10	10			10	10
	0.5					12	12	3	3						
	0.75			10	10							10	10		
veldspuit met standaard dop in open perceel	0.25	90	90							90	90			90	90
	0.5					75	75	97	97						
	0.75			90	90							90	90		
vliegtuigspuit in open perceel	0.75														
Totaal		100	100	100	100	100	100	100	100	100	100	100	100	100	100

- Arable crops (a)

2004	Teelt vrije zone (m)	AARDAPP_ CONS		AARDAPP_ FABR		AARDAPP_ POOT		BRUINE_ BONEN		CICHOREI		ERWTEN_ GROEN	
		dop-12.5		dop-12.5		dop-12.5		dop+25		dop-12.5		dop+25	
		neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts
veldspuit met 50% dop in open perceel	0.25												
	0.5							48.3	48.3	44.7	44.7	42.3	42.3
	1.5	40.3	40.3	42.5	42.5	32.9	32.9						
veldspuit met 75% dop in open perceel	0.25												
	0.5							10.9	10.9	16.3	16.3	15.4	15.4
	1.5	35.9	35.9	19.4	19.4	24.2	24.2						
veldspuit met 90% dop en vanggewas	0.5												
veldspuit met 90% dop in open perceel	0.25												
	0.5							14.3	14.3	6.8	6.8	24.7	24.7
	1	8.1	8.1	14.5	14.5	26.8	26.8						
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5									23.5	23.5		
	1			6.4	6.4								
veldspuit met luchtondersteuning en 75% dop in open perceel	0.5									8.6	8.6		
	1												
veldspuit met luchtondersteuning en 90% dop in open perceel	0.5												
veldspuit met standaard dop in open perceel	0.25												
	0.5							26.5	26.5			17.6	17.6
	1.5	15.7	15.7	17.3	17.3	16.1	16.1						
Totaal		100	100	100	100	100	100	100	100	100	100	100	100

- Arable crops (b)

	Teelt	GRASZAAD		POOT_ PLANTUIEN		SUIKER BIETEN		VLAS		WINTER TARWE		ZAAUIEN		ZOMER GERST		ZOMER TARWE	
2004 (vervolg)	vrije	dop+25		dop+0		dop+25		dop+25		dop+25		dop+0		dop+25		dop+25	
	zone (m)	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts
veldspuit met 50% dop in open perceel	0.25	59.2	59.2							44.5	44.5			64.8	64.8	38.6	38.6
	0.5					44.1	44.1	33.3	33.3								
	1.5			15.0	14.2							39.9	35.7				
veldspuit met 75% dop in open perceel	0.25	12.6	12.6							27.5	27.5			12.9	12.9	25.1	25.1
	0.5					22.2	22.2	12.6	12.6								
	1.5			8.2	7.7							32.2	28.8				
veldspuit met 90% dop en vanggewas	0.5				5.4												
veldspuit met 90% dop in open perceel	0.25	16.9	16.9							9.5	9.5					9.5	9.5
	0.5					13.9	13.9	37.1	37.1								
	1			41.8	39.5							21.0	18.9				
veldspuit met luchtondersteuning en 50% dop in open perceel 0.5	0.5																
	1			7.7	7.3							6.9	6.2				
veldspuit met luchtondersteuning en 75% dop in open perceel	0.5																
	1												5.0				
veldspuit met luchtondersteuning en 90% dop in open perceel	0.5			21.3	20.2												
veldspuit met standaard dop in open perceel	0.25	11.3	11.3							18.5	18.5			22.3	22.3	26.7	26.7
	0.5					19.8	19.8	17.0	17.0								
	1.5			6.1	5.8								5.4				
Totaal		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

— Arable crops (a)

		GRASZAAD		POOT_ PLANTUIJEN		SUIKER BIETEN		VLAS		WINTER TARWE		ZAAIUIJEN		ZOMERGERST		KOOLZAAD	
2008	Teelt	dop+25		dop+0		dop+25		dop+25		dop+25		dop+0		dop+25		dop+25	
	vrije zone (m)	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts
veldspuit met 50% dop in open perceel	0.25	50	50							49	49			65	65		
	0.5					50	50	39	39							39	39
	1.5			13	13							20	20				
veldspuit met 75% dop in open perceel	0.25	24	24							30	30			22	22		
	0.5					26	26	20	20							20	20
	1.5			16	16							23	23				
veldspuit met 90% dop en vanggewas	0.5			4	4												
veldspuit met 90% dop in open perceel	0.25	20	20							15	15			7	7		
	0.5					18	18	41	41							41	41
	1			49	49							43	43				
veldspuit met luchtondersteuning en 50% dop in open perceel	0.25	6	6							6	6			6	6		
	0.5					6	6										
	1			18	18							14	14				
Totaal		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

- Arable crops (b)

		GRASZAAD		POOT_ PLANTUIEN		SUIKER BIETEN		VLAS		WINTER TARWE		ZAAIUIEN		ZOMERGERST		KOOLZAAD	
2008 (vervolg)	Teelt	dop+25		dop+0		dop+25		dop+25		dop+25		dop+0		dop+25		dop+25	
	vrije zone (m)	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts
veldspuit met 50% dop in open perceel	0.25	50	50							49	49			65	65		
	0.5					50	50	39	39							39	39
	1.5			13	13							20	20				
veldspuit met 75% dop in open perceel	0.25	24	24							30	30			22	22		
	0.5					26	26	20	20							20	20
	1.5			16	16							23	23				
veldspuit met 90% dop en vanggewas	0.5			4	4												
veldspuit met 90% dop in open perceel	0.25	20	20							15	15			7	7		
	0.5					18	18	41	41							41	41
	1			49	49							43	43				
veldspuit met luchtondersteuning en 50% dop in open perceel	0.25	6	6							6	6			6	6		
	0.5					6	6										
	1			18	18							14	14				
Totaal		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

- Livestock

		GRASLAND		SNIJMAIS	
1998	Teelt vrije zone (m)	kale grond/gras		dop-12.5	
		neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts
rijenspuit	0.5			1	1
veldspuit met luchtondersteuning en standaard dop in open perceel	0.25	14	14		
	0.5			14	14
veldspuit met standaard dop in open perceel	0.25	86	86		
	0.5			85	85
Totaal		100	100	100	100

- Livestock

		GRASLAND		SNIJMAIS	
2004	Teelt vrije zone (m)	kale grond/gras		dop-12.5	
		neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts
veldspuit met 50% dop in open perceel	0.25	62.8	62.8		
	0.5			51.7	51.7
veldspuit met 75% dop in open perceel	0.5			14.9	14.9
veldspuit met luchtondersteuning en 50% dop in open perceel	0.25	10.2	10.2		
veldspuit met standaard dop in open perceel	0.25	26.9	26.9		
	0.5			33.4	33.4
Totaal		100	100	100	100

- Livestock

		GRASLAND		SNIJMAIS	
2008	Teelt vrije zone (m)	kale grond/gras		dop-12.5	
		neer-waarts	zij/op-waarts	neer-waarts	zij/op-waarts
veldspuit met 50% dop in open perceel	0.25	60.0	60.0		
	0.5			40.0	40.0
veldspuit met 75% dop in open perceel	0.25	20.0	20.0		
	0.5			15.0	15.0
veldspuit met 90% dop in open perceel	0.25	15.0	15.0		
	0.5			40.0	40.0
veldspuit met luchtondersteuning en 50% dop in open perceel	0.25	5.0	5.0		
	0.5			5.0	5.0
Totaal		100	100	100	100

Appendix 3 Drift factors (standard ditch)

Tables in this appendix (for 1998, 2004, and 2008)

- Fruit orchards
- flower bulbs
- tree nurseries
- vegetables
- arable crops
- livestock

Teeltvrije zone = crop free zone

The drift emission factors in this appendix apply to the “Dutch standard ditch” used in registration for calculating the exposure concentration in surface water (edge of field ditch). The standard ditch is not used in the calculations but was added to the NMI database for reference only.

For calculations with the NMI, a set of 66 drift emission factors is available for each combination. This comprises 3 ditch classes x 22 regions.

Document versie Drift cijfers NMI3 V3.docx dd 10-06-2011.

– Fruit orchards

1998	Teelt vrije zone (m)	APPELEN			PEREN		
		dop-12.5	kaal	volblad	dop-12.5	kaal	volblad
		neer- waarts	zij-/op- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	zij-/op- waarts
dwaarsstroomspuit met windsingel	3		2.028	1.038		2.028	1.038
dwaarsstroomspuit in open perceel	3		13.448	8.571		13.448	8.571
onkruidspuit	0.75	4.283			4.283		
onkruidspuit in combinatie met een windsingel	0.75	1.457			1.457		
tunnelspuit in open perceel	3		2.028	1.038		2.028	1.038

– Fruit orchards

2004	Teelt vrije zone (m)	APPELEN			PEREN		
		dop-12.5	kaal	volblad	dop-12.5	kaal	volblad
		neer- waarts	zij-/op- waarts	zij-/op- waarts	neer- waarts	zij-/op- waarts	zij-/op- waarts
dwaarsstroomspuit met windsingel	3		2.028	1.038		2.028	1.038
dwaarsstroomspuit in open perceel	3		13.448	8.571		13.448	8.571
handspuitboom met standaard dop en vanggewas	1.5				1.094		
onkruidspuit	1.5	2.49					
onkruidspuit in combinatie met een emissiescherm	1.5				0.345		
onkruidspuit in combinatie met een vanggewas	1.5	1.094					
rijenspuit met vanggewas	1.5				0.318		

- Fruit orchards

2008	Teelt vrije zone (m)	APPELEN			PEREN		
		dop-12.5	kaal	volblad	dop-12.5	kaal	volblad
axiaalspuit in open perceel	3		13.448	8.571		13.448	8.571
axiaalspuit in open perceel met venturidop	3		2.028	1.038		2.028	1.038
axiaalspuit met reflectie- en emissiescherm	3		0.672	0.411		0.672	0.411
axiaalspuit met reflectiescherm	3		10.478	4.133		10.478	4.133
axiaalspuit met windsingel	3		2.028	1.038		2.028	1.038
dwardsroomsput met windsingel	3		2.028	1.038		2.028	1.038
dwardsroomsput in open perceel	3		13.448	8.571		13.448	8.571
dwardsroomsput in open perceel met venturidop	3		2.028	1.038		2.028	1.038
dwardsroomsput met reflectie- en emissiescherm	3		0.672	0.411		0.672	0.411
dwardsroomsput met reflectiescherm	3		10.478	4.133		10.478	4.133
onkruidspuit	1.5	2.49			2.49		
onkruidspuit in combinatie met een emissiescherm	1.5	0.345			0.345		
onkruidspuit in combinatie met een vanggewas	1.5	1.094			1.094		
tunnelspuit in open perceel	3		2.028	1.038		2.028	1.038

– Flower bulbs

	Teelt vrije zone (m)	GLADIOLEN	HYACINTEN	IRISSEN	LELIES	NARCISSEN	TULPEN
		dop-12.5	dop+0	dop+0	dop+0	dop+0	dop+0
1998							
handspuitboom met standaard dop	0.75	4.283	3.851	3.851	3.851	3.851	3.851
veldspuit met lichtondersteuning en standaard dop in open perceel	0.75	1.457	1.363	1.363	1.363	1.363	1.363
veldspuit met standaard dop in open perceel	0.75	4.283	3.851	3.851	3.851	3.851	3.851
vliegtuigsput in open perceel	0.75	12	12	12	12	12	12

– Flower bulbs

	Teelt vrije zone (m)	GLADIOLEN	HYACINTEN	IRISSEN	LELIES	NARCISSEN	TULPEN
		dop-12.5	dop+0	dop+0	dop+0	dop+0	dop+0
2004							
veldspuit met 50% dop en vanggewas	1.5						0.564
veldspuit met 50% dop in open perceel	1.5	1.094	1.061	1.061	1.061	1.061	1.061
veldspuit met 75% dop in open perceel	1.5	0.577	0.564		0.564	0.564	0.564
veldspuit met 90% dop en vanggewas	0.5						0.236
veldspuit met 90% dop in open perceel	1	0.345	0.315	0.315	0.315		0.315
veldspuit met lichtondersteuning en 50% dop in open perceel	1	0.345	0.315	0.315	0.315		
veldspuit met lichtondersteuning en 75% dop in open perceel	1	0.345	0.315		0.315		
veldspuit met lichtondersteuning en 90% dop in open perceel	0.5		0.236	0.236	0.236		
veldspuit met lichtondersteuning en standaard dop in open perceel	1.5		1.061	1.061			
veldspuit met standaard dop in open perceel	1.5	2.49	2.324	2.324	2.324	2.324	2.324

– Flower bulbs

2008	Teelt vrije zone (m)	GLADIOLEN dop-1.2.5	HYACINTEN dop+0	IRISSEN dop+0	LELIES dop+0	NARCISSEN dop+0	TULPEN dop+0
veldspuit met 50% dop en vanggewas	1.5						0.564
veldspuit met 50% dop in open perceel	1.5	1.094	1.061	1.061	1.061	1.061	1.061
veldspuit met 75% dop in open perceel	1.5	0.577	0.564	0.564	0.564	0.564	0.564
veldspuit met 90% dop en vanggewas	0.5						0.236
veldspuit met 90% dop in open perceel	1	0.345	0.315	0.315	0.315	0.315	0.315
veldspuit met luchtondersteuning en 50% dop in open perceel	1	0.345	0.315	0.315	0.315	0.315	0.315
veldspuit met luchtondersteuning en 75% dop in open perceel	1	0.345			0.315	0.315	0.315
veldspuit met luchtondersteuning en 90% dop in open perceel	0.5	0.318	0.236	0.236	0.236	0.236	0.236
veldspuit met luchtondersteuning en standaard dop in open perceel ¹⁾	1.5		2.324	2.324			

Veldspuit met luchtondersteuning is ten onrechte een te hoog driftcijfer toegekend (moet zijn: 1.06 ipv 2.324)

- Tree nurseries

1998	Teelt vrije zone (m)	BLOEM KWEKERIJ dop-1.2.5	BOS_ HAAGPLANTSN dop-1.2.5	LAAN_PARKBOMEN		ROZEN STRUJKEN dop-1.2.5	SIER CONIFEREN dop-1.2.5	VASTE_ PLANTEN dop-1.2.5	VRUCHT BOMEN dop+0
				dop-1.2.5	opzetters				
axiaalspuit in open perceel	2				10.418				
handspuitboom met standaard dop	0.5	5.398	5.398						
	0.75					4.283	4.283	4.283	3.851
onkruidspuit	0.5		5.398						
	0.75			4.283		4.283	4.283	4.283	3.851
onkruidspuit in combinatie met een windsingel	0.75			0.741					
veldspuit met lichterondersteuning en standaard dop in open perceel	0.5	1.726	1.726						
	0.75					1.457	1.457	1.457	1.363
veldspuit met standaard dop in open perceel	0.5	5.398	5.398						
	0.75					4.283	4.283	4.283	3.851

– Tree nurseries

2004	Teelt vrije zone (m)	BLOEM KWEKERIJ dop-1.2.5	BOS_HAAG PLANTSN dop-1.2.5	LAAN_PARKBOMEN		ROZEN STRIJKEN dop-1.2.5	SIER CONIFEREN dop-1.2.5	VASTE_ PLANTEN dop-1.2.5	VRUCHT BOMEN dop+0
				dop-1.2.5	opzetters				
axiaalspuit in open perceel	5				2.865				
axiaalspuit met windsingel	5				2.865				
dwarsstroomspuit in open perceel	0.5	5.398	5.398						
	1.5					2.49		2.49	
handspuitboom met standaard dop	0.5	5.398	5.398						
	1.5			2.49			2.49		
onkruidspuit i.c.m. een vanggewas	1.5			1.094					
rijenspuit	1			0.345		0.345	0.345		
veldspuit met 50% dop en vanggewas	0.5		0.903						
	1.5					0.577			
veldspuit met 50% dop in open perceel	0.5	1.726	1.726						
	1.5			1.094		1.094	1.094		1.061
veldspuit met 75% dop in open perceel	1.5			0.577			0.577		
veldspuit met 90% dop in open perceel	0.5	0.611							
	1								0.315
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5		0.611						
	1								0.315
veldspuit met luchtondersteuning en 90% dop in open perceel	0.5								0.236
veldspuit met luchtondersteuning en standaard dop in open perceel	1.5								2.324
veldspuit met standaard dop en vanggewas	1.5					1.094			
veldspuit met standaard dop in open perceel	0.5	5.398	5.398						
	1.5					2.49	2.49		2.324

