ATLAS OF PESTICIDE CONCENTRATIONS IN DUTCH SURFACE WATERS: A PILOT STUDY

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SUMMARY

A pilot study was conducted to explore the potential for geographically mapping concentrations of individual pesticides in Dutch surface waters and compiling these maps into a National Pesticide Atlas. This atlas could be used for various purposes: 1) To see where specific pesticides are monitored, observed and find out whether these are problematical. 2) To explore the relationship between environmental pesticide levels and land use, using the results as feedback to improve national pesticide admission procedures (post-registration review) 3) To review the quality of the present Dutch pesticide monitoring system.
For the study we used measured data for the years 1997 and 1998, preparing maps for six illustrative pesticides. The data are presented on a grid scale of 5x5 km^2. Pesticide concentrations are compared with three standards: the EU drinking water standard , the maximum tolerable risk (MTR) level and the admission standard set by the Dutch Pesticide Admission Board (CTB).
The results show that all these pesticides can be satisfactorily mapped at the national level and that for most of the compounds investigated a useful relationship can be established between environmental concentration and land use. The maps also serve to show up gaps in the present pesticide monitoring system. The study yielded several new insights, among them that standards were found to be exceeded in areas and at times of the year not anticipated on the basis of land use and pesticide use statistics.
As a follow-up to this pilot study a new project has been started to develop an internet version of the pesticide atlas for all measured pesticides in The Netherlands.

INTRODUCTION

Although the current pesticide admission procedures becoming more and more strict for the environmental issues, in many West-European countries pesticides are being found in surface water. By putting geographical information concerning landscape, land use and pesticide use into the risk assessment researches tried to predict the potential contamination of surface water more accurate: 'potential risk mapping' (SCI, 2003). Up to now there is hardly any attention paid to included the actual pesticide measurements from existing monitoring programs and projects.
In the Netherlands pesticide concentrations in surface waters are monitored by a number of different regional water authorities, with results being amalgamated and reported periodically by the National Commission of Integral Water Management, CIW (CIW, 2000). These reports also have demonstrated repeatedly that there are still high levels of several pesticides in some Dutch surface waters (RIVM, 2002), reducing water quality and posing a threat to the aquatic ecosystem (De Snoo & De Jong, 1999). The periodical reports published by CIW provide at a national level information concerning which pesticides are being monitored, trends in pesticide levels and whether or not these are problematical. Until now no attempt have been made to present the data at the level of individual active ingredients in spatial terms. Neither have the monitoring data been used to explore relationships between land use (crops) and / or pesticide use. Since the link with land use or pesticide use was missing, the monitoring data hardy could be used for the re-approval of active ingredients by the Dutch Board on the Admission of Pesticides (CTB).
Geographic presentation of individual pesticide concentrations in the form of maps has several advantages compared with traditional (tabular) presentation: 1) The maps show where a pesticide is monitored, the level at which it is observed and whether this level is

problematical. 2) The maps can be used to explore how pesticide levels relate to land use and pesticide, using the results as feedback to improve national pesticide admission procedures (post-registration). 3) Finally, the maps can be used to review the quality of the current monitoring system.
Against this background a pilot study was therefore conducted to assess the potential for presenting such maps in the form of a Pesticide Atlas of the Netherlands. In the pilot study data quantity and quality (spatial and over time) of the current monitoring programs and projects was assessed. For some individual pesticides a geographical presentation was made comparing the measurements with different environmental standards and also with land use.

RESEARCH SET-UP

Data quality and quantity
As a database for the study CIW pesticide monitoring data for 1997 and 1998 were used, with prior checks being made on data quality and quantity. For a geographically presentation of the data, it needs co-ordinates. The percentage of measurements, sites and substances with co-ordinates is determined

Geographical comparison of concentrations with standards
To assess the general potential for geographically mapping these data, six pesticides were selected on the basis of three criteria: 1) high toxicity, 2) sufficient sampling sites and 3) widespread use. The following compounds were selected for further investigation: the herbicides atrazine (criteria 2, 3) and metribuzin (1), the fungicides carbendazim (1), iprodion (2) and vinclozolin (2) and the insecticide propoxur (1).
To establish the optimum scale for presentation, the data were mapped at three different scale levels: by geographic coordinate, in grid squares of 1*1 km^2 and in grid squares of 5*5 km^2. The latter two are the scales at which ecological (flora and fauna) databases are maintained in the Netherlands (Van der Meijden *et al*., 1996)
Pesticide concentrations were compared with three standards: the EU drinking water standard, the maximum tolerable risk level (MTR, an ecotoxicological standard) and the admission standard set by the Dutch Pesticide Admission Board, CTB. The first of these standards has been set at 0.1 μg/l , for each individual pesticide, while the other two are pesticide-specific and vary.

