Content

Preface

Pesticides are today used as an integrated part of modern agriculture, both in Europe and throughout the world. From an environmental point of view there is a great need for monitoring data to increase our knowledge on the fate and behaviour of pesticides applied to agricultural fields. How do pesticides behave under real world conditions? Results from monitoring studies are also crucial when evaluating possible impact from different regulations and political decisions.

A Nordic cooperation on pesticide monitoring in the environment was initiated in 2001 when a report on Nordic Pesticide Monitoring Programs (TemaNord 2002:506) was prepared. This work was followed in 2003, when a workshop was held in Reykjavik, Iceland and it continued with a workshop held in Uppsala, Sweden, in February 2006. The aim of the Nordic pesticide monitoring network is to:

- Promote correspondence and exchange of data between the Nordic monitoring programs
- Harmonize monitoring programs and interpretation of monitoring data, including exchange of expertise regarding sampling methodology, selection of monitoring areas, analytical procedures, quality assurance procedures and laboratory comparisons.

The organisation committee would like to thank the Nordic Council of Ministers for realizing the workshop and this report through a generous project grant. We also thank Stina Adielsson at the Dept. of Soil Sciences, SLU, for all her hard work compiling this report.

Organising committee:
Jenny Kreuger (chairman), Sweden
Betty Bügel Mogensen, Denmark
Jaakko Mannio, Finland
Albert S. Sigurdsson, Iceland
Gro Hege Ludvigsen, Norway

Summary

A Nordic workshop on pesticide monitoring in the environment was held in Uppsala, Sweden, on the 6–7th of February 2006. The meeting was a continuation of an initiative in 2003 to start a Nordic network for people involved in pesticide monitoring.

Presentations on the current status of pesticide monitoring in the Nordic countries were given.

In Denmark pesticide monitoring is manly focused on ground water due to its importance as a source for drinking water. Beside the national monitoring program there is a unique monitoring system on leaching under controlled farming and water transport conditions, serving as an early warning system for pesticides. Other matrixes are studied within the national programme for monitoring and assessment for aquatic and terrestrial environments.

In Iceland monitoring of pesticides has been mainly on classical pesticides, for example DDT and PCB, in aquatic and costal areas.

The Norwegian monitoring of pesticides involves regular measurements in surface water from nine small agricultural catchments and three rivers. Drainage water, ground water, sediments and precipitation is included to a lesser extent.

The Swedish programme focuses on catchment scale monitoring with surface water monitoring in four catchments dominated by agriculture. Sampling of ground water and sediments is also done within these areas. Two rivers and a site for precipitation are included too.

Pesticide monitoring in Finland have, so far, mainly been screening investigations, both in surface water and ground water. Based on recent screening campaigns a more permanent monitoring programme will be established to meet the needs for the Water Framework Directive.

Other presentations involved the development of water quality standards for surface water and the ongoing work within the Nordic countries. Some information on the proceedings of the Water Framework Directive was given, as well as ideas on how to use the monitoring data in the regulatory process, for modelling or within risk assessment. Power point slides from most presentations are available on http://www.ust.is/ness/pest/workshop2006.html.

The deligates also participated in discussioin groups.

The workshop concluded that there was a common wish to increase exchange and cooperation within pesticide monitoring and proposals for further contacts and meetings were posed.

1. Groundwater monitoring in Denmark

Walter Brüsch, Carsten Langtofte Larsen & Lisbeth Flindt Jørgensen, Geological Survey of Denmark and Greenland, Denmark

1.1 Introduction

The groundwater programme is part of the Danish Monitoring Programme for Nature and Aquatic Environment established by the Danish State. The monitoring programme was initiated on 1 October 1988, and supplements environmental supervision by the regional authorities of air, groundwater, agricultural catchments, watercourses, lakes, sea, wastewater treatment plants and point sources.

The monitoring programme was revised in 1997, and was renamed the Danish Aquatic Monitoring and Assessment programme (NOVA- 2003). In 2003 a major revision was undertaken, and the new programme NOVANA covers the period 2004–2009, (the National Monitoring and Assessment Programme for the Aquatic and Terrestrial Environments). In addition to the areas previously monitored, NOVANA incorporates monitoring of species and terrestrial natural habitats. At the same time, the monitoring of nutrients and their effects and of hazardous substances has been reduced.

The groundwater programme is/was established to: 1) Monitor quality and quantity in order to enable a description of status and follow trends, making it possible to explain the causes of the observed changes. 2) Ensure sufficient amounts of groundwater with the right quality to cover the demand for drinking water, as well as to ensure the presence of sufficient water in nature to achieve standard set. 3) Document effects of environmental measures and schemes regarding groundwater quality and quantity. 4) Fulfil obligations under EU legislation as well as national legislation.

1.2 Extent of the programme

The groundwater monitoring programme consists of several parts; groundwater monitoring sites called GRUMO, agricultural monitoring catchments called LOOP and also monitoring at waterworks and by regional authorities. The analytic programme consists of four groups of compounds: main components, inorganic trace elements, pesticides and other organic micro pollutants. Which compounds that are measured within the different parts of the monitoring programme can be seen in Table 1.

Pesticides have been included in the monitoring programme since early 1990´s, when 8 pesticides were analysed. From 1998–2003 around 45 pesticides and metabolites have been analysed every year in the GRUMO and LOOP areas and from 2004–2009 app 34 pesticides and metabolites are investigated.

Examples on other organic micro pollutants monitored in ground water are Phenols and Phthalates (plasticizers) like Phenol Nonylphenol Nonylphenolethoxylates (mono- and diethoxylates), Dibuthylphthalates (DBP), DEHP and DNP; Chlorophenols like 2,4-dichlorophenol, 2,6-dichlorophenol and Pentachlorophenol; and also anionic detergents LAS (specific analysis).

Table 1. Sampling and elements of the NOVANA programme for groundwater

	Groundwater monitoring sites					Agricultural monitoring catchments	Waterworks	Regional authorities
Element	Young ground-water	Old ground-water	New wells	Wells with limited prog.	Redox wells	Groundwater wells	Well control and water abstraction	Water abstrac-tion
Grundwater abstraction volume							x	x
Position of water table	x	x	x	x	x		x	x
Main chemical ele-ments	x	x	x	x	x	x	x	
Inorganic trace ele-ments	x	x				x	x	
Organic micropollutants	x					x	x	
Pesticides and degra-dation products	x		x		x	x	x	
Groundwater dating			x		x	x		

1.2.1 Groundwater monitoring sites (GRUMO)

The most important part of the groundwater monitoring programme is the ground water monitoring areas, called GRUMO-areas, evenly distributed in Denmark (Figure 1). This part of the programme involve more than 1,000 wells located in 70 monitoring areas represent the main aquifer types found in Denmark. The groundwater monitoring sites are selected to represent regional geology, hydrology, land use, etc.

Figure 1. Location of the Danish Groundwater Monitoring Areas. Groundwater monitoring sites, GRUMO, (•) and agricultural monitoring catchment areas, LOOP, (◊) in the proposed river basin districts.

At the GRUMO sites there are several types of wells. Groundwater in the smaller, subsurface aquifers is monitored using point-monitoring wells monitoring younger groundwater (Figure 2), groundwater in the larger, deeper-lying aquifers is monitored using line-monitoring wells situated in older groundwater. In addition, groundwater is also monitored in a single abstraction well (the volume monitoring well) in the main aquifer, at each groundwater monitoring site. Samples from the abstraction well represent drinking water quality and the groundwater is often a mixture of groundwater from different reservoirs or levels in the sampled reservoir.

Six "redox" multi level sampling wells were installed to improve understanding of the chemical processes associated with the oxygen and nitrogen fronts and relation to changes in the water table. The "redox" wells are established in aquifers with well-developed oxic, anoxic and upper reducing zones, i.e. predominantly unconfined sand aquifers and the analytic programme include pH, redox potential (Eh), Oxygen, main component, pesticides and other organic micro pollutants.

Analysis for pesticides is restricted to the "young" groundwater in existing wells, with the analysis being performed once per year. Table 2 gives the pesticides included in the analysis and also states the number of samples from the different groundwater fractions.

There are 70 established groundwater monitoring sites, 50 of these have 23 wells each and are subject to the full analytical programme. At the other 20 sites monitoring is restricted to the young groundwater (dated to be generated after 1940) and only a limited number of analyses are performed.

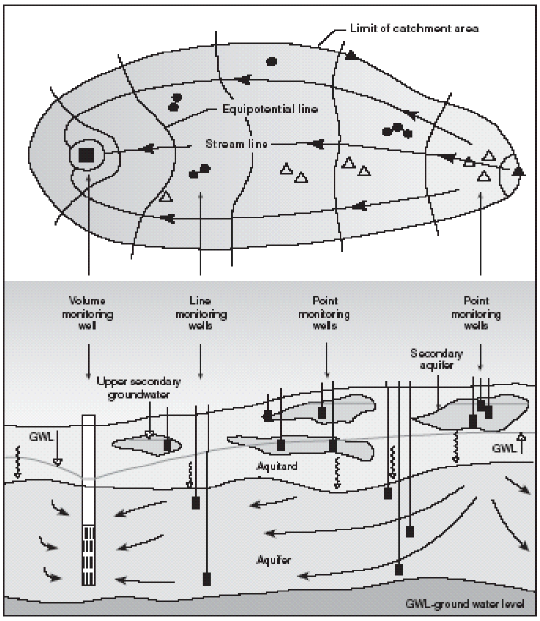

Figure 2. Principle of the point, line and volume monitoring wells applied in the GRU-MO-areas. The catchment area is defined by the extraction well. The screens are only used for sampling of ground water, and only small amount of groundwater is removed from the reservoirs.

1.2.2 Groundwater monitoring in agricultural catchments (LOOP)

The national groundwater monitoring programme also includes approx. 85 screens for sampling groundwater from shallow aquifers in five agricultural monitoring areas (LOOP- areas), se Figure 1. The LOOP areas focus especially on describing the quality, status and trends of the newly formed groundwater below agricultural fields. In order to ensure the best possible knowledge of when the groundwater in the wells in the LOOP-areas was formed, the groundwater from all the intakes are CFC dated. CFCs (Chlorofluorocarbons) are synthetic halogenated volatile organic compounds manufactured since 1930. CFCs can be detected analytically in ground water in pg/l concentrations. The concentration in groundwater is used to date groundwater using information on CFC concentrations in rainwater in the period from 1930 and forward.

Pesticides and pesticide degradation products are analysed in eight wells four times a year in each agricultural monitoring catchment (Table

2). Micro pollutants and a limited number of inorganic trace elements are analysed in the same wells every third year, main chemical elements are analysed more often.

1.2.3 Waterworks (well control)

The water quality and findings of e.g. pesticides and metabolites in water works/plants wells (well control) provides considerable knowledge about the qualitative status of the groundwater in the aquifers presently in use. The information is influenced by measured pollution over the past 10–15 years, during which many contaminated wells have been closed because of pesticide concentrations ≥ 0,1 µg/l. The information is therefore statistically unreliable such that the extracted groundwater seems less contaminated by pesticides than it really is. Well control thus primarily comprises control of the raw material used to produce drinking water and does not comprise general monitoring of the quality of the groundwater. The number of pesticides investigated in the water abstraction wells depend on the local conditions and the amount of abstracted groundwater.

Only a small part of the well control costs is covered by NOVANA as the programme only pays salary costs in connection with data transfer and reporting. The waterworks cover the actual sampling and analysis costs.

Table 2. Pesticides and metabolites and sampling frequency, subprogram for ground water

Pesticides, metabolites	Frequency				Detec. limit
	Young groundwater*	New wells*	Redox wells*	LOOP	
Aminomethyl phosphon acid (AMPA)	1	1	6	4	0,01µg/l
Atrazine	1	1	6	4	0,01µg/l
Bentazone	1	1	6	4	0,01µg/l
4-CPP	1	1	6	4	0,01µg/l
2,4-D	1	1	6	4	0,01µg/l
2,6 DCPP	1	1	6	4	0,01µg/l
Desaminodiketometribuzine	1	1	6	4	0,01µg/l
Desethylatrazine	1	1	6	4	0,01µg/l
Desethyldesisopropylatrazine	1	1	6	4	0,01µg/l
Desethylterbutylazine	1	1	6	4	0,01µg/l
Desisopropylatrazine	1	1	6	4	0,01µg/l
Dichlobenile	1	1	6	4	0,01µg/l
2,6-Dichlobenzamide (BAM)	1	1	6	4	0,01µg/l
2,6-Dichlorbenzoe acid	1	1	6	4	0,01µg/l
Dicoprop	1	1	6	4	0,01µg/l
Diketometribuzine	1	1	6	4	0,01µg/l
Dinoseb	1	1	6	4	0,01µg/l
Diurone	1	1	6	4	0,01µg/l
DNOC	1	1	6	4	0,01µg/l
Glyphosate	1	1	6	4	0,01µg/l
Hexazinone	1	1	6	4	0,01µg/l
Hydroxyatrazine	1	1	6	4	0,01µg/l
Hydroxysimazine	1	1	6	4	0,01µg/l
Hydroxyterbutylazine	1	1	6	4	0,01µg/l
Isoproturone	1	1	6	4	0,01µg/l
MCPA	1	1	6	4	0,01µg/l
Mechloroprop	1	1	6	4	0,01µg/l
Metamitrone	1	1	6	4	0,01µg/l
Metribuzine	1	1	6	4	0,01µg/l
4-nitrophenole	1	1	6	4	0,01µg/l
Pendimethalin	1	1	6	4	0,01µg/l
Simazine	1	1	6	4	0,01µg/l
Terbuthylazine	1	1	6	4	0,01µg/l
Trichloro acetic acid (TCA)	1	1	6	4	0,01µg/l

* Sampling within the GRUMO-areas.

Special monitoring programs have been reported e.g. sampling and analysing drinking water from 625 small water plants supplying single house holds in sand and till areas in 2004. This project has also been followed-up by an investigation of transport and infiltration of glyphosate and AMPA in fractured till.

1.3 Data management and reporting

The Danish counties carry out the data collection in the ground water monitoring programme. By law these data – as well as the analytical data collected by the water works are reported yearly in quality assured version to the Geological Survey of Denmark and Greenland, GEUS. GEUS is the national data centre for chemical analysis of ground and drinking water. Data are accessible for other research institutes, private companies, etc.

1.3.1 Modelling

The groundwater level and abstraction data are together submitted once a year, while selected data are to be submitted continually. Water balance modelling includes e.g. following elements:

Modelling of flow pathways and water balance in local catchments (including groundwater monitoring sites, agricultural monitoring catchments, etc.)

Modelling of water balance and groundwater at the river basin district scale.

1.4 Economy

Ground water total: The counties have a total financial consumption on 25,100,000 DKK (3,308,000 EUR) including manpower, sampling, reporting etc., while the total financial consumption in the state/research institutes is 1,700,000 DKK (224,000 EUR).

Table 3. Analytical expenses for pesticide monitoring in groundwater

Analytic expenses	Price DKr.	Number	Frequency	Total DKr.
GRUMO, young ground water	7,899	569	1	4,494,791
New wells, surface near ground water	7,899	321	1	2,113,105
Redox wells,	7,899	8	6	379,174
New redox wells	7,899	4	6	157,989
Total				7,145,058

The economic frame of the national monitoring programme is restricted and decided by the Danish Ministry of the Environment. In the last revisions of the groundwater monitoring both analytical programme and number of sites were reduced.

1.5 List of publications

All reports from the ground water monitoring system can be found on GEUS' web site:

www.geus.dk
www.pesticidvarsling.dk
http://www.geus.dk/program-areas/water/denmark/index-water-dk-uk.htm

The last groundwater monitoring report:

GEUS, Danmarks og Grønlands Geologiske Undersøgelse, 2005: Grundvand 2004. Status og udvikling 1989-2004. (ed. L. F. Jørgensen). (only available from www.geus.dk)

2. Pesticides in the Danish monitoring and assessment programme for aquatic and terrestrial environment

Susanne Boutrup
National Environmental Research Institute, Denmark

2.1 Introductions

Environmental pesticide monitoring in Denmark is a part of the national programme for monitoring and assessment for aquatic and terrestrial environment, NOVANA. The programme includes monitoring of pesticides as well as other chemical, physical and biological parameters. Atmospheric deposition, point sources, agricultural catchments, ground water, watercourses, lakes, marine waters, species and terrestrial natural habitats are monitored. The programme period is 2004–2009.

The objectives of NOVANA are to:

- describe sources of pollution and other pressures and their impact on the status of the aquatic and terrestrial environments and identify trends
- generally document the effect of national action plans and measures directed at the aquatic and terrestrial environments – including whether the objectives are achieved and whether the trends are in the desired direction
- meet Denmark's obligations in relation to EU legislation, international conventions and national legislation
- contribute to enhancing the scientific basis for future international measures, national action plans, regional management and other measures to improve the aquatic and terrestrial environments, including contributing to develop various tools.

Today the program is performed in coordination between the Ministry of Environment and the regional authorities (counties). The later is, together with topic centres, responsible for the practical performance (a more detailed description is found under the heading Data management and reporting). Due to a reconstruction of the Danish administrative system the counties won't exist after 1 January 2007 and the current tasks will then be carried out by regional governmental authorities. The topic centres will continue their tasks. The monitoring activities carried out by the regional authorities are funded via government block grants. The expenses of the Ministry of Environment are allocated via the Government Budget.

2.2 Extent of the programme

Pesticide monitoring is included in the sub programmes for agricultural catchments, groundwater, watercourses and lakes and to a lesser degree in the sub programmes for atmospheric deposition, point sources and marine waters. The pesticides included in the individual sub programmes are listed in Appendix 1. The number of sites and frequencies are listed in Table 1.

Table 1. Number of sites and frequency for pesticide monitoring in NOVANA (2004–2009)

	Atmospheric deposition	Point sources (storm water)	Agricultural catchments	Watercourses
Number of sites	2	4	LOOP-areas, see	5
Frequency	6 samples over 1 year	9 samples over 3 years	separate report on groundwater	12 samples every year

	Marine			
	Sediment	Mussels	Fish	Water
Number of sites	about 50	about 30	4	-
Frequency	1 sample within 6 years	1 sample each year	1 sample each year	1 sample within 6 years

In NOVA-2003, the monitoring programme prior to NOVANA, pesticide monitoring in watercourses was performed in three different types of watercourses:

- “big” watercourses representing big catchments (12 samples per year)
- small watercourses in agricultural catchments (6 samples per year)
- watercourses in agricultural catchments (16 samples per year).

It was expected to find higher concentrations of pesticides in samples from the watercourses representing agricultural catchments in the spraying season, but the expectations were not met. For that reason the pesticide monitoring is only performed in the big watercourses in NOVANA in order to measure the basic concentrations.

Pesticides in lakes were found in concentrations very close to the detection limits in NOVA-2003. For that reason it was decided not to monitor pesticides in lakes in NOVANA as a routine run part of the programme but in stead to include a one-year screening of both lakes and an additional number of watercourses. The details of the pesticide screening programme are not decided yet and therefore it is not included in Table 1. The screening will take place in 2008 or 2009.

The sampling methods can briefly be described as:

- Samples of atmospheric deposition are collected using cooled wet-only samplers with an average time of 1–2 months.
- Samples from storm water are taken as flow proportional sub samples from the water stream with intervals of 15 minutes, only a small amount of the samples are used for pesticide analysis.
- Samples from freshwater (watercourses and lakes) are taken as spot samples by dipping the sample bottle in the water and let water from right under the surface run into the bottle.
- Samples from marine waters are taken from the surface water in 0.3–1 m depth by letting the sample bottle flow in the water until it is full.
- Samples of marine sediment and biota are taken as a number of sub samples from the same monitoring sites and afterwards pooling into one sample.

2.2.1 Pesticdes

The total programme includes 52 substances, 34 pesticides and 18 metabolites (Appendix 1). 13 of these pesticides are still in use or were used in 2002–2004 (Table 2). The use of metribuzine and simazine was banned in 2005 and the use of fenpropimorph was restricted. Terbutylazine was not re-registered in 2005 and is therefore not used any longer.