- Tree nurseries

2008	Teelt vrije zone (m)	BLOEM KWEKERIJ	BOS_HAAG PLANTSN	LAAN_PARKBOMEN		ROZEN STRUKEN	SIER CONIFEREN	VASTE_ PLANTEN	VRUCHT BOMEN
				dop-12.5	opzetters				
axiaalspuit in open perceel	5				2.865				
axiaalspuit in open perceel met venturidop	5				2.865				
axiaalspuit met windsingel	5				2.865				
dwaarsstroomspuit met windsingel	0.5	0.611	0.611						
	1					0.345			
dwaarsstroomspuit in open perceel	0.5	5.398							
	1.5					2.49		2.49	
	5				2.865				
handspuitboom met standaard dop	0.5	5.398	5.398						
	1.5			2.49			2.49		
onkruidspuit i.c.m. een vanggewas	1.5			1.094					
rijenspuit	0.5	0.611	0.611						
	1			0.345		0.345	0.345	0.345	0.315
veldspuit met 50% dop in open perceel	0.5	1.726	1.726						
	1.5			1.094		1.094	1.094	1.094	1.061
veldspuit met 75% dop in open perceel	1.5			0.577		0.577	0.577		
veldspuit met 90% dop in open perceel	0.5	0.611							
	1			0.345		0.345	0.345	0.345	0.315
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5	0.611	0.611						
	1					0.345	0.345	0.345	0.315
veldspuit met luchtondersteuning en 90% dop in open perceel	0.5								
	0.5					0.318	0.345	0.345	0.236

– Vegetables

1998	Teelt vrije zone (m)	AARD	AS	PREI	SCHOR	SLUIT	SPRUIT	STAM	WAS_	WINTER	WITLOF
		BEIEN	PERGES	dop-12.5	SENEREN	KOOL	KOOL	BONEN	BOSPEEN	PEEN	WORTEL
handspuitboom met standaard dop	0.75	dop-12.5 4.283	dop+0 3.851	dop-12.5	dop+25	dop+25	dop-12.5	dop+25	dop+25	dop-12.5	dop+25
handspuitboom met standaard dop en windsingel	0.75	0.44	0.386								
Rijenspuit	0.75	0.44		0.44						0.44	
rijenspuit met windsingel	0.75	0.182									
veldspuit met luchtondersteuning en standaard dop en windsingel	0.75	0.741	0.693								
veldspuit met luchtondersteuning en standaard dop in open perceel	0.5					1.363	1.726	1.363			1.363
	0.75	1.457	1.363	1.457	1.226				1.226	1.457	
veldspuit met standaard dop en windsingel	0.75	0.44	0.386								
veldspuit met standaard dop in open perceel	0.5					3.851	5.398	3.851			3.851
	0.75	4.283	3.851	4.283	3.174				3.174	4.283	

– Vegetables

2004	Teelt vrije zone (m)	AARDBEIEN	ASPERGES	BLOEM KOOL	PREI	SCHOR SENEREN	SLUIT KOOL	SPRUIT KOOL	STAM BONIEN	WAS_ BOSPEEN	WINTER PEEN	WTLOF WORTEL
beddenspuit met overkapping in open perceel	1		0.315									
handspuitboom met standaard dop	1.5	2.49										
rijenspuit	1	0.345	0.315									
veldspuit met 50% dop en vanggewas	1.5				0.577							
veldspuit met 50% dop in open perceel	0.5			1.726			1.363	1.726	1.363			1.363
	1.5	1.094	1.061		1.094	1.005				1.005	1.094	
veldspuit met 75% dop in open perceel	0.5			0.903			0.693	0.903	0.693			0.693
	1.5	0.577	0.564		0.577	0.543				0.543	0.577	
veldspuit met 90% dop en vanggewas	0.5										0.318	
veldspuit met 90% dop in open perceel	0.5						0.386	0.611	0.386			0.386
	1					0.275				0.275	0.345	
veldspuit met luchtondersteuning en 50% dop in open perceel	0.5			0.611				0.611				
	1	0.345			0.345							
veldspuit met luchtondersteuning en standaard dop in open perceel	1.5	1.094										
	0.5			5.398			3.851	5.398	3.851			3.851
veldspuit met standaard dop in open perceel	1.5	2.49	2.324		2.49	2.056				2.056	2.49	

– Vegetables

2008	Teelt vrije zone (m)	AARD BEIEN dop-12.5	AS PERGES dop+0	BLOEM KOOL dop-12.5	PREI dop-12.5	SCHOR SENEREN dop+25	SLUIT KOOL dop+25	SPRUIT KOOL dop-12.5	STAM BONEN dop+25	WAS_ BOSPEEN dop+25	WINTER PEEN dop-12.5	WITLOF WORTEL dop+25	BROC COLI dop-12.5
beddenspuit met overkapping in open perceel	1		0.315										
dwaarsstroomspuit in open perceel	1.5		2.324										
handspuitboom met standaard dop	1.5	2.49											
rijenspuit	1	0.345	0.315										
veldspuit met 50% dop en vanggewas	1.5				0.577								
veldspuit met 50% dop in open perceel	0.5			1.726			1.363	1.726	1.363			1.363	1.726
veldspuit met 75% dop in open perceel	1.5	1.094	1.061		1.094	1.005				1.005	1.094		
veldspuit met 90% dop in open perceel	0.5			0.903			0.693	0.903	0.693			0.693	0.903
veldspuit met 90% dop en vanggewas	1.5	0.577	0.564		0.577	0.543				0.543	0.577		
veldspuit met 90% dop in open perceel	0.5			0.611			0.386	0.611	0.386			0.386	0.611
veldspuit met lichtondersteuning en 50% dop in open perceel	1	0.345	0.315		0.345	0.275				0.275	0.345		
veldspuit met lichtondersteuning en standaard dop in open perceel	1.5	2.49											
veldspuit met zakpijpen	1.5		1.061										

– Arable crops (a)

1998	Teelt vrije zone (m)	AARDAPP_	AARDAPP_	AARDAPP_	AARDAPP_	CICHOREI	ERWTEN_
		CONS	FABR	POOT	BONEN		
rijenspuit	0.5	dop-12.5	dop-12.5	dop-12.5	dop-12.5	dop-12.5	dop+25
	0.75	0.44	0.44	0.44		0.611	
veldspuit met lichterondersteuning en standaard dop in open perceel	0.25						
	0.5				1.363	1.726	1.363
	0.75	1.457	1.457	1.457			
veldspuit met standaard dop in open perceel	0.25						
	0.5				3.851	5.398	3.851
	0.75	4.283	4.283	4.283			
vliegtuigspuit in open perceel	0.75	12		12			

– Arable crops (b)

1998 (vervolg)	Teelt vrije zone (m)	ERWTEN_	GRAS	POOT_	SUIKER	VELD	WINTER	ZAAI UIEN	ZOMER
		GROEN	ZAAD	PLANTUIJEN	BIETEN	BONEN	TARWE		GERST
rijenspuit	0.5	dop+25	dop+25	dop+0	dop+25	dop+25	dop+25	dop+0	dop+25
	0.75				0.386				
veldspuit met lichterondersteuning en standaard dop in open perceel	0.25		1.575				1.575		1.575
	0.5	1.363			1.363	1.363			
	0.75			1.363				1.363	
veldspuit met standaard dop in open perceel	0.25		4.794				4.794		4.794
	0.5	3.851			3.851	3.851			
	0.75			3.851				3.851	
vliegtuigspuit in open perceel	0.75								

– Arable crops (a)

2004	Teelt vrije zone (m)	AARDAPP_ CONS	AARDAPP_ FABR	AARDAPP_ POOT	BRUINE_ BONEN	CICHOREI	ERWTEN_ GROEN
veldspuit met 50% dop in open perceel	0.25	dop-12.5	dop-12.5	dop-12.5	dop+25	dop-12.5	dop+25
	0.5				1.363	1.726	1.363
	1.5	1.094	1.094	1.094			
veldspuit met 75% dop in open perceel	0.25						
	0.5				0.693	0.903	0.693
	1.5	0.577	0.577	0.577			
veldspuit met 90% dop en vanggewas	0.5						
	0.25						
	0.5				0.386	0.611	0.386
veldspuit met luchtondersteuning en 50% dop in open perceel	1	0.345	0.345	0.345			
	0.5					0.611	
	1		0.345				
veldspuit met luchtondersteuning en 75% dop in open perceel	0.5					0.611	
	1						
	0.5						
veldspuit met luchtondersteuning en 90% dop in open perceel	0.25						
	0.5				3.851		3.851
	1.5	2.49	2.49	2.49			

– Arable crops (b)

2004 (vervolg)	Teelt vrije zone (m)	GRAS ZAAD	POOT_ PLANTUIJEN	SUIKER BIETEN	VLAS	WINTER TARWE	ZAAI UIJEN	ZOMER GERST	ZOMER TARWE
veldspuit met 50% dop in open perceel	0.25	1.575				1.575		1.575	1.575
	0.5			1.363					
	1.5		1.061				1.061		
veldspuit met 75% dop in open perceel	0.25	0.809				0.809		0.809	0.809
	0.5			0.693	0.693				
	1.5		0.564				0.564		
veldspuit met 90% dop en vanggewas	0.5		0.236						
	0.25	0.513				0.513			0.513
	0.5			0.386	0.386				
veldspuit met luchtondersteuning en 50% dop in open perceel	1		0.315				0.315		
	0.5								
	1		0.315				0.315		
veldspuit met luchtondersteuning en 75% dop in open perceel	0.5								
	1						0.315		
	0.5		0.236						
veldspuit met standaard dop in open perceel	0.25	4.794				4.794		4.794	4.794
	0.5			3.851	3.851				
	1.5		2.324				2.324		

– Arable crops (b)

2008 (vervolg)	Teelt vrije zone (m)	GRAS	POOT_	SUIKER	VLAS	WINTER	ZAALUIEN	ZOMER	ZOMER	ZOMER	KOOL
		ZAAD	PLANTUIEN	BIETEN	dop+25	TARWE	ZOMER	GERST	TARWE	ZAAD	
veldspuit met 50% dop in open perceel	0.25	dop+25 1.575	dop+0	dop+25	dop+25	dop+25	dop+0	dop+25	dop+25	dop+25	dop+25
	0.5			1.363	1.363						1.363
	1.5		1.061				1.061				
veldspuit met 75% dop in open perceel	0.25	0.809				0.809		0.809	0.809	0.809	
	0.5			0.693	0.693						0.693
	1.5		0.564				0.564				
veldspuit met 90% dop en vanggewas	0.5		0.236								
	0.25	0.513				0.513		0.513	0.513	0.513	
	0.5			0.386	0.386						0.386
veldspuit met luchtondersteuning en 50% dop in open perceel	1		0.315				0.315				
	0.25	0.513				0.513		0.513	0.513	0.513	
	0.5			0.386							
	1		0.315				0.315				

- Livestock

1998	Teelt vrije	GRASLAND	SNIJMAIS
	zone (m)	kale grond/gras	dop-12.5
rijenspuit	0.5		0.611
veldspuit met luchtondersteuning en standaard dop in open perceel	0.25	0.971	
	0.5		1.726
veldspuit met standaard dop in open perceel	0.25	3.108	
	0.5		5.398

- Livestock

2004	Teelt vrije	GRASLAND	SNIJMAIS
	zone (m)	kale grond/gras	dop-12.5
veldspuit met 50% dop in open perceel	0.25	0.971	
	0.5		1.726
veldspuit met 75% dop in open perceel	0.5		0.903
veldspuit met luchtondersteuning en 50% dop in open perceel	0.25	0.451	
veldspuit met standaard dop in open perceel	0.25	3.108	
	0.5		5.398

- Livestock

2008	Teelt vrije	GRASLAND	SNIJMAIS
	zone (m)	kale grond/gras	dop-12.5
veldspuit met 50% dop in open perceel	0.25	0.971	
	0.5		1.726
veldspuit met 75% dop in open perceel	0.25	0.622	
	0.5		0.903
veldspuit met 90% dop in open perceel	0.25	0.451	
	0.5		0.611
veldspuit met luchtondersteuning en 50% dop in open perceel	0.25	0.451	
	0.5		0.611

Appendix 4 Compounds and drainage group

Tables in this appendix

1. The number of substances per drainage group
2. Parent compounds with the drainage group number and the number of metabolites
3. Metabolites with the drainage group number
4. Substance properties (parents)

Section 3.1.3 describes the drainage group of the compounds in the database NMI 3. The list of compounds (active ingredients and metabolites) is included in this appendix.

1 The number of compounds per drainage group.

drainage group	Description	# parents	# metabolites
1	Model	36	12
2	Metamodel	143	21
3	emission = 0	109	
totaal		288	33

2 Parent compounds

rabnr	rabnaam	drainage groep	aantal metabolieten
8	THIODICARB	2	1
9	BUTOCARBOXIM	3	0
10	DODEMORF	2	0
15	TRIAZOFOS	2	0
20	KASUGAMYCINE	2	0
21	PYRETHRINEN	3	0
22	1_NAFTYLAZIJNZUUR	2	0
23	PYRIMETHANIL	1	0
27	ACLONIFEN	2	0
30	METHIOCARB	1	0
31	CYPROCONAZOOL	2	0
38	IPRODION	2	0
40	CARBOFURAN	1	0
41	HYMEXAZOOL	3	0
42	IMAZALIL	2	0
46	FOLPET	3	0
48	PROPACHLOOR	2	0
49	BENFURACARB	3	1
51	METHAMIDOFOS	2	0
52	FENARIMOL	2	0
53	FENPICLONIL	2	0
54	FENPROPIMORF	3	0
55	PENCONAZOOL	2	0

rabnr	rabnaam	drainage groep	aantal metabolieten
56	PROCYMIDON	1	0
57	CLOPYRALID	1	0
59	ETRIMFOS	2	1
60	HEXYTHIAZOX	2	0
65	NITROTHAL_ISOPROPYL	2	0
75	ETHOPROFOS	1	0
78	CHLOORTOLURON	2	0
79	TRICLOPYR	2	0
84	BROMUCONAZOOL	2	0
86	ETRIDIAZOOOL	2	0
89	PROCHLORAZ	2	0
91	THIOFANAAT_METHYL	2	1
93	PACLOBUTRAZOL	2	0
94	DAZOMET	3	0
95	ATRAZIN	1	2
96	DESMETRYN	2	0
98	DNOC	2	0
99	HALOXYFOP_ETHOXYETHYL	3	0
101	IMAZAMETHABENZ_METHYL	2	0
102	ISOPROTURON	1	0
106	PYRIDAAT	3	1
107	QUINMERAC	2	0
112	CYHEXATIN	2	0
113	DELTAMETHRIN	3	0
115	FENBUTATINOXIDE	3	0
117	FOXIM	3	0
118	PYRIDABEN	2	0
119	TEFLUBENZURON	2	0
122	VAMIDOTHION	3	0
131	BENZYLADENINE	3	0
136	BITERTANOL	2	0
138	METALAXYL	1	1
140	PROPICONAZOOL	2	0
142	DAMINOZIDE	3	0
143	AMITROL	2	0
144	PARAQUAT_DICHLORIDE	3	0
145	FENITROTHION	2	0
146	PERMETHRIN	2	0
150	THIOMETON	3	0
154	LINDAAN	2	0
158	CARBENDAZIM	1	0
159	GLYFOSAAT	3	0
160	TERBUTRYN	2	0
161	FOSETYL_ALUMINIUM	3	0
162	FURALAXYL	2	1
165	GIBBERELLA_ZUUR_A3	3	0
168	DIQUAT_DIBROMIDE	3	0
169	EPTC	3	0
170	FLUAZIFOP_P_BUTYL	2	1