Time
Besides the spatial spread of the data, their spread in time was also examined. The data covered two years. To this end the average number of monthly measurements was recorded.

Land use
Finally, some of the resultant pesticide maps were compared visually with maps showing categories of land use in which the respective pesticide is commonly used. For this purpose three sources were used: the national land use statistics compiled by Netherlands Statistics (CBS, 1997), the national land use database LGN, based largely on satellite imagery (LGN-1, 1986), and the LKN digitised database of landscape ecological characteristics of the Netherlands (Bolsius *et al*., 1990).

RESULTS

Data quality and quantity

Our examination of the raw data showed that at over half the sampling sites (43%), half the measurements (51%) and 74% of the measured substances, no geographical co-ordinates had been reported (Table 1). These co-ordinates are obviously required if individual pesticide concentrations are to be presented in map form. Given the efforts put into all this monitoring, this represents a real loss.

Table 1. Overview of the quality of the pesticide data in the database (1997 – 1998)

Parameter	Year	Total number	Number with known co-ordinates	Percentage with known co-ordinates
No. of measurements	Both	151,178	77,523	51
No. of monitoring sites	1997	497	206	41
	1998	671	309	46
	Both	759	330	43
No. of pesticides monitored at one site minimum	1997	179	130	73
	1998	195	143	73
	Both	197	146	74
Average number of measurements per pesticide	Both	767	529	69
Average number of sites per substances	Both	-	67	-

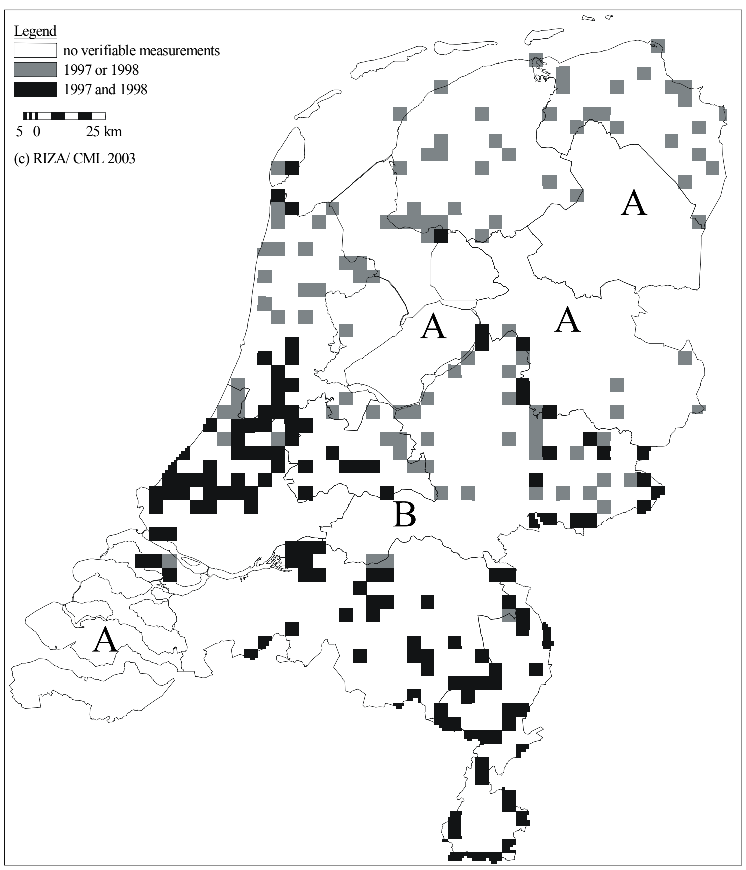

Figure 1 Spread of measurements in respective years

As can be seen from Figure 1, in the northern Dutch provinces measurements were restricted to one year (mostly 1998), in the eastern Dutch provinces measurements were only carried out in 1997, while in the southern provinces monitoring extended to both years. In some provinces of the Netherlands there are no measurements presented, due to the lack of geographical co-ordinates (Zeeland, Drenthe and Flevopolders: area A). In the middle of the Netherlands (area B) no pesticide data were available in the CIW-pesticide database.