Table 2. Yearly sails of pesticides (kg active ingredient) included in the Danish monitoring programme (Ref. Statistics from the Danish EPA)

Substance	2002	2003	2004
Bentazone	52,632	38,411	32,442
Dichlorprop	1,344	971	1,470
Diuron	25,344	20,312	15,764
Ethofumesate	18,010	12,863	14,331
Fenpropimorph	87,362	76,281	25,606
Glyphosate	1,022,720	1,033,063	1,073,104
MCPA	152,275	163,729	82,423
Mechlorprop	1,346	1,632	8,887
Metamitron	96,296	104,969	39,371
Metribuzin	5,576	8,506	-
Pendimethalin	98,813	129,969	146,418
Simazine	-	12,000	32,500
Terbutylazine	144,907	64,170	44,760

The eleven herbicides used in 2004 (all but fenpropimorph) represent 65% of the total amount of herbicides sold in Denmark in 2004. Glyphosate was dominating. Glyphosate has been sold in Denmark since 1975, and the amount is still increasing (Figure 1). In 2004 46 % of the total sold amount of herbicides was glyphosate.

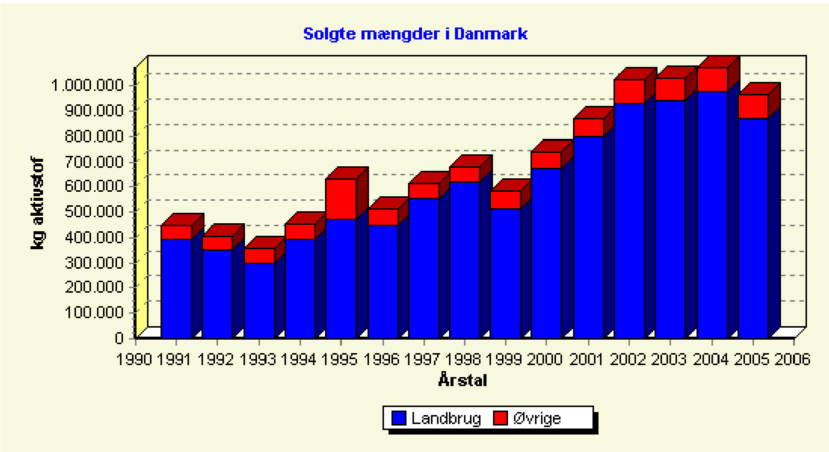

Figure 1. Sold amounts of glyphosate (kg active ingredient) in Denmark in 1991–2004.

Several of those pesticides, which are not in use any longer, were banned in 1996 or before. Table 3 shows when the pesticides were banned, or the use stopped because the producer didn't apply for renewed registration.

Table 3. Pesticides in the Danish monitoring programme which are banned or not in use any longer

Substance	Time and reason for no usage
2,4-D	Not in use since mid 1990s
Aldrine	Banned 1992
Atrazine	Banned 1996
Chloridazon	Not in use since mid 1990s
DDE pp'-	Not in use since mid 1980s
DDT pp'-	Not in use since mid 1980s
Dichlobenil	Banned 1997
Dichlorprop	Restricted use (lawns)
Dieldrine	Not in use since mid 1980s
Dinoseb	Banned 1996
Disulfoton	Not in use
DNOC	Not in use since mid 1990s
Endrine	Banned 1992
Fenpropimorph	Banned 2005 (restricted use)
Hexachloro-cyklohexane (lindane)	Banned 1992
Hexazinon	Banned 1996
Isodrine	Not in use
Isoprutoron	Banned 1999
MCPA	Restricted use (lawns)
Mechlorprop	Restricted use (lawns)
Metazachlor	Not in use since mid 1990s
Metribuzine	Banned 2005
Simazine	Banned 2005
Terbutylazin	Not in use since 2005
Trichloro acetic acid (TCA)	Not in use

2.2.2 Analytical methods

We do not set up demands for choosing analytical methods, but we set up demands for the quality of the analytical methods used in the monitoring. The demands for detection limits are listed in Appendix 1. As a principle the laboratories have to be accredited, but when the monitoring of pesticides and other hazardous substances started up in 1998 only few Danish laboratories were accredited to the analyses and different system had to be set up. This means that the Danish EPA nominates laboratories that are qualified to analyse the individual substances. This nomination is based on an evaluation of the laboratories' results upon performance testing or similar documentation of the analytical quality.

2.2.3 History

Monitoring of pesticides in groundwater started in 1993. Monitoring in point sources, freshwater and marine areas was added in 1998 and atmospheric deposition in 2004. The number of pesticides in NOVA-2003 (1998–2003) included totally 89 substances. The list can be found in http://www.dmu.dk/NR/rdonlyres/D0336A0A-ADE3-4DBF-AC71-1D0155461874/0/NOVAprogrambilag.pdf. The list was in 2004 reduced to the current 52 substances. One main reason for reducing the number was that many of the substances were not detected at all throughout the previous 6-year monitoring period. Another reason was that new monitoring needs had to be met in the programme within an unchanged budget.

2.3 Data management and reporting

In the current administrative system data is collected, evaluated and stored in databases at the counties (called Regional authorities in Figure 2). Once a year the counties report monitoring data to the individual topic centres in formats defined by the topic centres. The topic centres are responsible for international data reporting. After reconstruction of the Danish administrative system data will be stored in national databases with one joint database for each subject area.

Regional authorities:
• sampling
• data collection
• data processing
• quality assurance
• data storage
• regional reporting

NERI:
• state monitoring of open marine waters, air quality, species
• certain laboratory analyses
• overall coordination of the monitoring programme

Topic centres:
• national databases
• quality assurance
•method development – including technical instructions,
• data processing
• national reporting
• international reporting

Topic Centres:
•Biodiversity and Terrestrial Nature
• Groundwater and Wells
• Inland Surface Waters
• Air Quality
• Marine Data
• Hydrological Point Sources
• Agricultural Monitoring Catchments

Consultants:
• field work
• analyses
• data processing
• reporting

Laboratories:
• chemical analyses

Consultants:
• marine modelling
• certain biological analyses

Laboratories:
• chemical analyses

Figure 2. Roles of the parties carrying out NOVANA.

The data collector is the primary responsible for quality assurance. Assessment and reporting of data is an important part of the quality assurance. The counties are responsible for ensuring the data quality before reporting to the topic centres. The topic centres subject data an electronic control by assessing whether or not data are "realistic" and afterwards a "manual" control during the annual report writing process.

Until 2006 the counties have from the regional point of view written yearly reports on the results of the monitoring for each sub programme and the topic centres have written yearly national reports based on the reports from the counties. The main results are collected in a yearly summary report to which the Government is part of in the target group. In addition, all reports have politicians, NGOs and other interested as target groups. The reports from the counties and the topic centres have within the last couples of years changed into indicator based reporting. As a principle data collected by taxpayers' money is freely assessable, and thus reports are freely assessable from web-sites. The summary report and the reports from the topic centres can be found at http://www.dmu.dk.

It is not decided how monitoring data will be reported after reconstruction of the administrative system. Monitoring data will most likely be yearly reported by the topic centres. Besides, a portal which gives assess to all environmental data will be established and data presentation and a kind of reporting are under consideration. The monitoring data will together with other data be used when the regional governmental centres report in order to meet regional needs in connection with planning and administration.

2.4 Economy

The budget in the current monitoring is divided into budgets for each sub programme and budgets for the counties and the Ministry of Environment (table 4).

Table 4. Counties and Ministry of Environment financing of NOVANA in 2005 prices given in mill. Euro (a years and total costs per year)

	Counties				Min. of Envir.	
	Man year (number)	Manpower	Operating	Total	Man year (number)	Total
Background monitoring of air quality and atmospheric deposition		-		-	10,8	1,4
Point sources	35,1	2,6	1,8	4,3	2,4	0,3
Agricultural catchments	11,7	0,9	1,2	2,0	2,3	0,3
Groundwater	17,2	1,3	2,5	3,8	2,3	0,3
Watercourses	31	2,3	2,0	4,3	5,7	0,6
Lakes	19,8	1,4	1,4	2,8	2,8	0,3
Marine waters	35,7	2,6	3,3	6,0	8,3	1,4
Species and terrestrial habitats	19,5	1,4	0,9	2,3	3,5	0,8
Nationwide Air quality Monitoring Programme			0,4	0,4	9,2	1,1
Marine model complex			0,6	0,6		
Development tasks and crosscutting data			0,5	0,5	1,5	0,2
Coordination, Secretariat etc.					4,5	1,0
Total	170	12,4	14,5	27,0	53,3	7,7

In the total costs are included costs for employees working with the monitoring as well as operating expenses. The costs for employees comprise coordination, quality assurance, data management, reporting and sampling. The costs have not been subdivided into these segments. The costs in Ministry of Environment are almost costs for man power and are for that reason not split in table 4 as it is the case of the costs for the counties.

The financing is based on an agreement back in 1998 between the counties and the Ministry of Environment on the prices for the individual activities in the programme. The prices have not been changed except indexation, although it is expected – and known – that the prices for many of the chemical analysis are lower than presupposed in the agreement due to discounts based on agreements between laboratories and counties on the whole amount of analysis. The lower price on the chemical analysis is expected to correspond with higher wages.

Description including strategy and further details of the programme can be found in English at website:

http://www.dmu.dk/International/Monitoring/NOVANA/

and in Danish on:

http://www.dmu.dk/Overv%C3%A5gning/NOVANA/.

2.5 List of publications

A report which in English summarises the results and assessments on monitoring in 2003 can be found at:

http://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR561.PDF.

Reports in Danish can be found at: www.dmu.dk.

Reports concerning monitoring, including pesticide monitoring in surface water in 2004 can be found at:

agricultural catchments:
http://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR552.PDF.

watercourses:
http://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR554.PDF.

summary:
http://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR558.PDF.

Appendix 1.

	Detection limits							
	Ground water	Water courses	Storm water	Marine				Atmospheric
				sediment	mussels	fish	water	deposition
	ug/l	ug/l	ug/l	ug/kg TS	ug/kg vv	ug/kg vv	ug/l	ug/l
2,6-dichlorbenzamid (BAM)	0,01	0,01	0,01					
2,4-D	0,01							
4-nitrophenol	0,01	0,01						0,01 *3)
2,4-dinitrophenol								0,01 *3)
2,6-dichlorbenzoesyre	0,01							
2,6-DCPP	0,01							
3-methyl-2-nitrophenol								0,01 *3)
3-methyl-4-nitrophenol								0,01 *3)
4-CPP	0,01							
Aldrine			0,01		0,5 [19)]			
Aminomethylphosphonsyre (AMPA)	0,01	0,01	0,01					
Atrazine	0,01	0,01					0,002	0,01
Bentazon	0,01							
Chloridazon								0,01
DDT pp'-				0,1	0,1	0,6		
DDE pp'-				0,1	0,1	0,6		
Desaminodiketometribuzin	0,02							
Desethylatrazine	0,01							0,01
Desethylterbutylazine	0,01	0,01						0,01
Desethyldesisopropylatrazine	0,01	0,01						
Desisopropylatrazine	0,01	0,01						0,01
Dichlobenil	0,01							
Dichlorprop	0,01							0,01
Dieldrine			0,01		0,5 [19)]			
Diketometribuzin	0,02							
Dinoseb	0,01							
Disulfoton								0,01
Diuron	0,01	0,01					0,002	0,01
DNOC	0,01	0,01						0,01
Endrine			0,01		0,5 [19)]			
Ethofumesate								0,01
Fenpropimorph								0,01
Glyphosate	0,01	0,01	0,01					
Hexachloro-cyklohexane (lindane)			0,01	0,1	0,1	0,6		
Hexazinone	0,01							

	Detection limits							
	Ground water	Water courses	Storm water	Marine				Atmospheric
				sediment	mussels	fish	water	deposition
	ug/l	ug/l	ug/l	ug/kg TS	ug/kg vv	ug/kg vv	ug/l	ug/l
Irgarol							0,002	
Isodrine			0,01		0,5 [19)]			
Isoprutorone	0,01	0,01						0,01
MCPA	0,01	0,01	0,01					0,01
Mechlorprop	0,01	0,01						0,01
Metamitrone	0,01							0,01
Metazachlor								0,01
Metribuzine	0,01							
Pendimethaline	0,01							0,01
Sea-Nine							1,0	
Simazine	0,01	0,01	0,01				0,002	
Terbutylazin	0,01	0,01						0,01
Trichloroacetic acid (TCA)	0,01	0,01						
Zink-pyrethion[20)]							1,0	

3. The Danish pesticide leaching assessment programme – a post registrarion monitoring programme

Jeanne Kjær, Geological Survey of Denmark and Greenland, Øster Voldgade 10, DK-1350 Copenhagen K., Denmark
Preben Olsen, Danish Institute of Agricultural Sciences, Research Centre Foulum, DK-8830 Tjele, Denmark
Ruth Grant, National Environmental Research Institute, Vejlsøvej 25, DK-8600 Silkeborg, Denmark

3.1. Introduction

In 1998, the Danish Government initiated the Pesticide Leaching Assessment Programme (PLAP), an intensive monitoring programme aimed at evaluating the risk of pesticide leaching under field conditions. The PLAP is intended to serve as an early warning system providing decision makers with advance warning if approved pesticides leach in unacceptable concentrations. The programme focuses on pesticides used in arable farming and monitors leaching at 5 agricultural test sites representative of Danish conditions. The objective of the PLAP is to improve the scientific foundation for decision making in the Danish registration and approval procedures for pesticides, enabling field studies to be included in risk assessment of selected pesticides. The specific aim of the programme is to analyse whether pesticides applied in accordance with current regulations leach at levels exceeding the maximum allowable concentration of 0.1 µg/l.

The Danish Government funded the first phase of the programme from 1998 to 2001, while the Ministry of the Environment and the Ministry of Food, Agriculture and Fisheries are funding a prolongation from 2002 to 2009. The work is conducted by the Geological Survey of Denmark and Greenland (GEUS), the Danish Institute of Agricultural Sciences (DIAS) and the National Environmental Research Institute (NERI) under the direction of a management group comprising members from the participating institutions as well as the Danish Environmental Protection Agency.

3.2 Extent of the programme

The PLAP initially included six locations representing a range of Danish soil and climate conditions (Figure 1). Monitoring started 1999 on Tylstrup, Jyndevad and Faardrup and in 2000 at Silstrup Estrup and Slæggerup. Monitoring at the loamy site Slaeggerup was ended on 1 July 2003, while monitoring at the remaining five sites continues until end of 2008.

3.2.1 Agricultural management

Cultivation of the sites is in line with conventional agricultural practices applied in the regions, whereas pesticides are applied in the maximal permitted dose in accordance with the regulations. In order to describe water transport and especially to assure that the water being sampled had infiltrated on the test field, a bromide tracer (30 kg KBr/ha) was applied on each field. In addition to data on pesticide use (dose, substance) numerous information related to the soil and crop management is being registered e.g. tillage depths, phenological crop development whenever a farming operation is conducted, local conditions regarding climate and soil at time of a pesticide application. As of now 29 pesticides and their relevant metabolites are included in the programme (see Table 1).

3.2.2 Monitoring

To avoid artefact leaching of pesticides, all installation as well as soil sampling deeper than 20 cm b.g.s. have been restricted to a buffer zone surrounding the treated area (Figure 1). Precipitation is measured on all sites using a tipping bucket rain gaugeas well as soil moisture (TDR) and soil temperature in various depths. Concentrations of bromide and pesticide are measured in drainage water, ground water and soil water from the unsaturated zone:

Soil water samples are collected monthly using 16 teflon suction cups clustered in four groups installed 1 and 2 m b.g.s. at two downstream location (see Figure 2). Each group of suction cups thus consists of four individual cups covering a horizontal distance of 2 m. The chemical analyses were performed on a single, pooled water sample for each of the four groups.

Groundwater samples are collected monthly from several monitoring wells installed in the surrounding buffer zone (Figure 2). Each monitoring well consists of four 1 m screens covering the upper approx. 4 m of the saturated zone. At the loamy sites horizontal monitoring wells were additionally installed 3.5 m beneath the test site. Each horizontal monitoring well consisted of 18 m screens providing integrated water samples that characterise groundwater quality just beneath the test site (Figure 2).

At the loamy sites drainage water was originally sampled by means of both flow- and time proportional sampling. From July 2004 only flow proportional samples are taken. Now sample collection starts when the accumulated flow rate exceeds a predefined volume of runoff, being dependent on the season e.g. a 200 ml sample is collected for every 3,000 l of runoff during the "winter" period (1 September to 31 May) whereas only 1,500 l of runoff is needed for the taking of a sample during the "summer" period (1 June to 31 July). Chemical analysis was then performed on a weekly basis on a pooled sample.

3.2.3 Analytical methods and quality assurance procedures

The analyses of pesticides were all performed in commercial laboratories, accredited for analysis of pesticide by the Danish EPA. The field monitoring work has been supported by intensive quality assurance entailing continuous evaluation of the analyses employed. Every fourth month, two external control samples were analysed at the laboratories along with the various water samples from the test sites. Two stock solutions of different concentrations (0.05 µg/l and 0.117 µg/L) were prepared from two standard mixtures in ampules prepared by Promochem, Germany. Blank samples consisting of HPLC-grade water (Rathburn Chemicals Ltd, Walkerburn, Scotland) were sent to the laboratory each month together with the water samples. All samples included in the control were labelled with coded reference numbers so that the laboratories were unaware of which samples were controls and blanks. In addition to specific quality control under the PLAP, each of the laboratories takes part in the proficiency test scheme employed by the Danish Environmental Protection Agency when approving laboratories for the Nationwide Monitoring and Assessment Programme for the Aquatic and Terrestrial Environments (NOVANA).

3.3 Data management and reporting

Data are stored in an Access database held at GEUS. Once a year data are evaluated and publised in an annual report available (free of charge) on www.pesticidvarsling.dk. Moreover data are presented at various national and international workshops/conferences as well as in peer-reviewed articles (see publication list).

3.4 Economy

Total annual cost of the programme amount to approximately 1,079,000 Euro, of which 533,000 Euro pays the staff running the programme and the remaining 546,000 Euro pays the working expenses (tenancy fee, analysis etc.). Pesticide analyses amount to 350,000–400,000 Euro per year.

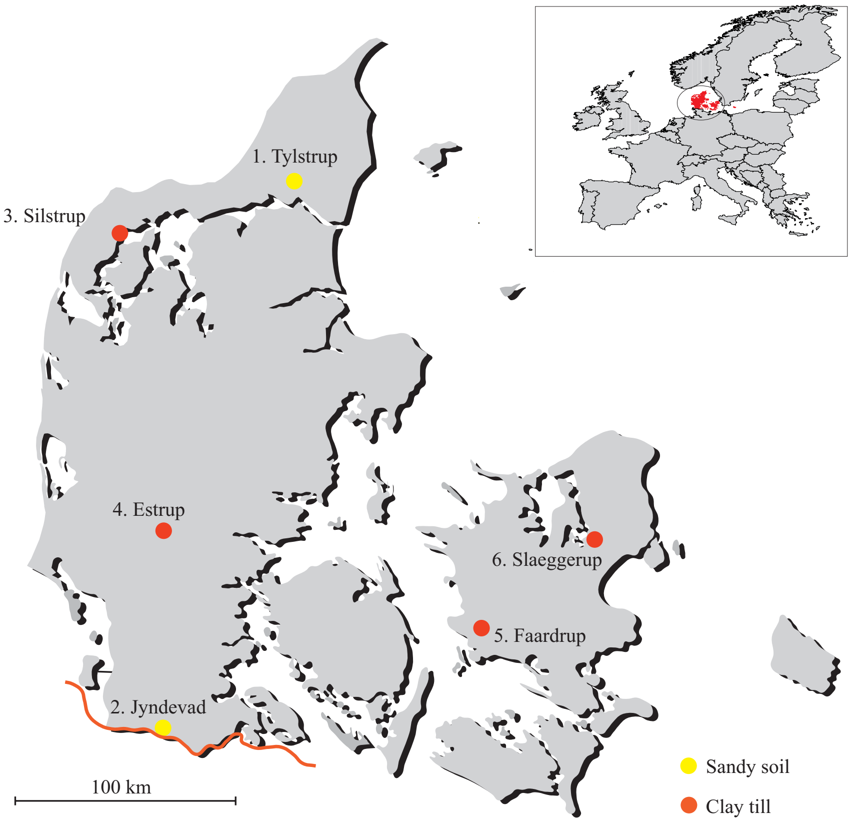

Figure 1. Location of the PLAP sites Tylstrup, Jyndevad, Silstrup, Estrup and Faardrup. Monitoring at Slaeggerup was terminated on 1 July 2003.