rabnr	rabnaam	drainage groep	aantal metabolieten
179	VALIDAMYCINE	3	0
181	2_4_D	2	0
185	MCPA	1	0
186	PROSULFOCARB	2	0
187	CHLOORFENVINFOS	1	0
188	CHLOORPYRIFOS	2	0
189	FENOXYCARB	2	0
190	FENPROPATHRIN	3	0
194	DIMETHOMORF	2	0
195	MALEINE_HYDRAZIDE	2	0
197	CYCLOXYDIM	3	0
198	DICHOORPROP_P	2	0
199	METHABENZTHIAZURON	3	0
201	ESFENVALERAAT	3	0
212	CHLOORTHALONIL	2	0
213	FENAMIFOS	3	1
214	CHLOORBROMURON	2	0
216	TERBUTYLAZIN	1	2
217	TRIADIMENOL	1	0
224	FLUAZINAM	2	0
225	TOLYLFLUANIDE	3	1
227	ASULAM	3	0
235	DIETHOFENCARB	2	0
236	DIFENOCONAZOOL	2	0
237	FENMEDIFAM	3	0
238	CARBARYL	2	0
242	MANCOZEB	3	0
245	PROPAQUIZAFOP	3	0
249	DODINE	2	0
250	PENCYCURON	2	0
251	PYRIFENOX	2	0
252	THIABENDAZOOL	2	0
253	GIBBERELLIN_A4_A7	3	0
260	BIFENOX	2	0
262	CARBEETAMIDE	2	0
268	ALDICARB	2	1
280	3_INDOLYLBOTERZUUR	3	0
284	FENOXAPROP_P_ETHYL	3	2
286	METRIBUZIN	1	0
287	TRI_ALLAAT	2	0
288	OMETHOAT	3	0
293	CYMOXANIL	3	0
295	1_NAFTYLACEETAMIDE	3	0
296	DIFLUFENICAN	2	0
299	FLUROXYPYR	1	0
300	METAZACHLOOR	2	0
301	METOBROMURON	2	0
302	METOLACHLOOR	2	0
303	PROMETRYN	2	0

rabnr	rabnaam	drainage groep	aantal metabolieten
305	MALATHION	2	0
306	MEVINFOS	3	0
308	PIRIMICARB	2	0
309	PIRIMIFOS_METHYL	1	2
311	VINCHLOZOLIN	2	0
312	ZINEB	3	0
314	METSULFURON_METHYL	1	0
316	FOSFAMIDON	2	0
320	BUPIRIMAAT	2	0
322	MANEB	3	0
323	THIRAM	1	1
324	DIMETHOAAAT	2	0
330	BROMOXYNIL	3	0
331	DICHLORVOS	3	0
339	3_INDOLYLAZIJNZUUR	3	0
341	CHLORIDAZON	1	0
347	EPOXICONAZOOL	2	0
350	MONOLINURON	1	0
352	AZOCYCLOTIN	3	0
361	PYRAZOFOS	2	0
363	TRIFLUMIZOOL	2	0
365	BUMINAFOS	2	0
368	MINERALE_OLIE	3	0
369	AMITRAZ	3	0
370	AZINFOS_METHYL	2	0
379	GIBBERELINE	3	0
386	CAPTAN	3	0
389	CYROMAZINE	2	1
398	TEBUCONAZOOL	1	0
399	ETHEFON	2	0
401	CLODINAFOP_PROPARGYL	3	0
405	DICHLOFENTHION	2	0
407	IMIDACLOPRID	1	0
411	TRIFORINE	2	0
413	QUIZALOFOP_P_ETHYL	3	0
425	AZACONAZOLE	2	0
427	BENOMYL	1	1
428	FLUTOLANIL	2	0
429	STREPTOMYCINE_SULFAAT	3	0
431	MECOPROP_P	2	0
432	METAMITRON	2	0
434	ABAMECTINE	3	0
435	ACEFAAT	2	0
443	HALOXYFOP_P_METHYLESTER	3	0
444	FENTIN_ACETAAT	2	0
445	PROPAMOCARB_HYDROCHLORIDE	2	0
448	LINURON	2	0
451	DIAZINON	2	0
456	FENTIN_HYDROXIDE	2	0

rabnr	rabnaam	drainage groep	aantal metabolieten
458	LENACIL	1	0
460	TRICHOORFON	3	0
467	GLYFOSAAT_TRIMESIUM	3	0
472	MIERENZUUR	3	0
476	PROPYZAMIDE	2	0
477	FLUCYCLOXURON	3	0
482	ETHOFUMESAAT	2	0
483	CLOQUINTOCEET_MEXYL	3	0
486	BUPROFEZIN	2	0
488	METALDEHYDE	1	0
498	DESMEDIFAM	2	0
504	GUAZATINE	2	0
505	CHLOORMEQUAT	2	0
507	PROFAM	3	0
509	DIENOCHLOOR	3	0
510	HEPTENOFOS	3	0
518	DICHLORAN	2	0
519	SETHOXYDIM	3	1
520	SIMAZIN	1	0
525	BENAZOLIN	3	0
527	DIURON	1	0
534	BENTAZON	1	0
535	CLOFENTEZIN	2	0
545	LAMBDA_CYHALOTHRIN	3	0
555	DITHIANON	2	0
556	TOLCLOFOS_METHYL	2	0
558	OXAMYL	2	0
559	CHLOORPROFAM	3	0
560	DICAMBA	3	1
561	DINOTERB	2	0
563	GLUFOSINAAT_AMMONIUM	2	0
564	METOXURON	2	0
565	PENDIMETHALIN	2	0
566	RIMSULFURON	2	0
567	DIFLUBENZURON	2	0
568	FOSALONE	2	0
569	METHIDATION	2	0
570	PROPOXUR	1	0
578	METIRAM	2	0
580	DICHLORBENIL	2	0
581	CYFLUTHRIN	3	0
588	METHOMYL	2	0
594	KARVON_D	3	0
595	BROOMPROPYLAAT	2	0
697	HYDRAMETHYLNON	3	0
698	AZOXYSTROBINE	1	0
699	FLUDIOXONIL	2	0
700	KRESOXIM_METHYL	3	0
701	ZIRAM	3	0

rabnr	rabnaam	drainage groep	aantal metabolieten
702	TRINEXAPAC_ETHYL	3	1
703	AMIDOSULFURON	2	0
704	CINIDON_ETHYL	2	0
705	ISOXAFLUTOOL	1	2
707	SULCOTRION	1	0
708	TRIFLUSULFURON_METHYL	1	1
709	CODLEMON	3	0
712	NICOSULFURON	3	0
713	PYRIPROXYFEN	2	0
714	TEBUFENPYRAD	2	0
715	TRIAZAMAAT	3	1
2051	BENTHIAVALICARB_ISOPROPYL	3	0
2060	BENZOEZUUR	3	0
2061	FOSETYL	3	0
2065	ISOXABEN	3	0
2074	QUIZALOFOP_ETHYL	3	0
2077	PROPAMOCARB	3	0
10000	CLOMAZONE	2	0
10001	CYPRODINIL	2	0
10002	DIMETHENAMIDE	2	0
10003	FENHEXAMIDE	3	0
10005	FIPRONIL	3	0
10006	FLORASULAM	1	1
10007	MESOTRIONE	2	0
10009	PYMETROZINE	2	0
10010	S_METOLACHLOOR	1	1
10012	MEPANIPYRIM	3	0
10013	CARFENTRAZONE_ETHYL	3	1
10014	CYAZOFAMID	2	0
10015	DIMETHENAMIDE_P	2	0
10016	METALAXYL_M	2	0
10017	MILBEMECTINE	2	0
10018	PROHEXADIONE_CALCIIUM	3	0
10019	SPINOSAD	2	0
10020	TRIFLOXYSTROBINE	3	0
10021	FAMOXADONE	2	0
10022	FENPROPIDIN	2	0
10024	QUINOXYFEN	3	0
10025	TEPRALOXYDIM	2	0
10026	AZADIRACHTINE_A	3	0
10027	FOSTHIAZAAT	2	0
10028	INDOXACARB	2	0
10029	MEFENPYRDIETHYL	3	0
10030	PICOXYSTROBIN	2	0
10031	PYRACLOSTROBINE	3	0
10032	SPIRODICLOFEN	3	0
10034	IODOSULFURON_METHYL_NATRIUM	2	1
10035	FORAMSULFURON	2	0
20010	BIFENAZAAT	3	0

rabnr	rabnaam	drainage groep	aantal metabolieten
20011	BOSCALID	2	0
20020	SPIROMESIFEN	3	0
20021	THIACLOPRID	2	0
20025	METHOXYFENOZIDE	3	0
20026	PROTHIOCONAZOOL	3	0
20027	FLUOXASTROBIN	2	0
20028	METRAFENONE	3	0
20029	METCONAZOOL	2	0
20031	FLONICAMID	3	0
20037	QUINOCLAMIN	3	0
20038	THIAMETHOXAM	2	0
20039	TOPRAMEZONE	3	0
20055	LUFENURON	3	0
20823	ACEQUINOCYL	3	0
20824	FLUOPICOLIDE	3	0
20825	IOXYNIL_OCTANOAT	3	0
20826	MANDIPROPAMID	3	0
20827	ZOXAMIDE	3	0
20828	FENAMIDONE	3	0
21002	PARATHION	2	0

3 Metabolites

ID	MetabolietNaam	rabnr	rabnaam	drainage groep
27	2-cyano-3-cyclopropyl-1-(2-methylsulfonyl-4-trifluoromethylphenyl)propan-1,3-dione	705	ISOXAFLUTOOL	2
28	2-diethylamino-4-hydroxy-6-methylpyrimidine	309	PIRIMIPHOS-METHYL	2
32	2-hydroxy-atrazine	95	ATRAZIN	2
37	2-methanesulfonyl-4-trifluoromethylbenzoic acid	705	ISOXAFLUTOOL	2
56	3,6-dichlorosalicylic acid	560	DICAMBA	1
84	5-hydroxy-florasulam	10006	FLORASULAM	1
90	6-chloro-2,3-dihydrobenzoxazol-2-one	284	FENOXAPROP-P-ETHYL	2
91	6-chloro-3-phenylpyridazin-4-ol	106	PYRIDAAT	1
93	6-ethoxy-2-ethyl-4-hydroxypyrimidine	59	ETRIMFOS	2
107	aldicarb sulfoxide	268	ALDICARB	2
116	carbendazim	427	BENOMYL	2
116	carbendazim	91	THIOPHANAAT-METHYL	1
117	carbofuran	49	BENFURACARB	1
118	carfentrazone chloropropionic acid	10013	CARFENTRAZONE-ETHYL	2
130	CGA354743/CGA380168	10010	S-METOLACHLOR	2
132	CL900056	715	TRIAZAMAAT	2
143	desethyl-atrazine	95	ATRAZIN	2
145	desethyl-terbuthylazine	216	TERBUTHYLAZIN	1

ID	Metaboliëtnaam	rabnr	rabnaam	drainage groep
16 5	fenamiphos-sulfoxide	213	FENAMIPHOS	1
16 7	Fenoxaprop-P	284	FENOXAPROP-P-ETHYL	1
16 8	fluazifop-P	170	FLUAZIFOP-P-BUTYL	2
18 2	hydroxy-terbuthylazine	216	TERBUTHYLAZIN	1
21 0	melamine	389	CYROMAZINE	2
21 4	methomyl	8	THIODICARB	2
21 8	methyl saccharin	708	TRIFLUSULFURON-METHYL	2
22 3	metsulfuron-methyl	10034	IODOSULFURON-METHYL-SODIUM	1
23 3	N-(2,6-dimethylphenyl)-N-(2-methoxyacetyl)alanine	138	METALAXYL	1
24 0	N,N-diethylguanidine	309	PIRIMIPHOS-METHYL	2
24 1	N,N-dimethyl carbamosulfonic acid	323	THIRAM	2
24 3	N,N-dimethyl-N-(4-tolyl)sulfamide	225	TOLYLFLUANID	2
24 5	N-2,6-dimethylphenyl-N-furoyl-(2)-alanine	162	FURALAXYL	1
27 1	sethoxydim-sulfoxide	519	SETHOXYDIM	2
28 3	Trinexapac-acid	702	TRINEXAPAC-ETHYL	2

4 Substance properties (parent compounds)

field name	description	units
RABnr	Unique reference to substance in Substance database	-
RabNaam	No input. For reference only.	-
RabNaamEng	No input. For reference only.	-
Casnr	No input. For reference only.	-
SpuitgroepType	either INFU (upward and sideward spraying) or NEER-WAARTS (downward spraying)	-
StofGroep	Product use in EU-substance list	-
Dampdruk_mPa	saturated vapour pressure	mPa
Molmassa_g_mol	molar mass	g mol ⁻¹
Oplosbaarheid_mg_l	solubility in water	mg L ⁻¹
DegT50_WS_d	half-life for degradation in water-sediment	d
DegT50_BODEM_d	half-life for degradation in soil	d
DegT50_WATER_d	half-life for degradation in water	d
DegT50_WATER_DINF_d	constant	d
DEGT50_GH_AIR_d	constant	d
DEGT50_GH_FLOOR_D	constant	d
DEGT50_GH_FOLIAGE_d	constant	d
Kom_L_kg	combined sorption coefficient	L kg ⁻¹
Kom_Basisch_L_kg	sorption coefficient for the conjugated base	L kg ⁻¹
Kom_Zuur_L_kg	sorption coefficient for the acidic molecule	L kg ⁻¹
phAfhankelijk_sorptie	switch denoting pH-dependent sorption	-
pKa	acid dissociation constant	-
LogKow	logarithm of the octanol-water partitioning coefficient	-
ETOX_OPWA_A_mg_L	lowest toxicity value for daphnia, algae and fish	(mg L ⁻¹)
ETOX_OPWA_C_mg_L	water quality standard Maximum Permissible concentration MPC (MTR)	(mg L ⁻¹)
ETOX_BODEM_A_mg_kg		mg a.i. kg dw ⁻¹
ETOX_BODEM_C_mg_kg		mg a.i. kg dw ⁻¹
ETOX_BODEM_2jr_mg_kg		mg a.i. kg dw ⁻¹
ETOX_BODEM_7jr_mg_kg		mg a.i. kg dw ⁻¹
ETOX_TERR_A_mg_kg	Dose causing 50% mortality in birds	(mg a.i. kg body weight ⁻¹ d ⁻¹)
ETOX_TERR_C_mg_kg	Dose causing no observed chronic effects on birds	(mg kg body weight ⁻¹ d ⁻¹).
datum	version date	-

Appendix 5 Crop data

Tables in this appendix

1. NMI crop area per crop group, in 3 survey years
2. Same as 1, with NMI crop codes
3. Crop interception fractions for spraying applications in arable crops (NMI 2)
4. Extrapolation of interception fractions in the NMI