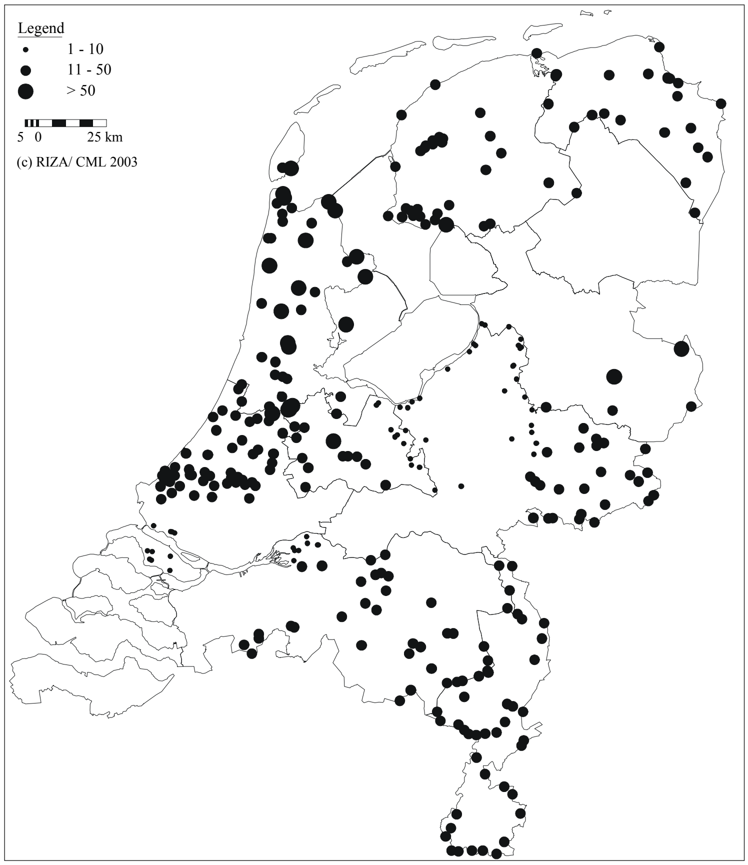

Figure 2 Number of pesticides monitored at each sampling site

Figure 2 shows how many pesticides were monitored at each sampling site. The number of pesticides varies with location.

Geographical comparison of concentrations with standards

As outlined in the set-up of the research, recorded environmental pesticide levels were compared with three different standards. The following series of maps (Fig. 3-5) show the sites where the various standards were exceeded. Outcomes differed for individual compounds, depending on the standard of comparison. In the case of atrazine the ecotoxicological standard (MTR, 2.9 μg/l) is rarely exceeded (Figure 3), although there is widespread exceeding of the EU drinking water standard of 0.1 μg/l (Figure 4). The maps for less frequently monitored pesticides show that a small number of sampling sites still provide a wealth of information. For example the ecotoxicological map of carbendazim show that on almost all places the concentrations exceed the MTR (0.11 μg/l) (Figure 5). The 5*5 km^2 spatial scale appears to be the most appropriate for presenting these pesticide data at the national level.