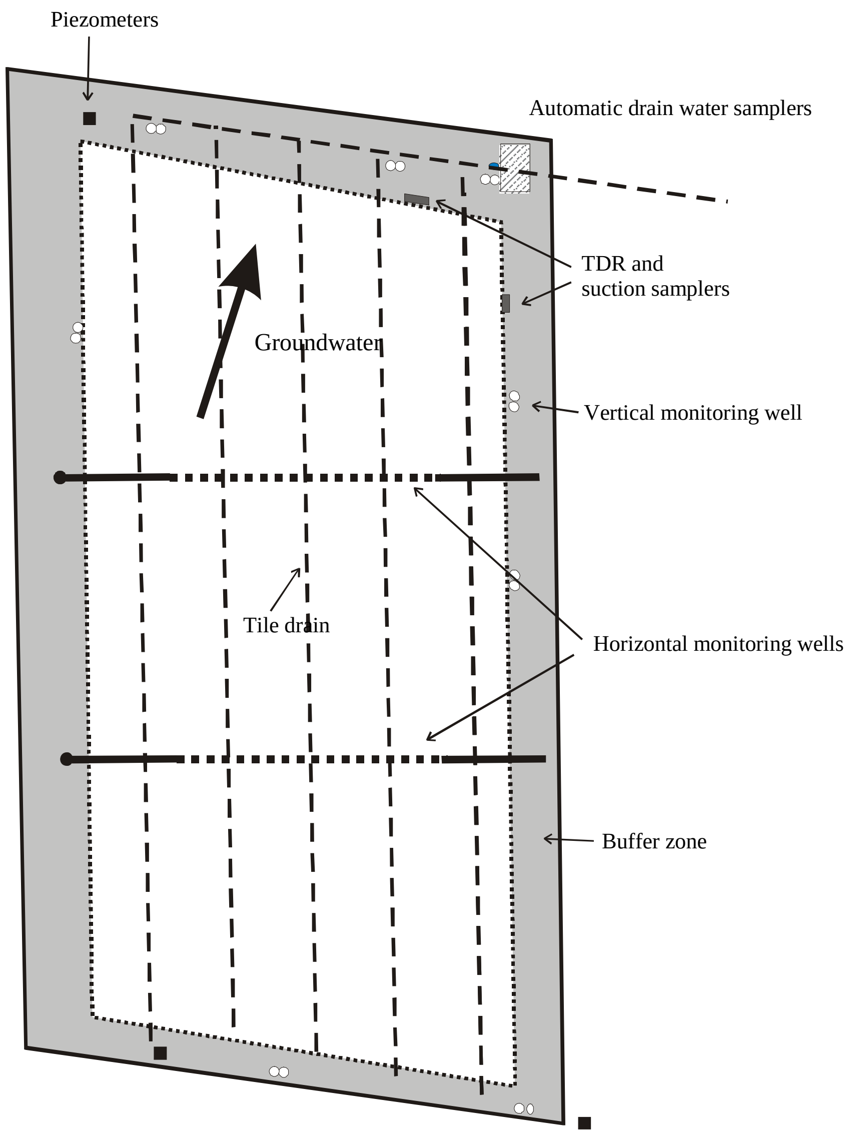

Figure 2. Overview of a tile-drained PLAP-site. The innermost area indicates the cultivated area, while the grey area indicates the surrounding buffer zone. The positions of the various installations are indicated, as is the direction of the groundwater flow (by an arrow).

Table 1. Pesticides and transform products included in the PLAP programme

Active ingredient	Transform product	Type[1)]	Sales figures (kg a.i sold in 2004)[2)]
Amidosulfuron	[3)]	h	280
Azoxystrobin	CyPM	f	22.698
Bentazon	AIBA	h	32.442
Bromoxynil		h	53.066
Clomazone	propanamid-clomazone		6.912
Desmedipham	EHPC	h	887
Dimethoat		i	9.389
Ethofumesat		h	14.331
Fenpropimorph	fenpropimorph-acid	f	Banned
Flamprop-M-isopropyl	flamprop-acid	h	2.272
Fluazifop-P-buthyl	fluazifop-acid	h	4.888
Fluroxypyr	fluroxypyr (free acid)	h	30.680
Glyphosat	AMPA	h	978.442
Ioxynil		h	50.786
Linuron		h	Banned
Mancozeb	ETU	f	304.421
Metamitron	desamino-metamitron	h	39.371
Metribuzin	desamino-diketo-metribuzin	h	Banned
	deamino-metribuzin		
	diketo-metribuzin		
Metsulfuron-methyl	triazinamin	h	752
MCPA	4-chlor,2-methylphenol		70.976
Pendimethalin		h	146.418
Phenmedipham	MHPC[4]	h	16.359
	3-aminophenol		
Pirimicarb	pirimicarb-desmethyl pirimicarb-desmethyl- formamido	i	1.040
Propiconazol		f	15.483
Prosulfucarb		h	494.016
Pyridat	PHPC	h	15.910
Rimsulfuron	PPU PPU-desamino		167
Terbuthylazin	desethylterbuthylazin hydroxyterbuthylazin desbuthylterbutylazin desethylhydroxyterbuthylazin	h	33.775
Triasulfuron	triazinamin[3]	h	119
Tribenuron-methyl	triazinamin-methyl[5]	h	2162

1) h: herbicide, i: insecticide, f: fungicide

2) Sales figures sold amount in 2004. Figures are taken from "Bekæmpelsesmiddelstatistikke" available on www.mst.dk.

3) Its degradation products – with which the leaching risk is mainly associated – are not included as methods for their analysis are not yet available.

Appendix – Selected list of publication

International contributions

Kjær, J., Olsen, P., Ullum, M. and Henriksen, T. (2005): Leaching of metribuzin metabolites and the associated contamination of a sandy Danish aquifer, Environmental Science and Technology, 39, 8374-8381.

Kjær, J., Olsen, P., Ullum, M., & Grant, R. 2004: Leaching of AMPA and Glyphosate in Danish agricultural soils, J. Environ. Qual. 34,608-620.

Kjær, J., Olsen, P., Barlebo, H.C., Juhler, R.K., Plauborg, F., Grant, R., & Brüch, W. 2004: The Danish Pesticide Leaching Assessment Programme. Monitoring results May 1999–June 2003. GEUS, Copenhagen, 110 pp + Appendices.

Kjær, J., Olsen, P. & Grant, R. 2004: Transportvägar för bekämpningmedel, övervakningprogram och erfarenheter från Danmark. Presentation at the workshop "Vad krävs för att undvika skadliga rester av kemiska bekämpningsmedel i dräneringsvattnet – i förlängningen en del av grund- / dricksvattnet ?" Alnarp, Sweden, 9 January 2004.

Kjær, J., Olsen, P. & Grant, R. 2003: Leaching assessment based on monitoring of pesticides in 6 different growing systems. Presentation at a workshop on monitoring of pesticides in Nordic environment. 19–21 March, 2003. Reykjavik, Iceland. Nordic Council of Ministers.

Kjær, J., Ullum, M., Olsen, P., Sjelborg, P., Helweg, A., Mogensen, B., Plauborg, F., Grant, R., Fomsgaard, I. & Brüch, W. 2003: The Danish Pesticide Leaching Assessment Programme. Monitoring results May 1999–June 2002. Third report. GEUS, Copenhagen, 123 pp + Appendices.

Kjær, J., Olsen, P. Ullum, M. & Grant, R. 2003: Leaching of glyphosate and AMPA as affected by soil properties and precipitation distribution. In: Del Re, A.A.M., Capri, E., Padovani, L., Trevisan, M. (eds): Pesticide in air, plant, soil and water system. Proceedings of the XII Symposium on Pesticide Chemistry, Piacenza, Italy. 4–6 June, 2003, pp. 107–114.

Van der Keur, P., Ullum, M., Kjær, J. & Plauborg, F. 2003: Assessment of the MACRO model sensitivity for water balance in the unsaturated zone. In: Del Re, A.A.M., Capri, E., Padovani, L., Trevisan, M. (eds): Pesticide in air, plant, soil and water system. Proceedings of the XII Symposium on Pesticide Chemistry, Piacenza, Italy. 4–6 June, 2003, pp 451–456.

Kjær, J., Ullum, M., Olsen, P., Sjelborg, P., Helweg, A., Mogensen, B., Plauborg, F., Jørgensen, J.O., Iversen, B.V., Fomsgaard, I. & Lindhardt, B. 2002: The Danish Pesticide Leaching Assessment Programme. Monitoring results May 1999–June 2001. Second report. GEUS, Copenhagen, 105 pp. + Appendices.

Ullum, M., Kjær, J., Plauborg, F. & Jørgensen, J.O. 2002: Model performance of an uncalibrated model with respect to groundwater recharge. XXVII EGS General Assembly. Nice, France. 21–26 April, 2002. European Geophysical Society. Geophysical Research Abstracts 4

Olsen, P., Kjær, J., Ullum, M. & Grant, R. 2002: The Danish Pesticide Leaching Assessment Programme – a field-based early warning system. Environmental Monitoring in Agriculture, Status, perspectives and future requirements. Nordic Council of Ministers. Ås, Norway. Extended abstract.

Kjær, J., Olsen, P., Sjelborg, P., Fomsgaard, I., Mogensen, B., Plauborg, F., Jørgensen, J.O. & Lindhardt, B. 2001: The Danish Pesticide Leaching Assessment Programme. Monitoring results May 1999–July 2000. GEUS, Copenhagen 60 pp. + Appendices.

Kjær, J., Olsen, P. & Lindhart, B. 2001: Leaching of pesticides from sandy Danish soil to ground water under field condition. 8th Symposium on Chemistry and fate of Modern Pesticides. Copenhagen. 21–24 August, 2001. International Association of Environmental Analytical Chemistry. Abstract volume, p. 52.

National contributions

Kjær, J. & Olsen, P. 2004: Udvaskning af glyphosat og AMPA under reelle markforhold, Resultater fra Varslingssystemet. Presentation at workshop on binding, transport and degradation of glyphosate in agricultural use. DIAS Flakkebjerg, 15 September 2004.

Olsen, P., Kjær, J. & Grant, R. 2004: Varslingssystemet for udvaskning af pesticider – Status efter tre års moniter-ing. DJF rapport Markbrug nr. 98. pp. 161–171. 1. Presentation at the Danish Plant Congress, January 2004.

Olsen, P., Kjær, J. & Grant, R., 2004: Pesticidudvaskning – status efter 3 års monitering i Varslingssystemet. DANSK VAND 1(72): 34–37.

Kjær, J, Olsen, P., & Grant, R. 2003: Udvaskes pesticider ved regelret brug – erfaringer fra Varslingssystemet, In: Bruun, B.(ed.): Kilder til pesticidforurening af grundvandet, ATV-møde Shæffergården, Gentofte, January, 2003, pp. 15–23. Presentation at a workshop on sources of pesticide contamination of groundwater.

Kjær, J., Jørgensen, J.O. & Olsen, P. 2002: Udvaskning af glyphosat og metribuzin, vurderet ud fra danske markforsøg. Presentation at the Nature and Environment Conference, Copenhagen. 22–23 August, 2002. Ministry of the Environment and National Environmental Research Institute, p. 89.

Olsen, P., Kjær, J. & Grant, R. 2002: Varslingssystemet for udvaskning af pesticider. DAVID – Grundvandsmøde. Nyborg. Dansk Vandingeniørsforening. December, 2002.

Kjær, J., Ullum, M., Olsen, P., Jørgensen, J.O. & Lindhart, B. 2002: Udvaskning af glyphosat vurderet ud fra tre markforsøg. ATV-møde, Vejle, March 2002, ATV Jord og Grundvand, pp. 373-384. Presentation at a workshop on soil and groundwater contamination.

Lindhardt, B., Kjær, J. & Olsen, P. 2001: Udvaskning af pesticider fra kartoffeldyrkning på sandjord, vurderet ud fra markforsøg. DJF-rapport Markbrug 40. 18th Danish Plant Protection Conference, Nyborg, March 2001, pp. 57-67.

4. Environmental monitoring of pesticides in Finland

Jaakko Mannio, Katri Siimes & Juhani Gustafsson, Finnish Environment Institute, Finland

4.1 Introduction

Environmental monitoring of pesticides in Finland is not as well established as monitoring on many other substances, e.g. eutrophicating compounds or heavy metals in different compartments of the environment. In drinking water pesticides and breakdown products are regularly monitored by waterworks. The pesticide use declined in Finland until mid 1990s, but has increased during last 10 years (Savela & Hynninen 2004, Figure1 & 2 in Appendix 1). Classical, already banned pesticides (DDTs, HCHs, chlordanes, HCB) are monitored in precipitation, humus layer, terrestrial and aquatic biota. Surface water monitoring has been merely sporadic, with campaigns conducted since mid 1980´s. These screening campaigns have included also modern pesticides in use. More details and references are found in TemaNord 506, 2002.

The environmental monitoring has been almost solely carried out by Finnish Environment Institute SYKE and Regional Environment Centres. Screening studies have in most cases been funded by the Ministry of Environment. Along the implementation of the EU Water Framework Directive in Finland, discussion on the “polluter pays” principle extended to the agriculture has grown, but so far no direct obligations are in act.

A pesticide screening survey in Finnish surface waters was performed in 2005 to generate data for intelligent design of the compulsory monitoring programs under Water Framework Directive. The survey covered 40 streams and over 100 substances.

Because of the elevated pesticide concentrations in groundwater a project (2003–2006) was established by the environment authorities in co-operation with waterworks, the Road Administration, The Rail Administration, Ministry of Agriculture and Forestry, Ministry of Social Affairs and Health and some other stakeholders to study more broadly the occurrence of pesticides in Finnish groundwaters.

Based on the results of the screening studies in stream waters and in groundwater, a more permanent monitoring of pesticides will be established in Finland. Due to less intensive agricultural activities in Finland, monitoring will most likely not be as extensive as in Sweden and Denmark.

4.2 Extent of the programme

4.2.1 Precipitation

Bulk precipitation has been monitored during summer months from 1995. At present two stations are operative, one in southern Finland connected to the Integrated Monitoring network of CLRTAP Convention, the other in Pallas in northern Finland connected to Arctic monitoring and run parallel to Swedish monitoring by IVL at Pallas as well. The sampling device is a glass funnel bulk sampler (wet+dry) modified by the Danish National Environmental Research Institute, and the intercomparison of sampling methods for deposition measurements were made in a joint project under the Nordic Council of Ministers. Monthly samples are collected 6–7 times from Evo and 5–6 times from Pallas. Deposition at the site is estimated using daily precipitation measurements samples by Finnish Meteorological Institute, samples are summed for the collection time.

Monitored pesticides:

DDTs	trans-nonachlor	heptachlorepoxides
α-,β- and γ-HCH	dieldrin	A + β -endosulfan
HCB	endrin	endosulfansulphate
atrazine	isodrin	Mirex
chlordanes	heptachlor	toxaphene

The samples have been analysed with GC-MS with SIM technique and internal standard. The limit of quantification is 0.01 ngl^{-1} for each of these substances. The analysis will be shifted from Technical Research Centre of Finland to SYKE in 2006 including an intercalibration exercise. In this connection, the list of analyses will be revised.

4.2.2 Surface waters

Surface water monitoring of both banned and in-use pesticides has been merely sporadic, with campaigns conducted since mid 1980´s (Rekolainen et al. 1988, Hirvi & Rekolainen 1995). These screening campaigns have included also modern pesticides in use. More details and references are found in TemaNord 506, 2002. Recently there has been no continuous, national programme for water phase monitoring of persistent, classical pesticides nor modern in-use substances.

A pilot screening campaign in 2004 and a broader screening survey in Finnish surface waters in 2005 were performed to generate data for intelligent design of the compulsory monitoring programs under Water Framework Directive. The pesticide pilot study in 2004 was conducted in six small catchments and six large lowland rivers. One station had both automatic (hourly subsampling) and manual biweekly sampling. In the other stations sampling density was four weeks in May–October. Altogether 100 samples were analyzed (Siimes et al. 2005).

The broader survey in 2005 covered 40 streams situated mainly in the southern and western coast. Sites were chosen randomly from a watershed register. Watershed areas with field percentage over 25 were included in the selection framework and five areas with field percentage < 10 were used as a reference. The sites were sampled twice during summer 2005. Additionally, six major lowland rivers were sampled monthly in May–October.

Pesticides were analysed using gas and liquid chromatography. These multi-residue methods gave information of the concentrations of over 100 substances (see results in Tabel 1, Appendix 2). Tribenuron-methyl and the sum of ditiocarbamates were analysed from selected samples using specific methods.

4.2.3 Groundwater

In Finland the occurrence of pesticides in groundwater has not earlier been studied extensively. Few years ago some waterworks discovered increased concentrations of pesticides and their breakdown products in their raw-water monitoring. In drinking water pesticides and breakdown products are regularly monitored. Because of the elevated pesticide concentrations in groundwater a project was established by the environment authorities in co-operation with waterworks, the Road Administration, The Rail Administration, Ministry of Agriculture and Forestry, Ministry of Social Affairs and Health and some other stakeholders to study more broadly the occurrence of pesticides in Finnish groundwaters (Gustafsson 2004). During years 2002–2005 nearly 300 groundwater samples were collected from 190 formations covering southern and central Finland.

Pesticides were analysed using gas and liquid chromatography. These multi-residue methods gave information of the concentrations of over 100 substances, of which 14 were detected.

Detected pesticides in monitoring studies:

BAM	Simazine	Desethyl-terbutylazine
Atrazine	Bentazone	Dichlorprop
DEA	Mecoprop	Propazine
DEDIA	Terbutylazine	Bromazile
DIA	Hexazinone	

4.2.4 Aquatic biota

Environmental authorities in Finland have been monitoring organic pollutants in inland and coastal waters since the end of the 1970's. DDT and its metabolites in fish have been analysed in Northern pike (*Esox lucius*) and vendace (*Coregonus albula*) in inland waters and in Northern pike, Baltic herring (*Clupea harengus*) and Baltic mussel (*Macoma baltica*) in the coastal areas. Additional persistent chlorinated pesticides were included during the last ten years.

Monitored pesticides:

α-HCH	HCB	p,p'-DDT
β-HCH	α-chlordane	p,p'-DDE
γ-HCH	trans-nonachlor	p,p'-DDD

Monitoring frequency for each species varies in most cases between one and three years (Nakari et al. 2002). At present, 13 inland and seven coastal sites are sampled. Sediments will be included in the programme, starting with profiles from six sites in 2006 as well as sedimentation in two major rivers (two samples).

4.2.5 Humus and terrestrial biota

A program for monitoring of contaminants in terrestrial ecosystems was implemented in Finland in 1993. The aim has been to study and monitor atmospheric loads of contaminants and their concentration levels and effects in the food chains of the Boreal ecosystems.

Monitored pesticides:

α-HCH	HCB	p,p'-DDT
β-HCH	α-chlordane	p,p'-DDE
γ-HCH	trans-nonachlor	p,p'-DDD

After pilot studies by Hirvi (1997, 2000) common shrew (Sorex araneus) and moose (Alces alces) have been chosen as they are common in Finland and Northern Europe, easy to catch and represent important parts of the ecosystem. The species were collected in the reference (high land) areas, where the expected pollution is low and contaminants originate mainly from airborne sources. Liver is the target matrix for pesticide analysis. Also humus layer is sampled. Presently these three matrices will be sampled in rotation every three year. Sites are the same as for precipitation; Evo and Pallas (no moose).

There are no recent information on concentrations in wild biota of the following compounds (pesticides): aldrin, dieldrin, endrin, heptachlor, mirex and toxaphene.