1. NMI crop names, crop groups and crop area in 3 survey years (ha)

Crop	Crop group	Area (ha)		
		1998	2004	2008
Winter wheat	Akkerbouw (arable farming)	127673	117121	140463
Sugar beets		112551	97392	71590
Ware potatoes		84023	72543	69187
Starch potatoes		56936	51490	45989
Seed potatoes		39889	39706	36506
Spring barley		36528	44683	45515
Grass (seed)		28418	25327	15625
Onions		13844	19889	20298
Peas		4589	4862	5969
Onions (bulbs)		4505	5604	5131
Chicory		4196	4918	3408
Haricot beans		2381	2658	1434
Field beans		1690	-	-
Summer wheat		-	20822	15867
Rape seed		-	-	2467
Flax		-	4461	2612
Tulips	Bloembollenteelt (flowerbulb cultivation)	9847	10873	11183
Lilies		3609	4358	4757
Daffodils		1572	1773	1930
Gladiolas		1360	1275	1059
Hyacinths		1181	1137	1365
Irissen		664	554	414
Roses (glasshouse)	Bloemisterij glas (glasshouse floristry)	931	848	584
Chrysanthemum		757	679	523
Pot plants (flowers)		636	767	941
Pot plants (green)		540	573	490
Bed plants		449	543	459

Crop	Crop group	Area (ha)			
		1998	2004	2008	
Freesias		241	191	129	
Lilies (greenhouse)		237	273	223	
Gerberas		219	227	208	
Orchids		206	233	206	
Carnation		117	-	-	
Alstroemeria		-	85	-	
Tree nursery	Boomkwekerij (cultivation of trees)	2955	3593	4444	
Floriculture		2432	2407	2556	
Shrubberies		2277	2301	2880	
Conifers		1822	2734	3039	
Fruit trees		1304	1146	1323	
Perennial plants		947	1389	1086	
Roses		716	463	548	
Mushrooms	Eetbare paddestoelen (mushrooms)	98	84	77	
Apple trees	Fruitteelt (fruit cultivation)	14679	10212	9290	
Pear trees		5938	6495	7467	
Tomatoes	Groenteteelt glas (greenhouse vegetables)	1305	1352	1600	
Sweet pepper		1010	1206	1184	
Cucumbers		710	623	622	
strawberries (greenhouse)		-	-	269	
Radish		-	109	-	
Green beans	Groenteteelt vollegrond (open air vegetables)	4852	4405	3429	
Carrots (winter)		4822	5453	5285	
Brussels sprouts		4622	3455	3243	
Industrial chicory roots		4242	2938	3162	
Leeks		3641	3039	3012	
Cabbage		2940	2574	3064	
Carrots		2934	2436	2658	
Asparagus		2304	2362	2477	
Strawberries		1967	2129	2925	
Salsify		1839	1020	959	
Cauliflower		-	2322	2540	
broccoli		-	-	1732	
Grass		Veehouderij (cattle farming)	1031771	983386	1018404
Fodder maize			239288	224368	241559

2 NL versie van Tabel 1 (met NMI gewascode)

Gewascode	Sector	jaar		
		1998	2004	2008
AARDAPP_CONS	Akkerbouw	84081	72495	69187
AARDAPP_FABR		56920	51485	45989
AARDAPP_POOT		39881	39702	36506
BRUINE_BONEN		2381	2658	1434
CICHOREI		4195	4918	3408
ERWTEN_GROEN		4589	4863	5969
GRASZAAD		28417	25324	15625
KOOLZAAD				2467
POOT_PLANTUIEN		4505	5604	5131
SUIKERBIETEN		112564	97408	71590
VELDBONEN		1690		
VLAS			4461	2612
WINTERTARWE		127776	117103	140463
ZAAIUIEN		13842	19894	20298
ZOMERGERST		36527	44662	45515
ZOMERTARWE			20805	15867
GLADIOLEN		Bloembollenteelt	1360	1275
HYACINTEN	1183		1137	1365
IRISSEN	664		554	414
LELIES	3609		4364	4757
NARCISSEN	1572		1773	1930
TULPEN	9848		10734	11183
ALSTROEMERIA	Bloemisterij glas		85	
ANJERS		117		
CHRYSANTEN		756	679	523
FREESIA		241	191	129
GERBERA		219	227	208
LELIE_GLAS		236	273	223
ORCHIDEEEN		206	233	206
PERKPLANTEN		449	543	459
POTPLANT_BLADE		540	573	490
POTPLANT_BLOEI		636	767	941
ROZEN		931	848	584
BLOEMKWEKERIJ	Boomkwekerij	2430	2407	2556
BOS_HAAGPLANTSN		2271	2301	2880
LAAN_PARKBOMEN		2955	3593	4444
ROZENSTRIJKEN		716	463	548
SIERCONIFEREN		1821	2735	3039
VASTE_PLANTEN		947	1389	1086
VRUCHTBOMEN		1305	1145	1323
CHAMPIGNONS	Eetbare paddestoelen	98	84	77
APPELEN	Fruitteelt	14676	10214	9290
PEREN		5937	6495	7467
AARDBEIEN_BT	Groenteteelt glas			269
KOMKOMMERS		710	623	622
PAPRIKA		1010	1206	1184

Gewascode	Sector	jaar			
		1998	2004	2008	
RADIJS			109		
TOMATEN		1305	1352	1600	
AARDBEIEN	Groenteteelt vollegrond	1965	2129	2925	
ASPERGES		2304	2362	2477	
BLOEMKOOL			2322	2540	
BROCCOLI				1732	
PREI		3641	3039	3012	
SCHORSENEREN		1839	1020	959	
SLUITKOOL		2941	2574	3064	
SPRUITKOOL		4621	3455	3243	
STAMBONEN		4852	4405	3429	
WAS_BOSPEEN		2934	2436	2658	
WINTERPEEN		4821	5454	5285	
WITLOFWORTEL		4241	2938	3162	
GRASLAND		Veehouderij	1031722	983417	1018404
SNIJMAIS			239284	224308	241559

2 Crop interception fractions for spraying applications to field crops in the NMI 2 (as used in the NMI 3) 1

crop	Sector	Mode of action	Application time (month number)												
			1	2	3	4	5	6	7	8	9	10	11	12	
Onions (bulbs)	Akkerbouw (arable farming)		-	-	-	0.145	0.166	0.428	0.457	0.171	-	-	-	-	-
Onions			-	-	0.116	0.166	0.428	0.457	0.457	0.137	-	-	-	-	-
Peas			0.013	0.013	0.065	0.187	0.383	0.709	0.720	0.307	0.013	0.013	0.013	0.013	
Field beans			-	-	-	-	0.175	0.750	0.900	0.788	-	-	-	-	
Seed potatoes			0.002	0.002	0.002	0.060	0.315	0.632	0.843	0.780	0.002	0.002	0.002	0.002	
Harricot beans			-	-	-	-	0.075	0.500	0.800	0.863	0.630	-	-	-	
Starch potatoes, Ware potatoes			0.002	0.002	0.002	0.019	0.162	0.459	0.688	0.891	0.750	0.088	0.002	0.002	
Sugar beets			0.013	0.013	0.013	0.078	0.187	0.239	0.415	0.796	0.796	0.502	0.013	0.013	
Flax, Spring barley, Summer wheat			-	-	0.014	0.377	0.855	0.868	0.824	0.309	-	-	-	-	
Chicory			-	-	-	0.075	0.200	0.260	0.463	0.900	0.900	0.563	-	-	
Winter wheat			0.047	0.047	0.164	0.398	0.856	0.868	0.824	0.823	0.247	-	0.018	0.047	
Grass (seed)			0.250	0.250	0.250	0.250	0.469	0.740	0.900	0.900	0.900	0.331	0.250	0.250	
Daffodils, Hyacinths, Tulips	Bloembollenteelt (flowerbulb cultivation)		-	-	0.183	0.262	0.357	0.492	-	-	-	-	-	-	
Gladiolas			-	-	-	-	0.044	0.500	0.363	0.329	0.308	0.039	-	-	
Lilies			-	-	-	-	0.060	0.498	0.364	0.328	0.307	0.038	-	-	
Irissen			-	-	0.183	0.262	0.357	0.548	0.568	0.213	-	-	-	-	
Floriculture		herb.	-	-	0.183	0.262	0.357	0.492	-	-	-	-	-	-	
Tree nursery	Boomkwekerij (cultivation of trees)	fung., insect.	0.100	0.100	0.100	0.100	0.264	0.290	0.290	0.290	0.290	0.290	0.106	0.100	
		herb.	0.080	0.080	0.080	0.080	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.080
Fruit trees		fung., insect.	0.120	0.120	0.120	0.120	0.383	0.420	0.420	0.420	0.420	0.420	0.308	0.120	
		herb.	0.118	0.118	0.118	0.118	0.354	0.388	0.388	0.388	0.388	0.388	0.287	0.118	
Roses		fung., insect.	0.010	0.010	0.010	0.026	0.164	0.467	0.700	0.907	0.764	0.702	0.089	0.010	
		herb.	-	-	-	0.018	0.157	0.429	0.640	0.826	0.697	0.641	0.088	-	
Shrubberies		fung., insect.	0.010	0.010	0.010	0.026	0.164	0.467	0.700	0.907	0.764	0.702	0.439	0.010	

crop	Sector	Mode of action	Application time (month number)											
			1	2	3	4	5	6	7	8	9	10	11	12
Perennial plants		herb.	-	-	-	0.018	0.157	0.429	0.640	0.826	0.697	0.641	0.404	-
		fung., insect.	0.010	0.010	0.010	0.613	0.700	0.700	0.700	0.700	0.700	0.700	0.438	0.010
		herb.	-	-	-	0.561	0.640	0.640	0.640	0.640	0.640	0.640	0.404	-
Conifers		fung., insect.	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560
		herb.	0.514	0.514	0.514	0.514	0.514	0.514	0.514	0.514	0.514	0.514	0.514	0.514
Apple trees, Pear trees	Fruitteelt (fruit cultivation)	fung., insect.	0.120	0.120	0.120	0.120	0.453	0.636	0.740	0.665	0.620	0.620	0.433	0.120
Leeks	Groenteteelt vollegrond (open air vegetables)	herb.	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Green beans			0.009	0.009	0.009	0.009	0.009	0.084	0.159	0.325	0.424	0.268	0.009	0.009
Salsify			-	-	-	-	-	0.100	0.575	0.863	0.270	-	-	-
Asparagus			-	-	-	-	-	0.082	0.199	0.454	0.454	0.454	0.283	-
Strawberries			-	-	-	-	-	0.100	0.238	0.500	0.500	0.500	0.313	-
Brussels sprouts, Cabbage, Cauliflour			0.234	0.234	0.234	0.234	0.351	0.335	0.058	0.234	0.234	0.234	0.234	0.234
Carrots (winter)			-	-	-	-	-	0.210	0.538	0.800	0.800	0.800	0.500	-
Carrots, Industrial chicory roots			0.006	0.006	0.006	0.006	0.077	0.250	0.770	0.852	0.852	0.852	0.535	0.006
Fodder maize	Veehouderij (cattle farming)		-	-	-	-	0.075	0.260	0.813	0.900	0.900	0.900	0.563	-
Grass			0.001	0.001	0.001	0.001	0.038	0.219	0.620	0.787	0.843	0.527	0.001	0.001
			0.050	0.050	0.169	0.411	0.794	0.900	0.900	0.900	0.900	0.120	0.020	0.023

1 in case of soil treatment (surface applications), the crop interception factor is 0.1 for all crops and application times.

3 Extrapolation of interception fractions in the NMI 2 (as used in the NMI 3)

reference crop	extrapolated to crop:
potatoes ¹	starch, ware and seed potatoes, tree nurseries, rose-bushes
apples ¹	apple trees, pear trees, fruit trees
beet ^{1,5}	sugar beet
chrysantemum ²	chrysantemum, carnation, roses and other greenhouse flowers
trees ¹	trees, conifers
cereals ¹	bread wheat, spring barley, grass seed
lilies ¹	lilies, gladiola
fodder maize ⁶	maize
spireas ³	permanent plants
sprouts ^{1,5}	Brussels sprouts
tomatoes ⁴	tomatoes, sweet pepper, cucumbers
tulips ¹	tulips, hyacinths, iris, daffodils
onions ¹	onions (bulbs), salsify, (seed) onions
vegetables ⁵	asparagus, beans, cabbages, carrots and chicory
other ^{5,7}	strawberries, meadow, lettuce, spinach

¹ Van de Zande et al. (2000); ² Tak (1995); ³ Van Kammen et al. (1998); ⁴ Bor et al. (1994); ⁵ MJP-G (1996); ⁶ Deneer et al. (1999), ⁷ expert judgment.

Appendix 6 Overview of spray drift treatments and crops

Overview of spray drift treatments and the crops where these are applied. The numbers in brackets correspond with the square brackets in Figure 7 of the main report (Section 3.2.2).

Spray application treatment	Crop base group	Crop subgroup	NMI Crops	Treatments
Downward directed spraying, crop-free buffer zone 0.25 m [1]	Culture Grassland	all	Grass	all
	Arable Crops	Cereals	Cereals	all
		Graszaadteelt	Grass (seed)	
	Fruit Crops		Apple trees, Pear trees	herbicides on bare soil
	Sierteeltgewassen	alley trees	Tree nursery	Herbicides on bare soil
	Kruidenteelt vers of gedroogd	Kruiden zaadgewassen	-	all
	temporarily uncropped area including edge of field strips		-	All, on bare soil only
	Veredelingsteelt en basiszaadproductie van akkerbouw-, groente- en fruitgewassen, kruiden en sierteeltgewassen		-	all
overige akkerbouwgewassen	hop	-	Weed control on bare soil	
Downward directed spraying, crop-free buffer zone 0.50 m [2]	All crops except those mentioned in [1] and [3]		Cichory, Peas, Rapeseed, Floriculture, Shrubberies, Haricot beans, Sugar beets, Fodder maize	all
	Vegetables		Cauliflower, Broccoli, Cabbage, Brussels sprouts, Green Beans	all
	Herbs		-	all

Spray application treatment	Crop base group	Crop subgroup	NMI Crops	Treatments
	Sierteeltgewassen	All, excluding alley trees (see [5] for fungicide and insecticides and [1] for herbicides)	-	
	Bladgroenten	Spinach	-	all
Downward directed spraying, crop-free buffer zone 0.75 m [3]	Arable Crops	potatoes	Potatoes	all
	Groenteteelt	Bladgroenten, except spinach (see [2])	-	all
		onions	Onions	
		medicinale wortelgewassen	-	
		wortelgewassen	Carrots, Salsify, Industrial chicory roots	
		aardpeer	-	
		asparagus	Asparagus	
		leek	Leeks	
	Sierteeltgewassen	Flowerbulb	Flowerbulb	all
		bulb flowers	-	
		boomkwekerijgewassen (except alley trees)	Roses, Conifers, Perennial plants, Fruit trees,	
	Fruits: small fruits	strawberries	Strawberries	all
		cranberries		
Fruits: small fruits		-	Fungicide/insecticide treatments in year 1 and 2 after planting	
Fruit crops [4]	fruit crops	All, except strawberries and cranberries (see [1])	Apple trees, Pear trees	All
				fungicide/insecticide (excepts for small fruits in year 1 and 2 after planting)
			herbicide other than downward directed (see [1])	
	overige akkerbouwgewassen	hop, vlas	Flax	Fungicide/insecticide
Nursery tree crops [5]	sierteeltgewassen	Alley trees	Tree nursery	Fungicide/insecticide

Appendix 7 Substance flow in soilless cultivation systems

For soilless systems NMI 3 distinguishes between 3 combinations of application method and object treated (Main report, Section 3.2.6):

- A) Application along with the nutrient solution;
- B) Application to the crop canopy; with no exposure of the root compartment;
- C) Application to the crop canopy, pot plant cultivation; with direct exposure of the root compartment.