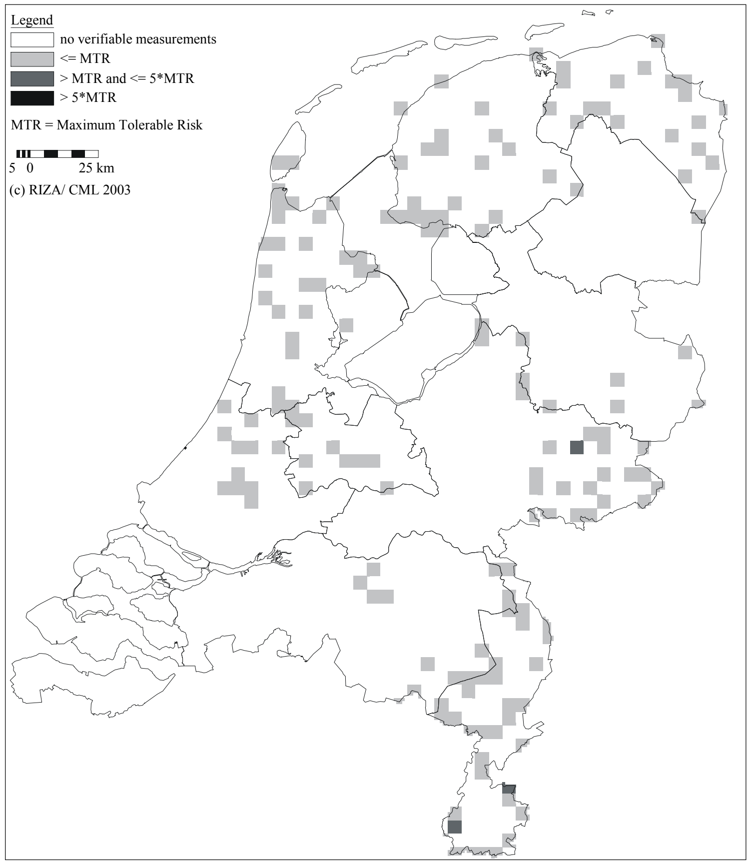

Figure 3 Atrazine: exceeding of MTR ('ecotoxicological map')