4.2.6 Quality assurance

SYKE's laboratory is recognised as the national reference laboratory in the environmental field, and is fully accredited for analytical work as testing laboratory T003 by the Finnish Centre for Metrology and Accreditation. SYKE is responsible of the analysis of the persistent chlorinated compounds in biota (accreditated In-house method K320, solid/liquid extraction/GC-ECD). Pesticide screening analyses in ground- and surface waters 2002–2005 have been carried out by Lahti Science and business park Ltd Research Laboratory with accredited In-house methods (G09, GC/MSD, L01, LC/MSD). In further monitoring, the Ambiotica laboratory of the University of Jyväskylä will carry out the analysis of pesticides in use.

4.3 Data management and reporting

The Environmental Administration has collected, stored and used environmental data since the early 1970s, when the first data systems e.g. water quality and hydrological registers were introduced. The data has been stored in the Environmental Information System (HERTTA), which is administered by Environmental Administration (Finnish Environment Institute SYKE, Ministry of the Environment and Regional Environment Centres). Pesticide data from surface waters is first entered in LIMS system of the analytical laboratory and later stored in HERTTA. The information content of HERTTA is continuously being enlarged as new subsystems are completed, but at present it does not provide a subsystem for contaminants in sediments and biota. Therefore, this data is either stored in LIMS if analysis is performed in SYKE, or as spreadsheets if analysed elsewhere.

The HERTTA- data system consists of various subsystems, which include information on e.g. environmental loading, monitoring of water quantity and quality, environmental protection, biological diversity and land use. The system includes a Map Service, with a connection to Geographical Information Systems of the Environmental Administration. HERTTA was developed to be the basic tool for people, who need environmental information in their work. Its main purpose is to streamline the simultaneous use of environmental information gathered from various sources. All employees in the Environmental Administration have access to the system. HERTTA extranet service is open for municipalities, provinces and partners working in cooperation with the Environmental Authorities. Other customers can have access to HERTTA by ordering permission to use it from the customer service of the Finnish Environment Institute.

Publication of the monitoring results is infrequent except for aquatic biota every third year. In many cases the (raw) data is delivered for international assessments (EEA, HELCOM, AMAP) and published only infrequently in journals. Screening studies will be reported in SYKE and congress publications and further in scientific journals. Web pages are updated infrequently.

4.4 Economy

Costs running the programme is very difficult to estimate. Sampling is integrated to other monitoring activities (eutrophication, acidification, metals) in almost all cases. Persistent OCP substances are analysed along heavy metals and PCBs, PCDD/Fs. Analysis costs for screening 100 samples per year is 20–30 t€. Analysis cost for planned monitoring for 2006 incl. laboratory work is ca. 50 €. Monitoring and reporting of aquatic and terrestrial biota is run by ca. 4–5 person per year. Screening projects employ 1–2 persons per year.

Appendix 1.

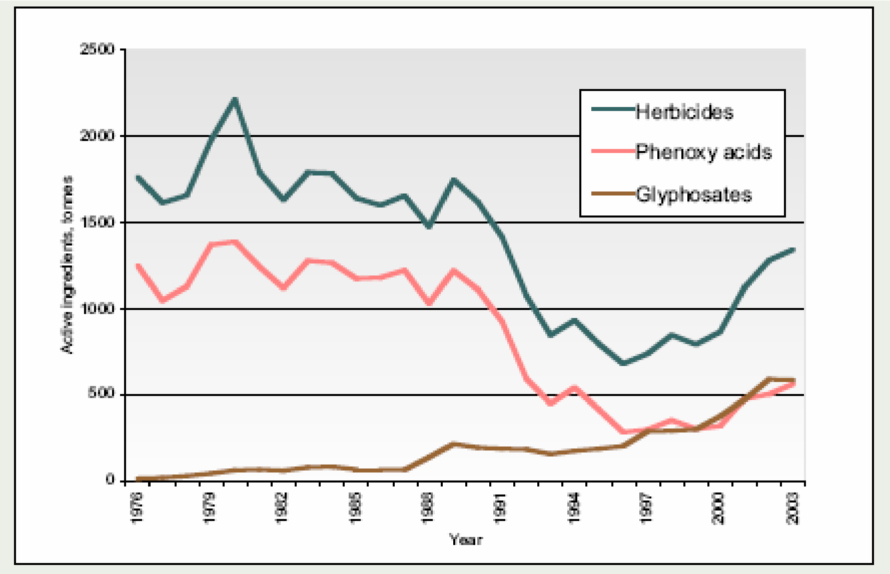

Figure 1. Pesticide sales in Finland.

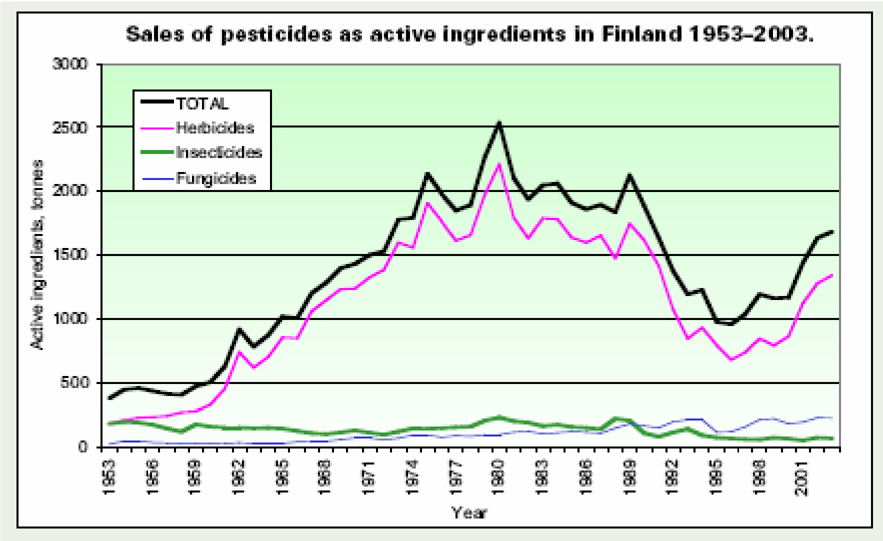

Figure 2. Herbicide sales in Finland.

Appendix 2.

Table 1. Summary of Finnish pesticide screening in surface waters in 2005: Detected 47 chemicals in deceasing order of detection percent. The column names are explained after the table

Substance	Use	In register	N	D	Q	Limit µg/l	Av µg/l	Max µg/l	EQS	Mac QS	Swe RV	Nor MF
MCPA	H	Yes	120	108	97	0.01	0.35	8.8!	1.6	15	10	13
dichlorprop	H	Yes	120	89	78	0.01	0.19	4.4			10	15
mecoprop	H	Yes	120	83	65	0.01	0.09	1.6			20	16
tralkoxydim	H	Yes	120	39	16	0.01	0.01	0.095				
bentazone	H	Yes	120	33	29	0.01	0.03	0.15			40	27
dimethoate	I	Yes	120	32	12	0.01	0.02	0.14	0.7		0.8	0.8
4-chlor-2-methylphenol	O	-	120	26	26	0.01	0.09	0.6				
metamitron-desamino	M	Parent	120	25	23	0.01	0.07	0.56				
simazine	H	2004	120	24	6	0.01	0.01	0.02	0.7			0.42
ethofumesate	H	Yes	120	23	15	0.02	0.06	0.31			30	
2,4-dichloro-phenol	O	-	120	20	10	0.05	0.09	0.64				
thifensulfuron-methyl	H	Yes	120	18	10	0.01	0.01	0.04!			0.01	0.05
tribenuron-methyl	H	Yes	46	6	5	0.01	0.03	0.075!	0.1	0.4	0.04	0.1
linuron	H	Yes	120	15	6	0.005	0.02	0.09				0.56
metamitron	H	Yes	120	12	12	0.01	0.08	0.26	32	170	1	
BAM	M	-	120	12	5	0.02	0.02	0.07				
atrazine	H	1991	120	12	4	0.005	0.00	0.007	0.6			0.43
azoxystrobin	F	Yes	120	11	9	0.005	0.01	0.03			0.9	0.9
terbutylazine	H	2004	120	10	6	0.005	0.01	0.01			0.02	0.02
dimethomorph	I	2003	120	10	4	0.01	0.03	0.12				
terbutylazine-desethyl	M	-	120	10	1	0.01	0.01	0.01				
fluroxypyr	H	2005	120	7	6	0.05	0.09	0.35			0.05 /100	19.9
terbutryne	H	2004	120	6	1	0.02	0.01	0.02				
flutolanil	F	2003	120	5	4	0.02	0.07	0.24				
2,4-D	H	Yes	120	5	2	0.01	0.01	0.02				2.2
diuron	H	Never	120	4	2	0.005	0.01	0.03	0.2			
triadimenol	F	Yes	120	3	3	0.1	0.23	0.39				
clopyralid	H	Yes	120	3	2	0.1	0.56	1.3			50	144
terbacil	H	2002	120	3	2	0.02	0.02	0.03				
bromacil	H	1986	120	3	0	0.01	0.01	0				
hexazinone	H	1999	120	2	2	0.02	0.04	0.05				
triflusulfuron-methyl	H	Yes	120	2	2	0.05	0.12	0.16				
picoxystrobin	F	Yes	120	2	1	0.02	0.02	0.02				
pirimicarb	I	Yes	120	2	1	0.02	0.02	0.02!			0.06	0.009
amidosulfuron	H	Yes	120	2	0	0.05	0.03	0			0.2	
DEA	M	-	120	2	0	0.02	0.01	0				
endosulfan-sulphate	M	-	120	1	1	0.02	0.02	0.02				
methabenz-thiazuron	H	Yes	120	1	1	0.005	0.03	0.03				
pyraclostrobin	F	Yes	120	1	1		0.02	0.02				
cyprodinil	F	Yes	120	1	1	0.01	0.01	0.01			0.2	0.18
DEDIA	M	-	120	1	0	0.1	0.05	0				
DIA	M	-	120	1	0	0.02	0.01	0				
isoproturon	H	Never	120	1	0	0.005	0.00	0	0.32			
carboxin	F	Yes	120	1	0	0.02	0.01	0			3	
napropamide	H	Yes	120	1	0	0.05	0.03	0				
omethoate	M	Parent	120	1	0	0.01	0.01	0				
trifluralin	H	Yes	120	1	0	0.02	0.01	0	0.03			

Use: H=herbicide, I=insecticide, F=fungicide, M=metabolite, O=other
In register: yes / the last year the chemical was in the Finnish pesticide register / parent, if the parent is in the register.
N: the number of samples. Parallel samples are handled here as one sample, which concentration is the mean of the samples.
D: the number of samples, where chemical was detected (for parallel samples even if detected in another)
Q: the number of samples, where concentration was above quantification limit (column: Limit µg/l).
Av: the average concentration for detected samples; half of quantification limit was used if detected but not quantified.
!: concentration has exceeded a Nordic reference value (the minimum of those given in the last four columns)
EQS: the EU environmental quality standard for annual mean concentration / Finnish national EQS (µg/l).
MACQS: EU / FIN value for the maximum acceptable concentration (µg/l).

Appendix 3. List of Publications

Fauser, P., Mogensen, B.B., Hirvi, J-P., Sigurdsson, A.S., Ludvigsen, G.H., Jacobsen, L.B., Westerberg, C. and Kreuger, J. 2002. Nordic Pesticide Monitoring Programs. Nordic Council of Ministers. TemaNord 2002:506. ISBN 92-893-0738-2. 56 p.

Gustafsson, J. 2004. Torjunta-aineiden esiintyminen pohjavedessä. Abstract: Occurence of pesticides in Finnish groundwater. In: Seppälä, J. & Idman, H. (Eds.). Maaperänsuojelu : Geologian tutkimuskeskuksen ja Suomen ympäristökeskuksen tutkimusseminaari 5.11.2004. Helsinki, Suomen ympäristökeskus. *Suomen ympäristö* 726, 77-81.

Henttonen, H., Hirvi, J-P., Gower, C.N. & Yoccoz, N. 2002. Contaminants in the common shrew (Sorex araneus) in northern Fennoscandia in relation to humus deposits. Extended abstract. Proceedings of the AMAP II Symposium held 1.-4. October, 2002 in Rovaniemi, Finland. http://www.amap.no/symposium2002/Posters-M01-M41.pdf

Hirvi, J-P. 1997. Bioindicators for monitoring of persistent contaminants in terrestrial ecosystems. The AMAP International Symposium on Environmental Pollution in the Arctic. p. 128-130. Extended Abstracts 432 pp. Tromsö, Norway June 1-5, 1997. Publication of the AMAP Secretariat, Oslo, Norway.

Hirvi, J.-P., 2000. Levels of POPs in two Boreal mammals (liver) and in precipitation in

the Evo region 1995 – 1998. Finnish Environment Institute database.

Hirvi, J.-P. 2004. Haitallisten aineiden esiintyminen metsämaan humuksessa. Abstract: Content of harmful substances in forest humus layer in Finland. In.: Seppälä, J. & Idman, H. (Eds.). Maaperänsuojelu : Geologian tutkimuskeskuksen ja Suomen ympäristökeskuksen tutkimusseminaari 5.11.2004. Helsinki, Suomen ympäristökeskus. Suomen ympäristö 726. p. 70-76.

Hirvi, J-P & Rekolainen, S. 1995. Pesticides in precipitation and surface water in Finland. In: Helweg, A. (Ed.). Pesticides in precipitation and surface water. Nordic seminar, Nov. 14-16th, 1994, Tune Landboskole, Denmark. TemaNord 1995:558. p. 12-18. Nordic Council of Ministers.

Korhonen, M., Kiviranta, A., Ketola, R., 1998. Bulk deposition of PAHs, PCBs and

HCHs in Finland in summer seasons 1993 - 1996. Toxicology and Environmental

Chemistry 66, 37 – 45.

Mannio, J., Suortti, A-M. & Örn, M. 2002. Mercury and organochlorine contaminants in freshwater fish in Lapland, Finland. Extended abstract. In: Proceedings of second AMAP International Symposium on Environmental Pollution of the Arctic. Rovaniemi, 1-4 October 2002. P-M38. http://www.amap.no/symposium2002/Posters-M01-M41.pdf

Nakari T., Suortti A-M. and Järvinen O. 2002. Contaminant monitoring in inland and coastal waters 1997-1999. Finnish Environment Institute, Report 271. ISBN 952-11-1323-5. 64 p.

Savela, M-L. & Hynninen, E-L. 2004, Slower growth of pesticide sales. Kemia-Kemi 31, 6:57-59.

Rekolainen, S., 1989. Occurrence of pesticides in drainage and surface water in Finland

– Results and present studies. Nordisk Planteværnskonference, pp. IX – X, Helsingør,

Denmark.

Siimes, K., Kalevi, K., Heinonen, J., Mannio, J**.** 2005. Pesticide screening in Finnish surface waters. In: Meriläinen, P., Sivula, L., Oikari, A. (eds.). *Seventh international conference of environmental sciences Jyväskylä, May 12-13, 2005.* Finnish Society for Environmental Sciences, University of Jyväskylä. P. 295-298. ISBN 951-39-2167-0.

5. Pesticide monitoring in Iceland

Albert S. Sigurðsson, Environment and Food Agency, Iceland

5.1 Introduction

In Iceland the monitoring of pesticides in the environment has been focused on several classical pesticides such as HCH, PCB etc. The main institutes involved are the Environment and Food Agency, the Marine Research Institute, the Department of Pharmacology and Toxicology of the University of Iceland, the Icelandic Meteorological Office, the Radiation Protection Institute, the Icelandic Fisheries Laboratories and several others are responsible for performing the programme and monitoring is funded by the Ministry of Environment.

5.2 Extent of the programme

Icelandic monitoring of chemicals in the environment has so far mainly focused on Icelands commitments to the OSPAR and AMAP programmes. Pesticides monitored are mainly classical pesticides (Table 1). The use of DDT, HCB, chlordane, dieldrin and PCB was very limited in the 1980s and the substances were banned in Iceland in 1996, except PCB which was banned in 1998. Water quality standards for DDT, HCB, HCH and several other substances were established 1994.

Table 1. The extent of monitoring of pesticides in Iceland

Media	Monitoring period	Substances
Marine biota (15 sampling locations per year, n=30/y)	Since 1992	HCH, HCB, PCB, chlordane, toxaphene and DDT
Air and precipitation (sampling in Westman Islands, n=24/y)	Since 1995	HCH, HCB, chlordane, dieldrin, toxaphene and DDT
Marine sediments (total 60 samples, various locations)	1992–1996	HCH, PCB, HCB and DDT
Birds (total 200 samples, various locations)	1979–2005	HCH, PCB, HCB, chlordane, toxaphene and DDT
Human milk (n=25, various locations)	1993	HCH, HCB and DDT
Human serum (n=3x40, total 120 samples, various locations)	1993, 1998, 2004	HCH, HCB, DDT, chlordane, toxaphene and PCB
Freshwater biota (Þingvallavatn-lake)	1996	HCH, PCB, HCB and DDT

Yearly sampling is done at various locations in the marine environment and at the Icelandic coast (Figure 1), except air and precipitation sampling which ranges from weekly to monthly samples. Nearly all samples are analysed at the Department of Pharmacology and Toxicology of the University of Iceland.

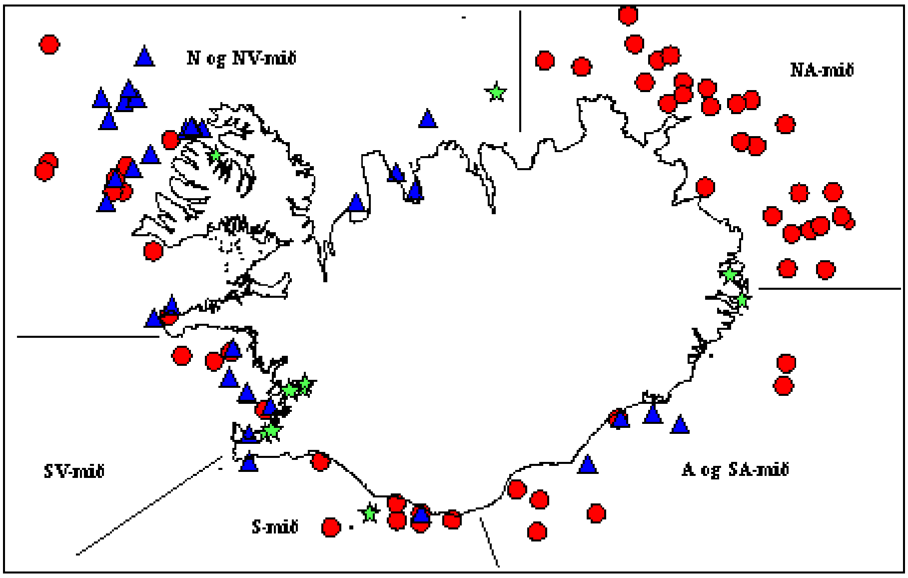

Figure 1. Locations of samples of marine biota, cod (circles), dab (triangles) and mussels (stars).

5.2.1 Future monitoring considerations

Currently, the Environmental and Food Agency is considering monitoring of Water Framework Directive (WFD) and OSPAR priority pesticide substances (Table 2) in groundwater and drinking water.

Table 2. Priority pesticide substances for future monitoring

CAS	Substance	Type	Framework
470-90-6	Chlorfenvinphos	Pesticide	WFD
465-73-6	Isodrin	Pesticide/Biocide	OSPAR
608-73-1	Hexachlorocyclohexane (HCH)	Pesticide	WFD
1912-24-9	Atrazine	Pesticide	WFD
2104-64-5	Ethyl O-(p-nitrophenyl) phenyl phosphonothionate (EPN)	Pesticide/Biocide	OSPAR
2227-13-6	Tetrasul	Pesticide/Biocide	OSPAR
2921-88-2	Chlorpyrifos	Pesticide	WFD
70124-77-5	Flucythrinate	Pesticide/Biocide	OSPAR

In Iceland we look forward to cooperate with the Nordic Environmental Pesticide Monitoring network and look forward to learn from those with established pesticides monitoring programmes.

5.3 Data management and reporting

The results are stored in databases at each institute. Marine data has been sent to the ICES databank (ices.dk). The most comprehensive overview of monitoring of chemicals in the environment in and around Iceland was published in 1999 (Egilson et.al. 1999). The Icelandic Fisheries Laboratories publishes yearly progress reports in English on the monitoring of the marine biosphere around Iceland (Yngvadottir et.al. 2002, Yngvadottir 2004 & Yngvadottir et.al. 2005).