Scenario A) Application with the nutrient solution

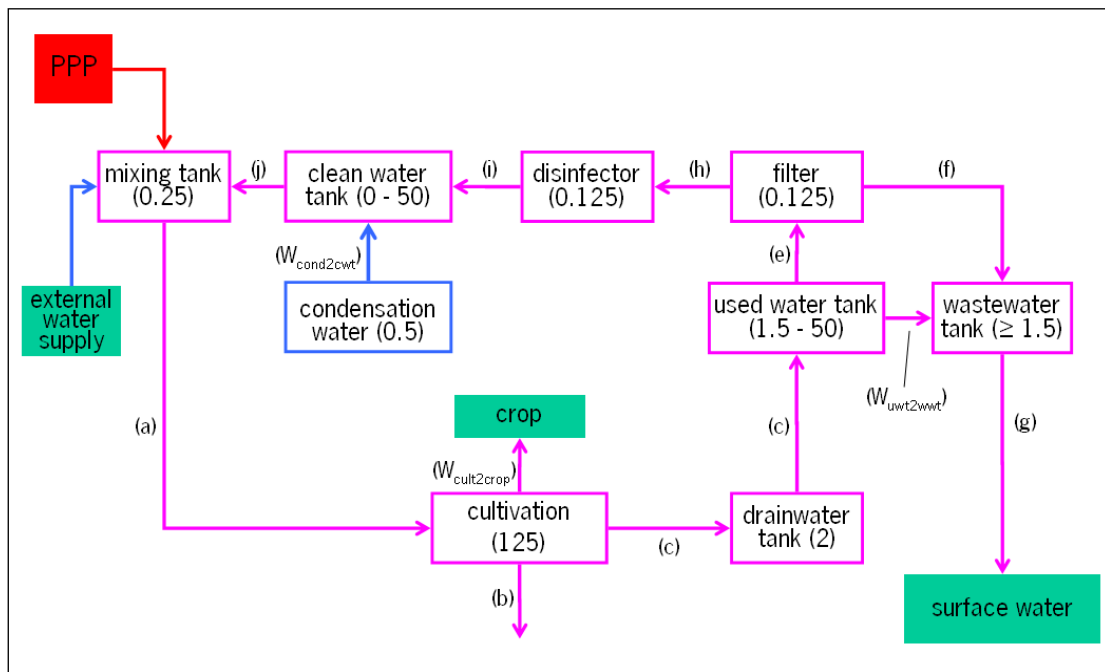


Figure 6.1

Flow chart for the nutrient solution and substance in the greenhouse substrate system applied along with the nutrient solution. Blue objects refer to water, red objects refer to the substance applied and the pink objects refer to the nutrient solution with the substance added. The values in brackets refer to the water volume in the tanks (m³). Green objects refer to external reservoirs and compartments.

Water fluxes

A schematic representation of the water flow system for this application scenario is given in Figure 6.1. The blue objects refer to water tanks/reservoirs and fluxes, the red objects refer to the substance applied and the pink objects refer to the nutrient solution with added substance. The values in brackets refer to the tank volume in m³. The green objects refer to external reservoirs and compartments.

Rain that falls on the roof of a greenhouse is collected in a basin and used for watering the crops. Before use, nutrients are added in the mixing tank. Pesticides are added to the nutrient solution in the mixing tank according to the application pattern (Figure 6.1). From the mixing tank the water is pumped to the plants (a) via the conducts and the substrate. Water and nutrients are partly taken up by the plants and the surplus is drained to the drain water collector tank (c). The supply rate exceeds the crop water demand in order to ensure continuous flow and a homogeneous solution within the system. The solution is pumped from the drain water collector tank to the used water tank, and can be reused as long as the sodium content does not exceed the sodium tolerance level of the crop.

The solution is pumped from the drain water collector tank to the used water tank (d). When the sodium level is below the tolerance level of the crop, the solution is filtered in the filter tank (e), disinfected in the disinfector (h) and collected in the clean water tank (i) before it can recirculate via the mixing tank (j). When the sodium level has been exceeded, the solution is discharged to the surface water via the waste water tank (g). At these discharge events, part of the mass dissolved in the waste water resulting from filter cleaning is discharged via the waste water tank as well (f).

At the end of the growing period, the waste water tank may be (partly) filled with water and substance in solution. It is assumed that the waste water tank is emptied at the end of the growing period. In the NMI 3 the content of the waste water tank is discharged at 60 days after the last application event. During this 60 days period the substance concentration in the waste water tank decreases by degradation.

The condensation water collected from the inner side of the glass panels is added to the clean water tank.

If the available rainwater in the basin is depleted, additional tap water is added to the solution. The flux entering the system is rainwater and tap water lumped together. Fluxes leaving the system are;

1. uptake by the crops ($W_{cult2crop}$),
2. leakage out of the system (b),
3. filter cleaning water disposed (f),
4. discharge to the surface water (g).

Depending on sodicity and crop tolerance discharge of the water and substance solution occurs from the used water tank via the wastewater tank waste water tank ($W_{uwt2wvt}$). It is assumed that the greenhouse discharges directly to the surface water hence no sewage system is involved.

For the calculation of the water fluxes within the model greenhouse, three time series of daily water fluxes are used as input. These water fluxes are provided in step (a):

- Daily water uptake by the crop, $W_{cult2crop}$;
- Daily condensation water fluxes, $W_{cond2dinh}$;
- Daily discharge to the waste water tank (which on its turn discharges to the surface water), $W_{uwt2wvt}$

These water fluxes are defined per hectare greenhouse surface area. The other water fluxes are derived from the three water fluxes above while preserving the water balance in the tanks and reservoirs. Most of the tanks and reservoirs are assumed to maintain a continuous maximum water volume. Only the water volumes in the used water tank and the clean water tank are allowed to fluctuate; V_{uwt} between 1.5 and 50 m³ and V_{cwt} between 0 and 50 m³, respectively. The relationships in Eq. (1) are used to derive the water fluxes :

$$\begin{aligned}
W_{(a)} &= R_{ws} W_{cult2crop} \\
W_{(b)} &= R_{ws} f_{cult} W_{cult2crop} \\
W_{(c)} = W_{(d)} &= W_{(a)} - W_{(b)} - W_{cult2crop} \\
W_{(e)} &= \max\left(0, W_{(c)} - W_{uwt2wwt} + \frac{V_{uwt} - \max(V_{uwt})}{dt}\right) \\
W_{(f)} &= f_{filt} W_{(e)} \\
W_{(g)} &= W_{uwt2wwt} + W_{(f)} \\
W_{(h)} &= (1 - f_{filt}) W_{(e)} \\
W_{(i)} &= W_{(h)} + W_{cond2dinf} \\
W_{(j)} &= \max\left(0, W_{(i)} + \frac{V_{cwt} - \max(V_{cwt})}{dt}\right)
\end{aligned} \tag{1}$$

W	water flux, with the symbols (a) to (j) referring to the fluxes as indicated in Figure 6.1 (m ³ d ⁻¹)
$W_{cult2crop}$	daily water uptake by the crop, provided in Step 1 (m ³ d ⁻¹)
$W_{cond2dinf}$	daily condensation water fluxes, provided in Step 1 (m ³ d ⁻¹)
$W_{uwt2wwt}$	daily discharge to the waste water tank, provided in Step 1 (m ³ d ⁻¹)
V_{uwt}	volume in the used water tank (m ³)
V_{cwt}	volume in the clean water tank (m ³)
R_{ws}	ratio water supply to crop demand (-)
f_{cult}	fraction leakage from cultivation tank (-)
f_{filt}	fraction loss due to regeneration of the filter (-)
dt	external internal time step (d, default 1 d)

The substrate and all the conducts between the mixing tank and the used water tank together are referred to as the cultivation tank. The fractions f_{cult} and f_{filt} are both equal to 0.01. The recirculation rate of the nutrient solution R_{ws} depends on the model crop used (Table 6.1).

Table 6.1

The recirculation rate of the nutrient solution (-).

Greenhouse model crop	R_{ws} (-)
Cucumber	1.33
Ficus	1.33
Sweet pepper	1.33
Phalaenopsis	1.33
Rose	1.50

Substance behaviour

After being applied to the mixing tank, the substance is transported with the water fluxes that flow through the greenhouse. In each reservoir in the greenhouse system, instant mixing of the substance is assumed. Furthermore, the substance degrades according to first order degradation. The conservation equation in each reservoir is solved according to:

$$\frac{dV_i c_i}{dt} = \sum_{j=1}^n q_{j,i} c_j - \sum_{k=1}^m q_{i,k} c_i - V_i k_w c_i \quad (2)$$

where:

- V_i volume of water in tank/reservoir i (m),
 dt internal timestep (d)
 c_i concentration in tank/reservoir i (kg m⁻³)
 q_{ij} flux from tank/reservoir i to j (m³ d⁻¹)
 $\sum_{j=1}^n q_{j,i} c_j$ sum of all incoming fluxes from the tanks ($1 \leq j \leq n$)
 n number of incoming water fluxes
 $\sum_{k=1}^m q_{i,k} c_i$ sum over all the outgoing fluxes to the tanks ($1 \leq k \leq m$)
 m number of outgoing water fluxes
 k_w first order rate coefficient for transformation in water (d⁻¹)

$$k_w = \frac{\ln(2)}{DegT50_{water,gh}} \quad (3)$$

First order degradation is assumed in all identified tanks, including the substrate tank (Figures 6.1, 6.2, 6.3). Degradation rates are adjusted to reflect local temperatures (see at the end of this section). In some of the tanks the degradation rate is assumed to be independent of the substance. The used half-lives for these tanks are given in Table 6.2.

Table 6.2

Tanks/reservoirs defined in the greenhouse models for crops growing on artificial soil with the appropriate half-life for first-order degradation.

Tank/reservoir	Scenario	Degradation	Half-life (d)
Crop canopy	A, B, C	DegT50_GH_Foliage_d	10
Greenhouse floor	B, C	DegT50_GH_Floor_d	1000
Disinfectant #	A, B, C	DegT50_WATER_DINF_d	= DegT50_WATER_d
Mixing tank	A, B, C	DegT50_WATER_d	Substance table
Cultivation tank			
Drainwater tank			
Used water tank			
Filter			
Clean water tank			
Wastewater tank			
Condensation water [§]	A	No substance	-
	B, C	DegT50_WATER_d	Substance table
Greenhouse air [§]	B, C	DegT50_GH_Air_d	1000
Basin	A, B, C	External source	-
Crop (excl. canopy)	A, B, C	External sink	-
Surface water	A, B, C	External sink (→ Step c)	-

§) Part of the reservoir "Condensation water and greenhouse air"

#) no separate conditions in the disinfectant are implemented

The cultivation tank and the drain water tank are located in the greenhouse where the temperature is assumed to be 20 °C. The temperature in the workroom where the other tanks are located is assumed to be 18 °C.

The total set of ordinary differential equations is solved numerically, by using the Euler method with a fixed time step of 1/360 d.

Root uptake

The uptake of the substance by the plant roots in substrate occurs along with the nutrients and the water. It is assumed that there is some barrier against uptake dependent on the octanol water partitioning coefficient. The daily mass taken up by the crop is defined by:

$$J_{cult2crop} = f_{tsc} W_{cult2crop} c_{cult} \quad (4)$$

$J_{cult2crop}$	daily mass uptake by the crop (kg a.i. d ⁻¹)
f_{tsc}	transpiration stream concentration factor (-)
$W_{cult2crop}$	daily water uptake by the crop (m ³ d ⁻¹)
c_{cult}	concentration in the cultivation tank (kg a.i. m ⁻³)

The transpiration stream concentration factor is derived according to Briggs et al. (1982) using the octanol water partitioning coefficient of the substance;

$$f_{tsc} = 0.784 \exp \left\{ \frac{-(\log(Kow) - 1.78)^2}{2.44} \right\} \quad (5)$$

f_{tsc}	transpiration stream concentration factor (-)
$\log(Kow)$	logarithm of the octanol water partitioning coefficient as listed in the substance table (-)

Scenario B) Application to the crop canopy; with no exposure of the root compartment.

Figure 6.2 gives the schematic representation of the water and substance fluxes in case the substance is applied to the crop by spraying or fogging/fumigation. The substrate is shielded, so there is no direct exposure of the root compartment. The shield surface is referred to as the greenhouse floor. The water flow system is similar to the water flow system in case the substance is applied with the nutrient solution. Contrary to Scenario A (Figure 6.1), the condensation water and the greenhouse air are considered as a single reservoir which may contain substance in solution and in the greenhouse air (vapour).

With respect to the substance behaviour, some additional storages and processes have to be taken into account compared to the applications along with the nutrient solution (Scenario A). Additional storages of substance are: the crop canopy, the condensation water and greenhouse air, and the greenhouse floor. Only via condensation water that flows from the glass surface area, the sidewalls and the roofs into the clean water tank, substance may enter the nutrient solution that is recycled within the greenhouse.

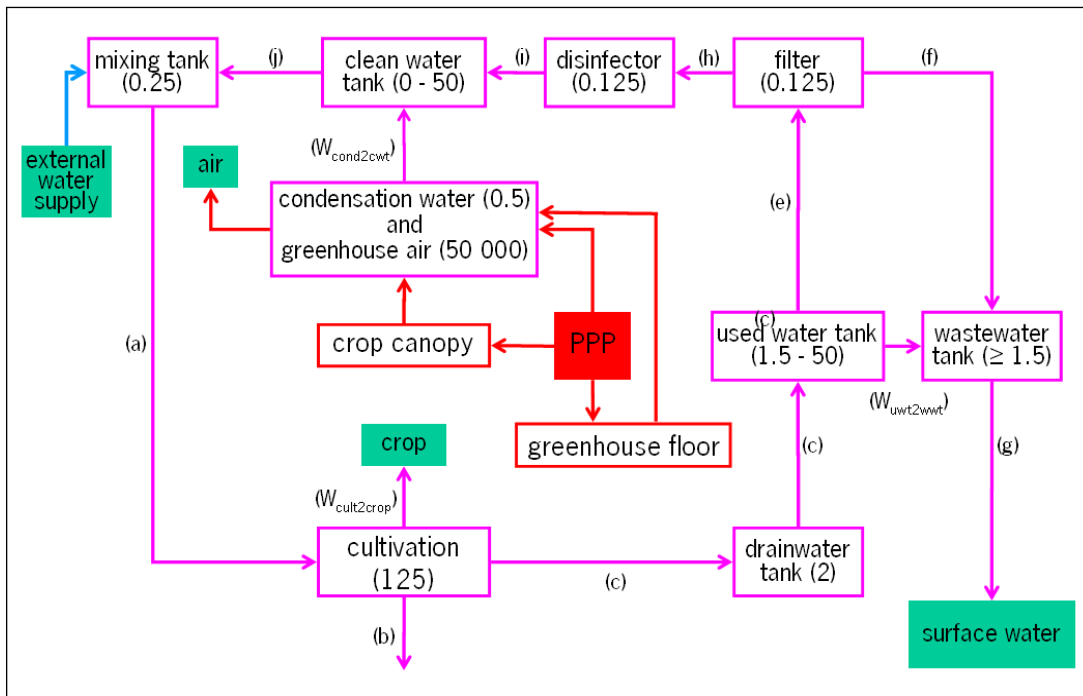


Figure 6.2

Flow chart for the nutrient solution and substance in the greenhouse substrate system applied by spraying, fogging or fumigating. The shield covering the substrate and the greenhouse soil is referred to as the greenhouse floor (see also Figure 6.1).