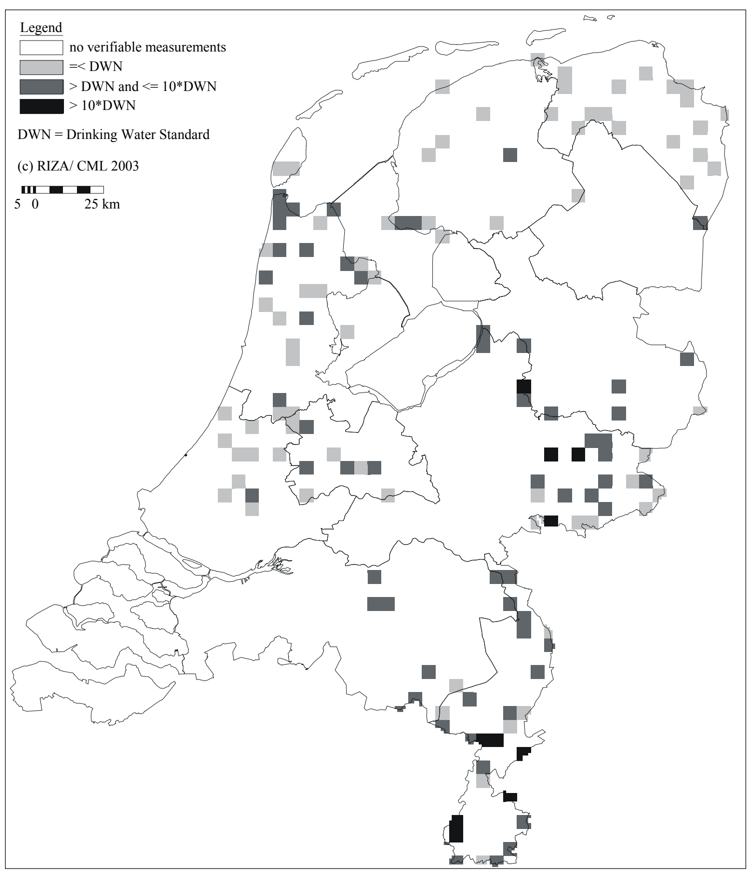

Figure 4 Atrazine: exceeding of EU drinking water standard

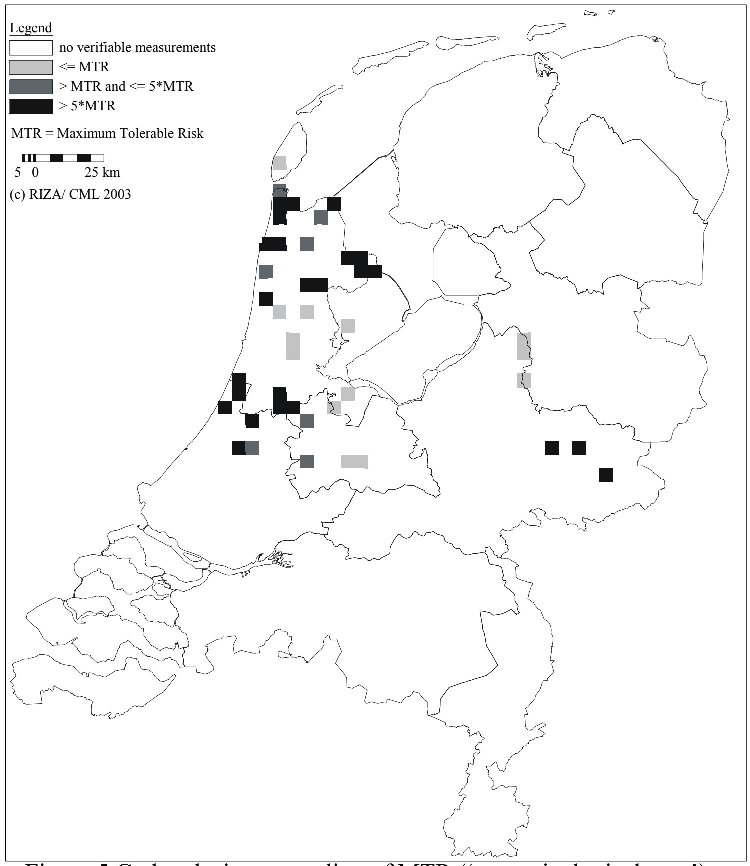

Figure 5 Carbendazim: exceeding of MTR (‘ecotoxicological map’)

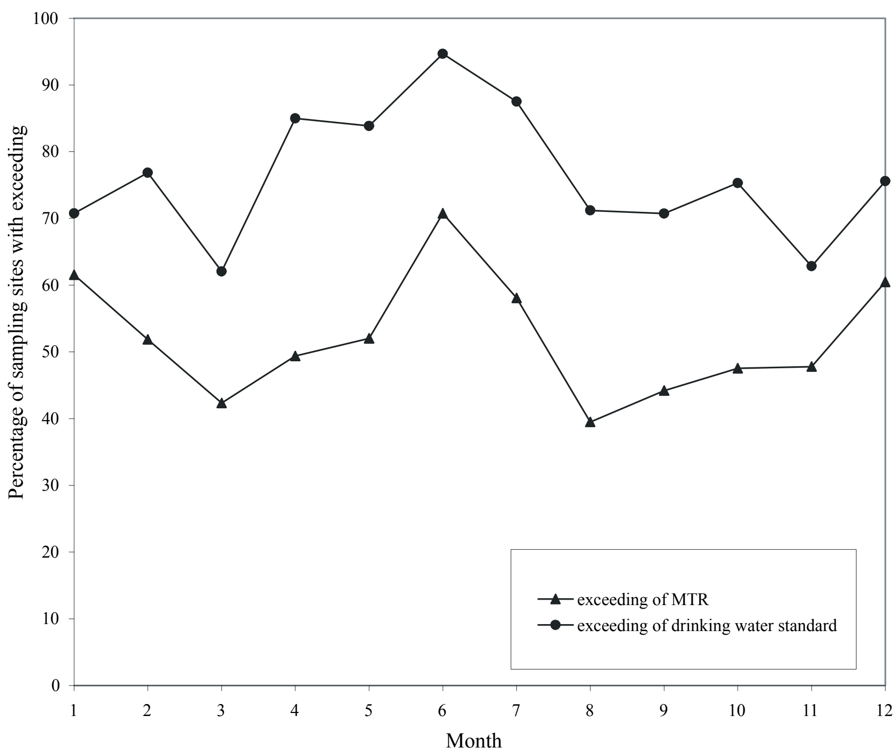

Figure 6 Percentage of sampling sites with exceeding per month for two standards

Time

Our trend analysis showed that standards are exceeded in all months of the year (Figure 6). It is remarkable that pesticide concentrations were also above the standards (see for example the MTR) during the winter period (December and January). In this period in most crops no pesticides are used.

Land use

As can be seen from the map of atrazine concentrations relative to the EU drinking water standard (figure 7), this standard was exceeded most frequently in the south and east of the Netherlands, in the provinces of Limburg and Gelderland, respectively, both districts where a lot of maize is cultivated. The herbicide atrazine is used almost exclusively on silage maize (Figure 8). The paucity of measurements in the province of Noord-Brabant (indicated by an arrow) and in eastern of Overijssel is thus remarkable, because these are also maize-growing districts. In contrast, there are numerous monitoring data from the northern provinces (Groningen, Friesland, Noord-Holland, Zuid-Holland) where relatively little maize is cultivated.