5.4 Economy

A comprehensive overview of budgets for pesticide monitoring is not available. The Environment and Food Agency pays a yearly sum of 900,000 DKK for analysis of pesticides, heavy metals and other POPs in marine environments.

5.5 List of publications

Egilson, D., Ólafsdóttir, E.D., Yngvadóttir, E., Halldórsdóttir, H., Sigurðsson, F.H., Jónsson, G.S., Jensson, H., Gunnarsson, K., Þráinsson, S.A., Stefánsson, A.S., Indriðason, H.D., Hjartarson, H., Thorlacius, J., Ólafsdóttir, K., Gíslason, S.R., Svavarsson, J., 1999. Information on levels of contaminants in Icelandic waters, precipitation, lakes and biota. AMSUM, March 1999, Reykjavík. 138 pages.

Ólafsdóttir K., Petersen, Æ., Thórðardóttir S. and Jóhannesson T., 1995. Organochlorine residues in gyrfalcons (falco rusticolus) in Iceland. Bull. Environ. Contam. Toxicol. 55:382-389.

Ólafsdóttir K., Skírnisson K., Gylfadóttir G. and Jóhannesson T., 1998. Seasonal fluctuations of organochlorine levels in the common eider (*Somateria mollissima*) in Iceland. Environmental Pollution 103:153-158.

Ólafsdóttir K., Petersen Æ., Magnúsdóttir E.V., Björnsson T. and Jóhannesson T., 2001. Persistent organochlorine levels in six prey species of the gyrfalcon (*Falco rusticolus*) in Iceland. Environmental Pollution, 112: 245-251.

Ólafsdóttir K, Petersen Æ, Magnúsdóttir EV, Björnsson T , Jóhannesson T . (2005). Temporal trends of organochlorine contamination in Black Guillemots in Iceland from 1976-1996. Environmental Pollution 133: 509-515.

Yngvadóttir, Eva and Halldórsdóttir, Helga. Monitoring of the marine biosphere around Iceland in 1996 and 1997. Reykjavik 1998. http://www.rf.is/media/utgafa//Skyrsla_20-98.pdf

Yngvadóttir, Eva and Halldórsdóttir, Helga. Monitoring of the marine biosphere around Iceland in 1997 and 1998. Reykjavik 1999. http://www.rf.is/media/utgafa//Skyrsla_06-99.pdf

Yngvadóttir, Eva; Halldórsdóttir, Helga; Ragnarsdóttir, Þuríður and Árnadóttir, Elín. Monitoring of the marine biosphere around Iceland in 2000-2001. Reykjavik, 2002. http://www.rf.is/media/utgafa//Verkefnaskyrsla_13-02.pdf

Yngvadóttir, Eva. Monitoring of the marine biosphere around Iceland in 2002-2003. Reykjavik, 2004. http://www.rf.is/media/utgafa//SKYRSLA05-04.pdf

Yngvadóttir, Eva; Halldórsdóttir, Helga; Uusinoka, Taru and Ragnarsdóttir, Þuríður. Monitoring of the marine biosphere around Iceland in 2003-2004. Reykjavik, 2005. http://www.rf.is/media/utgafa//Skyrsla13-05.pdf

6. The Pesticides Agricultural Montoring Programme (JOVA) in Norway

Gro Hege Ludvigsen, Bioforsk, Norway

6.1 Introduction

The Agricultural Environmental Monitoring Programme (JOVA) in Norway is founded by the Norwegian Agricultural Authority. The program is headed by "Bioforsk": Norwegian Institute for Agricultural and Environmental Research, Soil and Environment Division. The program also involves other research and governmental institutions locally responsible for some of the monitoring stations.

Aim of the program:

To document:

- the occurrence of pesticides in water and changes with time,
- to clarify the connection between the use on farmland and detection of pesticides in the catchments,
- the characteristics of the pesticides under Norwegian soil- and climatic conditions,
- if the approved regulations on the use of the pesticides have the expected effects.

To generate:

- knowledge on the most important pathways for pesticide transport and other factors (soil, climate, agronomics) in the catchment that are important,
- data that can be used for modelling pesticide leaching from agriculture and risk assessment of agricultural practise.

6.2 Extent of the programme

The Agricultural Environmental Monitoring Programme (JOVA) in Norway monitors and assesses pesticide losses from agricultural use. The JOVA-program also monitors nutrients (including nitrate) and erosion in streams and small catchments.

6.2.1 Locations

The pesticide monitoring program was started in 1995, but two of the locations have been monitored since 1990–1991. The basis for the monitoring programme is six rather small catchments that have continuous discharge measurements and water proportional sampling. These catchments vary in size from 70 to 680 hectares and the total number of farms varies from 5 to 30. The farmers keep records of all their farming operations including pesticide use and run their farms without any particular consultation or restrictions on farming practice. Two locations have water proportional sampling but no detailed collection of farming practice. In the other streams and rivers water sampling is done by grab samples. Catchment size varies from 20 till 230 km^2. Totally twelve locations have been monitored. Duration of year of sampling varies (Table 1).

In addition to monitor streams and rivers, the JOVA-program has monitored pesticides in drainage water (4 locations), groundwater (30 locations), sediments (6 locations) and precipitation (6 locations) for a limited number of years. Monitoring of some of the ground water locations started more than ten years ago and is still preformed. Duration and sampling strategies of these investigations differ from location to location.

Table 1. Characteristics of the catchments in the monitored streams and rivers

Cathments	Municipal	Area (km^2)	Crop area (%)	Temp (°C)	Precipitation (mm)	Soil type	Main Crop	Year sampling
Vasshaglona[1, 2, 4]	Grimstad	0,7	62	6,9	1230	sand and loam	vegetables, potatoes and grain	1995–2005
Skuterud[1, 2, 4]	Ås	4,5	61	5,5	785	silty clay	grain	1995–2005
Heia[2,3]	Råde	4,7	72	5,6	829	sand, silt and clay	vegetables, pota-toes and grain	1991–2005
Mørdre[1, 2, 4]	Nes	6,8	65	4,3	665	clay and silt	grain	1996–2005
Hotran[1, 4]	Levanger	19,4	80	5,3	892	silt, loam and clay	grain and gras	1995–2004
Skas-Heigre[1, 4]	Sandnes, Sola og Klepp	29,3	85	7,7	1180	clay, sand and gravel	gras and grain	1990–97, 99 2001–2005
Lier Kjellstad (Elverhøy)	Lier, Mo-dum, Asker, ,Dram.	303	14	5,2	940	clay and silt	vegetables, grain +	1997–1999 2001–2005
Hobøl	Oslo, Hobøl Ski, Ene-bakk	331	19	5,6	829	clay and silt	grain +	1997–1999 2001–2005
Time[1, 2, 4]	Time	1,1	85	7,4	1154	Silt and sand	gras	1995–2000, 2004–2005
Kolstad[1, 2, 4]	Ringsaker	3,1	68	4,2	585	clay or-ganic	grain	1995–2003
Finsal	Hamar	22,0	35	4,2	585	clay or-ganic	grain +	1995–1998
Storelva Klopp	Ree	147,3	42	6,0	1035	clay and silt	grain +	1995–1998

1 Discharge measurements and water proportional sampling

2 Information on use of pesticides, (chemical compound, quantity, date of use etc.)

3 Discharge measurements and water proportional sampling from the year 2004

4 Monitored for nutrients

6.2.2.Runoff measurement

Samples in streams and rivers are taken every 14th day from the month March or April (when the snow melts) to the end of December when frost appears. Some samples have also been taken during the winter months, specially the years when it has not been permanent frost in the soil. In some locations the terminations of the sampling seasons have been in October/November. The number of samples taken every year in one location varies from twelve to twenty. Within a location the numbers of samples taken every year are rather stable. From 2004 water proportional sampling has been restricted to run from May to the end of October. Additional grab samples have been taken during heavy rainfall all year. Information on the pesticides used in the six catchments is collected once every year. Information on the sampling strategies is given in column 1 in

Table 1. If nothing special is indicated, grab samples were taken every 14 days.

6.2.3 Chemical analyses

Determination of pesticide residues in water is mainly performed by gas chromatography with selective detectors after extraction with organic solvents – GC multimethod. In addition, some of the more polar herbicides like the phenoxy-acids require a derivatisation step before the chromatographic analysis – GC/MS multimethod. The compounds most commonly used are included. The number of substances analysed and the detection limits have been improved during the monitoring period. In 1995 only 27 substances where analysed and every year the number of pesticides analysed have increased, 53 pesticides was included in multimethods in 2004 (Table 2). In addition to the mother compounds, the multimethods included a limited number of metabolites. Detection limits and the number of pesticides analysed is given in Appendix 2. Most analyses are performed by the Bioforsk Lab (former called "Planteforsk pesticide laboratorie"). Some analyses are also performed by other labs (second part of Appendix 2).

Table 2. Number of pesticides (mother compounds) analysed every year.

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average
Number	27	31	36	40	45	47	47	48	52	53	43

In Norway 115 active ingredients are approved (2004). The multimethods analyses cover 36 of these pesticides (Appendix 2). Ten pesticides have been taken off the marked during the monitoring period. Seven of the pesticides analysed with multi-methods have been obsolete in Norway for many years. Additional analyses have been done for nine important compounds requiring special analyses.

Sales of pesticides in Norway have declined since the registration of use started in 1980. In 2004, 850 tons of pesticides were sold (Figure 1). Sales of different pesticides are given in Table 3 and Appendix 3.

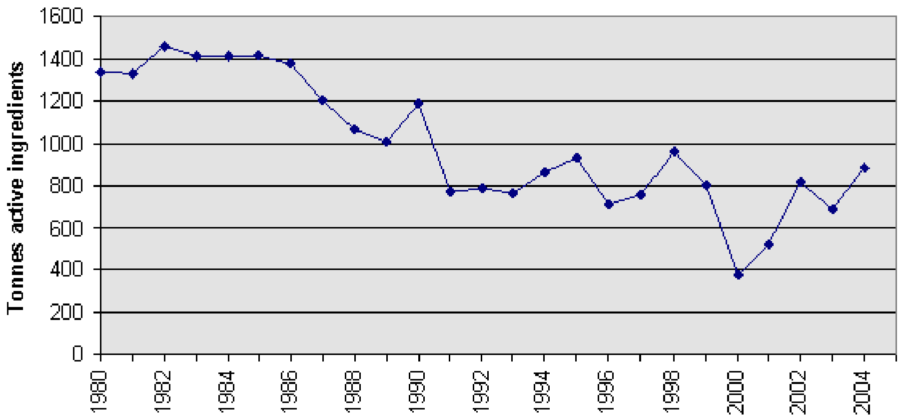

Figure 1. Development of sales of pesticides in Norway.

Table 3. Sales of different pesticides in Norway, given in tonnes of active ingredient averaged for 2000–2004

Sails	Herbicides	Fungicides	Insecticides	Others	Sum
Professionals	452	144	11	49	655
Hobby	99	0,4	0,9	0	100
Sum total	551	144	12	49	755

6.3 Data management and reporting

Data is collected by online monitoring and stored in the JOVA-database. Reports on the results are given every year or every second years. A report on detection of each individual pesticide is given to the Norwegian Food Safety Authority whenever a pesticide is evaluated for approval (normally every 5th year).

6.4 Economy

The whole JOVA-program, including pesticides and nutrients, had in 2005 a budget of about 620,000 €. In the year 2000 it was as high as 1 mill €. It is difficult to define the costs separately for pesticides. A rough estimate would be 250,000 € on the pesticides if all the water measurements and collection of information on farming practice to be for pesticides only. Cost for the analyses of pesticides solo is now about 70,000 € a year, cost for organizing, reporting and data-analysing is about 75,000 € a year. Field work, running of monitoring stations and sampling of primary data would cost roughly 100,000 € a year.

Appendix 1. List of publications

JOVA – Pesticides publications in English

Ludvigsen, G.H. & O. Lode, 2004. Fungicides in stream waters and rivers within agricultural catchments in Norway. Proceedings of the 3rd European Conference on pesticides and related organic micropollutants in the environment p 219-224.

Ludvigsen, G.H., O. Lode and R. Skjevdal, 2003. Retrieval of glyphosate and AMPA in Norwegian streams. Including studies on leaching during heavy rainfall. Proceedings of the XII Symposium Pesticide Chemistry 2003: 875-885.

Ludvigsen, G.H. and O. Lode, 2002. Trends of pesticides in Norwegian streams and rivers (1996-2000). Intern. J. Environ. Anal. Chem. 82:8-9, 632-643.

Ludvigsen, G.H. og O. Lode, 2001. Results from "JOVÅ"- The agricultural and environmental monitoring programme of pesticides in Norway 1995-1999. Fresenius Environmental Bulletin 10.no 5: 470-474.

JOVA – Pesticides reports in Norwegian

Ludvigsen, G.H. og O. Lode, 2005. Oversikt over påviste pesticider i perioden 1995-2004. Resultater fra JOVA: Jord- og vannovervåking i landbruket i Norge. Jordforsk-rapport 102/05.

Ludvigsen, G.H. og O. Lode, 2005. Tap av pesticider fra jordbruksareal - utvikling over tid. Resultater fra Jord- og vannovervåking i landbruket. Jordforsk-rapport 97/05.

Ludvigsen, G.H. og O. Lode, 2004. Oversikt over påviste pesticider i perioden 1995-2002. Resultater fra Jord- og vannovervåking i landbruket i Norge. Jordforsk-rapport 17/04.

Ludvigsen, G.H., 2003. Tap av pesticider fra jordbruksareal. Resultater fra Jord- og vannovervåking i landbruket 2002. Jordforsk-rapport 104/03.

Ludvigsen, G.H., T. Källqvist og Ø. Løvstad, 2002. Jordsmonnovervåking i Norge. Overvåking av fastsittende alger i bekker 1999-2000. Sammenheng mellom alger og pesticider. Jordforsk-rapport 16/02.

Ludvigsen, G.H. og O. Lode, 2002. Jordsmonnovervåking i Norge. Pesticider 2000. Jordforsk-rapport 6/02.

Ludvigsen, G.H. og O. Lode, 2002. Jordsmonnovervåking i Norge. Pesticider 2001. Jordforsk-rapport 82/02.

Ludvigsen, G.H. og O. Lode, 2001. Jordsmonnsovervåking i Norge. Pesticider 1999. Jordforsk-rapport 22/01.

Ludvigsen, G.H., 2000. Overvåking av fastsittende alger i bekker påvirket av plantevernmidler i 1999. Jordforsk-rapport 113/00.

Bechmann, M., G.H. Ludvigsen and O. Lode., 1999. Glyphosate and AMPA in Agriculturale Runoff. Jordforsk-rapport 69/99.

Bechmann, M., G.H. Ludvigsen og O. Lode., 1999. Glyfosat og AMPA i avrenning fra jordbruk. Jordforsk-rapport 32/99.

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Appendix 2.

Pesticid	Group	Approved in Norge Ψ	Detection limits Φ	Method
Aklonifen	Ugrasmiddel	Yes	0,02 µg/L	GC-MULTI M60
Aldrin *	Insektmiddel	No	0,02 „	„
Alfacypermetrin	Insektmiddel	Yes	0,05 „	„
Atrazin	Ugrasmiddel	No	0,02 „	„
Atrazin-desetyl *	Metabolitt	”	0,02 „	„
Atrazin-desisopropyl	Metabolitt	”	0,02 „	„
Azinfosmetyl	Insektmiddel	Yes	0,05 „	„
Azoksystrobin *	Soppmiddel	Yes	0,05 „	„
Cyprodinil	Soppmiddel	Yes	0,02 „	„
Cyprokonazol	Soppmiddel	Yes	0,02 „	„
DDD- o,p’ *	Metabolitt	No	0,02 „	„
DDD- p,p’	Metabolitt	”	0,02 „	„
DDE- o,p’ *	Metabolitt	”	0,02 „	„
DDE- p,p’	Metabolitt	”	0,02 „	„
DDT- o,p’	Insektmiddel	”	0,02 „	„
DDT- p,p’	Insektmiddel	”	0,02 „	„
Diazinon	Insektmiddel	Yes	0,02 „	„
2,6-diklorbenzamid (BAM)#	Metabolitt	No →2000	0,02 „	„
Dieldrin	Insektmiddel	No	0,02 „	„
Dimetoat	Insektmiddel	Yes	0,02 „	„
Endosulfan sulfat	Metabolitt	No	0,02 „	„
Endosulfan-alfa	Insektmiddel	”	0,02 „	„
Endosulfan-beta	Insektmiddel	”	0,02 „	„
Esfenvalerat	Insektmiddel	Yes	0,05 „	„
Fenitrotion	Insektmiddel	No →1997	0,02 „	„
Fenpropimorf	Soppmiddel	Yes	0,02 „	„
Fenvalerat	Insektmiddel	No →1997	0,05 „	„
Fluazinam	Soppmiddel	Yes	0,02 „	„
Heptaklor	Insektmiddel	No	0,02 „	„
Heptaklor epoksid	Metabolitt	”	0,02 „	„
Iprodion	Soppmiddel	Yes	0,02 „	„
Isoproturon	Ugrasmiddel	Yes/No →2005	0,02 „	„
Klorfenvinfos	Insektmiddel	Yes/No →2004 [β]	0,02 „	„
Klorprofam	Ugrasmiddel	No →2002	0,05 „	„
Lambdacyhalotrin	Insektmiddel	Yes	0,05 „	„
Lindan	Insektmiddel	No	0,02 „	„
Linuron	Ugrasmiddel	Yes	0,05 „	„
Metalaksyl	Soppmiddel	Yes	0,05 „	„

β not approved after 2004, but dispensation (essential use to 2007)

Pesticid	Group	Approved in Norge Ψ	Detection limits Φ	Method
Metamitron *	Ugrasmiddel	Yes	0,05 "	" GC-MULTIM60
Metribuzin	Ugrasmiddel	Yes	0,02 "	"
Penkonazol	Soppmiddel	Yes	0,02 "	"
Permetrin	Insektmiddel	Yes	0,05 "	"
Pirimikarb	Insektmiddel	Yes	0,02 "	"
Prokloraz	Soppmiddel	Yes	0,05 "	"
Propaklor	Ugrasmiddel	Yes	0,02 "	"
Propikonazol	Soppmiddel	Yes	0,05 "	"
Pyrimetanil	Soppmiddel	Yes	0,02 "	"
Simazin	Ugrasmiddel	No →1997	0,02 "	"
Tebukonazol	Soppmiddel	No →1998	0,05 "	"
Terbutylazin	Ugrasmiddel	No →1998	0,02 "	"
Tiabendazol	Soppmiddel	Yes	0,05 "	"
Vinklozolin	Soppmiddel	No →1998	0,02 "	"
				GC/MS-MULTI M15
Bentazon	Ugrasmiddel	Yes	0,02 "	"
2,4-D	Ugrasmiddel	No →1999	0,02 "	"
Dikamba	Ugrasmiddel	Yes	0,02 "	"
Diklorprop	Ugrasmiddel	Yes	0,02 "	"
Flamprop	Ugrasmiddel	Yes	0,1 "	"
Fluroksypyr	Ugrasmiddel	Yes	0,1 "	"
Klopyralid	Ugrasmiddel	Yes	0,1 "	"
Kresoksim	Metabolitt	Yes	0,05 "	"
MCPA	Ugrasmiddel	Yes	0,02 "	"
Mekoprop	Ugrasmiddel	Yes	0,02 "	"
Ioksynil analysed only in 1997-1999	Ugrasmiddel	Yes	0,2	

* Pesticidene aldrin, atrazin-desetyl, azoksystrobin, DDD – o,p', DDE – o,p', og metamitron are not accredated pr. 10.02.2004.
# 2,6-diklorbenzamid (BAM) is not accredited for detections <0,05 µg/L.
Φ Detection limits might be higher in polluted water.
Method M60 replaces former method M03
Ψ Last year of use is indicated if approval has been withdrawn the years 1995–2004.
Ugrasmiddel=Herbicide, Insektsmiddel=Insecticide, Soppmiddel=Fungicide, Metabolitt=Metabolite

Additional analyses preformed on a limited number of samples (not included in the table above):

Planteforsk Pesticidlaboratoriet:
- isoproturon, detection limit 0,01 µg/l,
- (isoproturon are in multimethods from the year 2004.)
- klormekvat, detection limit 0,05 µg/l.
- glyfosat + AMPA, from 2002 detection limit 0,01 µg/l.