Application

During spraying, fogging or fumigation the substance is distributed between the plant leaves, the greenhouse air and the greenhouse floor. The initial distribution over the crop canopy, the greenhouse air and condensation water, and the greenhouse floor is estimated according to:

$$\begin{aligned}
 A_{p,t=0} &= f_{int} A 10^{-4} \\
 A_{al,t=0} &= f_{al} A 10^{-4} \\
 A_{f,t=0} &= (1 - f_{int} - f_{al}) A 10^{-4}
 \end{aligned}
 \tag{6}$$

- A the nominal rate for a single application (kg a.i. ha⁻¹)
- $A_{p,t=0}$ areic mass deposited at the plants, at $t = 0$ (kg a.i. m⁻²)
- f_{int} fraction of the application rate that is intercepted by the crop (-)
- $A_{al,t=0}$ areic mass that is volatilized into the greenhouse air (kg a.i. m⁻²)
- $A_{f,t=0}$ areic mass deposited at the greenhouse floor, at $t = 0$ (kg a.i. m⁻²).
- f_{al} fraction of the application rate that has been volatilized into the greenhouse air (-).
- 10^{-4} factor to convert ha to m²

The fractions f_{int} and f_{al} depend on the application type and the growth stage of the crop. Since no detailed information is available on the relationship between application type, growth stage and these fractions, these are constants, i.e. the application loss $f_{al} = 0.03$ and the interception fraction $f_{int} = 0.9$ independent of the growth stage.

Processes on the crop canopy and the greenhouse floor

Continuous exchange of substance occurs between the crop canopy and the greenhouse air, and between the greenhouse floor and the greenhouse air. The following processes are considered:

- Volatilization
- Deposition

The exchange between the crop canopy and the greenhouse air depends on the concentration gradient between the laminar boundary layer directly above the crop canopy and the greenhouse air, and the areic mass on the plant. The conservation equation for the areic mass on plants reads:

$$\frac{dA_p}{dt} = J_{d,p} - J_{v,p} \quad (7)$$

A_p	areic mass on the plant (kg a.i. m ²)
$J_{d,p}$	deposition rate on the plant, per unit of cultivated area (kg a.i. m ² d ⁻¹)
$J_{v,p}$	volatilisation rate from the plant (kg a.i. m ² d ⁻¹)
dt	internal time step (d)

The deposition rate on the plant is given by:

$$J_{d,p} = LAI \frac{c_{air} - c_p}{R_{air}} \quad (c_{air} > c_p) \quad (8)$$

$$J_{d,p} = 0 \quad (c_{air} \leq c_p)$$

$J_{d,p}$	deposition rate on the plant (kg a.i. m ² d ⁻¹)
LAI	Leaf Area Index of the crop (-)
c_p	concentration in the gas phase at the crop canopy (kg a.i. m ⁻³)
c_{air}	concentration in the greenhouse air (kg a.i. m ⁻³)
R_{air}	laminar boundary layer resistance (= 1.16 10 ⁻³ d m ⁻¹)

The Leaf Area Index of the crop is assumed to be 5, independent of the greenhouse model crop or development stage.

The volatilization from the plant is given by:

$$J_{v,p} = \frac{A_p}{A_r} \frac{c_p - c_{air}}{R_{air}} \quad (c_p > c_{air}) \quad (9)$$

$$J_{v,p} = 0 \quad (c_p \leq c_{air})$$

$J_{v,p}$	volatilization rate from the plant (kg a.i. m ² d ⁻¹)
A_p	areic mass on the plant (kg a.i. m ²)
A_r	reference mass (= 10 ⁴ kg a.i. m ²)
c_p	concentration in the gas phase at the crop canopy (kg a.i. m ⁻³)
c_{air}	concentration in the greenhouse air (kg a.i. m ⁻³)
R_{air}	laminar boundary layer resistance (d m ⁻¹).

According to (Jacobs *et al.*, 2007), the laminar boundary layer resistance is estimated to be equal to $1.16 \cdot 10^3$ (d m^{-1}).

The concentration in the gas phase at the canopy is assumed to depend on the saturated vapour pressure, according to:

$$c_p = \frac{MM P_{sat} 10^{-6}}{R T_{gh}} \quad (10)$$

c_p	concentration in the gas phase at the crop canopy (kg a.i. m^{-3})
MM	molar mass (g mol^{-1})
P_{sat}	saturated vapour pressure (mPa)
R	molar gas constant ($8.314 \text{ J mol}^{-1} \text{ K}^{-1}$)
T_{gh}	temperature in the greenhouse (K)
S	solubility in water (mg l^{-1})
10^6	factor to convert mPa to Pa and (g mol^{-1}) to (kg mol^{-1})

The saturated vapour pressure is adjusted to reflect local temperature (see at the end of this section).

The exchange between the greenhouse floor and the greenhouse air depends on the concentration gradient between the greenhouse floor and the greenhouse air, and the areic mass on the greenhouse floor. The conservation equation for the areic mass on the greenhouse floor reads:

$$\frac{dA_f}{dt} = J_{d,f} - J_{v,f} \quad (11)$$

A_f	areic mass on the greenhouse floor (kg a.i. m^2)
$J_{d,f}$	deposition rate on the greenhouse floor ($\text{kg a.i. m}^2 \text{ d}^{-1}$)
$J_{v,f}$	volatilisation rate from the greenhouse floor ($\text{kg a.i. m}^2 \text{ d}^{-1}$)
dt	internal timestep (d)

The deposition on the greenhouse floor is given by:

$$J_{d,f} = \frac{c_{air} - c_f}{R_{air}} \quad (c_{air} > c_f) \quad (12)$$

$$J_{d,f} = 0 \quad (c_{air} \leq c_f)$$

$J_{d,f}$	deposition rate on the greenhouse floor ($\text{kg a.i. m}^2 \text{ d}^{-1}$)
c_f	concentration in the gas phase at the greenhouse floor (kg a.i. m^{-3})
c_{air}	concentration in the greenhouse air (kg a.i. m^{-3})
R_{air}	laminar boundary layer resistance (d m^{-1}), being $1.16 \cdot 10^3$ (Jacobs <i>et al.</i> , 2007)

The volatilization from the greenhouse floor is given by:

$$J_{v,f} = \frac{A_f}{A_r} \frac{c_f - c_{air}}{R_{air}} \quad (c_f > c_{air}) \quad (13)$$

$$J_{v,f} = 0 \quad (c_f \leq c_{air})$$

$J_{v,f}$	volatilization rate from the greenhouse floor (kg a.i. m ² d ⁻¹)
A_f	areic mass on the greenhouse floor (kg a.i. m ²)
A_r	reference mass (= 10 ⁴ kg a.i. m ²)
c_p	concentration in the gas phase at the greenhouse floor (kg a.i. m ⁻³)
c_{air}	concentration in the greenhouse air (kg a.i. m ⁻³)
R_{air}	laminar boundary layer resistance (d m ⁻¹).

The concentration in the gas phase at the greenhouse floor is assumed equal to the concentration at the crop canopy given by Eq. 10;

$$c_f = c_p \quad (14)$$

c_f	concentration in the gas phase at the greenhouse floor (kg a.i. m ⁻³)
c_p	concentration in the gas phase at the crop canopy (kg a.i. m ⁻³)

Partitioning between greenhouse air and condensation water

The conservation equation for the greenhouse air is given by:

$$\frac{dM_{ghair}}{dt} = (J_{v,p} + J_{v,f} - J_{d,p} - J_{d,f}) \quad (15)$$

M_{ghair}	mass in the greenhouse air and condensation water per unit area of greenhouse cultivation area (kg a.i. m ²)
$J_{v,p}$	volatilisation rate from the plant (kg a.i. m ² d ⁻¹)
$J_{v,f}$	volatilisation rate from the greenhouse floor (kg a.i. m ² d ⁻¹)
$J_{d,p}$	deposition rate on the plant (kg a.i. m ² d ⁻¹)
$J_{d,f}$	deposition rate on the greenhouse floor (kg a.i. m ² d ⁻¹)
dt	internal time step (d)

The partitioning of the substance between the greenhouse air and the condensation water is described with the Henry coefficient, which can be calculated from the substance properties:

$$K_H = \frac{c_{air}}{c_w} = \frac{0.001 P_{sat} MM}{RT_{gh} S} \quad (16)$$

K_H	dimensionless Henry coefficient, at T_{gh} (-)
c_{air}	concentration in the greenhouse air (kg a.i. m ⁻³)
c_w	concentration in the condensation water (kg a.i. m ⁻³)
P_{sat}	saturated vapour pressure, at T_{gh} (mPa)
MM	molar mass (g mol ⁻¹)
R	molar gas constant (8.314 J mol ⁻¹ K ⁻¹)
T_{gh}	temperature in the greenhouse (K)
S	solubility in water, at T_{gh} (mg l ⁻¹)
0.001	factor to convert mPa to Pa.

Both the saturated vapour pressure and solubility are adjusted for the temperature in the greenhouse (see at the end of this section).

The total mass in the condensation water and greenhouse air is given by:

$$M_{ghair} = (V_{air}c_{air} + V_c c_w) 10^{-4} \quad (17)$$

M_{ghair}	mass in the greenhouse air and condensation water per m ² area of cultivated area (kg a.i. m ²)
V_{gh}	volume of the cultivation part of the greenhouse per ha area of cultivated area (50000 m ³ ha ⁻¹)
c_{air}	concentration in the greenhouse air (kg a.i. m ⁻³)
V_c	volume of the condensation water per unit ha of cultivated area (0.53 m ³ ha ⁻¹)
c_w	concentration in the condensation water (kg a.i. m ⁻³)
10^{-4}	factor for conversion from ha to m ² .

Since $c_w = c_{air} / K_H$, Eq. 17 can be rewritten:

$$c_{air} = \frac{M_{ghair}}{V_{gh} + V_c / K_H} 10^4 \quad (18)$$

c_{air}	concentration in the greenhouse air (kg a.i. m ⁻³)
M_{ghair}	mass in the greenhouse air and condensation water per m ² cultivated area (kg a.i. m ²)
V_{gh}	volume of the cultivation part of the greenhouse per ha cultivated area (50000 m ³ ha ⁻¹)
V_c	volume of the condensation water per unit cultivated area (0.53 m ³ ha ⁻¹)
K_H	dimensionless Henry coefficient (-)

The volume of the cultivation part of the greenhouse $V_{gh} = 50000$ m³ per ha cultivated area, whereas the volume of condensation water (V_c) is estimated to be 0.53 m³ per ha cultivated area.

Once the mass equations to calculate M_{ghair} have been solved (Eq. 15), c_{air} can be derived using Eq. 18, and the concentration in the condensation water (c_w) can then be derived using Eq. 16.

Similar to the applications along with the nutrient solution there is first order degradation in all identified tanks, including the surface at the greenhouse floor, the greenhouse air, the condensation water, and the substance on the crop canopy. In some of the tanks the degradation rate is assumed constant and independent of the substance. The used half-lives for these tanks are given in Table 6.2. Degradation rates are adjusted for local temperature where necessary (see at the end of this section).

The temperature in the cultivation tank and the drain water tank located in the greenhouse is assumed to be 20 °C. The temperature in the workroom with the other tanks is assumed to be 18 °C. Also similar to the applications with the nutrient solution, Eq. (2) is used to calculate the uptake concentration as compared to the concentration of substance in the recirculation water.

Emission to the outside air

Emission of substance towards air occurs through transport with the ventilated greenhouse air. The daily-emitted mass of substance via the greenhouse air towards the air outside depends on the air exchange rate of the greenhouse and the concentration in the greenhouse air:

$$J_{2air} = N_{vent} V_{gh} c_{air} \quad (19)$$

J_{2air}	nominal emission rate from the greenhouse air towards the outside air, per ha cultivated area (kg ha ⁻¹ d ⁻¹)
N_{vent}	air exchange rate of the greenhouse (d ⁻¹)
V_{gh}	volume of the cultivation part of the greenhouse per ha cultivated area (m ³ ha ⁻¹)
C_{air}	concentration in the greenhouse air (kg a.i. m ⁻³)

The air exchange rate is estimated to be 50 d⁻¹. The nominal emission rate J_{2air} can be multiplied with the application rate and cumulated over 365 days, to obtain the emission to air per ha greenhouse.

The substance in the condensation water flows into the greenhouse recirculation system via the clean water tank. The residues in the recirculation water may ultimately be discharged to surface water.

Mass balances are solved for each tank on the basis of daily water fluxes, substance characteristics and application timing. The set of ordinary differential equations is solved numerically, by using the Euler method with a fixed time step of 1/360 d.

C) Application to the crop canopy; with direct exposure of the root compartment.

Figure 6.3 gives a schematic representation of the water and substance fluxes in case the substance is applied to the crop by spraying, fogging or fumigation, with direct exposure of the root compartment. This system refers mainly to flooded tables. The scheme is applicable to the cultivation of pot plants where the individual pots are not covered by plastic. The water flow system is similar to the flow system of the other application scenarios for soilless cultivation. The system differs from the shielded roots system in that direct application to the recirculation water forms an additional source of substance that may be emitted to the surface water.

Pesticide supply

During spraying, fogging or fumigation the substance is distributed between the plant leaves, the substrate, recirculation water and the greenhouse air. The initial distribution over the crop canopy ($M_{int,appl}$), the greenhouse air and condensation water ($M_{ghair,appl}$), the substrate ($M_{sub,appl}$) and the cultivation reservoir ($M_{cult,appl}$) is estimated according to:

$$\begin{aligned}
 M_{int,appl} &= f_{int} M_{appl} \\
 M_{ghair,appl} &= f_{air} M_{appl} \\
 M_{sub,appl} &= (1 - f_{int} - f_{air}) P_{pot} M_{appl} \\
 M_{cult,appl} &= (1 - f_{int} - f_{air}) (1 - P_{pot}) M_{appl}
 \end{aligned} \tag{20}$$

where M_{appl} (kg d⁻¹) is the total applied mass, f_{int} (-) is the fraction of the total mass that is intercepted by the greenhouse crop, f_{air} (-) is the fraction of the total applied mass that volatilizes into the greenhouse air and P_{pot} (-) is the fraction of the production surface area covered with pots. Similar to the root-shielded application scenario, $f_{air} = 0.03$ and $f_{int} = 0.9$, independent of the growth stage and application technique. $P_{pot} = 0.9$.

Continuous exchange of substance occurs between the crop canopy, the substrate, the recirculation water and the greenhouse air. This exchange depends on the concentration gradient between the greenhouse air and the concentration directly above the canopy, substrate and recirculation water;

$$\begin{aligned}
J_{canop2air} &= A_{gh} f_{ex_canopy} \frac{C_{g,0} - C_{air}}{R_{air}}; \\
J_{sub2air} &= A_{gh} f_{ex_sub} \frac{C_{g,sub} - C_{air}}{R_{air}} \\
J_{cult2air} &= A_{gh} f_{ex_cult} \frac{C_{g,cult} - C_{air}}{R_{air}}
\end{aligned} \tag{21}$$

where $J_{canop2air}$ (kg d⁻¹) is the mass exchange rate between the crop canopy and greenhouse air, $J_{sub2air}$ (kg d⁻¹) the mass exchange rate between the substrate and greenhouse air, $J_{cult2air}$ (kg d⁻¹) the mass exchange rate between recirculation water and greenhouse air, R_{air} (d m⁻¹) is the laminar boundary layer resistance, being $1.16 \cdot 10^{-3}$ (Jacobs *et al.*, 2007). A_{gh} is the surface of the greenhouse, which is 10,000 m².

The concentration in the gas phase at the canopy ($C_{g,o}$, kg m⁻³) is calculated according to Eq. (10).

The concentration in the gas phase at the substrate surface is derived from the formula given by Smit *et al.*, 1997):

$$C_{g,sub} = \frac{C_{sub}}{(\rho_{soil} f_{om} K_{om} + \theta_{liq}) / K_H + \theta_{gas}} \tag{22}$$

Where C_{sub} is the concentration of the substance in the substrate (soil, kg m⁻³), ρ_{soil} is the bulk dry density of soil (1000 kg/m³), f_{om} (-) is the fraction organic matter in the substrate (a value of 0.1 is assumed), K_{om} (m³ kg⁻¹) is the sorption constant to organic matter, θ_{liq} and θ_{gas} are the volume fractions of liquid resp. gas in the soil (values of 0.4 and 0.2 are assumed resp.; the value of θ_{gas} is not critical), and K_H is the dimensionless Henry coefficient (Eq. 16).