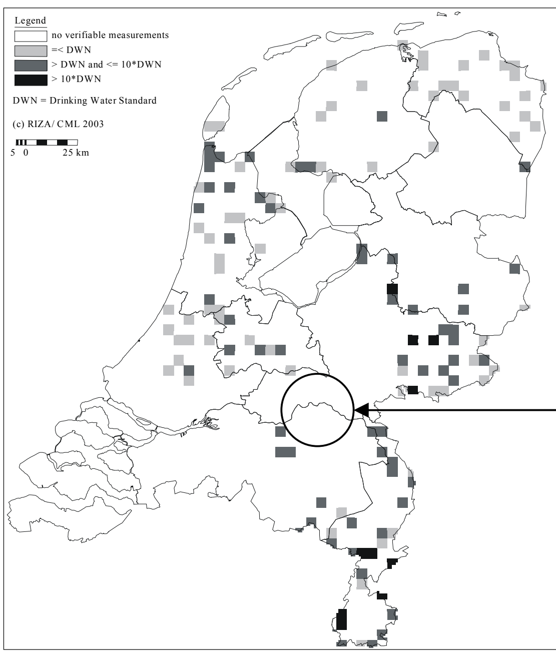

Figure 7 Atrazine concentrations relative to the EU drinking water standard (0.1μg/l)

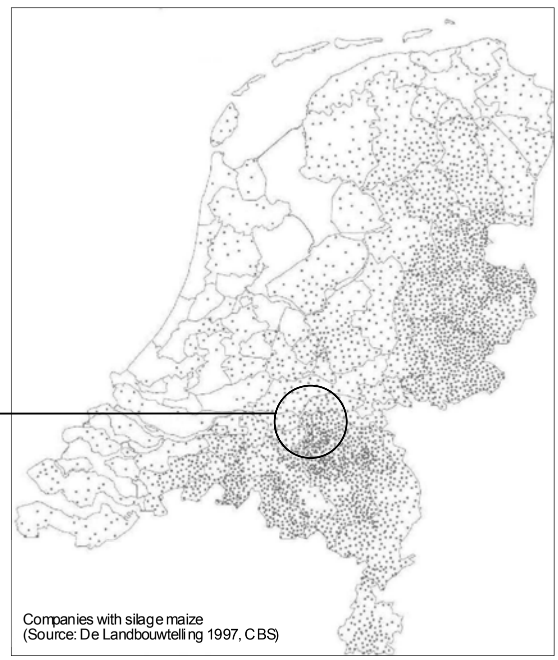

Figure 8 Density of companies with silage maize

CONCLUSIONS AND FURTHER RESEARCH

The results demonstrate that the adopted procedure yields maps that provide a good visual impression of the geographic spread of surface water pesticide concentrations in the Netherlands. If geographic co-ordinates are properly recorded in future monitoring programmes and projects, the number of locations mapped can be increased substantially. Grid squares of 5*5 km^2 appear to be an appropriate scale for data presentation. For the investigated pesticides the resultant maps can be usefully linked with existing maps of land use. The maps also serve to show up gaps in the present pesticide monitoring system. The study yielded several new insights. Standards were found to be exceeded in areas and at times of the year not anticipated on the basis of available data on land use. For example, in the winter months the MTR standard is exceeded, although in most crops no pesticides are used. It became clear, moreover, that the maps can be used as a tool for optimising pesticide monitoring, by improving the spatial and temporal spread of sampling sites as well as the range of pesticides monitored. Finally, the maps can be used in the registration process. On the one hand as a tool for post-registration of individual pesticides on the Dutch market (re-approval) and on the other hand to improve and validate the models used for estimating the environmental concentration of pesticides in surface water (see for example SCI, 2003).

As a follow-up to this pilot study a new project has been started to develop an *internet version* of the pesticide atlas, as a collaborative effort between CML and Royal Haskoning. The aim is to plot measured concentrations (in 1999-2000) of some *200 pesticides* in Dutch surface waters on nation-wide maps. This internet tool (http://www.bestrijdingsmiddelenatlas.nl*)* is scheduled for completion at the end of 2003 and will allow the atlas to be accessed by a wide variety of users, including policy-makers at both the national and supra-regional level. The maps will be downloadable, enabling them to be linked with geographical mappings of pesticide use and land use. In principle, the data could also be linked with data concerning the presence of aquatic flora and fauna.

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