Sveriges Landbruksuniversitet, Institusjon for Organisk Miljøkemi:
- tribenuron-metyl, detection limit 0,02 µg/l (1997).
- ETU (metabolite of mankozeb, detection limit 0,05 µg/l (1995–1996).

Miljø Kjemi / Eurofins, Danmark/:

- glyfosat + AMPA detection limit 0,01 μg/l (1997–2001).
- ETU (metabolite of mankozeb, detection limit 0,01 μg/l (1998).
- tribenuron-metyl, detection limit 0,03 μg/l (1999).
- tribenuron-metyl, detection limit 0,01 μg/l (2000–2001).
- tribenuron-metyl, detection limit 0,02 μg/l (2002).
- triazinamin-metyl (metabolite of tribenuron-metyl, detection limit 0,02 μg/l (2002).
- klorsulfuron, detection limit 0,01 μg/l (2000–2001).
- triasulfuron, detection limit 0,01μg/l (2000–2001).
- tifensulfuron-metyl, detection limit 0,01 μg/l (2000–2001).
- metsulfuron-metyl, detection limit 0,01 μg/l (2000–2001).

7. Environmental Monitoring of Pesticides in Sweden

Stina Adielsson & Jenny Kreuger, Swedish University of Agricultural Sciences, Sweden

7.1 Introduction

Environmental monitoring of pesticides in Sweden started during the mid-80's as short term, research based, investigations of possible occurrence of pesticides in streams and rivers. Long-term, systematic monitoring of different compartments of the aquatic environment has gradually evolved and today it includes several monitoring sites with sampling in different matrixes such as surface water, ground water, sediments and precipitation. The Swedish Environmental Protection Agency (Swedish EPA) is the authority responsible for all the Swedish environmental monitoring programmes. The pesticide monitoring programme is performed by the Division of Water Quality Management, in collaboration with the Section of Organic Environmental Chemistry, at the Swedish University of Agricultural Sciences (SLU).

The monitoring programme, including sampling of surface water, groundwater and sediments, aims to quantify and follow variations of pesticides in time and space, both regarding concentrations and transported amounts (http://www.naturvardsverket.se/, select Miljöövervakning, Jordbruksmark, Handbok för miljöövervakning, Bekämpningsmedel typområden). Sampling is concentrated to catchments dominated by agriculture and two rivers in agricultural areas. Pesticide occurrence in surface water is related to the used amounts in the catchments. A long-term intention is to follow alterations in occurrence of pesticides in the environment as a result of changes in regulation, politics and educational efforts. Moreover the monitoring programme as a whole intends to follow long-term trends and to use the results in evaluation of the Environmental Quality Objectives set up by the Swedish Government (http://www.internat.naturvardsverket.se/).

Pesticides are also measured in precipitation to get an overview of potentially harmful substances deposited over the south of Sweden. The programme forms a basis to estimate long-range transport of pesticides in the atmosphere.

There is also a 'general pesticide database' available, including data from all investigations of pesticide occurrence in the aquatic environment performed in Sweden. The database forms a basis to get a nationwide picture of pesticides detected, or not detected, in the Swedish environment based on investigations performed by local and regional authorities, e.g. the national county boards, waterworks and water conservation associations. The work is administrated by the Division of Water Quality Management at SLU and funded by the Swedish EPA. Overall results from the database are published in reports and also available on the internet (via the web page of http://vv.mv.slu.se/bekampningsmedel).

7.2 Extent of the programme

The geographical distribution of the pesticide monitoring programme can be seen in Figure 1. The programme includes four intensive study areas (M42, N34, O18 and E21), two rivers (Vege å and Skivarpsån) and one site for precipitation sampling (Vavihill). *The intensive study areas* are catchments (800–1600 ha) dominated by agriculture and represent four different regions with varying climate, soil and cropping systems. *Surface water* is sampled in the rivers draining the catchments. Samples are taken as weekly time-integrated samples, collected with automatic ISCO-samplers. Details on sampling and analysed substances can be seen in Table 1 and Appendix 1. Area M 42 has a longer sampling season than the other three areas due to its location in the very south of Sweden with a longer cropping season. *Groundwater* samples are taken four times per year from two sites within each catchment. One site is in a recharge area and one in a discharge area and at each site permanent groundwater tubes are installed at two depths. *Sediment* samples are collected manually once a year to get a picture of the amounts of pesticides that might deposit in the top layer of the bottom sediment.

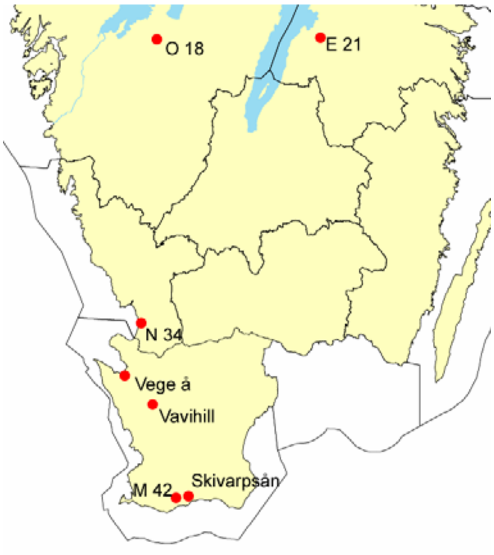

Figure 1. Location of sampling sites within the Swedish pesticide monitoring programme.

Farmers in the intensive study areas are interviewed each year to gather information on cropping and when, where, how much and what pesticide substance they have been using on each field during the year. Stream flow is measured continuously in the streams to allow calculations of transported amounts. Data on the precipitation in the areas are collected from precipitation stations handled by SMHI (the Swedish Meteorological and Hydrological Institute). The intensive study areas are also subject to studies on nutrient losses to water.

Table 1. The different elements of the Swedish pesticide monitoring programme in 2004. Numbers are given for each sampling site, weather conditions decide the exact number of samples

Description	Water source	Sampling season	Number of samples per season	Number of analysed substances
Intensive study area M42	surface water	May-Dec	29	83
	groundwater	Apr, Aug, Nov	16	74
	sediments	late summer	1	52
Intensive study areas N34, O18 and E21	surface water	May-Oct	19-21	83
	groundwater	Apr, Aug, Nov	16	74
	sediments	late summer	1	52
River Skivarpsån and Vege å	surface water	May-Nov	9	74
	sediments	late summer	1	52
Precipitation (Vavihill)	rainwater	May-Sep	12	85

The two *rivers* (90–500 km^2) are located in the very south of Sweden, in areas dominated by agricultural production. *Surface water* is sampled manually giving momentary samples, twice a month during May–June and once a month during July–November. *Sediment* samples are taken once a year in each river following the same procedure as in the intensive study areas. Flow measurements are collected from permanent gauging stations handled by SMHI.

Rainwater for pesticide analysis is collected at Vavihill, a rural background site in a forested area in the county of Skåne (Figure 1). A 0,5m^2 funnel made of polished stainless steal is used to collect the rainwater (bulk deposition), from the funnel the water runs into a glass bottle located in a refrigerator underneath the funnel. Sampling is event-related with samples being collected after a minimum of 5–10 mm of rain and with no longer than 14 days between onset of rainfall and the sampling occasion.

7.2.1 Analysis

The number of substances included in the analytical procedure varies between 52 and 85 in the different matrices (Table 1). Pesticides are selected to be included in the analysis based on different aspects, e.g. national sales statistics, use within the monitoring catchments (information from farmer interviews), inclusion in the Annex 10 of the Water Framework Directive (WFD), data from registration procedure implies that the compound is leachable and/or have a low Water Quality Standard (WQS) and persistence (i.e. still detected in the aquatic environment although no longer used).

In Appendix 1 information is given on pesticides analysed in 2004, including information on sales figures for each pesticide during the same year or when the compound was banned. During 2005 a few additional substances have been added, such as cyprodinil, fenitrothion, florasulam, imidacloprid and iodosulfuron-methyl. All pesticide analyses since the start of the screening and monitoring programmes have been performed at the Section of Organic Environmental Chemistry, Department of Environmental Assessment, SLU. The laboratory is accredited by SWEDAC since 1994 and participates regularly in Nordic intercalibrations.

7.2.2. History

In 1998 measurements of pesticides were included in the screening programme run by the Swedish EPA, with occasional sampling of a number of rivers and a few lakes during a two year period. Previous monitoring of pesticides in the aquatic environment had been performed within one small agricultural catchment, since 1990, with funding from several different sources, mainly research and regional authorities. Since 2000 this site was funded by the Swedish EPA's National Monitoring Programme and later included into the current monitoring programme as one of the intensive study areas (Skåne, M42). As a precursor for setting up a national pesticide monitoring programme, screening was performed during 2001 with nine catchments being investigated, as well as two rivers, urban storm run-off water, urban sewage water and sediments. The current national monitoring programme for agricultural areas, as described above, was launched in 2002 and includes both nutrients and pesticides and is funded by the Swedish EPA. Monitoring of pesticides in deposition (rain water) started in 2002 and is since 2003 a part of the national monitoring programme for air.

7.2.3 Quality assurance procedures

To maintain a high quality throughout the program efforts are made to have, as far as possible, properly trained personnel responsible for different aspects of monitoring performance, e.g. collecting samples, handling equipment, interviewing the farmers, performing analysis, database management and overall responsibility for the programme. As far as possible, efforts are made to keep field staff (especially those doing the farmer interviews) and other key persons unchanged bringing continuity and experience to the programme. Sampling of groundwater is especially sensitive to contamination and therefore one person (from the Geological Survey of Sweden), with special training, is doing all the groundwater sampling. The whole procedure of monitoring is carefully documented. All the analysis are performed by an accredited laboratory and the results are reviewed both by the personal at the laboratory and by persons in charge of the monitoring programme before accepted, if results are deviant they are reanalysed. Blank samples are also taken to evaluate the sampling quality.

7.3 Data management and reporting

A database in Access environment is used to store the data. From this kind of database it is easy to draw data for different purposes, it can also be used to perform calculations. Another advantage is that all kinds of data can be stored together to keep all the available information in one place. Information is also kept on paper as a safety measure. Calculations on transported amounts (from concentrations and stream flow) are made for the intensive study areas on a seasonal basis. Transported amounts are also compared to applied amounts of pesticides in the catchment, resulting in calculations of loss rates, i.e. transported amounts leaving the catchment in percent of applied amount.

Trends and changes in patterns are identified and published in yearly reports to the Swedish EPA. The reports are publicly accessible and easily available at the web page of the Division of Water Quality Management, SLU (http://vv.mv.slu.se/bekampningsmedel). In Appendix 2 there is a list of publications, including different reports and articles. Some basic information on the monitoring programme is also presented on the web page mentioned above and there are far-reaching plans to improve information at this site.

7.4 Economy

The total budget for monitoring pesticides within the Swedish National Environmental Monitoring Programme was ca € 345,000 in 2005. Approximately 20% is spent on sampling, collecting field data and information on pesticide use from the farmers, ca 50% is spent on pesticide analysis and 30% on quality assurance, data storage, project management and reporting.

Appendix 1.

Substances analysed in 2004 divided on different matrixes, analytical method, limit of detection, national sails figures and year of banning. Metabolites and bi-products are presented under their mother substance

Substances	Analytical method OMK	Limit of detection (µg/l)	Rivers of intensive study	Ground water	Rivers in Skåne	Precipitation	Sediments	Sales 2004 (tons)	Banned (year)
aklonifen (H)	51:5	0,01	X	X	X	X	X	18,2	
alaklor (H)	51:5	0,01	X	X	X	X	X	-	1978
aldrin (I)	51:5	0,003				X		-	1970
alfacypermetrin (I)	51:5	0,01	X	X	X	X	X	1,6	
amidosulfuron (H)	49:6	0,01	X					0,9	
atrazin (H)	51:5	0,005	X	X	X	X	X	-	1989
DEA (N)	51:5	0,006	X	X	X	X		-	
DIPA (N)	51:5	0,02	X	X	X	X		-	
azoxystrobin (F)	51:5	0,02	X	X	X	X	X	11,6	
benazolin (H)	50:8	0,005	X	X	X	X		-	2003
bentazon (H)	50:8	0,005	X	X	X	X		16,5	
betacyflutrin (I)	51:5	0,02	X	X	X		X	1,7	
bitertanol (F)	51:5	0,02	X	X	X	X	X	5,3	
cinidonetyl (H)	51:5	0,02	X	X	X	X		0,1	
cyanazin (H)	51:5	0,01	X	X	X	X		2,3	
cyflutrin (I)	51:5	0,02	X	X	X	X	X	<0,1	

Substances	Analytical method OMK	Limit of detection (µg/l)	Rivers of intensive study	Ground water	Rivers in Skåne	Precipitation	Sediments	Sales 2004 (tons)	Banned (year)
cypermetrin (I)	51:5	0,02	X	X	X	X	X	1,9	
cyprodinil (F)	54:1						X	18,9	
2,4-D (H)	50:8	0,005	X	X	X	X		-	1990
DDT-p,p (I)	51:5	0,002				X	X	-	1975
DDD-p,p (B, N)	51:5	0,001				X	X	-	
DDE-p,p (N)	51:5	0,001				X	X	-	
DDT-o,p (B)	51:5	0,001				X	X	-	
deltametrin (I)	51:5	0,01	X	X	X	X	X	0,6	
diflufenikan (H)	51:5	0,003	X	X	X	X	X	8,8	
dikamba (H)	50:8	0,005	X	X	X	X		1,5	
diklobenil (H)	51:5	0,002				X		-	1990
BAM (N)	51:5	0,008	X	X	X	X		-	
diklorprop (H)	50:8	0,005	X	X	X	X		6,1	
dikofol (I)	51:5	0,01				X		-	1990
dimetoat (I)	51.5	0,02	X	X	X	X		3,4	
diuron (H)	51:5	0,008	X	X	X	X	X	-	1992
α-endosulfan (I)	51:5	0,005	X	X	X	X	X	-	1995
β-endosulfan (I)	51:5	0,006	X	X	X	X	X	-	1995
endosulfansulfat (N)	51:5	0,01	X	X	X	X	X	-	
esfenvalerat (I)	51:5	0,01	X	X	X	X	X	2,3	
etofumesat (H)	51:5	0,006	X	X	X	X	X	5,2	
fenmedifam (H)	51:5	0,05	X	X	X	X	X	14,4	
fenoxaprop-P (H)	50:8	0,01	X	X	X	X		3,1	
fenpropimorf (F)	51:5	0,005	X	X	X	X	X	45,3	
flamprop (H)	50:8	0,005	X	X	X	X		-	2002
flupyrsulfuron-metyl(H)	49:6	0,01	X					0,1	
fluroxipyr (H)	50:8	0,01	X	X	X	X		31,6	
flurtamon (H)	51:5	0,02	X	X	X	X		0,1	
glyfosat (H)	53:0	0,02	X	X	X		X	255,2	
AMPA (N)	53:0	0,1	X	X	X			-	
heptaklor (I)	51:5	0,002				X		-	#
heptaklorepoxid (N)	51:5	0,004				X		-	
hexaklorbensen (F, B)	51:5	0,0002				X	X	-	1980
hexazinon (H)	51:5	0,01	X	X	X	X		-	1994
imazalil (F)	51:5	0,03	X	X	X	X	X	2,3	
iprodion (F)	51:5	0,01	X	X	X	X	X	6,7	
isoproturon (H)	51:5	0,006	X	X	X	X	X	61	
karbosulfan (I)	51:5	0,01	X	X	X	X	X	0,1	
karbofuran (I, N)	51:5	0,01	X	X	X	X	X	-	
karfentrazonetyl (H)	51:5	0,01	X	X	X	X		0,2	
klopyralid (H)	50:8	0,01	X	X	X	X		7,9	

Substances	Analytical method OMK	Limit of detection (µg/l)	Rivers of intensive study	Ground water	Rivers in Skåne	Precipitation	Sediments	Sales 2004 (tons)	Banned (year)
klordan-γ (I)	51:5	0,0002				X		-	1969
klorfenvinfos (I)	51:5	0,005	X	X	X	X	X	0,1	
kloridazon (H)	51:5	0,02	X	X	X	X		13,4	
klorpyrifos (I)	51:5	0,005	X	X	X	X	X	0,1	
klorsulfuron (H)	49:6	0,01	X					-	1999
kvinmerak (H)	50:8	0,006	X	X	X	X		5,2	
lambda-cyhalotrin (I)	51:5	0,01	X	X	X	X	X	-	
lindan (γ-HCH) (I)	51:5	0,005	X	X	X	X	X	-	1989
α-HCH (B)	51:5	0,005	X	X	X	X	X	-	
β-HCH (B)	51:5	0,01				X	X	-	
δ-HCH (B)	51:5	0,0003				X	X	-	
MCPA (H)	50:8	0,005	X	X	X	X		110,9	
mekoprop (H)	50:8	0,005	X	X	X	X		4,2	
metabenstiazuron (H)	51:5	0,02	X	X	X	X	X	-	
metalaxyl (F)	51:5	0,01	X	X	X	X		3,5	
metamitron (H)	51:5	0,02	X	X	X	X		72,7	
metazaklor (H)	51:5	0,006	X	X	X	X	X	29,6	
metribuzin (H)	51:5	0,01	X	X	X	X		5,9	
metsulfuron-metyl (H)	49:6	0,005	X					0,1	
pendimetalin (H)	51:5	0,01	X	X	X	X	X	4,3	
permetrin (I)	51:5	0,03	X	X	X	X	X	0,5	
pirimikarb (I)	51.5	0,005	X	X	X	X	X	1,6	
prokloraz (F)	51:5	0,03	X	X	X	X		9,9	
propikonazol (F)	51:5	0,01	X	X	X	X	X	31,3	
propyzamid (H)	51:5	0,01	X	X	X	X	X	2,1	
prosulfokarb (H)	51:5	0,008	X	X	X	X	X	14,9	
pyraklostrobin (F)	51.5	0,1	X	X	X	X		22	
quinoxyfen (F)	51:5	0,005				X		-	#
rimsulfuron (H)	49:6	0,01	X					0,2	
simazin (H)	51:5	0,005	X	X	X	X	X	-	1994
spiroxamin (F)	54:1						X	3,2	
sulfosulfuron (H)	49:6	0,01	X					0,9	
terbutryn (H)	51:5	0,008	X	X	X	X	X	-	2003
terbutylazin (H)	51:5	0,004	X	X	X	X	X	-	2003
DETA (N)	51:5	0,003	X	X	X	X		-	
tifensulfuron-metyl (H)	49:6	0,007	X					0,7	
tolklofosmetyl (F)	51:5	0,007	X	X	X	X	X	0,2	
tolylfluanid (F)	51:5	0,008	X	X	X	X		12,1	
tribenuronmetyl (H)	49:6	0,01	X					2,1	
trifluralin (H)	51:5	0,005	X	X	X	X		-	1990

Substances	Analytical method OMK	Limit of detection (µg/l)	Rivers of intensive study	Ground water	Rivers in Skåne	Precipitation	Sediments	Sales 2004 (tons)	Banned (year)
triflusulfuron-metyl (H)	49:6	0,01	X̲					0,4	
vinklozolin (F)	51:5	0,006	X	X	X	X̲	X̲	-	1996
Sum			83	74	74	85	52	887	

H= Herbicide, I= Insecticide, F= Fungicide, M=Metabolite (degredation product), B= Bi-product.
X = Substance included in the analysis, though not detected above the limit of detection (LOD).
X̲ = Substance included in the analysis and detected above LOD on one or several occasions.
- = Not sold in Sweden.
= Never registered in Sweden.
Limit of detection (LOD) is primary given as the median values for surface water and groundwater during 2004, when these are missing the detection limit for precipitation is given.
Sales figures are from the Swedish Chemicals Inspectorate.