The concentration in the substrate is equal to the mass in the substrate divided by the mass of substrate:

$$C_{sub} = M_{sub} / S_{cult} \tag{23}$$

where M_{sub} is the substance mass in the substrate in the pot plants and S_{cult} is the mass of substrate corresponding to 1 hectare of tables (900,000 kg).

Substituting Eq. (23) into Eq. (22) results in:

$$C_{g,sub} = \frac{\rho_{soil} M_{sub}}{S_{cult} \{ \rho_{soil} f_{om} K_{om} + \theta_{liq} \} / K_H + S_{cult} \theta_{gas}} \tag{24}$$

The concentration in the gas phase at the cultivation surface, $C_{g,cult}$ is given by:

$$C_{g,cult} = K_H \frac{M_{cult}}{V_{cult} + f_{om} K_{om} S_{cult}} \tag{25}$$

where M_{cult} (kg) is the substance mass in the cultivation tank, V_{cult} (m³) is the volume of the cultivation tank, i.e. 125 m³, and S_{cult} (kg) is the mass of substrate (i.e. soil) in the cultivation tank, i.e. 900,000 kg.

Equilibrium between pore water and substrate is assumed. Equation 25 reflects that the gaseous concentration above the culture water is governed by the 'freely dissolved' i.e. non-sorbed concentration of the substance. Sorption of the substance to organic matter in the substrate in the pot plants will result in a decrease of the concentration in the gas phase above the culture water.

The exchange fractions $f_{ex,canopy}$, $f_{ex,sub}$ and $f_{ex,cult}$ depend on the direction of the concentration gradient:

$$\begin{aligned}
 f_{ex,canopy} &= \begin{cases} M_{canop} / M_{ref} & \text{for } C_{g,0} \geq C_{air} \text{ and } M_{canop} > 0 \\ LAI & \text{for } C_{g,0} < C_{air} \end{cases} \\
 f_{ex,sub} &= \begin{cases} M_{sub} / M_{ref} & \text{for } C_{g,sub} \geq C_{air} \text{ and } M_{floor} > 0 \\ P_{pot} & \text{for } C_{g,sub} < C_{air} \end{cases} \\
 f_{ex,cult} &= \begin{cases} (1 - P_{pot})M_{cult} / M_{ref} & \text{for } C_{g,cult} \geq C_{air} \text{ and } M_{cult} > 0 \\ (1 - P_{pot}) & \text{for } C_{g,cult} < C_{air} \end{cases}
 \end{aligned} \tag{26}$$

where M_{canop} (kg) refers to the mass on the crop canopy, M_{sub} (kg) refers to the mass on the substrate, M_{ref} (kg) refers to the reference mass, which is set to 1 kg, LAI (-) refers to the Leaf Area Index of the crop. The LAI is assumed to be 5, independent of the crop type or development stage.

Once the mass equations to calculate M_{ghair} have been solved (Eq. 20), the concentration in the greenhouse air can be calculated. From this the concentration of the substance in the condensation water, C_{cond} (kg m⁻³), is calculated using the air-water partitioning coefficient according to Eq. (16) and (18), and using volumes of the cultivation part of the greenhouse and of the condensation water of 50,000 m³ and 0.53 m³ resp.

The substance in the condensation water flows into the greenhouse recirculation system via the clean water tank. Residues in the recirculation water may ultimately be discharged to surface water.

Mass balances are solved for each tank on the basis of daily water fluxes, substance characteristics and application timing. The set of ordinary differential equations is solved numerically, by using the Euler method with a fixed time step of 1/360 d.

with

f_T	temperature correction factor (-)
$P_{sat,ref}$	the saturated vapour pressure of the substance at reference temperature (mPa)
P_{sat}	the saturated vapour pressure (mPa)
ΔH_{vol}	molar enthalpy of volatilisation (J mol ⁻¹) (95000 J mol ⁻¹)
R	molar gas constant (J mol ⁻¹ K ⁻¹) (value 8.314 J mol ⁻¹ K ⁻¹)
T_{ref}	reference temperature (K) (value 293.15 K ≡ 20 °C)
T_{gh}	temperature in the greenhouse (K)

The solubility in water is adjusted for the temperature in the greenhouse, using for all substances the default molar enthalpy of dissolution in water;

$$S = \frac{S_{ref}}{f_T} \quad (31)$$

$$f_T = \exp\left(\frac{-E_{dis}}{R} \left(\frac{1}{T_{ref}} - \frac{1}{T_{gh}}\right)\right) \quad (32)$$

f_T	temperature correction factor (-)
S_{ref}	the substance solubility in water at reference temperature (mg L ⁻¹)
S	the solubility in water (mg L ⁻¹)
E_{dis}	molar enthalpy of dissolution (J mol ⁻¹), (27000 J mol ⁻¹)
R	molar gas constant (J mol ⁻¹ K ⁻¹) (value 8.314 J mol ⁻¹ K ⁻¹)
T_{ref}	reference temperature (K) (value 293.15 K ≡ 20 °C)
T_{gh}	temperature in the greenhouse (K)

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Appendix 8 Review of the scientific panel (in Dutch)

Afbakening

De taak van de wetenschappelijke begeleidingsgroep (wbg) was in de praktijk beperkt tot discussies op basis van Powerpoint presentaties vanuit de projectgroep over de conceptuele opzet van de NMI en tot het beoordelen van het rapport 'Dutch Environmental Risk Indicator for Pesticides – NMI-3'. De begeleidingsgroep speelde dus geen rol in de kwaliteitsborging van de databases en van de software waarmee de NMI-3 berekeningen worden uitgevoerd. De verantwoordelijkheid voor deze borging ligt zodoende bij de auteurs van het rapport. Verder zijn in de rapportage geen voorbeeldberekeningen opgenomen. Om deze reden kan de werkgroep geen uitspraak doen over de plausibiliteit van de resultaten die met de NMI-3 verkregen worden.

Proces

De leden van de wbg zijn een aantal keren bij elkaar geweest. Tijdens deze bijeenkomsten is gedetailleerd commentaar geleverd, dat door de auteurs in het algemeen goed verwerkt is. De wbg maakt zich wel enige zorgen over de afstemming van de rapportage en de software. Op detailniveau zijn namelijk zeer recentelijk (nadat de definitieve berekeningen zijn opgeleverd) nog aanpassingen van de rapportage uitgevoerd. Onduidelijk is daarom of de resultaten van de definitieve berekeningen en dit rapport met elkaar in overeenstemming zijn; de begeleidingsgroep kan daarom op dit punt geen garanties afgeven (zie ook voorgaand punt).

Alleen geschikt voor berekenen trend

Uit de rapportage blijkt duidelijk dat de NMI-3 uitsluitend geschikt is voor het berekenen van de trend van de belasting van het oppervlaktewater. Het instrumentarium is met nadruk niet geschikt voor het berekenen van:

- de zogenoemde 'distance to target',
- de absolute waarde van de 'exposure toxicity ratio', en
- de berekening van het risico voor het waterleven.

Deze beperkingen zijn ook aangegeven in het rapport.

Dat dit niet mogelijk is, hangt met name samen met de wijze waarop de concentratie in het oppervlaktewater wordt berekend. In de NMI-3 wordt per toepassingen alle gewasbeschermingsmiddel als het ware in 6405 grote vaten gemengd oppervlaktewater gestopt. Het geschatte volume van deze vaten heeft slechts zijdelings een relatie met het werkelijke volume, en ook kan ervan worden uitgegaan dat het water in werkelijkheid niet volledig is gemengd. De zo verkregen concentratie heeft daardoor geen fysische betekenis. Om deze reden is vergelijking met een norm in absolute zin dus niet zinvol.

Milieubelasting van verschillende bronnen niet optellen

Binnen de NMI-3 worden verschillende modellen gebruikt om de emissie naar het oppervlaktewater te berekenen. Aangezien deze modellen een verschillende grondslag hebben, kan de milieubelasting vanuit de verschillende routes niet bij elkaar worden opgeteld (deze beperking is ook aangegeven in het rapport). Belangrijk element hierbij is dat voor de verschillende routes om redenen van de beschikbaarheid van gegevens andere percentielen zijn gebruikt. Voor de akkerbouw is bijvoorbeeld het 90-percentiel gebruikt, voor de fruitteelt het 70-percentiel en voor de kassen is het percentiel niet bekend.

Bijdrage drainage, atmosferische depositie en drift niet goed te bepalen

In de NMI-3 wordt de bijdrage van drift en atmosferische depositie opgeteld en die van drainage apart berekend. Per toepassing en rekenplot wordt alleen de emissieroute die de hoogste bijdrage aan de milieubelasting levert meegenomen, de andere wordt op nul gezet. Dit was een pragmatische oplossing, omdat volledige integratie van de NMI-3 en GeoPEARL niet mogelijk en wenselijk was. In werkelijkheid komen de bijdragen van de verschillende blootstellingsroutes bovenop de concentratie die dan al door de overige blootstellingsroutes wordt veroorzaakt. Uit de rapportage van de beslisboom water bleek bijvoorbeeld de bijdrage van drainage aan de jaarlijkse piekconcentratie voor imidacloprid 40% te zijn voor een scheurende kleigrond, waar deze in de NMI-3 0% is. Het is onduidelijk of deze vereenvoudiging van de berekeningsmethode grote effecten heeft op de berekende trend.

Exposure Toxicity Ratio minder geschikt voor schatting echte toxische druk

Zoals hierboven vermeld is de NMI-3 niet geschikt om de absolute waarde van het risico van en de impact op het waterleven te schatten. De nu gebruikte indicator - de Exposure Toxicity Ratio - schaaft de concentraties echter wel realistisch op de intrinsieke toxiciteit van de stoffen, door te delen door de normconcentratie. Verder gaat de ETR uit van concentratieadditie voor alle stoffen. Op de relatieve schaal (deze stof is erger dan die, en deze plek is erger belast dan die andere) is deze indicator voldoende.

Mochten de concentraties in de toekomst beter geschat kunnen worden en de blootstellingspaden beter bij elkaar opgeteld kunnen worden, dan lijkt de toxische druk (msPAF) gebaseerd op de acute LC50 een betere schatter voor de impact op het waterleven. De daarbij behorende berekeningen moeten dan worden uitgevoerd volgens het gemengde model (optellen van concentraties voor stoffen met gelijke werkzaamheid en respons additie voor groepen van stoffen met een ongelijk werkzaamheid). Deze procedure wordt op dit moment door de beslisboom werkgroep multistress getoetst.

Emissiemodule voor grondgebonden teelten in kassen verouderd

De emissiemodule voor grondgebonden teelten in kassen gaat uit van berekeningen met het metamodel van PEARL voor open teelten, waarbij standaard 0.1% van de dosering bij de emissie wordt opgeteld. Dit getal is gebaseerd op expert judgement en leidt voor sterk sorberende stoffen tot een zware overschatting van de milieubelasting.

Aanbevelingen

Voor de evaluatie van het Nationaal Actieprogramma moeten vermoedelijk beheersmaatregelen worden doorgerekend. Om het model voor dit doel geschikt te maken adviseert de wbg om tijdig te beginnen met de nodige veranderingen:

- voer een gevoeligheidsanalyse uit, zodat inzichtelijk wordt welke variabelen van invloed zijn op de berekende indicatoren en welke maatregelen hierop ingrijpen. Een matrix, waarin verschillende combinaties van teeltvrije zone en drift reducerende techniek worden doorgerekend, zou bijvoorbeeld bijzonder behulpzaam zijn bij het interpreteren van de resultaten;
- pas de NMI zodanig aan, dat gerekend wordt met een watervolume dat gebaseerd is op een sloot naast een behandeld perceel (en dus niet met het watervolume van een plot). Op deze manier sluit de berekende concentratie in oppervlaktewater beter aan bij de realiteit en wordt berekening van de distance to target indicator alsmede het oppervlak waarop de norm wordt overschreden beter haalbaar. Bij de berekening van de distance to target indicator past wel de kanttekening dat de dosering in de praktijk nauwkeuriger beschikbaar dient te zijn - de CBS enquêtes bevatten deze informatie niet. De wbg adviseert daarom te laten onderzoeken in hoeverre de dosering in praktijksituaties kan worden geschat met aanvullende informatie en welke onzekerheid voortvloeit uit het gebruik van dergelijke informatie;
- onderzoek of de exposure toxicity ratio vervangen kan worden door een maat die de gevoeligheid van meerdere soorten integreert en ook mengseltoxiciteit beter kan integreren, zoals de msPAF;

- zorg voor een betere afstemming van de conceptuele basis van de deelmodellen. Schenk hierbij aandacht aan het tijdspercentiel en harmoniseer deze;
- pas het model zodanig aan dat de bijdragen van de verschillende emissieroutes gelijkwaardig in kaart kunnen worden gebracht;
- zorg voor een update van de module voor grondgebonden teelten;
- zet de wiskundige concepten van wijzigingen in de NMI op papier voordat met de softwareontwikkeling wordt begonnen en bespreek die met een (toekomstige) wbg.

Tenslotte

Wij bevelen verder aan dat de begeleidingscommissie vooraf zijn goedkeuring geeft aan de beleidsmatige aannames die ten grondslag liggen aan de berekening van de distance-to-target indicator en van het oppervlak waarop de oppervlaktewaternorm wordt overschreden. Bijvoorbeeld de spray drift in de akkerbouw is nu gebaseerd op 90 percentielen in de tijd. Het ligt niet zonder meer voor de hand om een oppervlak waarop de norm wordt overschreden, te baseren op gebeurtenissen die slechts eenmaal in de tien jaar gebeuren op een bepaalde locatie.

Wij bevelen tenslotte aan dat een toekomstige wetenschappelijke begeleidingsgroep niet alleen verantwoordelijk is voor de beoordeling van de wetenschappelijke concepten, maar ook voor de beoordeling van de kwaliteit van de invoer en van de met de NMI verkregen resultaten.

1 december 2011

Wetenschappelijke begeleidingsgroep NMI-3

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Appendix 9 Pesticide environmental risk indicators literature search conducted in 2009

The NMI 3 was developed within the framework of Research Theme BO-12.07-004, and with additional contributions from the Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu). With these additional financial contributions (project numbers WOT-04-007-037 and WOT-04-007-063), new risk indicators for groundwater, the soil ecosystem, and the terrestrial ecosystem were implemented in the NMI 3. The methodology of the risk indicators for these environmental compartments is described in the main report (Alterra Report 2250.1). Also within the framework of project WOT-04-007-037, a literature search was conducted in 2009. The aim of this literature search was to give an overview of risk indicators used at national scale in EU member states, and to compare these with the Dutch Environmental Indicator for pesticide risk, NMI 2. The results of this literature search conducted in 2009 are described in this appendix.

Pesticide environmental risk indicators

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Abstract

In the Netherlands the Dutch Environmental Indicator NMI 2 for plant protection products is used to estimate the environmental impact of pesticides (1). This is calculated using pesticide sales, application methods, geographical information, pesticides properties, climate data, crop properties and other factors. Similar indicators exist in many other countries. In 2009, a literature search was performed on pesticide environmental risk indicators which are able to estimate the total risk of pesticides on a national scale. Two types of risk indicators are available: The first type is similar to the NMI 2 using ratios between the predicted environmental concentration and some quality standard. The second type simply adds scoring factors based on very dissimilar things like toxicity, bioaccumulation or occupational hazard. The second type uses arbitrary weighing factors which differ from author to author. The NMI 2 might be elaborated with extra modules on worker exposure and bioaccumulation plus consumer exposure. In the future the ratio based environmental risk indicators might be replaced with more advanced statistical methods based on exposure and sensitivity distributions.

1.1 Introduction.

Pesticide environmental risk indicators can be used to describe risk trends over the years. This helps governments to evaluate their crop protection policies. It is not sufficient to monitor the sales of a number of pesticides over the years. Typically there is a change in pesticide use over the years due to the admission of new pesticides and the termination of old pesticides. Generally the new pesticides have less environmental hazards compared to the old ones. The crops differ over the years because profitable crops become more popular while the area of other crops declines. Also the weather during the growing season has an impact on the pesticide use and also on the pesticide emission to surface water. Improvement of spraying techniques can reduce the impact of pesticides on surface water. The concentration of pesticides in surface water can decrease rapidly after spraying due to sorption to sediment, evaporation, degradation and dilution. The toxic

effect of a short but high dose of a pesticide can be considerable for sensitive organisms. The absence of sensitive organisms in surface water cannot always be attributed to pesticide use since many other factors like eutrophication, fishery, predators, parasites, diseases etc. can also play a role in an ecosystem. The large spatial and temporal variation of pesticide concentrations in surface water makes it difficult to assess the environmental risk of pesticides from measurements alone. It is difficult and costly to determine a huge number of pesticides and their degradation products in a frequent sampling scheme over large areas of surface water. Some pesticides are very difficult to determine at low concentrations. Bioassays can be used to determine whether surface water samples are toxic. Ecological observations give clues to the ecological status of surface water. The combination of environmental modeling, chemical analysis, bioassays and ecological observations are needed to assess the impact of pesticides on surface waters. The following chapters however will focus exclusively on the environmental modeling. The comparison between the Dutch Environmental Indicator (NMI 2) and other environmental risk indicators will yield possibilities to improve the models. Before a comparison between the NMI 2 and other models can be made it is necessary to introduce the NMI 2.

1.2 The Dutch Environmental Indicator/NMI version 2.

1.2.1 Input.

In the Netherlands the Dutch Environmental Indicator for plant protection products has been developed (1) by two Dutch institutes namely Alterra and RIVM. The NMI 2 consists of a software package which is described on the Internet (www.pesticidemodels.eu) (2). The NMI 2 uses pesticide sales and other input like:

- crop distribution during the survey years 1998, 2004
- pesticide interception by crops depending on growth stage
- distribution of greenhouses with soil or substrate cultivation
- long-term average monthly temperature and other climate data
- pesticide application methods and techniques
- drift to surface water data, leaching fractions, and point source emission factors
- pesticide fate and ecotoxicological quality standards

Geographical databases with local meteorological, physical and chemical soil conditions, boundary conditions for drainage flow and groundwater flow using a 250 m grid are used together with crop distribution maps using a grid of 1 km² over the Netherlands. Over 60 different crops are distinguished. The major ones are 10,000 km² grass, 2000 km² fodder maize, 1000 km² of winter wheat, sugar beets and potatoes. Different application techniques like field spraying, granules, fogging, dipping are accounted for in the NMI 2 model. The spray drift and the crop interception fractions were derived from elaborate experimental data (1).

1.2.2 Emissions

The NMI 2 model uses the above input to calculate emissions of pesticides to air, groundwater, and surface water. Volatilisation to air is calculated from the application spray, plants leaves and soil surface. The NMI 2 uses a metamodel of the PEARL model to calculate the leaching to groundwater. This PEARL model is validated by a number of experimental studies (3, 4). The amount of pesticide reaching surface water is calculated from spray drift and from drainage via the groundwater. The NMI 2 also calculates a number of points source emissions of pesticides from farm yards.

1.2.3 Soil

The amount of pesticide reaching the ground is calculated from the application rate and several loss fractions accounting for transport by air (1). The model assumes that the pesticides are homogeneously mixed through a layer of 5 cm of soil. Except for the cases when the pesticides are incorporated in soil. In that case a mixing layer of 20 cm is assumed (1). The degradation rate of the pesticide in soil is used to calculate a time weighed average concentration over 2 weeks. This yields the Predicted Environmental Concentration (PEC). For each application the PEC is divided by Predicted No Effect Concentration (PNEC) for soil organisms to calculate the number of Environmental Indicator Units (EIU) per grid cell. The PNEC of each pesticide is calculated from terrestrial toxicity tests for a number of different soil organisms using European guidelines (5). For the evaluation of the Dutch policy on sustainable crop protection, which contains operational targets for the reduction of environmental risk based on quality standards, the PEC is related to the Maximum Permissible Concentration in soil (MPC_{soil}) instead of the PNEC.

The total EIU per 1 km² grid cell resulting from all pesticide applications is a measure of the combined toxicity of the major pesticides.

1.2.4 Groundwater

For groundwater the calculated PEC is compared with the 0.1 µg pesticide/liter groundwater that is allowed by European legislation (7).

1.2.5 Surface water

The exposure of surface water is of course strongly dependent on the presence of surface water in each grid cell. For each grid cell the length of the ditches were measured and stored in the database. The NMI 2 assumes that the ditches are all 1 m wide, 0.3 m deep and have side slopes of 45°. This gives 210 liter surface water per meter of ditch (1). The nominal application rate of a pesticide is multiplied by a drift fraction to calculate the amount of pesticide reaching the ditch. Dissipation and volatilization rates are calculated for each pesticide to account for the removal of the pesticide from the water phase. Multiple pesticide applications are also accounted for. The PEC is calculated as a time weighed average concentration over 3 weeks. This PEC is divided by the PNEC to give the EIU for each application containing surface water. For the evaluation of the Dutch policy on sustainable crop protection, which contains operational targets for the reduction of environmental risk based on quality standards, the PEC is related to the Maximum Permissible Concentration in surface water (MPC_{sw}) instead of the PNEC.

1.2.6 Terrestrial ecosystems

In the NMI 2 the partridge has been chosen as standard species for the terrestrial ecosystem. The model is also useful for other birds and also for mammals when the food uptake data are available. For the moment only the impact of sprayed pesticides is accounted for. Seed dressings and other applications are not yet incorporated in the NMI 2. The Daily Chemical Intake DCI is calculated from the pesticide dose and the food uptake. The EIU for each terrestrial grid cell is calculated by dividing the DCI with the No Observed Effect Concentration (NOEC).

1.2.7 Adding up EIU values

Standard NMI 2 output files contain the total EIU resulting from all applications per 1 km² grid cell: 1) per crop, 2) per pesticide, and 3) all crops and pesticides. At regional or national scale level, the aggregated EIU per crop-pesticide combination is calculated. The EIU values are calculated from the predicted environmental concentration and the predicted no effect concentration using:

$$\text{EIU} = \text{PEC}/\text{PNEC}$$

While this formula is presented in European guidelines (8) it can be used to determine whether a specific pesticide concentration conforms to legislation. It is however not clear what happens at EIU values which are not equal to 1. An EIU value of 0.1 of one pesticide might be much more toxic than the same value for another pesticide. This depends on the sensitivity distribution of species for a certain pesticide. Pesticides with a broad species sensitivity distribution on one hand will be very toxic for some species but not toxic at all for other species. Pesticides with a narrow distribution on the other hand will be almost equally toxic for all species. The multi-substance potentially affected fraction of species is a better approach to summarize the toxicity of multiple pesticides (9). It is however not yet incorporated in the NMI 2 while it is already incorporated in the PERPEST model which can predict the effect of pesticides in a certain water body (10).

1.2.8 Applications

The NMI 2 is used for the interim evaluation of the Dutch policy on sustainable plant protection, showing a considerable reduction of the environmental risk of pesticides in the Netherlands between 1998 and 2005 (6). The results of the NMI 2 were compared with the results of different surface water monitoring programs. Large differences between measurements and model calculations are still present. Both the monitoring program and the NMI 2 must be improved. The NMI 2 module which calculates emissions from greenhouse horticulture needs to be improved. Banned pesticides are not incorporated in lack of usage data. The measurements need smart, coordinated monitoring schemes and lower detection limits (11).

1.3 Literature search

In order to compare the NMI 2 with other indicators a literature search was performed in the scientific database Scopus. A query for TITLE-ABS-KEY(pesticides “risk indicator”) yielded 31 results. The most cited one (12) reported about the CAPER project (Concerted Action on PEsticides Risk indicators). This project evaluated eight pesticide risk indicators developed in Europe. It was a cooperation of authors from 14 European countries. This publication was used as a starting point to find 12 related publications on pesticides risk indicators which did cite this one directly and indirectly. A relatively recent report of the FOOTPRINT project gave an up-to-date overview of the different functional tools for pesticide risk assessment and management (13). The FOOTPRINT project will give tools to make assessments of pesticide contamination in 2009 (14). At this stage European wide information on soils, climate types, crops and pesticide use is becoming available (14). Also the XIII symposium on pesticide chemistry in 2007 gave information about recent developments (<http://www.symposiumpesticide.org>). The elaborate proceedings of the conference were searched for papers on risk indicators. In the next paragraphs the information from literature is summarized.

Table 1 gives an overview of the indicators of environmental risk. Quite a few indicators were mentioned in the FOOTPRINT report (13) but were not accompanied by references. The table has a column called “Regional” (Reg.), which scores whether the index is suited as an indicator for regional or higher scale pesticide risks. The

higher scale might be a country, a catchment area of a river or even a continent. Many indicators are designed to determine the risk of pesticides at the farm level but not at a national scale. The lower rows in the table have a score in the regional column according to the FOOTPRINT report since no literature references are available. The other scores in column Reg. or Ratio are given by the author of this report after reading the literature references. The column Ratio makes a distinction between the indicators based on PEC/PNEC ratios (Exposure Toxicity Ratios/ETR) and the other indicators. Some of these other indicators are quite arbitrary and for instance do not predict concentrations in soil, groundwater or surface water. Typically these other indicators add up scores from very different endpoints like toxicity, persistence or leakage to groundwater. The FOOTPRINT indicator did not receive a score in the Ratio column because it is not finished yet. It is however likely to be very interesting when it is fully reported in the near future.

1.3.1 Indicators which add up PEC/PNEC ratios

The German SYNOPSIS indicator (15) is comparable with the NMI 2. Both models calculate an initial Predicted Environmental Concentration and a chronic PEC. Both relate the chronic PEC with a corresponding duration of a toxicity test which is used to calculate the PNEC. The SYNOPSIS indicator also uses Bioconcentration Factors for the risk evaluation of soil and surface water. This is not performed in the NMI 2 which will be a drawback when old-fashioned bioaccumulative pesticides like DDT are used. The bioconcentration factor in SYNOPSIS is not really well incorporated into the model since it was not reported in a recent paper on the application of SYNOPSIS in Mexico (16). In a recent comparison with eight other indicators, the SYNOPSIS indicator was selected as the best European indicator by American researchers (17). The NMI 2 was not included in this comparison.

The Belgian PRIBEL indicator (18) is an extension of the Pocer indicator (19) which was only suitable for farm level risk assessments. The authorities in Belgium aimed at a 25% impact reduction of pesticides in 2010 compared with 2001. Therefore the PRIBEL was developed to calculate the impact of pesticides on a national scale. The indicator assesses both the risk to the environment and the human risk from occupational exposure. Only the latter risk was elaborated in a symposium paper (18) but the general principle can easily be applied for environmental risk evaluation. The NMI 2 does not contain a module to calculate the human risk from occupational exposure. On the local scale a risk index RI for pesticide operators was calculated in the PRIBEL indicator as the quotient of the internal exposure and the acceptable operate exposure level (both expressed in mg/kg body weight/workday). This risk index is multiplied by a so-called "frequency" F to calculate the impact. The frequency F is obtained by dividing the total used quantity Q (kilogram active substance) of a specific pesticide per crop in Belgium by the application rate (kilogram active substance/hectare) of that pesticide (18). The dimension of F is hectare. The total risk $RI * F$ is comparable to the EIU of the NMI 2. Both are a risk factor summed up over an area for Belgium or the Netherlands. Independently from each other both the Belgium and the Dutch researchers came up with a rather similar approach.

The environmental yardstick is a simple indicator for the ecological impact of pesticides (20). It calculates environmental impact points which are very similar to the EIU values.

1.3.2 Arbitrary indicators

The Italian PRISW1 indicator (21) can be used as a site-specific tool for mapping the risk of pesticides in surface waters. The model uses an arbitrary score index of EC50/PEC ratios for algae, daphnia and fish to convert pesticide concentrations to a toxicity index. The weight factors for algae, daphnia and fish are 3, 4 and 5.5 respectively. The EC50/PEC ratios are converted into score values in an arbitrary way (21).

Table 1*The different pesticide environmental risk indicators.*

	Acronym	Reg.	Ratio	Country	Name	References
1	NMI 2	Y	Y	Netherlands	Dutch environmental indicator	(2)
2	EYP	Y	Y	Netherlands	environmental yardstick	(20)
3	PRIBEL	Y	Y	Belgium	pesticide risk indicator for Belgium	(18)
4	SYNOPS	Y	Y	Germany		(15)
5	ARI	Y	N	Italy	aquatic risk indicators	(22)
6	PRISW1	Y	N	Italy		(21)
7	FOOTPRINT	Y		Europe		(14)
8	PERPEST	N	Y	Netherlands	predicting ecological risks of pesticides	(10)
9	EIQ	N	Y	USA Great Britain?		(24)
10	ERI	N	N	Chile	environmental risk index	(25)
11	HD	N	N	Denmark	hasse diagram	(26)
12	PESTSCREEN	N	N	Spain		(27)
13	EIOVI	N		Italy		(28)
14	FOCUS	N		Europe		(29)
15	HAIR	N		Europe		(30)
16	IPEST-B	N		France		(31)
17	NERI	N		Norway	Norwegian environmental risk indicator	(23)
18	p-EMA	N		UK	environmental management for agriculture	(32)
19	PIRI	N		Australia	pesticide impact rating index	(33)
20	POCER	N		Belgium	pesticide occupational and environmental risk indicator	(19)
21	SEPTWA	N		Belgium	system for the evaluation of pesticide transport to waters	(34)
22	SEQ	N		Belgium	sum of spread equivalents	(35)
23	WEBFRAM2	N		UK		(36)
24	AARI	Y		Netherlands		
25	ADSCOR	Y				
26	CHEMS-1	Y				
27	PAF	Y		Netherlands		
28	PI	Y				
29	Rating system	Y				
30	REXTOX	Y				
31	SIRIS	Y		France		
32	SRI	Y		Sweden		
33	SyPEP	Y		Belgium	system for predicting the environmental impact of pesticides	
34	DIAPHYT	N				
35	EcoRR	N				
36	EPRIP	N				
37	I-phy	N				
38	PERI	N				
39	PESDECIDE	N				

This approach will be subjected to environmental validation (21). The arbitrary nature of the PRISW indicator makes it difficult to predict what kind of effects will happen at a certain value of the index. Other pesticide risk indicators are also used in Italy. The ARI indicator combines REXTOX (Ratio of EXposure to TOXicity), ADSCORE (ADditive SCORing) and SYSCOR (SYnergistic SCORing). These indicators content of both acute and chronic risk 43 aquatic species, algae, daphnia and fish (22). The authors indicate that they will use the HAIR tools

developed in an European framework program when these become available. The Norwegian NERI model also uses a score index which adds up things like toxicity for earthworms, leaching potential, persistence, bioaccumulation and formulation type (23). The same is true for the British EIQ index (24). Also for these models it is difficult to predict what kinds of effects will happen at a certain value of the index.

1.4 Conclusions

At the mid-term evaluation of the Dutch crop protection policy, which was conducted in 2006 (11), the NMI 2 is a state-of-the-art pesticide risk indicator which is able to produce national evaluations of changes in pesticide policy. It is part of a family of Exposure Toxicity Ratio based indicators which at this stage seemed to be superior of the more arbitrary indicators which add up scores from very different endpoints. The NMI 2 might be elaborated with a module on occupational exposure of pesticide operators and with a module on bioaccumulation and consumers risks. In the future adding up PEC/PNEC ratios will become old-fashioned because better ecotoxicological models will become available. These models will use statistical exposure and sensitivity distributions.

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