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8. Derivation and Application of WQS for Pesticides in Sweden

Jeanette Asp, Swedish Chemicals Inspectorate, Sweden

8.1 Swedish Water Quality Standards

Deriving WQS for pesticides in surface waters is part of the Swedish government's strategy to achieve its environmental goals. The Swedish Chemicals Inspectorate has therefore derived Swedish WQS for 102 pesticides in surface waters, published on the internet on 28 April 2004 (www.kemi.se, select the following headlines: Bekämpningsmedel; Växtskyddsmedel; Växtskyddsmedel i Sverige; Riktvärden för ytvatten).

The Swedish term for WQS is guideline values (Riktvärden). They are set to protect all water organisms against adverse effects that may be caused by exposure to a chemical substance. They are meant to reflect an exposure concentration below which unacceptable effects in the aquatic ecosystem will most likely not occur (Asp[a] et al, 2004).

When selecting priority substances for which environmental quality objectives should be calculated, Sweden has committed itself to follow a number of priority lists containing substances subjected to reduction measures (e.g. HELCOM, OSPARCOM). Sweden is also obliged to prioritise substances placed on the lists agreed by the EU (e.g. four priority lists for existing chemicals as well as a number of lists attached to different directives such as Water Directive (2000/60/EC) or Plant Protection Products Directive (91/414/EC). Mainly WQS are derived for pesticides assessed within the existing monitoring program and for pesticides with great volumes of sold amounts in Sweden (Andersson, A).

8.2 The Swedish method of deriving WQS

Within the EU, different systems for deriving Water Quality Standards of pesticides are being used. The water framework directive 2000/60/EG is intended to refine and harmonize water quality monitoring in member states, as well as methodology for deriving WQS. The Swedish method of deriving WQS is primarily based on the Technical Guidance Document in support of Commission Directive on risk assessment for new notified substances (93/67/EEC) (European Commission, 2001).

The Swedish WQS are general and can be applied to both marine and freshwater ecosystems, they are expressed as dissolved concentrations of chemical substances. WQS in Sweden are expressed as one single value protecting aquatic organisms against both acute and chronic effects. They are nation-wide and do not take site specific conditions into consideration.

8.3 The main steps of the procedure

The process begins with collection of all available information about a substance. The collected data has to be evaluated (toxicity tests should have been performed according to internationally accepted guidelines). Primarily, assessment reports produced by EU, the Swedish National Chemicals Inspectorate (KemI), OECD and Nordic cooperation programme are collected. Databases like Riskline (KemI), Aquire and Pesticide Ecotoxicity Database of USEPA is also used. Two types of information are collected, (i) toxicity data and (ii) information about physical and chemical properties of a substance. The toxicity data is used to derive a quality objective, while the physical and chemical properties of the chemical material help to understand fate and behaviour of the substance in the aquaic environment. Persistence and bioaccumulation data are of special importance. Information on persistence and bioaccumulation of the substance indicate real exposure and is collected in order to see whether quality objectives for other parts of the aquatic ecosystem i.e. sediment and biota are needed.

As the majority of pesticides are applied a limited number of times during a season, effects caused by both chronic and acute exposure is considered when deriving Swedish WQS. The WQS thereby guarantee protection against both chronic and acute effects (based on both NOEC and L(E)C50 values).

The collected toxicity data is used to derive a quality standard. Data set should represent both structure and function of the aquatic ecosystem and therefore results should represent three trophic levels of the aquatic ecosystem and their representative organisms; producers (algaes), primary consumers (daphnia) and secondary consumers (fish). According to TGD it is assumed that ecosystem sensitivity depends on the most sensitive species. To protect the whole aquatic system against chronic effects caused by exposure to chemical substances, derivation of the standards should therefore be based on the most sensitive species. The most sensitive species is selected by identification of the lowest result in the dataset.

Results from the three trophic levels are summarised in a table in a protocol. The next step is to extrapolate the lowest reliable effect or no effect concentration identified under laboratory conditions, to an ecosystem level under field conditions. This extrapolation is always associated with a certain degree of uncertainty which is handled with dividing the chosen concentration with an appropriate uncertainty factor. In the TGD this level is called PNEC (Predicted No Effect Concentration).

$$\frac{\text{The lowest NOEC/L(E)C50}}{\text{Uncertainty Factor}} = \text{WQS}$$

With uncertainty factors (between 10 and 1,000 depending on quality, quantity and type of the data) a possible safe concentration is lowered to the final WQS value. Field data are handled from case to case depending on quality. The method of applying "uncertainty factors" is stipulated in fixed guidelines in TGD, but the principles for application of factors are modified when WQS for pesticides are calculated in order to take into account their application to the environment and their mode of action.

Table 1. Uncertainty factors to derive water quality objectives

Data available	Uncertainty factors
At least one short-term L(E)C50 from each of three trophic levels of the dataset (fish, Daphnia and algae)	1,000
One long-term NOEC (either fish or Daphnia)	100
Two long-term NOECs from species representing two trophic levels (fish and/or Daphnia and/or algae)	50
Long-term NOECs from at least three species (normally fish, Daphnia and algae) representing three trophic levels	10
Field data and model ecosystem	Case-by-case basis

The Uncertaity Factors are applied in order to compensate for

- Lack of data
- Any uncertainties connected with extrapolation of results from laboratory tests to real aquatic systems
- Variations in sensitivity between different species
- Variations between different laboratories
- Also, it is the only available method for handling with risks for synergistic and endocrine effects

Physical and chemical properties of the chemical are summarised in text in the protocol. The text is for understanding fate and behaviour of the substance in water and environment. Also information about metabolites can be found in the protocol (Asp[a] et al, 2004).

8.4 How do the Swedish WQS compare to measured concentrations in surface water?

Pesticides detected in higher concentrations than WQS have decrease during the last ten years. A review of a Swedish database including pesticide monitoring data at the Division of Water Quality Management

(Swedish University of Agricultural Sciences) showed that during the period 1998–2003, 22 substances exceeded Swedish WQS. During 2003 only, 10 of 81 pesticides analysed, were detected at least once, in surface waters in concentrations above WQS. Pesticides detected at higher concentrations than WQS mainly belonged to the herbicide group (e.g. terbutylazin, isoproturon, sulfosulfuron, metazachlor, metribuzin and metamitron) (Kreuger et al, 2004).

8.5 How are WQS applied in Sweden?

WQS is a good tool to assess the potential effects that pesticides may have on aquatic life. They are used out by local authorities, county authorities, water boards and other actors that carry out measurements of pesticides in surface waters. Instructions for the collection of monitoring data, or conditions to be fulfilled for a practical use of WQS have been established (NV, 2004). In minor surveys with occasional grab samples the measured pesticide concentration tends to be very random. When relating measured concentration to WQS it is therefore important to keep in mind that pesticide concentrations can change very rapidly.

WQS are mainly applicable to some form of long-term and systematic monitoring and can be compared with pesticide monitoring data at the Division of Water Quality Management (Swedish University of Agricultural Sciences) (Asp[a] et al, 2004).

8.6 Pesticide Toxicity Index (PTI)

Swedish environmental policy is based on 15 environmental quality goals adopted by the Swedish government. The Swedish chemicals inspectorate is the authority responsible for the environmental goal ‘A non toxic environment’. This particular goal will be monitored by for example application of indicators. Different indicators for monitoring the incidence of crop protection chemicals in surface waters have been subjected for deeper analysis and development (Asp[b], 2004). The indicators were intended to allow risks of environmentally hazardous substances detected, to be reported and presented in a transparent way.

An index method developed in the USA (by the U.S.Geological Survey) was considered preferable among examined indicators, since the method was less sensitive to changes in the number of substances investigated. It was also easier to interpret and explain in text and diagrams, compared to other indicators studied. The method is named Pesticide Toxicity Index (PTI) (Munn et al, 2001). It has been evaluated on the basis of results obtained within the Vemmenhög project (1993–2004) (Kreuger, 2002; Kreuger et al., 2004) and of environmental monitoring data taken from four agricultural catchments within the environmental monitoring programme (2002–2004) (Kreuger et al., 2004). The PTI combines pesticide exposure of aquatic biota (measured concentrations of pesticides in stream water) with toxicity estimates (WQS) to a single index value for a sample or site. The PTI approach is useful as a basis for comparing the potential significance of pesticides in different streams on a common basis, from one year to the next. Swedish PTI is the sum of toxicity quotients for each pesticide compound measured in one location:

$$\mathrm{PTI} = \sum_{i=1}^{n} \frac{E_i}{RV_i}$$

PTI = Pesticide Toxicity Index
E_i = Concentration of pesticide i
RV_i = WQS i
n = Number of pesticides

The data resource on which this indicator can currently be based (results from environmental monitoring programme) is created with continuity and the results have high comparability from one year to the next. The agricultural catchments ('Typområden på jordbruksmark') in which the investigations are carried out represent the large agricultural regions in Sweden.

However there are some preconditions for the indicator being properly used as a basis for monitoring the environmental goals in a long-term perspective. Compounds newly registered on the Swedish market must be allocated a WQS. Also some pesticides are more difficult than others to include in the more general analytical methods. Thus, the practical use of WQS is to some extent limited by the lack of analytical methods for certain pesticides and also due to inadequate analytical detection limits (mainly insecticides e.g. pyrethroids). On the other hand, about 20 substances detected in Swedish waters do not have a Swedish WQS (e.g. cyfluthrin, dicamba, ioxinil and prochloraz) and can hereby not be included in the indicator. The PTI will be used by the Swedish Chemicals Inspectorate to report and present the current progress towards achieving the environmental goal.

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9. Deriving Water Quality Standards for pesticides in Norway

Torsten Källqvist, Norwegian Institute for Water Research, & Gro-Hege Ludvigsen, Bioforsk, Norway

Quality Standards or "miljøfarlighetsgrenser" (MF) have been derived for use in connection with the JOVA pesticide monitoring program in Norway since 1995. The purpose of the MFs is to provide a tool to quantify the risk posed by various pesticide findings in the monitoring program. The MFs have been developed by the steering committee for the monitoring program and has no legal status. The MFs were originally defined as concentration levels which should not be exceeded in order to prevent toxic effects of short term exposure to pesticides. The MFs were derived from toxicity data provided by the producers in connection with the registration process. These data should as a minimum include short term toxicity data expressed as (EC50 or LC50) for representatives of three trophic levels, e.g. algae or aquatic plants, *Daphnia* and fish. Originally, the MF was derived by division of the lowest L(E)C50 with an assessment factor =100. This practice is in accordance with the recommendations for calculation of Predicted No Effect Concentrations (PNEC) for intermittent discharge of chemicals in the Technical Guidance Document (TGD) for risk assessment of new and existing chemicals in the EU (EC 2003).

The experience from applying the MFs on the monitoring data was that several pesticides frequently exceeded the MFs. In most cases this was due to herbicides, which occurred in concentrations exceeding MFs that were based on toxicity to algae. In the registration process these herbicides had been approved for use in Norway on the basis of a risk assessment performed in accordance with the EU "Uniform Principles" as established in Annex VI to Directive 91/414/EEC. This includes the calculation of Toxicity Exposure Ratios (TER) for short term exposure, which are defined as the lowest L(E)C50 divided by the predicted exposure concentration. Trigger values for TER that should not be exceeded have been defined. The trigger value is 100 when the lowest $L(E)C_{50}$ refers to *Daphnia* or fish, and 10 for algae. The lower trigger value for algae is motivated by the high potential for recovery of algal communities as compared to invertebrates and fish.

The TER trigger values can be compared to the assessment factors used for deriving the MFs. Thus, the assessment factor used for deriving the original MFs were a factor 10 higher than the TER triggers for substances for which algae were the most sensitive group of organisms. Biological surveys in those watercourses where MFs were exceeded due to herbicides did not show any effects on the periphyton algal communities that could be linked to peaks in herbicide concentrations (Ludvigsen et al. 2002). Furthermore, mesocosm experiments performed in Norway did not indicate any effects on periphyton at concentrations a factor 10 higher then the MFs for three herbicides (metribuzin, linuron and tribenuron-methyl) (Källqvist and Romstad 2002). On this background it was decided to revise the MFs that were derived from EC50-values for algae, by reducing the assessment factor from 100 to 10 in accordance with EU "Uniform Principles".

The advantage of the revised MFs was that the conservatism was the same as in the risk assessment on which approval of pesticides was based. Thus, in case these revised MFs were exceeded this was a strong indication that the assumptions on exposure on which the approval was based were not valid, and this could then be considered in the subsequent re-registration process.

A disadvantage of the MFs based on the Uniform Principles was that they may not be sufficiently conservative to prevent chronic toxic effects of long-term exposure. Furthermore, they were not in accordance with other international water quality standards as e.g. those derived for priority substances under the Water Framework Directive (Lepper 2001), and those in other Nordic countries, which were mainly derived according to the principles for deriving Predicted No Effect Concentrations (PNEC) in the Technical Guidance Document (TGD) for risk assessment of chemicals in the EU. In order to harmonise the Norwegian MFs with these Nordic and international water quality standards, a second revision of the MFs was performed in 2005.

The criteria for the second revision of the MFs were in general adopted from the TGD. Primarily, they are based on NOECs obtained from chronic toxicity tests on organisms from three trophic levels represented by algae, *Daphnia* and fish. In case such data are available the lowest NOEC is divided by an assessment factor 10 to obtain the MF. In case only data derived from short term toxicity tests with the same three categories of organisms are available, the lowest L(E)C50 is divided by the assessment factor 1,000, or 100 when an alga is the most sensitive organism[1]. Other assessment factors then 10, 100 or 1,000 may be applied in certain cases, depending on the amount and quality of the data, which species that are covered by the acute and chronic toxicity data etc. in accordance with the guidance given in the TGD.

[1] The use o the assessment factor 100 for algae is not in accordance with the TGD. It should be noted, however, that a short term growth inhibition test with algae (72–96 hours) is a chronic test and the "acute" EC50 and "chronic" NOEC are derived from the same test. The ratio EC50/NOEC in tests of toxic chemicals does normally not exceed 10. Thus, a factor 10 difference in the assessment factor applied on EC50 and NOEC is considered appropriate.

The data on which the revised TGDs were derived were cordially provided by the Swedish Chemical Inspectorate, KemI. Additional data for pesticides not included on the Swedish list of Quality Standards (http://www.kemi.se/templates/Page____1970.aspx), were obtained from the Norwegian Food Safety Authority.

The second revision generally led to a lowering of the MFs, which could be expected as they shall prevent from chronic effects of long term exposure and not only effects caused by intermittent exposure. However, for some pesticides the revised MFs were higher than the previous MFs. This was either due to differences in the data on which they were based, or that the differences between L(E)C50-values and the NOECs were lower than the differences between the assessment factors used to calculate the two MFs.

As a consequence of the revision of the MFs the number of pesticide findings exceeding the MFs will increase. The interpretation of these exceeding of MFs is, however, not straightforward. Since the MFs are based on long term effects they should be related to long-term exposure. The Norwegian pesticide monitoring programme is based on 14 days time-averaged samples or grab samples. 14 days exposure may be sufficient to induce chronic toxicity to some organisms and long-term effects on the ecosystems, but the variation of exposure during the 14-days period is not known. Furthermore, chronic toxic effects of intermittent exposure on organisms with short life cycles and high potential for recovery may not necessarily cause long-term effects on the ecosystem level. It should be noted that the Quality Standards derived for priority substances (including some pesticides) under the Water Framework Directive (WFD) are intended for comparison to the *annual average* concentration. If the same quality standards are applied on grab samples or 14-days average samples this would imply a higher level of protection than required in the WFD. Still, the MFs may be useful as environmental objectives, and in case they are exceeded this should be considered as a warning signal rather than a confirmation of an environmental effect.

As a supplement to the revised Norwegian MFs for protection against long-term environmental effects, adoption of a separate MF for effects of short term exposure should be considered. The use of separate MFs for intermittent and continuous exposure would be in accordance with the proposed quality standards for chemicals in the WFD, where both a Maximum Admissible Concentration (MAC) and a Quality Standard (QS) are derived.

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9.2 Explanation of abbreviations and acronyms

EC50 - Concentration of a substance that causes 50 % effect (e.g. growth reduction) in a toxicity test

LC50 - Concentration of a substance that is lethal for 50% of the test organsims in a toxicity test

MAC-QS – Maximum Admissable Concentration for transient concentration peaks (in WFR)

MF - "Miljøfarlighetsindeks" – Quality standard for pesticides usewd in the Norwegian pesticide monitoring programme

NOEC - No Observed Effect Concentration – the highest concentration tested that does not show a statistically significant toxic response as compared to a control

PNEC - Predicted No Effect Concentration. Upper concentration limit for no environmental effects

TER - Toxicity Exposure Ratio – Ratio between an effective concentration (eg. EC50) and the field exposure concentration

TGD - Technical guidance document

WFR - Water Framework Directive

QS – Quality Standard (in WFR)

10. Environmental Quality Standards for Pesticides in Finland

Susan Londesborough, SYKE, Finland

Enviromental Water Quality Standards (EQS) have been derived in Finland for six pesticides. The pesticides were selected by expert judgemnet on the basis of use volumes, use purposes and intrinsic properties. Environmental Quality Standard means the concentration of a particular pollutant in water, sediment or biota which should not be exceeded in order to protect human health and the environment. The derivation of EQS values is part of the implementation of the Water Framework Directive (2000/60/EC) and the Dangerous Substances Directive 76/464/EEC. In the Water Framework Directive the EQS values determine the border line between good and moderate status of waters.

The EQS values are derived according to methodology set in the Water Framework Directive. The methodology is equivalent to the methods given in the Technical Guidance Document for the risk assessment of new and existing chemicals in the European Union.

For details see Londesborough, S. 2005. Proposal for Environmental Water Quality Standards in Finland. Finnish Environment Institute, Helsinki. The Finnish Environment, Environmental Protection No 749. 177 p. ISBN 952-11-1951-9.

Available on the internet:
http://www.ymparisto.fi/default.asp?contentid=143511&lan=en

Table 1. Environmental Quality Standard derived in Finland for Pesticides.

	EQS-AA Fresh water µg/l	EQS- MAC Freah water µg/l	EQS-AA Marine Water µg/l	AA-EQS Sediment mg/kg d.w.	AA-EQS Secondary poisoning mg/kg fish (w.w.)
Dimethoate	0,7	-	0,07	-	-
Ethylenethiourea	200	200	20	-	-
MCPA	1,6	15	0,16	-	-
Metamitron	32	170	3,2	-	-
Prochloraz	1	7,3	0,1	0,3 – 0,4	3,3
Tribenuron-methyl	0,1	0,4	0,01	-	-

AA-annual average, MAC=maximum acceptable concentration, d.w. = dry weight, w.w. = wet weight

11. Pesticide monitoring in surface water within the Water Framework Directive

Susanne Boutrup, National Environmental research Institute, Denmark

11.1 Water Framework Monitoring

Pesticides have to be included in monitoring according to the Water Framework Directive (WFD) in as well surveillance monitoring as operational monitoring if they are on the list of priority substances and discharged, or if they belong to other pollutants which are discharged in significant amounts. Besides, pesticides might have to be included in investigative monitoring in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives.

Water is the matrix for compliance assessment. However, certain hydrophobic pesticides might not be found in water in significant concentrations, and the question of compliance with environmental quality standards (EQS) could better be addressed by monitoring suspended particulate, and measurements on sediment or biota more relevant for status and trend monitoring. Anyway, choosing other matrices than water has to be justified by technical knowledge and expert judgement.

11.2 Design of WFD monitoring programme

The programme for WFD pesticide monitoring will in Denmark be designed on the basis of results from previous and current monitoring programmes (described in a separate article in this report). The Danish national programme for monitoring and assessment for aquatic and terrestrial environment (NOVANA) will be set up in order to meet the WFD needs for surveillance monitoring.

The pesticides can be divided in three groups:

- pesticides included in the current monitoring programme
- pesticides included in previous programme, but not the current since the data have justified to stop further monitoring
- pesticides without any monitoring data.

Trifluralin and endosulfan are pesticides on the List of Priority substances. Both were included in the previous Danish monitoring programme, but they are neither included in the current programme nor will be included in the Danish WFD-monitoring. The reason for that is that endosulfan was not found at all in freshwater and trifluralin was found in 4 out of about 1,000 samples. Besides, endosulfan has not been sold in Denmark since 1994 and trifluralin not since 1997. These facts will be the justification for no WFD-monitoring of the two pesticides.

Alachlor, chlorfenvinphos and chlorpyrifos are pesticides on the List of Priority substances as well. No Danish monitoring data exist for these pesticides. Alachlor has not been used in Denmark since mid 1980s, chlorfenvinphos has only been sold in very small amounts since mid 1990 and was banned 2004 while chlorpyrifos is still in use. Before these three pesticides will be included in the Danish monitoring programme it has to be justified by a screenings investigation that it is relevant to include them. This approach is according to the strategy for including new substances in the Danish monitoring programme.

11.3 References

Directive 2000/60/EC establishing a framework for Community action in the field of water policy.

Decision No 2455/2001/EC establihing the list of priority substances in the field of water policy and amending Directive 2000/60/EC

National Monitoring and Assessment Programme for the Aquatic and Terrestrial Environment. Programme Description – Part 1. NERI Technical Report, No 532

http://www.dmu.dk/NR/rdonlyres/0DDB35D3-31DC-42F4-BA13-2956723158CA/0/FR532_www.pdf.

12. Use of pesticide monitoring data within the regulatory process

Terje Haraldsen, Norwegian Food Safety Administration, Norway

The legal basis of the approval of pesticides in Norway is an Act of 5 April 1963 concerning plant protection products etc. EFTA (Iceland, Liechtenstein, and Norway) and EU have an EEA (European Economical Area) agreement. 91/414/EC is included in the agreement, but the EFTA States are free to limit access to their markets according to the requirements of their existing legislation. Studies from the industry indicate inherent properties, but data for Nordic climate is usual lacking in the documentation. International evaluations (OECD, EU) often form the basis of our hazard identifications. We use the FOCUS models and national scenarios for exposure assessments. The Norwegian Scientific Committee for Food Safety, (earlier The Pesticides Board) does the risk assessment and the Norwegian Food Safety Authority (NFSA) does the exposure assessments and the risk management.

A lot of pesticides are detected in the JOVA-programme and gets restrictions in use afterwards. Bentazone and metribuzine are examples of substances with heavy restriction in use after a lot of detections in the monitoring programme. Bentazone was the active ingredient most frequently detected in the monitoring programme. It was detected at 13 locations, in very many samples and in all season, and in the following season(s). It was detected 6 years after spraying at Kvithamar in Trøndelag after been used on a relatively small fraction of the agricultural area in the fields. The use of the pesticide was restricted from 1998 and the sale was reduced from 27,6 ton in 1997 to 6,4 ton in 2004. Detections of the pesticide have been significantly reduced since 1996 (from 68 to about 10 yearly). The average concentration is low (< 0.1 mg/L). Metribuzine is another example of a mobile pesticide with a lot of detections in surface and ground water, and some in toxic concentrations, too. In 1999 the Pesticide Board recommends reduced dose and a new agronomic strategy and decided to follow up on monitoring data in 2001. In 2001, in the evaluation of new monitoring data, bentazone was still frequently detected in the environment, not reduced as required and it was considered withdrawal. But the industry appealed to NFSA, who accepted industry arguments, agreed that the time-series after dose reduction were too short and approved continued use. The sales have not decreased much and the use in the fields is nearly the same. The detections of metribuzine are still relatively frequent and there is no statistically significant decrease in the number of detections and in the concentrations. Metribuzine has more mobile metabolites than the active ingredient and the metabolites are not included in the monitoring programme**.** EU has nearly finished evaluating metribuzine and the provisionally conclusions are that metribuzin can be implemented on annex 1. Metribuzin is evaluated in our scientific committee these days and we do not know their conclusions.

Some conclusions after the results from the monitoring-programme are:

The monitoring data is a correction and supplement to the industry dossier. The degradation of e.g. bentazone under Norwegian conditions differs from the lab-studies (DT50 = 29 d (average)) and the field studies (DT50=14 d (average)), but the degradation at 10^{o}C is > 161 d and the mineralisation in soil is slow. Long time-series are necessary for an evaluation. Restricted use can entail fewer detections and lower concentrations, but not always as for metribuzine. We need more knowledge about use and pollution. These kinds of evaluations are difficult and a fundamental question is; how representative are the fields and the monitoring data?

13. Swedish national monitoring programme – Aim and structure

Britta Hedlund, Swedish EPA, Sweden

When we talk about “environmental monitoring” we primary mean long term, repeated measurements to analyse and describe the state of the environment and possible human exposure. Secondary we also mean screening. That is, e.g. emission control is not a part of the monitoring programme.

The main purposes for the monitoring programme is to:

- measure and describe the state and environment
- assess and follow up changes and trends in the environments
- identify threats
- analyse the impact by pollutions from various emission sources
- assess the extent of international and national impact
- provide basis for developing the environmental protection work
- follow up effects of accomplished measures

The main monitoring demands today comes from *International reporting,* standing for about half of the current programme, and *Indicators for environmental objectives*, like ”A non toxic environment”. The results are however also used for different kinds of assessments.

The Swedish environmental monitoring programme is divided into 10 different programme areas: air, landscape, mountains, forest, wetlands, agriculture, freshwater, sea & costal areas, health related environmental monitoring and toxic substance coordination.

Monitoring of pesticides is only a minor part of the programme. Investigations dealing with levels of pesticides can be found within the programme areas air, agriculture, health related environmental monitoring and (sometimes) the screening programme within the toxic substance coordination.

Within the air-programme pesticides are measured in rainwater at one location in Skåne. The measurements at four agricultural reference areas are a part of the agricultural monitoring programme. Some estimations of human exposure for pesticides are also carried out.

14. Different aspects on using results from pesticide monitoring programs

Jenny Kreuger, SLU, Sweden

In Sweden approximately 160 different pesticides are used. The applied amounts have decreased with 60% during the last 10 years but the applied area has not decreased since the early 80's. These are reasons for performing pesticide monitoring.

There are many parties interested in monitoring results, not only the environmental authorities, but also regulatory authorities, agricultural authorities, farmers union, chemical companies, research society and not least, the public.

Sweden has set up national environmental goals and there is a governmental programme on pesticide risk reduction, both these include pesticide commitments. Membership in the European Union also brings a need for data, for example within the EU thematic strategies, the Water Framework Directive and the Drinking Water Directive. Data can be further used to follow-up on the registration process and on political decisions such as CAP and risk reduction programmes. Compliances can also be made to quality standards. Within the research area results from pesticide monitoring is important in risk evaluation as well as for calibration and validation of exposure models.

To be really useful monitoring has to be long-term, this is costly, but it is important to gain high quality information since the variations between years are significant.

15. Group discussions

The participants of the workshop were divided into four discussion groups. Four topics were introduced and each group was responsible for one topic, but all groups were asked to comment on all topics. The tpics were:

- The use of monitoring data in the regulatory process (15.1)
- The role of pesticide modelling to enhance our understanding and use of monitoring data (15.2)
- Water Qualiyt Standards for pesticides in surface water within the Nordic countries (15.3)
- How should the pesticide monitoring network be structured in the future and how to benefit from eachother? (15.4)

Discussions were held on both days in totally three hours. The groups presented their conclusions in a session and a general discussion was held on each topic.

15.1 The use of monitoring data within the regulatory process

A short review on the situation on the use of monitoring data in the regulatory process in the Nordic countries:

- Denmark is using their "early warning system" (further described in chapter 3)
- Norway is trying to use their monitoring data, even if there is ten years of monitoring, one major problem is that the time series are short. Another problem is that the analytical spectre has increased every year, making interpretation of the results more difficult
- Sweden has started to use monitoring data quite recently
- Finland is in the same situation as Sweden but with less data available
- Iceland does not have monitoring on presently used pesticides.

In all countries the monitoring data is used as supplementary information in the regulatory process. On an EU basis it is not clear how to consider monitoring data in the regulatory process. Discussions are going on at the moment and a system with different scoring according to the type and reliability of the monitoring data is one of the suggestions.

A condition for using monitoring data in the regulatory process is that there are long time series with good quality available. This puts large demands on funding and a long term approach to monitoring. Another problem is that there are not always analytical methods available for analysing the metabolites and this is crucial to get a total picture of what is happening to a substance in the environment.

The regulatory authorities has a possibility to require that the applicants carry out post registration monitoring as a condition for the approval, but this possibility is seldom used.

15.2 The role of pesticide modelling to enhance our understanding and use of monitoring data

15.2.1 What are we modelling for?

- To help us learn about the real world (by comparing with monitoring data, models can help us to understand what we know, and even more important, what we don't know).
- To help target and improve monitoring programs (to make them more cost-effective, to identify potential risk areas and substances, to improve sampling protocols).
- To enable extrapolation of data from investgated areas to uninvestigated areas and to identify sources and transport pathways within a catchment (monitoring data is often very sparse).
- To assess the likely effects of mitigation measures for pesticide uses of concern.

15.2.2 What are the main difficulties?

Knowing the inputs! Both the input parameters to the model (e.g. soil conditions) and also what the pesticide uses are (compounds used, when, where, what dose), especially for larger catchments.

15.2.3 What kinds of tools should be used?

Modelling tools will be needed in the near future to help administrators and decision-makers, especially in the context of the Water Framework Directive. We will need different tools for different purposes.

- Non-process based tools (statistical methods) can be very useful for initial screening to identify causes of pollution. These methods make use of the monitoring data itself!

- Process-based models will be needed for other purposes e.g. to assess effects of mitigation measures, to improve the design of monitoring programmes, or for application to uninvestigated sites.
- 3D ‘fully distributed’ process-based hydrologic models do exist (e.g. MIKE-SHE in Denmark) and they can be valuable tools. However, they need lots of data, they are expensive and difficult to use, especially for larger areas. Their use is likely to be restricted to one or two locations, and smaller ‘test catchments’.
- Simpler process-based tools (e.g. simulation meta-models) could bridge the gap between the simple statistical methods and the complex process-based tools, but they do not yet exist. However, there are such developments in ongoing projects (e.g. the EU FOOTPRINT project).

15.3 Water Quality Standards for pesticides in surface water within the Nordic countries

Three of the Nordic countries (Sweden, Norway and Finland) have derived water quality standards (WQS) for surface water for a different number of substances, possibly also Denmark but detailed information was not available at the discussions. Sweden has derived WQS values for 102 substances, Norway for 56 substances, of which 20 are not included on the Swedish list. Finland has WQS values for six substances, which are all included both on the Swedish and the Norwegian lists. To derive WQS all countries used the criteria from the Technical Guidance Document, which also conform to criteria for Quality Standards (QS) in the Water Framework Directive, for deriving their WQS. There are however some differences in the application of the criteria.

- Finland derived separate QS for short and long term exposure, as in the Water Framework Directive.
- Norway derived QS for long term exposure, primarily based on chronic toxicity data, acute toxicity data was only used when chronic data was missing.
- Sweden derived QS both for short and long term exposure, finally selecting the lowest of the two values as a single QS to protect the aquatic environment from both long and short term exposure.

There are also differences on how the uncertainty factor has been included. The difficulties with deriving and using WQS values were discussed and some of the mentioned factors were

- how to handle zero values and values below the detection limit
- how to cope with synergistic effects

- whether to include metabolites in a WQS for the mother substance or to have a separate value for metabolites
- how to interpret results from monitoring studies in comparison with WQS values
- problems getting an acceptance for the WQS from the manufacturing industry
- WQS values not only for surface water but also for groundwater and the marine environment

It was agreed that there is a need for a common Nordic approach to WQS and a first step, to establish a mailing list, was taken at the meeting. Sharing of data for deriving the WQS values in a common Nordic database was a wish that was expressed, this is not possible at the moment but exchange of toxicity data including references is a feasible first step. Information on new or revised WQS values should also be shared.

A common Nordic understanding of the WQS values would be preferable. The Norwegian government uses their WQS as the best available knowledge and not really as binding standards. Results from monitoring data on substances with WQS values are used in registration and banning procedures. In Sweden there are discussions on making the WQS values legally binding, but so far they are not. Finland is planning to make their derived quality standards legally binding and until they are, they do not wish to call them WQS.

15.4 How should the pesticide monitoring network be structured in the future and how to benefit from each other?

15.4.1 Website(s)

A Nordic website gathering all sorts of information on pesticides was discussed, such a site could contain:

- links to national information on pesticide monitoring
- an overview of pesticide monitoring and screening and also research projects
- a list of Nordic pesticide specialists with contact information and what activities they are involved in
- links to relevant major reports
- list of amounts of pesticides used in each country (or a link to the information)
- list of regulatory pesticides (CAS number, name, chemical properties, legislation)
- list of pesticides found (over the detection limit) in different matrixes.

15.4.2 Network

To make a network, people need to get in touch with each other. Mailing lists with different subject was intended to be established. It was suggested to have organised phone meetings two to four times a year and to put minutes from those meetings on the webpage. Meeting with presentations and discussion groups was suggested to be held with an interval of two to four years, possibly with different topics. A common Nordic overview report on pesticide monitoring could also be published (3-5 years interval).

It was pointed out that the Water Framework Directive will enhance cooperation through monitoring networks and different projects (e.g. Reference data base BRIDGE, BALANCE Baltic countries harmonizing data, SWIFT WFD intercalibration).

It was also mentioned that the Baltic counties might be interested in participating in a pesticide network.

15.4.3 Monitoring cooperation

In the long perspective an aim would be to have joint data analysis and interpretation as well as joint research and monitoring projects. Today there is a Nordic Screening Programme already working, but in the future funding might become a problem. Joint pesticide reports would be a natural result of joint programmes.

Sammanfattning

En nordisk workshop om miljöövervakning av bekämpningsmedel hölls i Uppsala, Sverige, den 6–7 februari 2006. Sammankomsten var en frotsättning på ett initiativ från 2003, som innebar ett fösöka att starta ett närverk för personer som är engagerade i miljöövervakning av bekämpningsmedel.

Under workshopen gavs presentationer som beskrev den miljöövervakning av bekämpningsmedel som görs inom de olika nordiska länderna.

I Danmark är pesticidövervakningen till största delen inriktad på grundvatten eftersom det är Damnarks viktigaste dricksvattenkälla. Förutom det nationella miljöövervakningsprogrammet finns också ett unikt övervakningssystem med kontrollerade förhållanden vad gäller vattentransport och jordbrukshantering. Detta system kan varna för bekämpningsmedel som har hög benägenhet att lakas ut i ett tidigt skede. Andra matriser än grundvatten studeras inom det nationella programmet för miljöövervakning och miljöanalys av akvatiska och terresta miljöer.

På Island fokuserar pesticidövervakningen på klassiska substanser som DDT och PCB och då främst i akvatiska miljöer och kustområden.

Det norska miljöövervakningsprogrammet för bekämpningsmedel innefattar regelbundna mätningar i ytvatten från nio små jordbruksdominerade avrinningsområden samt tre åar. Dräneringsvatten, grundvatten, sediment och nederbörd studeras också.

Sveriges pesticidövervakningsprogram är inriktat på avrinningsområdesnivå i första hand, mätningar av ytvatten görs i fyra jordbruksdominerade avrinningsområden. Provtagning av grundvatten och sediment görs också inom dessa områden. Dessutom ingår två andra åar samt nederbördsmätningar i övervakningsprogrammet.

Miljöövervakning av bekämpningsmedel i Finland har hittills varit mest fokuserad på s.k. screeningundersökningar, både i ytvatten och grundvatten. Med de senaste undersökningarna som grund planeras nu ett mer permanent miljöövervakningsprogram för att möta kraven på övervakning inom EU:s vattendirektiv.

En genomgång av de nordiska ländernas framtagande av riktvärden för ytvatten gjordes och det aktuella läget för EU:s vattendirektiv presenterades. Dessutom gavs information om olika aspekter på hur resultat från miljöövervakning kan användas vid registreringsförfarande samt inom modellering och riskvärdering. Power point-presentationer för de flesta presentationer som hölls under workshopen finns på http://www.ust.is/ness/pest/workshop2006.html. Deltagarna på workshopen deltog också i diskussionsgrupper.

Slutsatsen från workshopen var att det finns en allmänn önskan om att utöka samarbetet och utbytet inom nordisk miljöövervakning av bekämpningsmedel. Förslag för framtida kontakter och sammankomster lades fram.

Projektets förslag

Establishing a Nordic Pesticide Monitoring Network

Ola Glesne. +47 22 57 34 86. ola.glesne@sft.no, samt
Jenny Kreuger, Gro Hege Ludvigsen, Betty Bügel Mogensen, Jaakko Mannio, Albert S. Sigurdsson
200,000 DKK from MJS

Det finns både risker och fördelar med att använda kemiska bekämpningsmedel inom jordbruket. Frågan debatteras livligt, samtidigt som myndigheter ofta får hantera problem med förorenade dricksvattentäkter och ”gifter i vatten” som överskrider riktvärden. En rad politiska beslut har under åren fattats för att minska dessa risker. Men, hur vet vi då att de beslut som fattas verkligen ger avsedd effekt?

För att söka svar på denna fråga undersöks vilka halter av bekämpningsmedel som finns i våra vatten runt om i Norden. Dessa mätningar har ett stort allmänt förtroende – de fungerar som facit, om utvecklingen går åt rätt håll. Men sättet att mäta och hur mätningarna används och utvärderas, varierar mellan de nordiska länderna. Slutrapporten, från det nordiska seminariet i feb 2006, visar detta. Rapporten visar också att strategierna skiljer sig åt för hur vi följer upp effekterna i miljön och därmed resultatet av de politiska målen.

Norden har dock en unik chans att driva på miljöarbetet inom EU genom att praktiskt visa hur miljöarbetet kan utvecklas och samordnas.

Politiskt intressanta resultat och möjligheter

- Projektet föreslår därför att det skapas ett nordiskt program för att under en treårsperiod samordna arbetet inom Norden. Syftet med programmet är att harmonisera pågående arbete, genom utveckling och samordning av datainhämtning, analysmetodik, databearbetningar och utvärderingar.
- De resurser som satsas inom respektive land kommer genom detta program att på ett betydligt bättre sätt kunna utnyttjas och möjliggör dessutom inspel till miljöarbetet inom den europeiska gemenskapen.

Kontakpersoner för MJS, den 30 oktober 2006
Anders Emmerman och Magnus Gröntoft (sekr.)

Appendix

List of workshop participants

Aastrup, Mats: Geological Survey of Sweden
Adielsson, Stina: Swedish University of Agricultural Sciences
Asp, Jeanette: Swedish Chemicals Inspectorate
Autio, Sari: Finnish Environment Institute
Boutrup, Susanne: National Environmental Research Institute
Brüsch, Walter: Danmarks og Grønlands Geologiske Undersøgelse
Christiansen, Agnethe: Bioforsk Lab
Fauser, Patrik: National Environmental Research Institute
Gudmundsdottir, Elin G.: Environment and Food Agency if Iceland
Gustafsson, Juhani: Finnish Environment Institute
Hagerberg, Anna: County Administration Board of Skåne
Hanze, Karin: Swedish Chemicals Inspectorate
Haraldsen, Terje: Norwegian Food and Safety Authority
Hedlund, Britta: Swedish Environmental Protection Agency
Hedström, Ingrid: Swedish Board of Agriculture
Jarvis, Nick: Swedish University of Agricultural Sciences
Kjaer, Jeanne: Danmarks og Grønlands Geologiske Undersøgelse
Kollerud, Johan: Norwegian Agricultural Authority
Kreuger, Jenny: Swedish University of Agricultural Sciences
Källqvist, Torsten: Norwegian Institute for Water Research
Lewin Pihlblad, Lotta: Geological Survey of Sweden
Londesborough, Susan: Finnish Environment Institute
Ludvigsen, Gro Hege: Center for Soil and Environmental Research
Mannio, Jaakko: Finnish Environment Institute
Mogensen, Betty Brügel: National Environmental Research Institute
Nerkegård, Lena: Swedish Environmental Protection Agency
Olafsdottir, Kristin: University of Iceland
Ruuttunen, Pentti: MTT Agrifood Research Finland
Sigurdsson, Albert: Environment and Food Agency of Iceland
Siimes Katri, Finnish Environment Institute
Skaufel Simensen Ingunn, Norwegian Pollution Control Authority
Stenröd, Marianne: Norwegian Crop Research Institute